Principles of trunk injection and practical considerations

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Funding

Development of an automated delivery system for therapeutic materials to treat HLB infected citrus

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Overview

I. Trunk injection basics
II. Methods of injection
III. Tree anatomy/physiology
IV. Other considerations
V. Summary

I. Trunk injection basics

What is trunk injection?

- A targeted delivery of crop protection materials into the stem or trunk of a woody plant as an alternative to spraying or soil drenching (“Endotherapy”)
- Injection occurs into the xylem (not the phloem) from where the materials are then distributed throughout the plant with the transpiration stream

Advantages

- Precise delivery of crop protection materials
- Elimination of spray drift
- Reduced risk for worker exposure
- Reduced risk for non-target organisms
- Reduced pesticide load into the environment
- Potentially longer residual activity of materials

Areas of use

- Residential and commercial landscapes, forest areas, and other uncultivated non-agricultural areas
- Non crop-bearing ornamental trees, large woody shrubs, and palms in urban environments and residential areas
- Few crop-bearing agricultural crops (peach, pear)

Targets

- *Insects* (stem and leaf feeding, bark boring)
- *Nematodes* (wood nematodes)
- *Fungi* (powdery mildew, blight, rust, scab, etc.)
- *Bacteria* (bacterial blight, bacterial leaf scorch, *Xylella*)
- *Phytoplasmas* (lethal yellows/bronzing)
- *Other* (delivery of nutrients, growth regulators, etc.)

Diseases

Forestry

- Dutch elm disease (fungus - xylem)
- Oak wilt disease (fungus - xylem)
- Emerald ash borer (larvae - bark)
- Pine bark beetle (larvae - bark)
- Sudden oak death (Phytophthora -trunk)

Britannica.com

IMAGE: DAVID CAPPAERT/BUGWOOD.ORG

Diseases

Agriculture

- Apple, pear – scab, fire blight, root rot
- Avocado – root rot, thrips

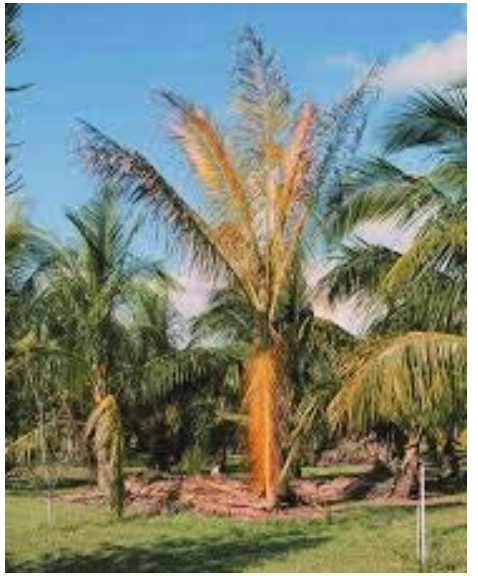
Viticulture

- Grapevine downy and powdery mildew

Ornamental

- Palm lethal yellowing/bronzing

https://ohioline.osu.edu/factsheet/plpath-fru-23



https://edis.ifas.ufl.edu/pdffiles/PP/PP14600.pdf

Registered crop production materials

Company	Product	Content	Use	Frequency	Registered crop
Mauget	Stemix Plus 1-1-1	NPK, Cu, Fe, Mn, Zn	Nutritional	1 per year	
Mauget	Imisol	Debacarb 1.7%, Carbendazim .3%, Imidacloprid 5%	Systemic insecticide/fungicide	Do not treat within 3 months of previous application	None
Mauget	ArborFos	Potassium salts of Phosphorous Acid 45.8%	Systemic fungicide	Preventative application	Avocado, citrus, coconut, apples, pears, loquats, quince, tree nuts
Mauget	Dinocide	Dinotefuran 12%	Systemic insecticide	1 per year	None
Mauget	Mycojet Ultra	OTC Hydrochloride 4.3%	Systemic antibiotic	1 per year	None
Mauget	Imicide	Imidacloprid 10%	Systemic insecticide	1 per year	None
Mauget	Abasol	Debacarb 1.7%, Carbendazim .3%, Abamectin .46%	Systemic insecticide/fungicide	Do not treat within 3 months of previous application	None
Mauget	Inject-a-min Manganese 1%	NPK, Cu, Fe, Mn, Mo, Zn	Nutritional	1 per year	
Mauget	Abacide 2	Abamectin 1.9%	Systemic miticide/insecticide	Preventative application	None
Mauget	Tebuject 16	Tebuconazole	Systemic fungicide	Preventative application	None
Mauget	Inject-a-min Iron-Zinc	NPK, Cu, Fe, Mn, Mo, Zn	Nutritional	1 per year	
Mauget	Vigor 53	Soluble Potash 25%	Nutritional		Avocado, olives, citrus, grapes, nut crops, pome fruits, stone fruits
Arborjet	Ace-jet	Acephate 97.4%	Systemic insecticide	As needed	None
Arborjet	IMA-jet (10)	Imidacloprid 5% (10%)	Systemic insecticide	Preventative application	None
Arborjet	Tree-age	Emamectin Benzoate 4%	Systemic insecticide	Preventative application	None
Arborjet	Arbor-OTC	OTC Hydrochloride 39.6%	Systemic antibiotic	1 per growing season, repeat as necessary	None
Arborjet	Phospho-jet	Potassium salts of Phosphorous Acid 45.8%	Systemic fungicide and plant resistance activator		Apples, loquats, pears, quince, avocado, citrus, coconut, berries, mango, stone fruit, tree nuts
Arborjet	Mn-jet Fe	Potash, B, Cu, Fe, Mn, Zn	Nutritional	As needed	None
Arborjet	Palm-jet Mg	NPK, Mg, B, Fe, Mn, Zn	Nutritional	As needed	None

Registered crop production materials

Company	Product	Content	Use	Frequency	Registered crop
Arborsystems	Boxer	Emamectin Benzoate 4%	Insecticide/miticide	Annual maximum application rate of 8.5g a.i. per tree	None
Arborsystems	Greyhound	Abamectin B1 1.9%	Insecticide	1 or 2 per year	None
Arborsystems	Pointer	Imidacloprid 5%	Insecticide	1 per year	None
Arborsystems	Retriever	Acetamiprid 8.5%	Insecticide	As needed	None
Arborsystems	Shepherd	Propiconazole 14.3%	Fungicide	1 per year	none
Arborsystems	Whippet	Potassium salts of Phosphorous Acid 45.8%	Systemic fungicide	Preventative application	Almond, Apple, Avocado, macadamia, pineapple, stone fruit
Arborsystems	Terrier	OTC Hydrochloride 4.3%	Systemic antibiotic	1 per year	None
Arborsystems	Springer	OTC Hydrochloride 4.3%	Systemic antibiotic for palms	As needed	None
Arborsystems	Pinscher	Dikegulac-sodium 18.5%	Plant growth regulator	1 per year	None
Arborsystems	Greentree Pro Nutribooster	NPK 0-15-10	Nutritional	1 per year	None
Arborsystems	Iron/Manganese Nutribooster	Fe 8.5%, Mn 3.5%	Nutritional	As needed	None
Arborsystems	Manganese nutribooster	Mn 5%	Nutritional	As needed	None
Sorbus International	EnerBite	Phosphonic Acid and potassium salt	Nutritional	Every two years	
Rainbow Treecare	Bacastat	Oxytetracycline 18.3%	Antibiotic	As needed	None
Rainbow Treecare	Arbotect 20-s	Thiabendazole Hypophophite 26.6%	Fungicide	1 per year	None
Rainbow Treecare	Mectinite	Emamectin Benzoate 4%	Insecticide	1 every 2 years	
Rainbow Treecare	Alamo	Propiconazole 14.3%	Fungicide	1 per year	None
Tree Tech	Dendrex	Acephate 98%	Instecticide	As needed	None
Tree Tech	Vivid 2	Abamectin 1%	Insecticide/miticide	As needed	None
Tree Tech	Alsa PropiconazolePropiconazole 14.3%	Propiconazole 14.3%	Fungicide	As needed	None
Tree Tech	Systrex	Triadimefon .88%	Fungicide	As needed	None
Tree Tech	Tree Tech OTC	OTC Calcium Complex 4.57%	Antibiotic	As needed	Citrus*, nuts, pome fruits, stone fruits (*non- crop bearing)
Tree Tech	Snipper	Indole-3 butyric acid 4%	Plant growth regulator	1 per year	None
Tree Tech	Nutri-ject Supreme	NPK, Fe, Mn, ZN	Nutritional	As needed	
Tree Tech	Nutri-ject Fe Mn Zn	NPK, Ca, Mg, Cu, Fe, Mn, Zn	Nutritional	As needed	

II. Methods of injection

Methods of injection







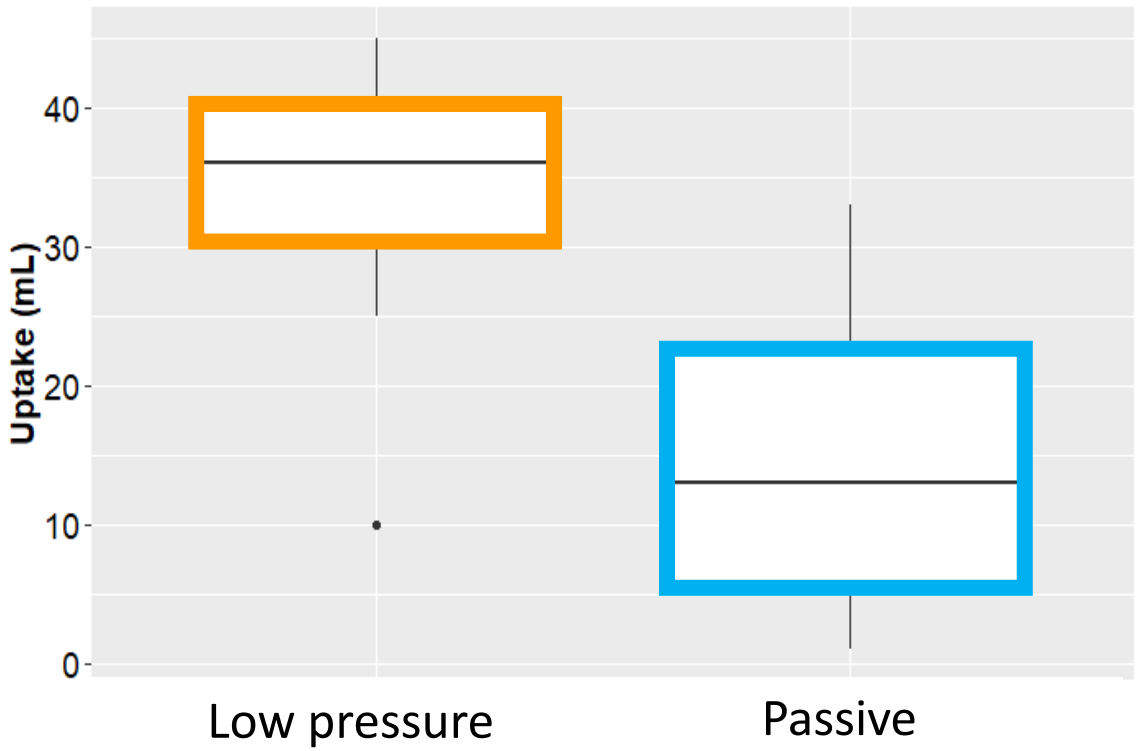

Most technologies are drill-based. Few are no-drill (needle)-based.
All require relatively large injection holes.

Fast high-pressure injection

Slower medium pressure injection

Low pressure/passive transfusion

Low pressure vs passive transfusion

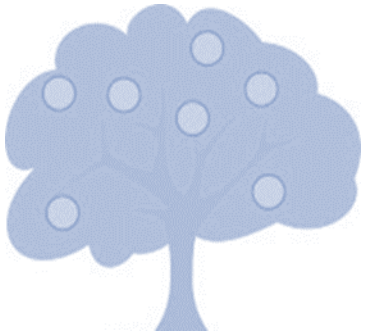


More material is taken up when pressure is applied.

Concerns

- Logistical problems (time, labor, cost)
- Wounding of trees
- Secondary infections
- Xylem vessel destruction and embolisms
- Impact on long-term tree vitality
- Impact on pollinators
- Residues in fruit
- Time and resources to get label for use

III. Tree anatomy/physiology



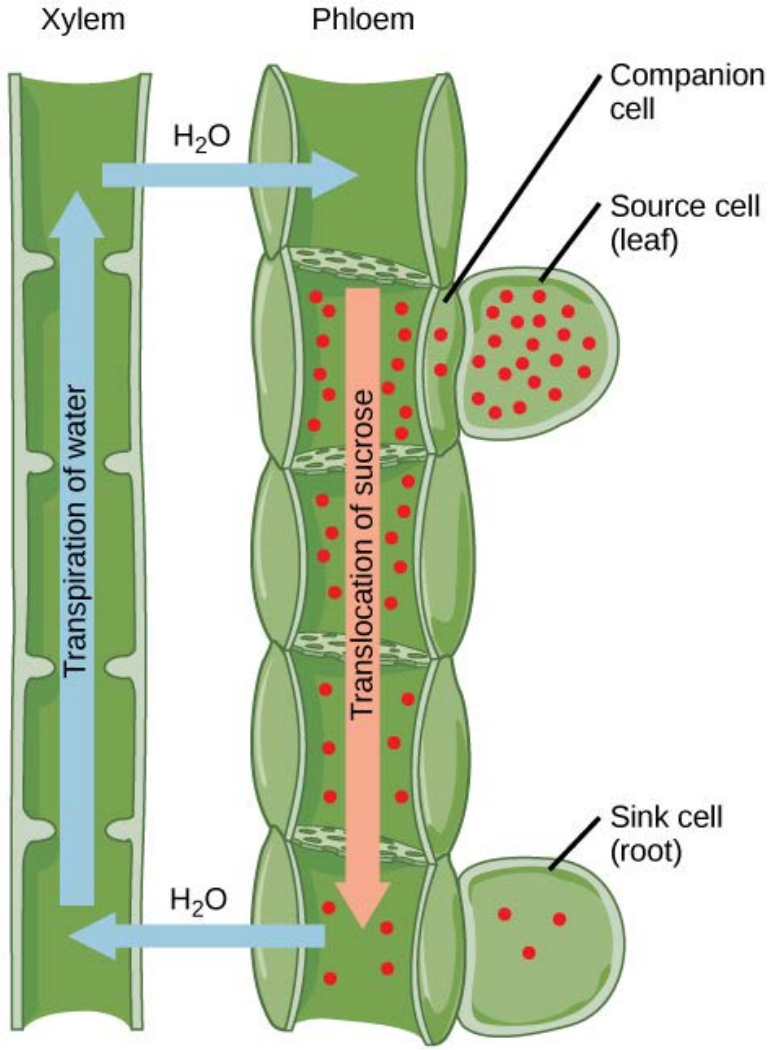
Long distance transport systems

Xylem

- Passive transport
- Unidirectional – from roots to leaves ⬆
- Driving force is transpiration

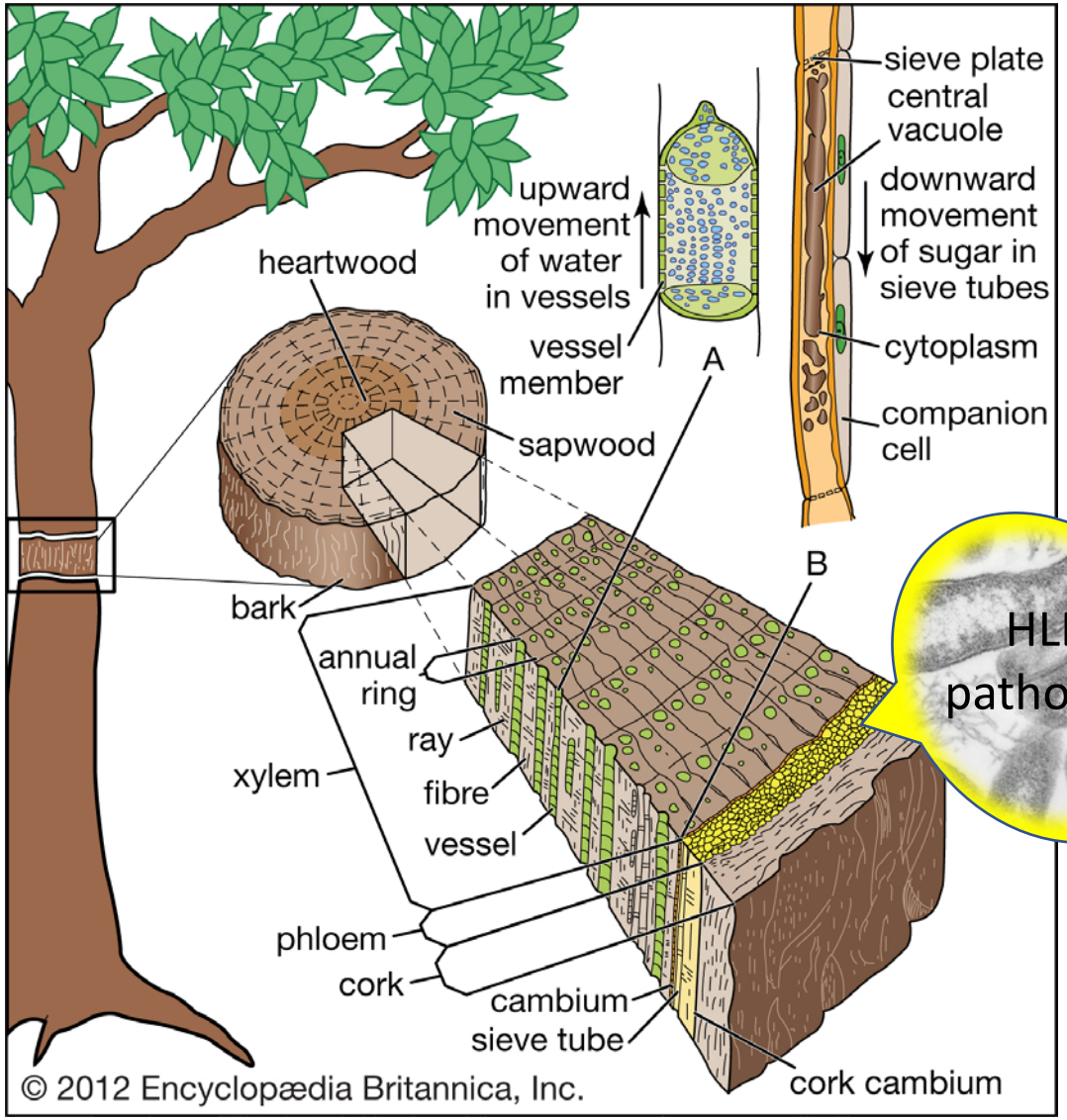
Phloem (→HLB)

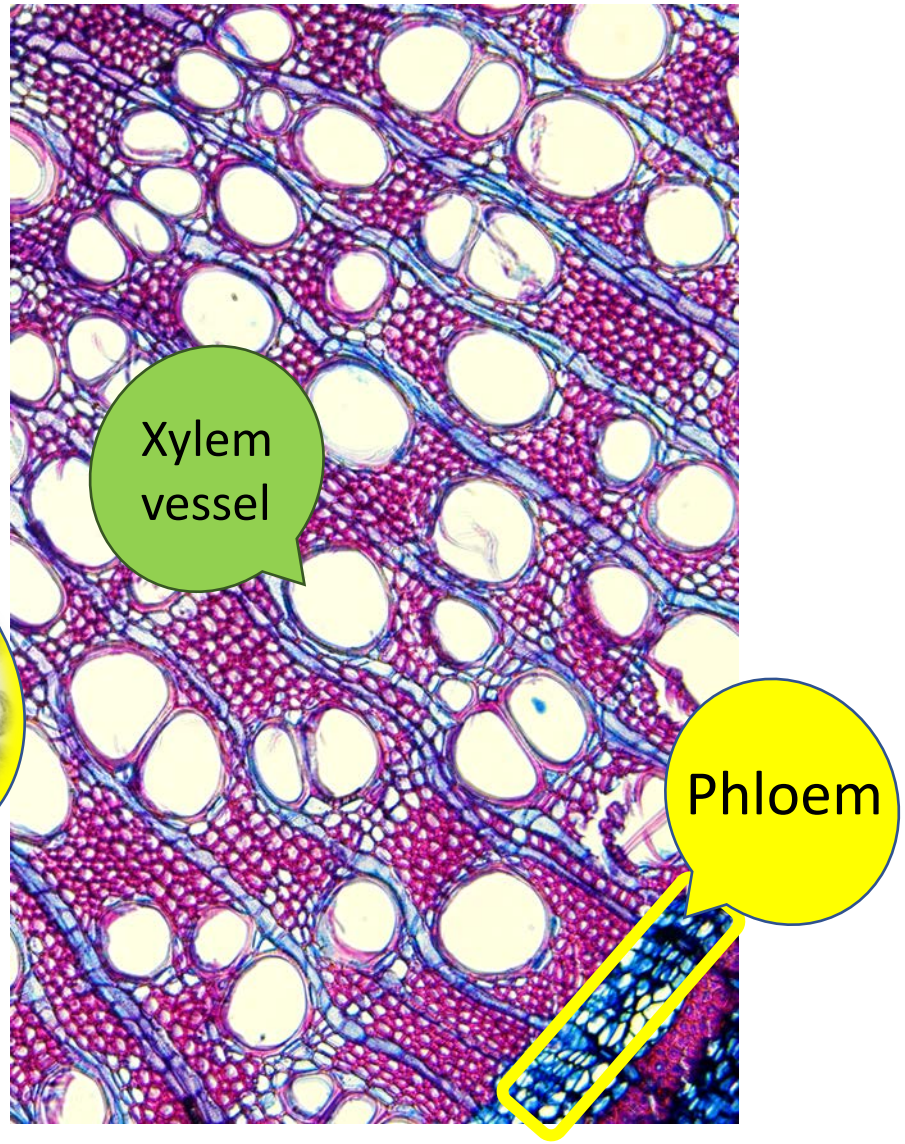
- Active transport
- Bidirectional - from source to sink tissue ⬍



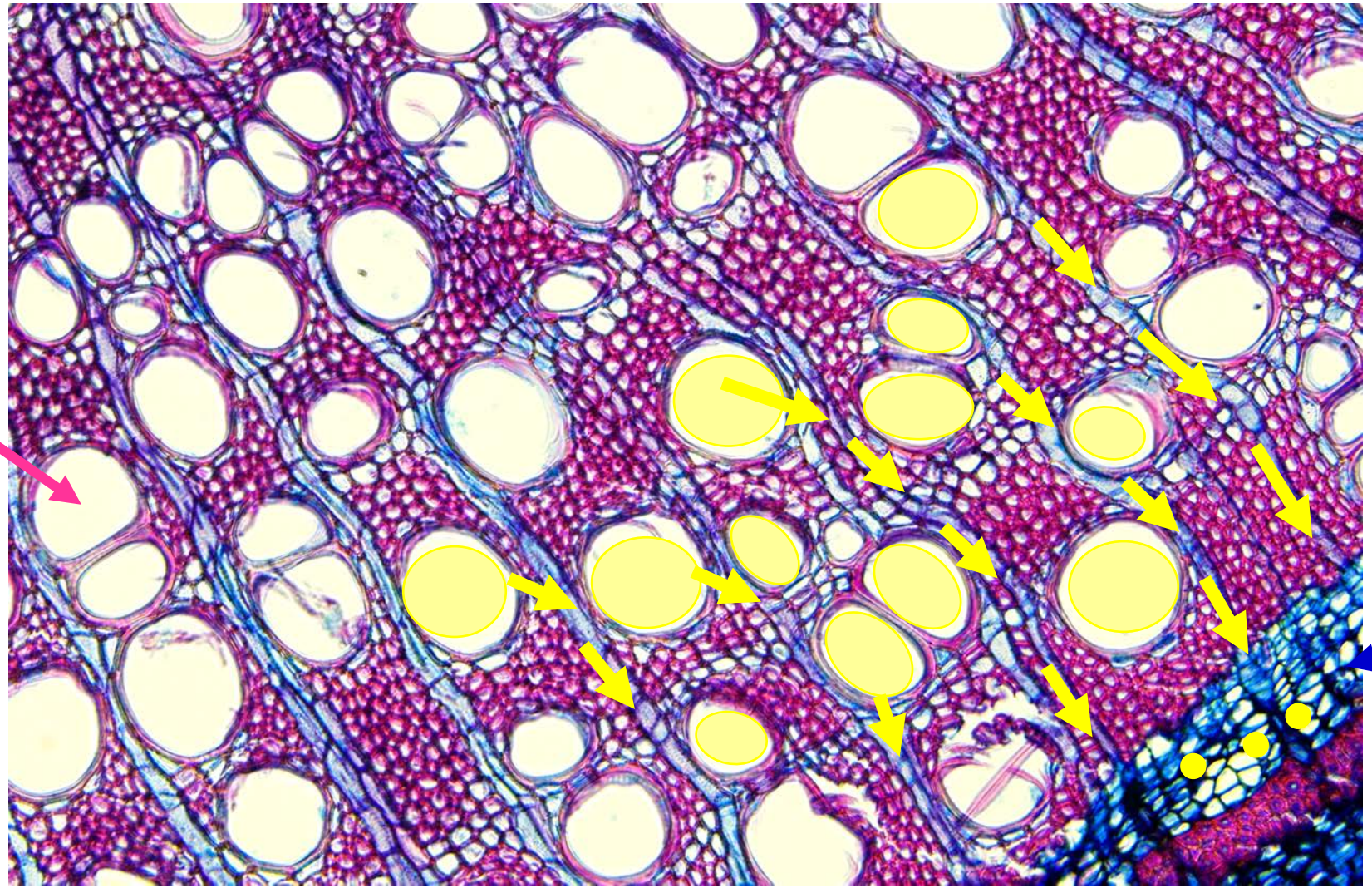
http://bio1520.biology.gatech.edu/nutrition-transport-and-homeostasis/plant-transport-processes-ii/

Tree anatomy





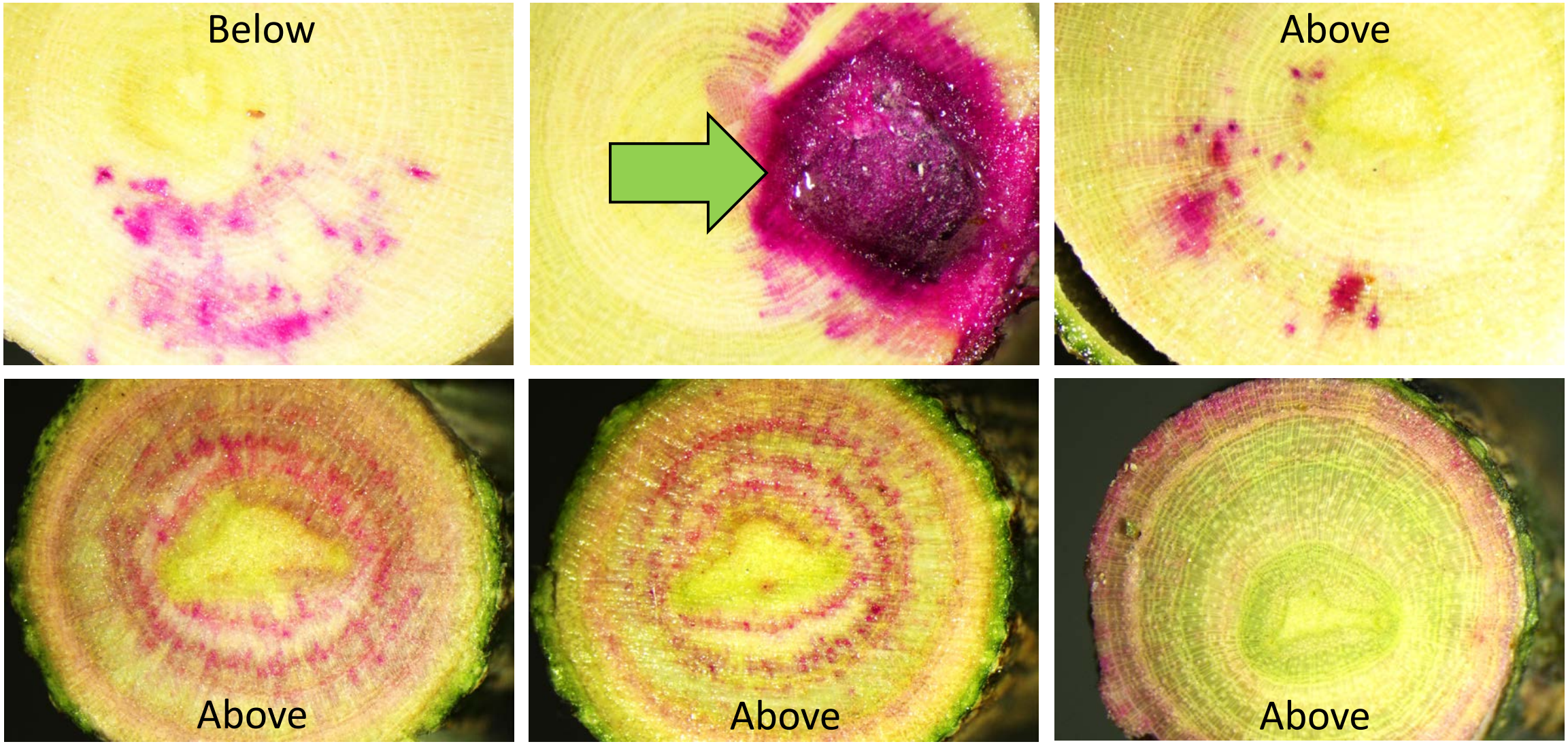
Xylem and phloem exchange



IV. Other considerations

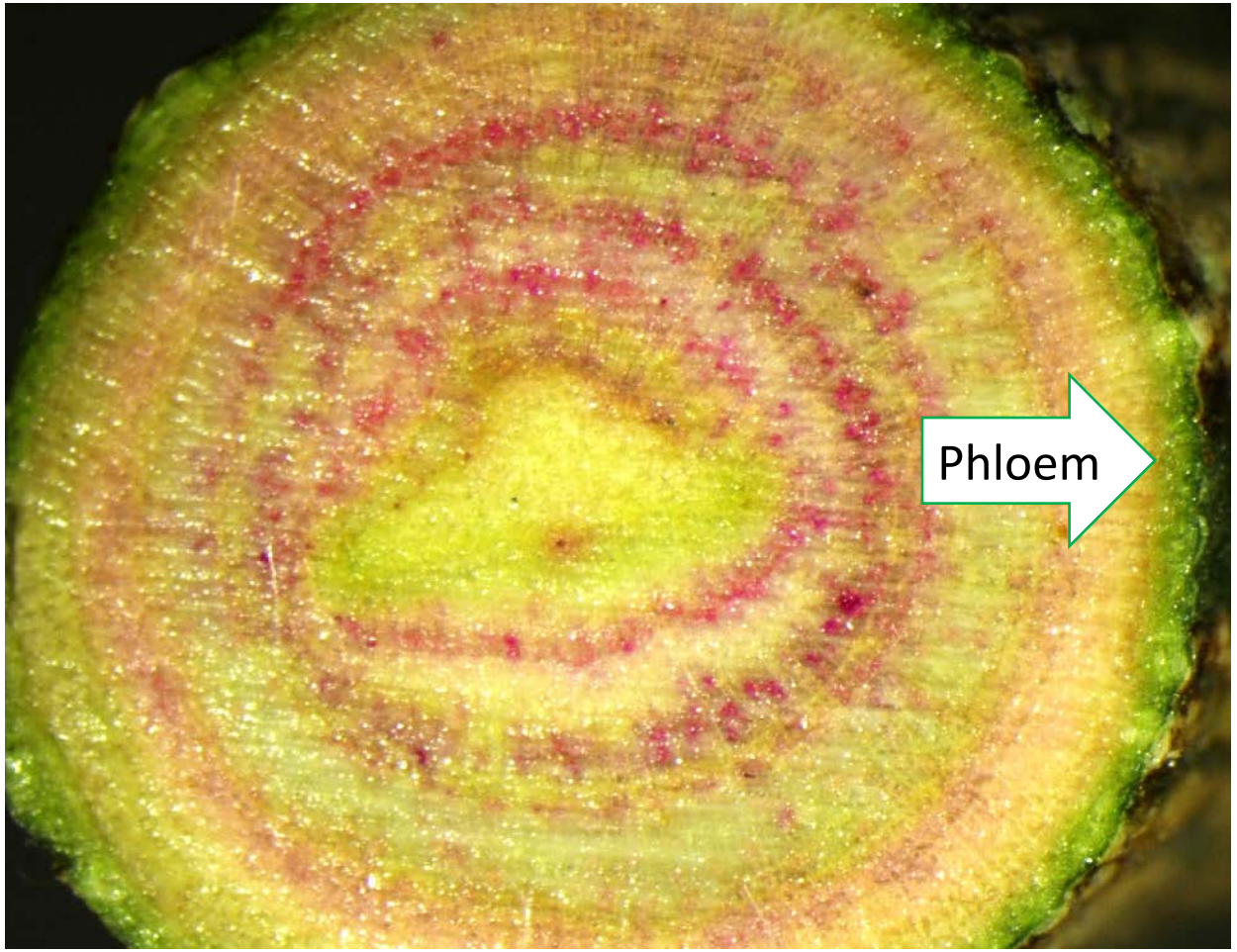
High pressure injection

Young greenhouse grown tree

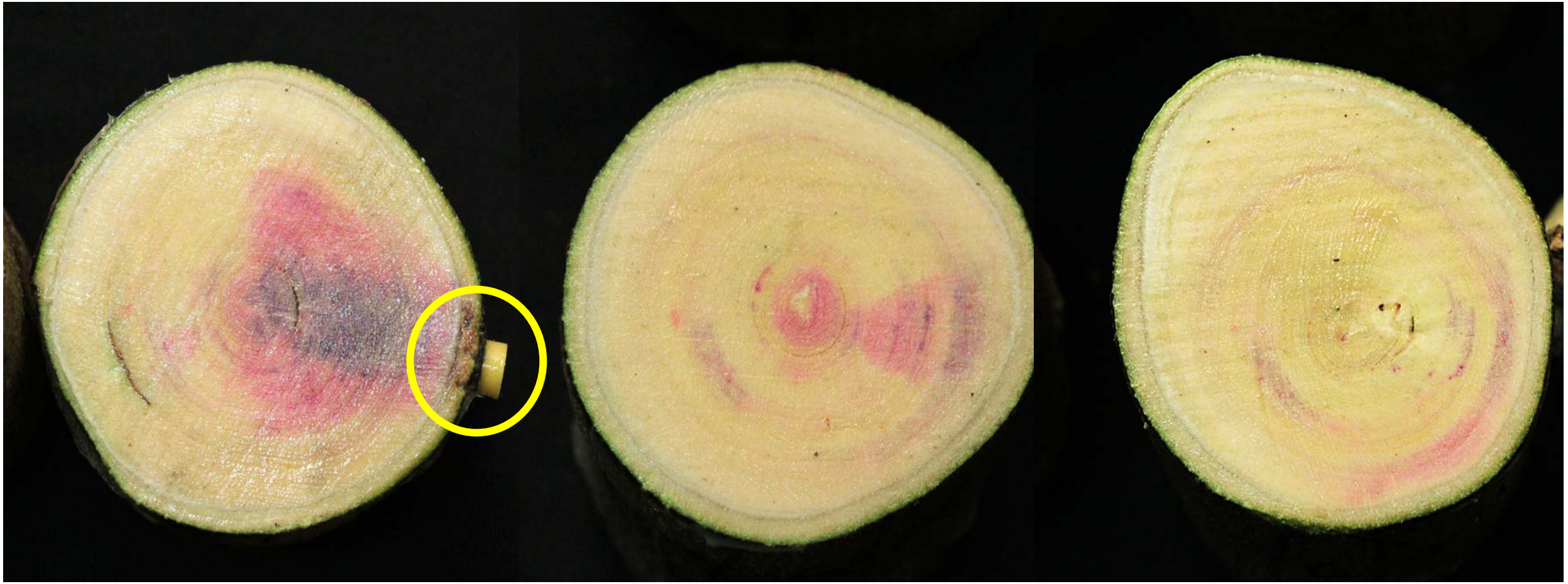


Natural uptake through roots

The phloem is located in the inner bark.



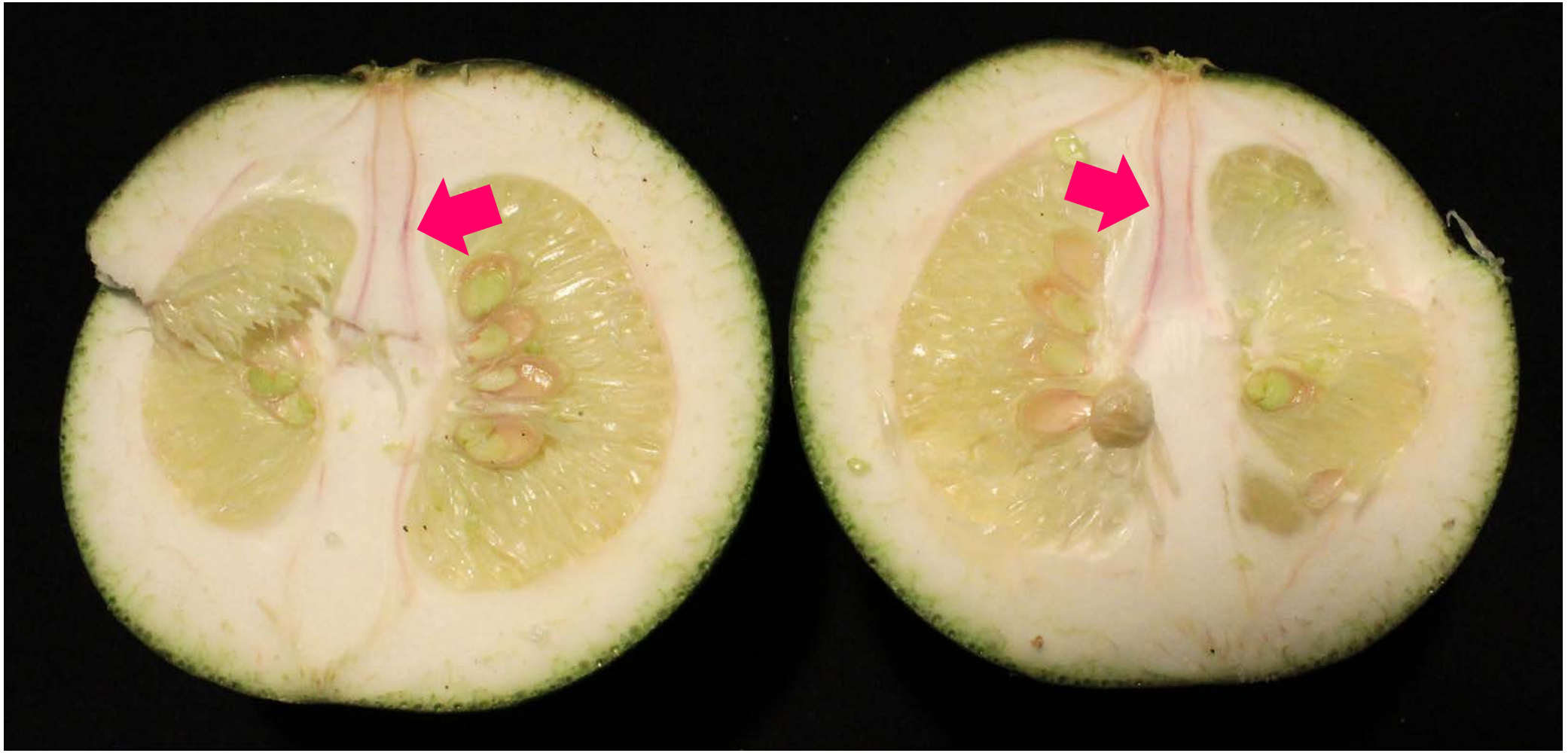
High pressure injection



Injection site

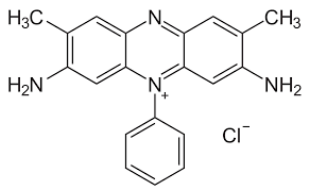
Above injection site

Residues in the fruit?

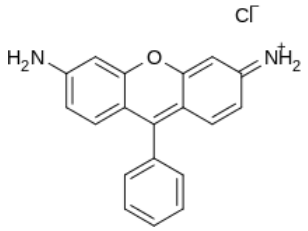


Mobility depends on the chemical properties

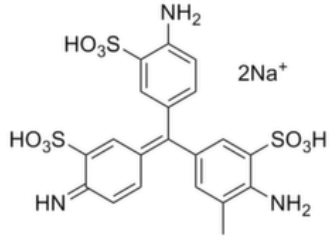
Safranin



Rhodamine



Acid Fuchsin



Trunk injury

Closed

Open

Mostly closed, but bark cracking

Open, bark cracking

Necrosis

No compounds injected

Trunk injury




Different compounds injected

V. Summary

- HLB is caused by a pathogen that resides in the phloem (not in the xylem)
- Trunk injections deliver materials into the xylem from which the materials need to be distributed through the tree and into the phloem
- Different chemicals will vary in their mobility through the xylem and translocation to the phloem

- Trunk injections will injure a tree
- Phytotoxicity may occur
- Secondary infections may occur at the injection site
- Xylem vessels may embolize
- Multiple injections may be needed to control *C*Las levels

Does the benefit gained by tree injection outweigh the risk of wounding caused by the treatment?

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