

# Crop Growth

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## 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.

# Environment - Crop Growth

## Root Growth and Development

**Temporal Trends  
in root growth,  
development and  
distribution**

**Maize**

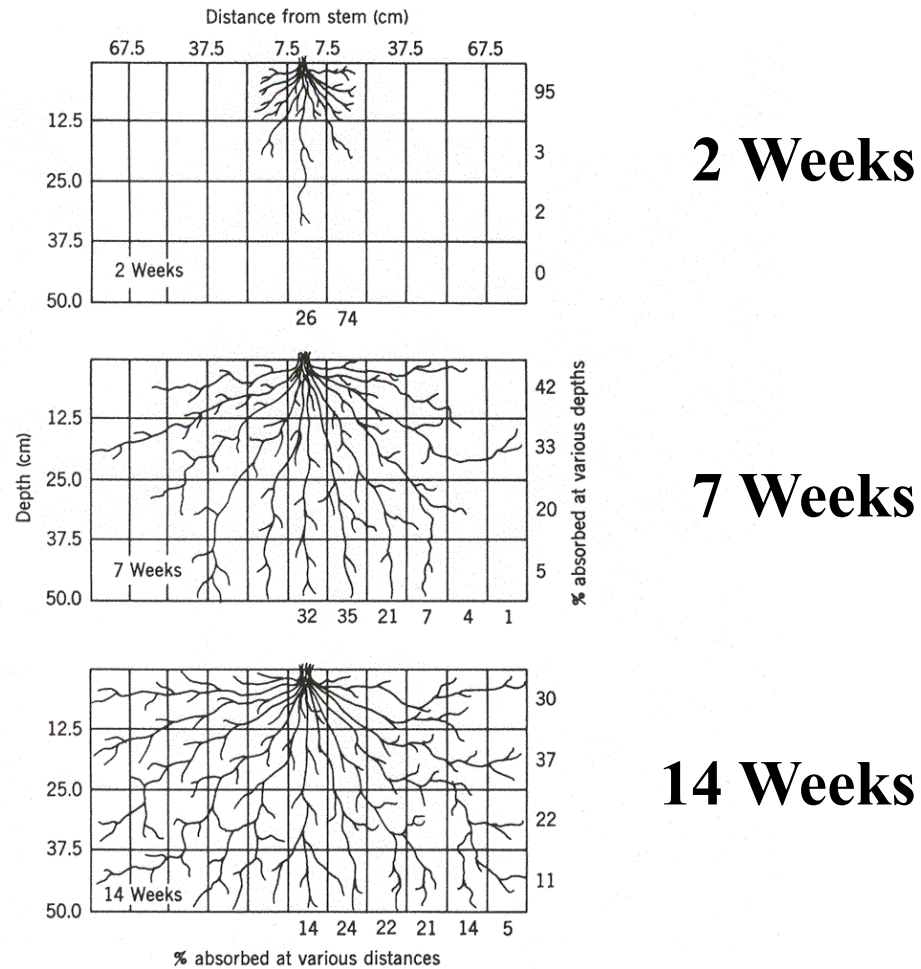


Figure 5.6 Expansion of a maize root system growing in a clay loam soil, based on the uptake of radioactive phosphorus placed in the soil at various depths and distances horizontally from the seedlings. Numbers at right are percentages of total  $^{32}\text{P}$  absorbed from various depths, those across the bottom are percentages absorbed at various distances horizontally from the seedlings. From Kramer (1983), after Hall *et al.* (1953).

# Environment - Crop Root Growth

## Temporal Trends in Root Growth and Development

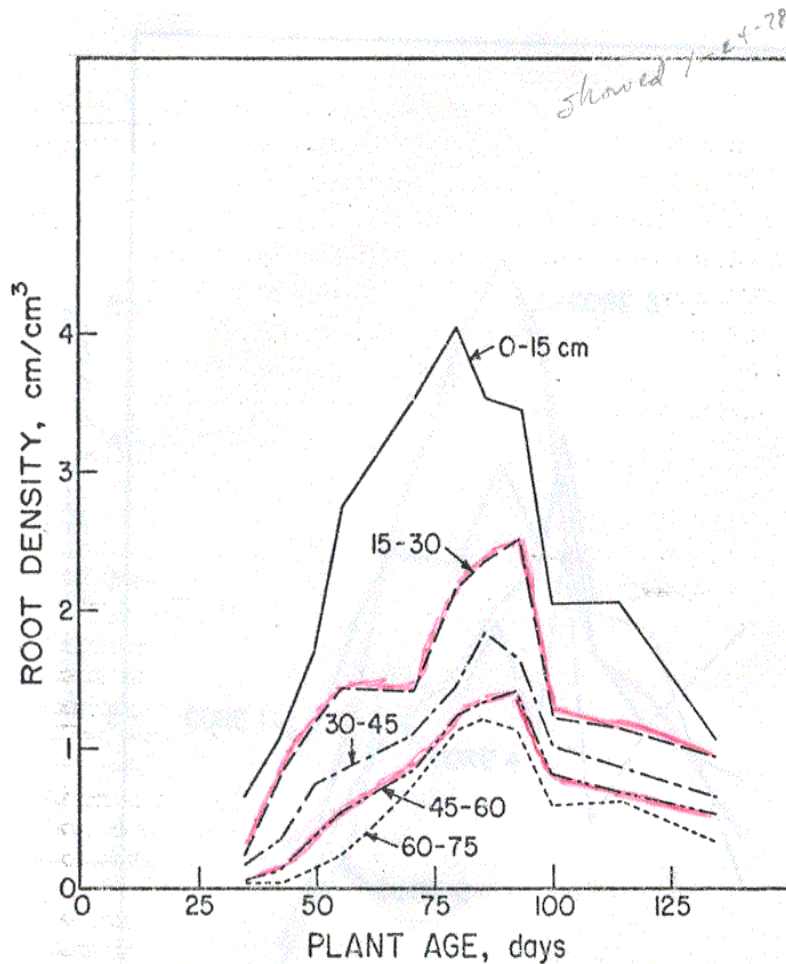
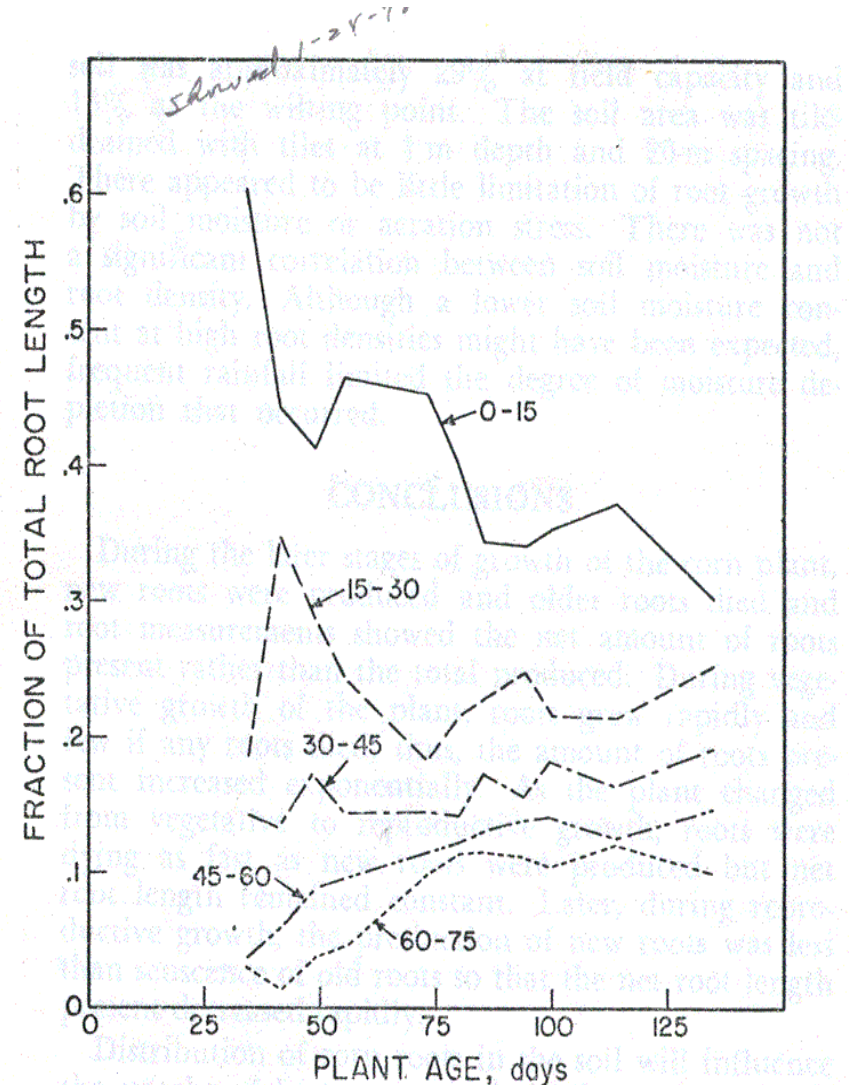


Fig. 1. Relation of plant age to root density at five soil depths during corn growth in 1971.



# Environment - Crop Growth

## Root Growth and Developmental – Mass Partitioning - Acock

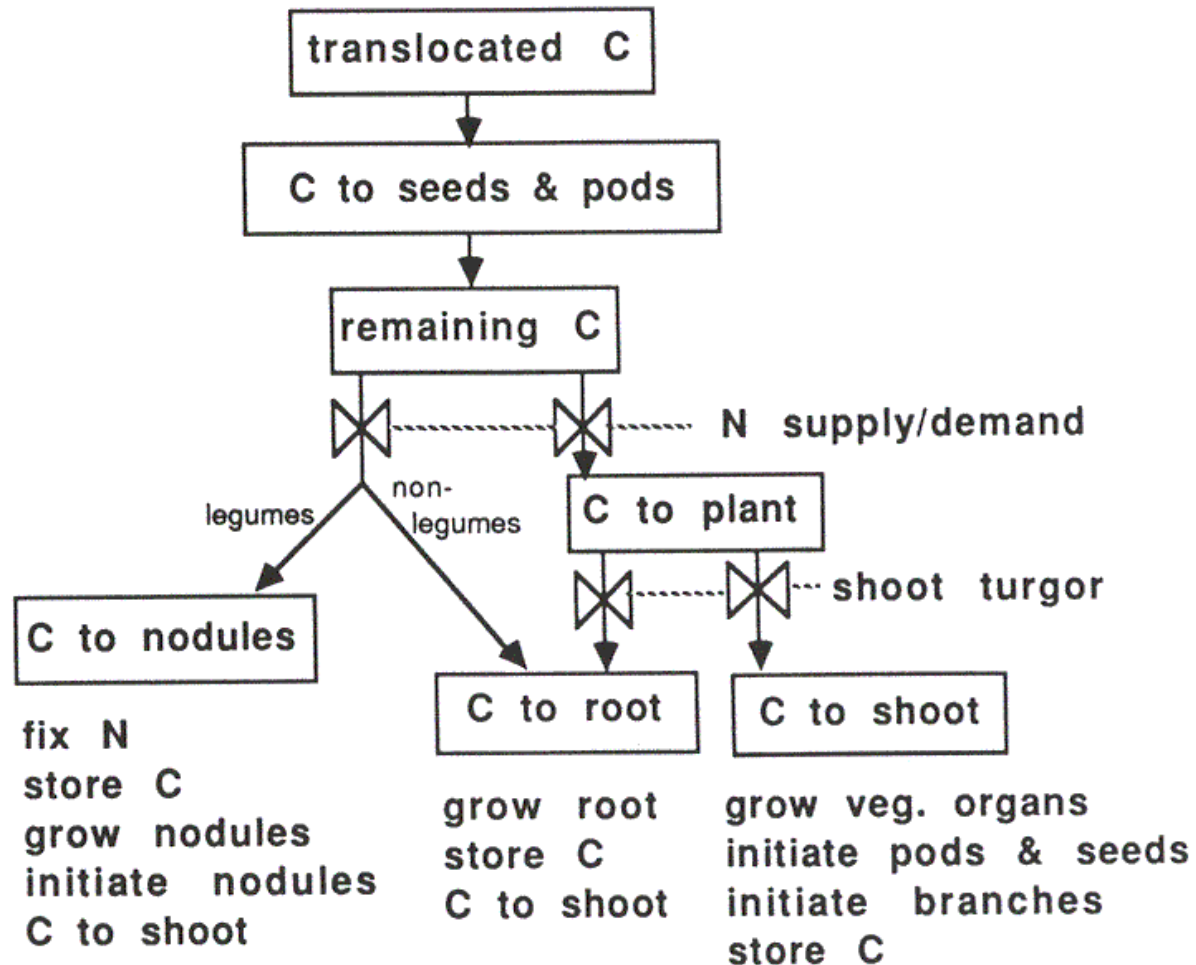


Fig. 4-5. A hypothetical scheme for partitioning C between organs on plants.

# Environment - Crop Growth

## Root Growth and Development

### Effect of Soil Temperature on Root Growth

#### *Pinus* seedlings

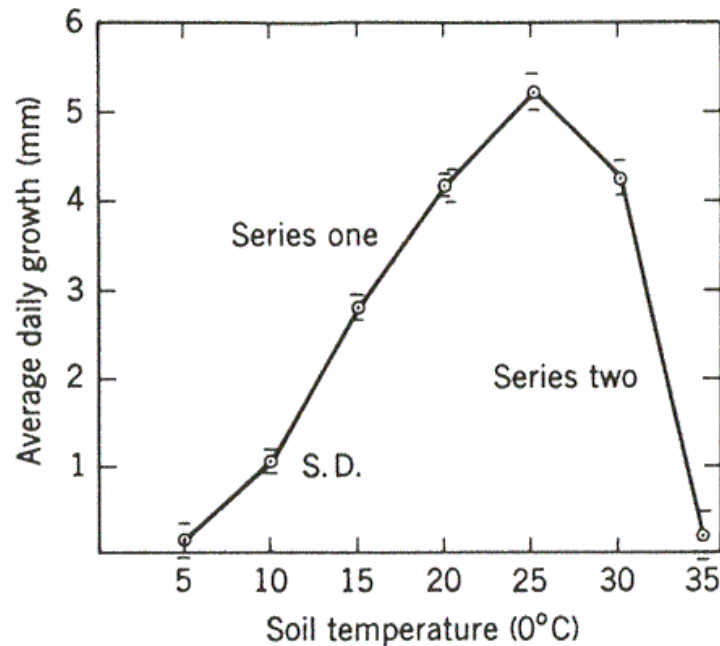


Figure 5.20 Relationship between soil temperature and root elongation of *Pinus taeda* seedlings under controlled conditions. From Kramer (1983), after Barney (1951).

# Environment - Crop Growth

## Root Growth and Development

### Root Weight

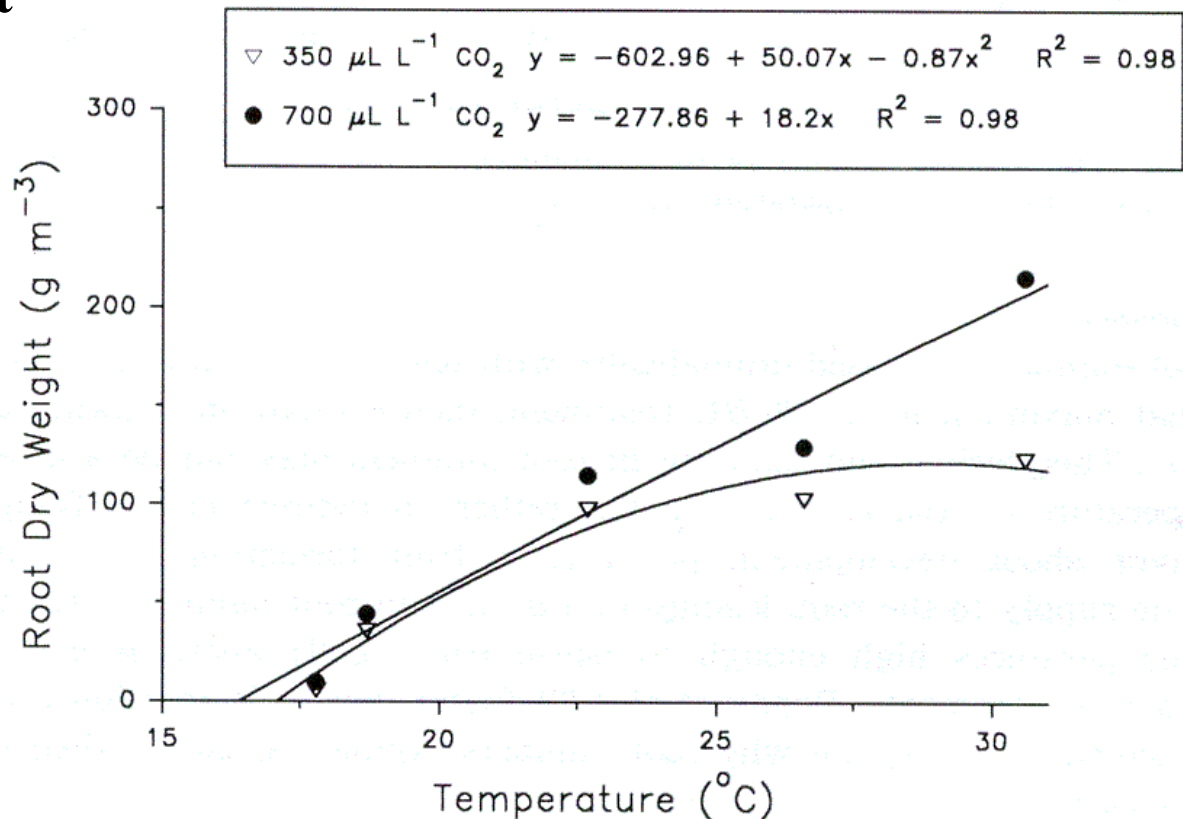


Fig. 1. Root dry weight of cotton plants as influenced by  $[\text{CO}_2]$  and temperature harvested at 70 DAE.



# Environment - Crop Growth

## Root Growth and Development

### Root Numbers

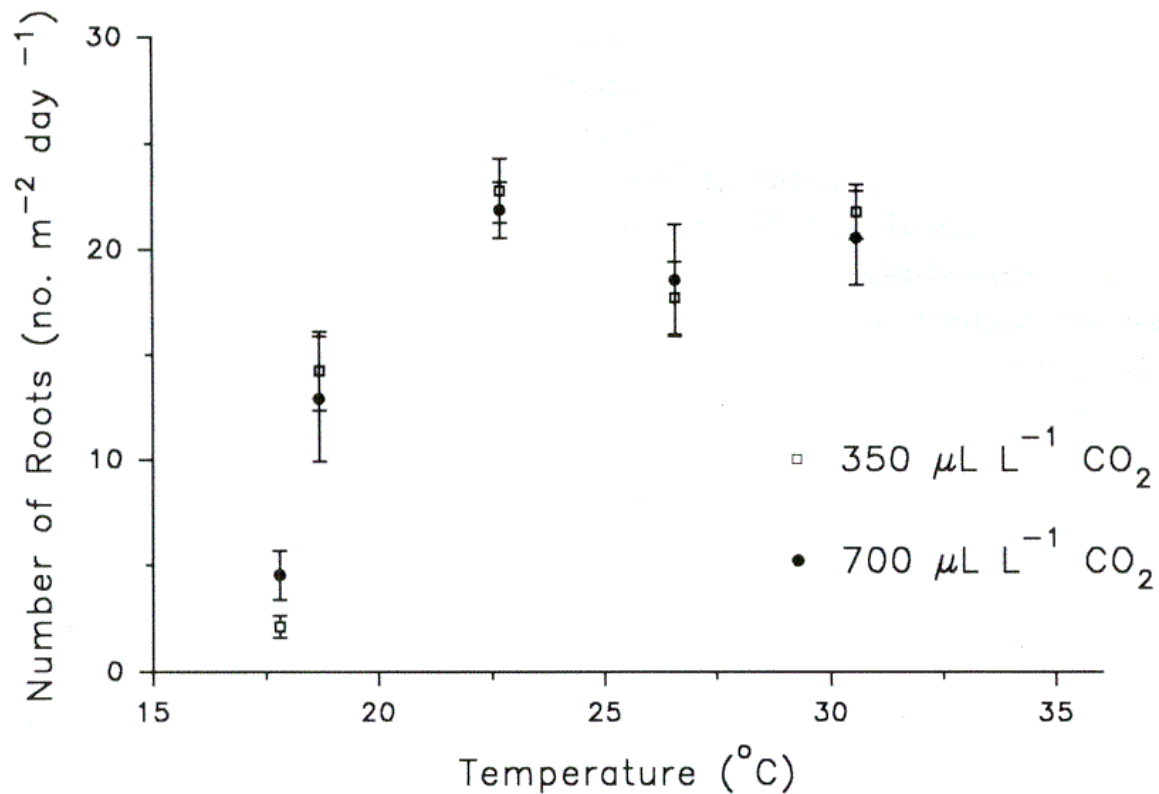


Fig. 2. The average number of roots produced on the glass face over the season as influenced by [CO<sub>2</sub>] and temperature treatments.

# Environment - Crop Growth

## Root Growth and Development

### Root Growth Rate

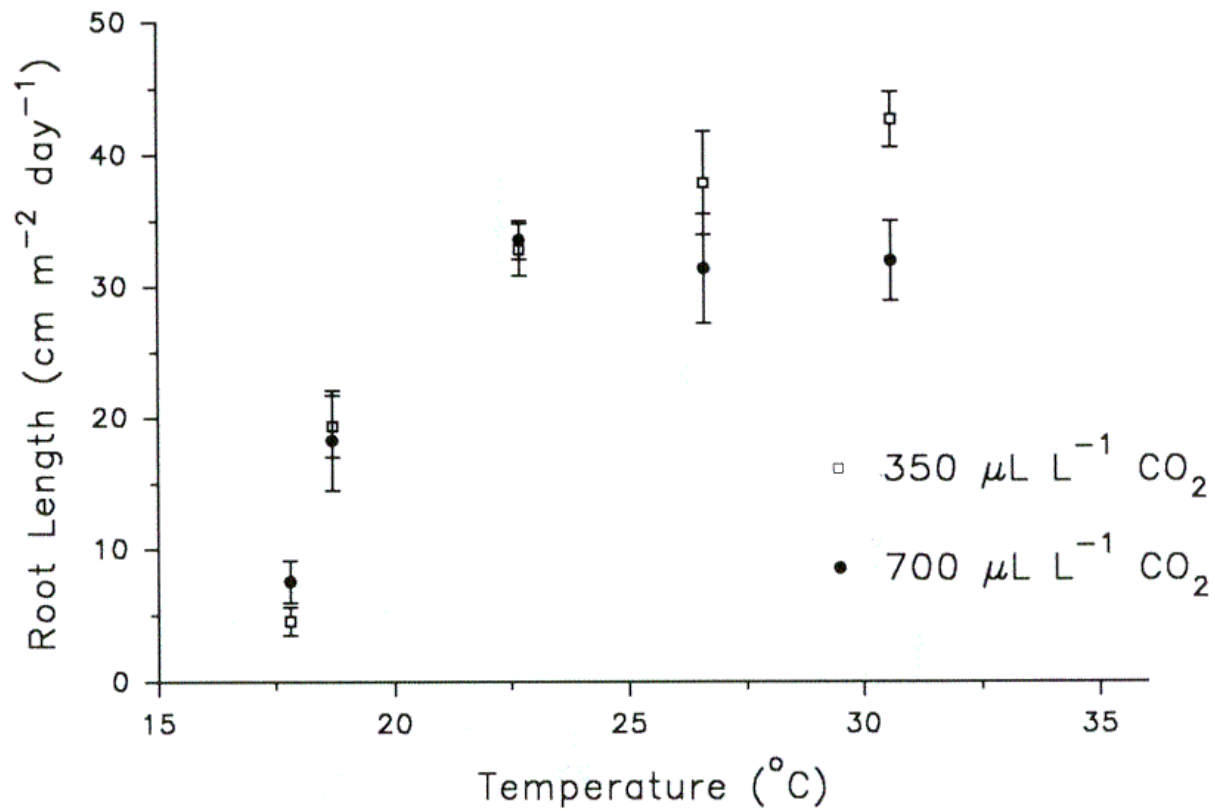
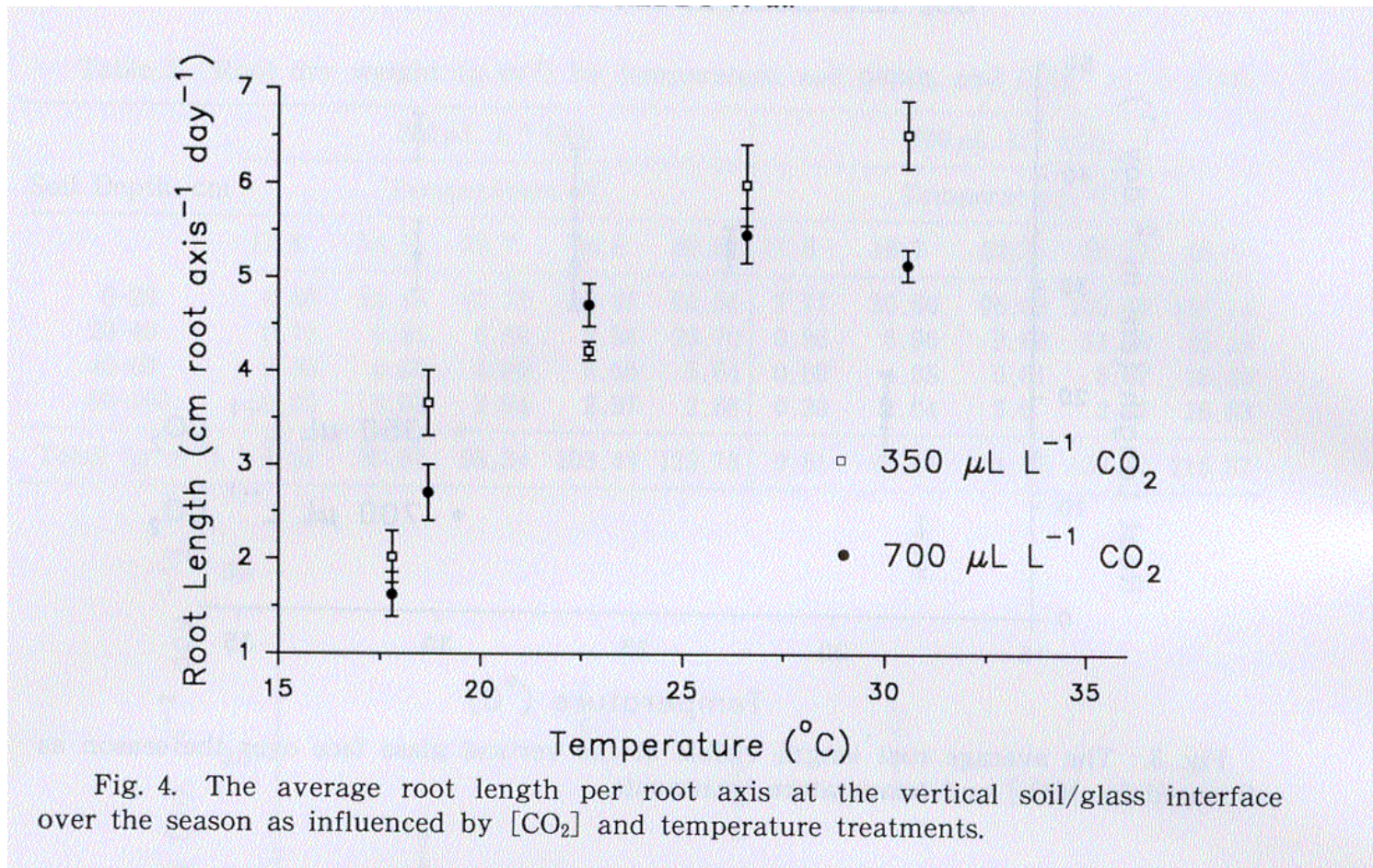


Fig. 3. The average root length visible at the vertical glass face over the season as influenced by [CO<sub>2</sub>] and temperature treatments.

# Environment - Crop Growth

## Root Growth and Development

### Root Growth Rate



# Environment - Crop Growth

## Root Growth and Development

### Competition between plants

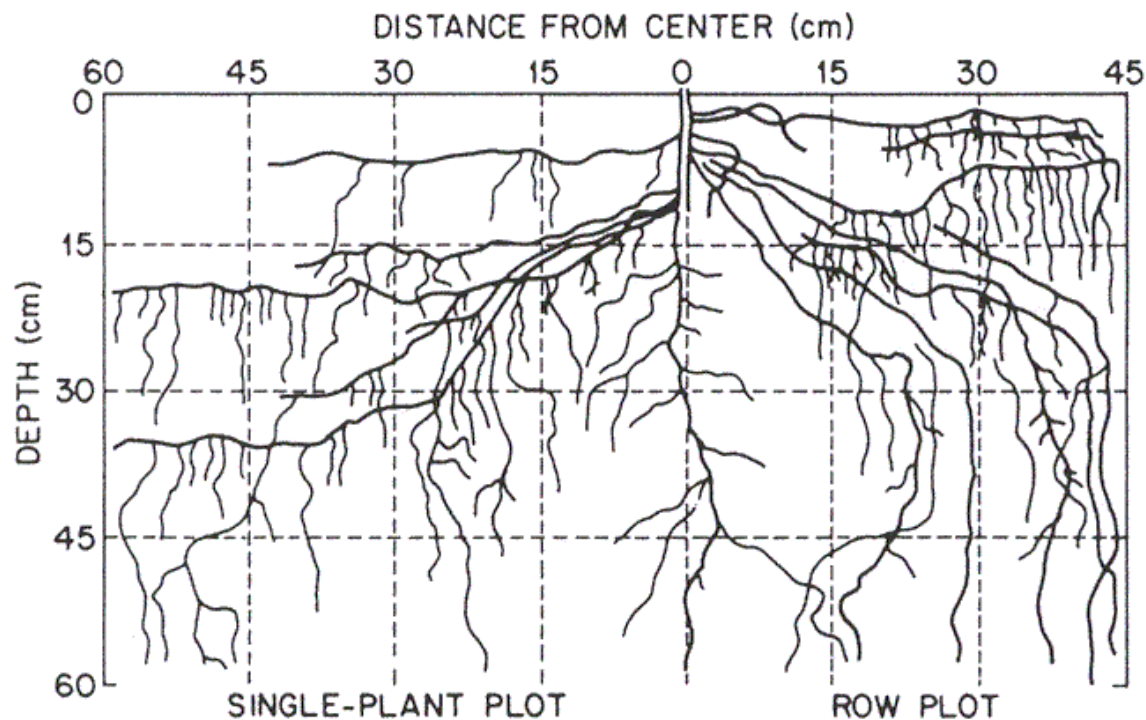


Figure 5.21 Difference in lateral root extension of an isolated soybean root system (left side) and that of a plant growing in a row. From Kramer (1983), after Raper and Barber (1970a).

# Environment - Crop Growth

## Root Growth and Development

**Soil compaction and root growth, development and distribution**

**11 week-old oat plants**

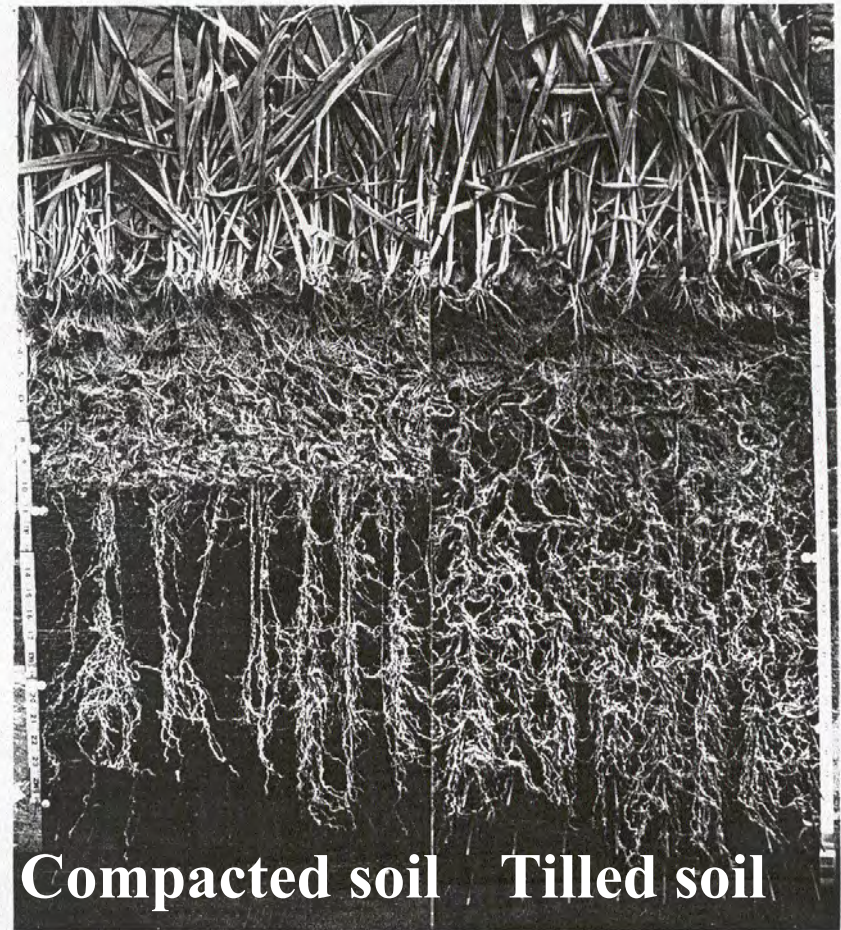


Figure 5.16 Effect of a compacted layer of soil on root penetration by 11-week-old oat plants. (Left) Undisturbed soil with dense mass of roots above the compacted layer, but few below it. (Right) Uniform penetration of roots into soil loosened by tillage to a depth of 50 cm. The restriction of root penetration was caused by mechanical resistance, as aeration was not limiting below the compacted layer. From Kramer (1983). Courtesy of H. D. DeRoo, Connecticut Agricultural Experiment 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 6.10 Wilted maize in a flooded field. Water is standing between the rows which were flooded for 3 weeks. Photograph by J. S. Boyer.

# Environment - Crop Growth

## Root Growth and Development

### Water and Root and Shoot Growth

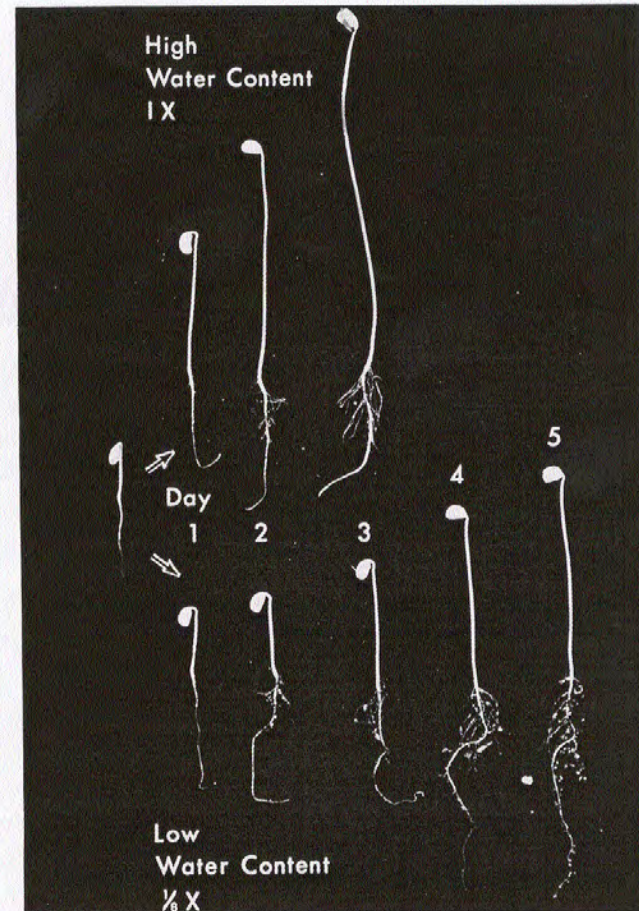


Figure 11.9 Soybean seedlings germinated in the dark and transplanted either to vermiculite containing adequate water (1x) or limited water (1/8x). The 1/8x vermiculite contained one-eighth of the water in the 1x vermiculite and had a water potential of  $-0.3$  MPa compared to  $-0.01$  MPa in the 1x control. Note the marked inhibition of stem (hypocotyl) growth for the first 2 days in 1/8x vermiculite followed by a modest resumption of growth. Roots continued to develop as fast at 1/8x as at 1x.

# Environment - Crop Growth

## Root Growth and Developmental Responses to CO<sub>2</sub>



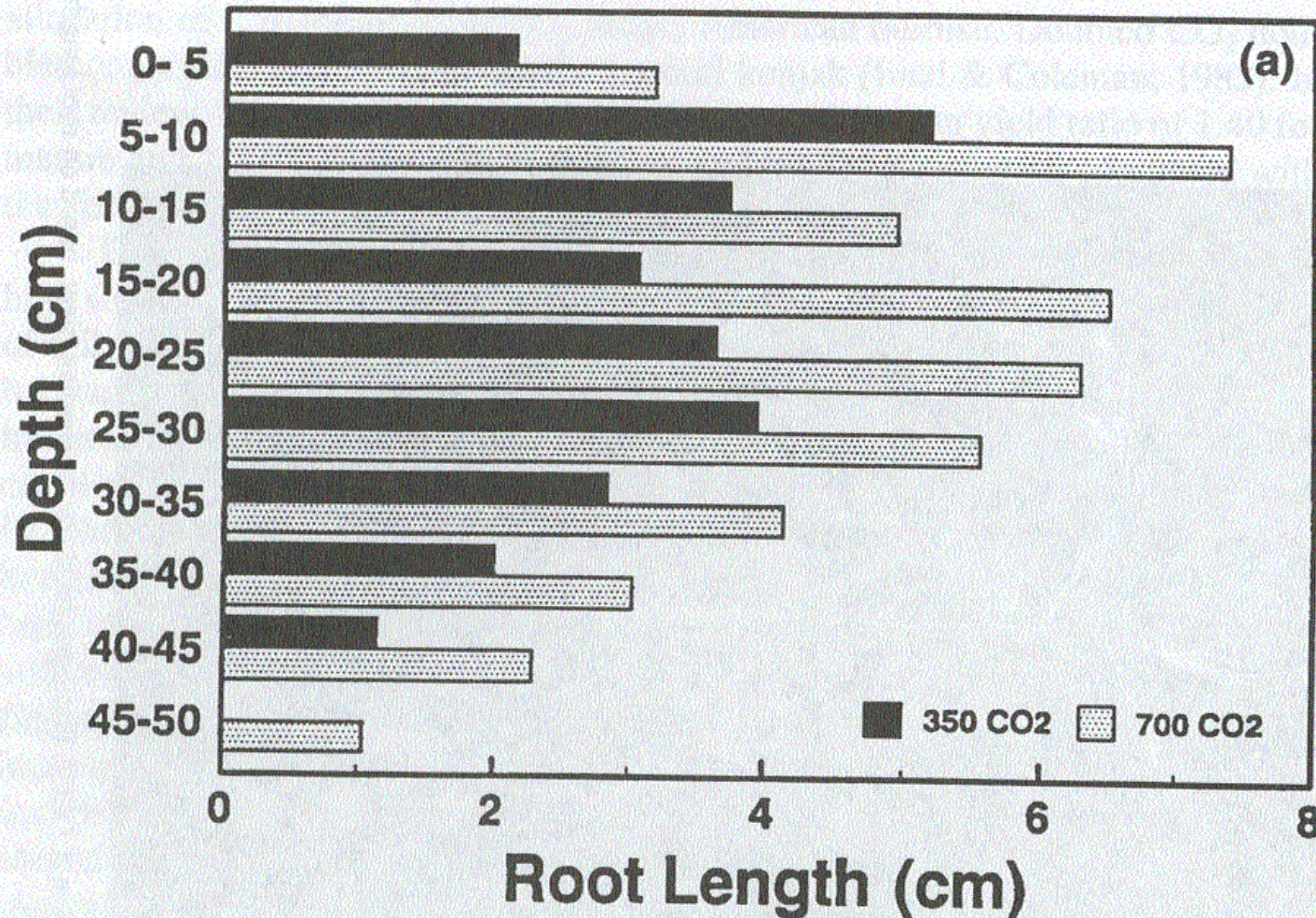
Fig. 1-1. Photographs of 18-d-old soybean plants grown at (a) 350  $\mu\text{mol mol}^{-1}$  and (b) 700  $\mu\text{mol mol}^{-1}$  CO<sub>2</sub>. Photographs show the median plant, based on root length, for each treatment (Rogers et al., 1992a).



# Environment - Crop Growth

## Root Growth and Developmental Responses to CO<sub>2</sub>

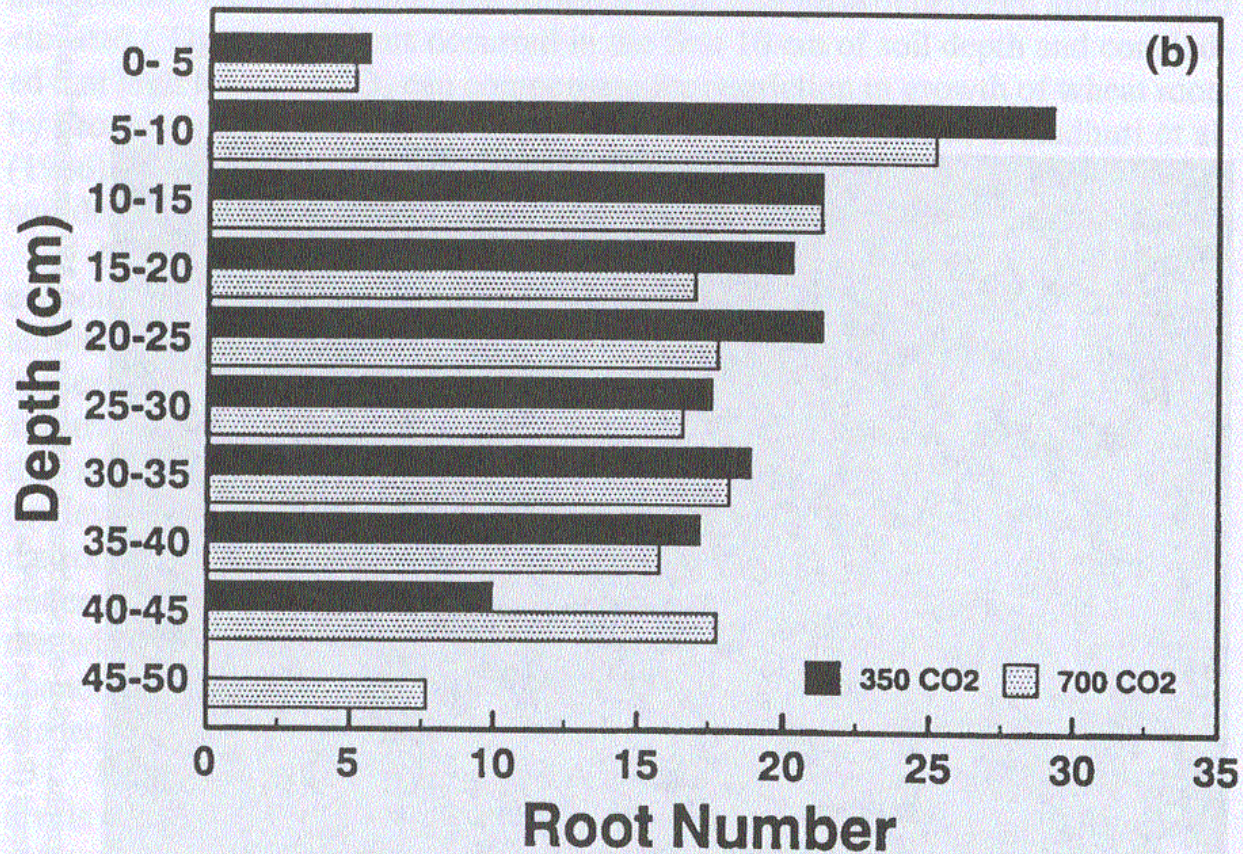
### Soybean, 18 days old



# Environment - Crop Growth

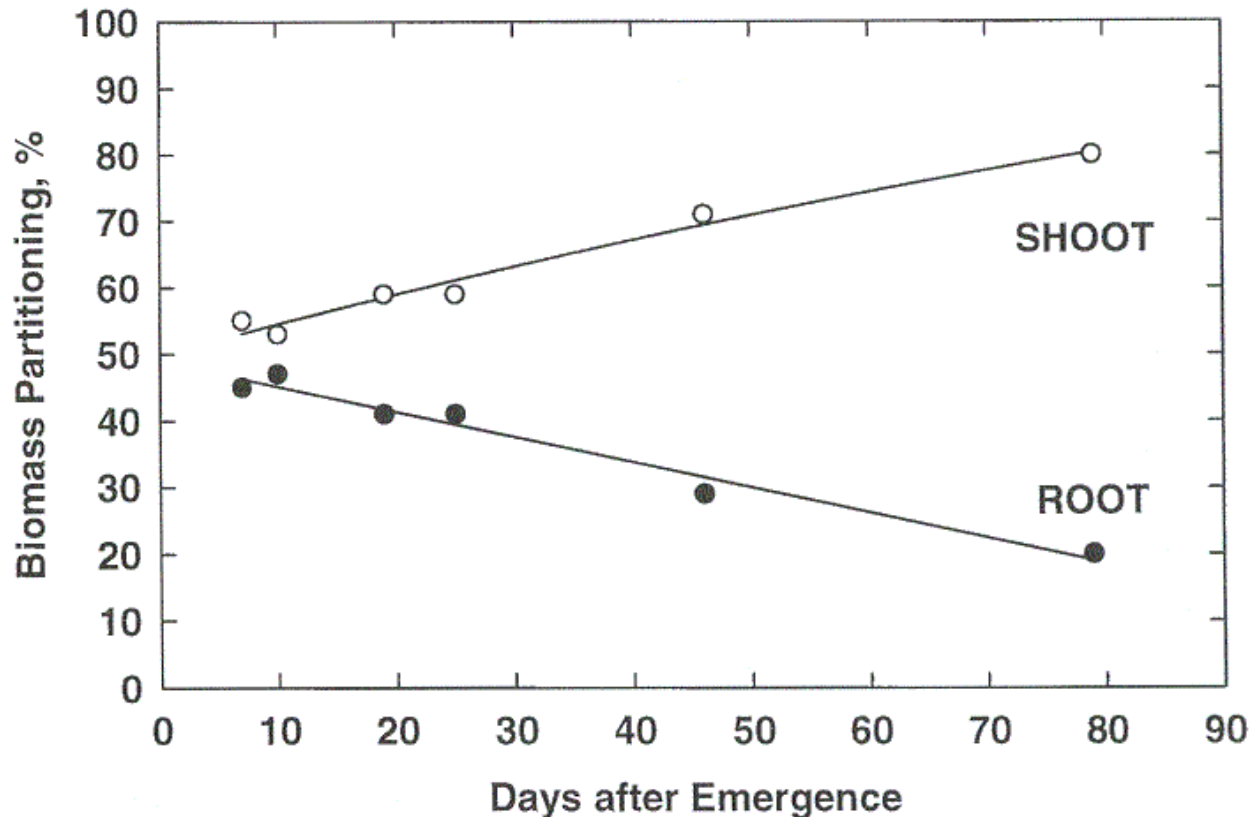
## Root Growth and Developmental Responses to CO<sub>2</sub>

**Soybean, 18 days old**



# Environment - Crop Growth

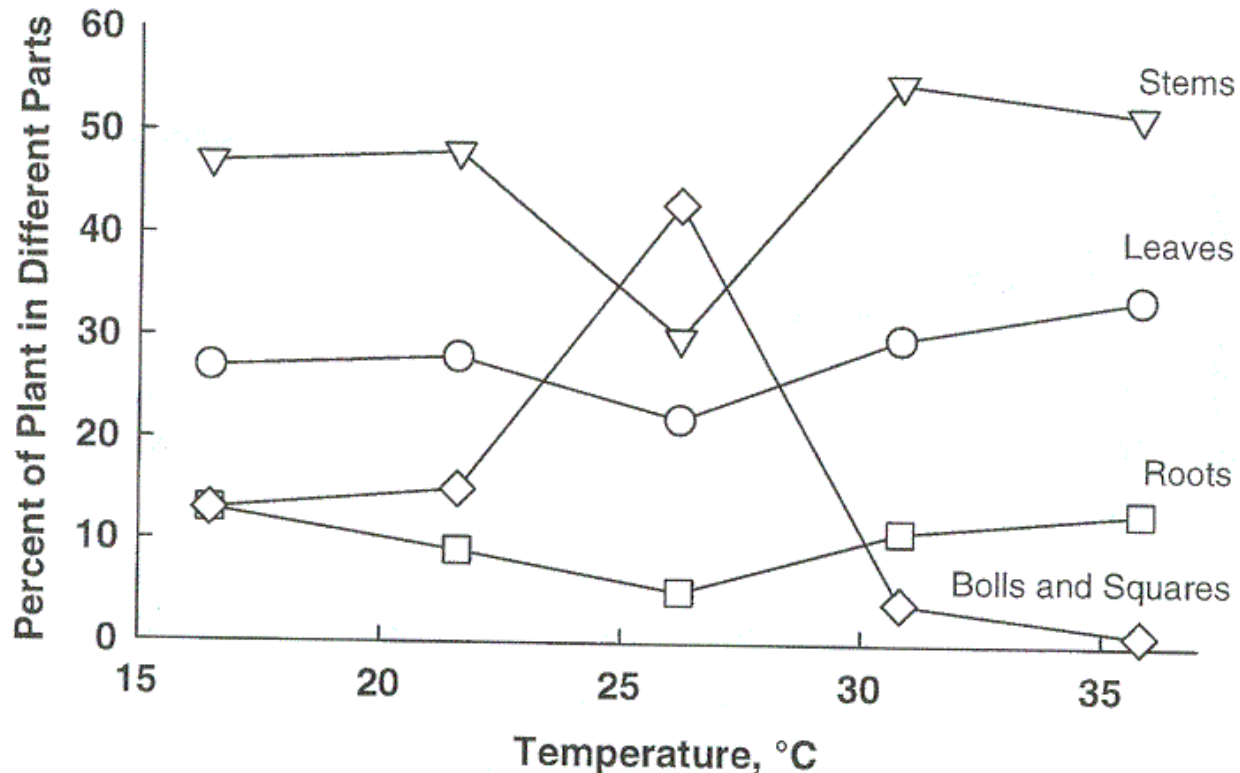
## Root Growth and Developmental – Mass Partitioning - Cotton



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

# Environment - Crop Growth

## 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).

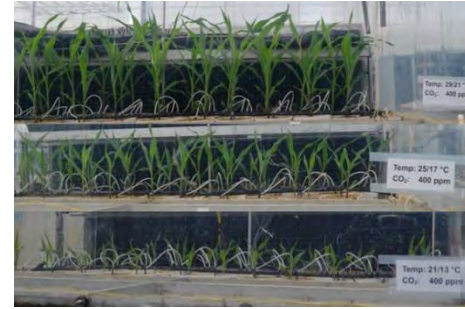
# Environment - Crop Root Growth and Development

## 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)**

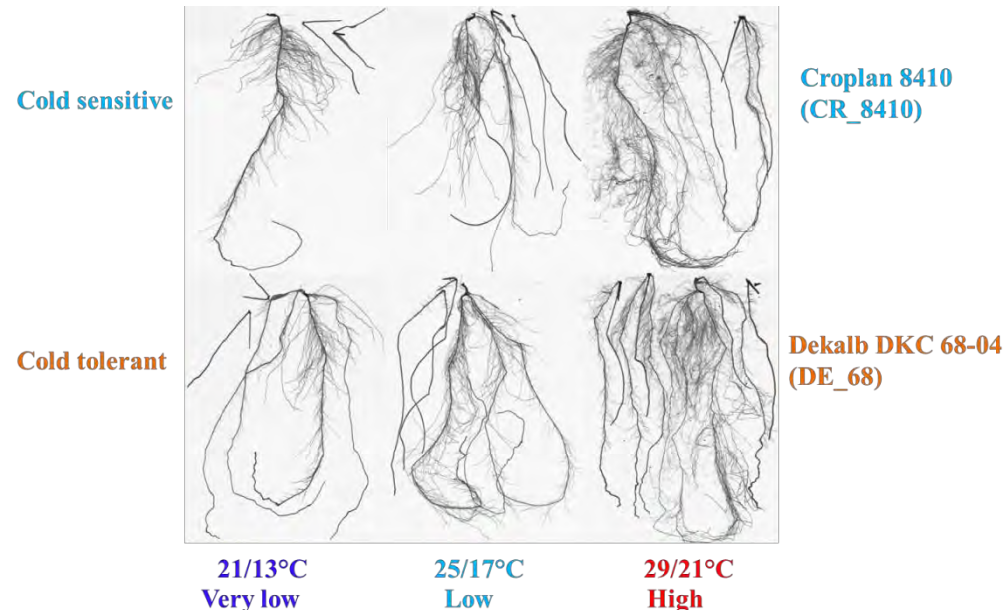


Win-RHIZO dual Scan optical root scanner

18-day old corn  
at 3 Temp.

- **Images were analyzed using WinRHIZO Pro Software:**

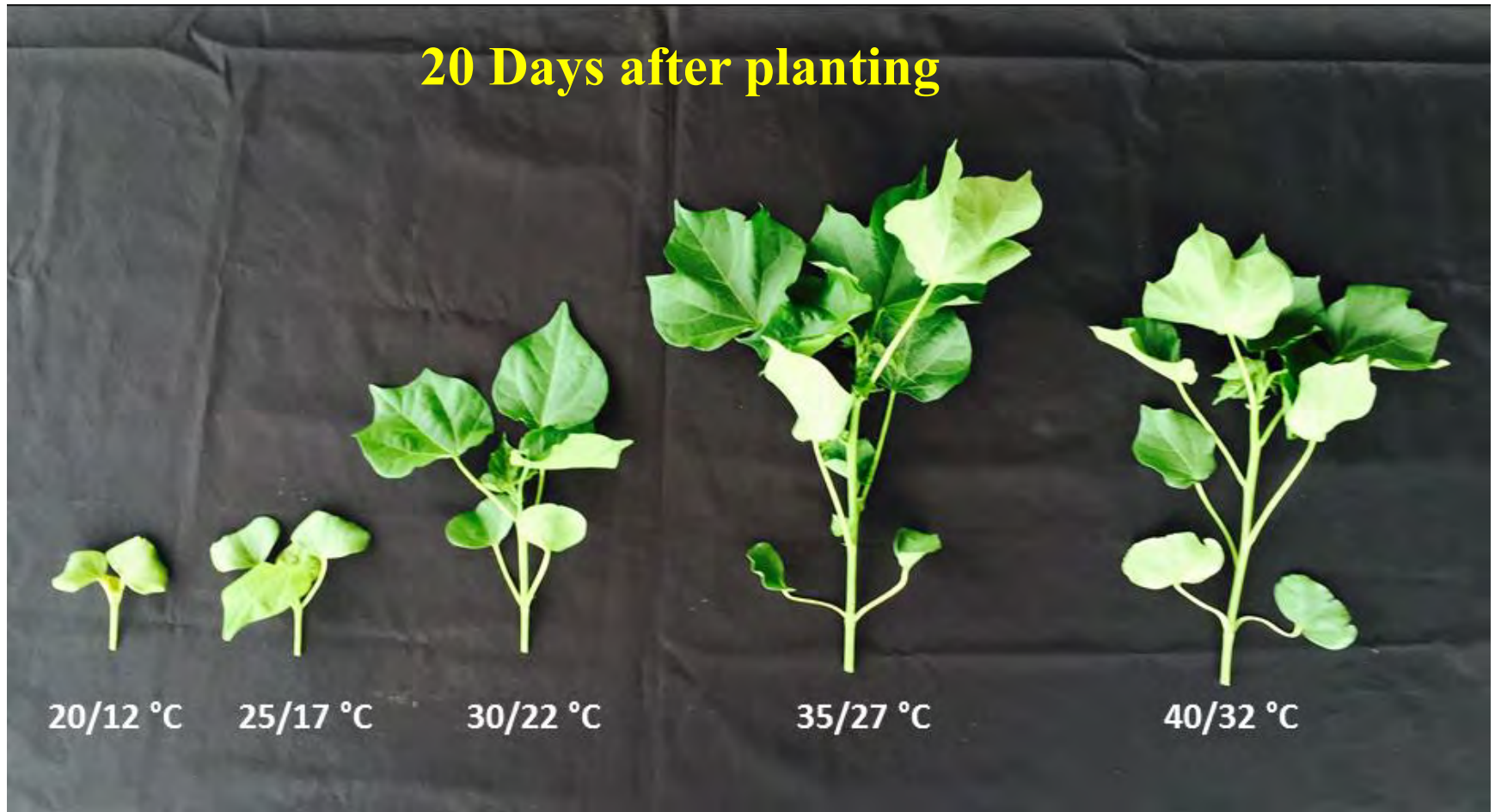
- ✓ Cumulative root length
- ✓ Root surface area
- ✓ Average root diameter
- ✓ Root length per volume
- ✓ Root volume
- ✓ Root numbers
- ✓ Roots with laterals
- ✓ Root tips
- ✓ Root forks
- ✓ Root crossings
- **Simulation models for root systems**



# Environment - Crop Growth

## Shoot Growth and Developmental - Cotton

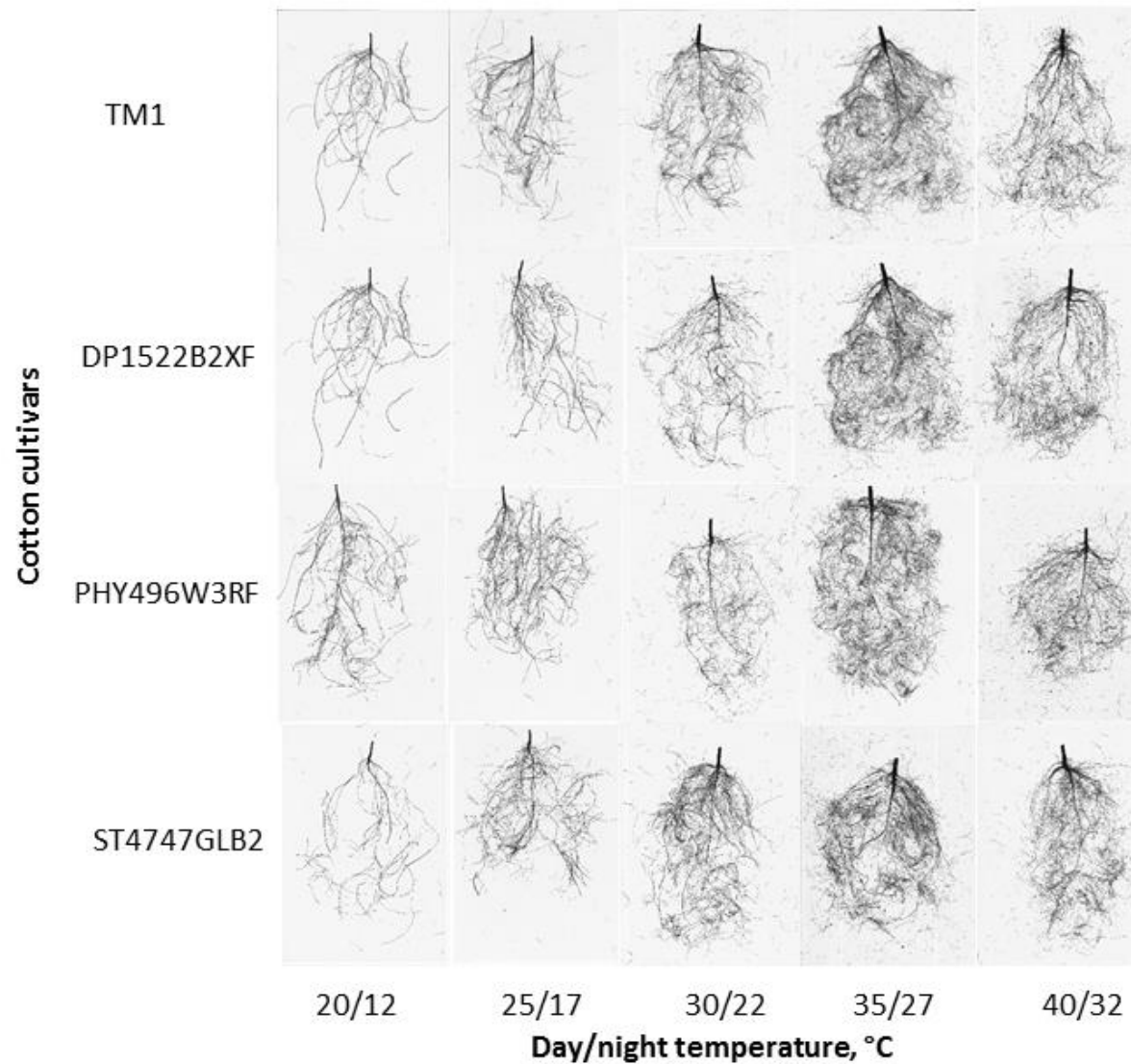
**20 Days after planting**



**Day/Night Temperature Treatments**

# Environment - Crop Growth

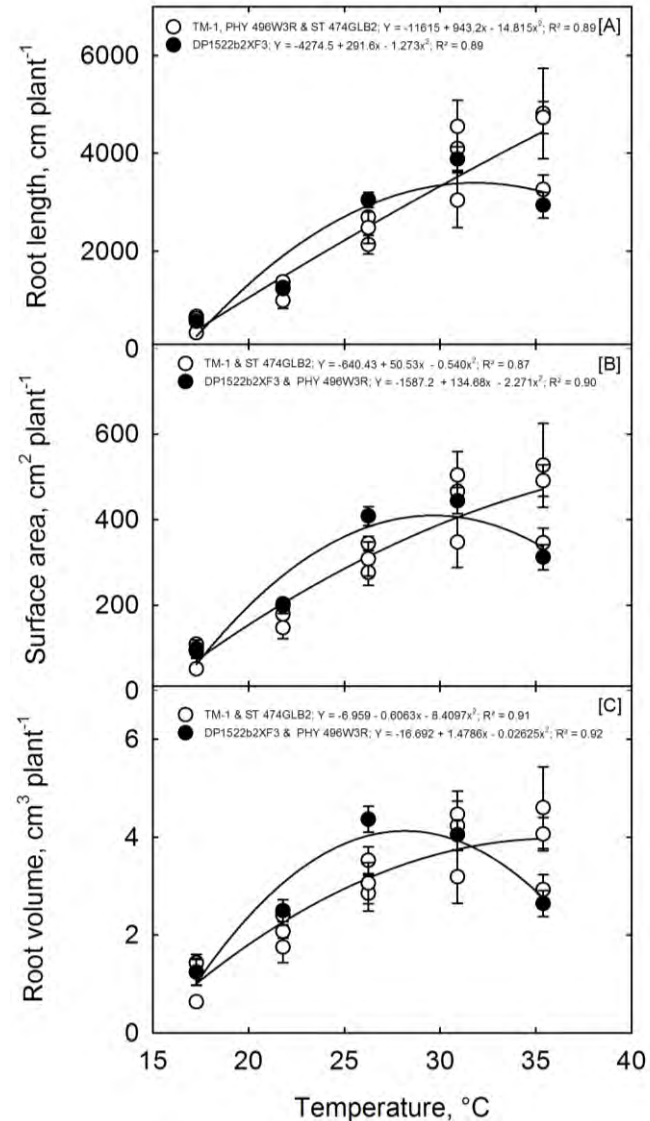
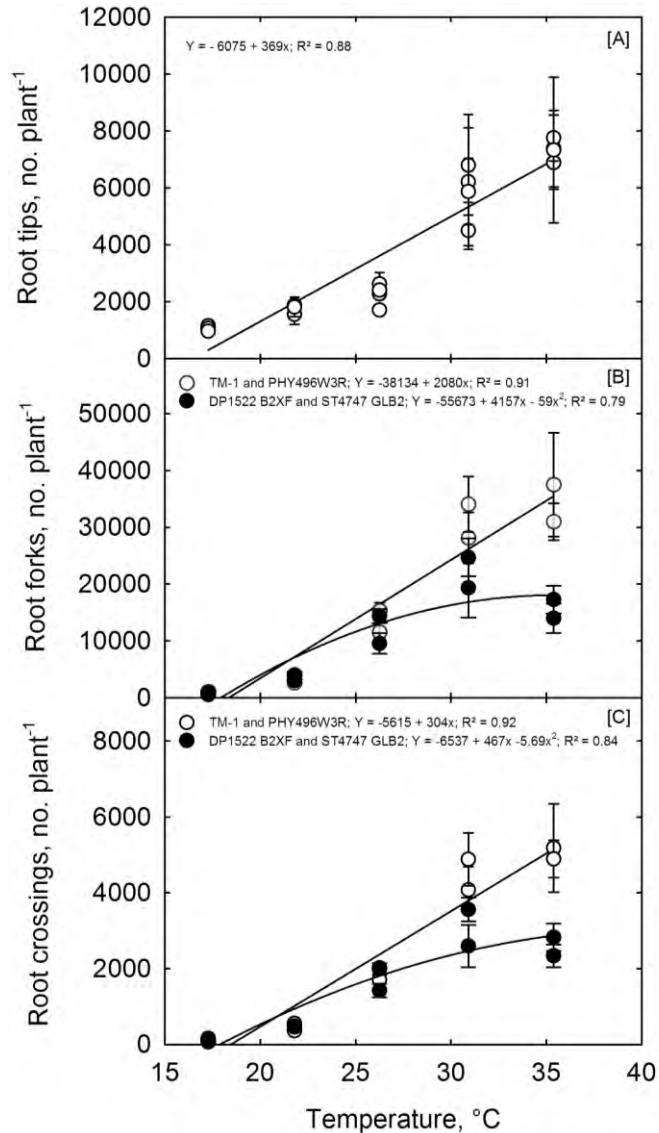
## Root Growth and Developmental - Cotton





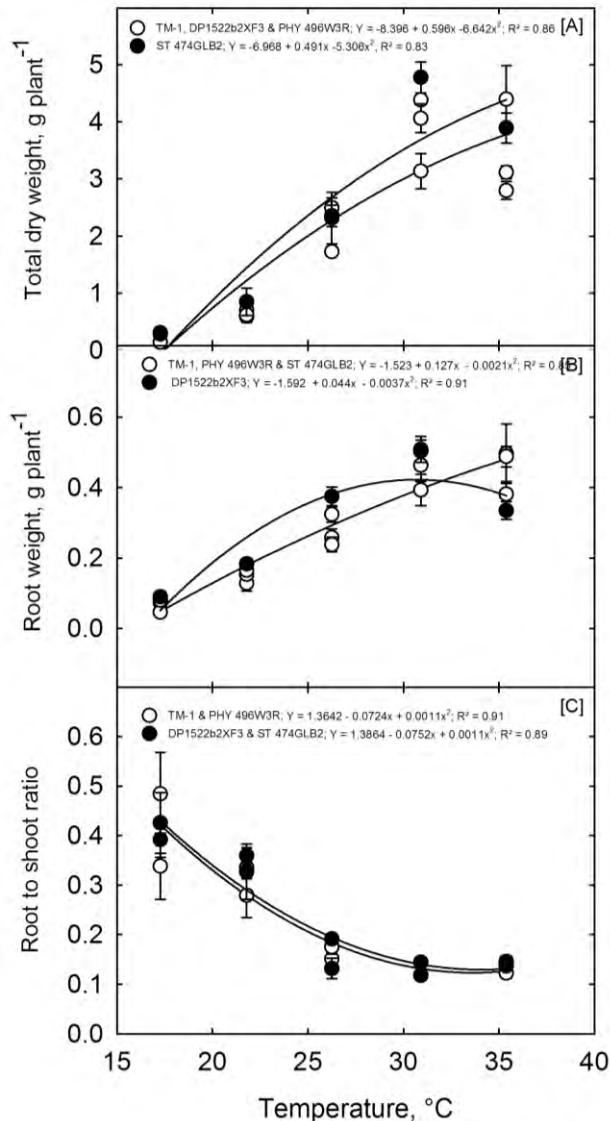
# Environment - Crop Growth

## Root Growth and Developmental - Cotton



# Environment - Crop Growth

## Root Growth and Developmental - Cotton



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[doi:10.2134/agronj2016.07.0439](https://doi.org/10.2134/agronj2016.07.0439)