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# **Manures , Fertilizers and Soil Fertility Management**

## **12. Essential plant nutrients and its role**

**Edited by Monisankar Bera**



# 12.1

**Primary or major nutrients:** are those nutrients required relatively in large quantities by the plants for its growth and development. Ex: N, P and K.

**Secondary nutrients:** are those nutrients which are required by plants in moderate amounts and given secondary importance in its supply and management.

Ex: Ca, Mg and S.

**Micronutrients:** The nutrients which are utilized by plants in relatively smaller quantities for their growth and development, but these are equally important & essential to plants as macronutrients.

Ex: Fe, Mn, Zn, Cu, B, Mo, Cl and Ni.



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## 12.2

The plant content of mineral elements is affected by many factors and their concentration in crops varies considerably.

Nutrient		Relative concentration (Times)	Concentration (%)
Primary	N, K	400-1000	1-1.5
	P	30	0.1-0.3
Secondary	Ca, Mg	100-200	0.2-0.5
	S	30	0.1
Micro	Fe, Mn, B	1-2	0.002-0.01
	Others	<1	<0.002



## 12.3

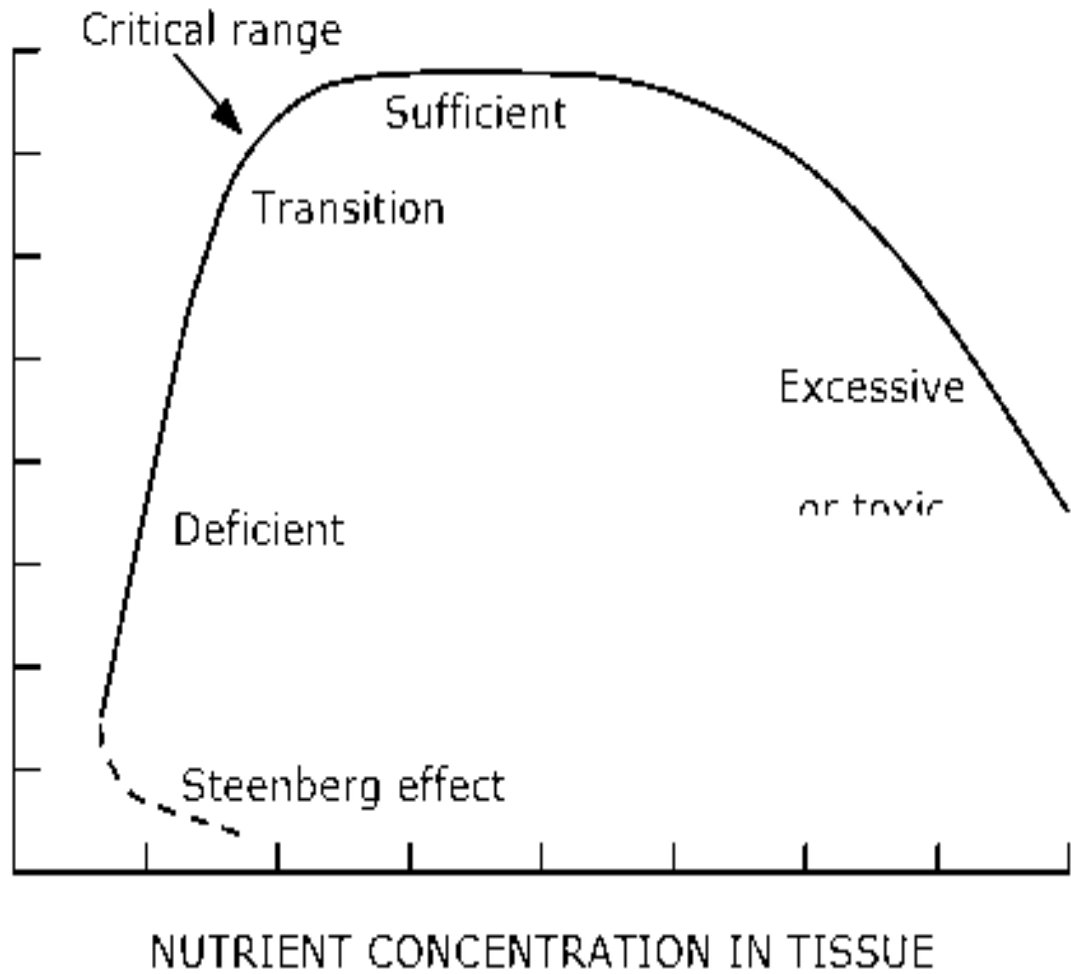
- ❑ **Deficient:** When the concentration of an essential element is low enough to limit yield severely and distinct deficiency symptoms are visible then that element is said to be deficient. Extreme deficiencies can result in plant death. With moderate or slight deficiencies, symptoms may not be visible, but yields will still be reduced.
- ❑ **Critical range:** The nutrient concentration in the plant below which a yield response to added nutrient occurs. Critical level or ranges vary among plants and nutrients but occur somewhere in the transition between nutrient deficiency and sufficiency.



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PLANT YIELD



NUTRIENT CONCENTRATION IN TISSUE

# 12.4



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- ❑ **Sufficient:** Concentration range in which added nutrients will not increase yield but can increase nutrient concentration. The term luxury consumption is used to describe nutrient absorption by the plant that does not influence yield.
- ❑ **Excessive or toxic:** When the concentration of essential or other elements is high enough to reduce plant growth and yield then it is said to be toxic. Excessive nutrient concentration can cause an imbalance in other essential nutrients, which also can reduce yield

Nutrient	Uptake form	Mobility in Soil	Mobility in Plant
Nitrogen	$\text{NO}_3^-$ , $\text{NH}_4^+$	Mobile in the form of $\text{NO}_3^-$ , immobile in the form of $\text{NH}_4^+$	Mobile
Phosphorus	$\text{HPO}_4^{2-}$ , $\text{H}_2\text{PO}_4^-$	Immobile	Somewhat mobile
Potassium	$\text{K}^+$	Somewhat mobile	Very mobile
Calcium	$\text{Ca}^{2+}$	Somewhat mobile	Immobile
Magnesium	$\text{Mg}^{2+}$	Immobile	Somewhat mobile
Sulfur	$\text{SO}_4^-$	Mobile	Mobile
Boron	$\text{H}_3\text{BO}_3$ , $\text{BO}_3^-$	Very mobile	Immobile
Copper	$\text{Cu}^{2+}$	Immobile	Immobile
Iron	$\text{Fe}^{2+}$ , $\text{Fe}^{3+}$	Immobile	Immobile
Manganese	$\text{Mn}^{2+}$	Mobile	Immobile
Zinc	$\text{Zn}^{2+}$	Immobile	Immobile
Molybdenum	$\text{MoO}_4^-$	Somewhat mobile	Immobile
Chlorine	$\text{Cl}^-$	Mobile	Mobile

<b>Nutrient</b>	<b>Role in Plant Growth</b>
Nitrogen	Chlorophyll, amino acids, proteins
Phosphorus	DNA/RNA, ATP, cell membrane
Potassium	Plant metabolism, stress response, regulation of water loss
Calcium	Cell wall formation
Magnesium	Photosynthesis, chlorophyll
Sulphur	Amino acids, proteins, oils, chlorophyll
Boron	Cell wall, sugar transport, seed and fruit formation, hormone development
Copper	Lignin production, photosynthesis, plant metabolism
Iron	Chlorophyll and enzyme production
Manganese	Photosynthesis, respiration, nitrogen assimilation
Zinc	Chlorophyll, enzymes, proteins, growth hormones
Molybdenum	Nitrogen cycle
Chlorine	Opening and closing stomata (respiration)



<b>Nutrient</b>	<b>Sign of Deficiency</b>
<b>Nitrogen</b>	Yellowing in the middle of the leaf, reduced and red-brown new growth
<b>Phosphorus</b>	Purple or reddish discolorations on leaves, poor growth, poor rooting, early fruit drop
<b>Potassium</b>	Yellowing of leaf margins and veins, crinkling or rolling leaves, poor growth
<b>Calcium</b>	Yellowing new growth, localized tissue necrosis
<b>Magnesium</b>	Interveinal chlorosis (yellow leaves with green veins)
<b>Sulphur</b>	Yellowing throughout the plant, necrotic tips on new growth
<b>Boron</b>	Cell wall, sugar transport, seed and fruit formation, hormone
<b>Copper</b>	Pale green, withered new growth, yellowing, wilting
<b>Iron</b>	Yellowing in new growth
<b>Manganese</b>	Interveinal chlorosis on new growth, sunken tan spots on leaves
<b>Zinc</b>	Interveinal chlorosis on new growth
<b>Molybdenum</b>	Yellowing of leaf margins on new growth
<b>Chlorine</b>	Yellowing of leaf margins on old growth

A young green plant with several leaves is growing in dark brown soil. The soil is textured and contains many small, light-colored granules, likely fertilizer. The plant is positioned on the left side of the frame, and the word "NITROGEN" is written in white capital letters on the right side of the image.

NITROGEN



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# 12.8

## Functions of Nitrogen

- Promotes growth of leaves and stems
- Gives dark green color and improves quality of foliage
- Necessary to develop cell proteins and chlorophyll



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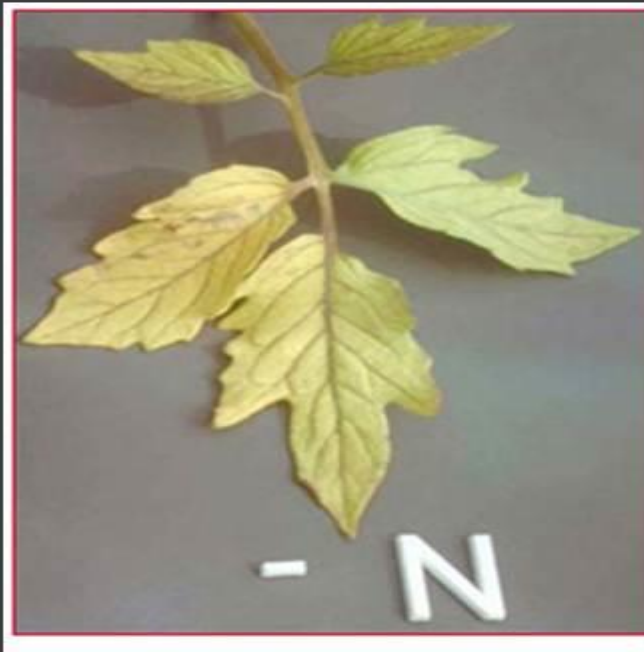
## Nitrogen

- The chlorosis symptoms shown by the leaves are the direct result of nitrogen deficiency.
- As the deficiency progresses these older leaves become uniformly yellow (chlorotic).
- Branching is reduced in nitrogen deficient plants resulting in short, spindly plants.
- The yellowing in nitrogen deficiency is uniform over the entire leaf including the veins.



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Recovery of deficient plants to applied nitrogen is immediate (days) and spectacular.



Nitrogen deficient tomato leaf



Healthy tomato leaf

A young green plant with several leaves is growing out of dark brown soil. The soil is textured and contains many small, light-colored granules, likely fertilizer. The plant is positioned on the left side of the frame. The word "PHOSPHOROUS" is written in large, white, sans-serif capital letters across the upper right portion of the image.

PHOSPHOROUS



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# 12.9

## Functions of Phosphorus

- Stimulates early formation and growth of roots
- Provides for fast and vigorous growth and speeds maturity
- Stimulates flowering and seed development
- Necessary for the enzyme action of many plant processes

# Phosphorus

- The necrotic spots on the leaves are a typical symptom of phosphorus (P) deficiency.
- A major visual symptom is that the plants are dwarfed or stunted.
- Developing a distinct purpling of the stem, petiole and the lower sides of the leaves.
- Severe deficiency conditions there is also a tendency for leaves to develop a blue-gray luster.





In older leaves under very severe deficiency conditions a brown netted veining of the leaves may develop



Healthy tomato leaf



Phosphorus deficient tomato leaf

A young green plant with several leaves is growing in dark brown soil. The soil is textured and contains small white granules, likely fertilizer. The plant is positioned on the left side of the frame, and the word "POTASSIUM" is written in white capital letters on the right side of the image.

POTASSIUM



12.10

## Functions of Potassium

- Formation and transfer of starches, sugars and oils
- Increases disease resistance, vigor and hardiness
- helps cells maintain their internal pressure e.g. stomata opening
- Increase the availability of other elements.

# Potassium

- The leaves show marginal necrosis (tip burn).
- The leaves show more advanced deficiency status, with necrosis in the interveinal spaces between the main veins along with interveinal chlorosis.
- The onset of potassium deficiency is generally characterized by a marginal chlorosis, progressing into a dry leathery tan scorch on recently matured leaves.

Because potassium is very mobile within the plant, symptoms only develop on young leaves in the case of extreme deficiency.



Potassium deficient tomato leaf

Initial symptoms on tomato leaf





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## Functions of Calcium

- Promotes early root growth.
- Encourages seed production
- Important part of cell walls
- Keep soil neutral

# Calcium

- The calcium-deficient leaves show necrosis around the base of the leaves.
- Classic symptoms of calcium deficiency include blossom-end rot (BER) burning of the end part of tomato fruits.
- The blossom-end area darkens and flattens out, then appearing leathery and dark brown, and finally it collapses and secondary pathogens take over the fruit.



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Plants under chronic calcium deficiency have a much greater tendency to wilt than non-stressed plants.



Calcium-deficient leaves



Blossom-end rot







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# Functions of Magnesium

- Influences the intake of other essential nutrients
- Helps make fats
- Assists in translocation of phosphorus and fats



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# Magnesium

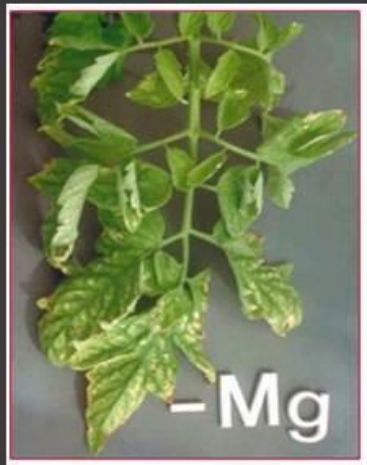
- Magnesium-deficient tomato leaves show advanced interveinal chlorosis, with necrosis developing in the highly chlorotic tissue.
- In its advanced form, magnesium deficiency may superficially resemble potassium deficiency.
- In the case of magnesium deficiency the symptoms generally start with mottled chlorotic areas developing in the interveinal tissue.



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The interveinal laminae tissue tends to expand proportionately more than the other leaf tissues, producing a raised puckered surface, with the top of the puckers progressively going from chlorotic to necrotic tissue.



Magnesium deficient tomato  
leaf





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## Functions of Sulfur

- Promotes root growth and vigorous vegetative growth
- Essential to protein formation. E.g. Sulfur containing amino acid.



# Sulphur

- The veins and petioles exhibit a very distinct reddish color.
- The visual symptoms of sulfur deficiency are very similar to the chlorosis found in nitrogen deficiency
- However, in sulfur deficiency the yellowing is much more uniform over the entire plant including young leaves.



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With advanced sulfur deficiency brown lesions and/or necrotic spots often develop along the petiole, and the leaves tend to become more erect and often twisted and brittle





12.14

# Manganese

## Functions

plant metabolism  
nitrogen transformation

- These leaves show a light interveinal chlorosis developed under a limited supply of Mn.
- The early stages of the chlorosis induced by manganese deficiency are somewhat similar to iron deficiency.
- As the stress increases, the leaves take on a gray metallic sheen and develop dark freckled and necrotic areas along the veins.



A purplish luster may also develop on the upper surface of the leaves.







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# Iron

- Functions of Iron
  - Essential for chlorophyll production
  - Helps carry electrons to mix oxygen with other elements



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## Iron

- The iron-deficient leaves show intense chlorosis at the base of the leaves with some green netting.
- The most common symptom for iron deficiency starts out as an interveinal chlorosis of the youngest leaves, evolves into an overall chlorosis, and ends as a totally bleached leaf.
- The bleached areas often develop necrotic spots.



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Iron deficiency is strongly associated with calcareous soils and anaerobic conditions, and it is often induced by an excess of heavy metals





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# Copper

## ○ Functions

- Helps in the use of Iron
- Helps respiration



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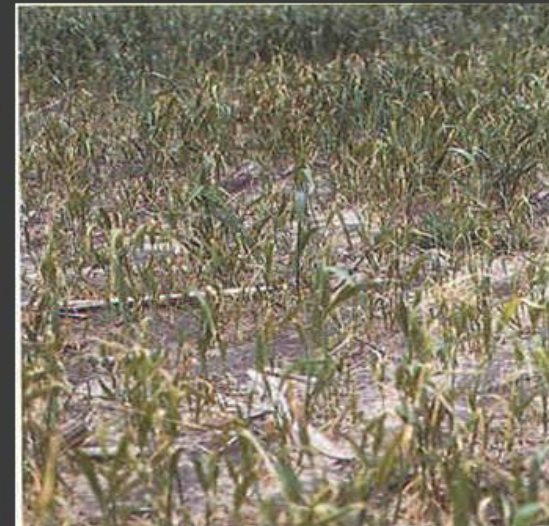
## Copper

- The copper-deficient leaves are curled, and their petioles bend downward.
- Copper deficiency may be expressed as a light overall chlorosis along with the permanent loss of turgor in the young leaves.
- Recently matured leaves show netted, green veining with areas bleached to a whitish gray.



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Some leaves develop sunken necrotic spots and have a tendency to bend downward.





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## Zinc

- **Functions**
  - plant metabolism
  - helps form growth hormones
  - reproduction



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## Zinc

- This leaf shows an advanced case of interveinal necrosis.
- In the early stages of zinc deficiency the younger leaves become yellow and pitting develops in the interveinal upper surfaces of the mature leaves.
- As the deficiency progresses these symptoms develop into an intense interveinal necrosis but the main veins remain green, as in the symptoms of recovering iron deficiency





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Figure 1. Zinc deficiency on rice



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# Boron

- Functions
  - affects water absorption by roots
  - translocation of sugars



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## Boron

- The boron-deficient leaf shows a light general chlorosis.
- Boron deficiency symptoms generally appear in younger plants at the propagation stage.
- Slight interveinal chlorosis in older leaves followed by yellow to orange tinting in middle and older leaves.
- Leaves and stems are brittle and corky, split and swollen miss-shaped fruit .



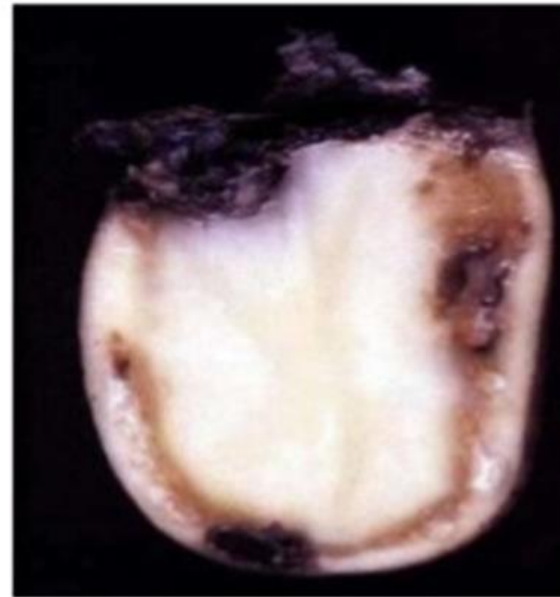
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## Browning of cauliflower



- The important nutrient for sugar beet is (Boron).
- The first dose at age 60-70 days.
- The second dose before the harvest within 30 days, to push the saccharides transmission from the leaves to the roots.



• Black heart



• Hollow heart



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# Molybdenum

- Functions
  - plant development
  - reproduction
- Deficiency symptoms
  - stunted growth
  - yellow leaves, upward curling leaves, leaf margins burn



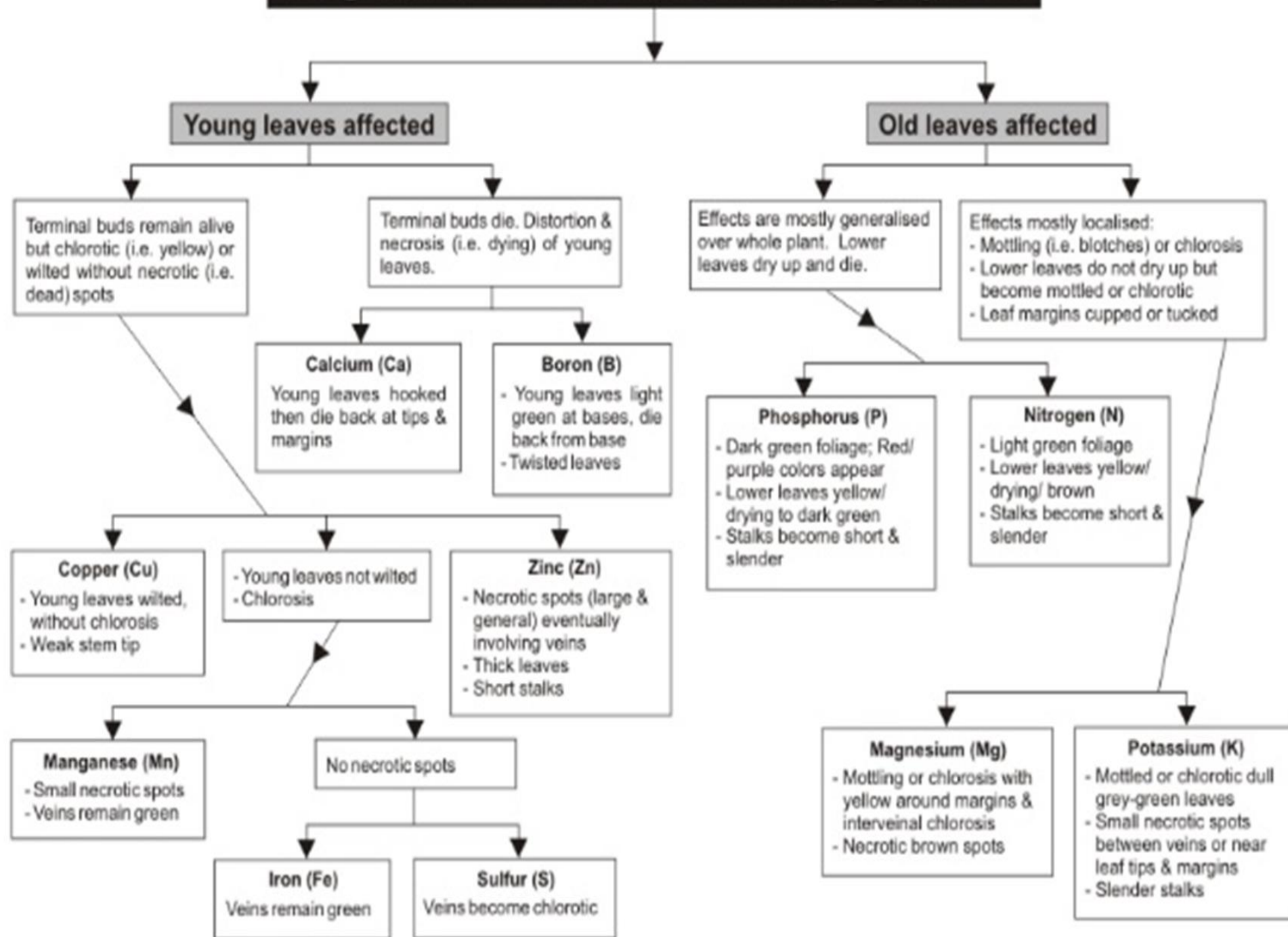
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Mo- whip tail

# Diagnostic flow-chart for deficiency symptoms

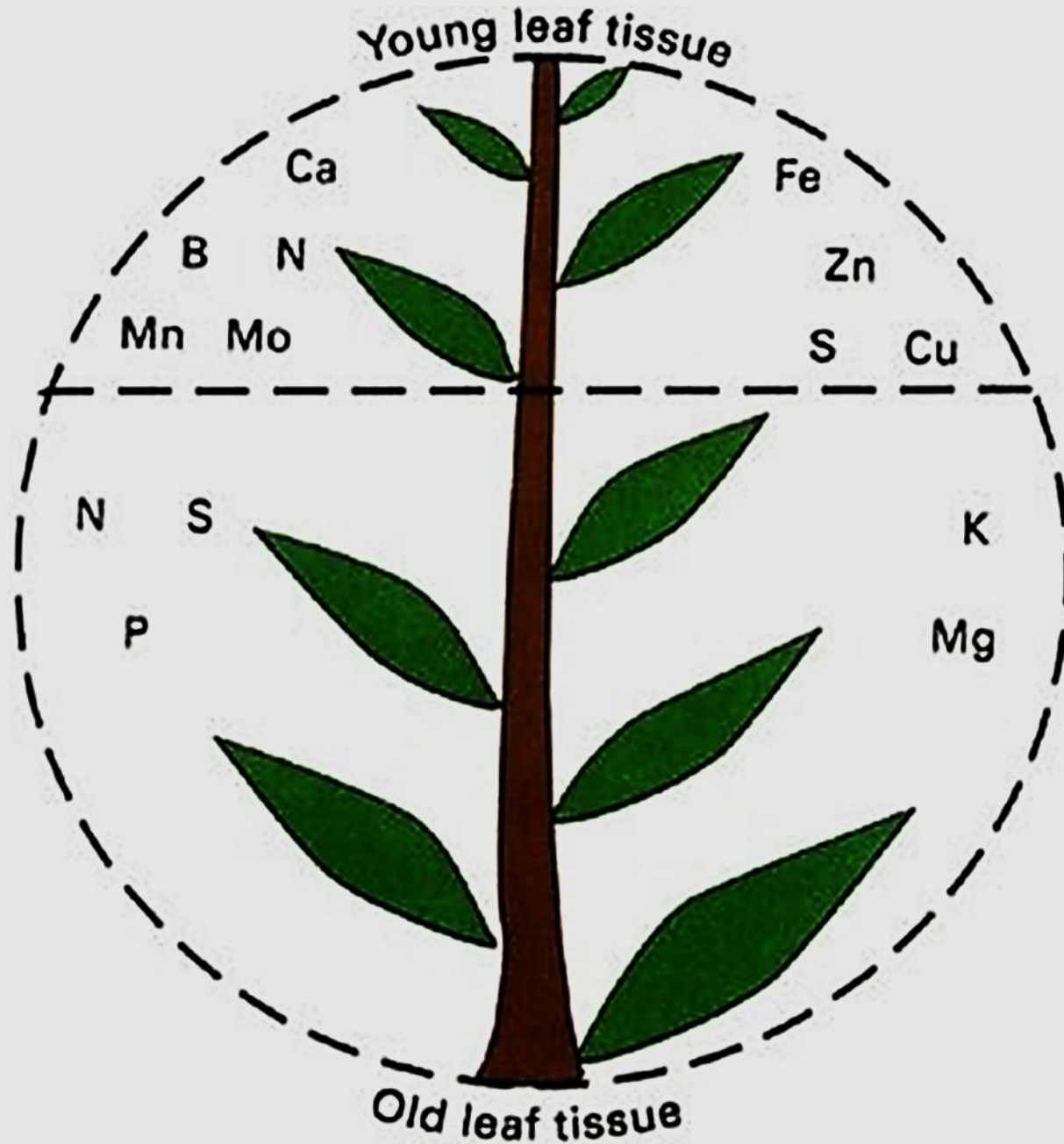






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**Thank you**