

Crop Growth

Root Growth and Development

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Roots: The Hidden Half

Crop growth and Development and Environment

The Roots, the Hidden Half

- ✓ Temporal trends in root growth and development
- ✓ Effects of environmental factors on root growth and development.

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Temporal Trends in root growth, development and distribution

Maize

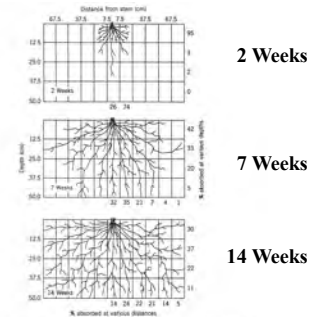


Figure 1.6. Expansion of a maize root system growing in a clay loam soil, based on the spatial distribution of phosphorus placed at the soil at various depths and distances horizontally from the seedling. Numbers at left are percentages of total P absorbed from various depths, those across the bottom are percentages absorbed at various distances horizontally from the seedling. From Koenig (1943), after Hall et al. (1971).

Environment - Crop Root Growth Temporal Trends in Root Growth and Development

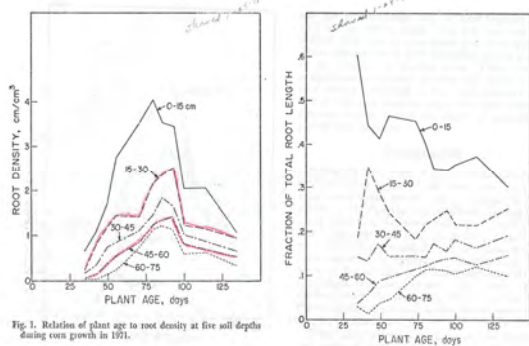


Fig. 1. Relation of plant age to root density at five soil depths during corn growth in 1971.

Environment - Crop Growth Root Growth and Developmental - Mass Partitioning - Acock

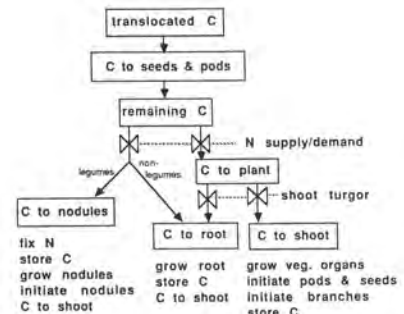


Fig. 4-5. A hypothetical scheme for partitioning C between organs on plants.

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Effect of Soil Temperature on Root Growth *Pinus* seedlings

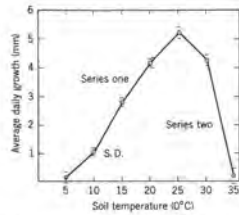


Figure 5.20 Relationship between soil temperature and root elongation of *Pinus taeda* seedlings under controlled conditions. From Kramer (1983), after Barney (1951).

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Root Weight

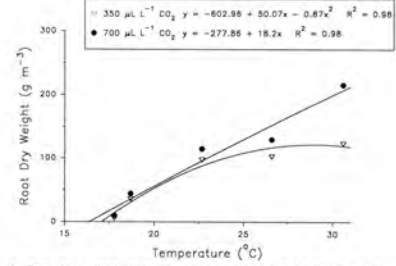


Fig. 1. Root dry weight of cotton plants as influenced by [CO₂] and temperature harvested at 70 DAE.

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Root Numbers

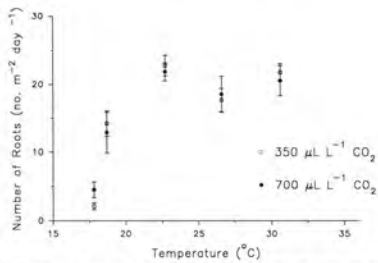


Fig. 2. The average number of roots produced on the glass face over the season as influenced by [CO₂] and temperature treatments.

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Root Growth Rate

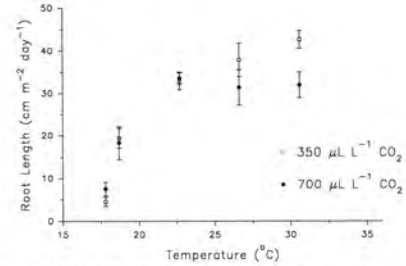


Fig. 3. The average root length visible at the vertical glass face over the season as influenced by [CO₂] and temperature treatments.

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Root Growth Rate

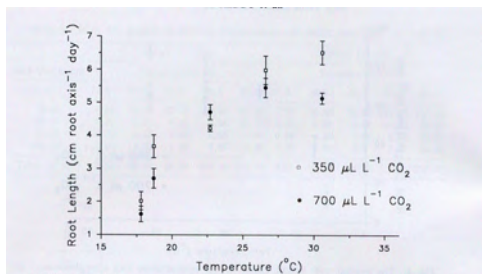


Fig. 4. The average root length per root axis at the vertical soil/glass interface over the season as influenced by [CO₂] and temperature treatments.

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Competition between plants

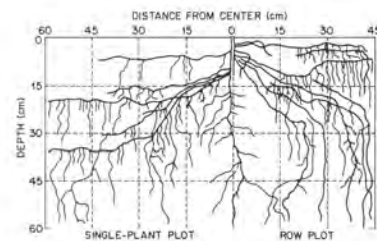


Figure 5.21 Difference in lateral root extension of an isolated soybean root system (left side) and that of a plant growing in a row. From Kramer (1983), after Kaper and Barber (1970a).

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Soil compaction and root growth, development and distribution

11 week-old oat plants



Figure 3.18. Effect of a compacted layer of soil on root penetration by 11-week-old oat plants. Right: Uncompacted soil with 30 cm layer of tilled soil above the compacted layer. The low density of (light) colored penetration of roots into soil beneath the tillage to a depth of 50 cm. The extension of root penetration was caused by mechanical disturbance in previous soil use. Source: Figure 3.18. From Reader (1995). Courtesy of B. B. Dalman, Commercial Agricultural Extension Station.

Wilted Maize in Flooded Field:

Deficient aeration of soil root not only reduces root growth but also reduces the absorption of water and minerals.

The decrease in water absorption is caused chiefly by an increase in the resistance to radial movement into roots, but a decrease in the osmotic driving force (probably resulted a decreased uptake of salt).

There are wide differences among species of plants with respect to the effects of flooding on water absorption.



Figure 4.10. Wilted maize in a flooded field. Water is standing between the rows which were flooded for 3 weeks. Photograph by J. S. Boyer.

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Water and Root and Shoot Growth



Figure 2.10. Soybean seedling germinated in the dark and transferred either to non-saline over-saturated aqueous water (1X) or brackish water (2X). The 18-h, reversible control one-night of the roots in the 1X or non-saline brackish water potential of -0.12 MPa compared to -0.25 MPa in the 2X control. Note the marked inhibition of stem (hypocotyl) growth for the line 2 days in 2X brackish water followed by a marked reversion of growth. Roots continued to develop as fast as 18-h as at 1X.

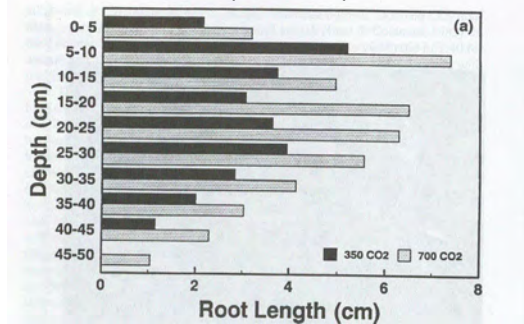
Environment - Crop Growth Root Growth and Developmental Responses to CO₂



Fig. 1-1. Photographs of 18-d-old soybean plants grown at (a) 350 $\mu\text{mol mol}^{-1}$ and (b) 700 $\mu\text{mol mol}^{-1}$ CO₂. Photographs show the median plant, based on root length, for each treatment (Rogers et al., 1992a).

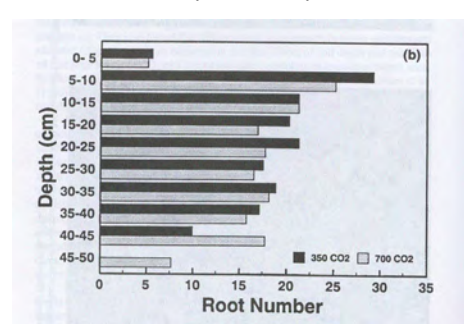
Environment - Crop Growth Root Growth and Developmental Responses to CO₂

Soybean, 18 days old



Environment - Crop Growth Root Growth and Developmental Responses to CO₂

Soybean, 18 days old



Environment - Crop Growth
Root Growth and Developmental – Mass Partitioning - Cotton

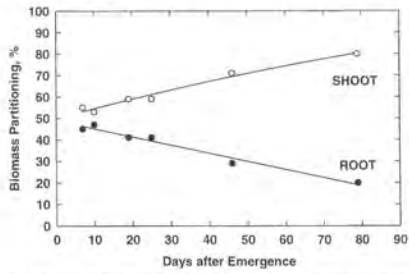


Figure 16 The effect of plant age on biomass partitioning of biomass to roots and aboveground parts (Hodges *et al.*, 1993).

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Root Growth and Developmental – Mass Partitioning - Cotton

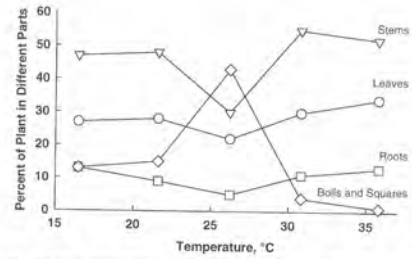


Figure 17 The role of temperature on cotton plant partitioning among different organs (V. R. Reddy *et al.*, 1991).

Environment - Crop Root Growth and Development
Concluding Remarks

- Progress has been made in recent years in understanding crop root growth and developmental responses to environmental stresses.
- However, quantitative relationships between root growth and developmental responses and environmental stresses are still inadequate.
- New techniques are needed to quantify the responses.
- Models systems may be useful to test hypothesis and validate certain assumptions.

New Systems are Coming,
but Challenges are also Present

- Root images – WinRHIZO dual Scan optical scanner (Regent Instruments Inc., Quebec, Canada)



18-day old corn at 3 Temp.

- Images were analyzed using WinRHIZO Pro Software:

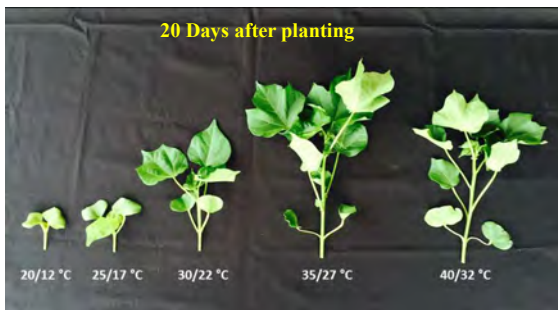
- ✓ Cumulative root length
- ✓ Root surface area
- ✓ Average root diameter
- ✓ Root length per volume
- ✓ Root volume
- ✓ Root numbers
- ✓ Roots with laterals
- ✓ Root tips
- ✓ Root forks
- ✓ Root crossings

- Simulation models for root systems



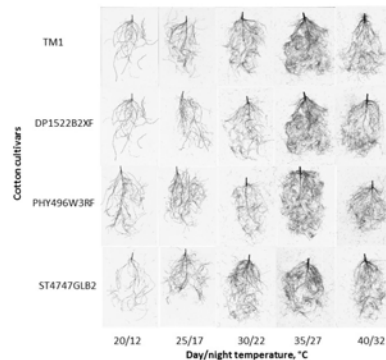
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Shoot Growth and Developmental - Cotton

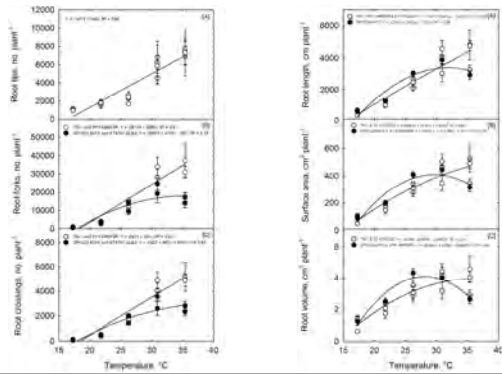


Day/Night Temperature Treatments

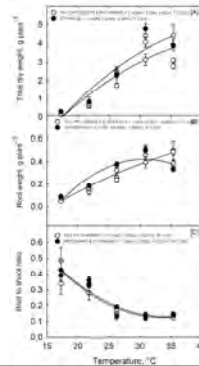
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doi:10.2134/agronj2016.07.0439