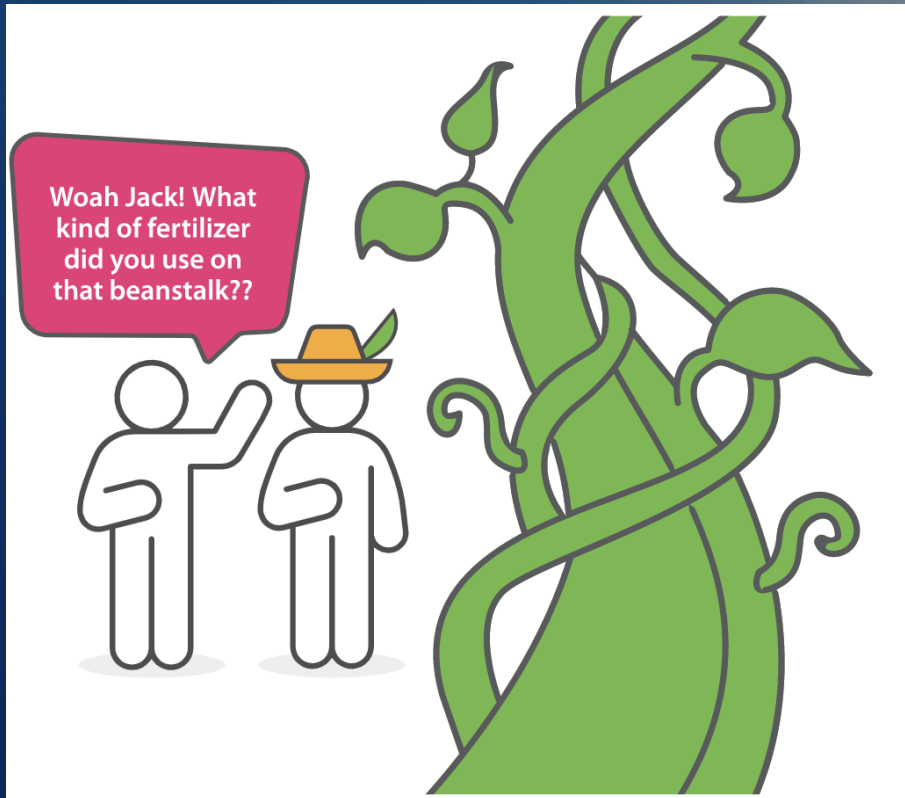


# Fertilizers



Why, what,  
where, when,  
how

...for a happy  
tree!

# Fertilizing – it's not rocket-science, or is it? ...

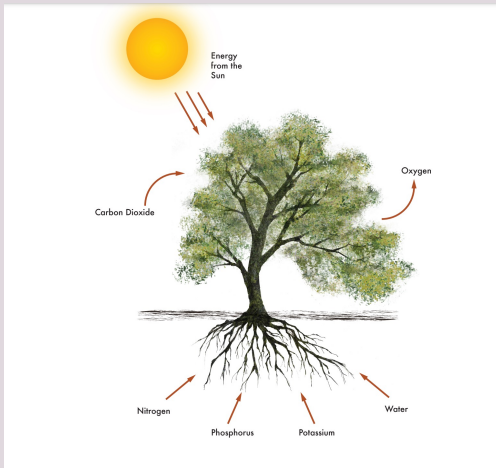
- Rocket science deals with equations, physics, and math
- Fertilizing is simple in principle
- But a tree has life – cannot be described analytically

$$du = -\frac{u_c dm_v}{m_v} - \frac{D}{m_v} dt - g \cos \theta dt.$$

????????



# A tree is a living organism



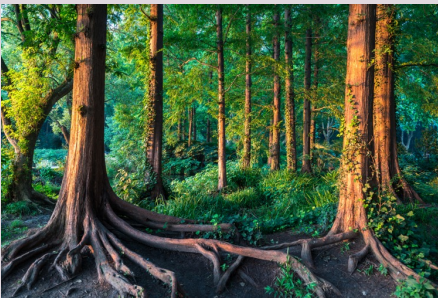
Reproduces ...



Sleeps ...

Heals

Breathes ... Eats ... Drinks ... Digests



# Hydraulic engineering and a food factory



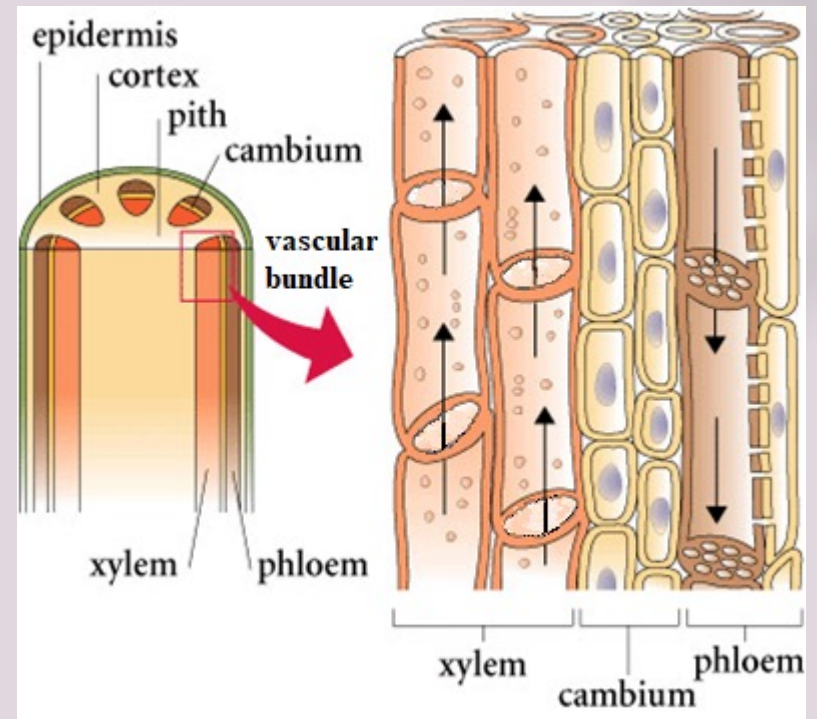
2 one-directional transport systems



Upward transport - roots to the foliage by the xylem



Downward transport – foliage to roots by the phloem cells



# Trees in the Wild are Free!



An artist's impression of a stand of cladoxylopsida trees, which formed Earth's first forests. PETER GEISEN

- Appeared 400 million years ago (Devonian period)  
Deep tap roots
- Large and powerful root systems
- Access to desired nutrients
- Tailored to their environment



# Bonsai are captive

- Not usually landscape trees
- Limited space to grow
- Good drainage is important
- Very little decomposition of organics
- So ... they need food regularly





# Fertilizers and Feeding – in 2-part Harmony

Part 1: A quick “this is what you do”

and

Part 2: A luxurious study of the why and wherefore

# Part 1 – Never Mind the Why and Wherefore ...

- Do this
- Safari Park Rules
  - Apex granular fertilizer
  - Top dressing
  - Nutrients provided at each watering
  - Replenish as needed

- Or this
- Jaya's Maverick Rules
  - Orchid food dissolved in water
  - Pour over roots after watering
  - Walk among and talk to trees



Part 2 - the why and wherefore

The long and winding road .....

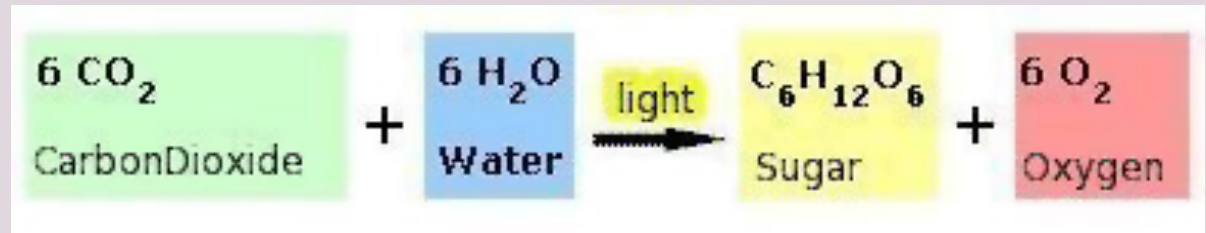
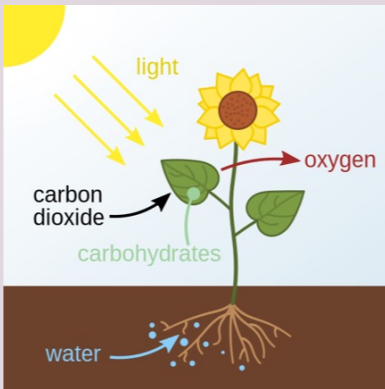
# Fertilizers and Nutrients



- Nutrients are food
- Fertilizers contain food and filler

# Nutrients - Non mineral components

- Hydrogen, oxygen and carbon that come from air and water



# Nutrients– Mineral components

- Mineral nutrients come from the soil and are absorbed by the roots when taking in water. They can be
  - Macronutrients
    - Primary – nitrogen (N), phosphorus (P) and potassium (K)
    - Secondary – Calcium (Ca), Magnesium (Mg), Sulphur (S)
  - Micronutrients – Boron (B), Copper (Cu), Iron (Fe), Chloride (Cl), molybdenum (Mo), Zinc (Zn)
- Most fertilizers contain both macro and micronutrients
- Both non-mineral and mineral components are found in C-H-O-P-K-N-S Ca-Fe.

# The Big Three Macro Components

N	P	K
<i>N is for Nitrogen</i> <i>Healthy foliage</i>	<i>P is for Phosphorous</i> <i>Healthy roots</i>	<i>K is for Potassium</i> <i>Healthy immune system</i>

N-P-K

# NPK – a fertilizer grade, a national standard

- Plantone (5-3-3)
  - Total nitrogen 5%
  - Available phosphate P<sub>2</sub>O<sub>5</sub> – 3%
  - Soluble Potash K<sub>2</sub>O – 3%
- Orchid food (20-20-20)
  - Total nitrogen 20%
  - Available phosphate P<sub>2</sub>O<sub>5</sub> – 20%
  - Soluble Potash K<sub>2</sub>O – 20%

All commercial fertilizers provide this information

# Types of Fertilizers

- **Organic/Biological - microbial support**
- Liquid
  - Superthrive – 0.5,0,0 plus Vitamin B-1 0.09%
  - Fish emulsion 2-4-5
- Solid premixed or not
  - Plant-tone 5-3-3
  - Dr. Earth Premium Gold 4-4-4
  - Rapeseed cake 5-2-1
  - Milorganite 5-2-0
- Slow release
  - Biogold – 5.5-6.5-3.5

- **Inorganic/Chemical – limited microbial support**
- Liquid
  - Miracle Grow 12-4-8
- Solid
  - Orchid food 20-20-20
- Controlled release
  - Apex 16-5-9
- Straight – one nutrient
  - Ammonium sulphate 21-0-0
- Slow release
  - Osmocote 10-10-10

# No single correct answer!

## *Organic*

- Slow, broken down by microbes
- Feeds soil microbes
- Could be expensive
- Attracts wildlife
  
- **Good soil is Key**

## *Inorganic*

- Immediate availability to plant
- Widely available tailored to species
- Limited microbial activity support
- Toxic in excess
  
- **Good soil is Key**



# Growing Medium (Soil)

- Support root network
- Balance drainage and moisture retention
- Anchor for roots
- Hospitable environment for **microbes**

# Fungi – the Good, the Bad and the Ugly

- Good Fungi can help

- Myco-rhizae (fungus and root)
- Enhance nutrient absorption
- Endo-mycorrhizal (inner)
- Ecto- mycorrhizal (outer)

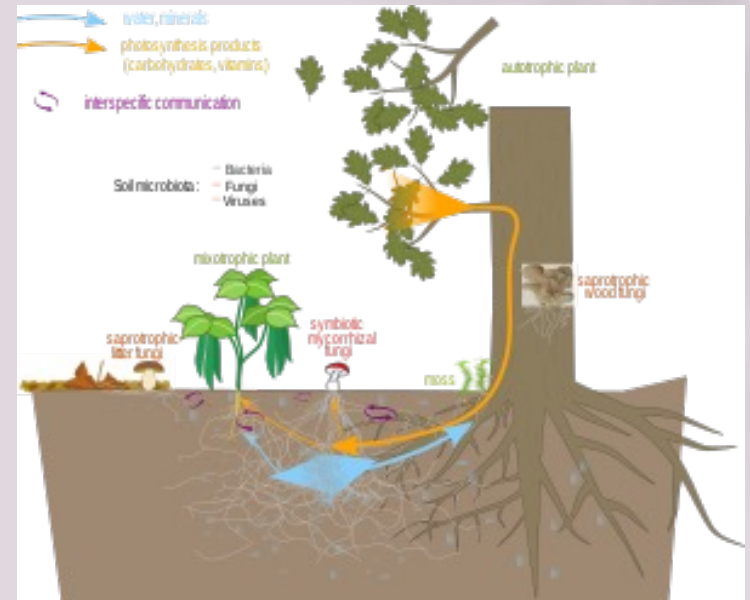
- Bad Fungi can kill

- Juniper tip blight
- Pines Needle blight
- Mold, Mildew, Rust
- Fusarium, pythium, phytophthora

Can turn rogue!

# Fertilizer Helpers - Fungi

- Fungus + hyphae (root-like threads) = Mycelium
- Fungus is embedded in the tree roots
- Tree - feeds the fungus with glucose and sucrose
- Fungus – virtual root system for the tree
- Tree – virtual photosynthesis agent for the fungus



# Mycorrhizal Fungi

## Endomycorrhizal Fungi:

- *Glomus intraradices*
- *Rhizophagus intraradices*
- *Rhizophagus irregularis*
- *Glomus mosseae*
- *Funneliformis mosseae*
- *Glomus aggregatum*
- *Claroideoglomus claroideum*
- *Glomus etunicatum*
- *Claroideoglomus etunicatum*
- *Glomus deserticola*
- *Glomus clarum*
- *Glomus monosporum*
- *Paraglomus brasilianum*
- *Gigaspora margarita*

## Ectomycorrhizal Fungi:

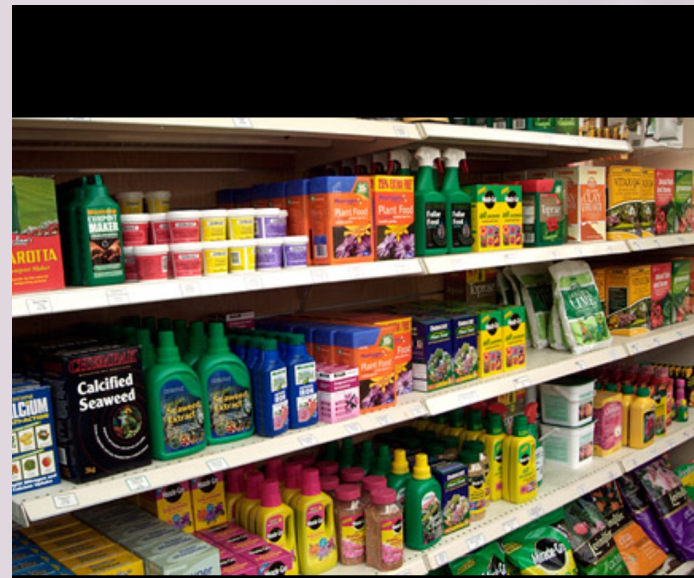
- *Rhizopogon villosulus*
- *Rhizopogon luteolus*
- *Rhizopogon amylopogon*
- *Rhizopogon fulvigleba*
- *Pisolithus tinctorius*
- *Suillus granulatus*
- *Laccaria bicolor*
- *Laccaria laccata*
- *Scleroderma cepa*
- *Scleroderma citrinum*
- *Truffles (yum!)*

# Organic Fertilizers Feed Microbes

- Roots exude - sugary substance, favors expansion of microbes
- Microbes create a network in the soil
- Organic matter broken down by microbes, humic acid released
- Triggers the tree - nutrition present, tree takes up nutrition
- feeds microbes, in sync with tree needs
- Chemical fertilizers do not enhance microbial activity (fungi, white webbing)

# Decisions, Decisions!

- There are a wide range of fertilizers available for home gardeners
- Fertilizers can correct plant nutrient deficiencies
- Fertilizers are not a substitute for good soil care! Weeding, re-potting, spraying for bugs...



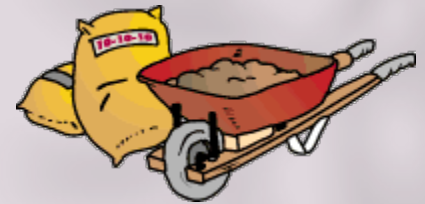
A selection of fertilisers in a garden centre. Image: RHS/Tim Sandall

# Where to Apply

- Top dressing – apply to soil surface
- Base dressing – incorporate into soil before sowing or planting
- Watering on - water onto plant roots
- Foliar feeding – apply to plant leaves



# Please, Sir, Can I Have Some More?

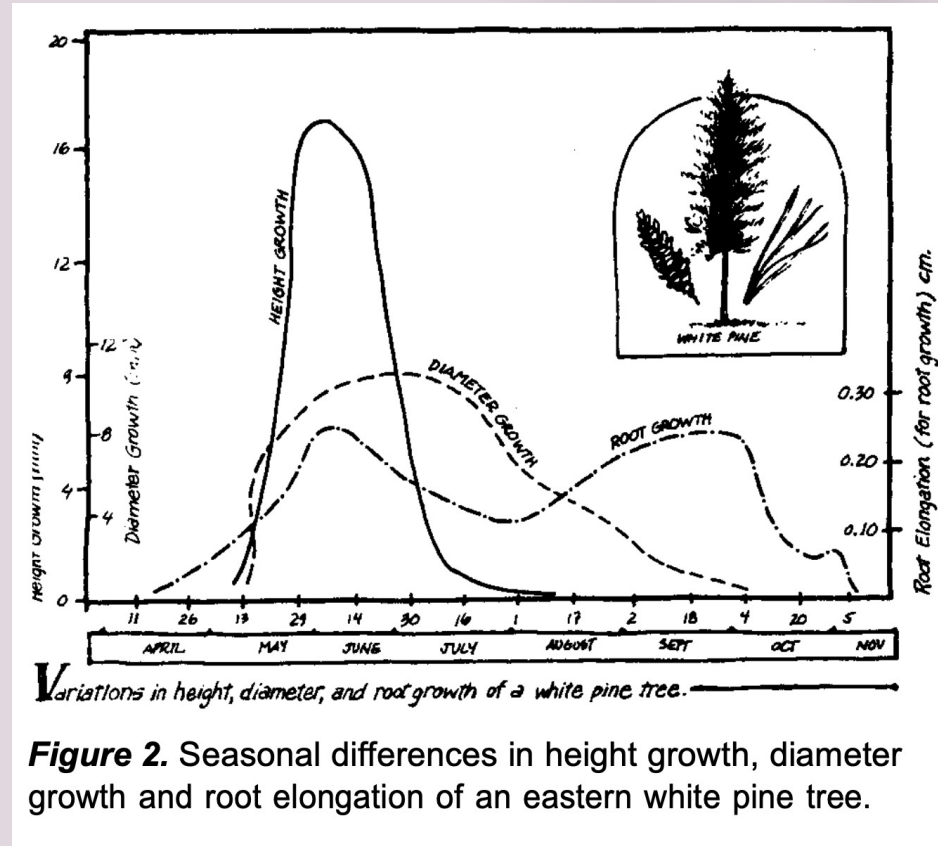


- Soil pH affects the availability of nutrients
  - Macronutrients tend to be less available in soils with low pH
  - Micronutrients tend to be less available in soils with high pH
- Clays and organic soils retain nutrients well
  - But bonsai do not like heavy soils, they want well drained soil
- Sandy soils lose nutrients during watering
  - Therefore, bonsai need to be fed regularly so nutrients are always available



# Trees Need Nourishment Almost Year-Round

- In temperate zone trees, roots grow earlier in the year before shoots elongate, and diameter growth begins even later
- In nature, trees find food naturally in the soil created by decaying matter
- They also partner with different fungi to absorb more nutrients from the water in the soil.



# Bonsai Calendar

	Growing Season	Winter	Notes
Conifers	Weekly	Once or twice	No fertilizer for 2-3 months after spring candle pruning on pines
Deciduous	Weekly	Ease up during dormancy	Use low Nitrogen
Tropicals	Weekly	Monthly	Grow year-round
Sick trees, just repotted trees	Never!	What Never?	No Never! Well, hardly ever.

Check Ronan-Mosse masterpiece for details!

	Jan	Feb	March	April	May	June	July	August	September	October	November	December
<b>Conifers</b>												
Japanese Black Pine <sup>3</sup>	Repot		Fertilize						Fertilize			
	Prune, bend,wire					Pull Needles					Prune, thin, wire	
	Graft					Decandle <sup>2</sup>					Bud selection, Needle pull	

# Summary

- Why
  - Trees need food, it is pleasant for the bonsai caretaker to feed them
- What
  - Any good quality balanced fertilizer from a reputable nursery
- Where
  - On the soil surface, on the foliage
- When
  - During the growing season, with some caveats
- How
  - Consistently



# To learn more ...

San Diego Bonsai Club.com/resources/	Newsletter/Sep 2022	Charlie Moss article	Fertilizers
San Diego Bonsai Club.com/resources/	Articles	Bob Hale slides	Soil: It's What Goes in the Pot
San Diego Bonsai Club.com/resources/	Articles	Bob Hale slides	Fertilizers: The other thing that goes in the pot (besides soil)
San Diego Bonsai Club.com/resources	Seasonal Task Schedule - "Bonsai Calendar"	Susan Ronan and Charlie Mosse slides	

- Ryan Neil's talk on Bonsai Mirai Fertilizers 101
- <http://www.ncagr.gov/CYBER/kidswrld/plant/nutrient.htm>
- <https://www.rhs.org.uk/garden-jobs/fertilisers>
- <https://mycorrhizae.com/how-it-works/>
- <https://en.wikipedia.org/wiki/Mycorrhiza>

Loveliest of trees, the cherry now  
Is hung with bloom along the bough,  
And stands about the woodland ride  
Wearing white for Eastertide.

Now, of my threescore years and ten,  
Twenty will not come again,  
And take from seventy springs a score,  
It only leaves me fifty more.

And since to look at things in bloom  
Fifty springs are little room,  
About the woodlands I will go  
To see the cherry hung with snow.





In the end is the beginning...

*Merely corroborative detail, intended to give artistic verisimilitude to an otherwise bald and unconvincing narrative ...*

# Macronutrients

## Nitrogen (N)

- Nitrogen is a part of all living cells and is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy.
- Nitrogen is a part of chlorophyll, the green pigment of the plant that is responsible for photosynthesis.
- Helps plants with rapid growth, increasing seed and fruit production and improving the quality of leaf and forage crops.
- Nitrogen often comes from fertilizer application and from the air (legumes get their N from the atmosphere, water or rainfall contributes very little nitrogen)

## Phosphorus (P)

- Like nitrogen, phosphorus (P) is an essential part of the process of photosynthesis.
- Involved in the formation of all oils, sugars, starches, etc.
- Helps with the transformation of solar energy into chemical energy; proper plant maturation; withstanding stress.
- Effects rapid growth.
- Encourages blooming and root growth.
- Phosphorus often comes from fertilizer, bone meal, and superphosphate.

## Potassium (K)

- Potassium is absorbed by plants in larger amounts than any other mineral element except nitrogen and, in some cases, calcium.
- Helps in the building of protein, photosynthesis, fruit quality and reduction of diseases.
- Potassium is supplied to plants by soil minerals, organic materials, and fertilizer.

## Calcium (Ca)

- Calcium, an essential part of plant cell wall structure, provides for normal transport and retention of other elements as well as strength in the plant. It is also thought to counteract the effect of alkali salts and organic acids within a plant.
- Sources of calcium are dolomitic lime, gypsum, and superphosphate.

## Magnesium (Mg)

- Magnesium is part of the chlorophyll in all green plants and essential for photosynthesis. It also helps activate many plant enzymes needed for growth.
- Soil minerals, organic material, fertilizers, and dolomitic limestone are sources of magnesium for plants.

## Sulfur (S)

- Essential plant food for production of protein.
- Promotes activity and development of enzymes and vitamins.
- Helps in chlorophyll formation.
- Improves root growth and seed production.
- Helps with vigorous plant growth and resistance to cold.
- Sulfur may be supplied to the soil from rainwater. It is also added in some fertilizers as an impurity, especially the lower grade fertilizers. The use of gypsum also increases soil sulfur levels.



# Micronutrients

## Micronutrients

### Boron (B)

- Helps in the use of nutrients and regulates other nutrients.
- Aids production of sugar and carbohydrates.
- Essential for seed and fruit development.
- Sources of boron are organic matter and borax

### Copper (Cu)

- Important for reproductive growth.
- Aids in root metabolism and helps in the utilization of proteins.

### Chloride (Cl)

- Aids plant metabolism.
- Chloride is found in the soil.

### Iron (Fe)

- Essential for formation of chlorophyll.
- Sources of iron are the soil, iron sulfate, iron chelate.

### Manganese (Mn)

- Functions with enzyme systems involved in breakdown of carbohydrates, and nitrogen metabolism.
- Soil is a source of manganese.

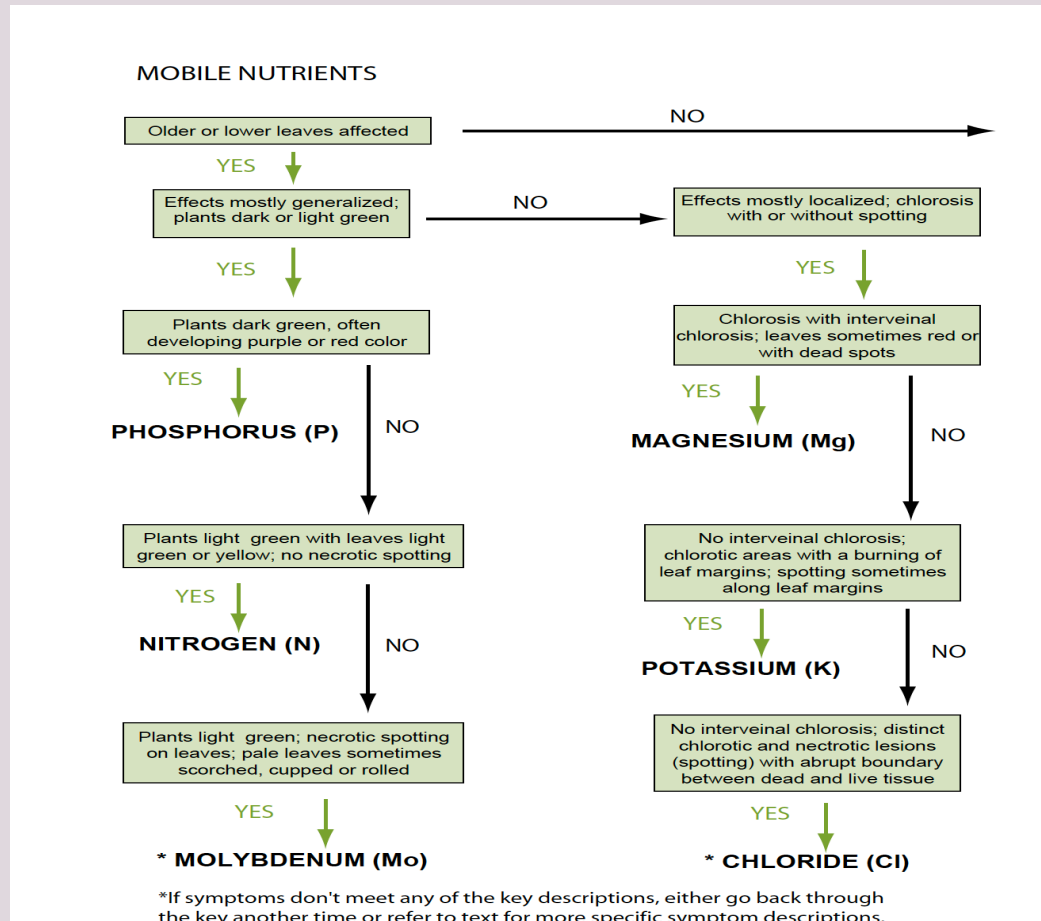
### Molybdenum (Mo)

- Helps in the use of nitrogen
- Soil is a source of molybdenum.

### Zinc (Zn)

- Essential for the transformation of carbohydrates.
- Regulates consumption of sugars.
- Part of the enzyme systems which regulate plant growth.
- Sources of zinc are soil, zinc oxide, zinc sulfate, zinc chelate.

# Diagnosing Nutrient Deficiencies



## IMMOBILE NUTRIENTS

