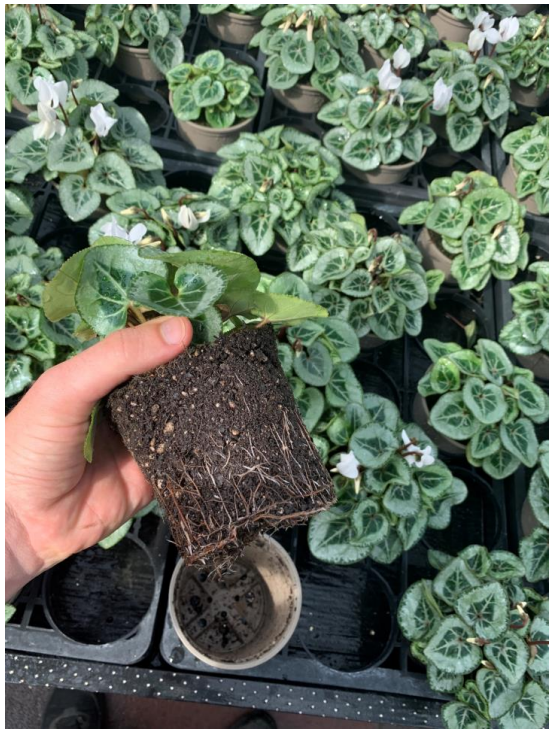
Creating a healthy root environment in peat-free growing media

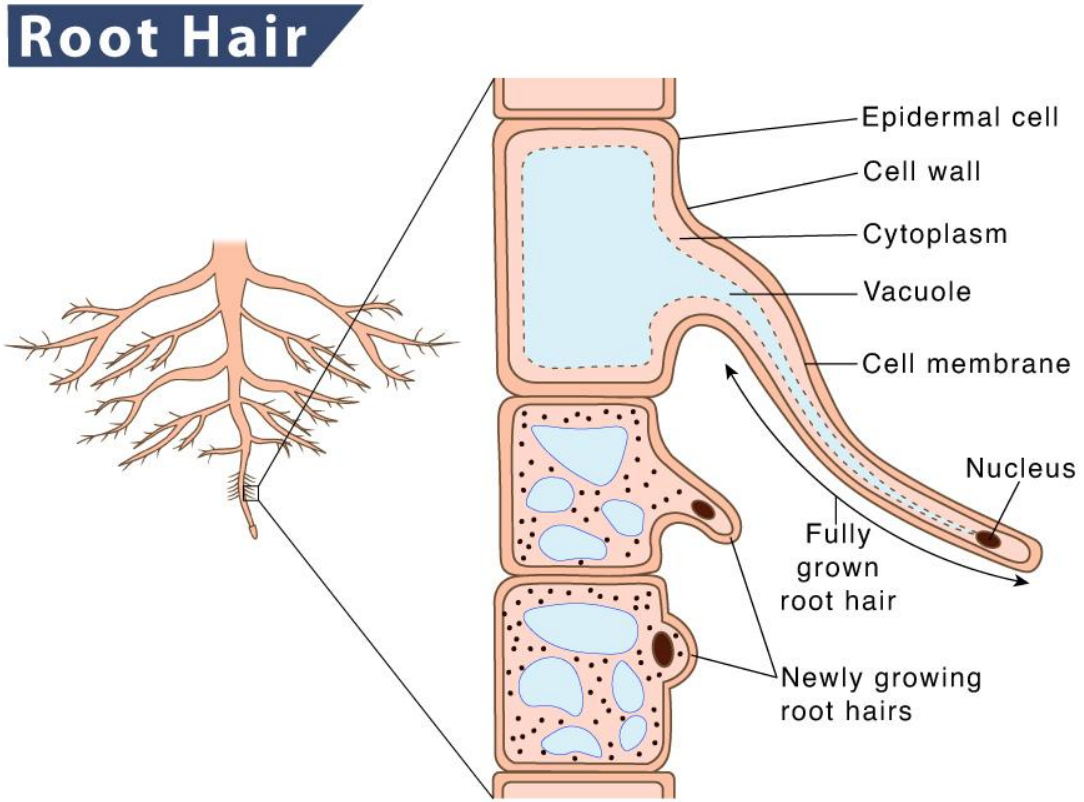


By Jack Haslam
Technical Development Manager at Fargro

Root system overview

- Absorbs
  - Water
  - Nutrients
  - Oxygen

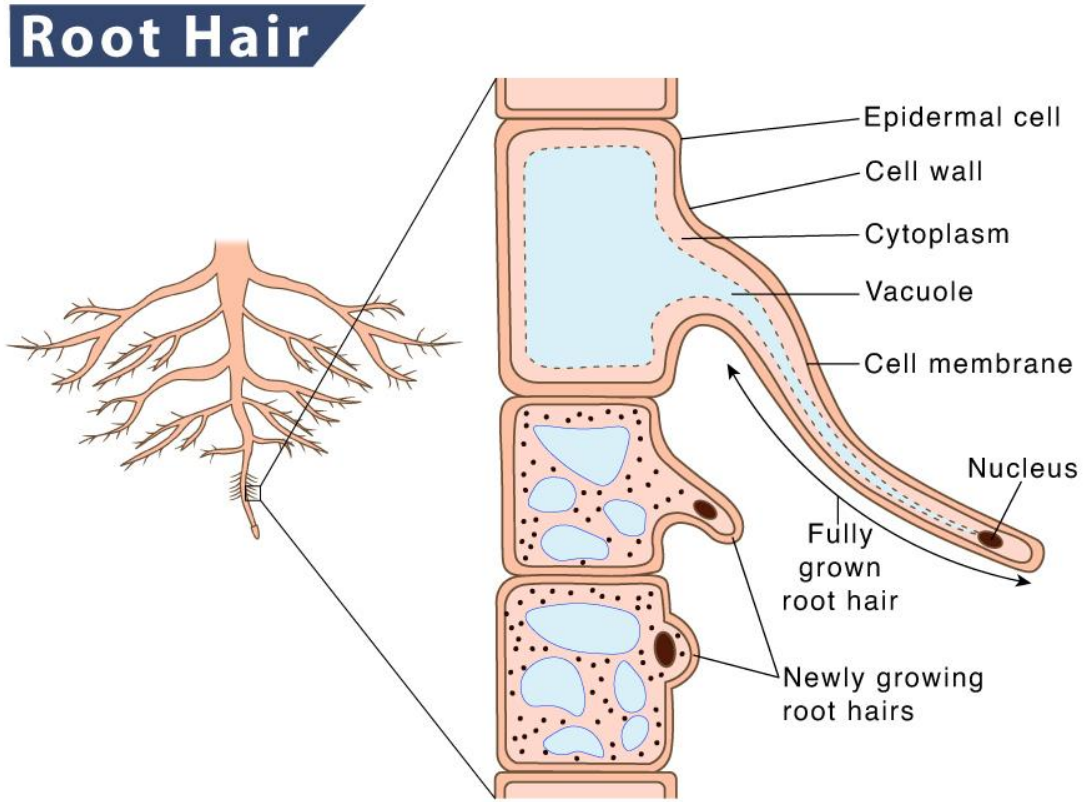
- Releases
  - Water
  - Sugars
  - Metabolites



Source: https://www.sciencefacts.net/root-hair.html

Root system overview

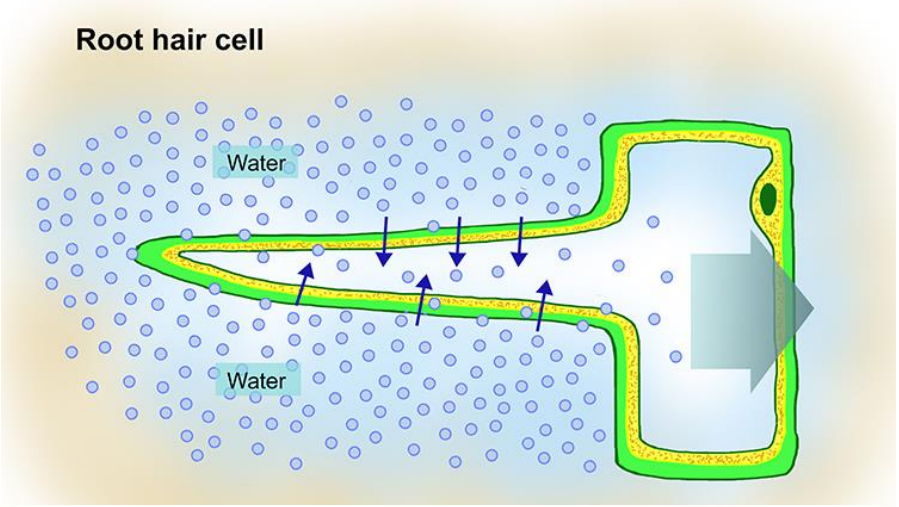
- Growing media contains pores of many different sizes
- These pores will be filled with either water or air
- Nutrients are in solution in water
- Roots will grow throughout the pot, with hairs protruding into pores

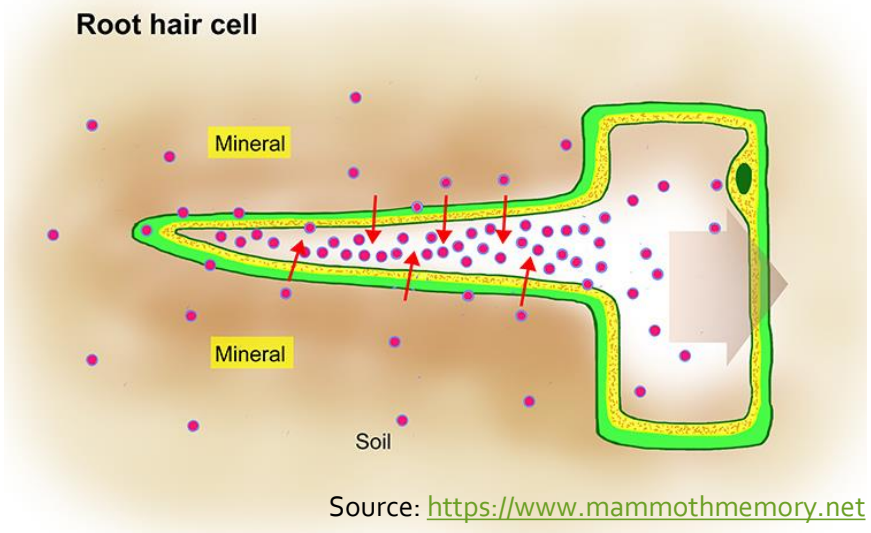


Source: https://www.sciencefacts.net/root-hair.html

Root osmotic balance

- Water uptake is done via osmosis
- This required concentration of nutrition to be higher in the cell than outside the cell – allowing the water to move in
- This is achieved by transporting nutrition in to and metabolites out of the cells using energy as well as flow of water up the plant



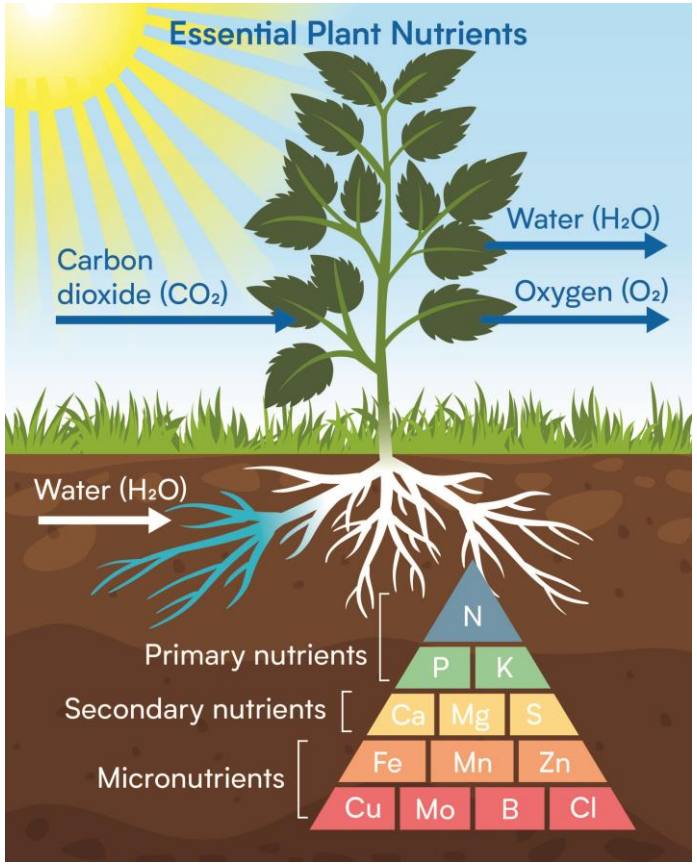


Source: https://www.mammothmemory.net

- *Osmosis: The movement water through a membrane from a solution of lower salt concentration to one of higher salt concentration to equalise the concentrations on each side of the membrane*

Root nutrient demand

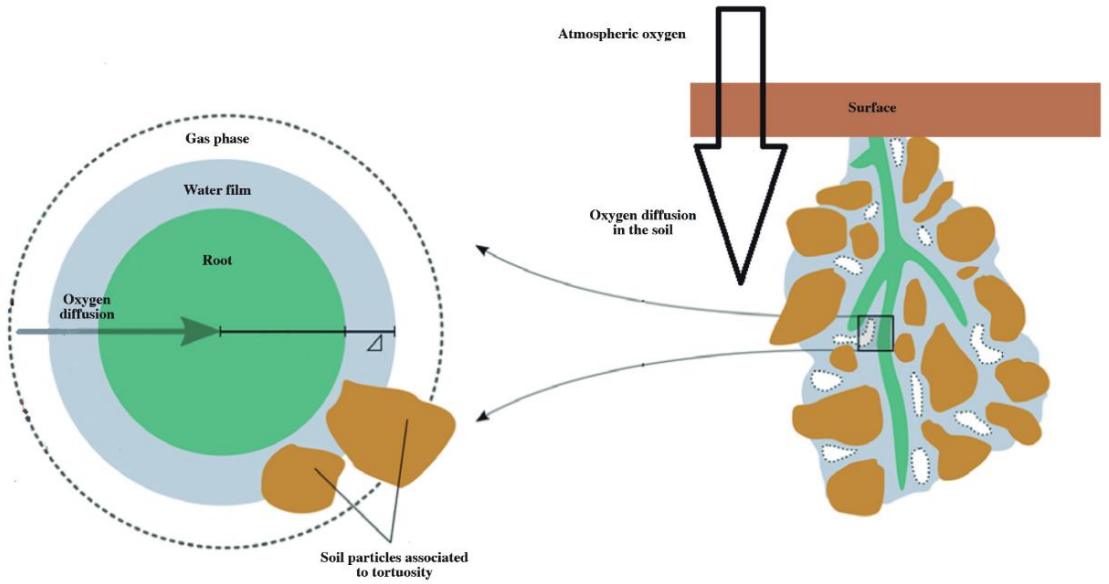
- Nutrients are required for healthy plant growth
- Mechanism of uptake can change depending on nutrient
- Some nutrients are 'transported' into the cell using energy
- Some come in with water via diffusion
- Nutrients are translocated around the plant to perform different functions



Source: Bek Diamond, Clemson University (2022)

Root oxygen demand

- Root cells require energy to function properly
- To do this they must respire – which requires sugar and oxygen
- Sugar is made in leaves by photosynthesis and sent down to the roots
- Oxygen is taken up directly by root cells
- Without oxygen the cells are weakened and will eventually die



Source: Neira et al., (2015)

Common root diseases

- Common Diseases
  - Fungi
    - Fusarium spp.
  - Oomycetes
    - Phytophthora spp.
    - Pythium spp.

Spores or live inoculum of microbes will attack and colonise roots, spreading into the plant to impact growth and kill the plant

REQUIRES POOR HYGEINE AND WEAKENED ROOTS

Root natural pathogen defence

- Root cells have natural resilience to infection from pathogens
  - Physical defences
  - Internal biochemical defences
  - Management of beneficial root microbiome

Most resilient when root cells are well watered, with sufficient oxygen and sugars to photosynthesise and appropriate nutrition to develop and grow

Risk factors for root disease

- Anaerobic conditions
  - Compaction
    - If your growing media becomes compacted it will reduce the amount of pores that hold oxygen
    - This will limit the ability of the roots to access oxygen
    - It also limits the ability of the root to expand throughout the media
  - Overwatering
    - Too much water in the growing media will displace air within the pores
    - This will make the root zone anaerobic and limit access to oxygen

Anaerobic conditions harm root cell health and favour pathogens – increasing risk of infection

Risk factors for root disease

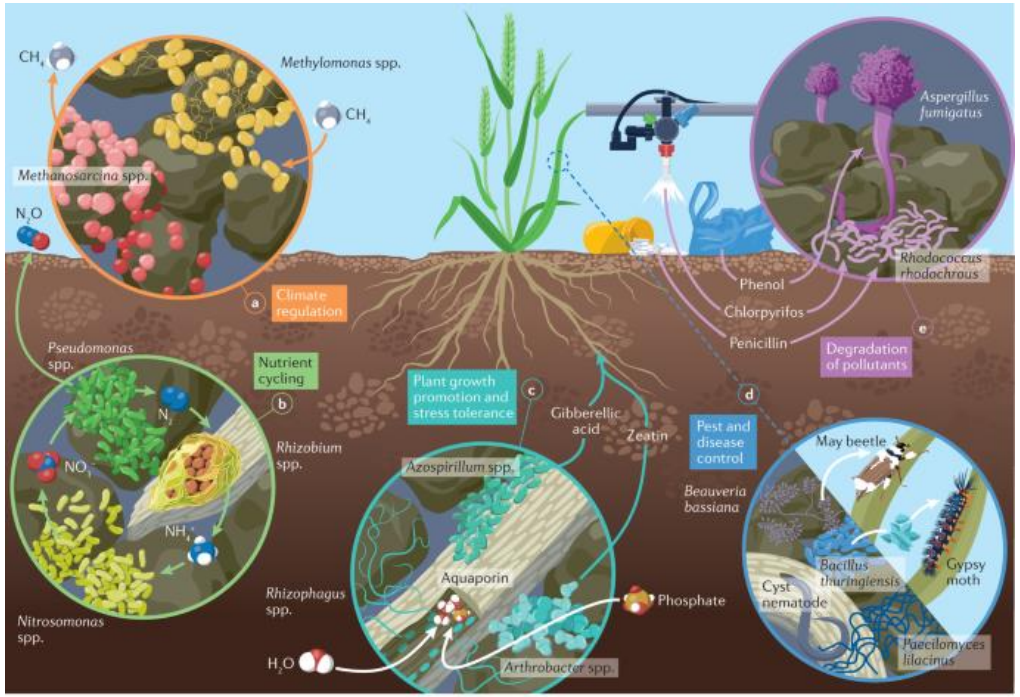
- Fertiliser root burn
  - Too much mineral fertiliser leads to root burn
  - It occurs due to excess salt levels in the soil surrounding the root
  - The root cannot properly obtain water from the soil because of the lack of osmotic pressure
  - This dries out the cells and kills them – limiting the plants natural resilience and providing an entry point for pathogens

Risk factors for root disease

- Fertiliser
  - Underfeeding
    - If underfed, then the nutrition is not sufficient to support root growth
    - This can occur due to incorrect applications, pH issues or leaching
    - This leads to weakened cells and weakened growth – reducing the natural resilience to pathogens
  - Irregular feeding
    - Plants will tailor their growth and development speed to the availability of nutrition
    - If the amount of available nutrition varies then this leads to problems with growth – increasing susceptibility to pathogens

Soil microbiome

- Within soil there is a community of microbes
- Some are beneficial, some are neutral, some are deleterious and some are pathogenic
- A healthy soil microbiome can deliver multitude of benefits
- An unhealthy microbiome will cause problems
- Healthy plants can manage microbiome in their favour



Source: Hartmann and Six, (2023)

Growing media microbiome

- Growing media will also have a microbiome, though it is generally more sterile than soil
- Fostering a healthy microbiome in growing media will deliver benefits and exclude pathogens
- This is done by selecting appropriate growing media, irrigation, fertilisation and growing environment

One of the strongest controls against root diseases

Requirements of growing media

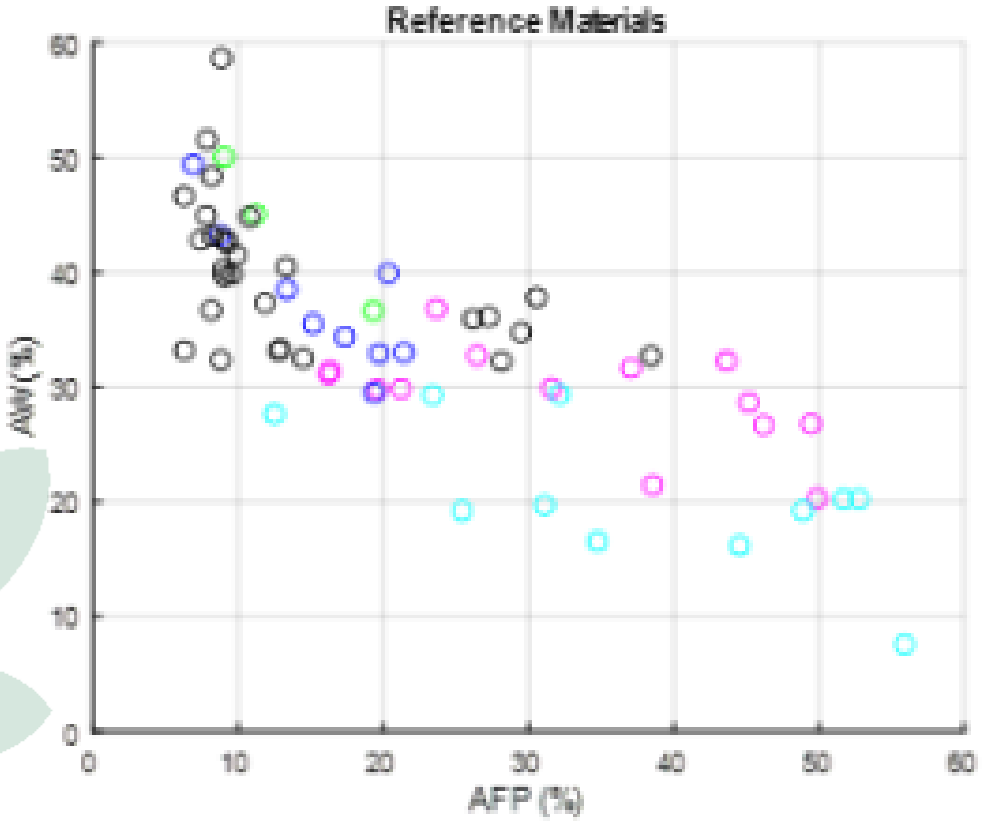
- Provide anchorage
- Facilitate gas exchange in rootzone
- Facilitate water uptake
- Facilitate nutrient uptake by the plant

Create environment that promotes crop health

Differences between peat and peat free

- Structure
  - Increased Air-Filled Porosity (AFP)
  - Lower Water Holding Capacity (WHC) and Available Water (AW)
- Chemistry
  - Higher pH and pH reduced buffering capacity
  - Lower Cation Exchange Capacity (CEC) and increased risk of leaching
  - Higher general nutrient presence in mix
  - Lower Ca and Mg due to lack of lime
  - Increased microbial activity

Growing media structure



Parameters: Available water (AW), Air filled porosity (AFP)

Point colours:

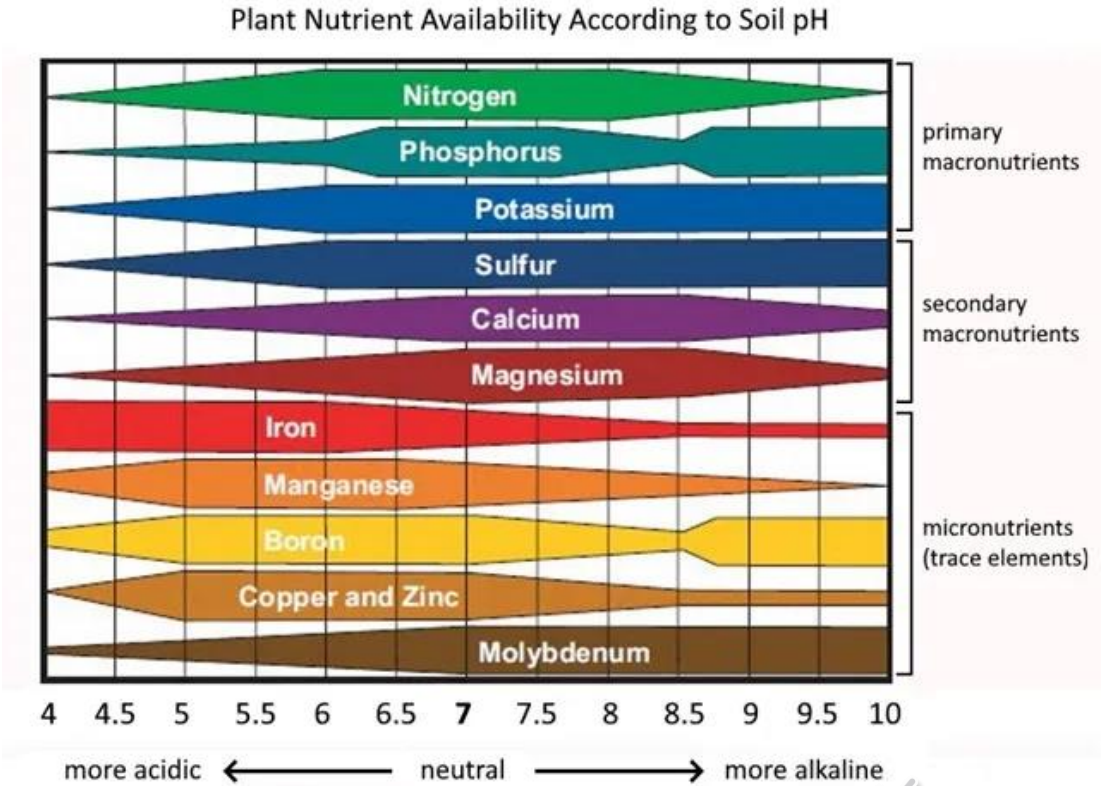
- **Peat (black)**
- **coir (blue)**
- **wood fibre (cyan)**
- **bark (pink)**
- **green compost (green)**

Source: ADAS

Growing media chemical profile

Raw material type	pH	EC (µS cm^{-1})	CEC (meq 100 cm^{-3})	AFP (%)	Available water (%) at 5kPa	Dry bulk density (g cm^{-3})
Coarse peat (10-25 mm)	4.2 - 4.7	15.0 – 49.0	15.1 - 42.8	13.3 - 38.4	32.5 – 44.6	0.12 - 0.19
Fine peat (0-5 mm)	4.1 - 4.7	24.2 - 49.8	10.5 - 20.9	8.2 - 9.1	35.0 – 43.0	0.09 - 0.17
Bark (0-8 mm)	5.7 - 6.4	98.0 - 246.1	13.9 - 22.0	16.3 – 26.3	30.1 - 34.2	0.16 - 0.23
Potting bark (5-16 mm)	5.3 - 5.8	20.2 - 46.3	7.3 - 11.9	38.6 - 49.4	35.0 - 43.0	0.15 - 0.17
Buffered coir (0-12 mm)	6.9 - 7.3	38.3 - 96.2	5.3 - 6.8	17.3 - 20.3	36.6 - 40.4	0.06 - 0.11
Green compost (0-10 mm)	7.5 - 8.2	456.6 - 1739.1	15.8 - 20.9	5.0 - 15.1	35.8 - 46.7	0.23 - 0.52
Wood fibre (all tested types [a])	5.4 – 8.3	5.3 – 441.1	9.0 - 14.9	25.4 - 51.7	13.2 – 24.7	0.06 - 0.11
Vermiculite (superfine - medium)	8.0 - 9.8	18.7 - 36.7	3.0 - 9.7	11.9 - 40.2	34.4 - 41.6	0.10 - 0.13
Perlite (fine - coarse)	8.0 - 9.2	5.2 - 9.7	0.8 - 2.1	21.3 - 36.2	21.4 - 24.2	0.05 - 0.12

Source: ADAS



We are seeing improved nutrient availability at higher pH in peat free compared to peat

Ingredients: Wood fibre

- **AFP: High (25% - 50%)**
- WHC: Low
- AW: Low (37% - 40%)
- pH: 4.4 – 6.0
- Buffering capacity: Low
- Cation Exchange Capacity: Low
- Electrical Conductivity: Low
- Microbial life: Low
- **Considerations: locks up N in first 8-10 weeks**

Ingredients: Coir

- AFP: Medium (17% - 20%)
- WHC: High
- **AW: High (37% - 40%)**
- pH: 6.0 – 7.3
- Buffering capacity: Low
- Cation Exchange Capacity: Low
- Electrical Conductivity: Low
- Microbial life: Low
- **Considerations: high in K**

Ingredients: Green compost

- AFP: Low (5% - 15%)
- WHC: High
- **AW: High (36% - 47%)**
- pH: 7.5 – 8.2
- Buffering capacity: Low
- **Cation Exchange Capacity: Medium**
- Electrical Conductivity: Very high
- **Microbial life: High**
- **Considerations: Quality and properties can vary widely**

Ingredients: Bark

- AFP: Medium (16% - 26%)
- WHC: High
- AW: Medium (30% - 34%)
- **pH: 5.7 – 6.4**
- **Buffering capacity: Medium**
- **Cation Exchange Capacity: Medium**
- Electrical Conductivity: Medium
- Microbial life: Low
- **Considerations: locks up N in first 8-10 weeks**

Ingredients: Perlite

- **AFP: High (21% - 36%)**
- WHC: High
- AW: Medium (21% - 24%)
- pH: 8.0 – 9.2
- Buffering capacity: Very low
- Cation Exchange Capacity: Very low
- Electrical Conductivity: Very low
- Microbial life: Low
- **Considerations: Concern over environmental impact of production**

Ingredients: Vermiculite

- **AFP: High (12% - 41%)**
- **WHC: High**
- **AW: High (34% - 42%)**
- pH: 8.0 – 9.8
- Buffering capacity: Low
- Cation Exchange Capacity: Low
- Electrical Conductivity: Medium
- Microbial life: Low
- **Considerations: Concern over environmental impact of production**

Additives: Wetting agents, Clays

- Wetting Agents:
  - Available Water: High
  - Water Holding Capacity: High
  - Generally last for a couple of months
  - **Considerations: some products are non-biodegradable so have poor environmental profile and can negatively impact soil biology**

- Clay:
  - Buffering capacity: High
  - Cation Exchange Capacity: High

Peat-free ingredients overview

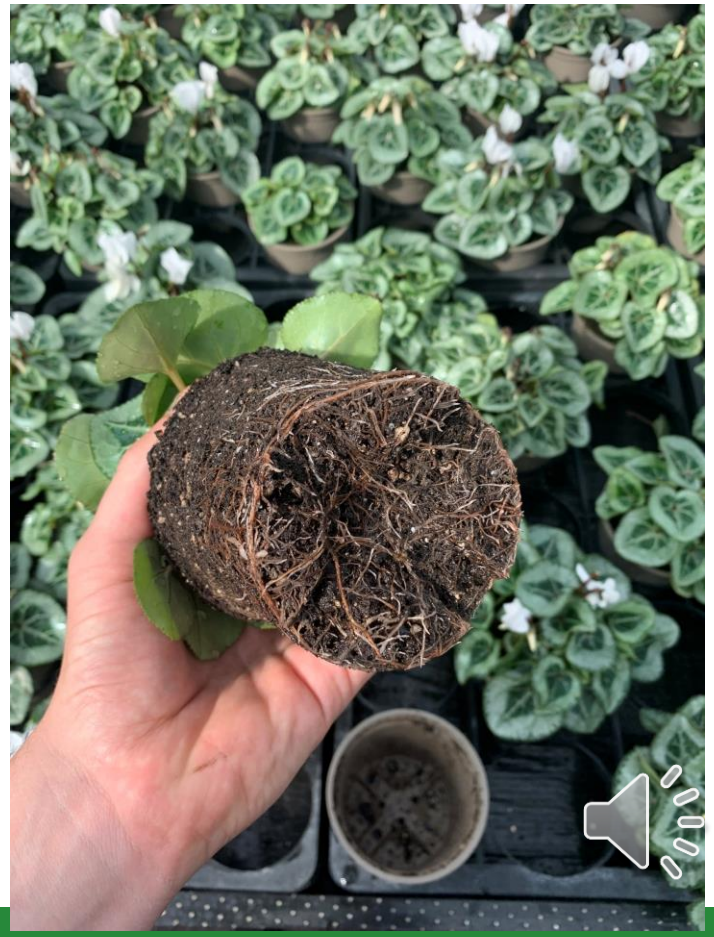
- **Wood fibre**: Aeration
- **Coir**: Water availability
- **Green compost**: water availability, nutrient adsorption, soil biology
- **Fine pine bark**: good pH, aeration, some buffering capacity
- **Perlite**: aeration and soil structure
- **Vermiculite**: aeration, water availability and soil structure
- **Clay**: Nutrient adsorption and pH buffering
- **Wetting agent**: improved water uptake and retention

Must be tailored to crop demands

Peat-free profile for disease

- **More aerobic**
  - Mixes are more open with reduced ability to hold and provide water than peat
  - Less conducive environment for root pathogens
- **More active microbiome**
  - Can encourage beneficial microbes more effectively
- **Nutrient and water delivery is more difficult**
  - This can lead to reduced crop health to limit natural resilience to pathogens and also costs money in wastage

Media and rooting



Nutrition: Fertilisation requirements

- Crop demands
  - Steady availability of macro and micronutrients
  - Consistent EC and water availability to facilitate nutrient uptake
  - Ca not available with lime so must be added
  - Will change between crops and between periods in crops life cycle
- Growing media demands
  - Nitrogen is immobilised by soil microbes in mixes containing bark and wood fibre

Nutrition: Mineral Fertiliser

- Integrated mineral fertilisers
  - Base fertilisers
    - Formulation: small granules
    - Balanced NPK
    - Release profile: from a few weeks to a few months
    - Immediately available nutrition to crop for establishment
  - Nitrogen
    - Formulation: small granules
    - All N
    - Release profile: 12-15 weeks
    - Stops competition between plant and growing media for N
  - Controlled Release Fertiliser (CRF) Granules
    - Formulation: small or large granules
    - Release profile: weeks to years (product dependent)
    - Can deliver comprehensive nutrient profile for lifetime of crop

Source: ICL

Nutrition: Liquid Mineral Fertiliser

- Liquid mineral fertiliser
  - Calcium nitrate
    - Very important for delivery of calcium due to lack in peat-free mixes
  - Potassium nitrate
    - Requirement for K is reduced due to availability in media
    - K feed strengthens plant to increase natural resistance
  - Other options also of use for specific crops

Nutrition: Mineral Fertiliser Considerations

Mineral fertilisers provide nutrition in a salt format that is readily available for plant uptake and so easily dissolved in water

- General considerations
  - EC risk
    - The dissolving of these nutrients into water increases the EC – which can lead to stress and root burn if not managed correctly
  - Leaching
    - The nutrients are easily dissolved in water - meaning they can be easily leached
    - Peat free media holds nutrition less tightly, increasing the risk of leaching
  - Release is influenced by environment
    - Chemical process mediates the release of nutrition and so higher temperatures can lead to faster release – which is sometimes contrary to plants requirements
  - Limited interaction with microbial life
    - Directly feeding the plant bypasses beneficial soil microbes, limiting the formation of a healthy microbiome and encouraging the propagation of pathogens

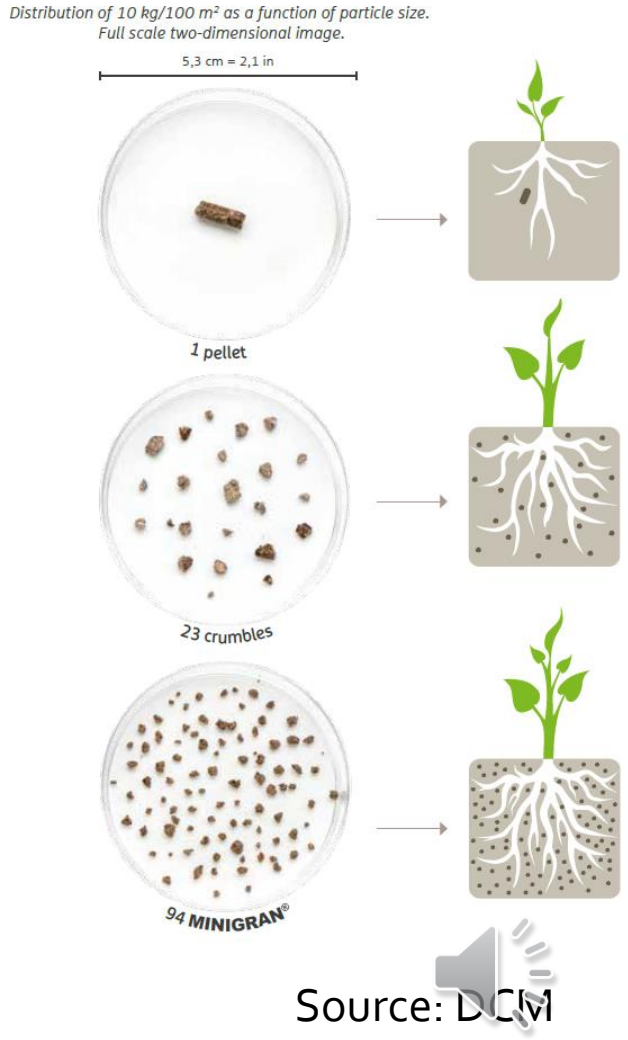
Nutrition: Mineral Fertiliser Considerations

- Specific considerations
  - Base fertiliser
    - Only present to support establishment and further feed is always required
  - Nitrogen
    - N lock up by microbes occurs for 8-10 weeks so if the release profile of the fertiliser is longer then this can lead to an intense release of N to the plant
  - CRF Granules
    - Release can be controlled by temperatures and so length of release can differ from target
  - Liquid Feed
    - Peat free media has higher propensity for leaching due to reduced CEC and so applications should be well targeted onto a healthy and well-developed root system

Nutrition: Organic fertiliser

- Integrated fertiliser
  - Formulation: miniature (DCM) to small granules
  - Variety of products with ranging NPKs, as well as secondary and micronutrient availabilities
  - Bound to organic material so leaching is reduced
  - Delivers comprehensive nutrition to crop
  - Encourages beneficial soil life
  - Release pattern: up to 150 days

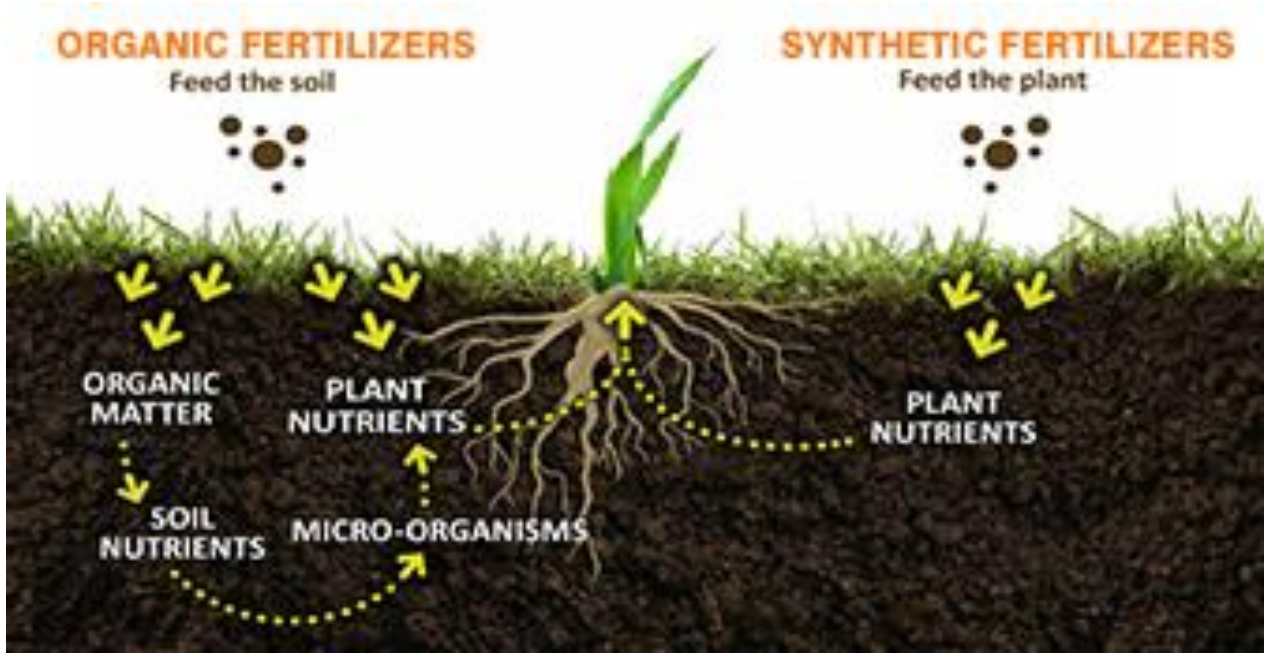
- Liquid fertiliser
  - Generally lower NPK but longer lasting release than mineral liquid feed
  - Many have biostimulant properties



Source: DCM

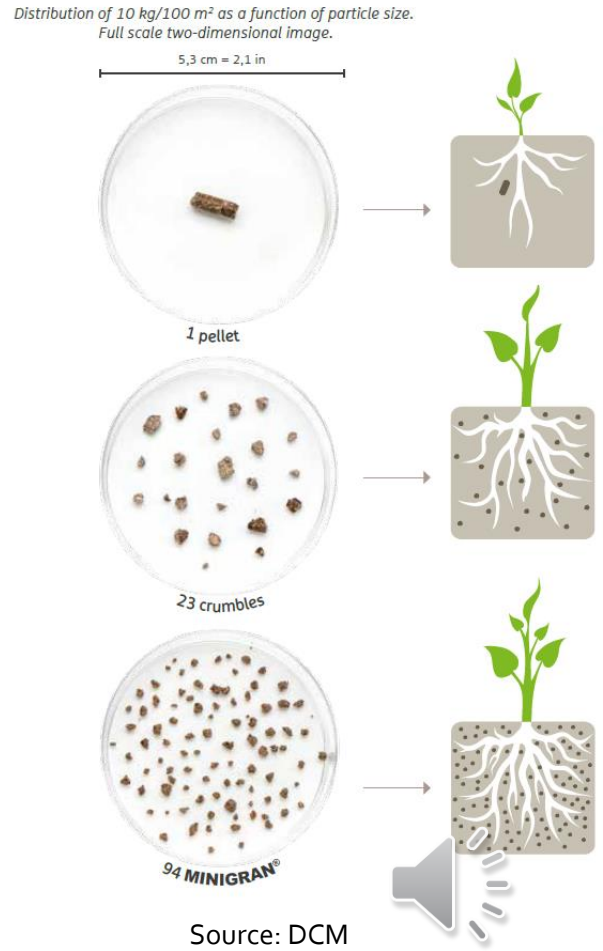
Nutrition: Organic fertiliser

- Release mechanism
  - Organic nutrients must be mineralised to be taken up by plant
  - Mineralisation dependents on biology (helped by presence of compost in growing media)
  - Microbe metabolic speed aligns with plant metabolic speed so that release is well suited to plant growth



Nutrition: Organic fertiliser Benefits

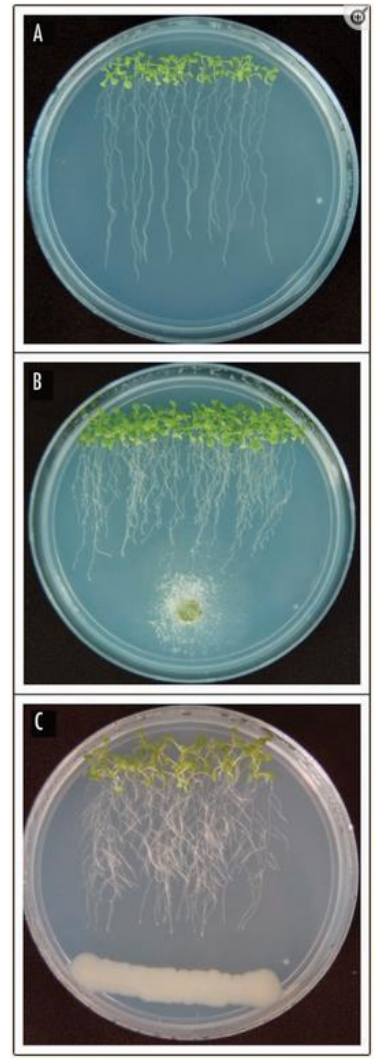
- Benefits of organic fertilisers
  - Uniformity
    - Small granule size provides uniform nutrition throughout the growing media
    - Release pattern delivers consistent EC to avoid shocking plant or burning the roots
  - Improved rooting
    - Distribution in growing media encourages plant to develop dense roots throughout the pot
    - This facilitates better uptake of added mineral fertiliser



Source: DCM

Nutrition: Organic fertiliser Benefits

- Improved soil biology
  - Nutrition
    - Fix or release nutrition that is directly unavailable to plants
    - Colonise roots and forage for nutrition within the growing media – massively increasing the reach of the root network
  - Anti-pathogen activity
    - Stimulate plants natural defences
    - Competitively exclude pathogens
  - Growth and development
    - Release plant hormones and signalling molecules to facilitate healthy and steady growth of root and shoot



Uninoculated

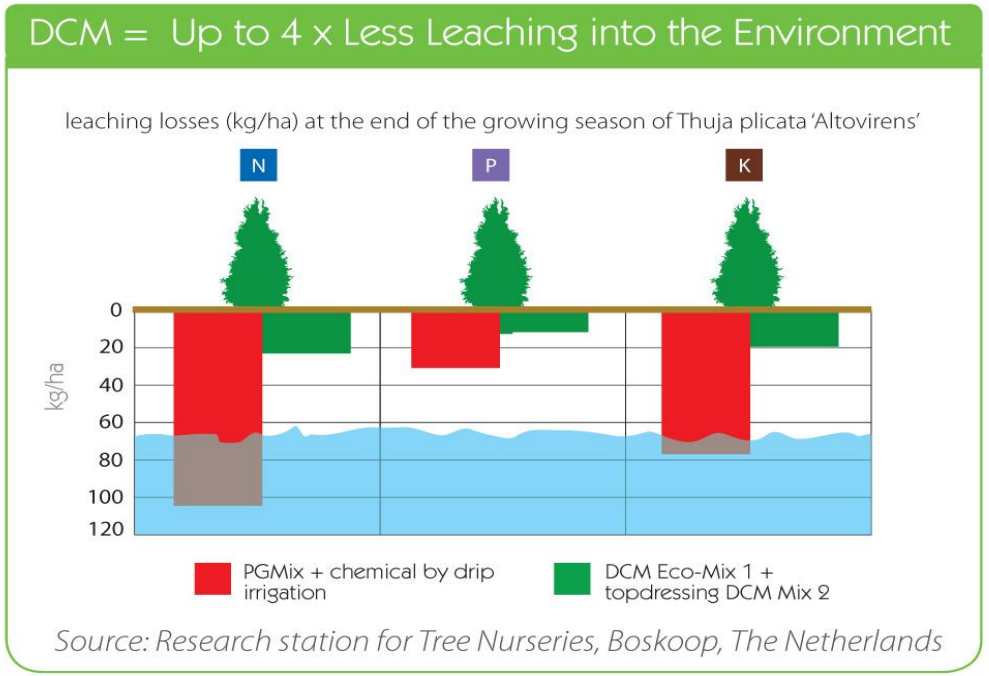
With *Bacillus*

With *Trichoderma*

Source: Ortiz-Castro et al., 2009

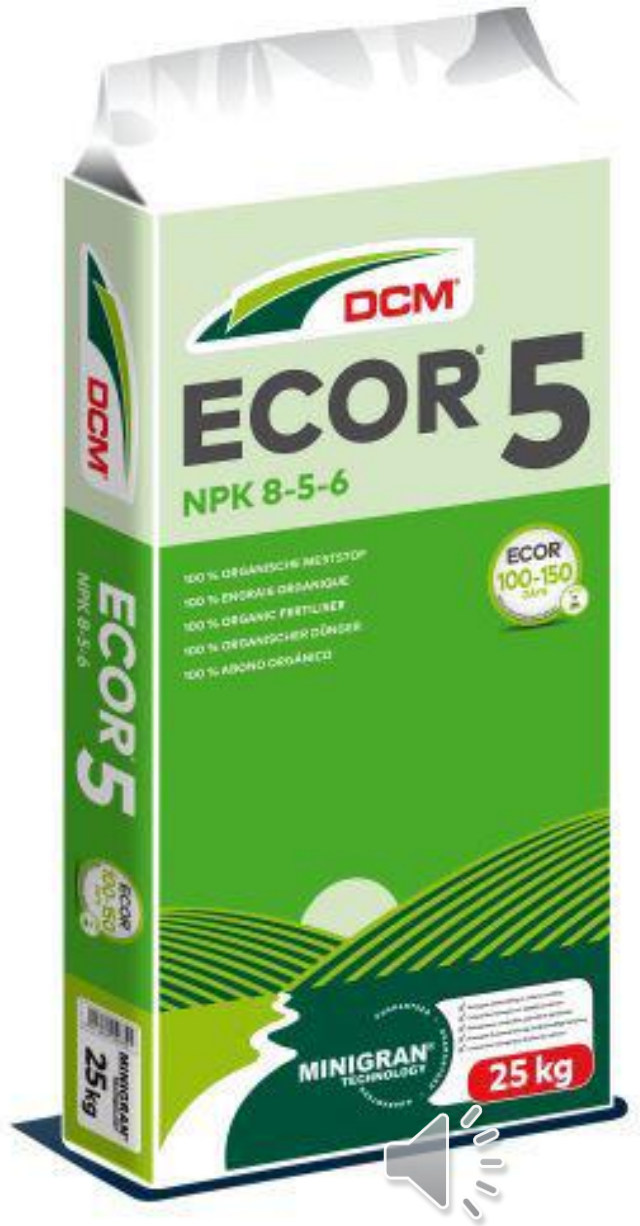
Nutrition: Organic fertiliser

- Benefits of organic fertilisers
  - Reduced water requirements
    - Uptake requires less water than mineral feeds and so crop can be grown in a drier manner
    - Controls disease pressure by keeping environment aerobic
  - Reduced leaching
    - Peat free mixes hold nutrition less tightly
    - But the strongly bound nutrients in organics are harder to leach as well as having a lower NPK
    - Mineral nutrients are released in line with plant demands so majority is used – reducing waste and costs



Nutrition: Organic Fertiliser

- Increased resistance to disease
  - Healthy microbiome
  - Low and consistent EC with comprehensive nutrient profile
  - Targeted NPK inputs
  - Limited irrigation
  - Improved efficacy of biopesticides



Nutrition: Organic fertiliser

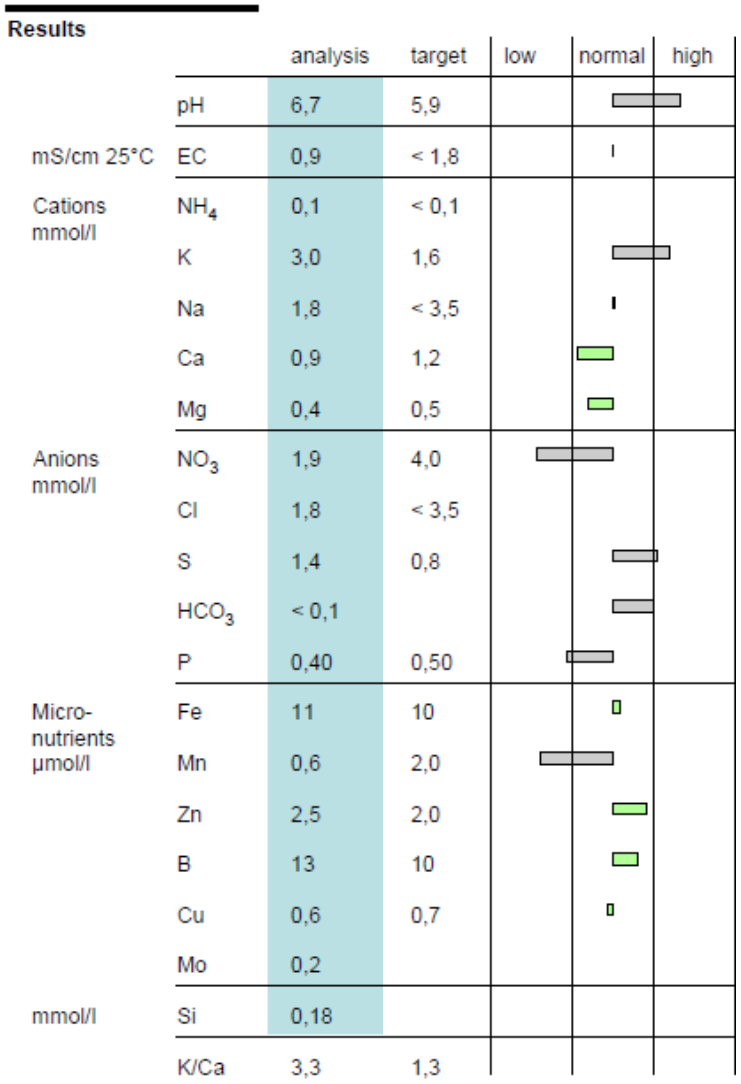
- Considerations with organic fertilisers
  - Release mechanism means that nutrition is not available immediately so they're well combined with mineral feed at the start
  - Increased microbial activity interacting with nutrition can lead to changes in pH and soil chemistry
  - Length of release is limited due to organic nature and so for longer term crops they're best combined with a longer releasing CRF or top dressing

Soil analysis

Understanding chemical and nutrient profile of the soil is vital

- Peat free considerations
  - Generally higher pH but nutrient availability is better at these levels
  - Fluctuations occur more easily than peat mixes

- Organic feed considerations
  - lower EC but consistent in time and throughout the pot
  - Low nitrate level as it must be mineralised



Results

		analysis	target	low	normal	high
	pH	6,7	5,9			
mS/cm 25°C	EC	0,9	< 1,8			
Cations mmol/l	NH_4	0,1	< 0,1			
	K	3,0	1,6			
	Na	1,8	< 3,5			
	Ca	0,9	1,2			
	Mg	0,4	0,5			
Anions mmol/l	NO_3	1,9	4,0			
	Cl	1,8	< 3,5			
	S	1,4	0,8			
	HCO_3	< 0,1				
	P	0,40	0,50			
Micro-nutrients µmol/l	Fe	11	10			
	Mn	0,6	2,0			
	Zn	2,5	2,0			
	B	13	10			
	Cu	0,6	0,7			
	Mo	0,2				
mmol/l	Si	0,18				
	K/Ca	3,3	1,3			

Source: Eurofins analysis of peat-free cyclamen crop

Irrigation

- Water delivery
  - Mix is more open than peat and so dries out quicker – but drying profile is different
  - Increased AFP means more scope for compaction – important to water gently
  - Use liquid wetting agent

- Nutrition delivery
  - Organic fertiliser can deliver nutrition in drier environment than mineral
  - Consider growing drier (which helps with pest and disease and reduces leaching)

Source: ICL

Summary

- Create a healthy root zone
  - Good structure
  - Good hygiene
  - Support beneficial biology
- Provide plant with tools to maximise natural resilience
  - Good irrigation
  - Good feeding
  - Good growing environment

Peat Free varies more than peat so requirements change between crops