



The consequences of flooding and mitigation strategies to consider

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Avocado Café

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Avocado Café

- The recent heavy rainfall and flooding events in California and global climate change
- Significant impacts on avocado and citrus orchards
- Planted on heavy soils or those with impeded drainage



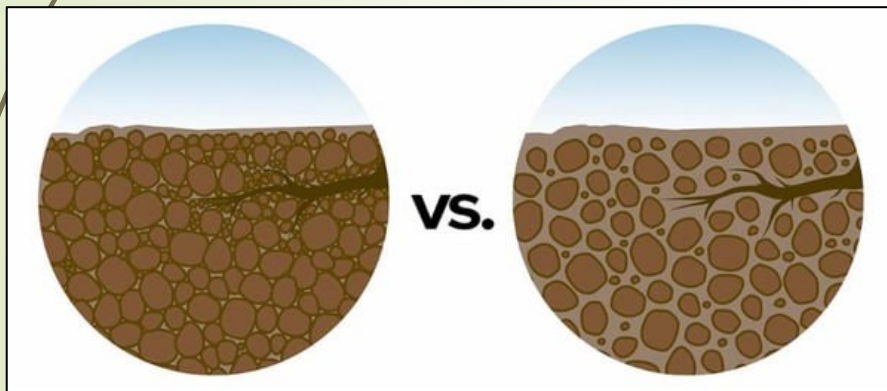
Photo: Trinity Fruit Sales

Cause of Flooding in Agriculture

Natural



Anthropogenic

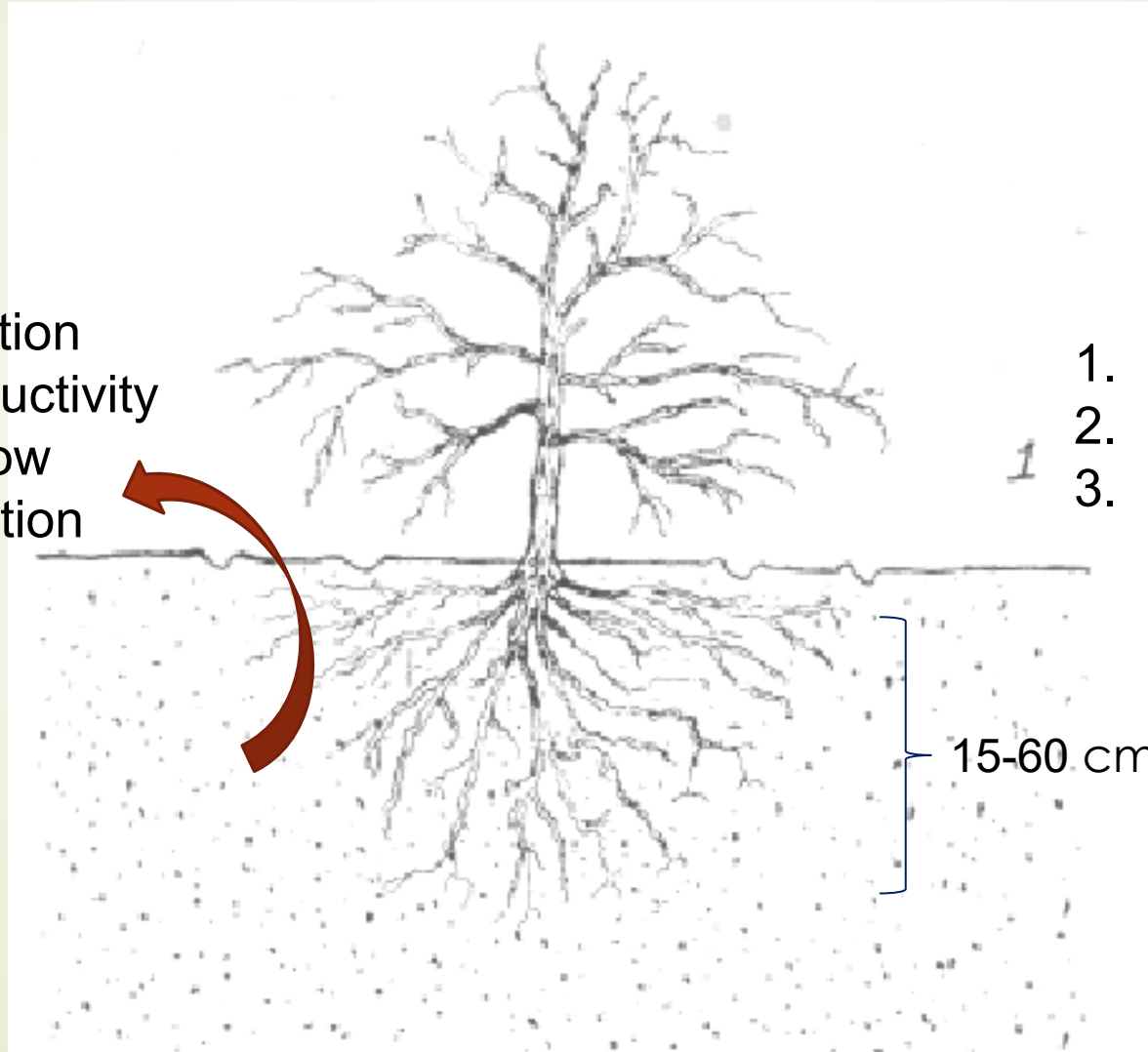


Soil compaction



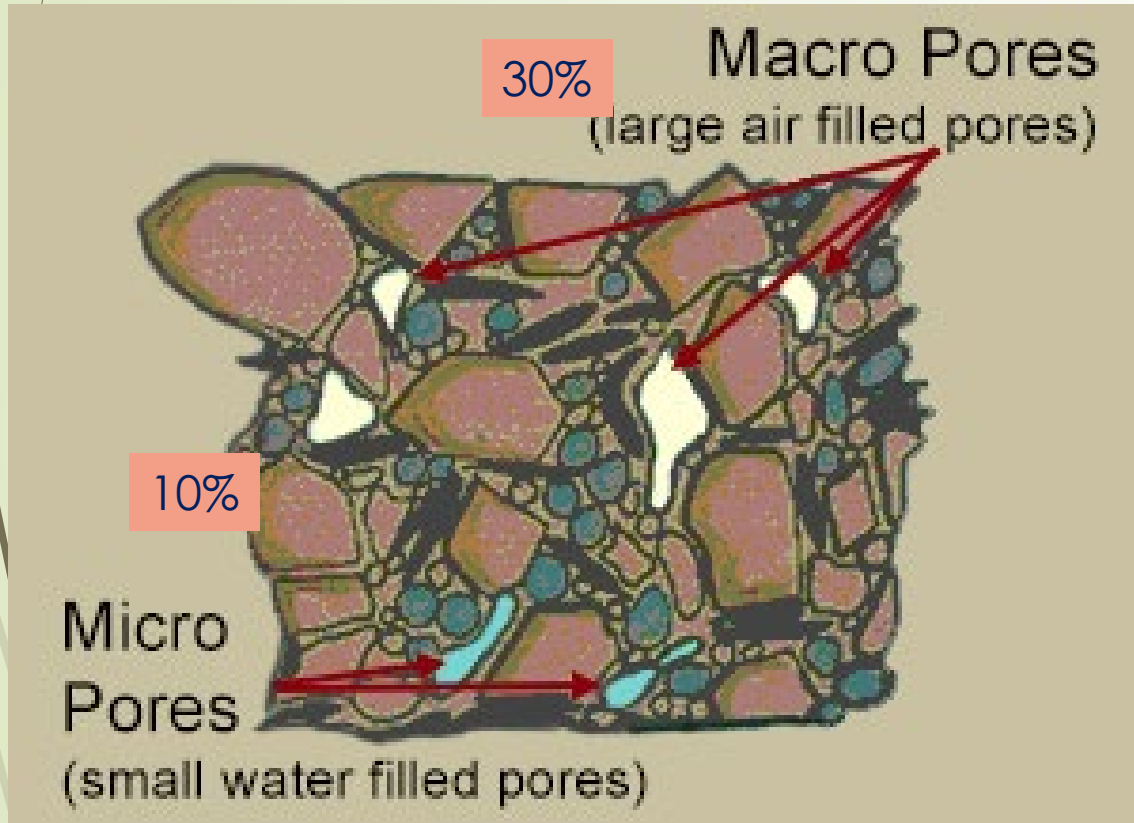
Avocado Susceptibility to Soil Flooding

- 4. High roots suberization
- 5. Low hydraulic conductivity
- 6. High sensitivity to low soil oxygen concentration



- 1. No spread beyond tree canopy
- 2. Few root hairs
- 3. Poor water uptake

What is Waterlogging?



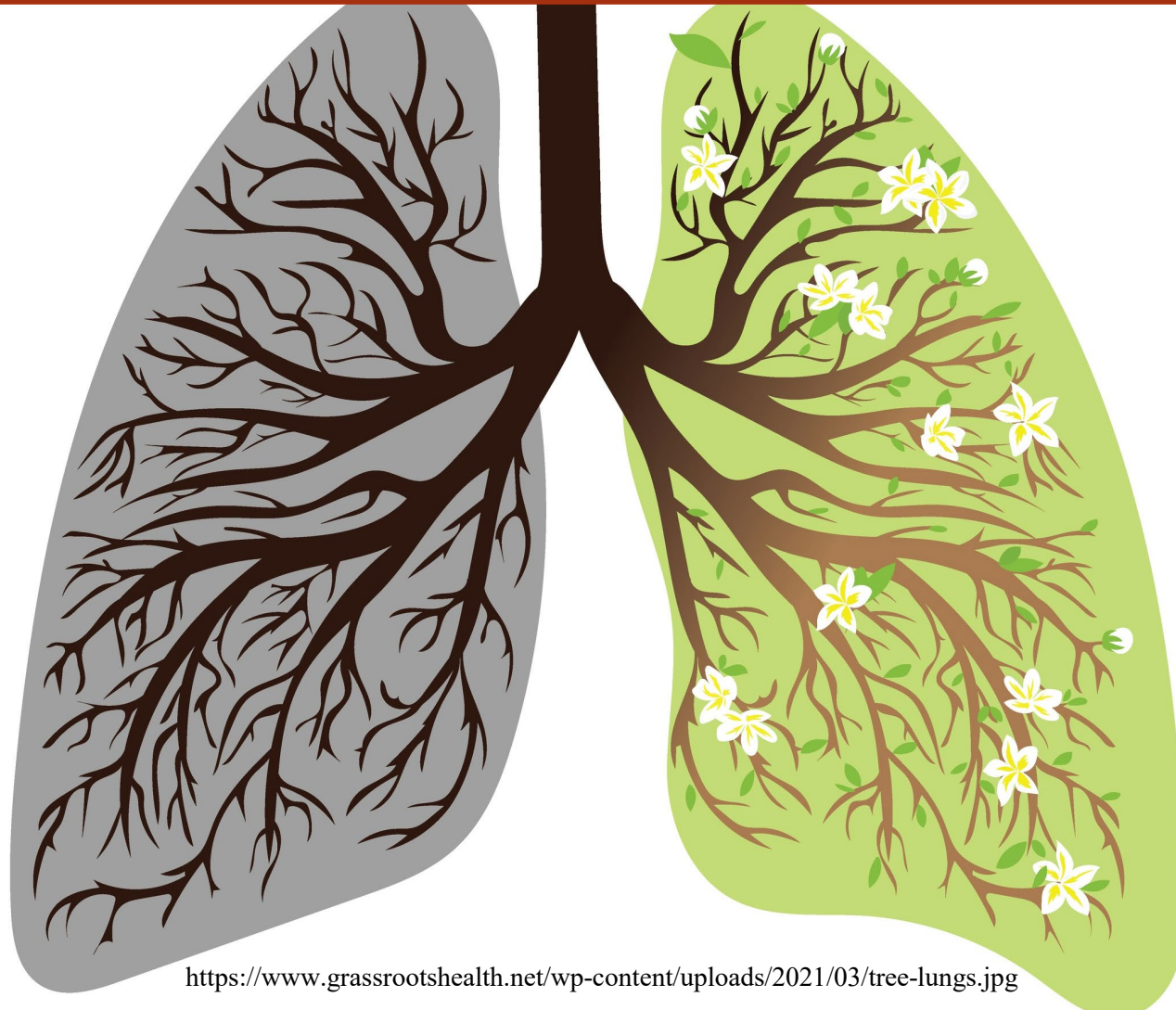
Water enters the soil at a faster rate than it can drain away.

- Heavy or prolonged rainfall
- Over-irrigation
- Flooding
- Permanent or temporary high water table

Duration and severity of the waterlogging event depends on:

- Amount of water entering the system
- Topography of the site
- Soil structure

Hypoxia

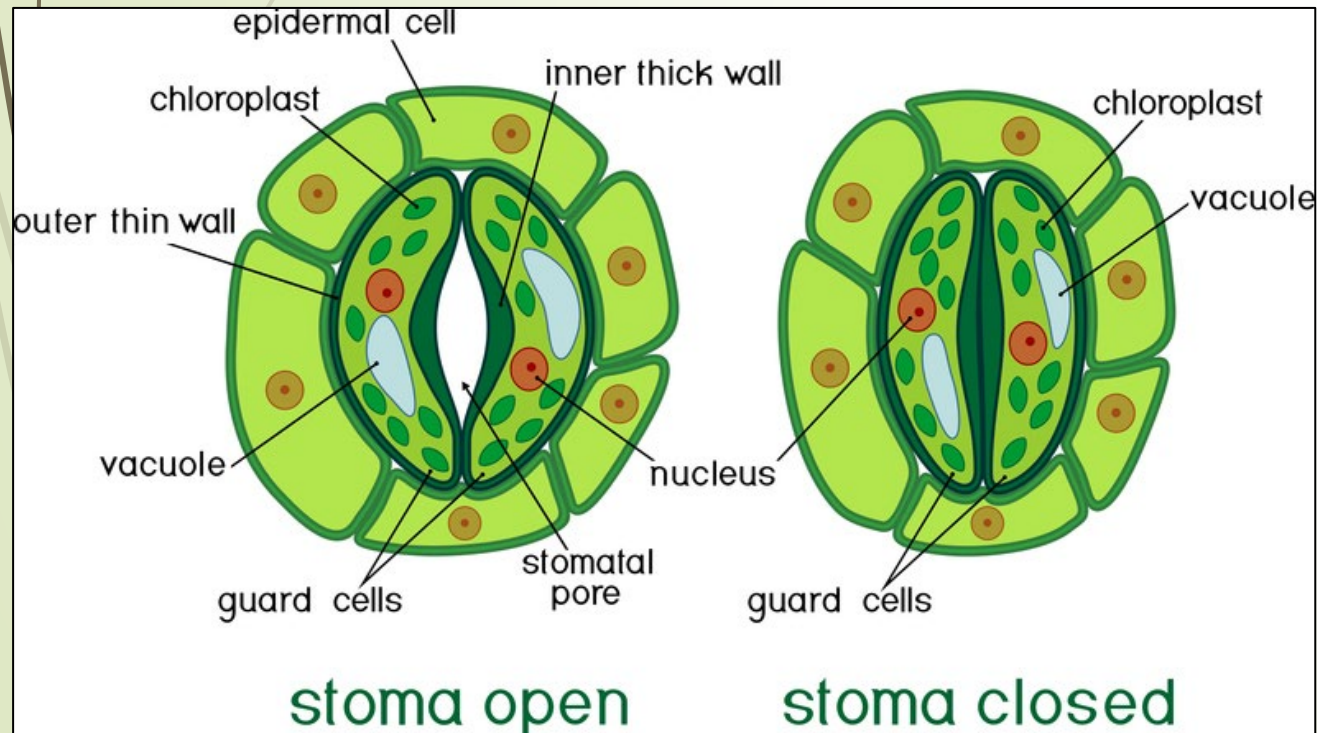


- Hypoxia refers to the reduction of oxygen below optimal levels for the normal functioning of the plant, organ, or cell
- Occurs at soil concentrations less than $2 \text{ mg O}_2 \text{ L}^{-1} \text{ H}_2\text{O}$
- Low oxygen occurs in poorly drained soils
- Short-term flooding

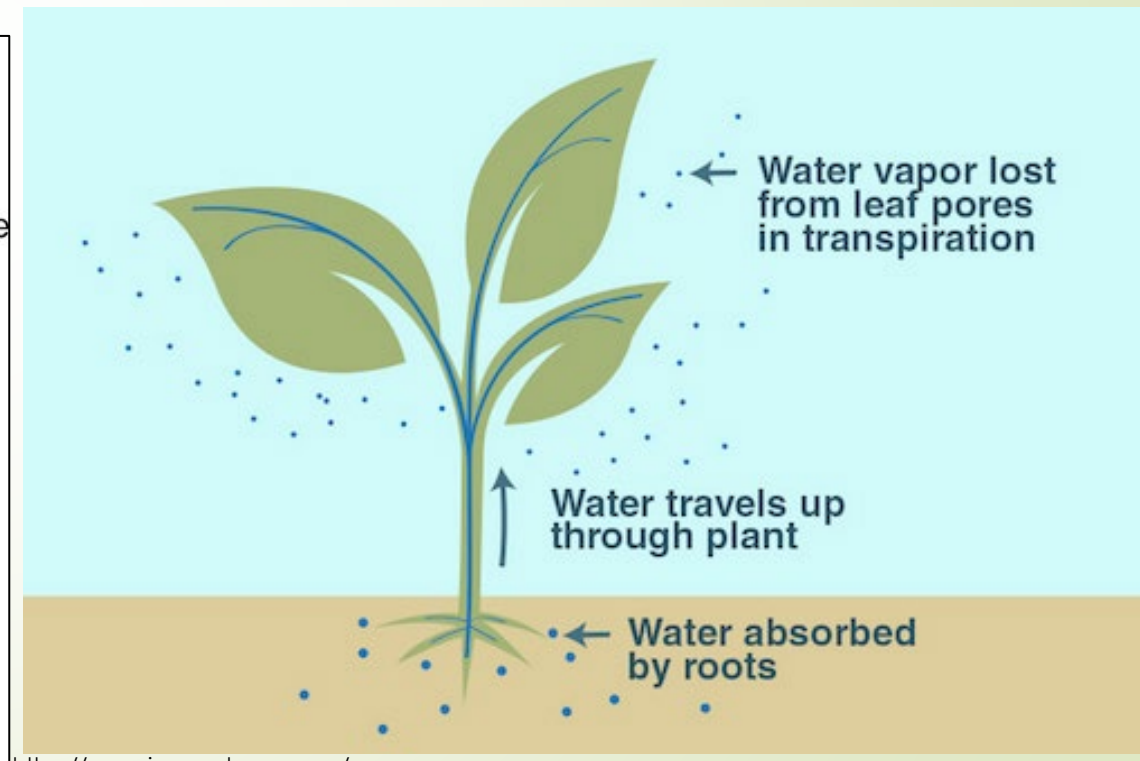
Physiological Responses

- Stomatal conductance (g_s) is the diffusion of gas, such as carbon dioxide, water vapor, and oxygen, through the stomata of a plant.
- Stomatal conductance occurs specifically through the stomata when they are open; The reverse is known as stomatal resistance.

Stomatal Conductance



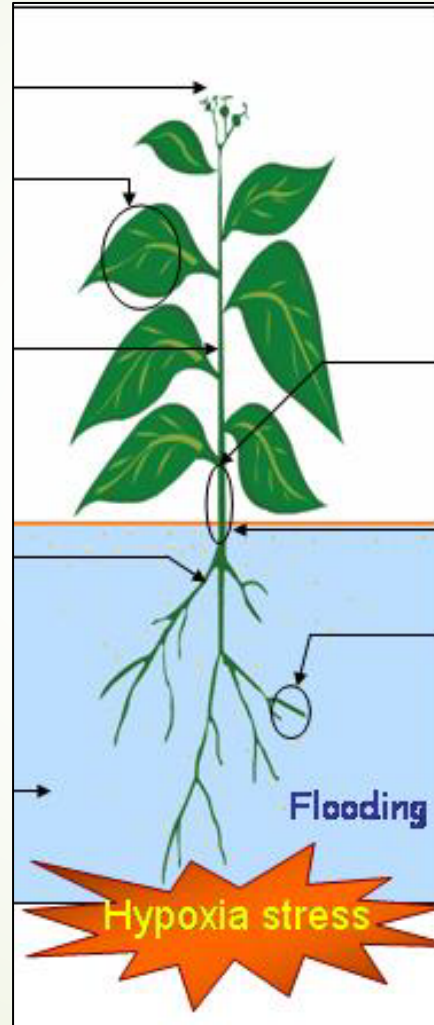
Reduction in Transpiration



Avocado Response to Waterlogging

Fruit production
Leaf abscission
Leaf size reduction
Reductions in net photosynthesis

Root necrosis

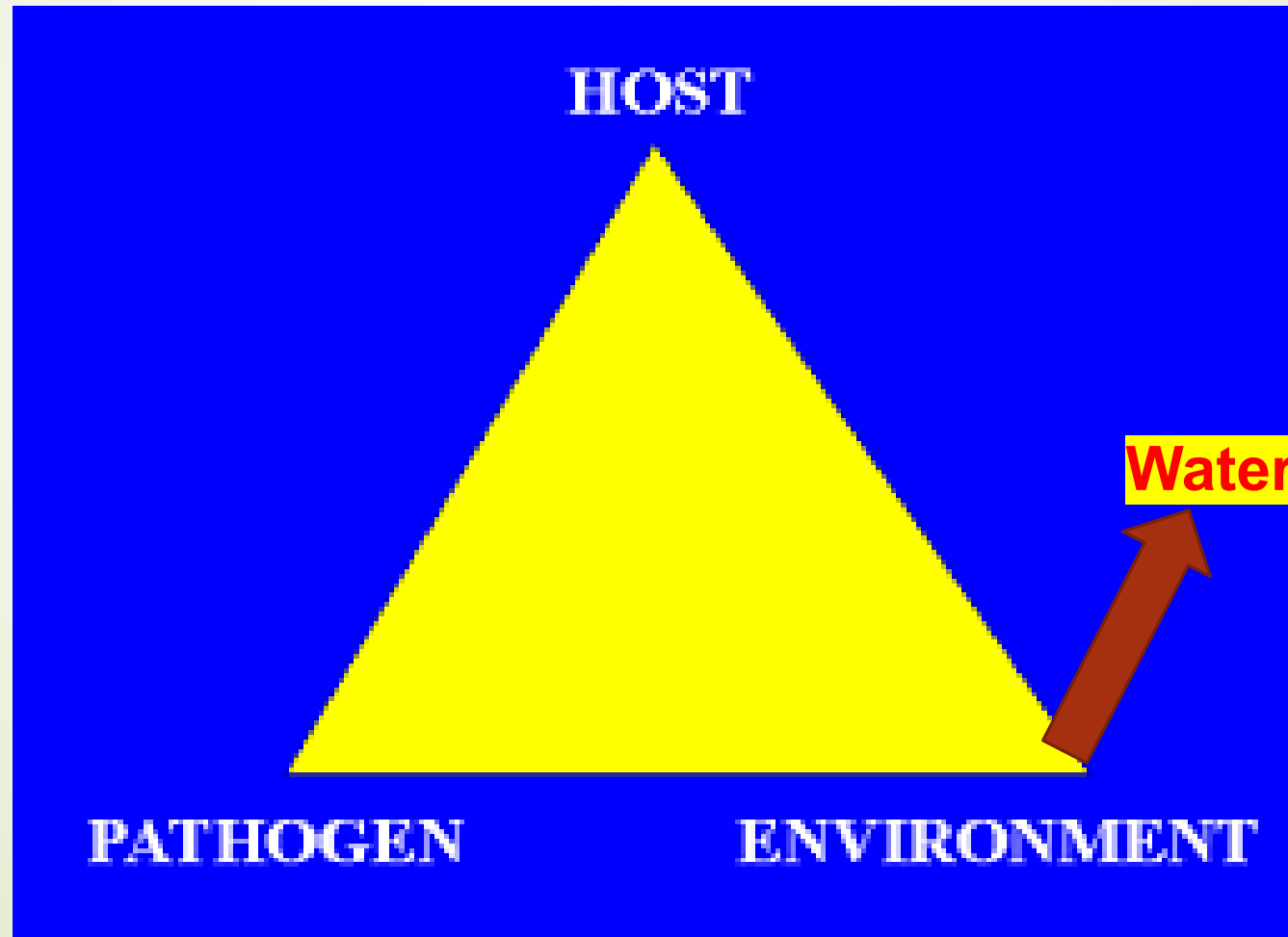


Inhibition of shoot growth

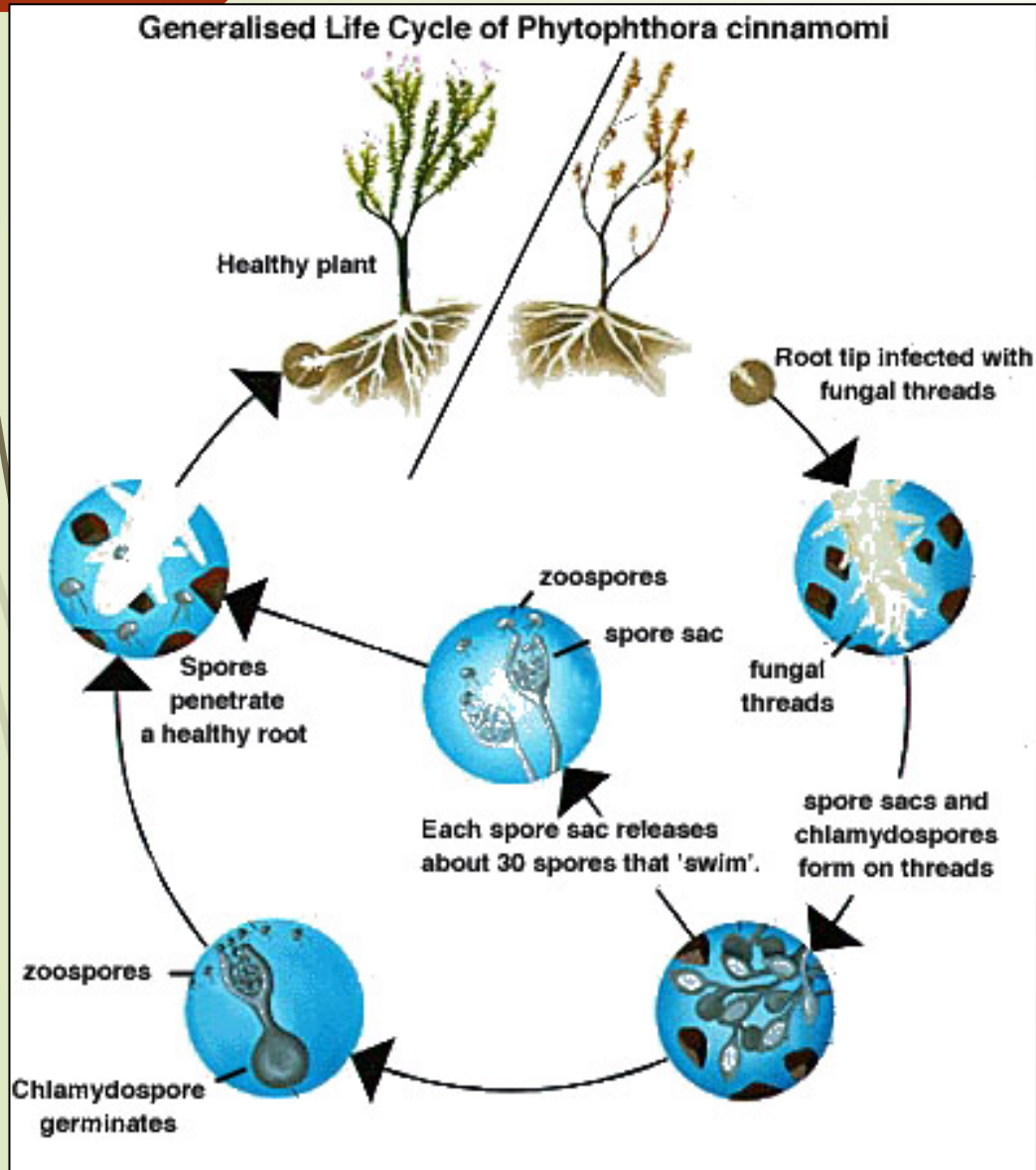
Inhibition of root growth

Waterlogging Associated Diseases

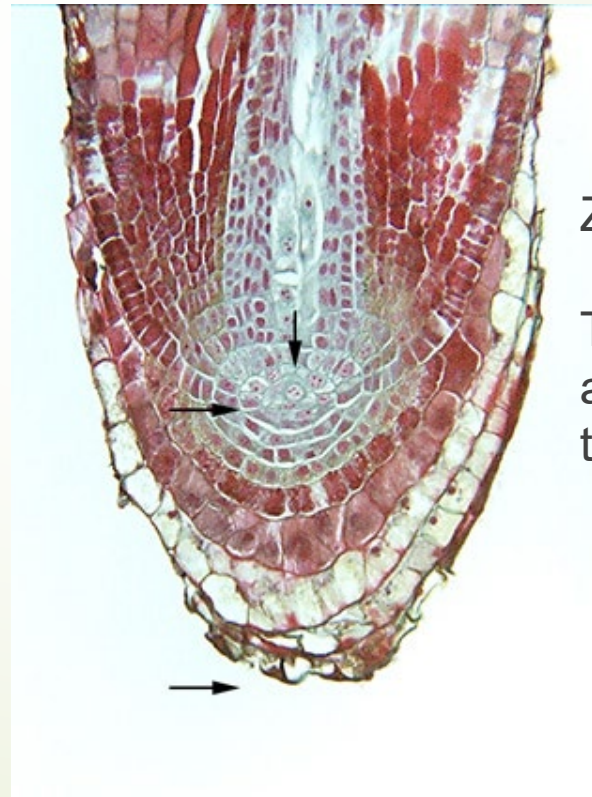
- ▶ This reduction of root volume caused by flooding can be exacerbated if *Phytophthora cinnamomi* (the cause of Phytophthora root rot; the major disease of avocado worldwide) is present in the soil.



Phytophthora Life Cycle



- Sporangia are formed as the soil dries
- Zoospores are released from the sporangia when the soil becomes saturated



Zoospores swim to the root tips:

They are attracted to carbohydrates and amino acids leaking from the thin walls

PRR Damage Under Flood Conditions

- Increase in zoospore motility, which leads to an enhanced ability of the oomycete to infect roots
- Increase in the susceptibility of the plant to infection under conditions of low oxygen caused by flooding
- Changes in soil chemistry
- Enhanced pathogen activity
- Combination of these factors

Duke 7 and Dusa

- ▶ Flooding had an immediate impact on root health, greater than that observed when plants were only infected with *P. cinnamomic*
- ▶ Combination of flooding and *P. cinnamomi* had the most devastating impact and caused extensive root necrosis and wilting.
- ▶ Visible symptoms of stress were generally more severe in 'Duke 7' plants
- ▶ Symptoms first observed in 'Duke 7' plants 10 days after flooding
- ▶ For 'Dusa™' 16 days after flooding

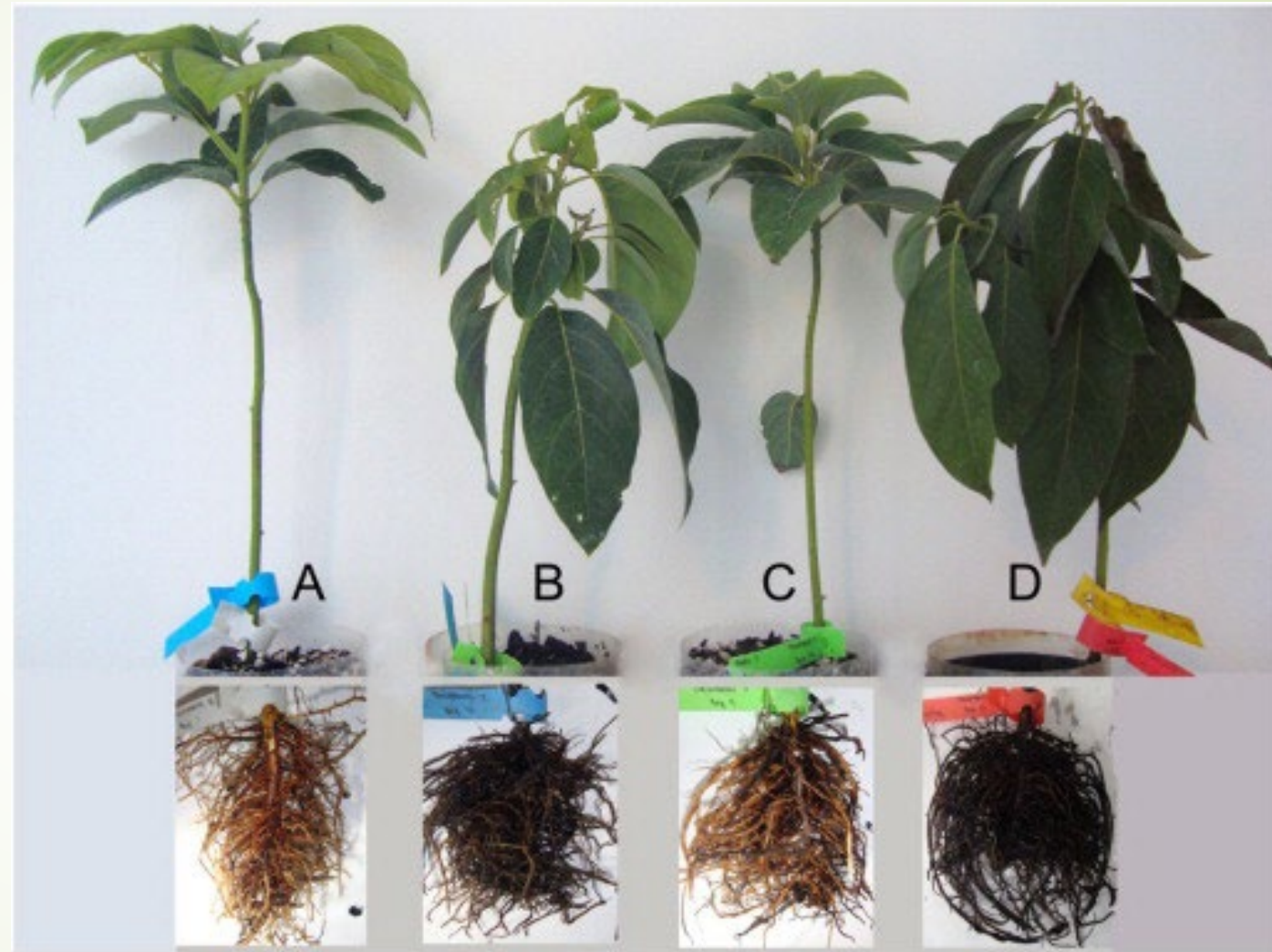
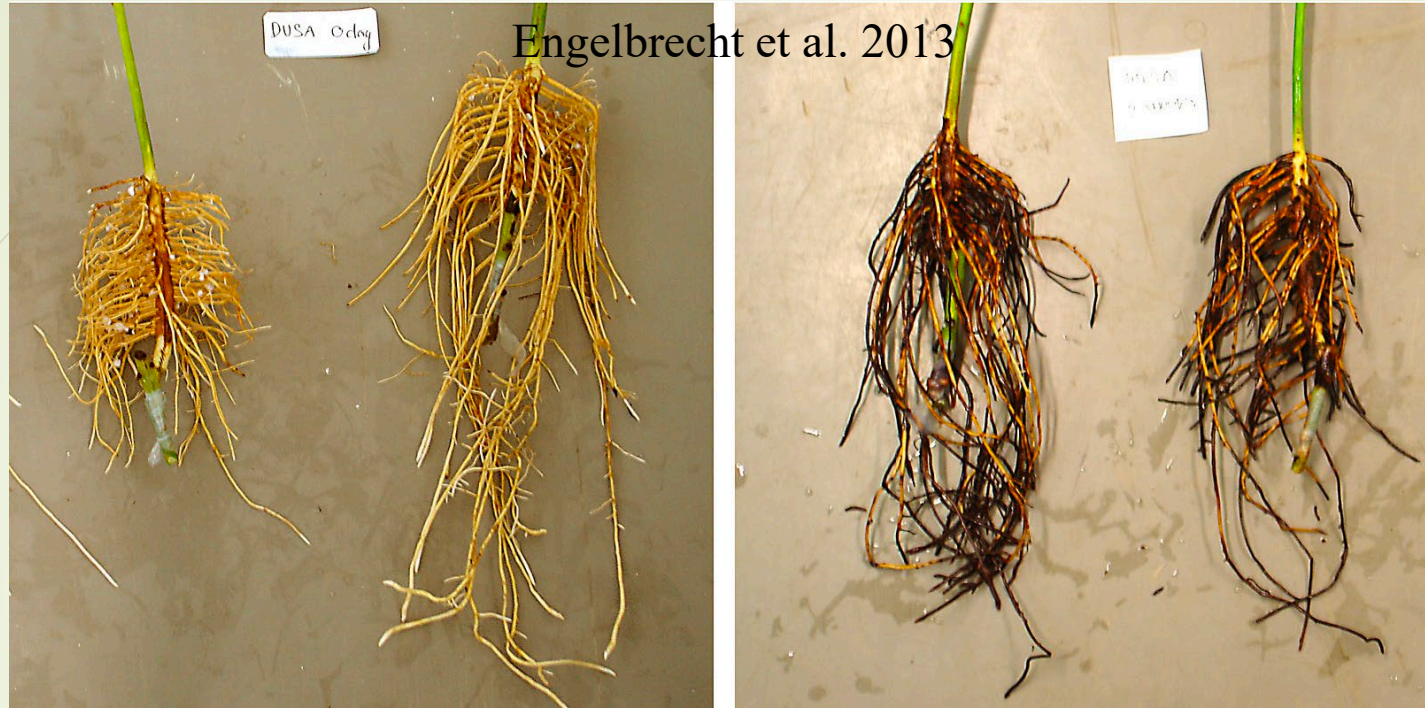

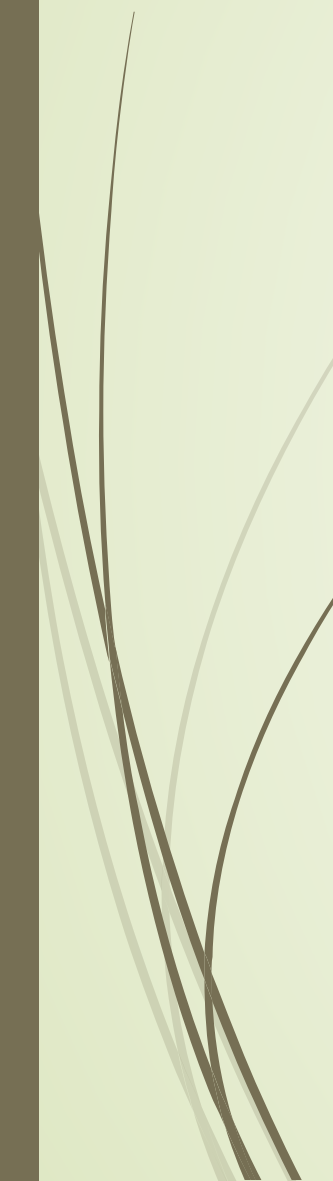


Fig. 1. Effects of *Phytophthora cinnamomi* and flooding on 'Duke 7' avocado plants. Healthy control plants (A), flooded plants (B), infected plants (C), and flooded and infected plants (D).



- Initial decline in P_N , g_s , and E in Dusa
- Recovery of g_s and P_N to control levels in infected 'Dusa™' plants recovery from stress and infection.
- Regeneration of feeder roots in these plants
- P_N , g_s and E were significantly reduced in infected 'Duke 7' suggesting lower relative PRR tolerance in 'Duke 7' plants.

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- Avocado trees that are flooded in the presence of *P. cinnamomi* have succumb much more rapidly than trees that are flooded in the absence of *P. cinnamomi*, with significant reductions in CO₂ assimilation (P_N), stomatal conductance (g_s), and transpiration (E).
 - Dependent on both the physical and chemical properties of the soil, as in fine textured soils, which are poorly drained and have a greater proportion of micropores.

PRR Symptoms

- The absence of small feeder roots in the advanced stages of decline
- If present: black and brittle and die



(Edward L. Barnard, Florida Department of Agriculture and Consumer Services, Bugwood.org) CC BY-SA 3.0

PRR symptoms

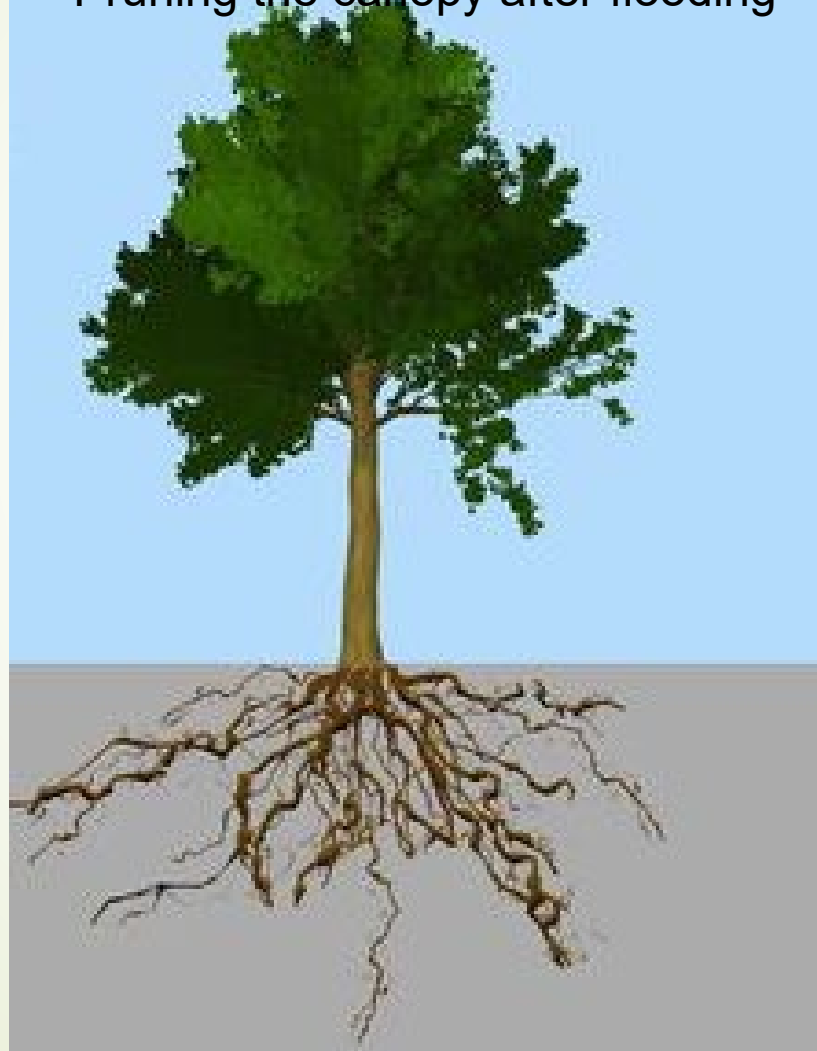
- Canopy decline: chlorotic leaves and wilted with necrotic tips
- Bare twigs and small branches, dieback
- Gradual decline of older trees or a quick death of those that are younger



Canopy Pruning

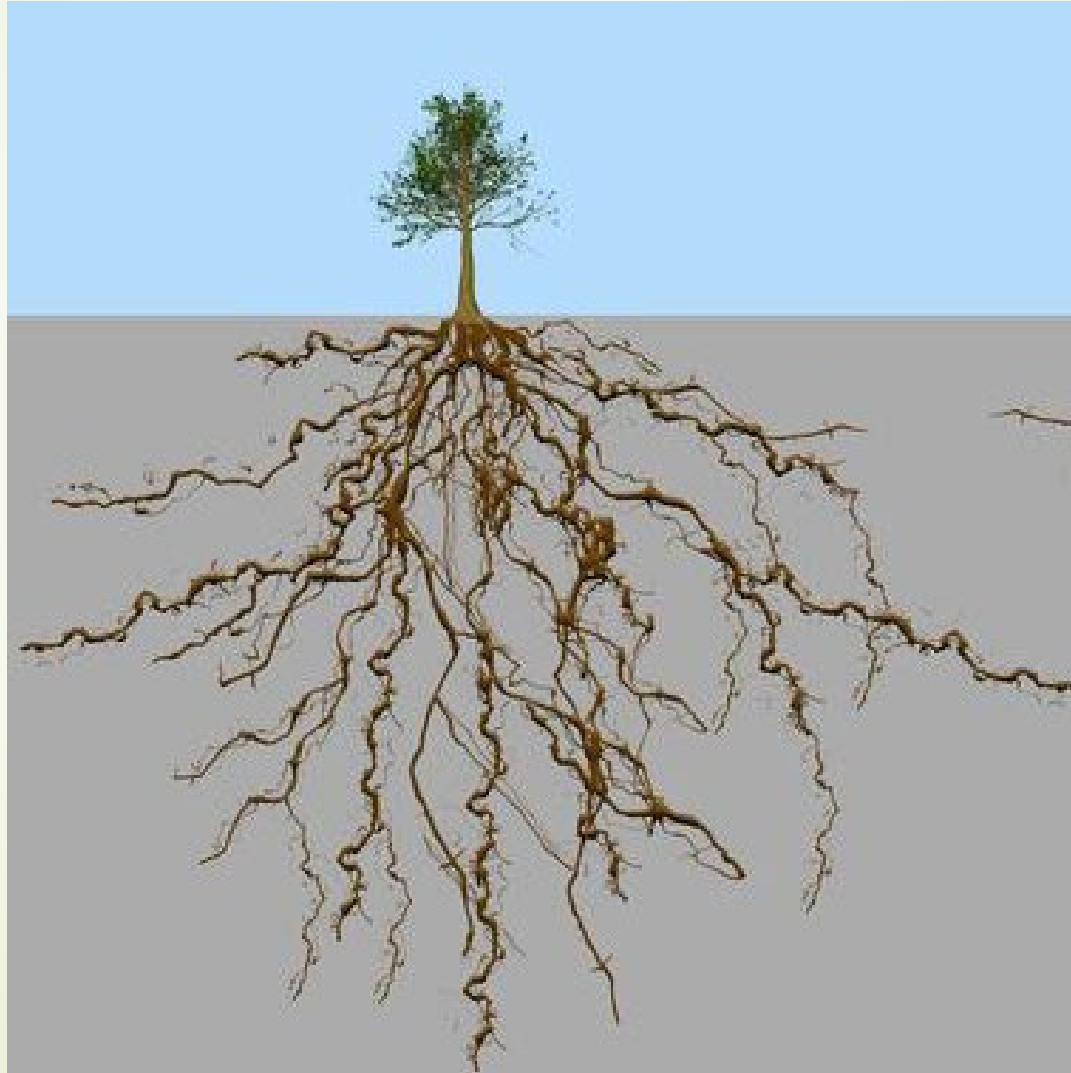
Balance between shoot to root ratio

Pruning the canopy after flooding



- ✓ Shoot to root ratio balance
- ✓ Lower tree weight
- ✓ Lower transpiration
- ✓ Lower water and food demand

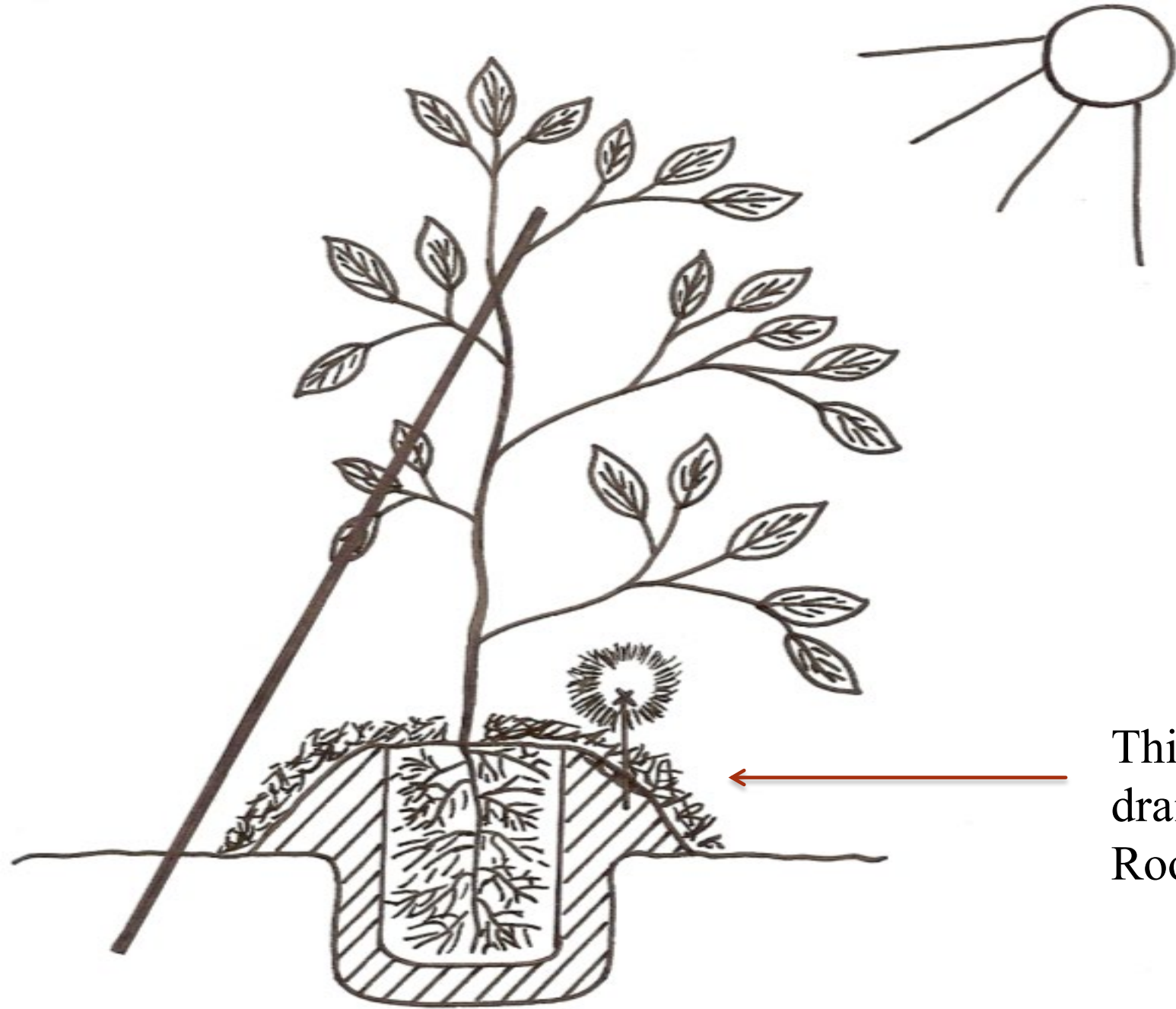
Pruning the canopy before flooding



Good Drainage/No Over-watering

- ▶ Saturated soils increase the zoospore infection and weaken the defenses of the roots
- ▶ Clay soils are worse than sandy soils





Mounding

This mound is essential to help water drainage and avoid root asphyxia – Root Rot

Management and Control of Root Rot




- Sanitation
- Clean Nursery Stock
- Planting in Mounds
- Irrigation Management
- Mulches
- Gypsum
- Chemicals
- Rootstocks



- Diseased nursery stock is the number one factor responsible for the disease spread
- Clean seed
- Clean water
- Disinfested soil
- Sanitation



Sanitation Comes First

- ▶ Fungus can spread on everything! (contaminated nursery stock, water in contact with infested soil including reservoirs).
 - ▶ Fungus can spread on anything that moves soil, including horse hooves, ladders, boxes and bins, shoes and cultivation equipment).
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Methods of Moving *Phytophthora*

- Infected nursery trees (Beware of 'good deals' or 'close-out' prices)

Boots



Apply Gypsum and Mulch

- ✓ Improve water conservation
- ✓ Increase soil organic matter allowing for deeper root growth
- ✓ Maintaining a constant soil temperature
- ✓ Adding to the nutrient content of the soil
- ✓ Suppression of soil borne diseases by increasing microbe activity
- ✓ Promotes both increased biological activity and physical properties

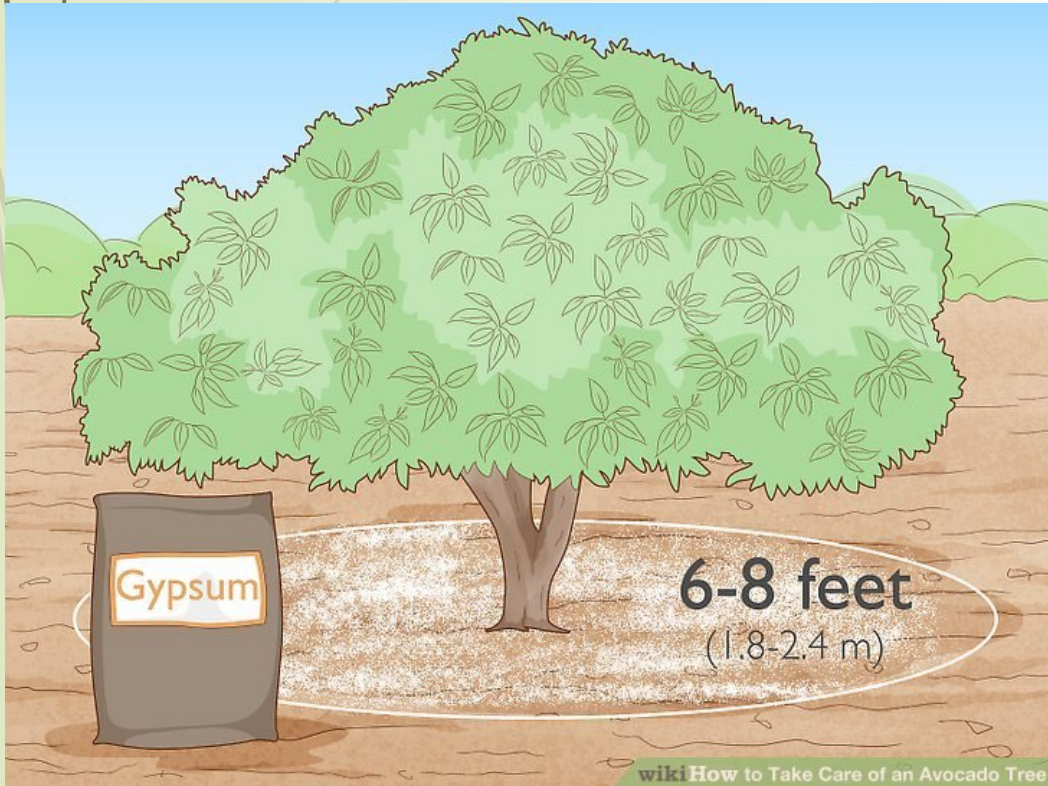
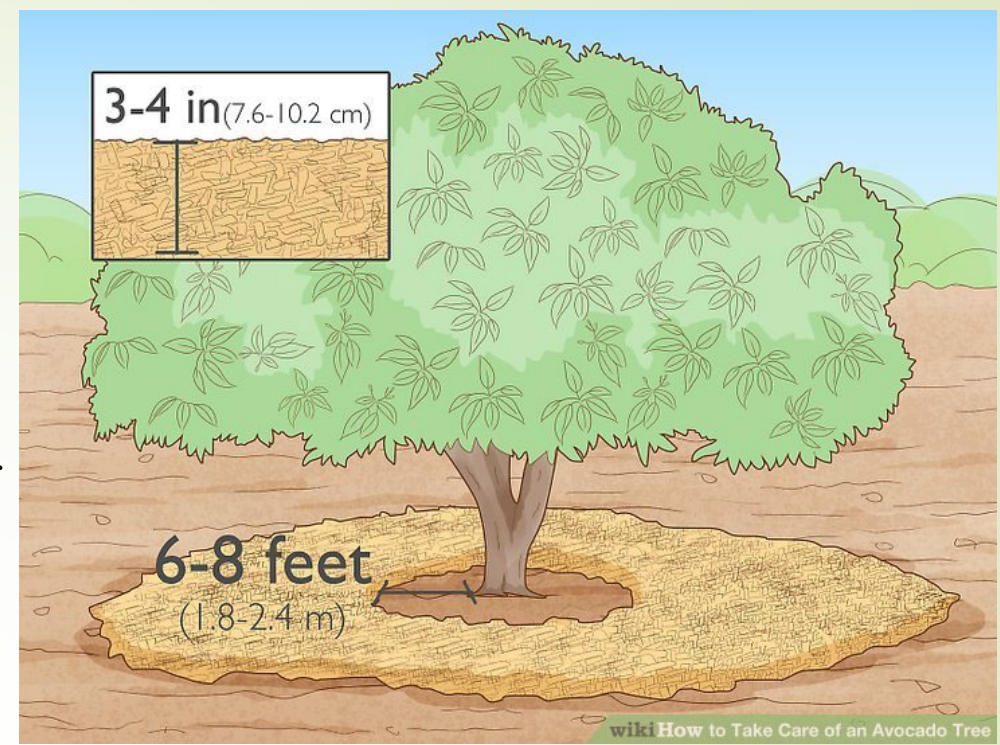


Fungal cellulase production is antagonistic to *Phytophthora*

- 4 to 6 inches of coarse wood chip mulch

- Keep mulch several inches away from the trunk (6–8 inches (15–20 cm))

- Additional layer of protection for roots from too much heat or cold



- Apply 25 lb gypsum under the canopy of each medium-sized tree

- Calcium suppresses the formation of *Phytophthora* spores

- Makes soil more porous and helps water, air and nutrient to penetrate the soil

Chemical Control

- Registered in California as a fertilizer
- Often confused with phosphoric acid, also registered as a fertilizer with no activity as an anti-fungal chemical
- Stimulates a defense response in the tree, e.g., tree produces it's own anti-fungal chemicals in response to the injection of phos acid
- Possibly stimulates the salicylic acid pathway
- All brands on the market work equally well

- ✓ Application through the irrigation system
- ✓ Sprayed onto bark or foliage
- ✓ Injected into soil with irrigation water (chemigation)
- ✓ Injected into trunk vascular tissue.

Buffered material is preferred, (0-28-25)

Acid form is 0-60-0, severe damage to bark



Have we got the perfect rootstock yet? No!

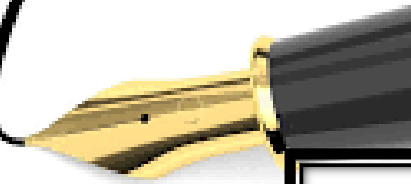
- ▶ So, do your best to keep root rot out of your grove!
- ▶ Make sure you have good drainage system!



Thank
you

Subtropical Plant Pathology Blog:

<https://subtropicalplantpathology.com/category/blog-posts/>



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