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Higher Education Modernization to boost Uzbekistan Agricultural system and promote excellence and regional development

ERASMUS+ GA number 101179517

THE ROOT SYSTEM

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Roots are the first interface between soil and plants

fundamental role for the interaction between plants and their ecosystem

FUNCTION

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- **Anchorage to the ground**
- **Uptake**: water and nutrients
- **Rhizosphere conditioning**: organic compounds production (organic acids, carbohydrates, fitosiderophores, H^+)
- **Transport**: water, nutrients, hormones, organic substances
- **Metabolism of assimilates and bioregulators**: aminoacidic synthesis, starch, hormones
- **Storage**: mineral nutrients, starch and metabolites for spring growth

ROOT ANATOMY

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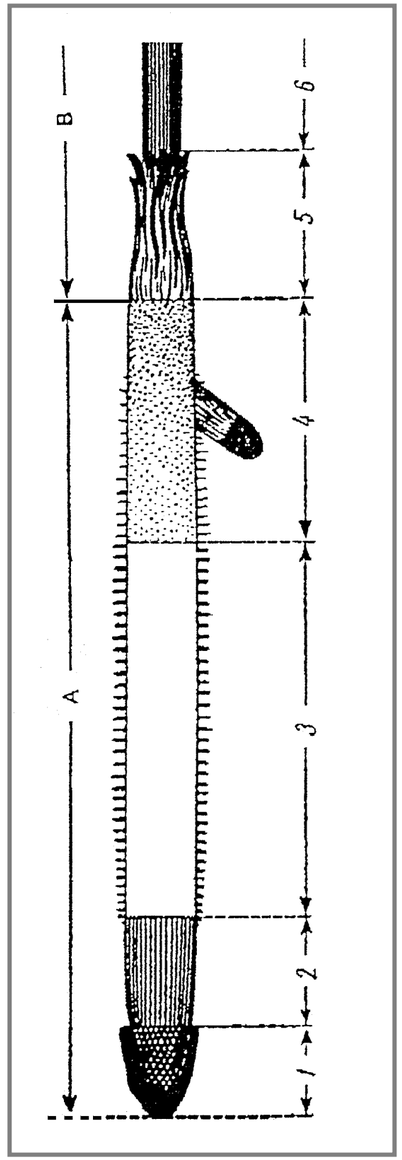
Secondary Roots:

5. Area of differentiation and maturation

6. Solute transport

Primary Root:

1. Root cap
2. Region of cell division
3. Root hairs
4. Region of elongation



Baldini, 1986

PRIMARY ROOT

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- ✓ primary growth
- ✓ white, easily breakable, thicker than secondary roots
- ✓ no reserve tissue
- ✓ main function is absorbing nutrients

APICAL REGION OF THE ROOT

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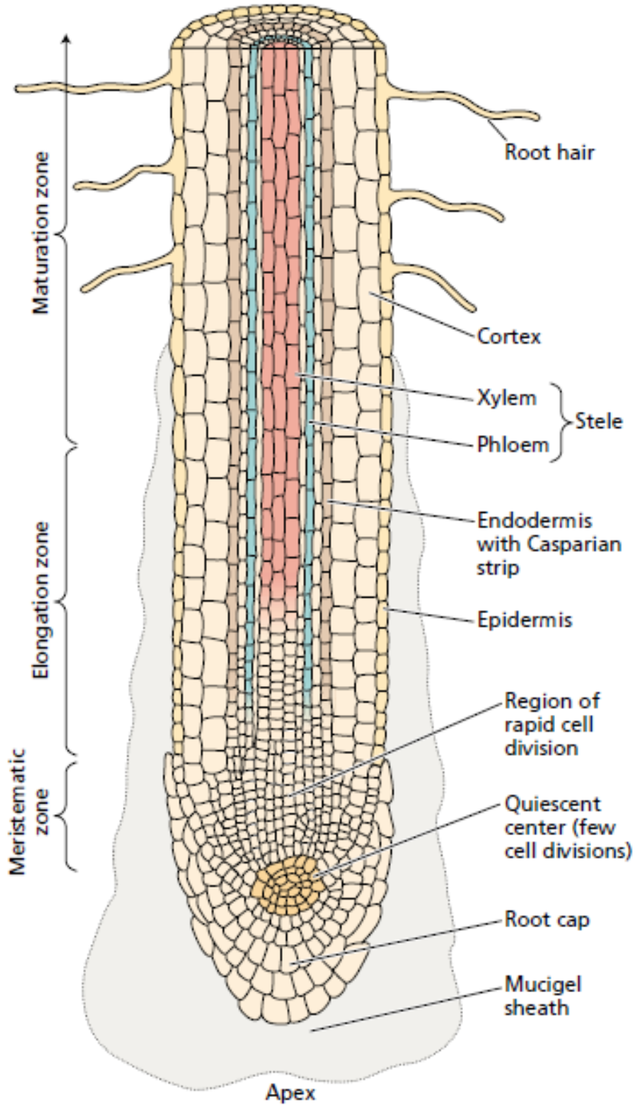
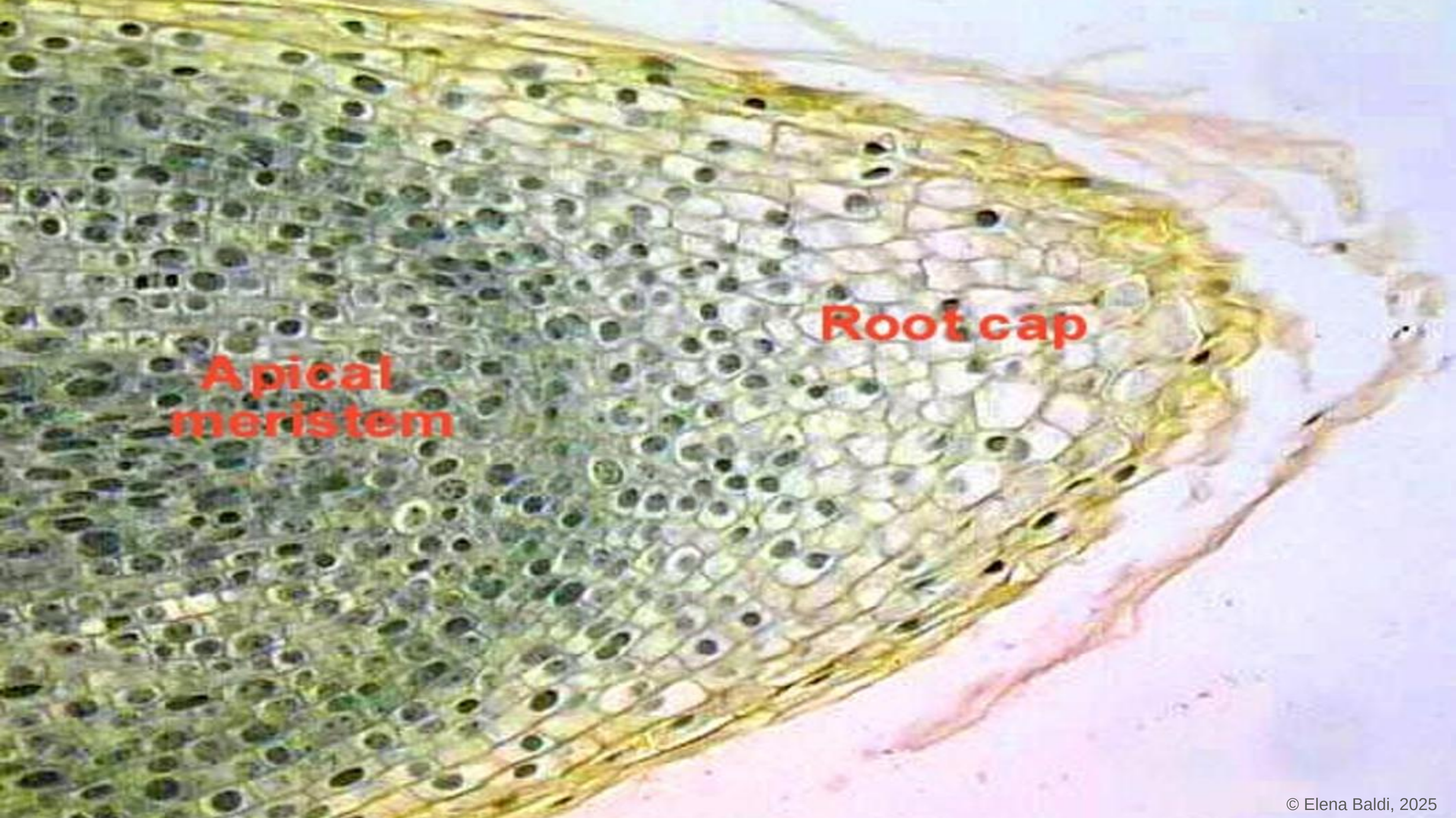
- ✓ The meristematic cell are located near the tip of the root
- ✓ In the elongation zone cell differentiate to produce xylem, phloem and cortex
- ✓ Root hairs appear in the maturation zone





ROOT HAIRS

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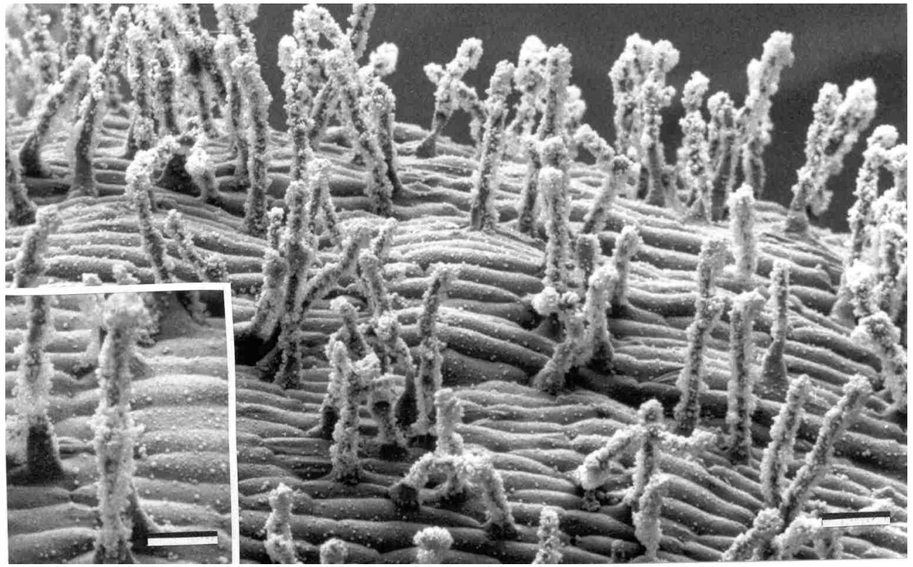
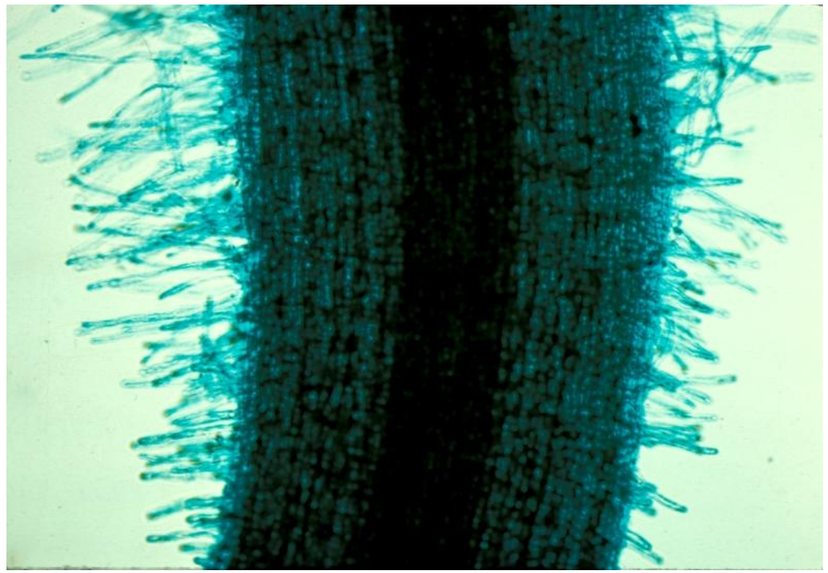
- ✓ Tiny one celled hair-like extensions of the epidermal cells located near the tips of roots
- ✓ Increase surface area
- ✓ Absorb water and minerals
- ✓ Secrete acid (H^+)
- ✓ Length and density vary in different species





Root hair morphology changes in relation to species

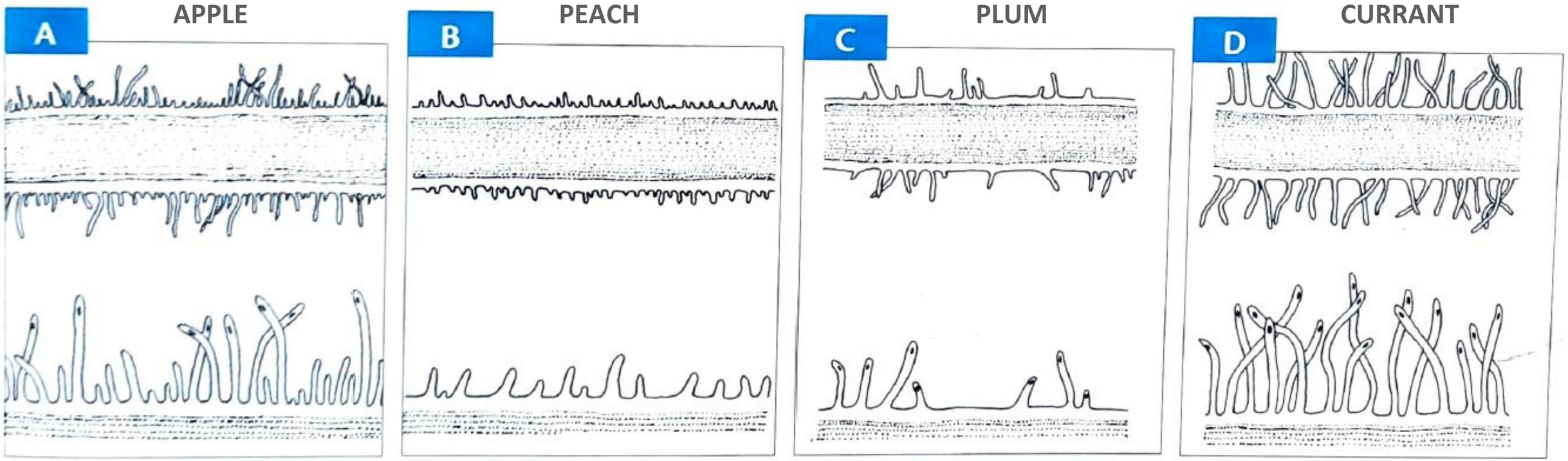
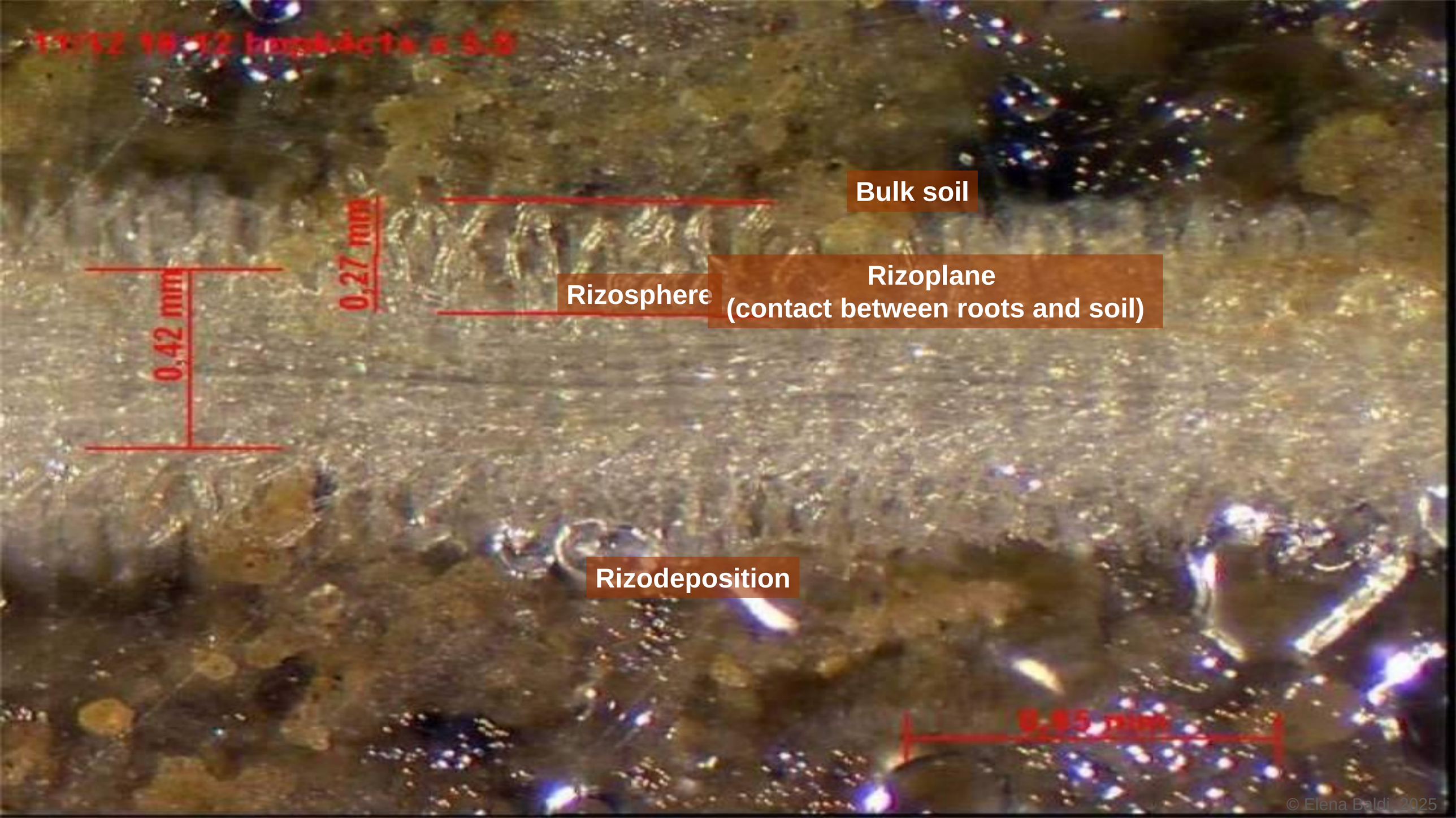


Fig. 1.3. Root hairs morphology of some fruit tree species: A, apple; B, peach; C, plum; D, currant. Below are enlargements with the localization of the nuclei of epidermal cells forming the root hair (from Baldini 1986, redrawn).

Sansavini et al. 2019. Principles of modern fruit Sciences



SECONDARY ROOT

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- ✓ conduction and reserve function
- ✓ brown color due to suberin accumulation
- ✓ tissue suberification induce a reduction of respiration a nutrient uptake

% of volume of different tissue in grape plants

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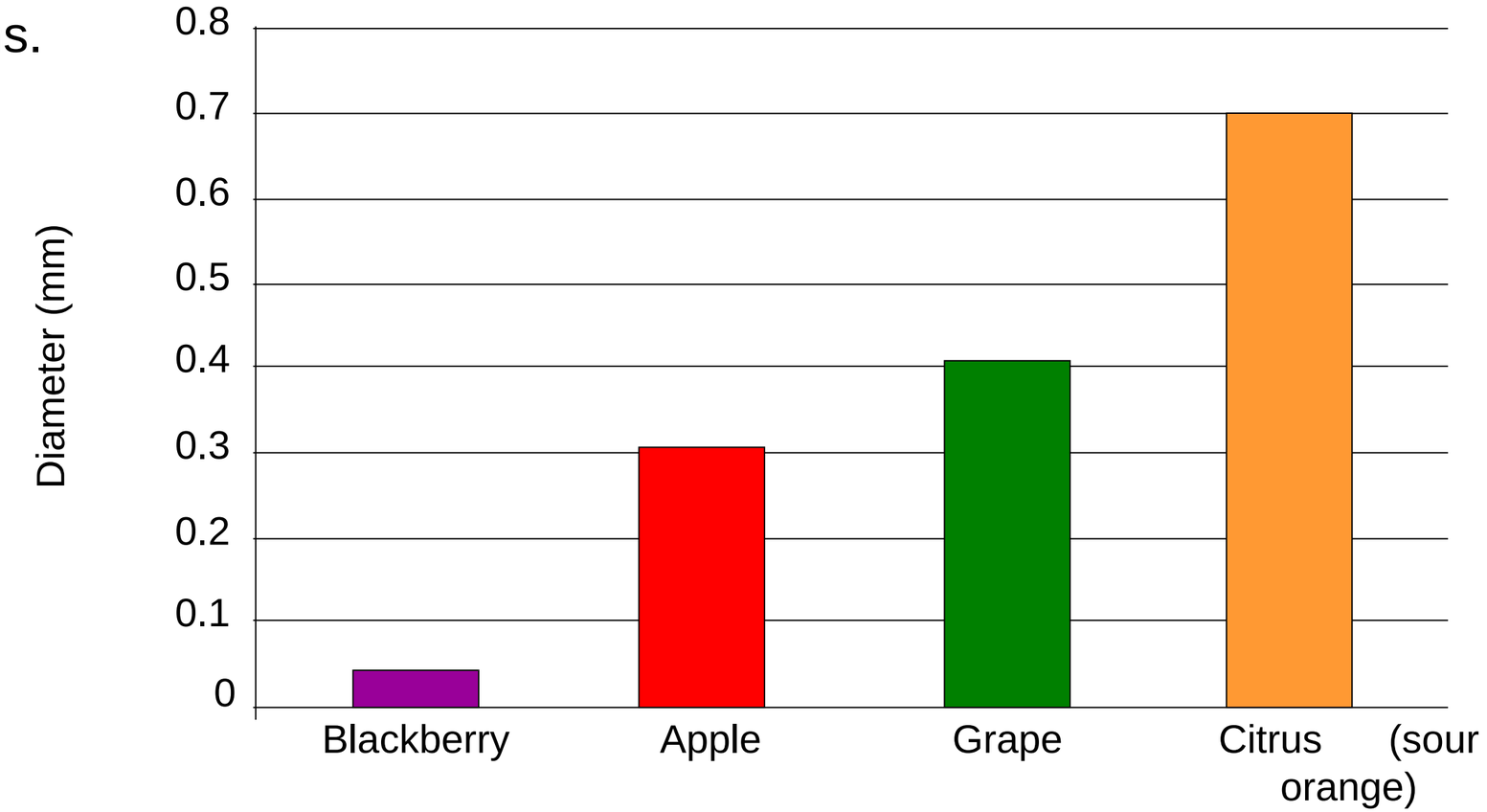
TISSUE	TYPE OF ROOTS			
	Primary	Secondary (1 year)	Secondary (2 year)	Secondary (3 year)
Uptake	89	0	0	0
Transport	1.4	6.1	12.6	13.8
Storage	0	60.9	30.6	30.8

Roots physiology and function also depends on order. . Roots that differ in diameter and order also differ in morphology, anatomy, and physiology.

McCormack_et_al-2015-New_Phytologist

Roots diameter also depends on species; thus, distinguishing fine and coarse roots by their diameter fails to reveal the differences in internal structure and function (i.e., order and position) of fine roots, resulting in large errors in estimating their turnover rates, lifespans, and below-ground contributions.



Eissenstant, 2015

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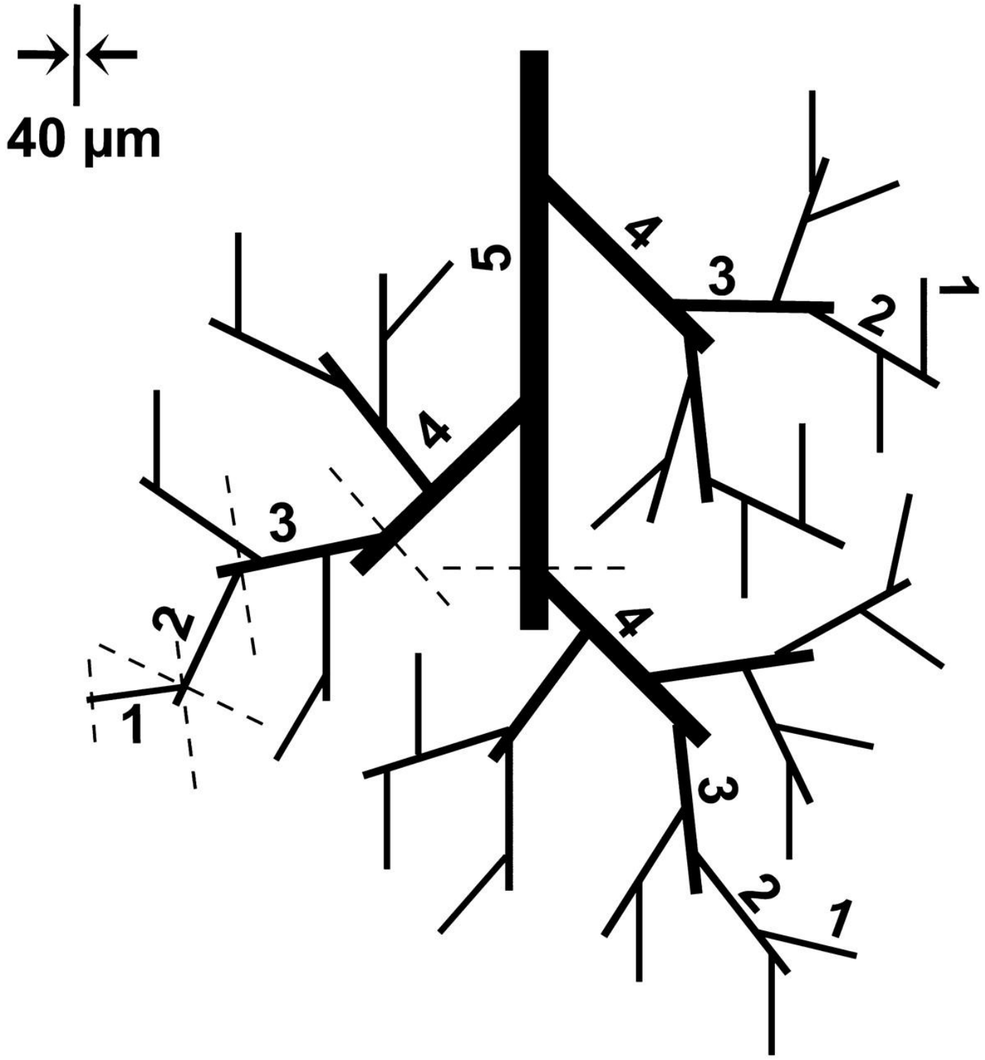
Distal roots made up the first-order roots (order I), the next segment comprised order II roots, and so on, moving down the root system to order VI



Luis R. Valenzuela-Estrada et al. Am. J. Bot. 2008;95:1506-1514

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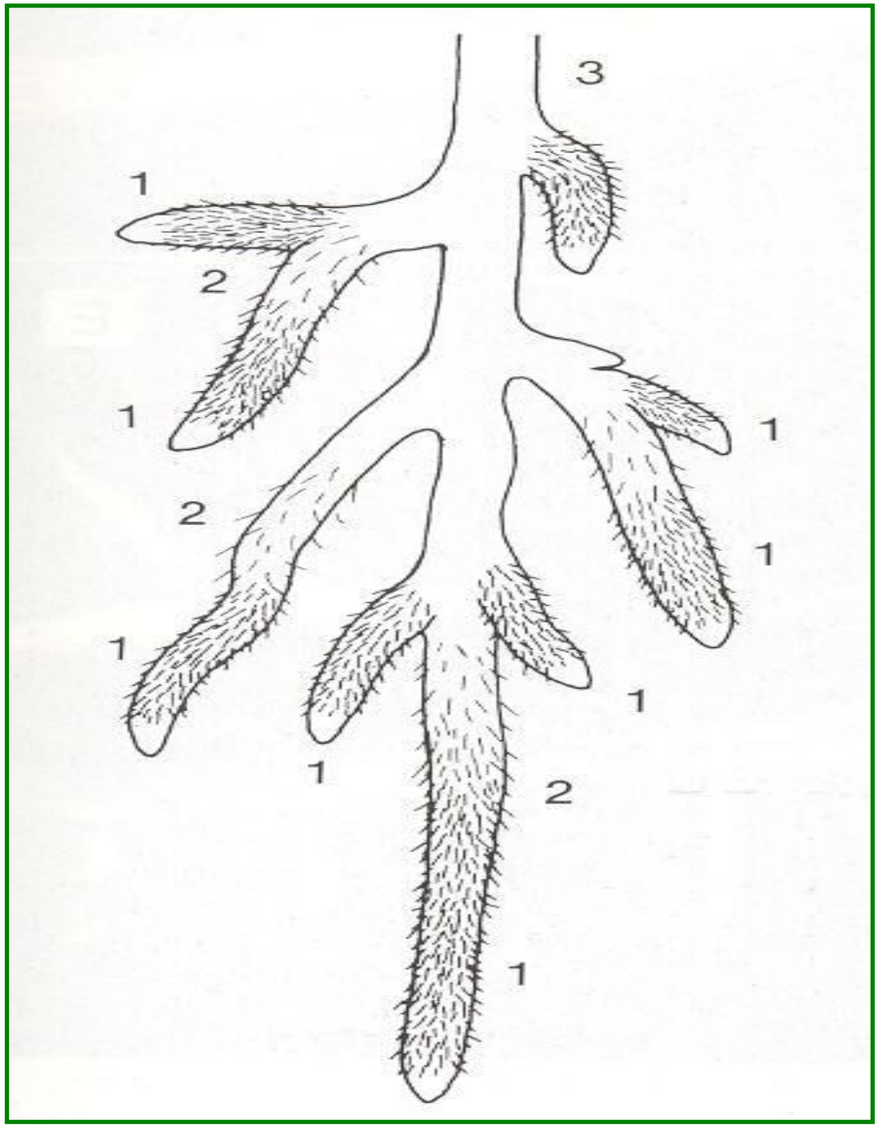
In relation to their position roots also change their function: :

- Absorbing (1) → primary structure, white, with root hairs, short and numerous. Short lifespan.
- Transition (2) → change from primary to secondary structure. Derive from absorbing roots that do not die. Solute transport.
- Conducting (3) → dark. Anchorage and solute transport.
- Elongation or exploring → long (20-25 cm), not older than 1 year, white and thin, can acquire secondary structure. Explore new volume of soil. Small percentage.



Baldini, 1986

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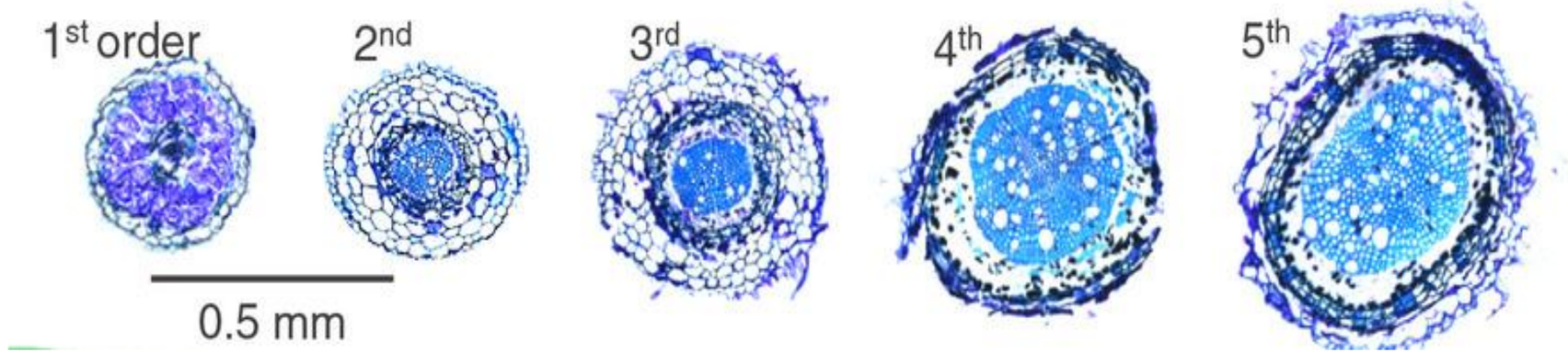

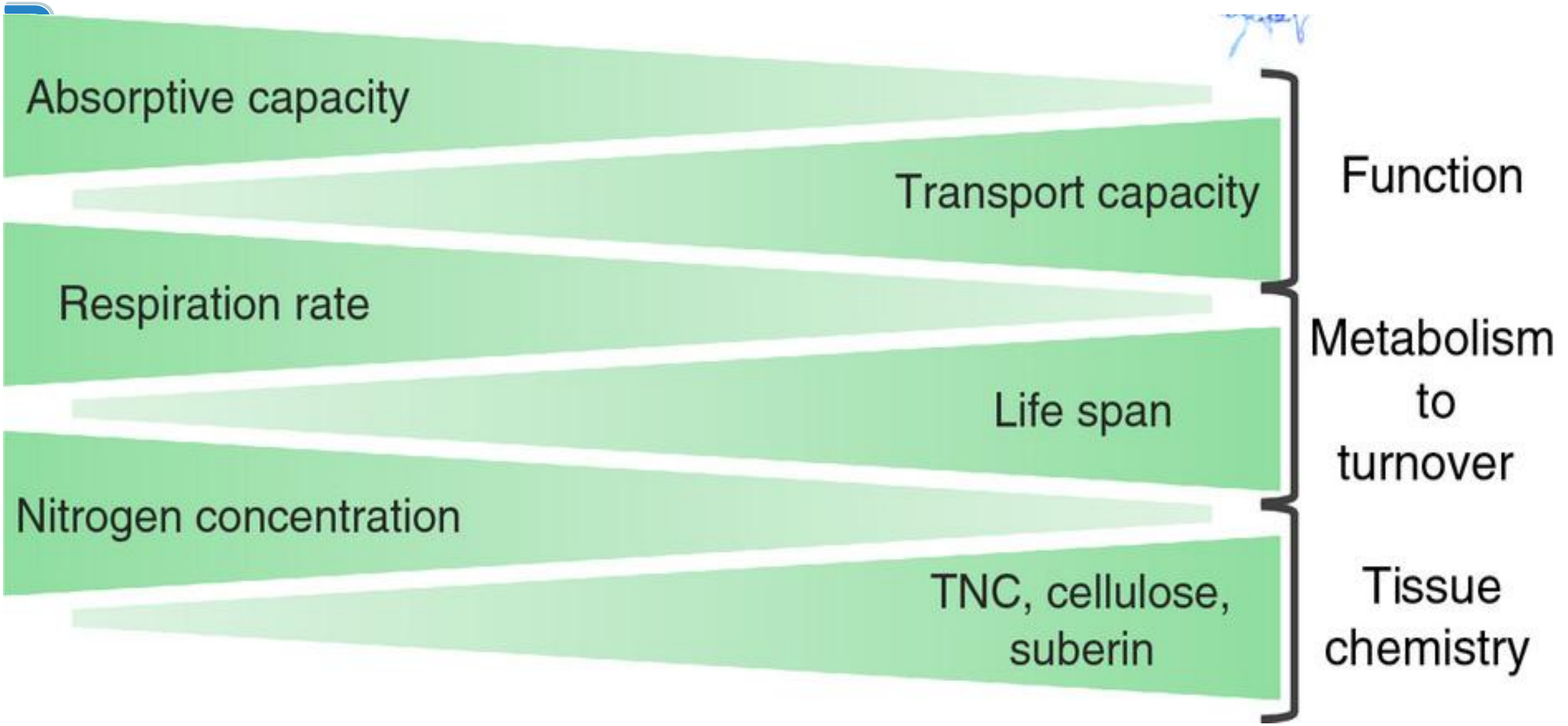

McCormack et al., 2015-New_Phytologist

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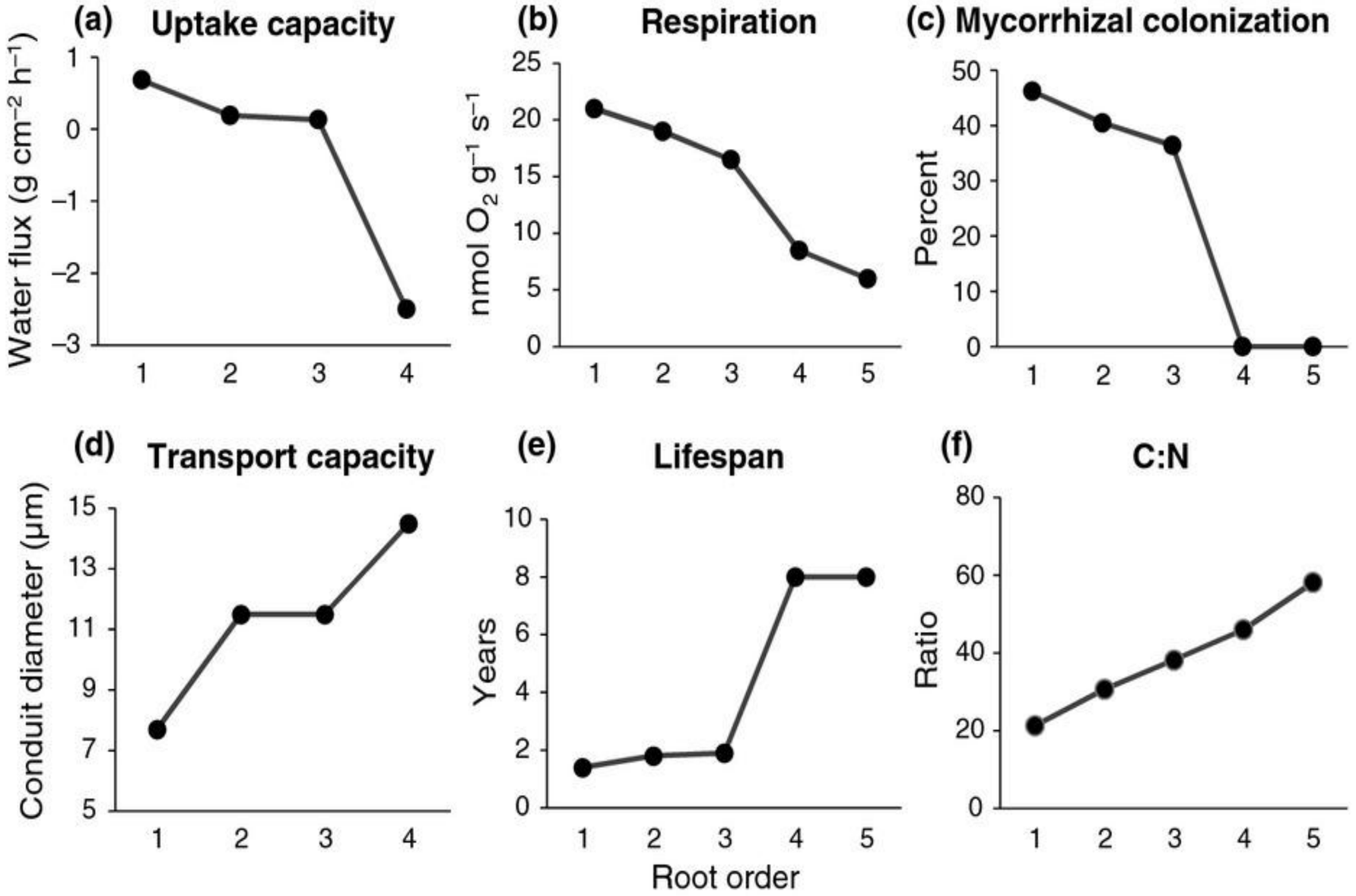

McCormack et al-2015-New_Phytologist

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THE ABILITY OF PLANTS TO OBTAIN WATER AND NUTRIENTS FORM THE SOIL IS RELATED TO THE CAPACITY OF EXPANSION OF THE ROOT SYSTEM

FACTORS INFLUENCING ROOT EXPANSION

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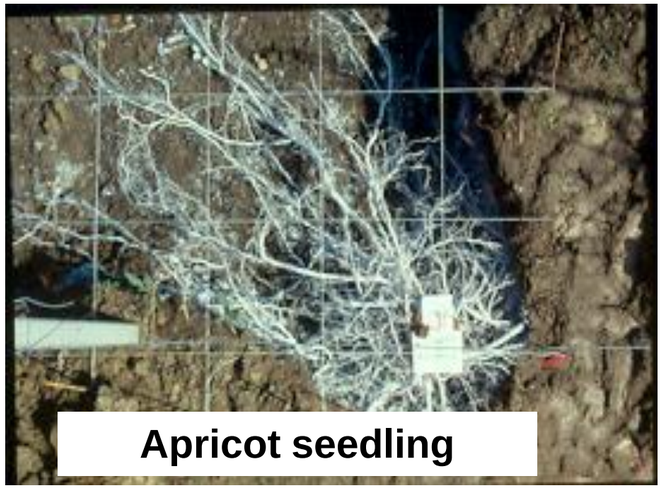
❑ Species

Puebla Adesoto 101 (*P. insititia*), 3 years



Apricot seedling

Pear (Fox 9)

GF677

FACTORS INFLUENCING ROOT EXPANSION

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- ❑ Species
- ❑ **Soil chemical and physical properties**
  - ✓ temperature
  - ✓ moisture
  - ✓ aeration
  - ✓ mineral nutrient availability
  - ✓ soil strength

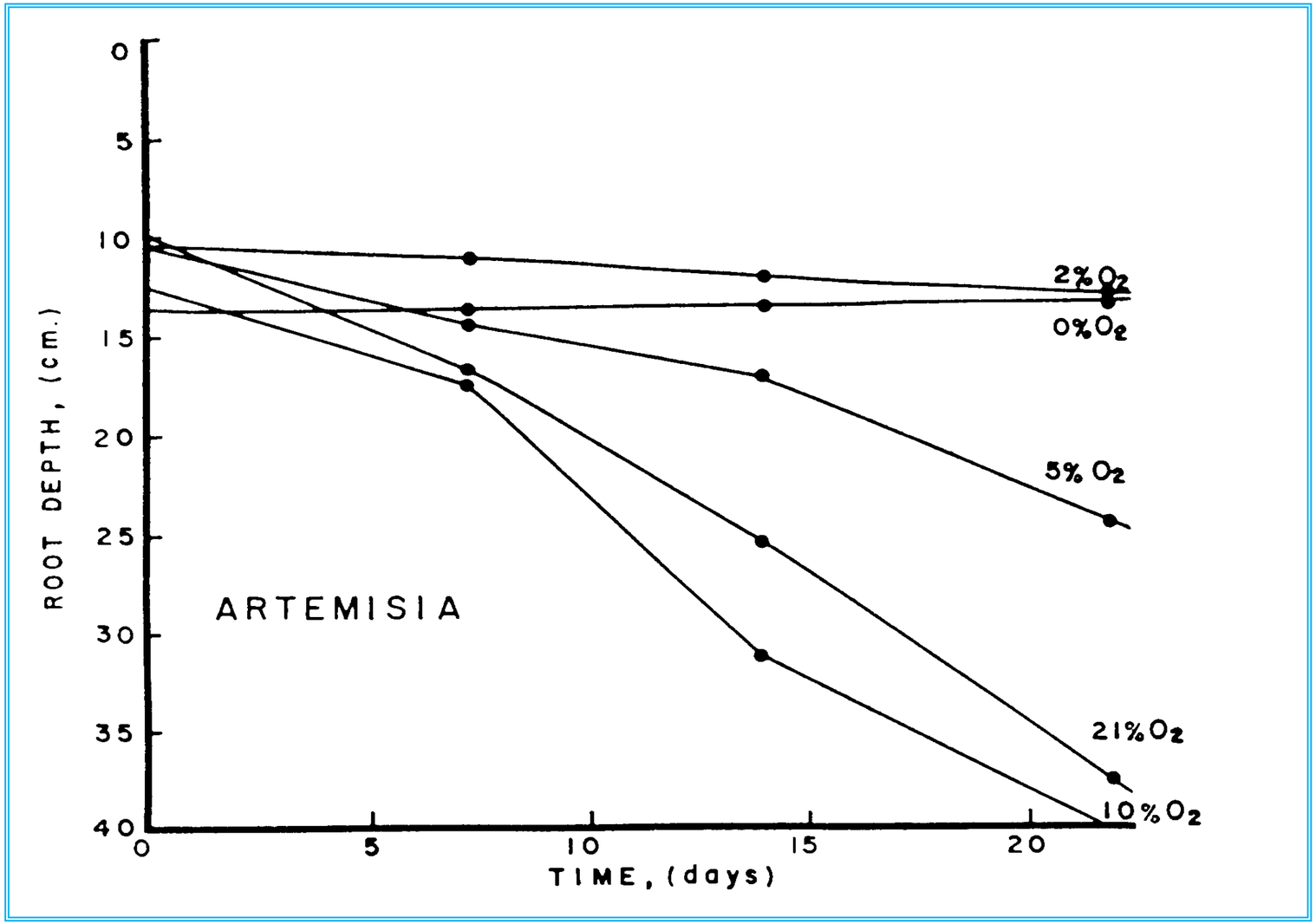
Apple and pear 10-20°C

Cherry 12-18 °C

Peach and apricot 18-22 °C

Plum 12-13 °C

Kiwifruit 16-18°C



Lunt et al., 1973

ROOT GROWTH (cm)

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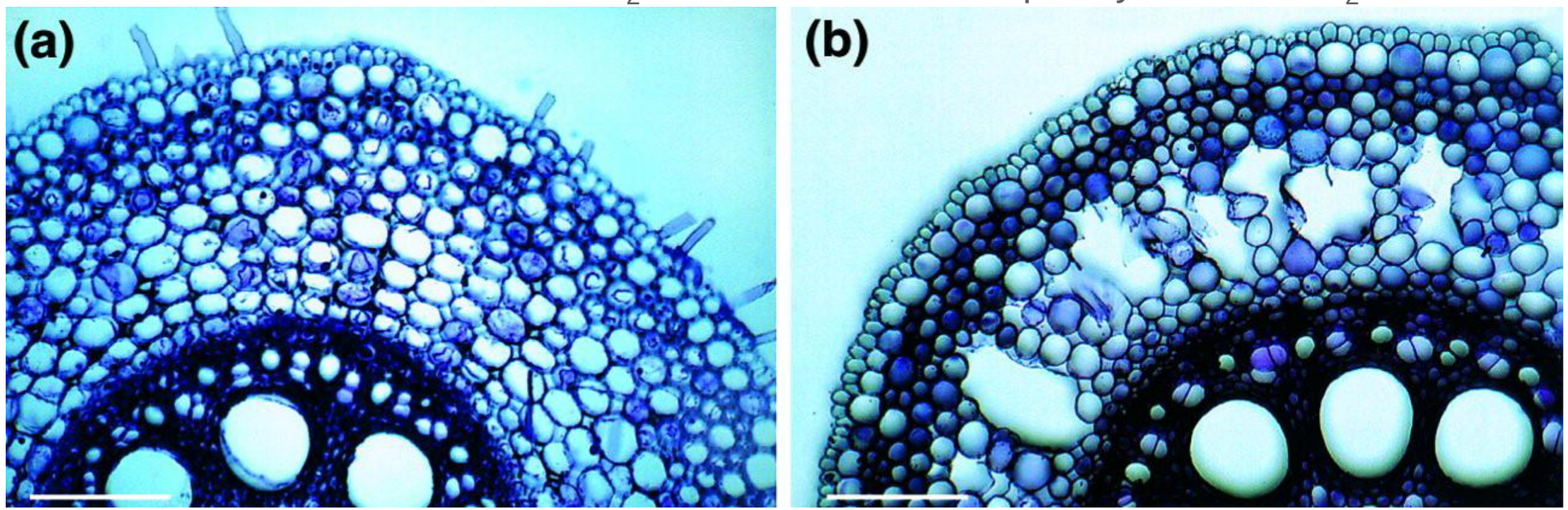
Geisler, 1964

	Aerated	Nonaerated
Main root	3.02 ± 0.03	0.6 ± 0.005
Primary laterals	2.64 ± 0.03	0.33 ± 0.001
Secondary laterals	0.92 ± 0.02	0.27 ± 0.001

The interconnected lacunae make up an internal aeration system, enabling parts of the plant to survive or grow for a time in environments that are O_2-deficient or even completely devoid of O_2



Drew et al., 2000

SOIL PHYSICAL STRUCTURE

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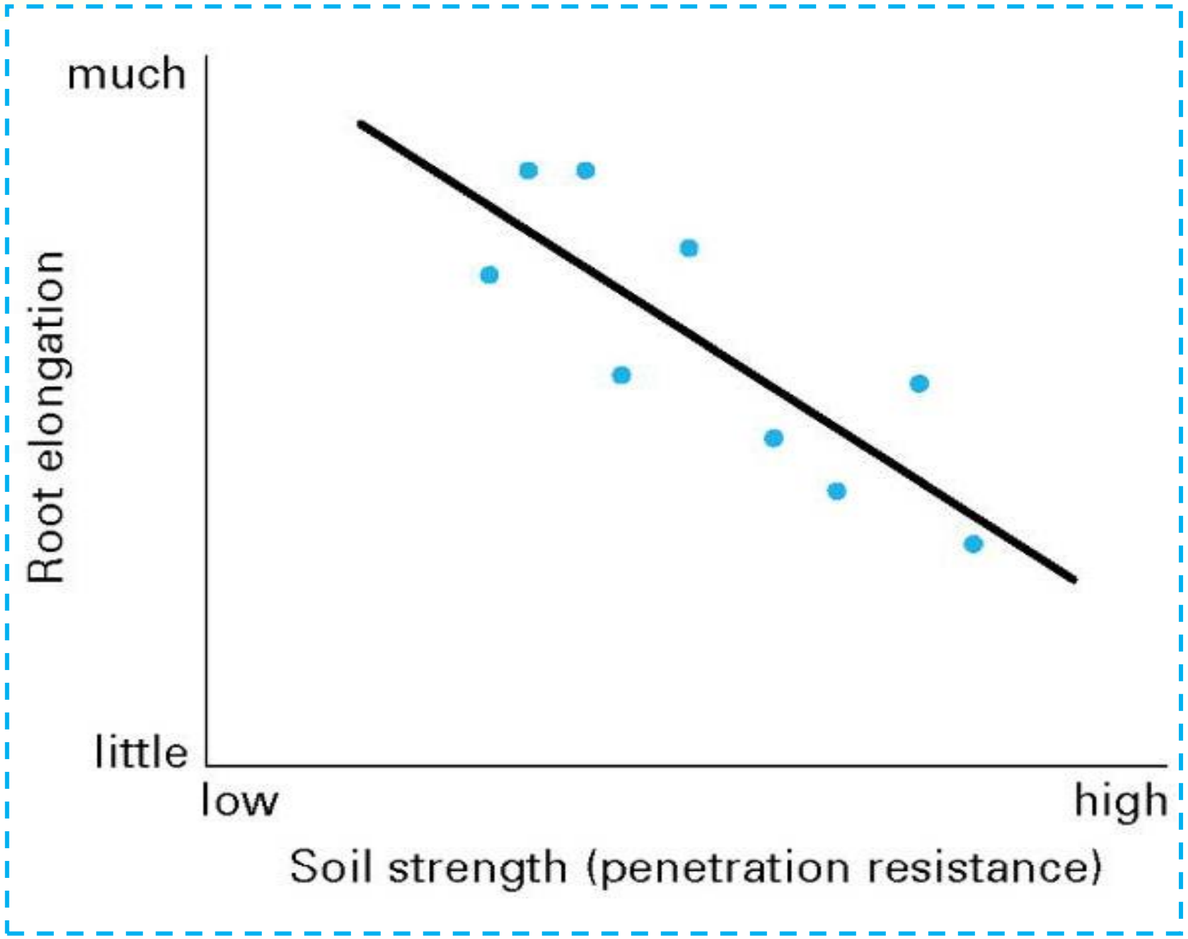
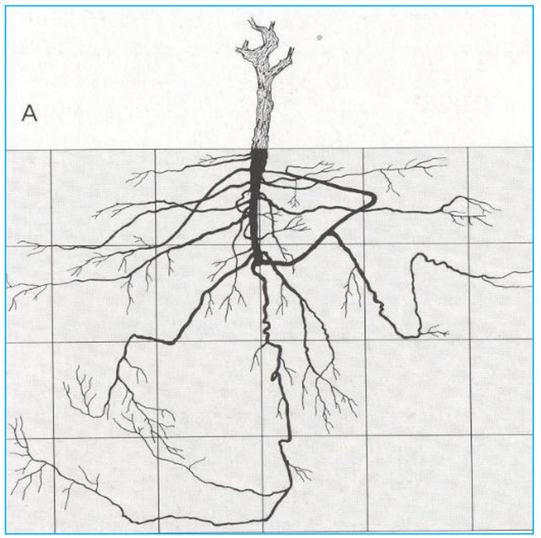
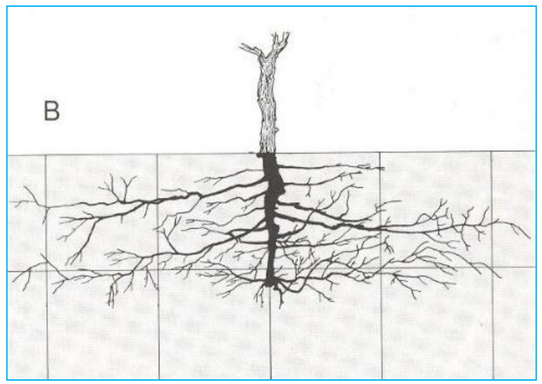


Soils: An Introduction, 5th Edition
by Michael J. Singer and Donald N. Munns

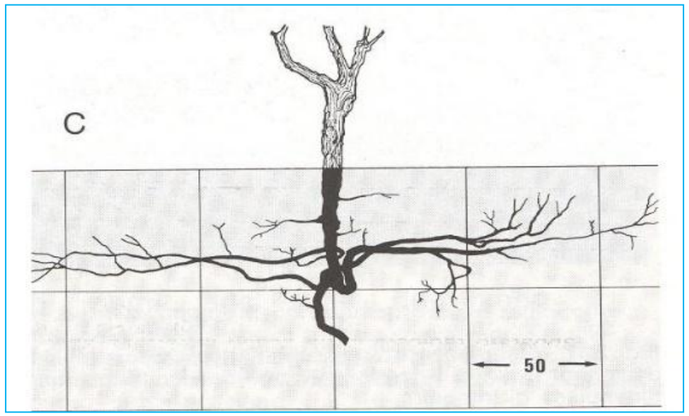
Baldini, 1986



Dry soil, hight depth, coarse structure



Medium texture, fresh and deep



Clay soil

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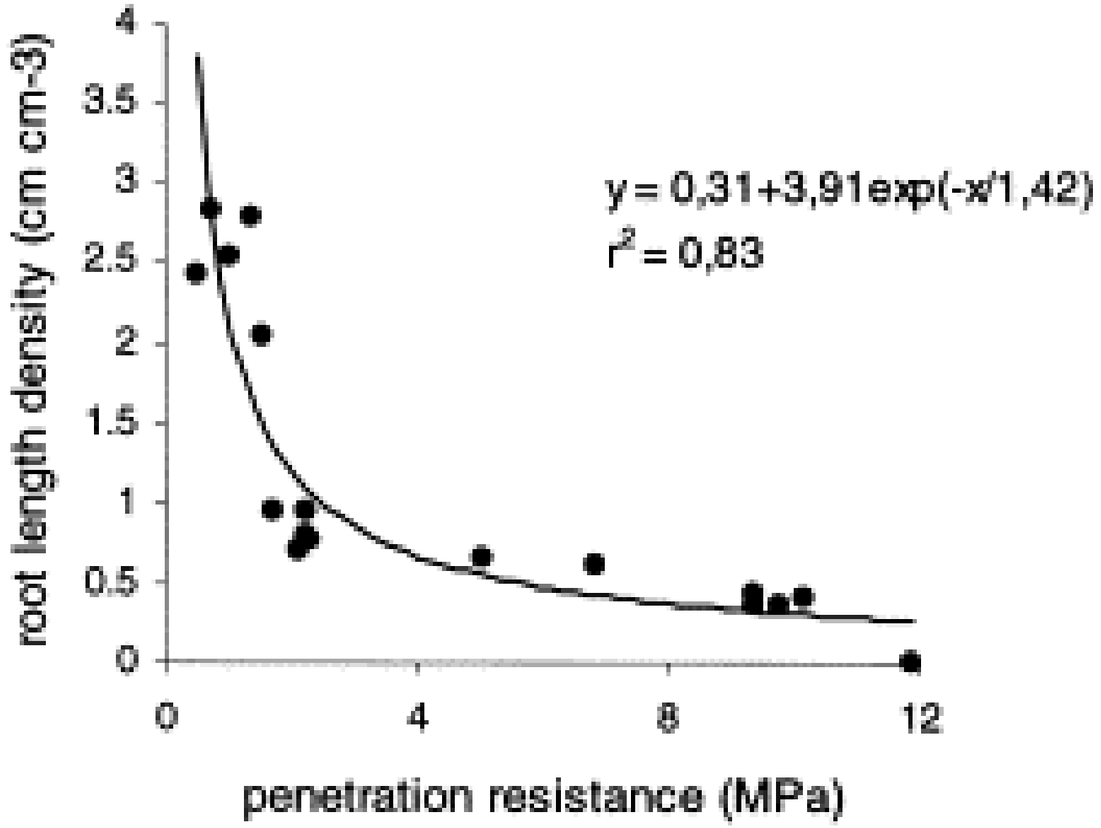
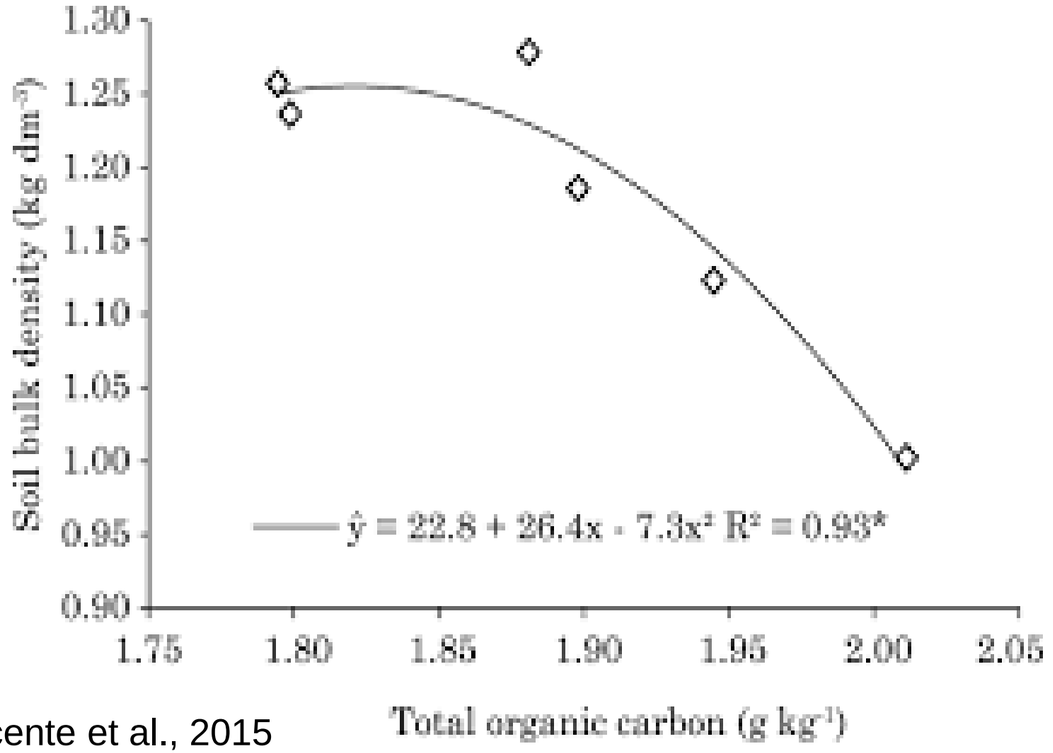


Pardo et al., 2000



Nascente et al., 2015

FACTORS INFLUENCING ROOT EXPANSION

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- ❑ Species
- ❑ Soil chemical and physical properties
  - ✓ temperature
  - ✓ moisture
  - ✓ aeration
  - ✓ mineral nutrient availability
  - ✓ soil strength
- ❑ **root:canopy ratio**

Effect of crop load on roots dry weight in 3-years apple trees

(source: Buwalda e Lenz, 1992)

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	NO FRUITS	WITH FRUITS
Leaf area (m^2 pt^{-1})	443	400
Fruits dry weight (g pt^{-1})	0	2994
Roots dry weight (g pt^{-1})	665	399

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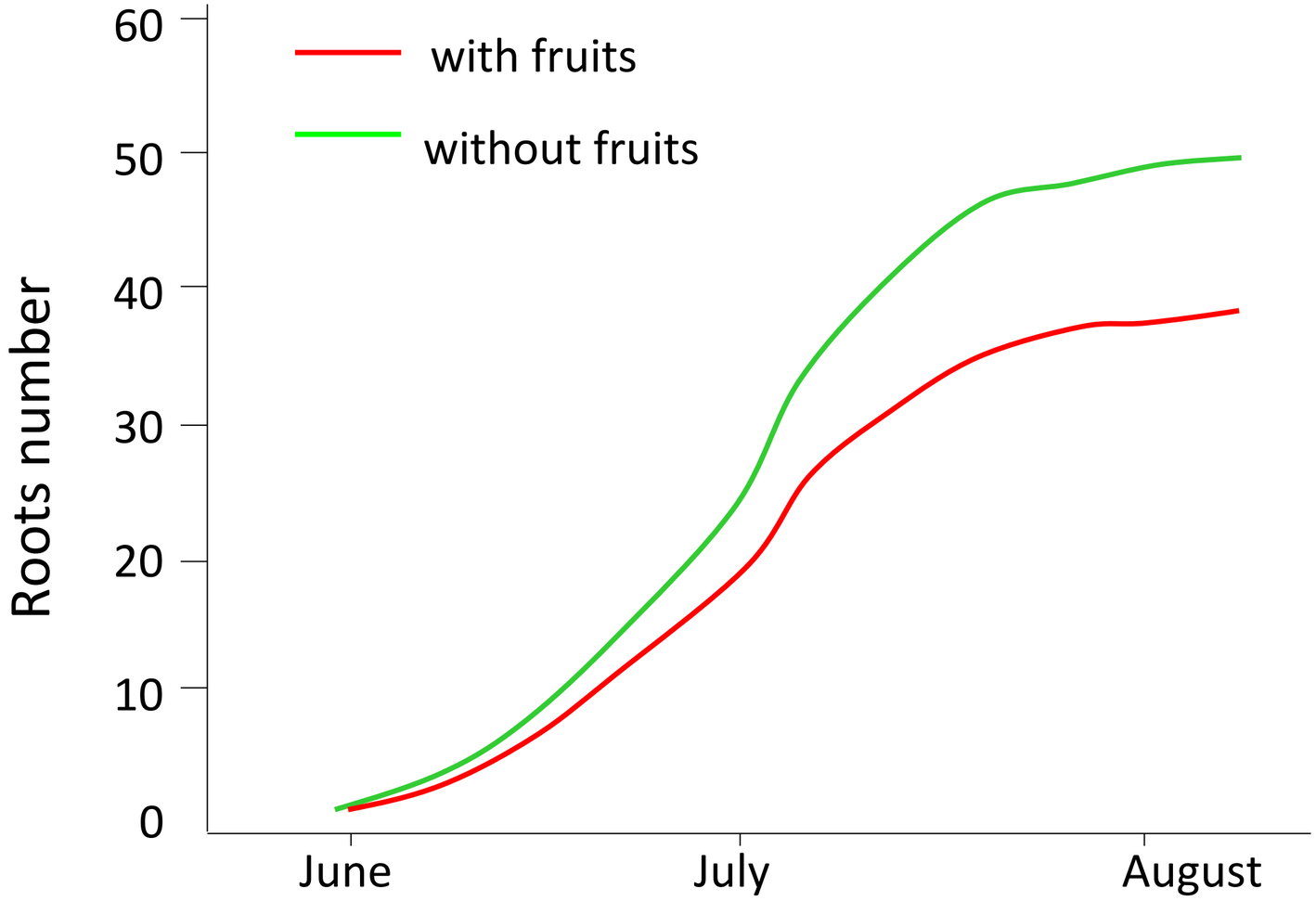

COMPETITION FOR CARBOHYDRATES

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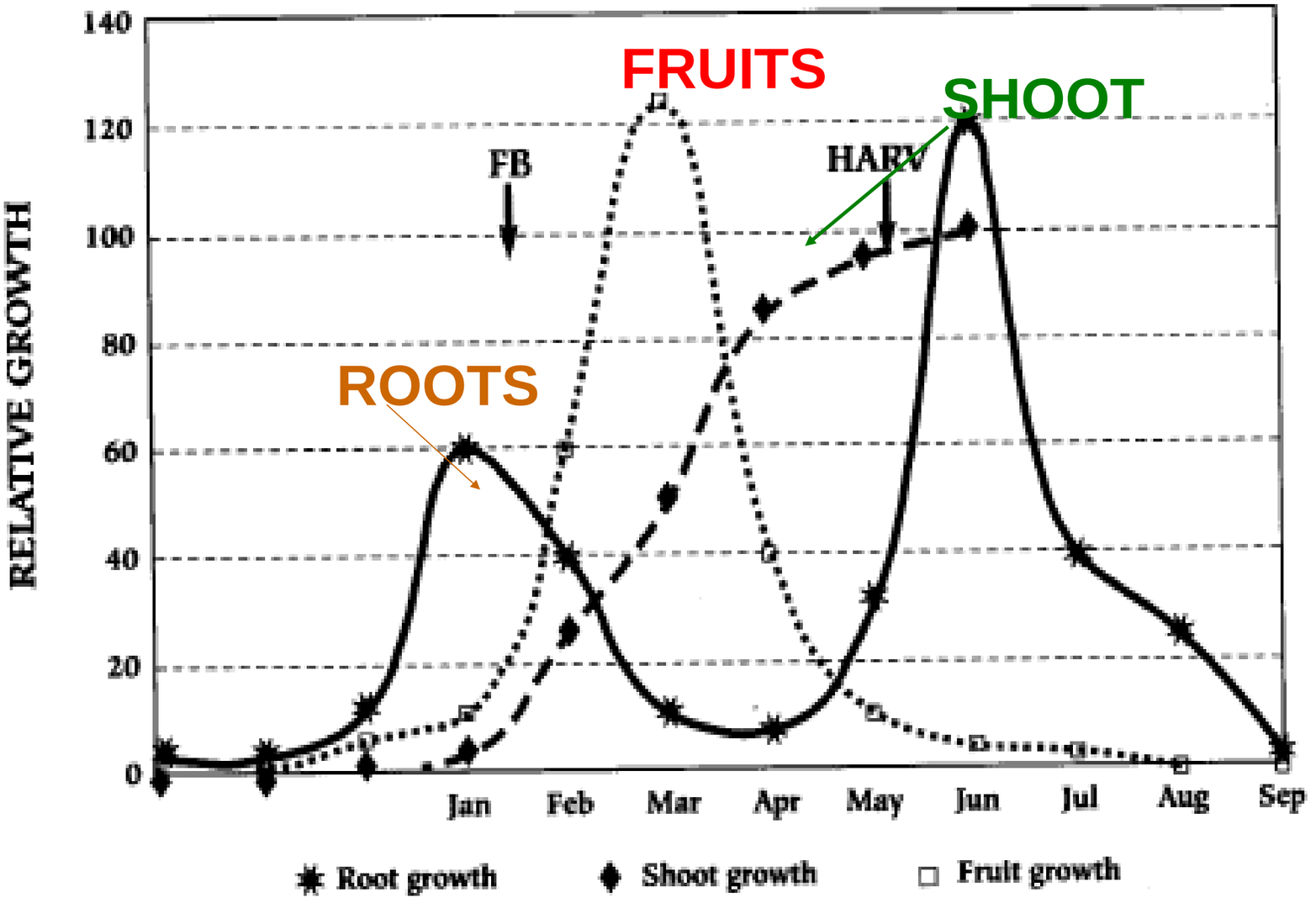
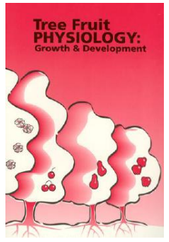
The relative growth of various organs of an apple tree. FB = full bloom; HARV = date of fruit harvest.





ROOT GROWTH

(Gala/M9)

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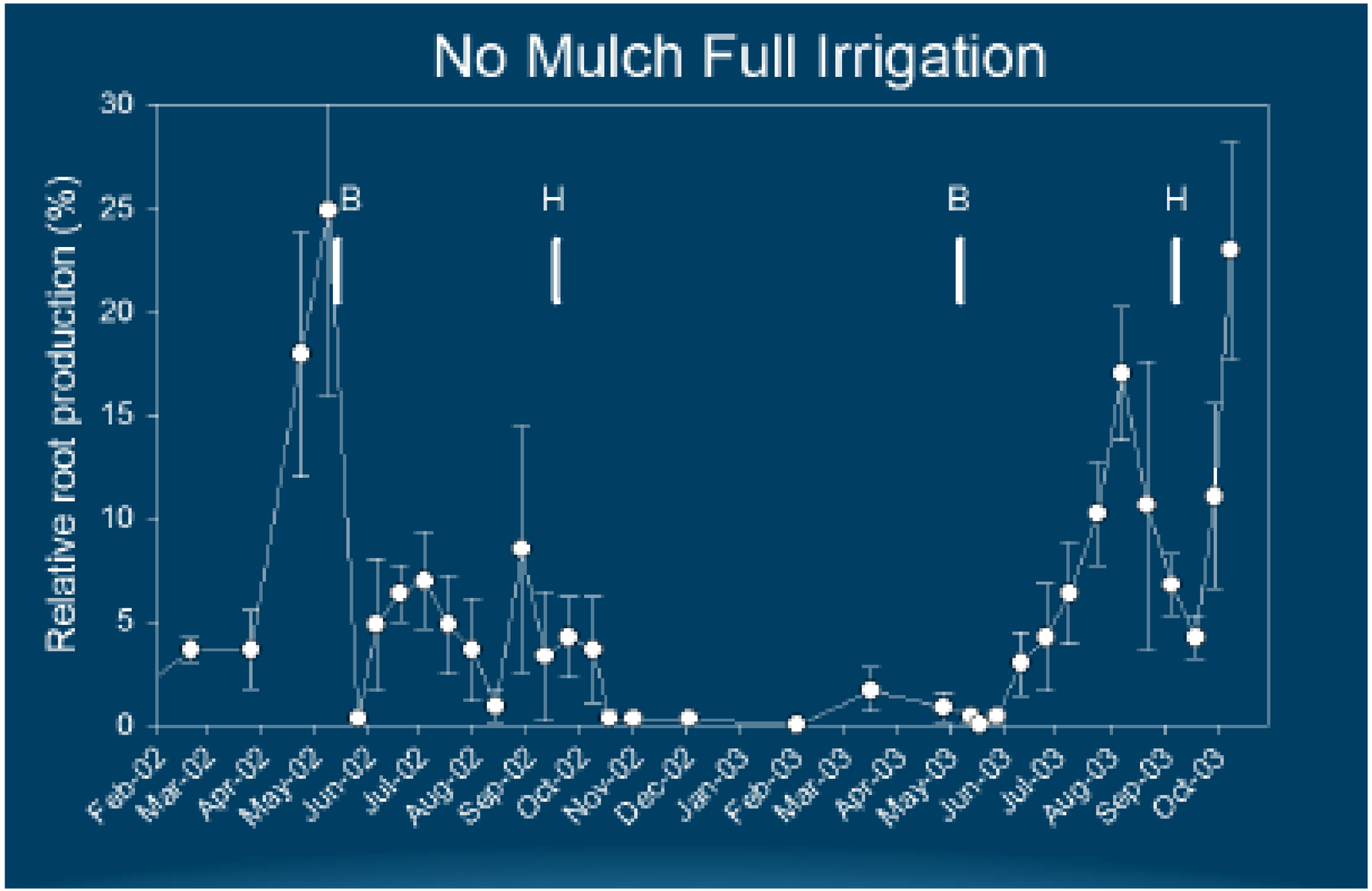

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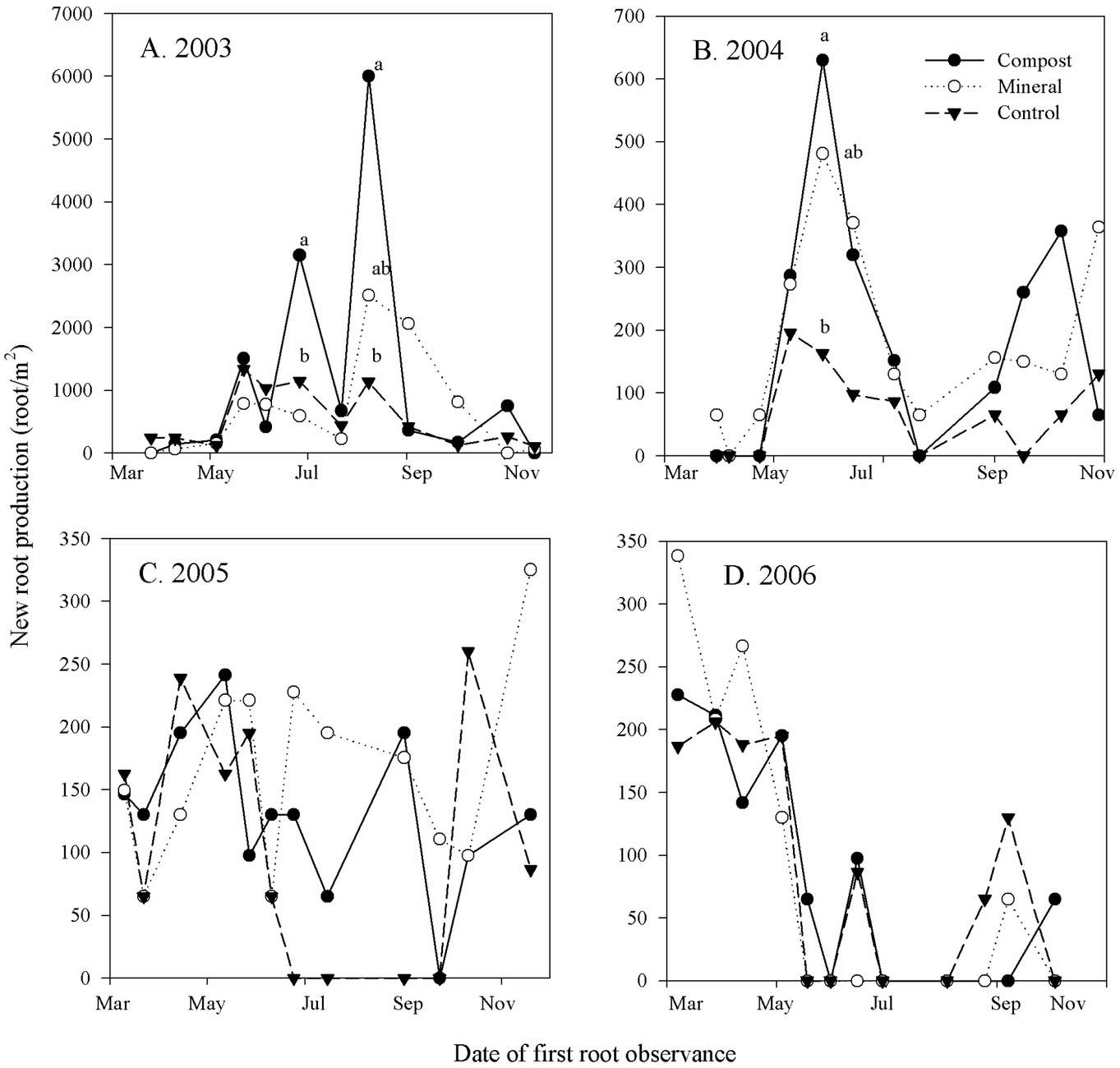
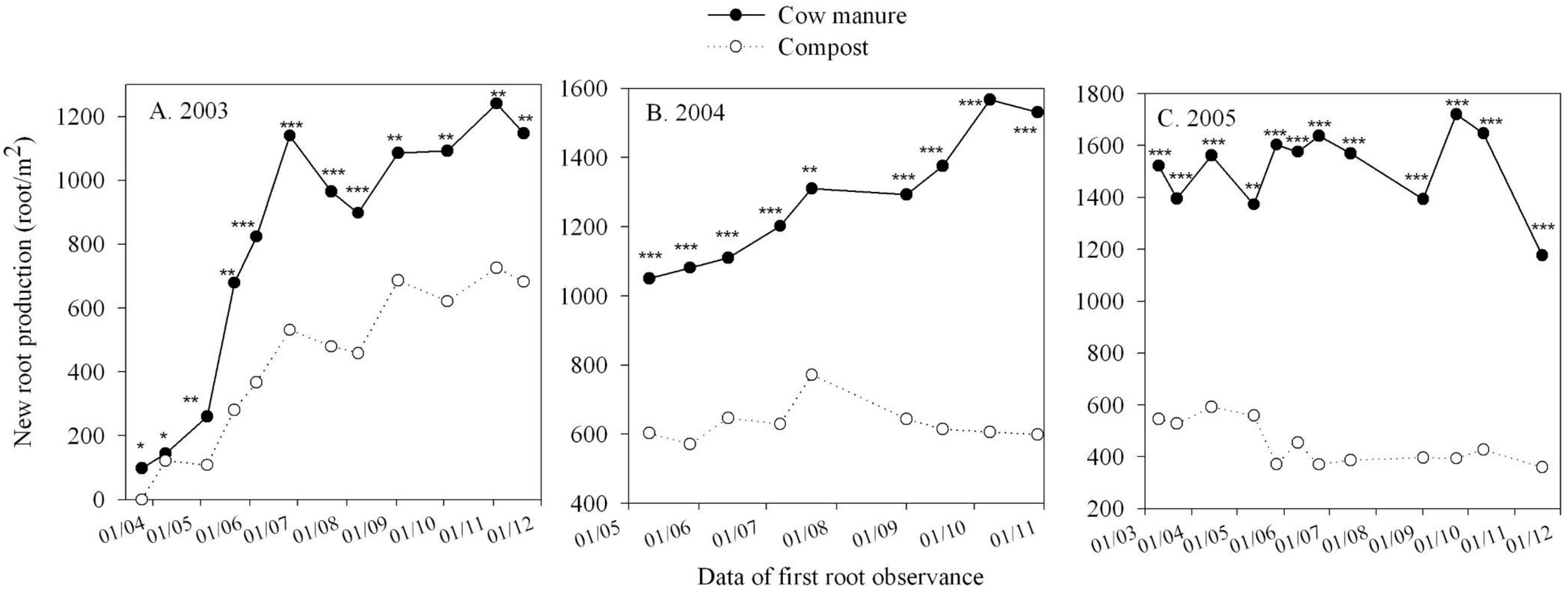


Baldi et al., 2010



Baldi eToselli, 2013

FACTORS INFLUENCING ROOT EXPANSION

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- ❑ Species
- ❑ Soil chemical and physical properties
  - ✓ temperature
  - ✓ moisture
  - ✓ aeration
  - ✓ mineral nutrient availability
  - ✓ soil strength
- ❑ root:canopy ratio
- ❑ **agronomic management**

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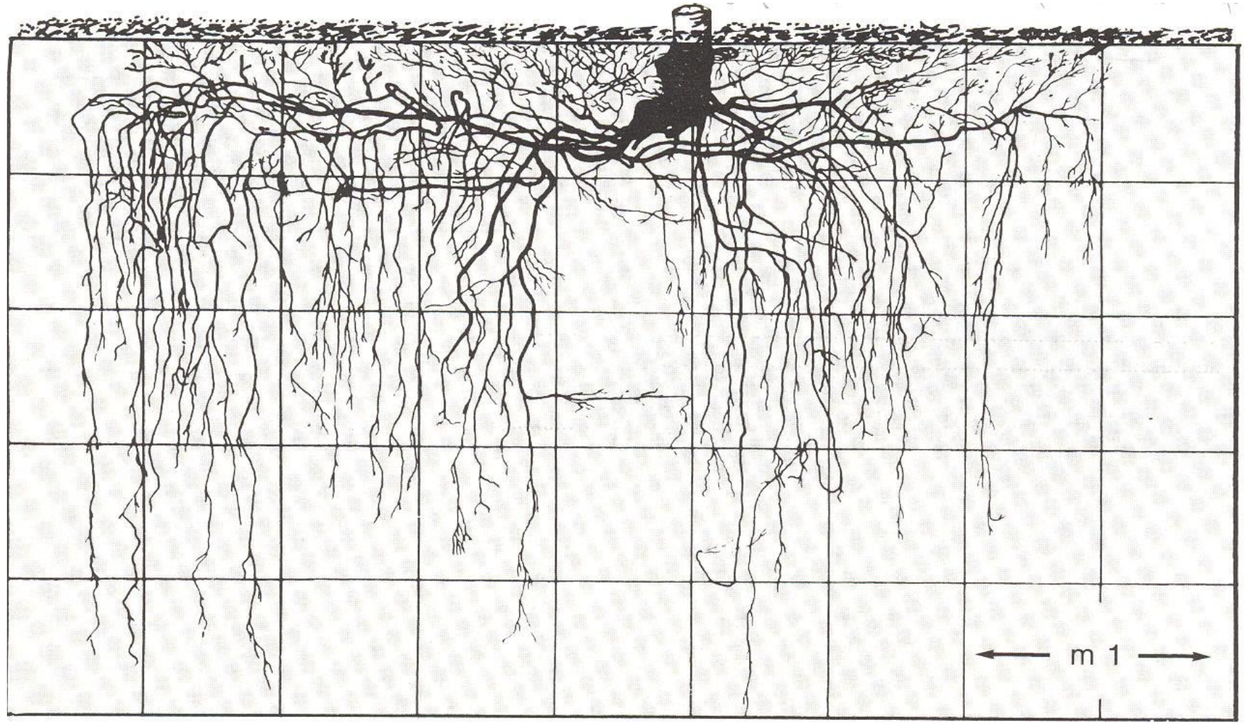
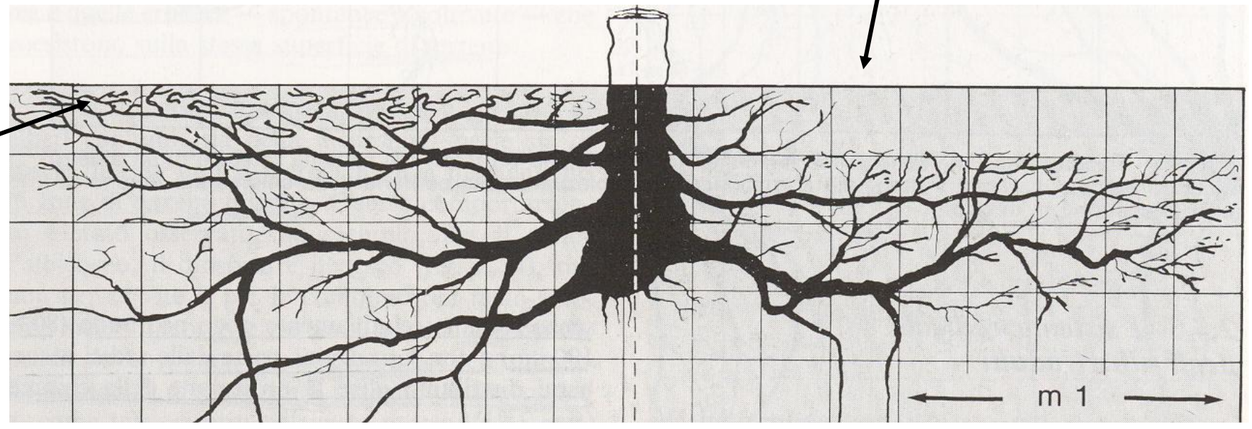


MULCHING

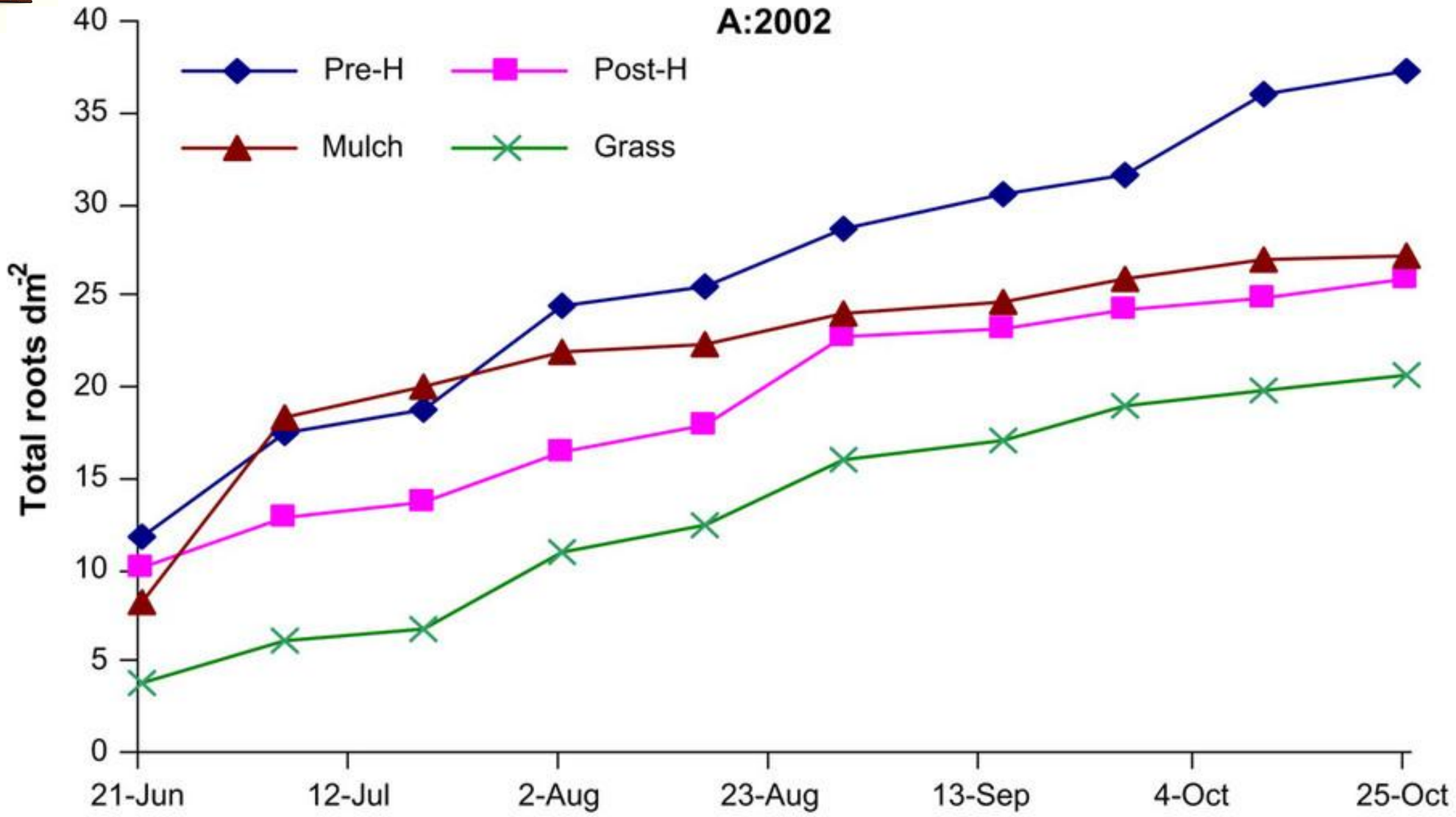
TILLAGE

20 cm depth

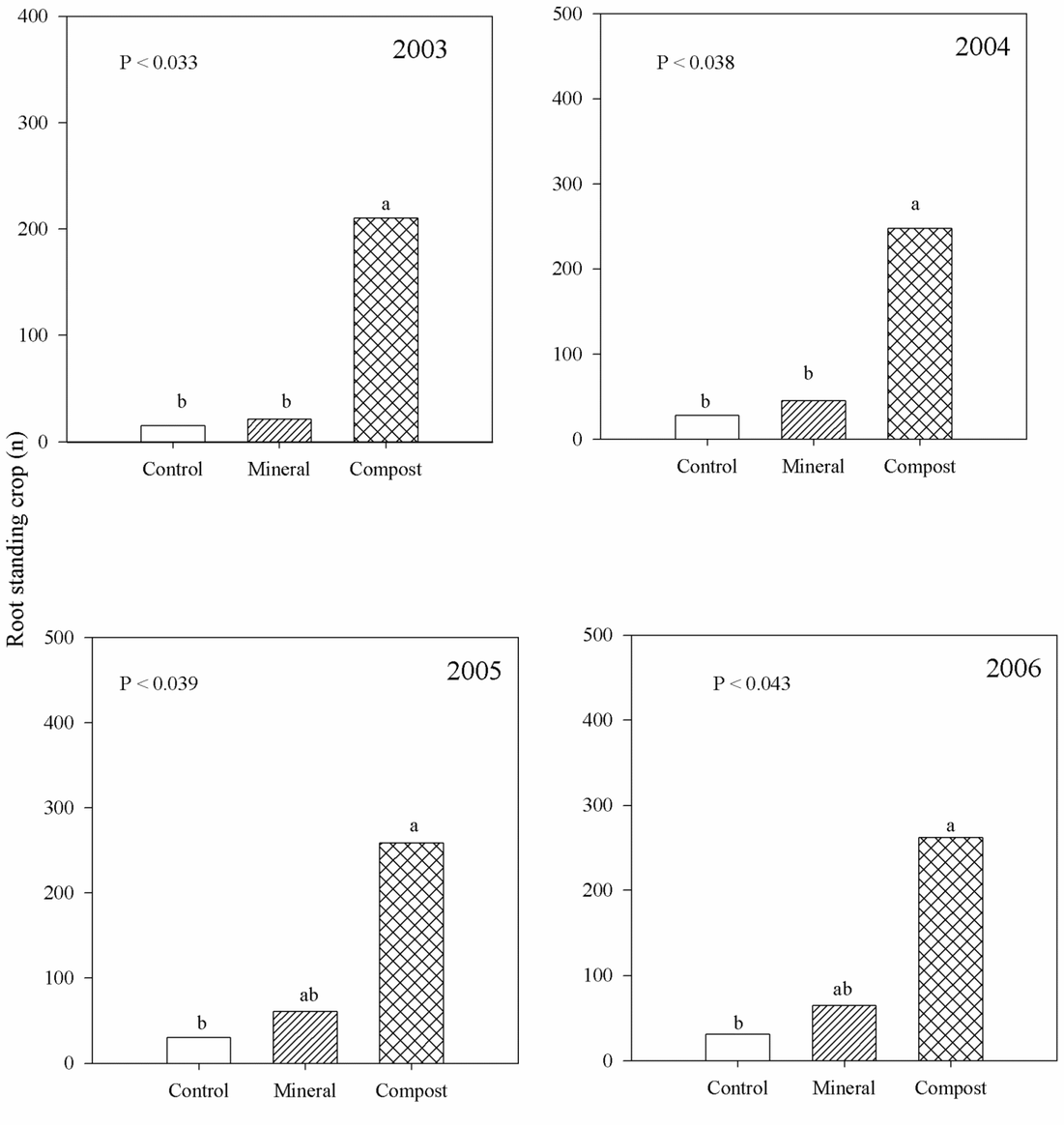


CHEMICAL
WEEDING

Baldini, 1986



Yao et al., 2009



Soil density:

1.25 mg m^{-3} control

1.20 mg m^{-3} compost

Baldi et al., 2010

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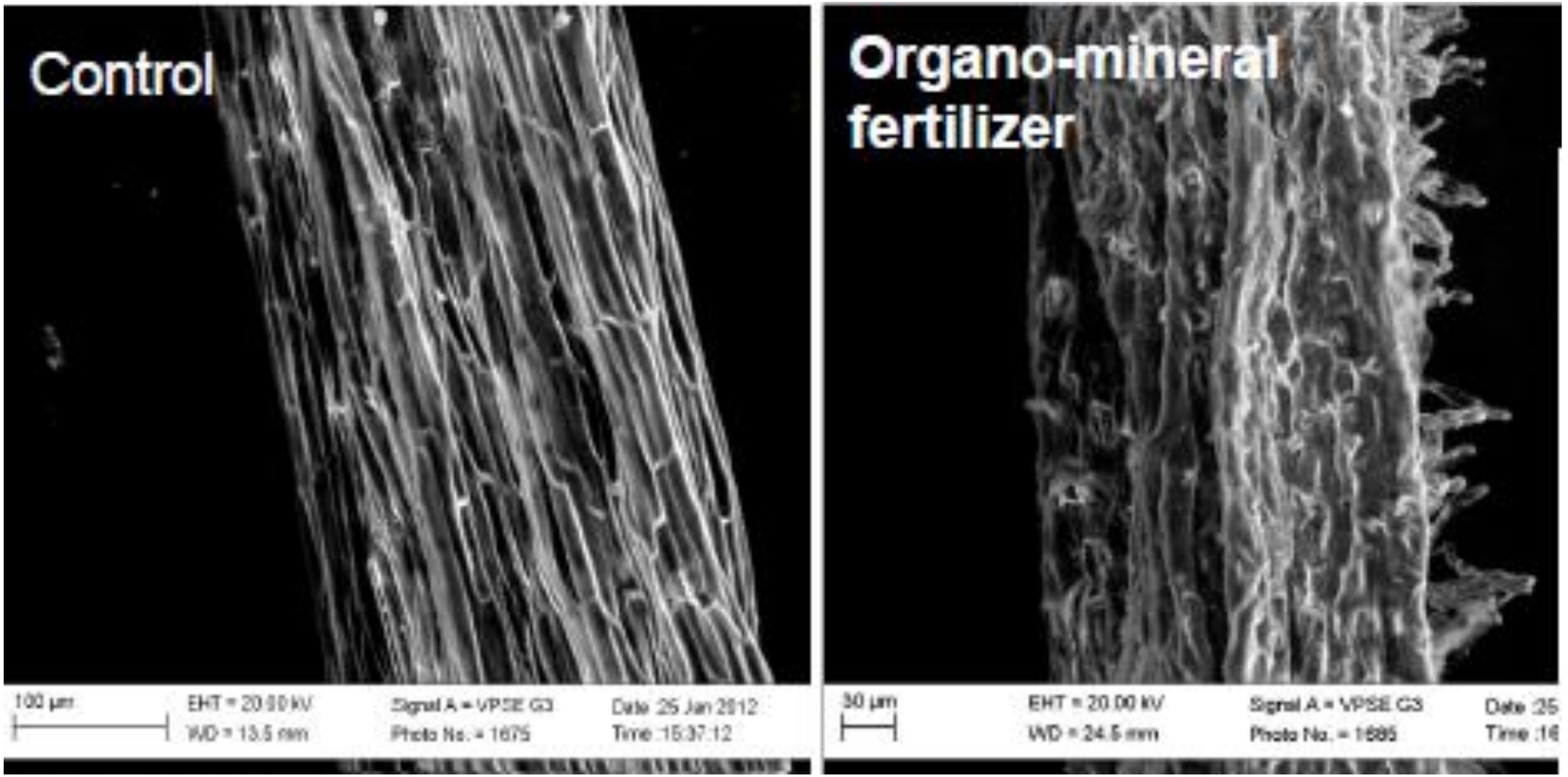

CONTROL

ORGANIC

Trinchera, 2015

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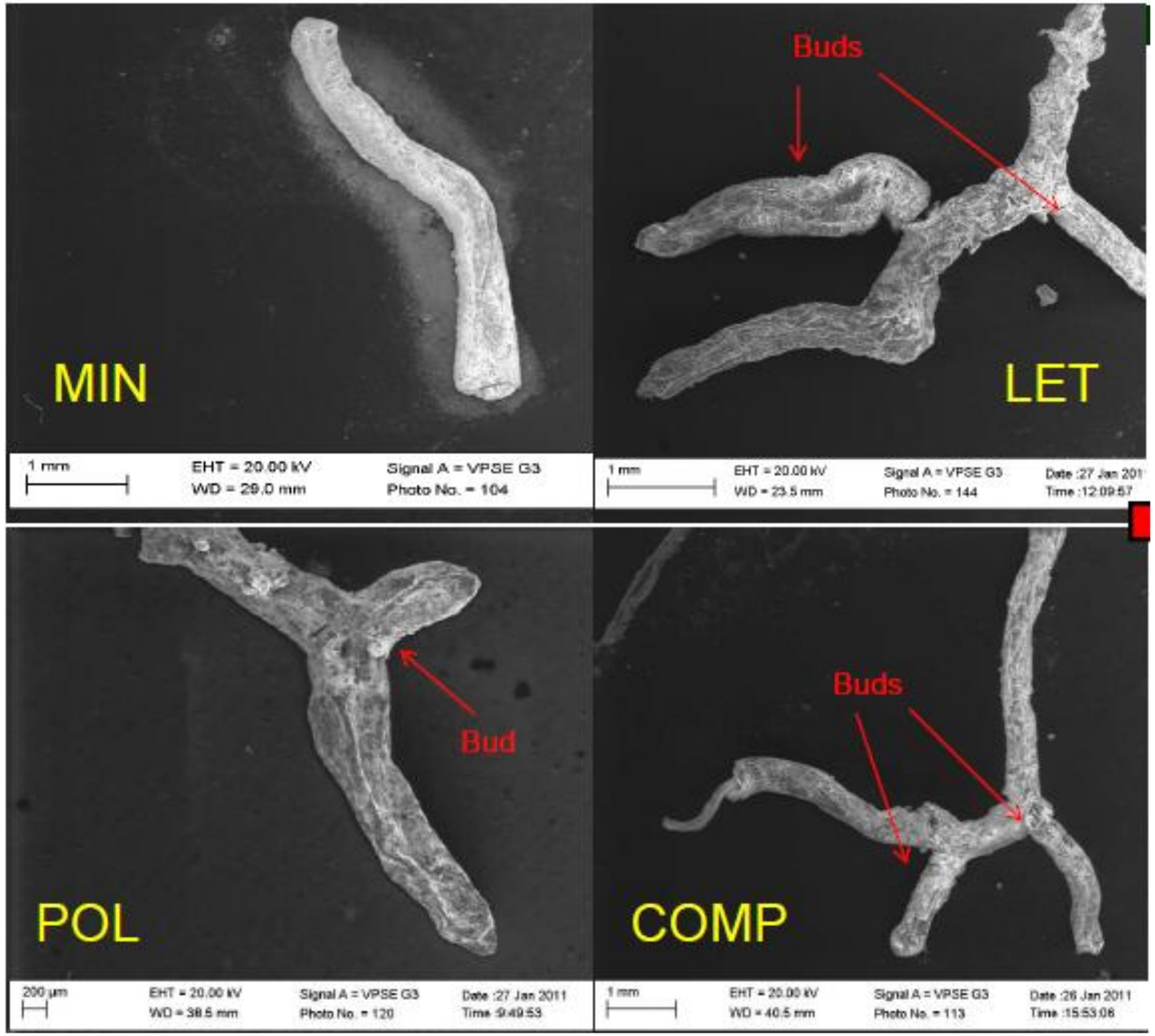

Trinchera, 2015

ORGANIC MATTER AND ROOT GROWTH

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0

4%

8%

Mazzanti, 2001

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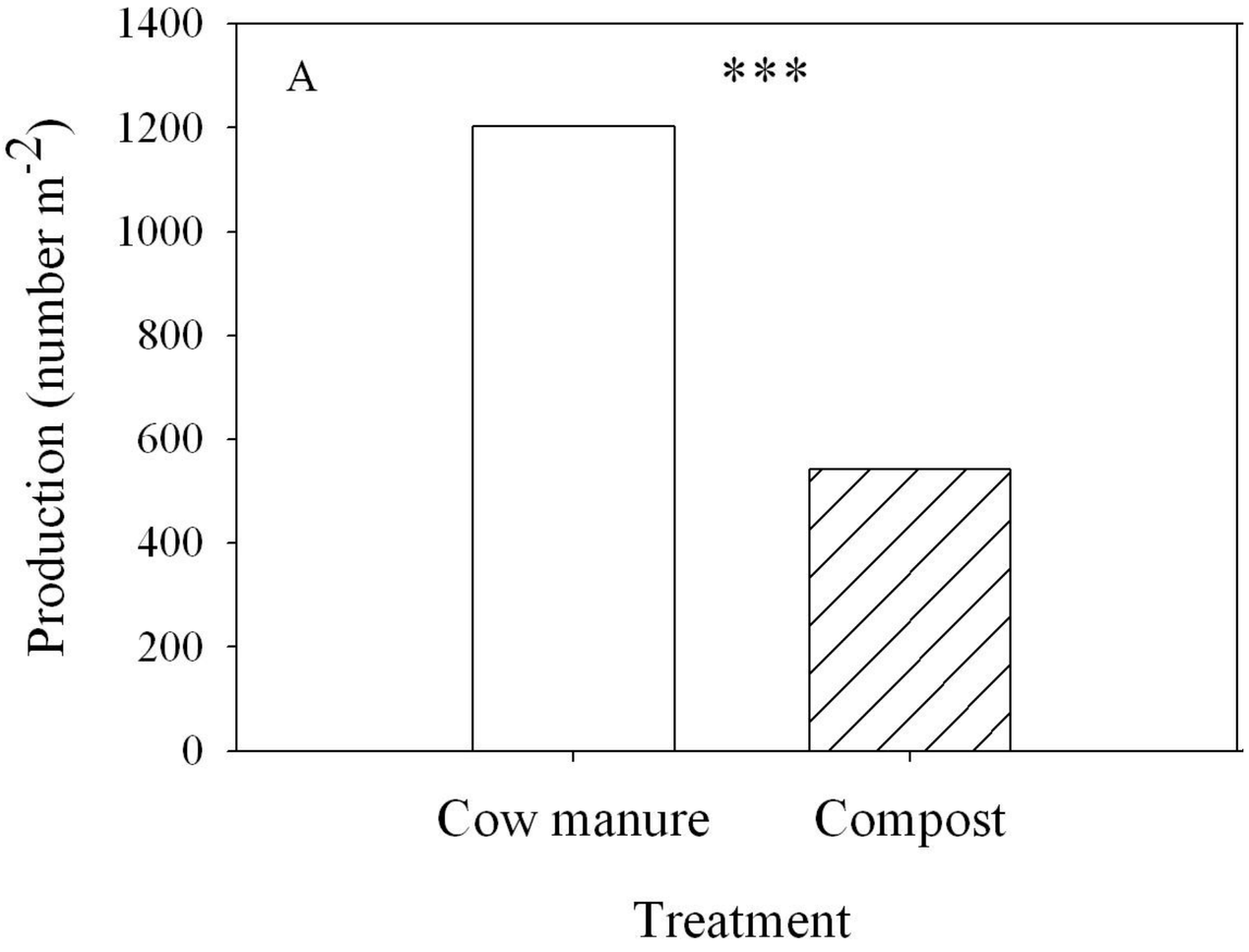
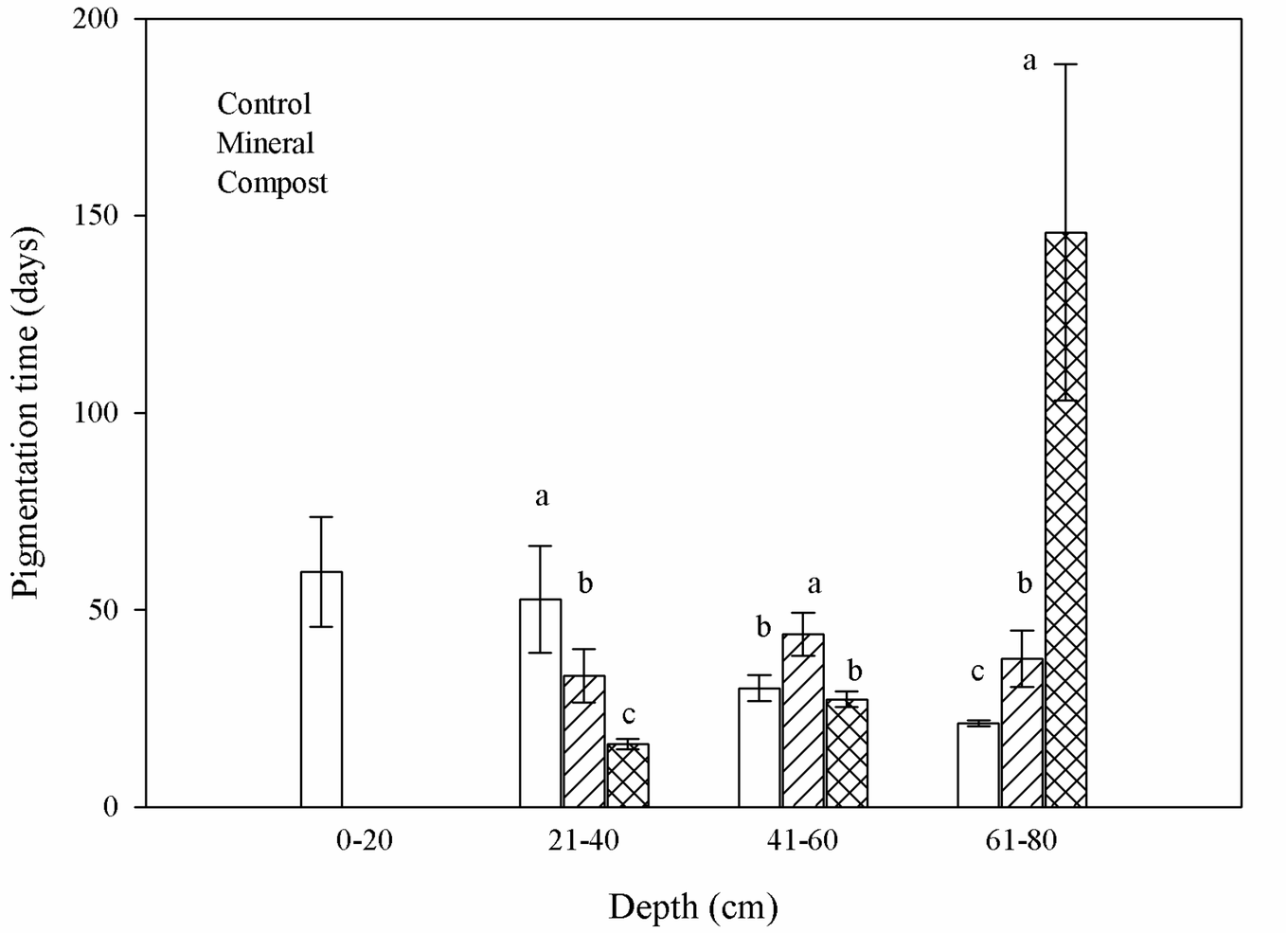
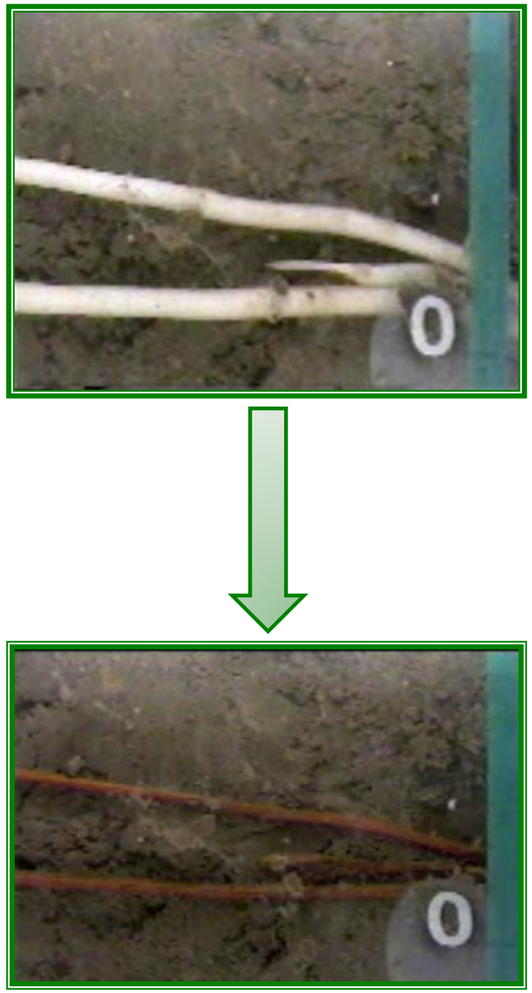


	HA+FA (%)
Cow manure	12
Compost	7.9

	PORES (%)
Cow manure	20-24
Compost	16-20

Baldi e Toselli, 2013





Baldi et al., 2010

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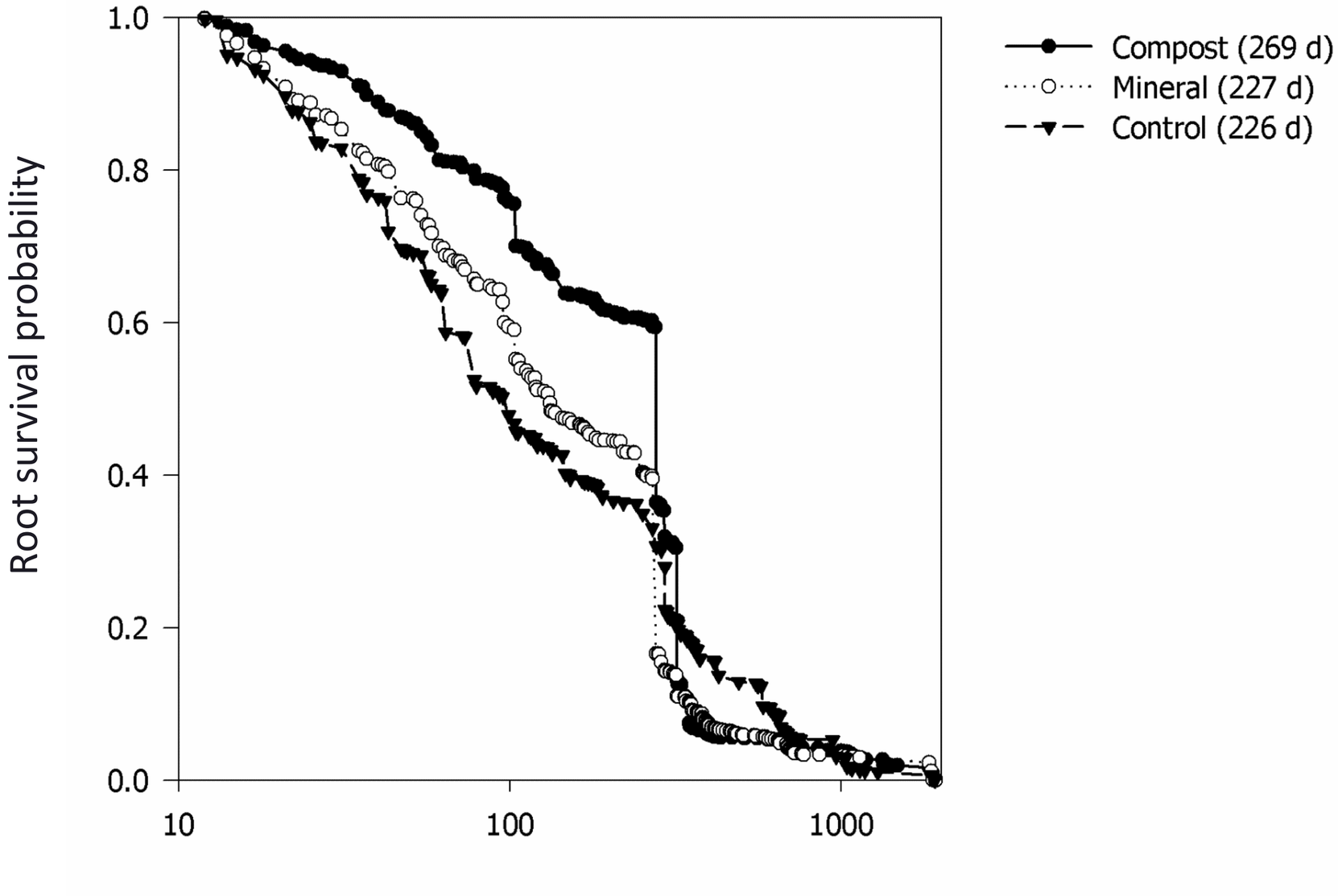

Baldi et al., 2010

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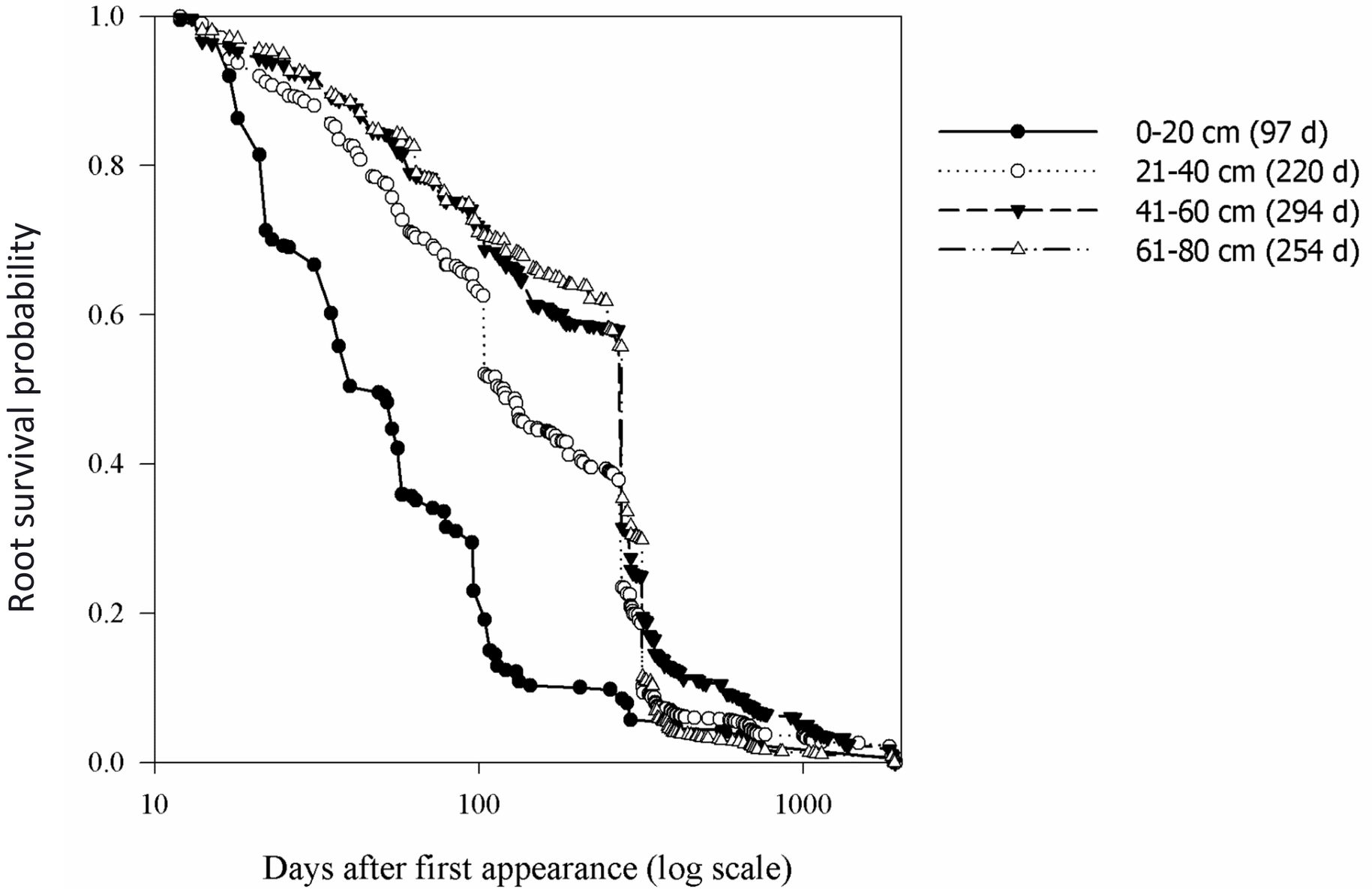
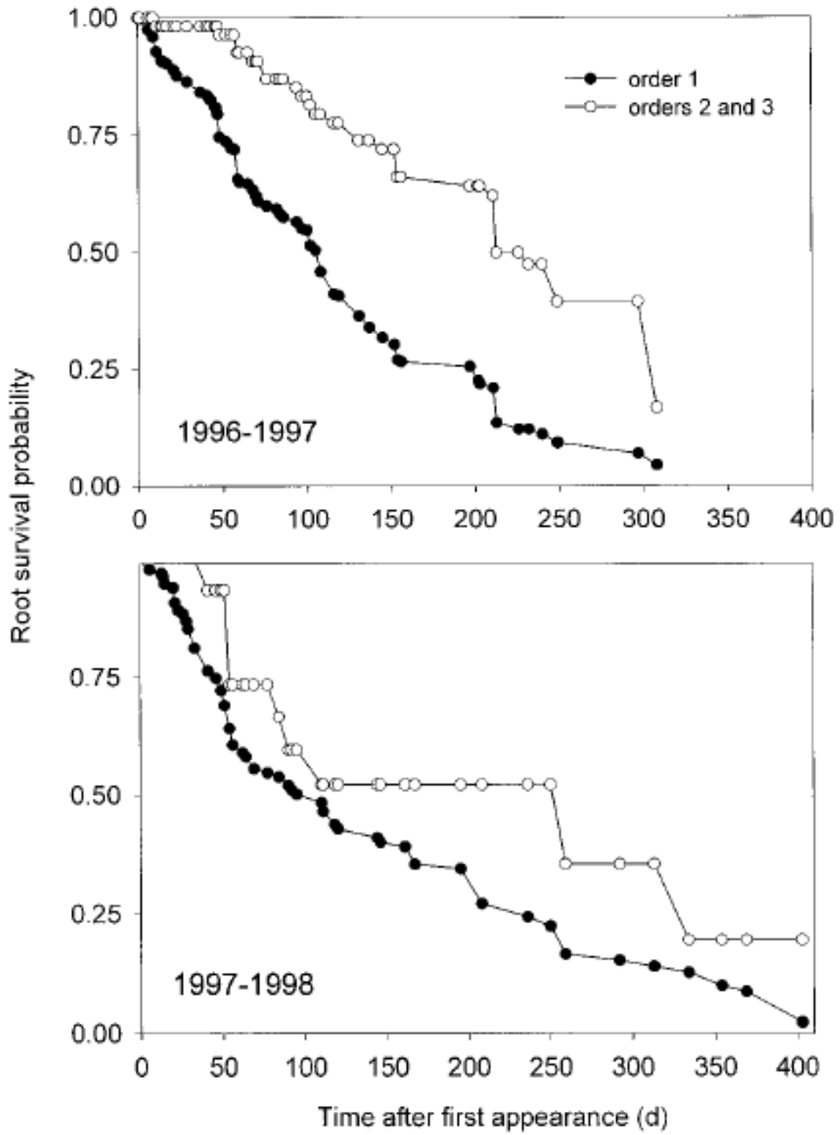


EFFECT OF ROOT ORDER ON SURVIVORSHIP (peach)



Wells et al., 2002

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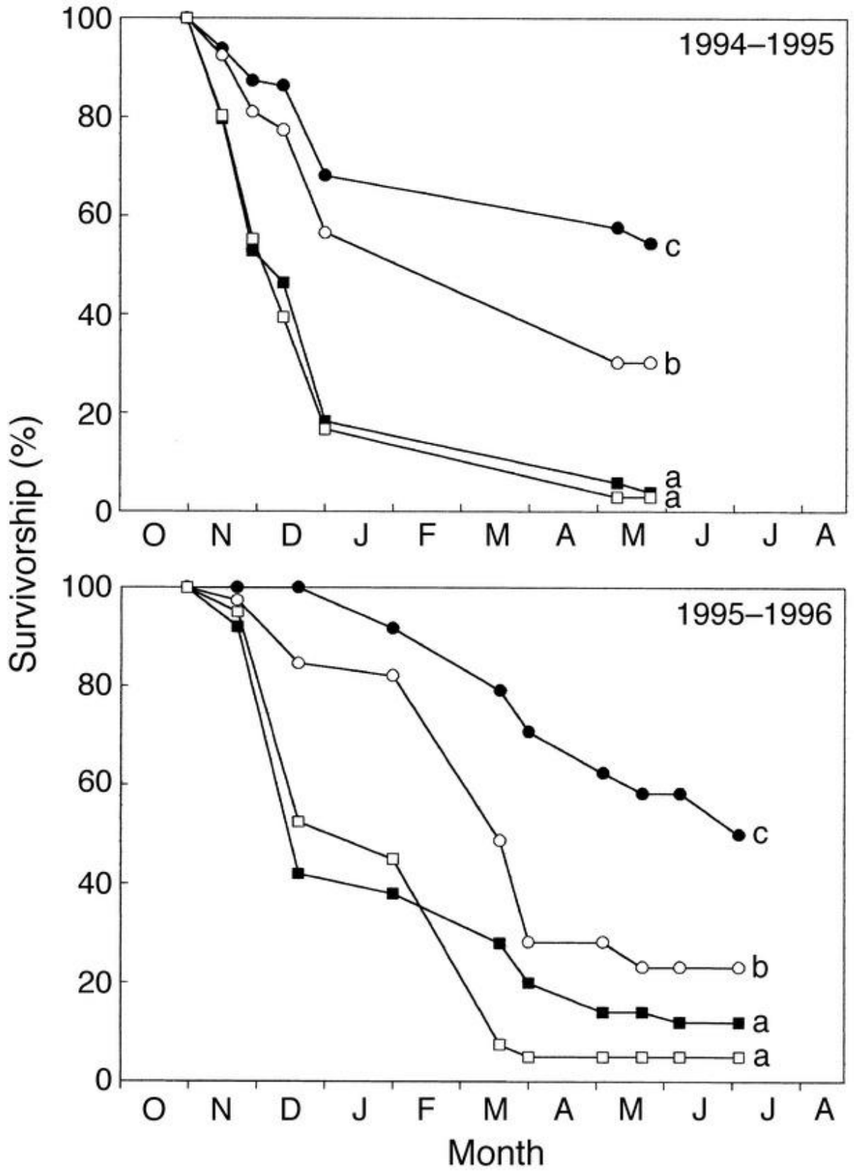
EFFECT OF ROOT DIAMETER ON SURVIVORSHIP (apple)



- 0.1-0.2 mm
- 0.2-0.3 mm
- 0.3-0.5 mm
- 0.5-1.1 mm

Wells and Eisenstat, 2001

MYCORRHIZAL FUNGI FACILITATE NUTRIENTS UPTAKE BY ROOTS

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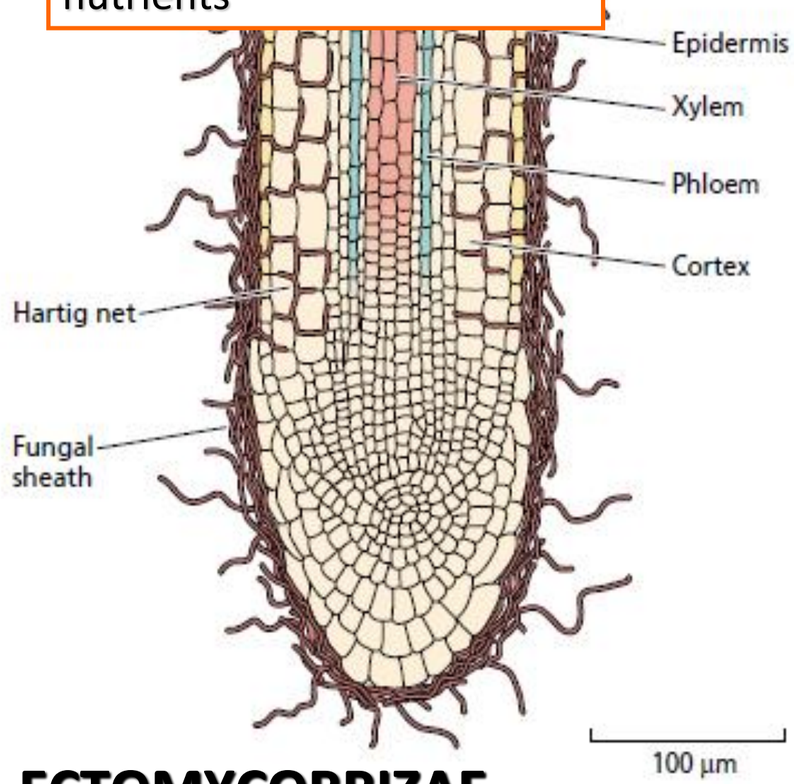
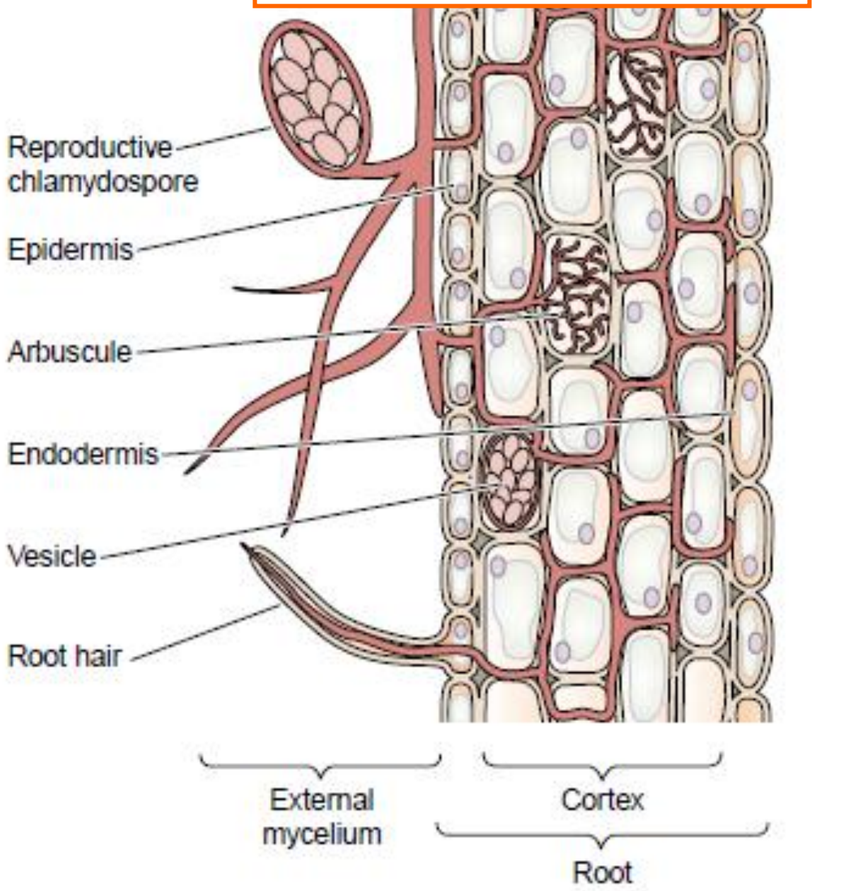
External fungal hypae can easily reach areas rich of nutrients



ECTOMYCORRIZAE

(birch, oak, spruce, pine, fr)

The external mycelium facilitates uptake of P



VESICULAR ARBUSCURAL

(fruit trees, grape)