Influence of plant and leaf structures, crop canopies and densities, cropping situation, and water quality used for spraying

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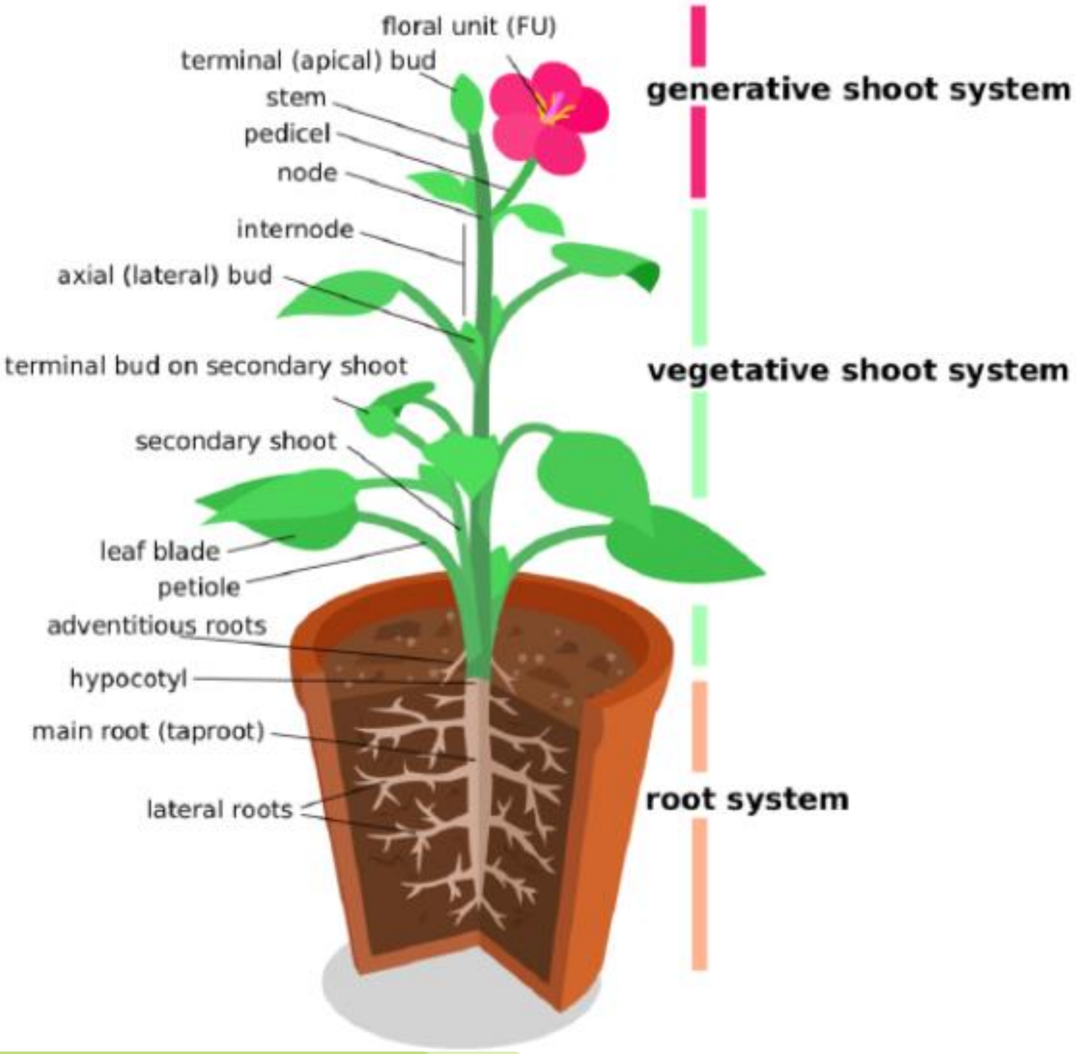
What I will cover

- Plant and leaf structures and shapes
- Crop canopies and densities
- Cropping situation (protected vs outdoor)
- Impact of water quality used for spraying

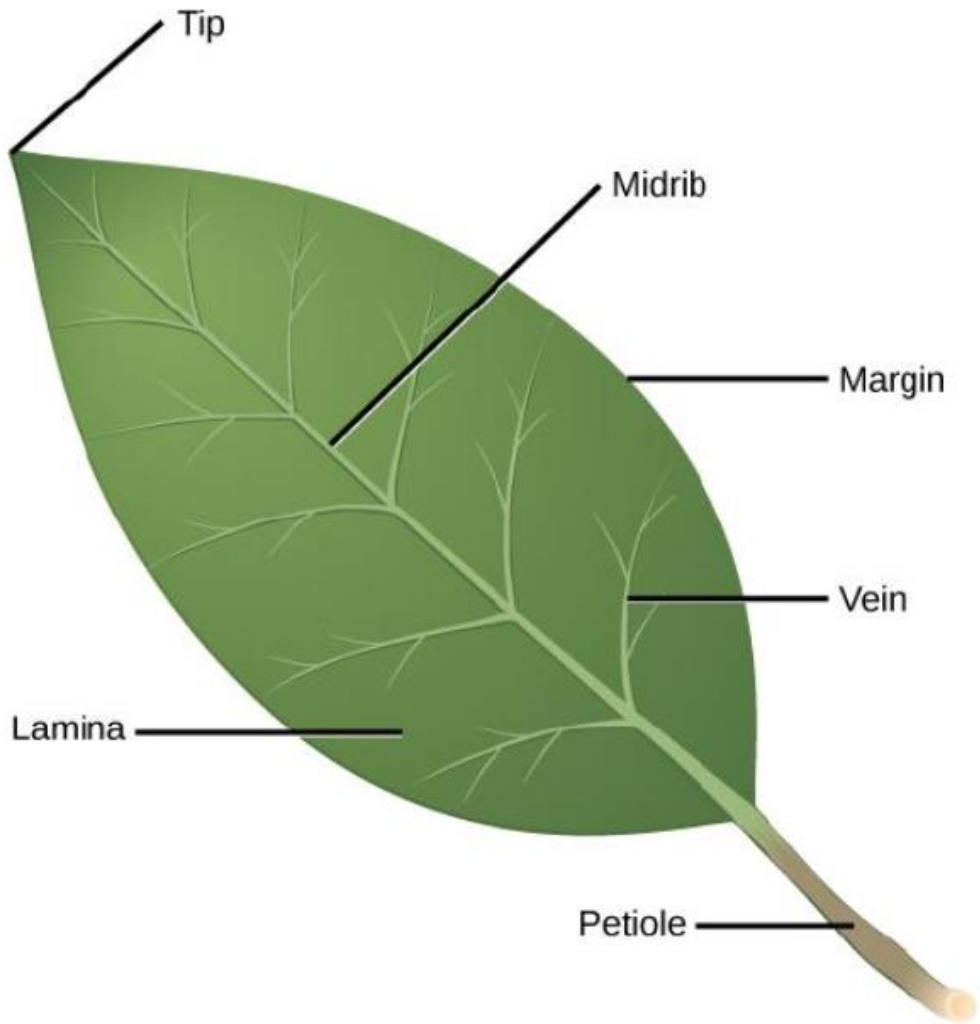
Plant structure (phytomorphology)

- Plant architecture varied and complex
- Designed to maximise leaf area exposed to light and support mode of growth
- Often designed to shed excess rainfall
- Roots – important for uptake of PPPs applied as drenches
- Stems – can be target for uptake of PPPs (e.g. paclobutrazol)
- Leaves – main target for PPP uptake, getting PPP underneath leaves problematic



Leaf structure

- Generally, a large surface area to absorb light
- Its upper surface is protected from water loss, disease and weather damage by a waxy layer
- Veins for structure and water/nutrient distribution
- Adapted to climate/stresses where the plant originates from



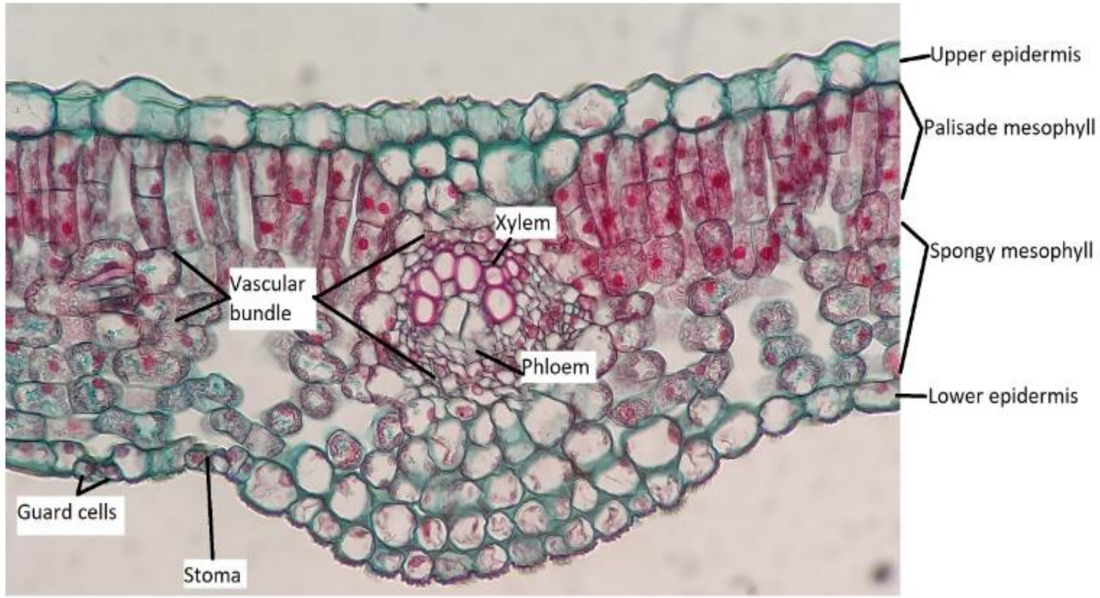
Leaf structure

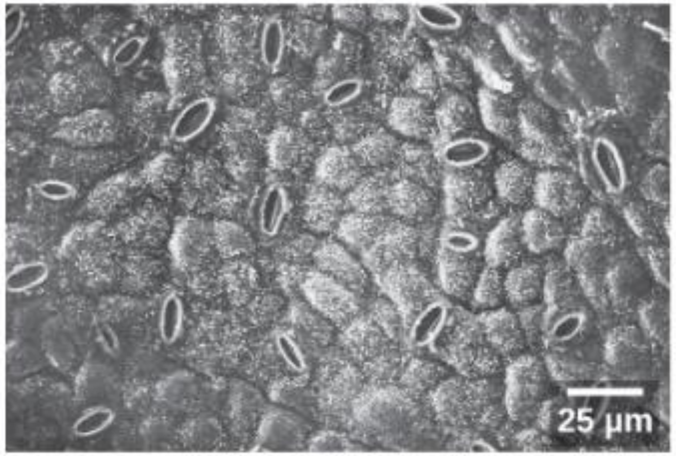
HTA

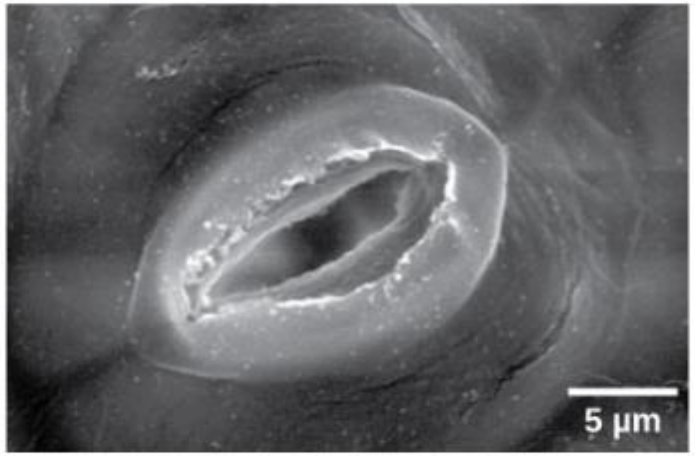
Plant adaptation	Function
Broad leaves	Provide a large surface area to absorb as much sunlight as possible.
Thin leaves	Provide a short diffusion pathway for gases to move into and out of cells.
Network of tubes (xylem and phloem)	To transport water, mineral ions and glucose (food) around the plant.
Lots of chloroplast	Contain a green substance called chlorophyll, which traps energy from the sun for photosynthesis.
Stomata	Tiny holes found mainly underneath the leaf to allow gases to diffuse into and out of the leaf. Each hole is a single stoma.
Guard cells	Controls the opening and closing of stomata.
Midrib	Provides strength throughout the leaf, keeping it upright and sturdy in the wind.
Petiole	Attaches the leaf to the stem.

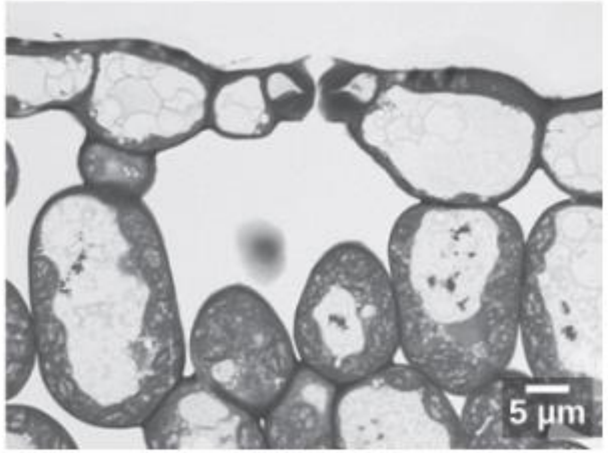
Leaf structure (internal)

- Upper epidermis and cuticle layer– protection
- Palisade layer – photosynthesis
- Mesophyll – gas exchange into leaf from stomata
- Xylem and phloem – transport system



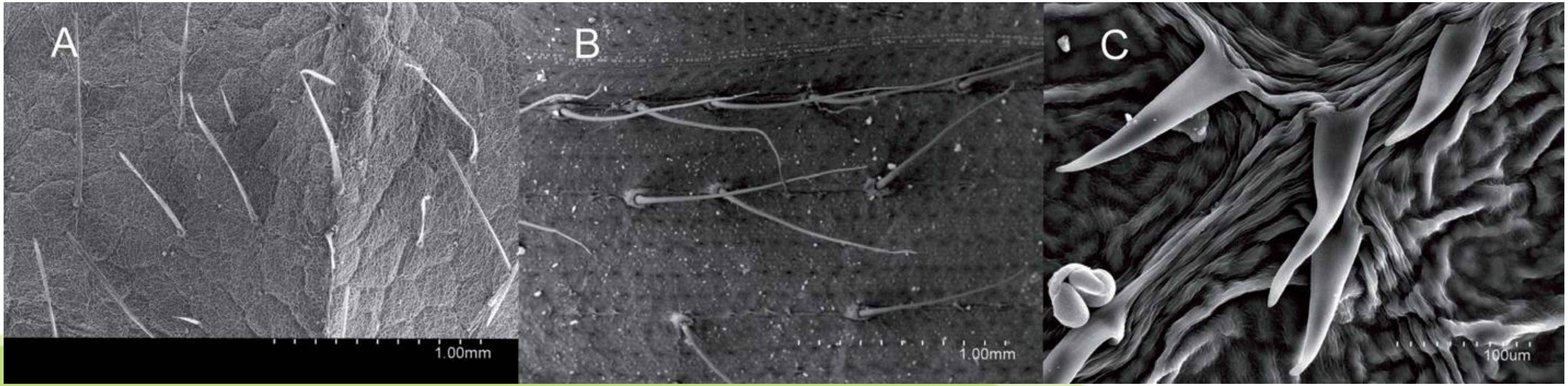






Leaf surface

- All aerial plant parts are covered by a hydrophobic cuticle that limits the bidirectional exchange of water, solutes and gases between the plant and the surrounding environment.
- Epidermal structures such as stomata, trichomes or lenticels may occur on the surface of different plant organs and play important physiological roles.

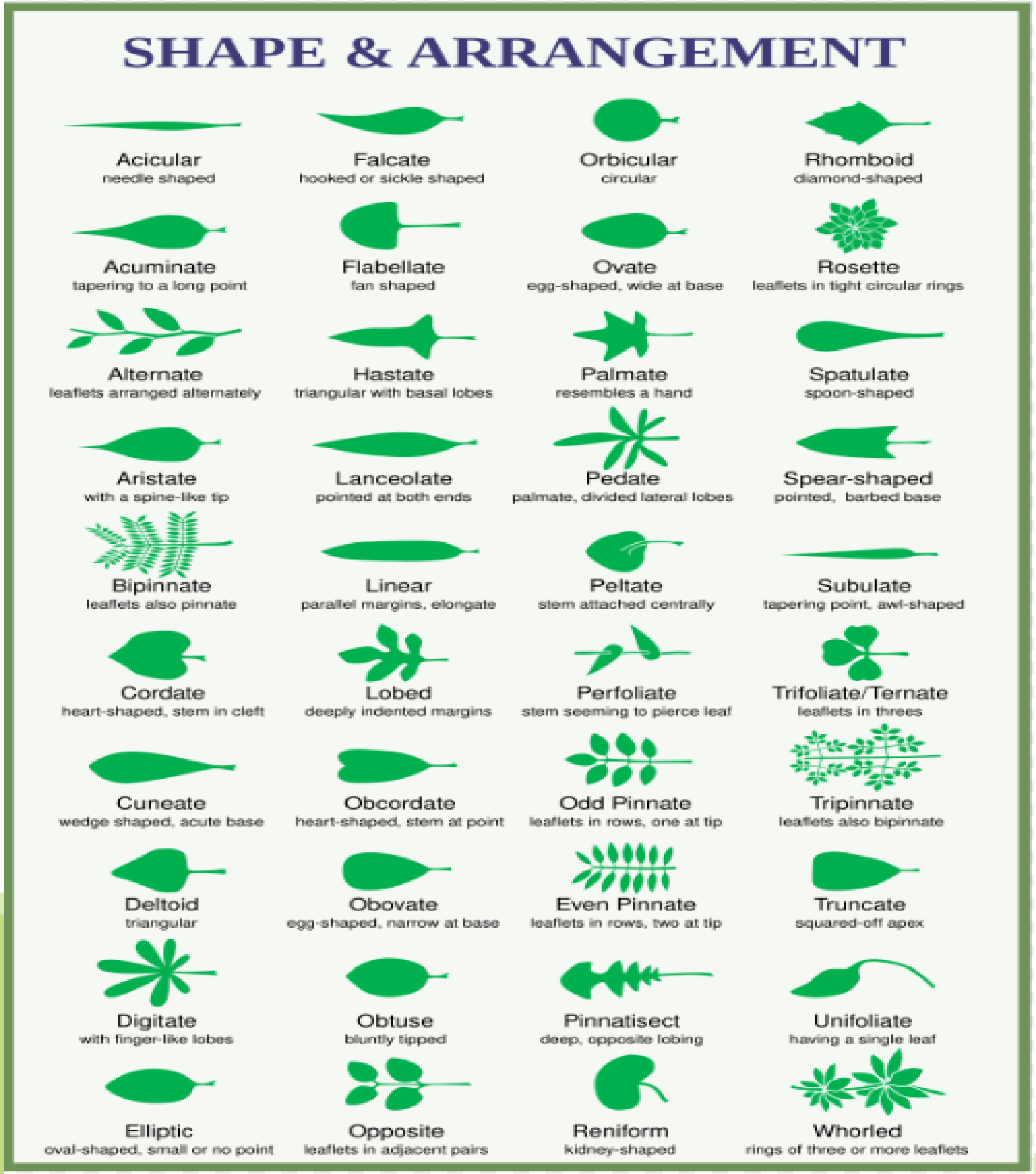


(Micrographs by V.Fernández, 2010) Adaxial surface of: (A) soybean; (B) maize; and (C) cherry leaf

Leaf cuticle – wax layer

- **The cuticle is a protective layer that covers the plant and separates it from the environment. In leaves this layer is hydrophobic and consists of an insoluble membrane submerged in solvent-soluble waxes. The cuticle of leaves is thought to have evolved as an adaptation during the transition from aquatic to terrestrial habitats, with its main function being to prevent excessive tissue water loss, but it also provides protection against UV radiation, being eaten, heat, mechanical stress, and pollution. Epicuticular wax is a waxy coating which covers the outer surface of the plant cuticle and is thicker in plants from arid climates.**

Leaf shapes



SHAPE & ARRANGEMENT
Acicular
needle shaped
Falcate
hooked or sickle shaped
Orbicular
circular
Rhomboid
diamond-shaped
Acuminate
tapering to a long point
Flabellate
fan shaped
Ovate
egg-shaped, wide at base
Rosette
leaflets in tight circular rings
Alternate
leaflets arranged alternately
Hastate
triangular with basal lobes
Palmate
resembles a hand
Spatulate
spoon-shaped
Aristate
with a spine-like tip
Lanceolate
pointed at both ends
Pedate
palmate, divided lateral lobes
Spear-shaped
pointed, barbed base
Bipinnate
leaflets also pinnate
Linear
parallel margins, elongate
Peltate
stem attached centrally
Subulate
tapering point, awl-shaped
Cordate
heart-shaped, stem in cleft
Lobed
deeply indented margins
Perfoliate
stem seeming to pierce leaf
Trifoliate/Ternate
leaflets in threes
Cuneate
wedge shaped, acute base
Obcordate
heart-shaped, stem at point
Odd Pinnate
leaflets in rows, one at tip
Tripinnate
leaflets also bipinnate
Deltoid
triangular
Obovate
egg-shaped, narrow at base
Even Pinnate
leaflets in rows, two at tip
Truncate
squared-off apex
Digitate
with finger-like lobes
Obtuse
bluntly tipped
Pinnatisect
deep, opposite lobing
Unifoliate
having a single leaf
Elliptic
oval-shaped, small or no point
Opposite
leaflets in adjacent pairs
Reniform
kidney-shaped
Whorled
rings of three or more leaflets

Crop canopies

- Flat
- Vertical/erect
- Row crop
- Bed formation
- Leaf wall area

Crop canopies

Crop canopies

Pot-thick vs spaced plants

Cropping situation - glasshouse

- High PAR
- Little to no diffusion
- Low natural air movement
- Quick cell division
- Softer cell walls
- Thinner cuticle layer
- Rapid soft growth
- Stomatal activity is much slower
- Potassium pump often is compromised due to humidities

Cropping situation - tunnel

- Cover material matters
- Good diffusion
- More air movement
- Thicker cuticle layer
- Lower PAR
- Some far-red light excluded
- Wax layer often much less prominent
- Stomatal activity better
- Potassium pump more regulated but still an issue

Cropping situation - outdoor

- Maximum PAR
- Air movement
- Thick cuticle layer
- Morphological changes based on abiotic pressure
- Stomatal activity is fully activated
- Potassium pump working to its maximum
- Red light exposure maximum

Water quality and plant protection products

Water hardness

- The alkalinity of hard water can influence the efficacy of products
- Wettable powders, mineral based and biopesticides can be affected
- Translocation of systemic products can be affected by hard water
- The ideal pH of a spray solution to get maximum leaf absorption is to make it the same as the leaf pH - 5.5-6.5

Water temperature

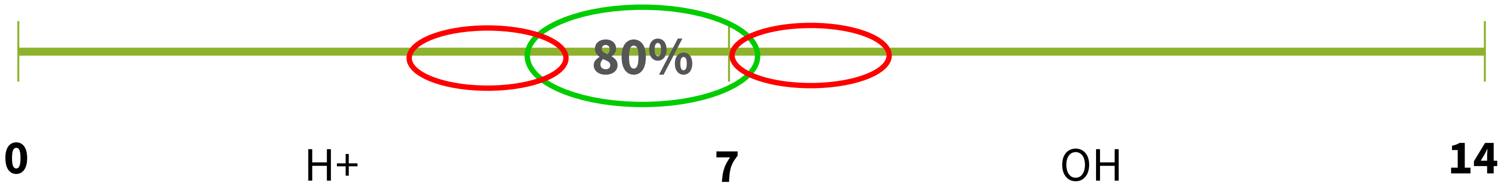
- Do not use water less than 10°C for spraying on plants
- Using warm water for mixing improves dissolvability, but may not be best for the product

Water parameters affecting PPP performance

- **pH**
  - Alkalinity – OH^-
  - Acidity – H^+
- **Carbonate $CaCO_3$ /bicarbonate HCO_3^-**
- **Electrical conductivity**
- **Turbidity**

What is pH?

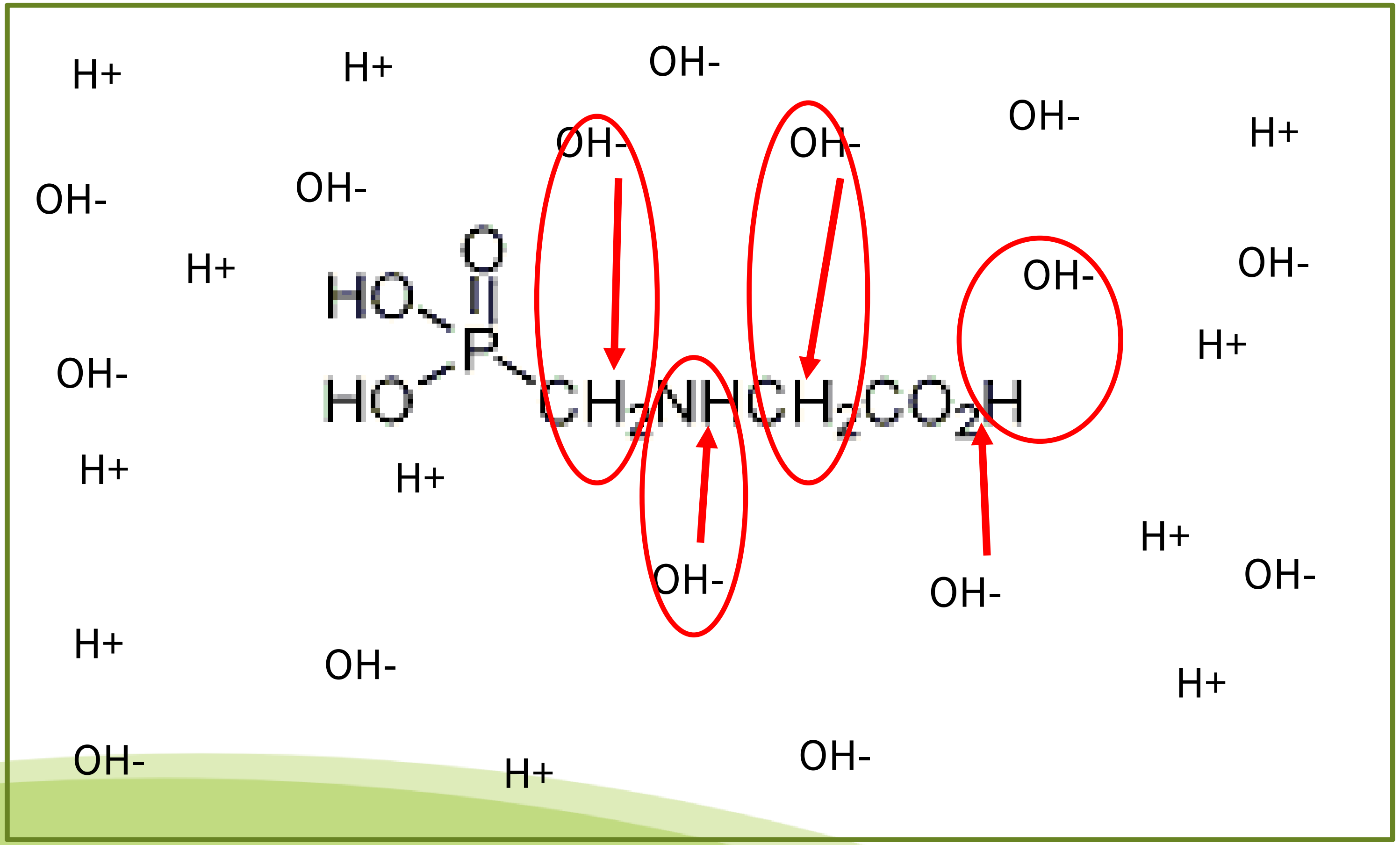
- The balance between the OH and H ions in solution.



- Examples of low pH hydrolisys
  - pymetrozine
  - Sulfonyl-urea herbicides
  - Acetamiprid

- Examples of high pH hydrolisys
  - Glyphosate
  - 2,4-D amine
  - Glufosinate-ammonium
  - Chloropiryfos
  - Bacillus thuringiensis
  - Clofentezine
  - Captan
  - indoxacarb

How does it work?



Carbonate/bicarbonate

- **Water hardiness**
  - Temporary – HCO3
  - Constant – CaCO3 and other positively charged metals (Mg, Fe)
- **Actives affected by total hardiness**
  - 2,4 D amine
  - Glyphosate
  - Fatty Acids
  - Clethodim
  - Indoxacarb
  - Iron more than 400ppm dissolves most actives
  - Optimum hardiness below 150ppm

Electrical conductivity

- **Salt formulated products:**
  - Fatty acids
  - Salts of glyphosate
  - Amonium salts – glufosinate ammonium
- ***Positive (cations)*** ***Negative (anions)***

Calcium (Ca++)	Sulphate(SO_4- -)
Magnesium (Mg++)	Chloride(Cl-)
Sodium (Na+)	Bicarbonate (HCO_3-)

- **EC< 0.5 mS no effects**

Turbidity

- **Haziness of the water**
  - Related to high organic matter and soil content
- **Active ingredient with soil/organic matter binding potential:**
  - Glyphosate
  - Diquat
  - Pyrethrins
  - Sulfunyl urea herbicides (Chikara, Eagle and others)

Compromised performance

- Mode of action
- Penetrating the insect cuticule
- Penetrating leaf surface
- Coverage
- Reduced persistence
- Slow activity

How to maintain performance?

- Water source knowledge
- Monitoring water parameters regularly
- Knowledge of active substances and reading product labels
- If it doesn’t look right, it’s generally not right!

Summary

Active ingredient	Optimum pH	Notes	pH5	pH 6	pH 7	pH 8	pH 9
2,4-d		Stable at pH 4.5 to 7					
Abamectin	6.0 - 7.0						
Acetamiprid		Unstable at pH below 4 and above 7					
Azadirachtin	3.0 - 7.0						
Bacillus thuringiensis	6	Unstable at pH above 8					
Bifenazate	<7						
Captan	5	pH 5 = 32 hrs; pH 7 = 8 hrs; pH 8 = 10 min	32h		8 hours	10 minutes	2 minutes
Chlorothalonil	6.0 - 7.0	Stable over a wide range of pH values					
Chlorpyrifos			63d		35d	1.5d	
Clofentezine					34h		4.5h
Cypermethrin							39h
Dicamba		Stable at pH 5 - 6					
Fenhexamid	5.5 - 6.5						
Flonicamid	4.0 to 6.0						
Fosetyl-aluminium	6	Stable at pH 4.0 to 8.0					
Glufosinate-ammonium	5.5						
Glyphosate	5-6						
Lambda-cyhalothrin	6.5	Stable at pH 5 - 9					
Myclobutanil		Not affected by pH					
Paraquat		Not stable at pH above 7					
Pymetrozine	7.0 - 9.0	(degrades at low pH)					
Spinosad	6	Stable at pH 5 – 7					200d

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