Establishing new trees – possible impacts of rootstock propagation method on young tree growth

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Rootstock breeding programs

UF/IFAS breeding program

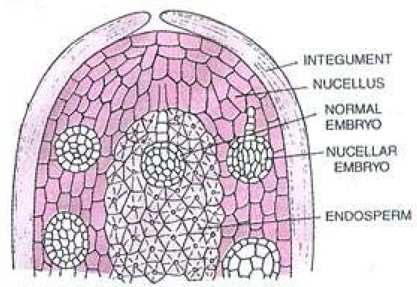
UFR-1, UFR-2, UFR-3, UFR-4, UFR-5, UFR-6, UFR-7, UFR-8, UFR-9, UFR-10, UFR-11, UFR-12, UFR-14, UFR-15, UFR-16, UFR-17, …

USDA breeding program

US-802, US-812, US-897, US-942, US-1279, US-1281, US-1282, US-1283, US-1284, US-1516, …

Rootstock propagation

- Traditionally, rootstock propagation occurs via seed (nucellar embryos).

- Clonal propagation is also possible through use of cuttings or tissue culture (vegetative propagation).


- All methods will yield genetically uniform plants.

Root systems

Tap root system

→ Plants grown from seed

Adventitious-type root system

→ Plants generated from stem cuttings and from tissue culture

Nursery performance

- Inferior root system
- Excessive sprouting
- Bud take
- Epigenetic effects
- Rootstock effects
- Higher costs

Field performance

- Early year survival
- Susceptibility to uprooting
- Water and nutrient uptake

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Number of rootstock propagations 2017 (DPI)

No	Rootstock	Propagations
1	Swingle	582,591
2	X-639	400,536
3	Kuharske	397,555
4	Sour orange	396,911
5	US-942	363,812
6	US-802	298,019
7	US-897	274,433
8	UFR-04	150,429
9	US-942-Tissue culture	119,204
10	US-812	110,274
25	US-897-Tissue culture	6,580
27	US-802-Tissue culture	6,179
28	US-812-Tissue culture	4,733
30	UFR-04-Tissue culture	4,452

Early studies using cuttings

ROOT SYSTEMS OF VARIOUS CITRUS ROOTSTOCKS

1945

E. M. SAVAGE, WILLIAM C. COOPER and R. B. PIPER
Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Dept. of Agriculture, Orlando

INTRODUCTION

Fifteen species and varieties of citrus are now being tested by this station for their value

darin, Morton citrange, Rusk citrange, sweet lime, calamondin, and yuzu (kansu). This paper presents results of a study of the root

Proc. Fla. State Hort. Soc. 89:11-14. 1976.

FIELD PERFORMANCE OF SEVERAL COMMON CITRUS SCIONS ON 'MILAM' ROOTSTOCK[1]

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Additional index words. sweet orange, grapefruit, blight, stem-pitting, burrowing nematode.

the history of the site was obtained from individual cooperators and commercial nursery records.

Measurements were made of tree size and spacing. Fruit samples were collected from each planting for standard analyses. Leaf samples, collected in August, were analyzed for N, P, K, Mg, and Ca (1). Fruit yield was determined by comparing harvest records with three count or by measurement in the plots during commercial harvest. Approx 10%

Proc. Fla. State Hort. Soc. 90:39-44. 1977.

ROOT SYSTEM CHARACTERISTICS OF CITRUS NURSERY TREES[1]

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cm) rows and budded with 'Valencia' (*Citrus sinensis* (L.) Osb.) scion in March, 1976. The trees received commercial care with irrigation provided by a permanent overhead system. Cuttings of the scion were rooted in the greenhouse, established in pots, and set in the nursery in June, 1976.

Six trees of each rootstock and 6 rooted cuttings were selected in February, 1977 for study of their root systems. The excavations were approx 40 to 48 inches (101.6 x 121.9 cm) in width and 24 inches (61 cm) deep. Adjacent trees were also removed when necessary in order to retrieve inter-

Collaborators

Dr. Kim Bowman

Dr. Mireia Bordas

Beth Lamb
Philip Rucks

Nate Jameson
Anna Jameson

USDA ARS

AGROMILLORA

Phillip Rucks Citrus Nursery, Inc.

Brite Leaf Citrus Nursery, LLC

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Plant material

Rootstock	Parentage	Propagation method
Cleopatra	C. reticulata	Seed, cutting
Swingle ★	C. paradisi x P. trifoliata	Seed, cutting, tissue culture (A)
US-802 ★	C. grandis x P. trifoliata	Seed, cutting, tissue culture (A,B)
US-812 ★	C. reticulata x P. trifoliata	Seed, cutting, tissue culture (A)
US-897 ★	C. reticulata x P. trifoliata	Seed, cutting, tissue culture (A,B)
US-942 ★	C. reticulata x P. trifoliata	Seed, cutting, tissue culture (A)
US-1516	C. grandis x P. trifoliata	Seed, cutting, tissue culture (A)
X-639	C. reticulata x P. trifoliata	Seed, cutting, tissue culture (A,B)

Objectives

Short-term (nursery)

- Study the effect of propagation method on root architecture and other traits of nursery-grown plants.
- Investigate potential interaction of propagation method and rootstock.
- Evaluate possible impact on grafting.

Long-term (field)

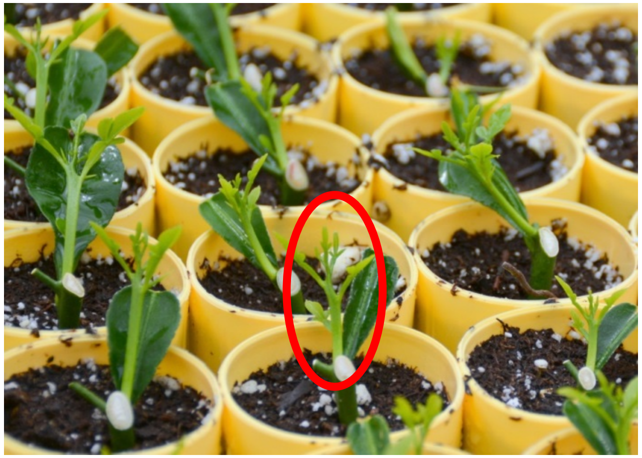
- Evaluate root structure and field performance of citrus trees on rootstocks propagated by different methods.

Propagation by seed

- Seeds were extracted from fruit from seed source trees (Dec 2015).
- Seeds were sown into racks of 3.8 x 21 cm cone cells containing potting mix.
- After germination, plants were irrigated and fertilized using a water-soluble fertilizer (20-10-20).

Propagation by cuttings

- Single node stem cuttings from greenhouse-grown plants were generated.
- Leaves remained on the nodes (reduced to 20-30% of original size).
- Basal ends were dipped into rooting powder (0.3% IBA).
- Cuttings were inserted into potting mix and placed on a mist bench under reduced light conditions until acclimatized.



Propagation by tissue culture

- Starting material: nucellar embryos or buds from foundation trees (DPI).
- Explants were placed on agar-nutrient medium and sub cultured to generate multiple shoot clusters.
- Single shoots were harvested and pre-rooted on agar-nutrient medium or directly rooted in potting medium.
- Plants were acclimatized under gradually reduced high humidity conditions.

Photo credit: Beth Lamb, Phil Rucks Nursery, Frostproof, FL

Propagation by tissue culture

Agromillora, Wildwood, FL

Time of assessment

- Time of assessment ranged from 8-18 weeks after planting into potting medium (depending on propagation method and rootstock vigor).
- Plants were assessed at a height of 22-25 cm.

Plant parameters assessed

- Plant biomass distribution
- Shoot to root ratio
- Number of primary and lateral roots
- Specific root length

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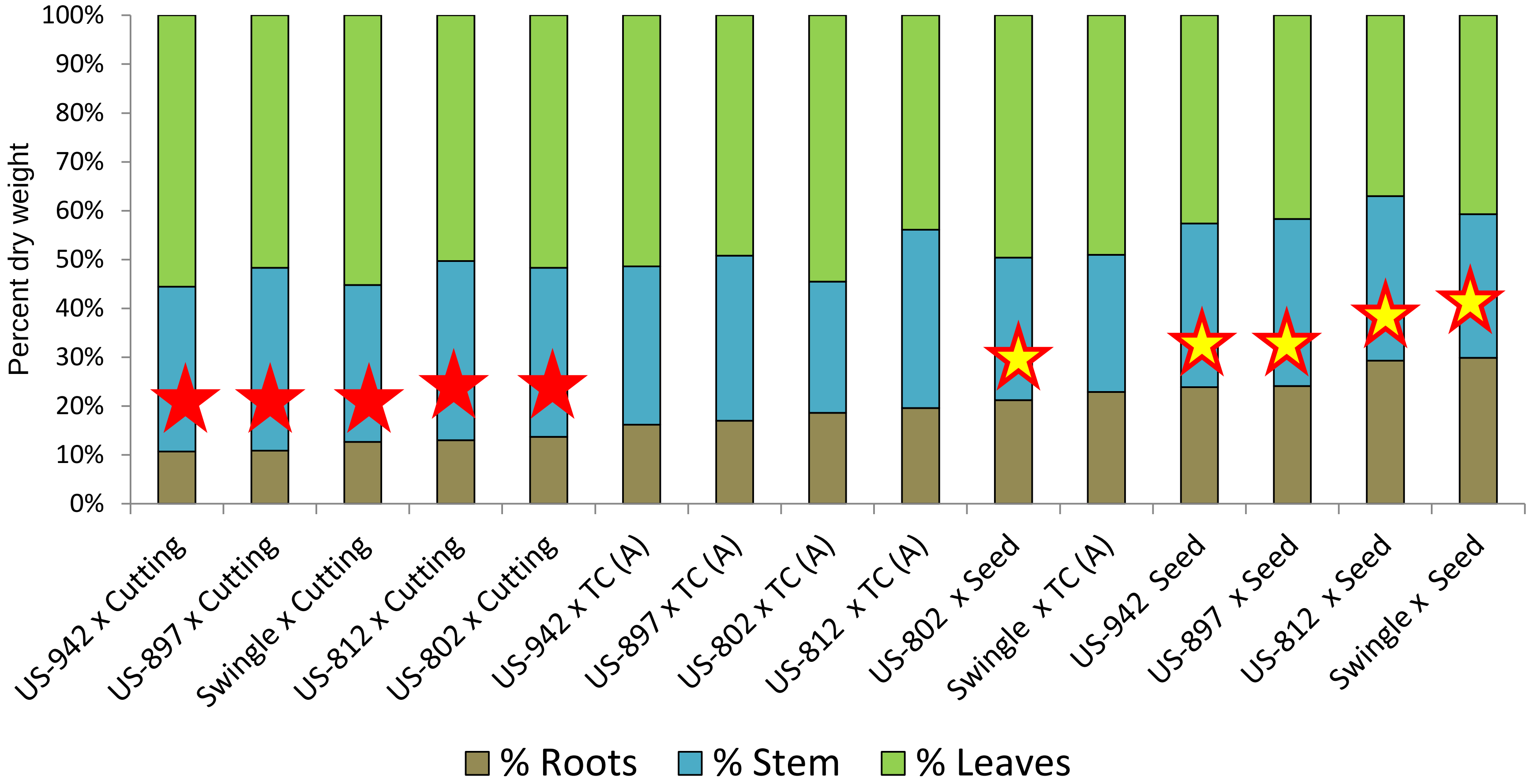
Biomass distribution



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Shoot to root ratio

		N	Shoot to root ratio
Propagation method	Cutting	30	7.5 a
	Tissue culture	30	4.5 b
	Seed	30	3.0 c
			P < 0.0001
Rootstock	US-942	18	5.6 a
	US-897	18	5.6 a
	US-802	18	4.9 ab
	US-812	18	4.6 b
	Swingle	18	4.2 b
			P = 0.0008
Rootstock x propagation method			P = 0.0777

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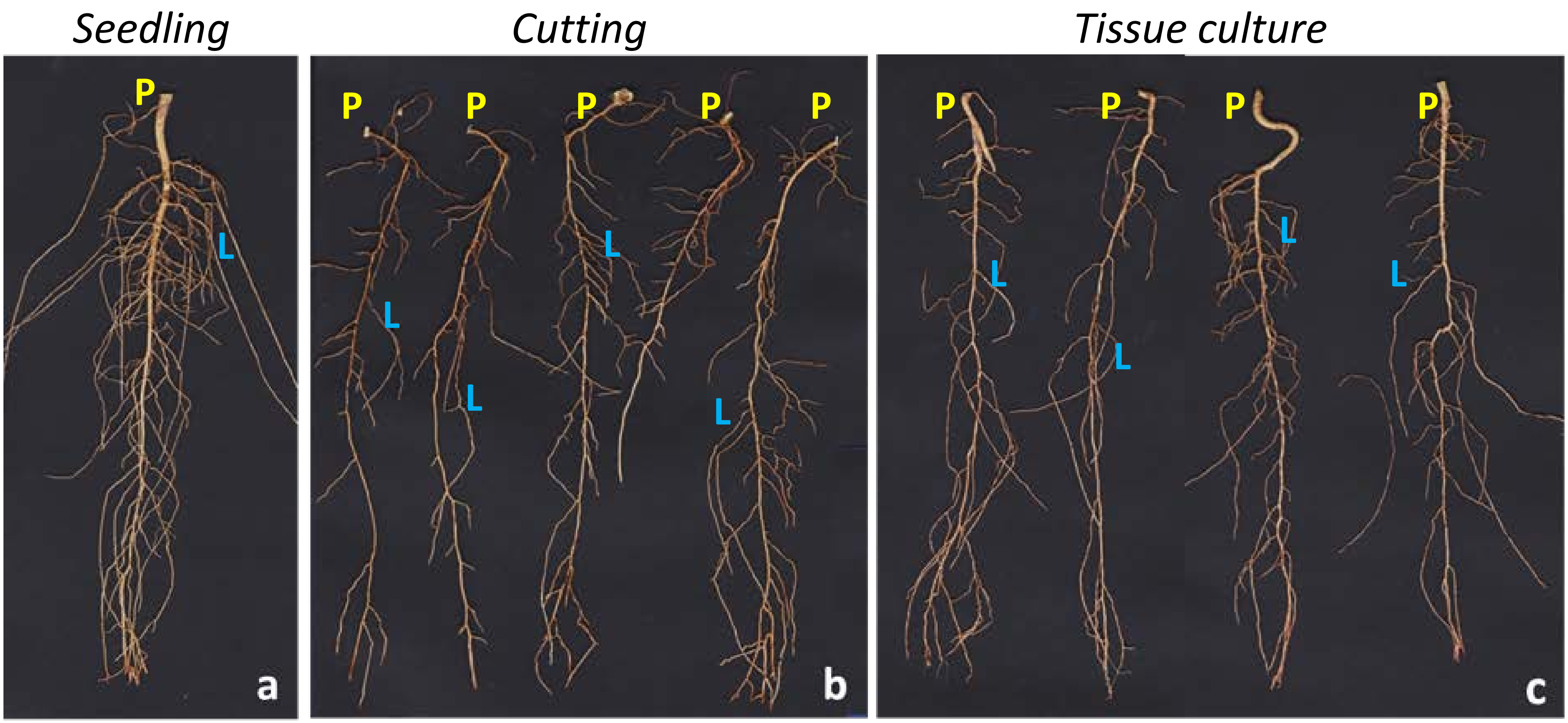
Biomass distribution & Shoot to root ratio

What does it mean?

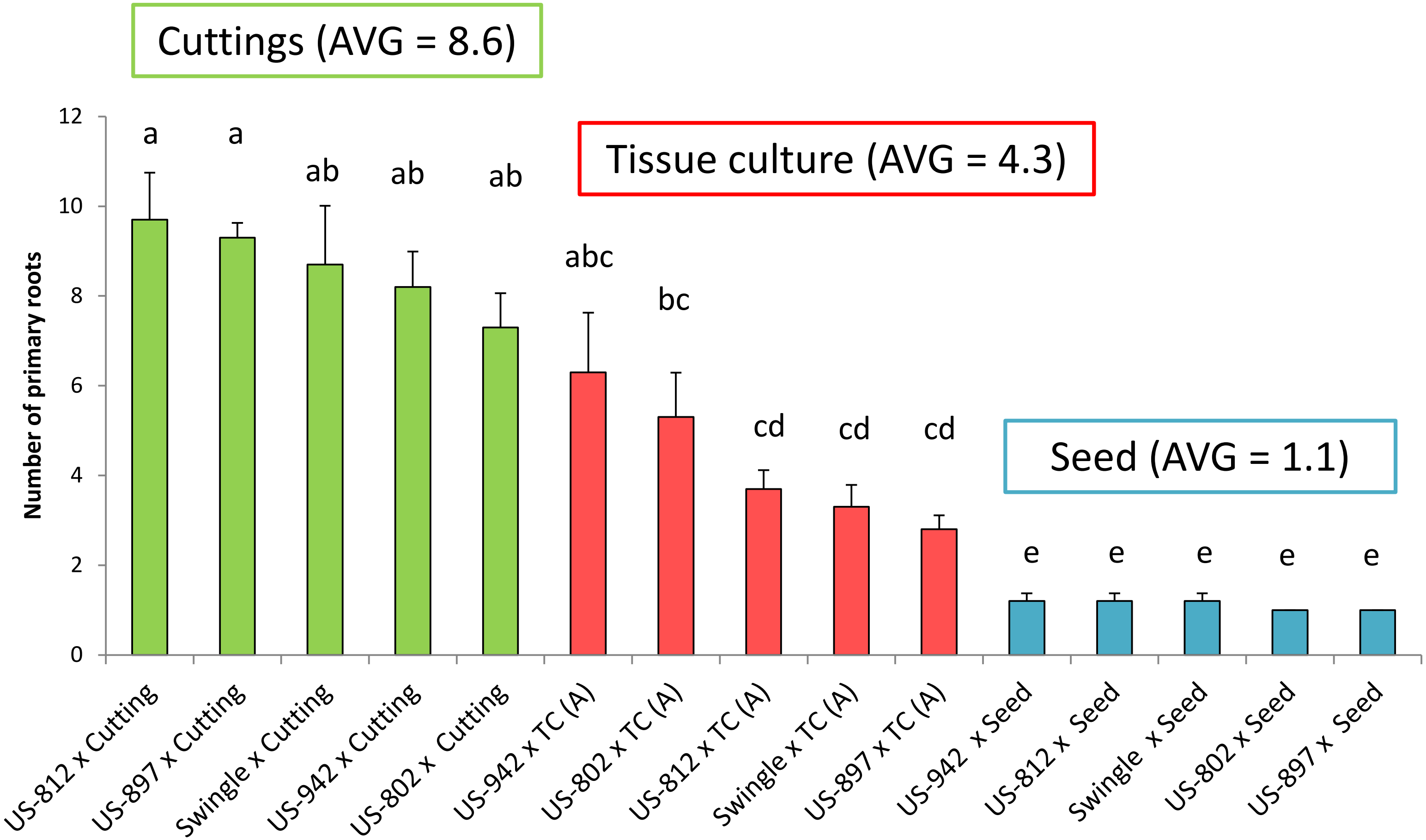
- Studies on different plant systems found a positive linear relationship between shoot to root ratio and the **internal nutrient status** of plants.
- The lower relative root mass and higher shoot to root ratio of plants from stem cuttings and tissue culture suggests a **high efficiency** of their root system.

Root architecture



Traits assessed:
- Number of primary roots (P)
- Number of lateral roots (L)
- Specific root length (m/g)

Primary roots



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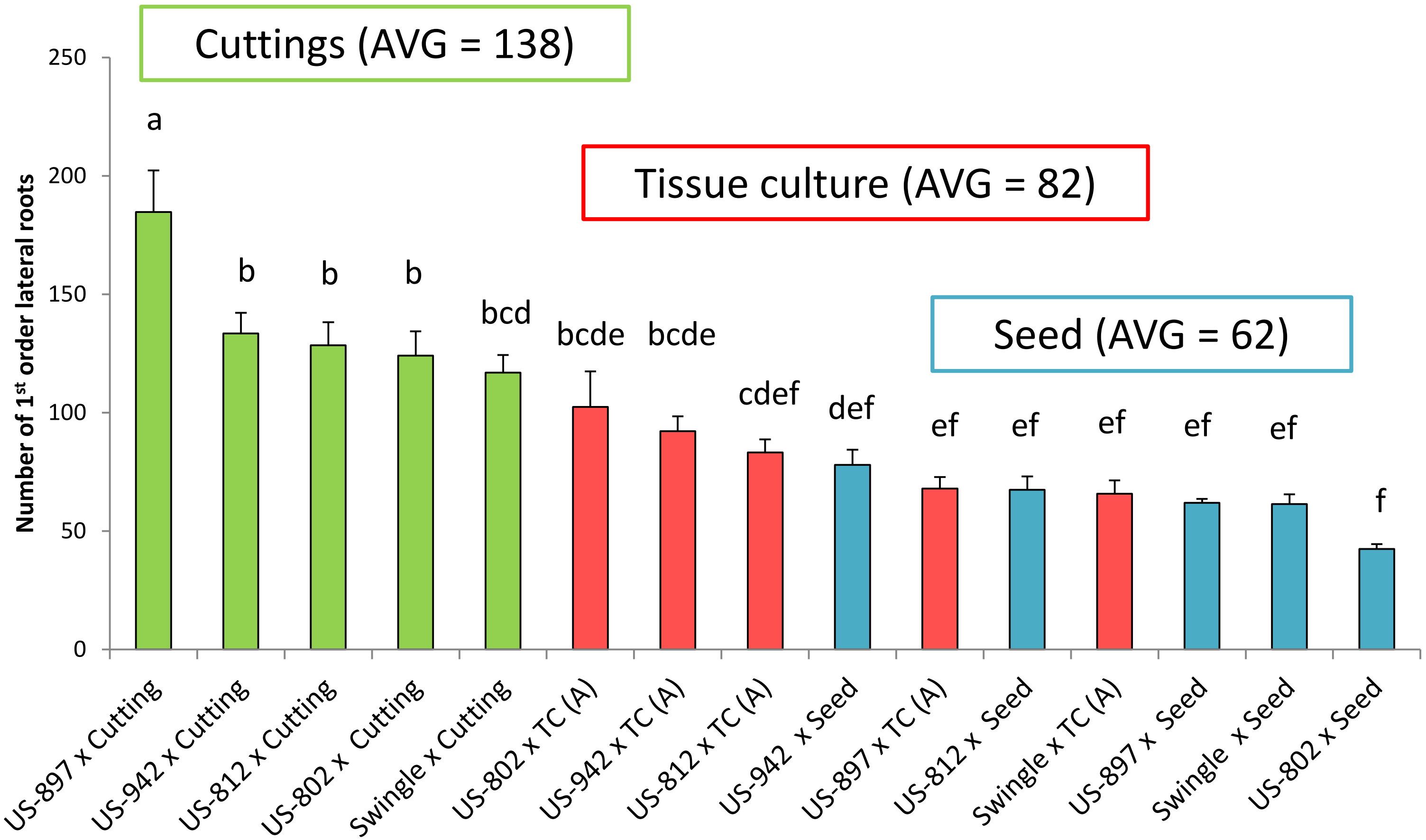
Lateral roots



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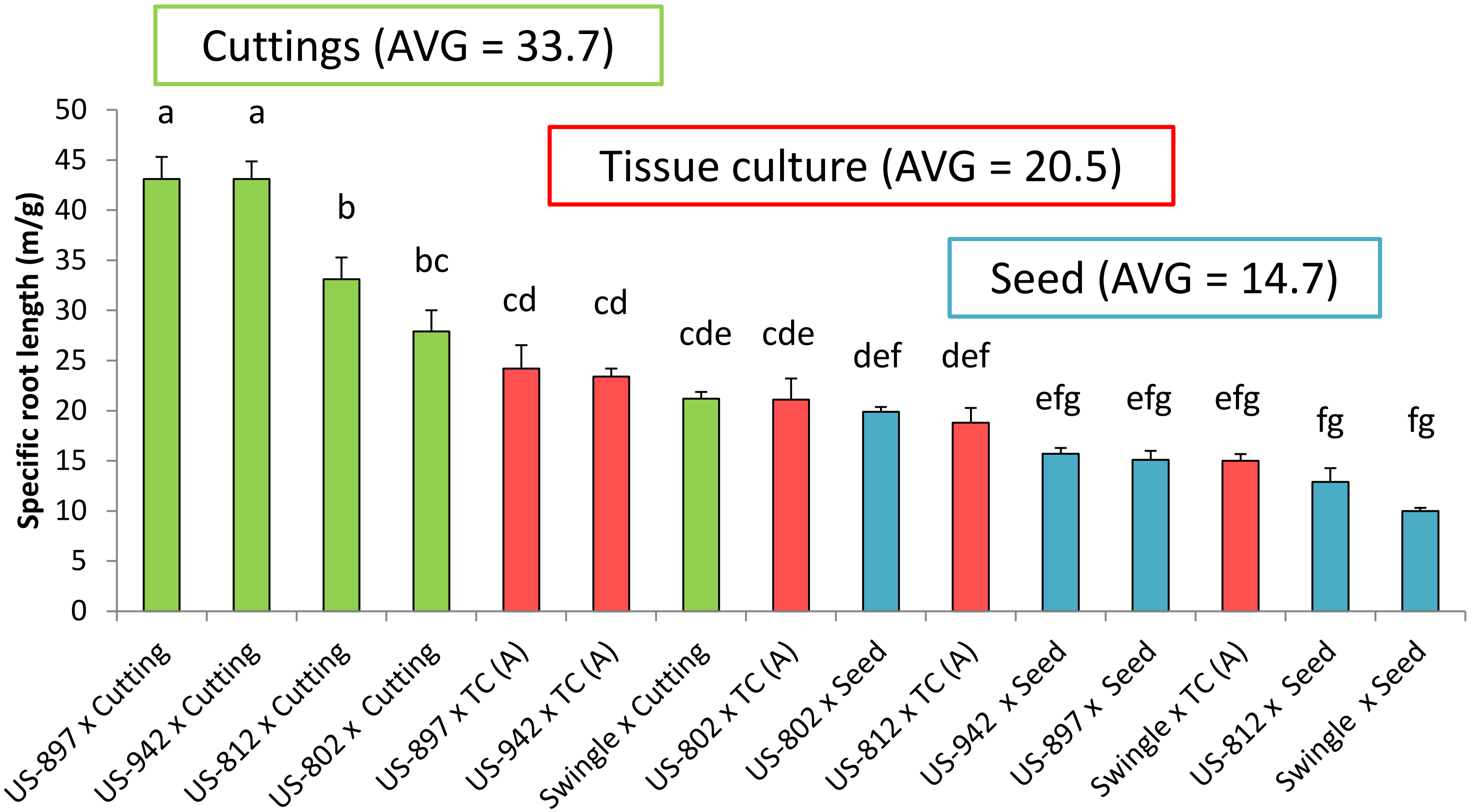
Specific root length (m/g)



Significant correlation with number of primary roots and number of lateral roots.

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Specific root length (SRL)

What does it mean?

- SRL provides a ratio of a standard unit of acquisition (root length) to resource investment (mass).
  → **High SRL = High Benefit Cost Ratio**

- Plants with high SRL build more root length for a given dry-mass investment and are generally considered to have **higher rates of nutrient and water uptake**, shorter root lifespan and **higher relative growth rates** than for low SRL plants.

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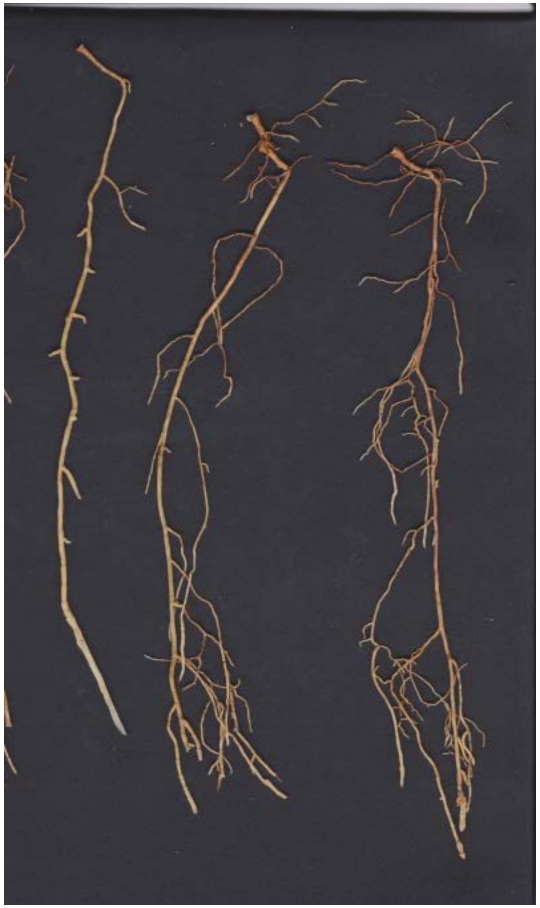
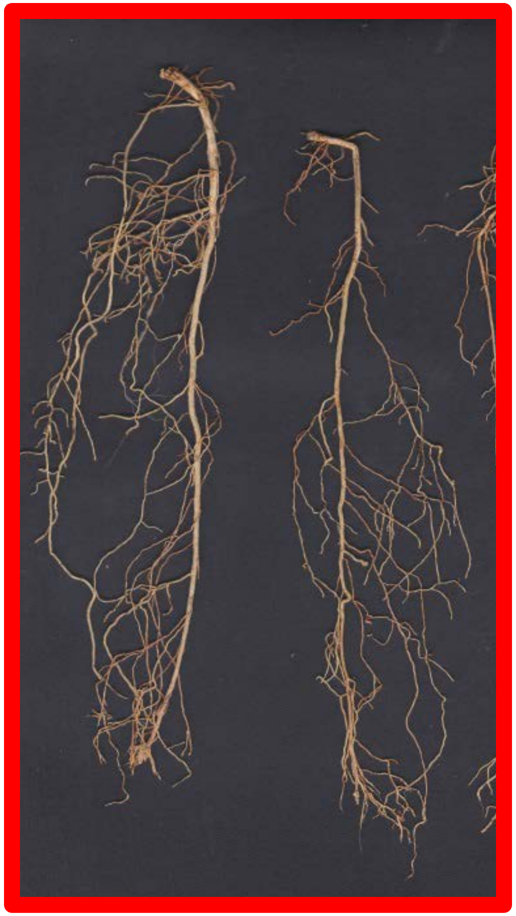
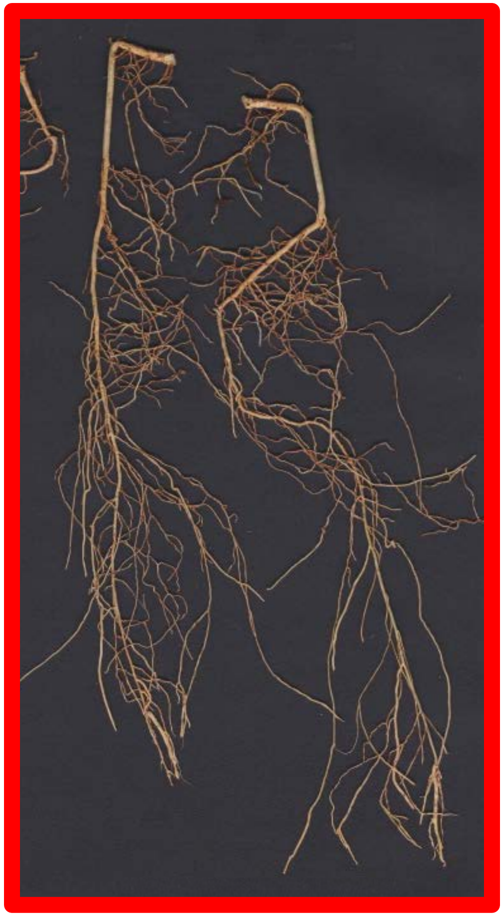
Rootstock effect



Swingle



US-897



US-942

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Summary

- Considerable differences in root architecture and biomass distribution were found not only based on **propagation method**, but also based on **rootstock**.
- Trend for higher shoot to root ratio, larger number of fine lateral roots, and higher SRL for plants propagated by cuttings and tissue culture compared with seedlings.

► Vegetatively propagated rootstocks appear to have a more **efficient root system** for uptake of nutrients and water compared with seed-grown rootstocks (at least at the early stages of development).

Possible implications for field performance?

Studies on other woody tree crops

Comparisons of growth of *Eucalyptus camaldulensis* from seeds and tissue culture: root, shoot and leaf morphology of 9-month-old plants grown in deep sand and sand over clay

David T. Bell[a], Paul G. van der Moezel[a,1], Ian J. Bennett[b,2], Jennifer A. McComb[b], Carol F. Wilkins[a], Simeon C.B. Marshall[a] and Anne L. Morgan[a]

[a]*Department of Botany, The University of Western Australia, Nedlands, W.A. 6009, Australia*
[b]*School of Biological and Environmental Sciences, Murdoch University, Murdoch, W.A. 6150, Australia*

- Strong morphological differences were found between different **genotypes**, but **no architectural differences**, above- or below-ground, were attributable to micropropagation.

Studies on other woody tree crops

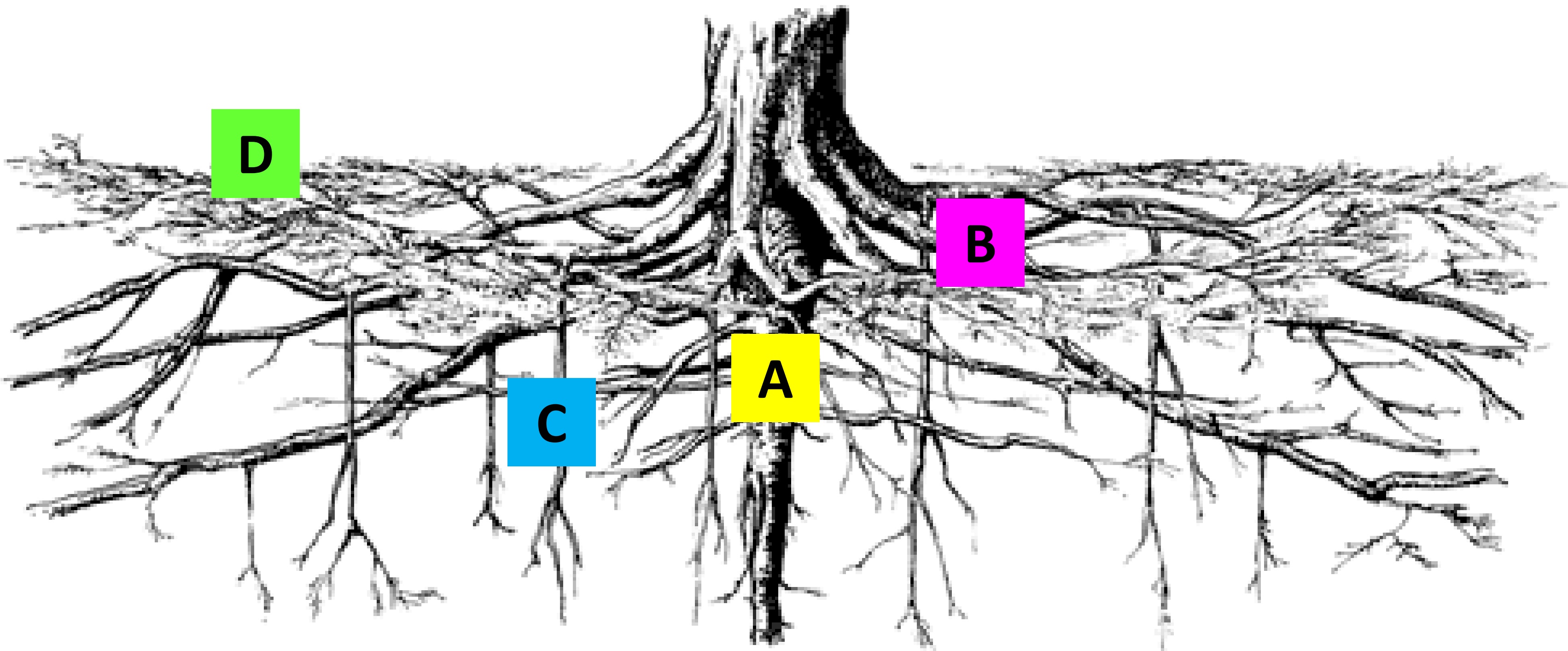
New Forests **16:** 251–264, 1998.

Propagation method influences first year field survival and growth of *Paulownia*

BEN A. BERGMANN
Department of Forestry, North Carolina State University, Campus Box 8002, Raleigh NC 27695-8002, USA

- **Shoot cuttings** and **micro-propagated** plants may be **preferred over seedlings** because they had greater survival, height, and trunk diameter after one year in the field.
- Field survival and growth depends on the **selection of superior clones**, particularly under unfavorable soil conditions.

Typical architecture of a woody tree



A <u>Tap root</u> - provides main support and anchorage

B <u>Lateral roots</u> - spread horizontally and help support and anchor the trunk

C <u>Sinker roots</u> - grow downward from lateral roots.

D <u>Fibrous roots</u> - masses of fine feeding roots close to ground surface

Source: Greenbeltconsulting.com


East coast


Ridge
Photo credit: Chris Oswalt

Conclusions

- The root architecture and anchorage in the upper zone of the soil will be the most critical factor in the susceptibility of citrus trees to wind-induced damage.
- Trees on rootstocks propagated by cuttings or tissue culture are not expected to be inferior to trees on rootstocks grown from seed.

✓ **Selection of rootstocks best adapted for a particular soil type/environment is critical!**

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Questions?

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