

Ecological Interactions

**Lessons from temperate alley cropping
systems**

Shibu Jose

Competitive

Synergistic

Competitive Interactions

Competition for

Light

Water

Nutrients

Phytotoxicity

Synergistic Interactions

Microclimatic modifications

Insect/pest control

Soil improvement

Nutrient capture

Black walnut-corn alley cropping



Pecan-Cotton alley cropping



Competition for light





← **9-year-old**

12-year-old →

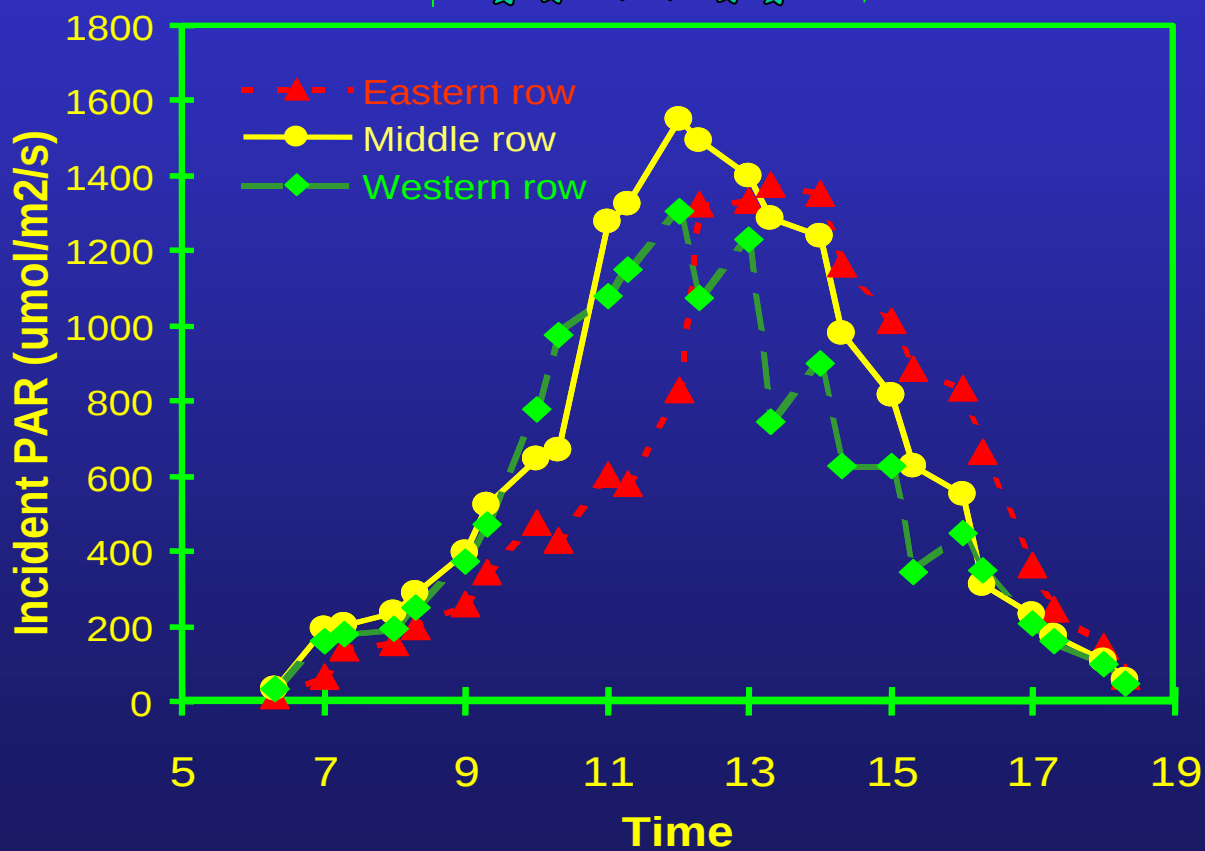




West

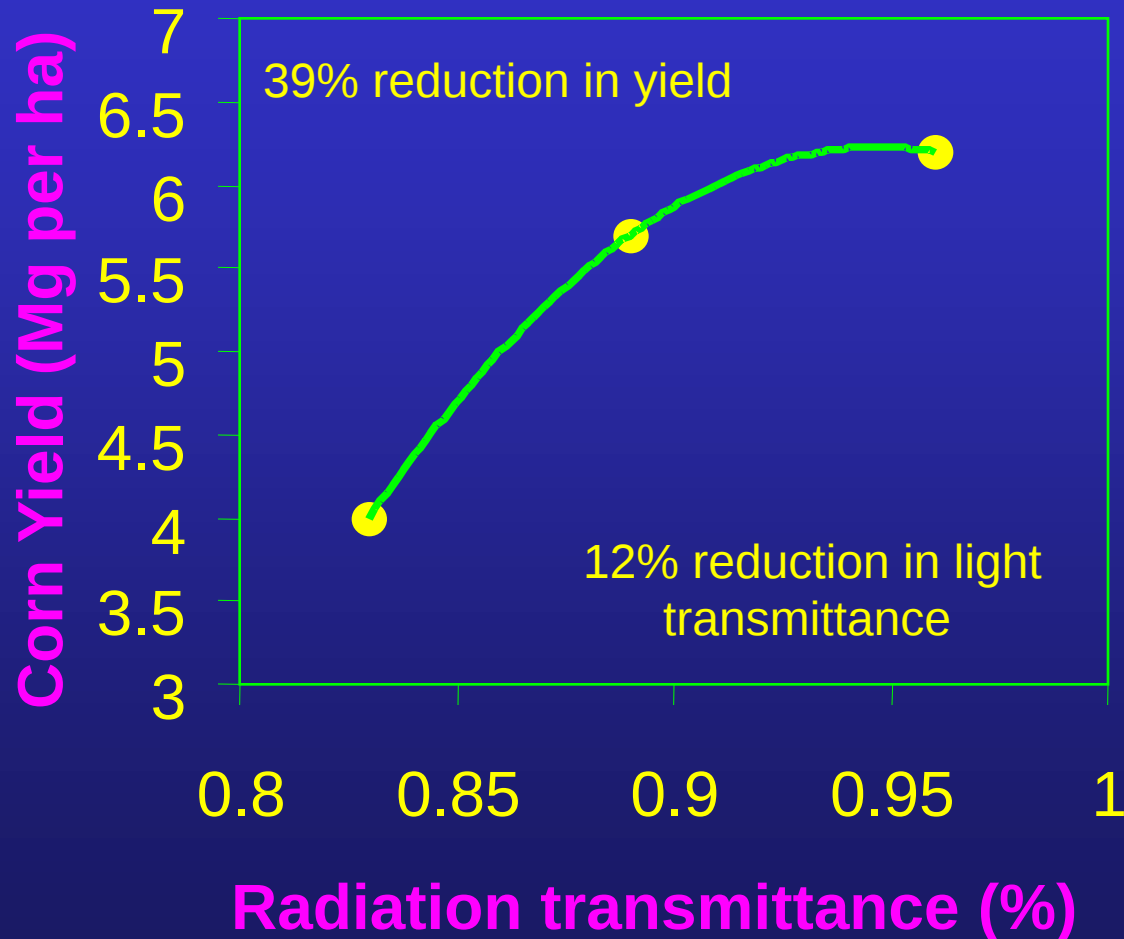


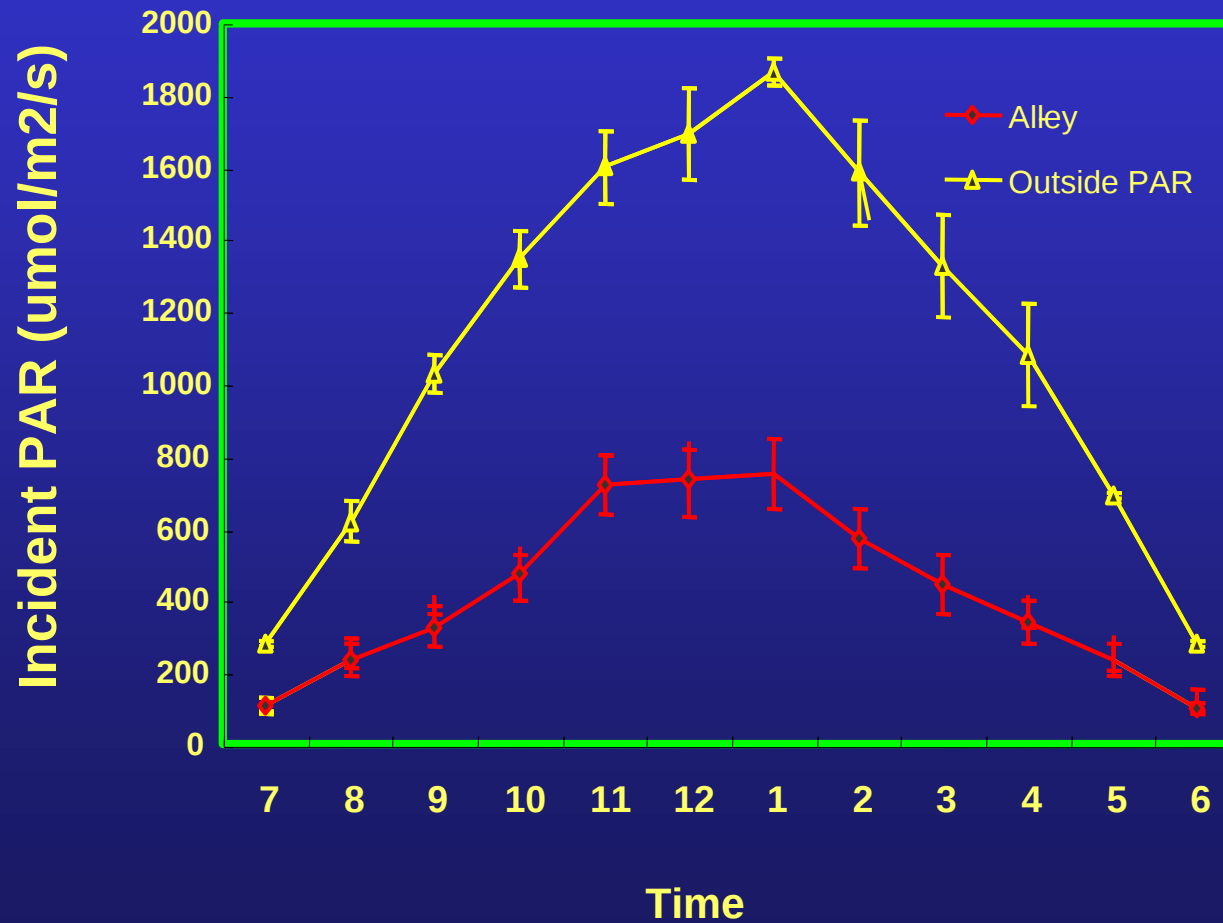
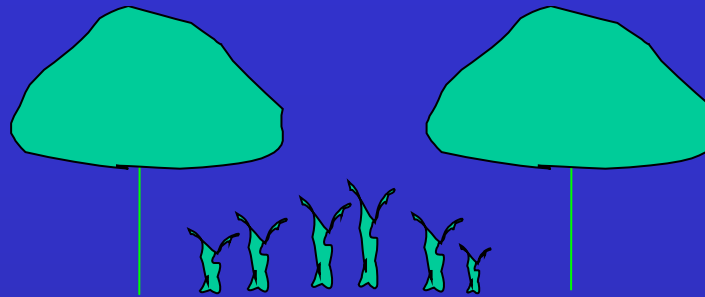
East



12-yr-old trees + corn

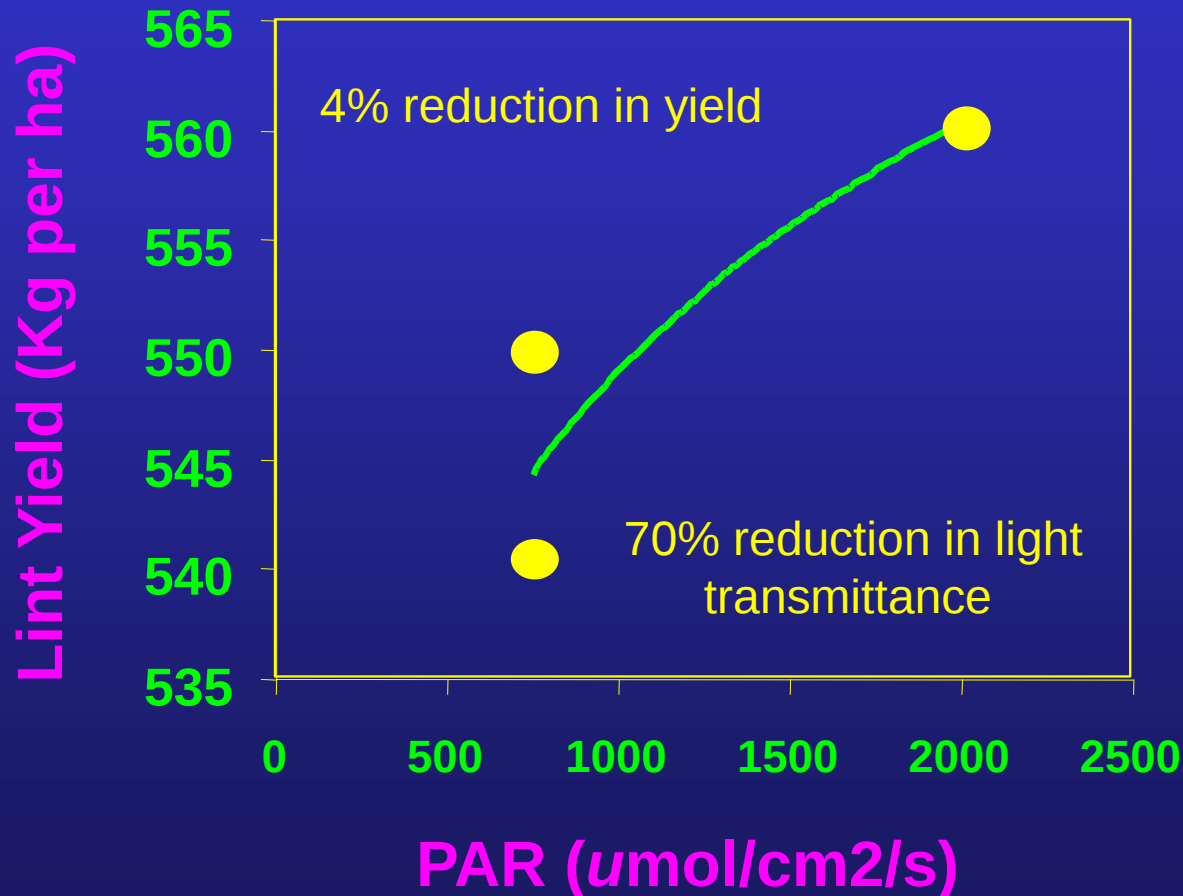
Corn yield as a function of radiation transmittance



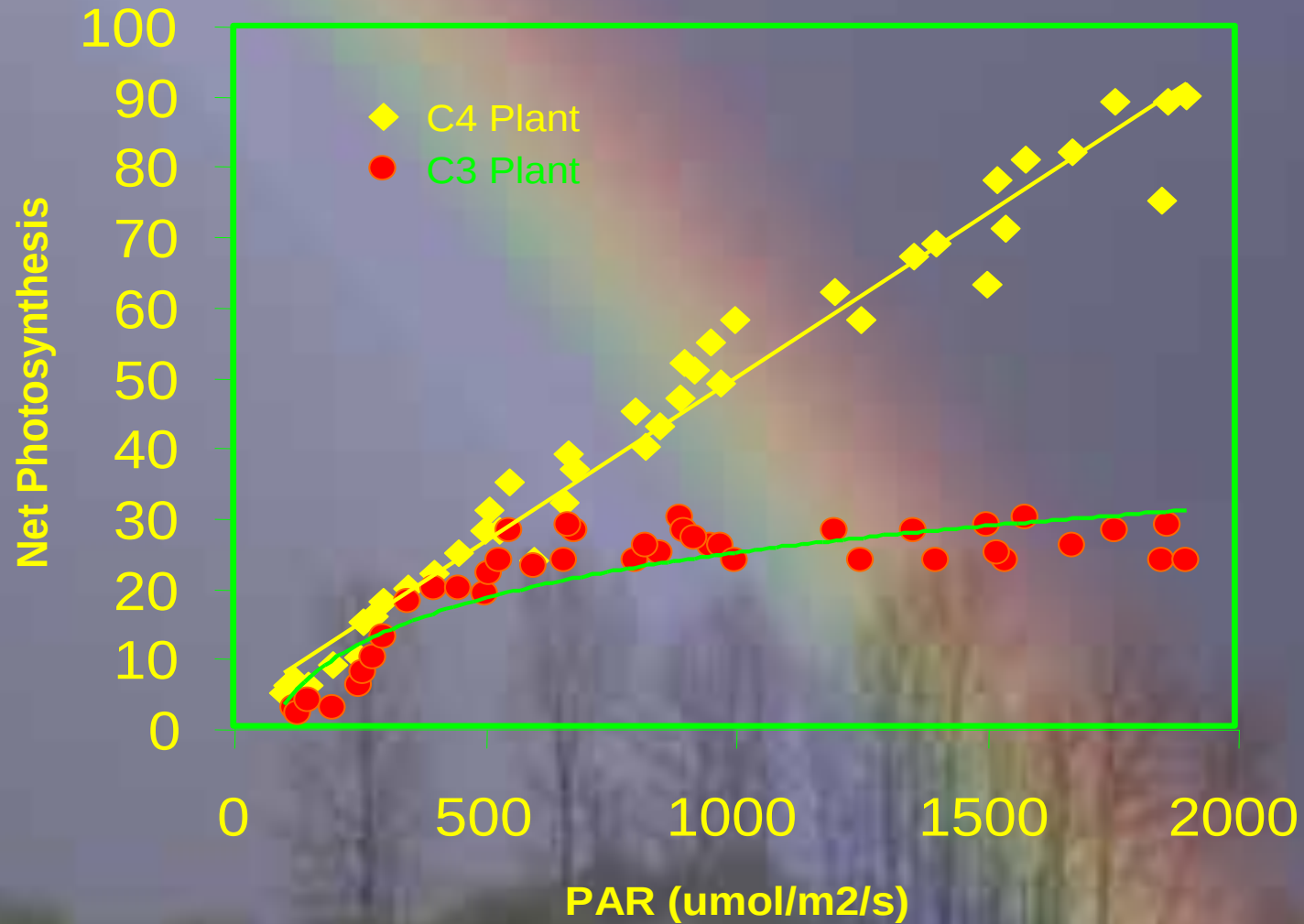


47-yr-old trees + cotton

Cotton yield as a function of radiation transmittance



PAR vs. P_{net}



As you know.....

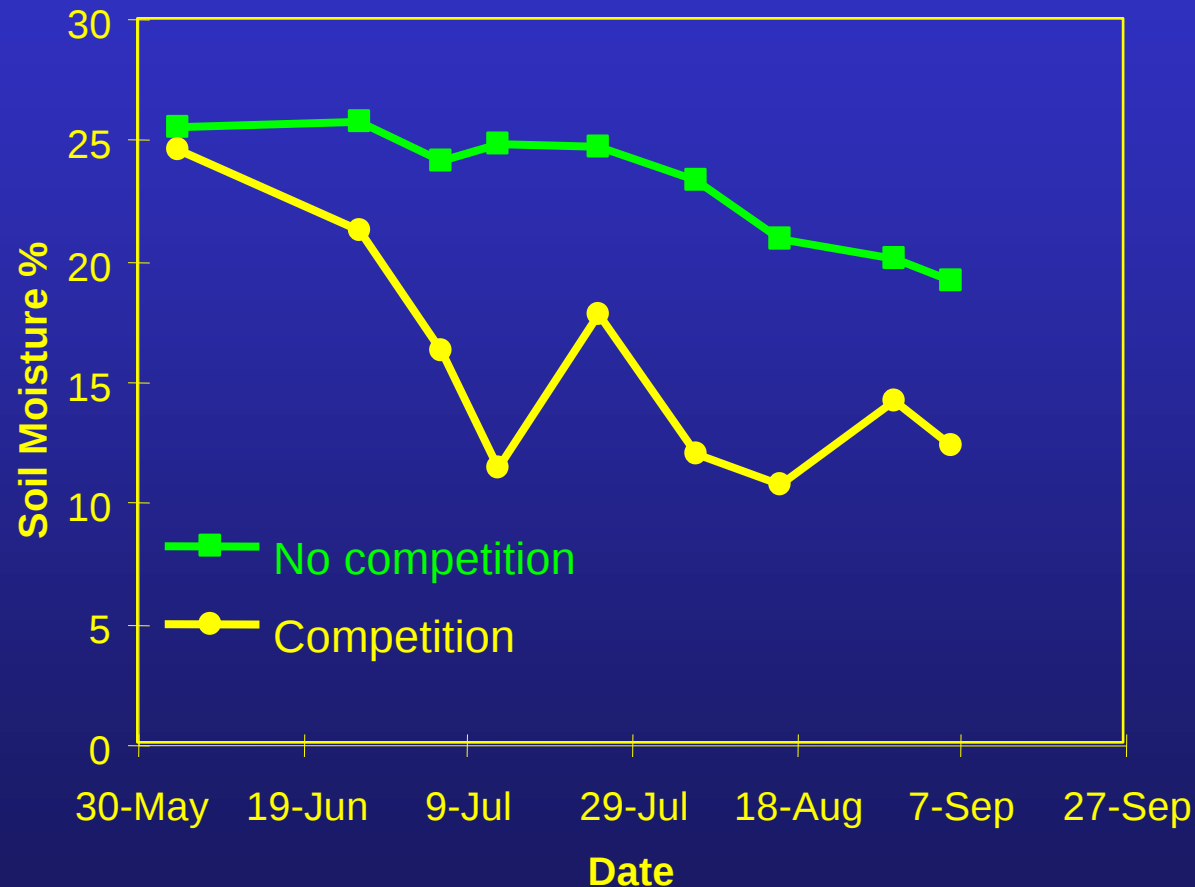
P_{net} per unit leaf area is
important

But, overall canopy P_{net}
drives productivity

Competition for water

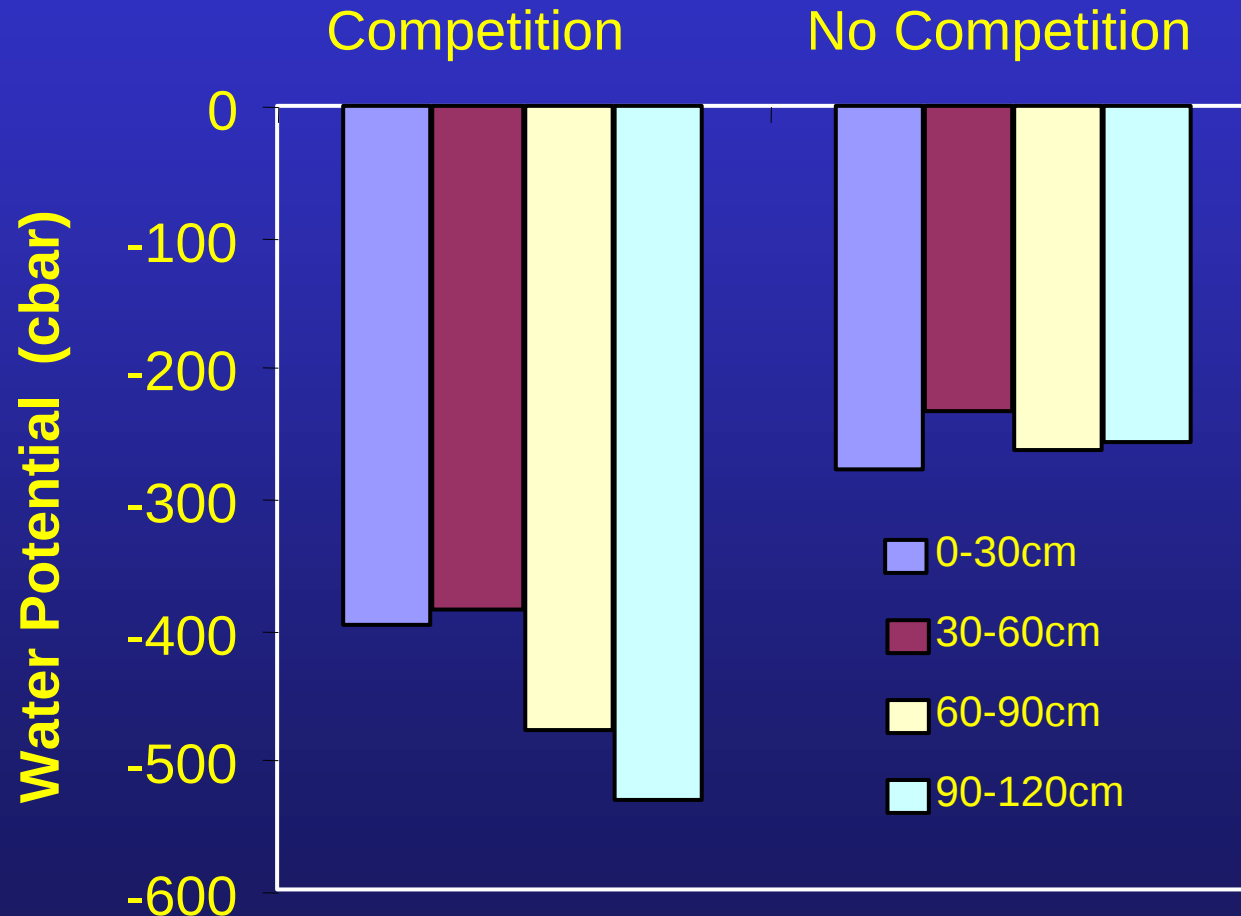
Leaf expansion is the first process inhibited by Water stress in plants

Alley soil water as influenced by tree competition (Black walnut-corn)

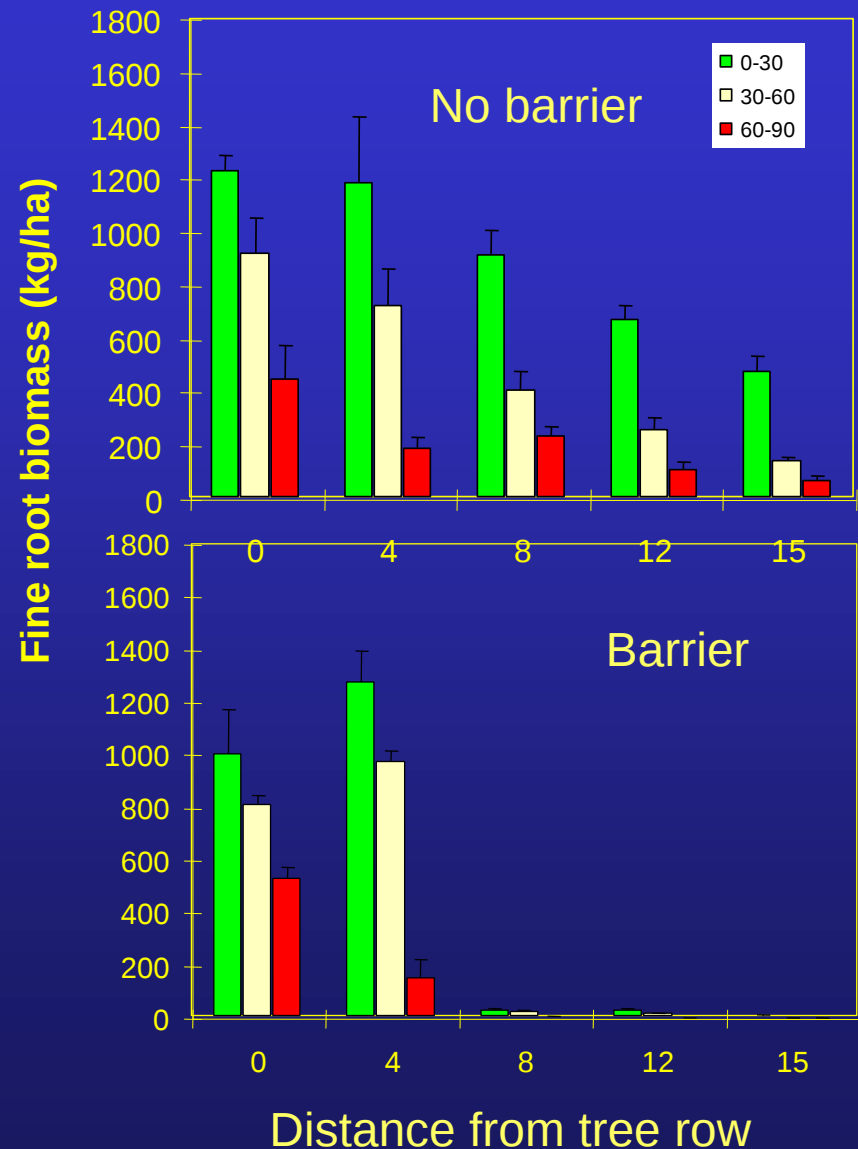




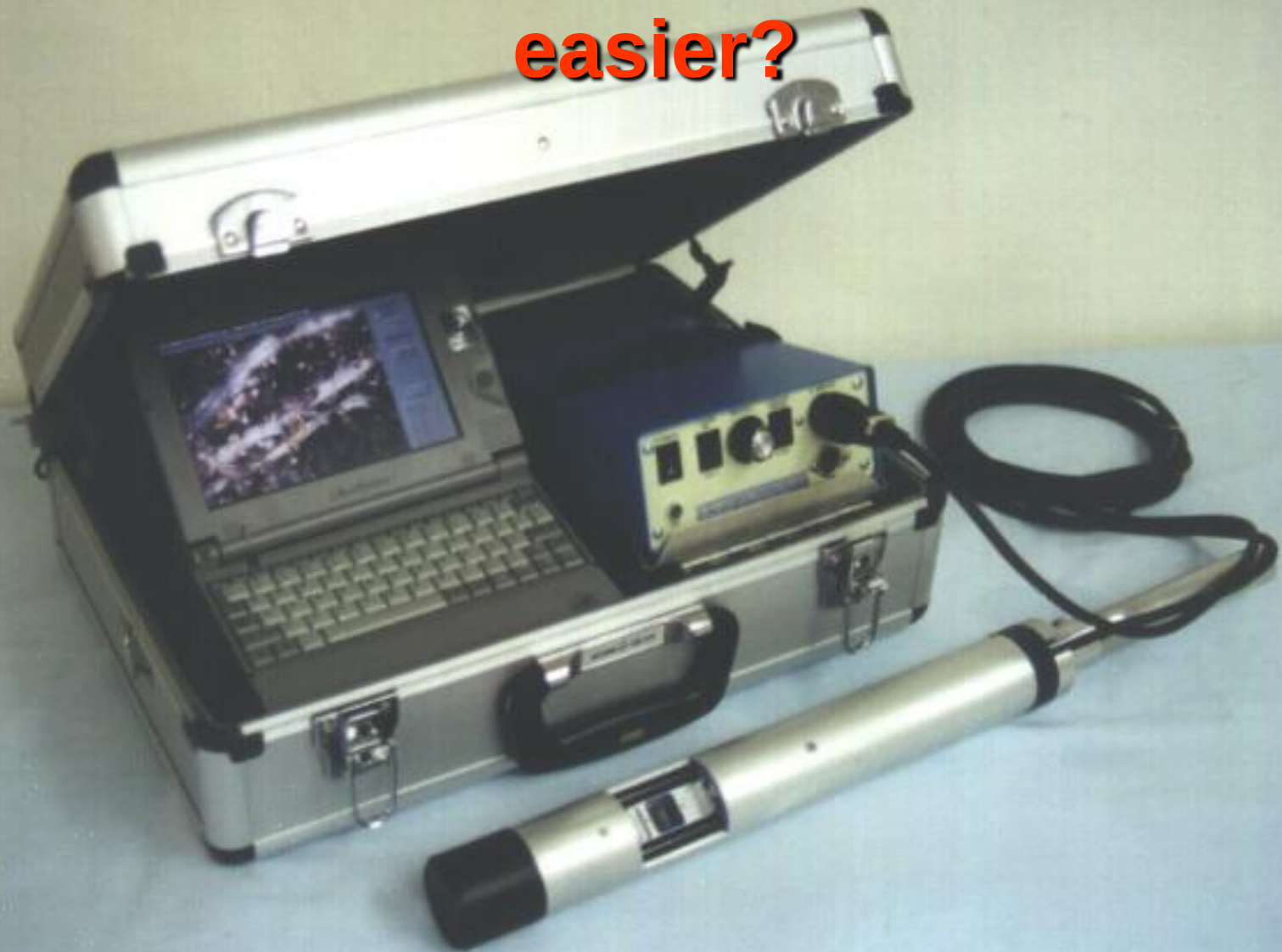
Alley soil water as influenced by tree competition (Pecan-cotton)



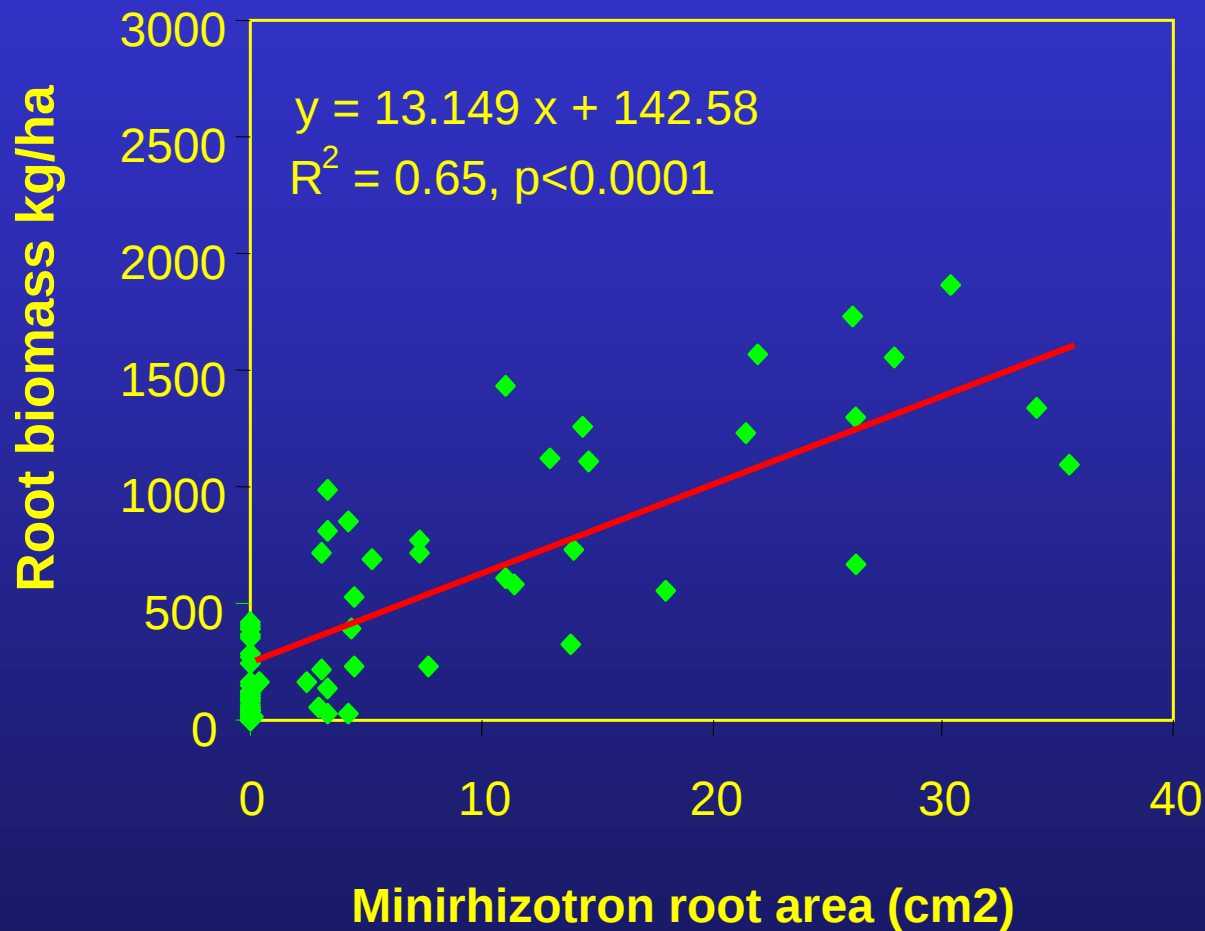
Rooting density is the key



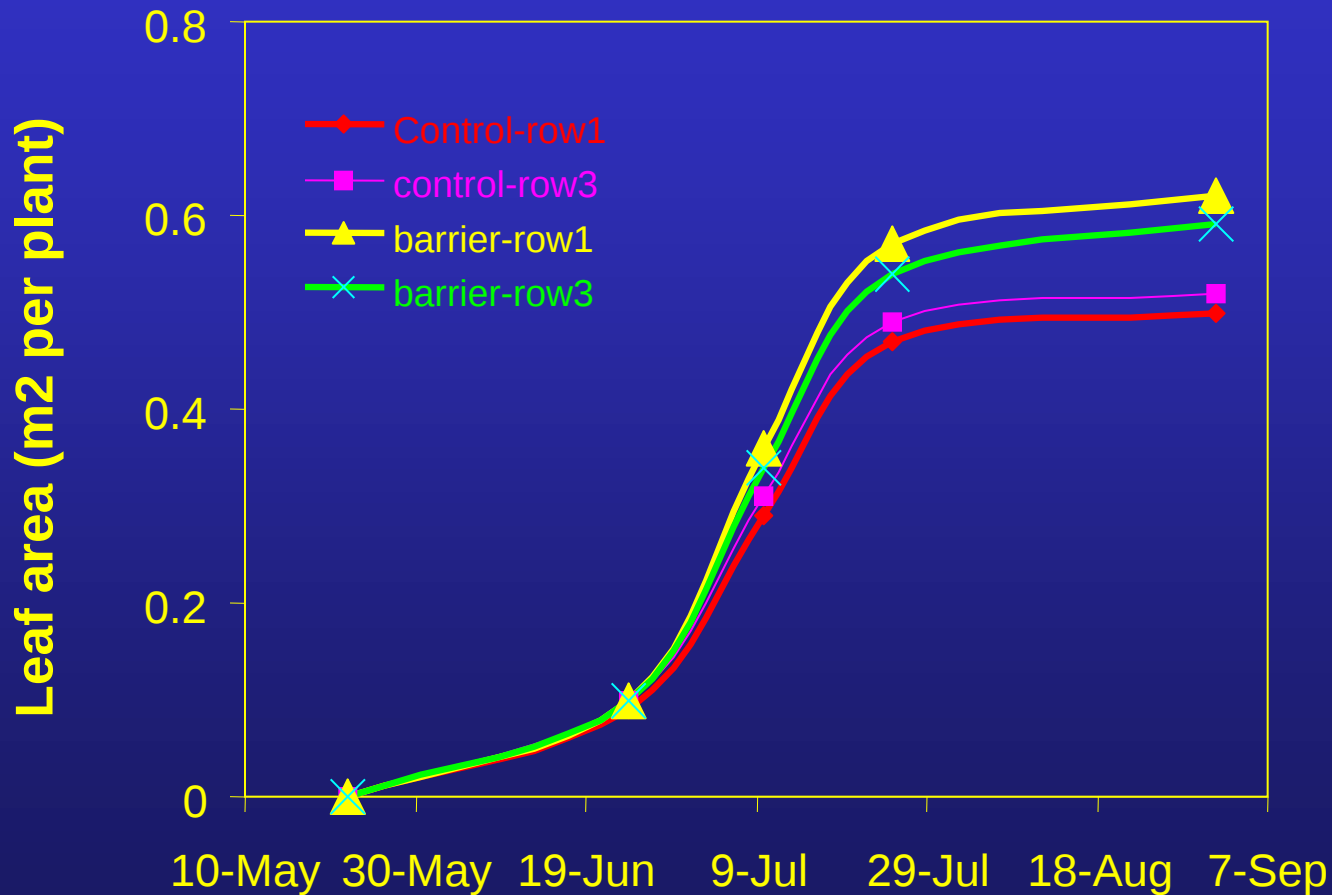
Minirhizotron: Root studeis made easier?



Root area vs. root biomass for Corn

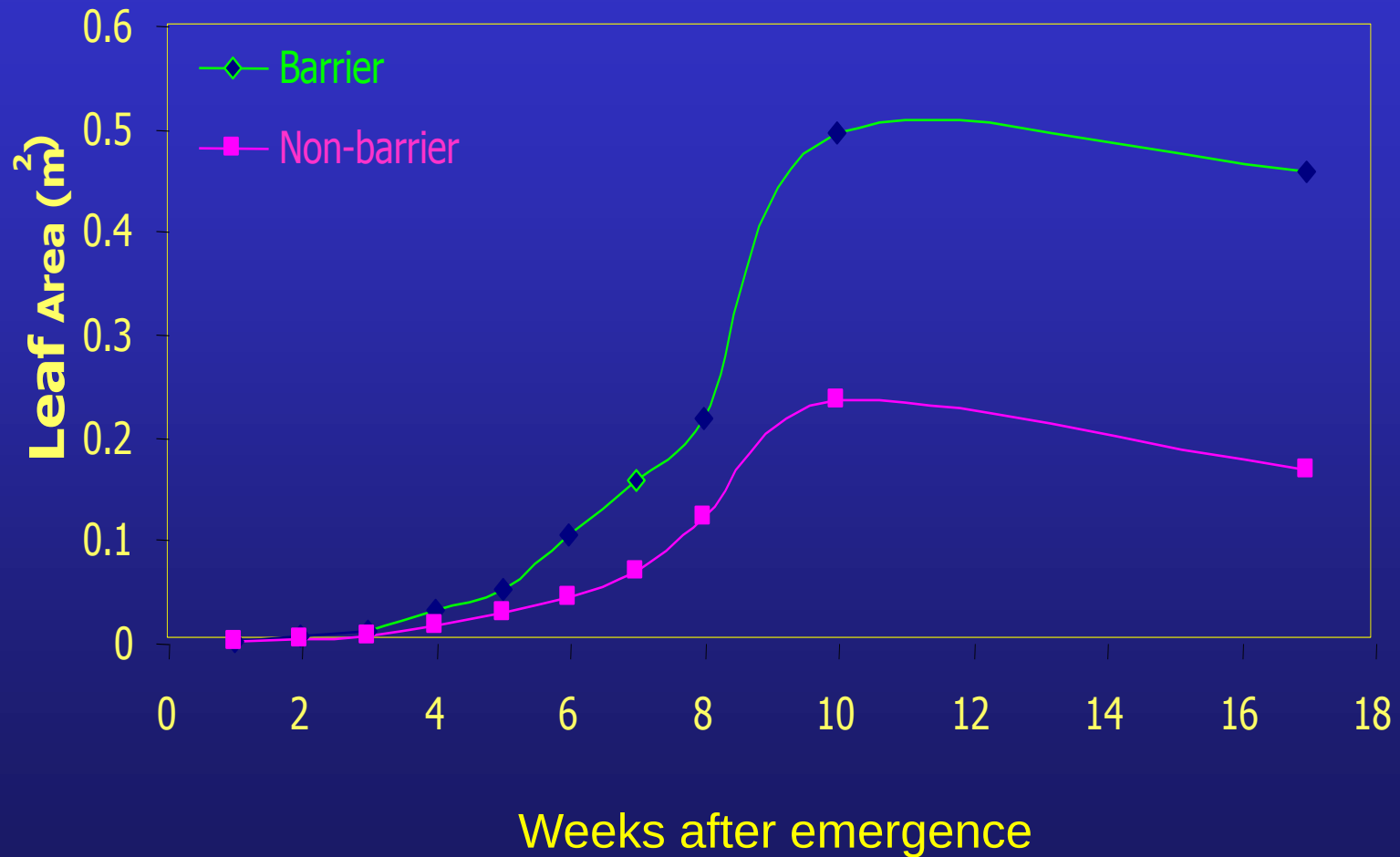


Water stress and leaf area-Corn

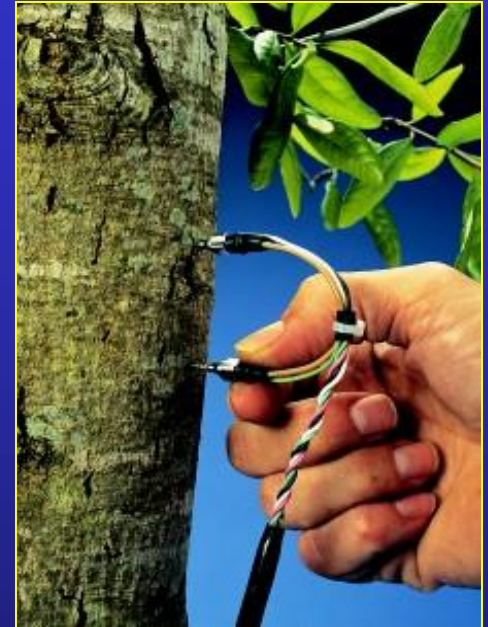




Water stress and leaf area-Cotton

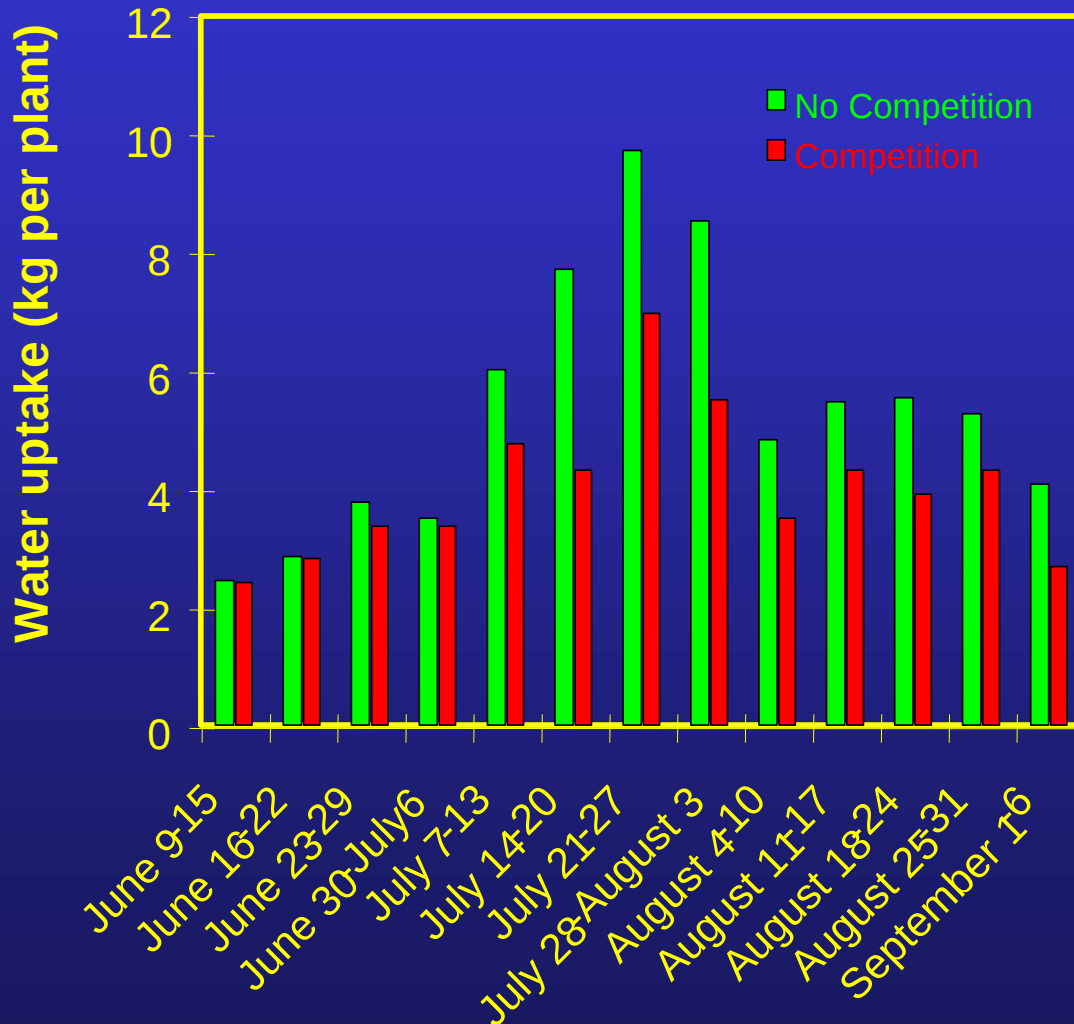


Water uptake

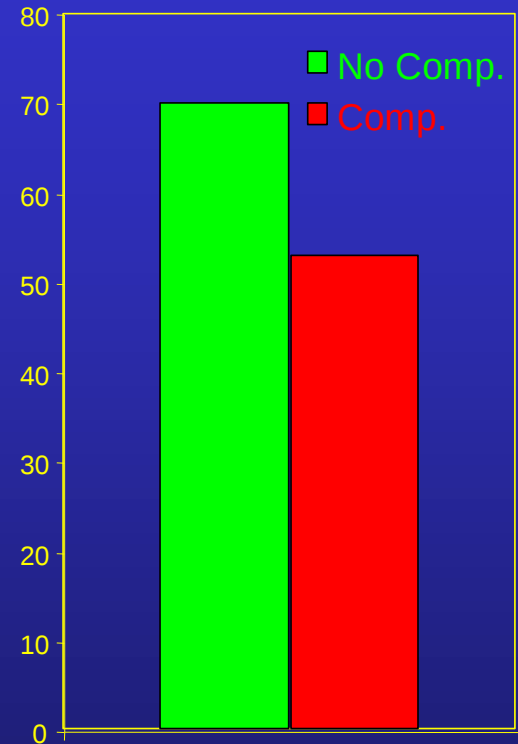


Corn water uptake

Weekly uptake

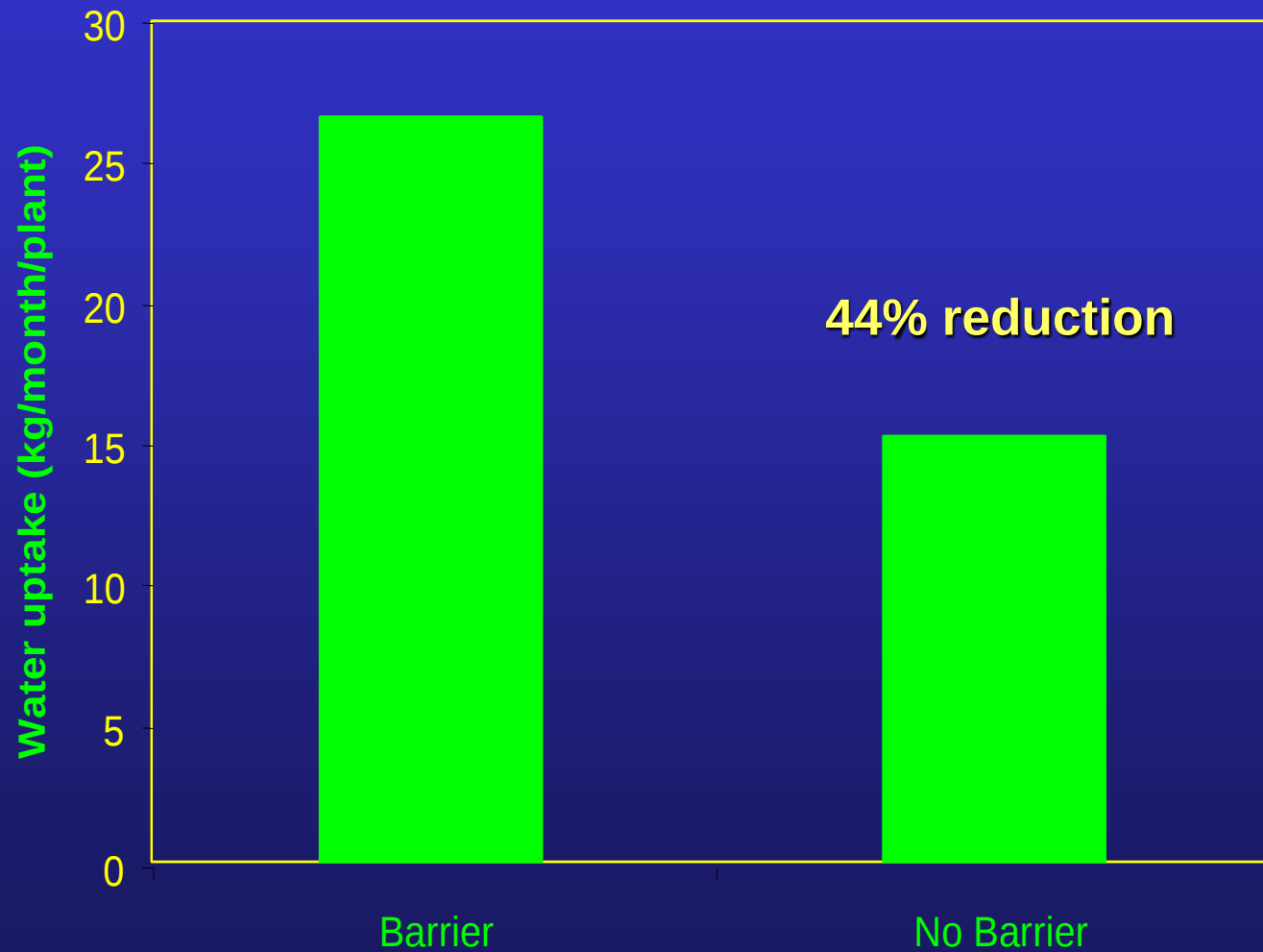


Growing season total



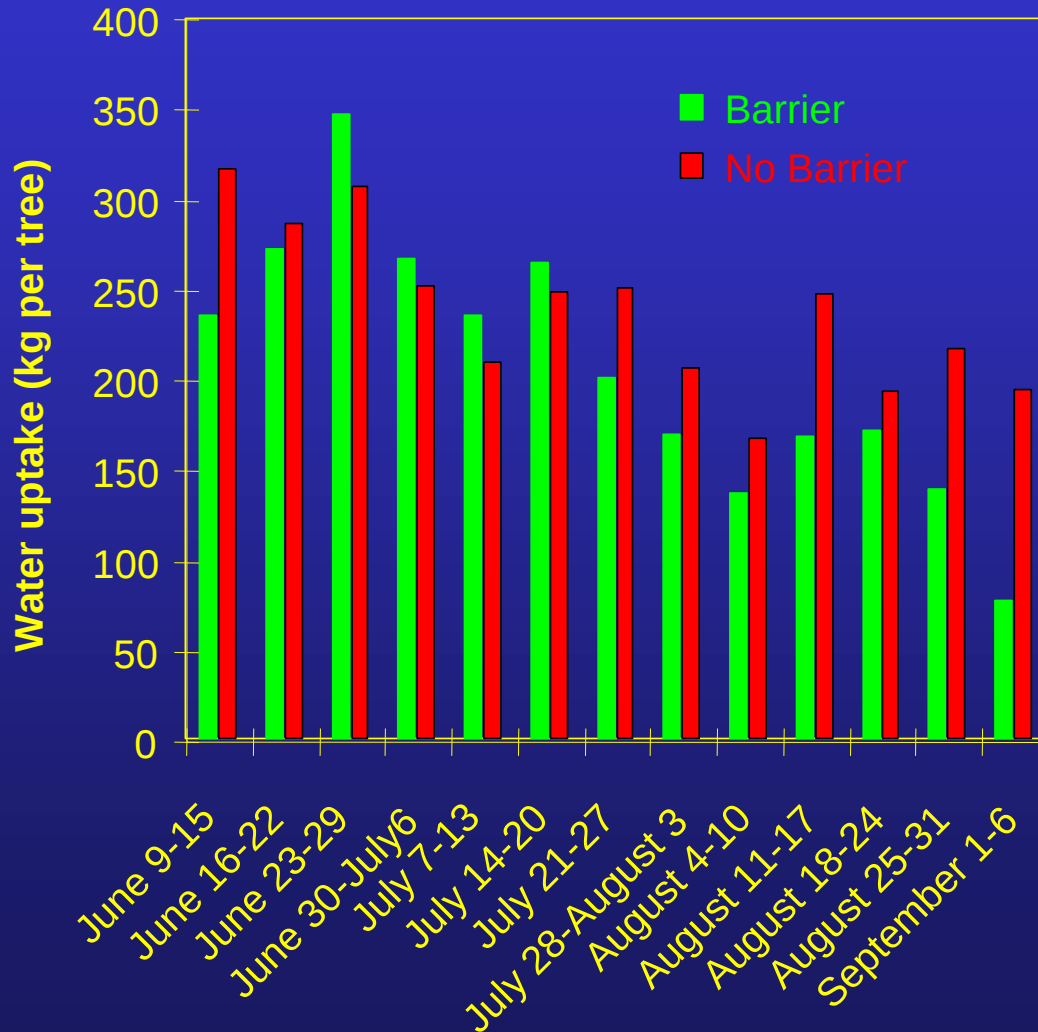
25.7% reduction

Cotton water uptake

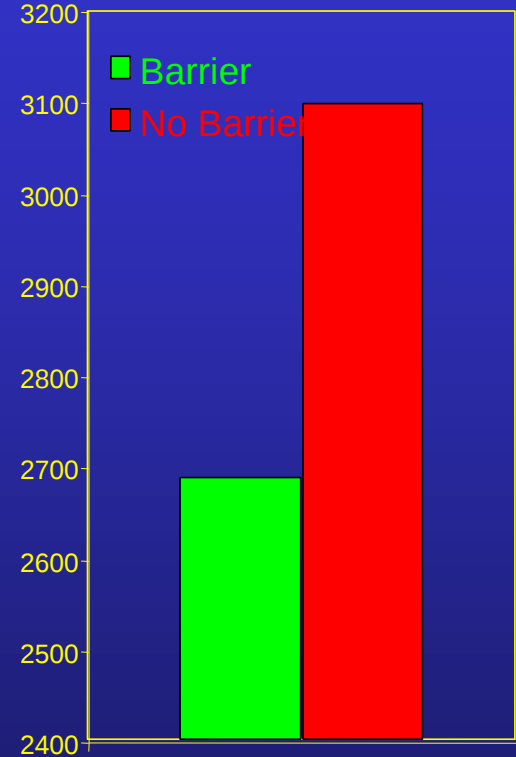


Black Walnut water uptake

Weekly uptake

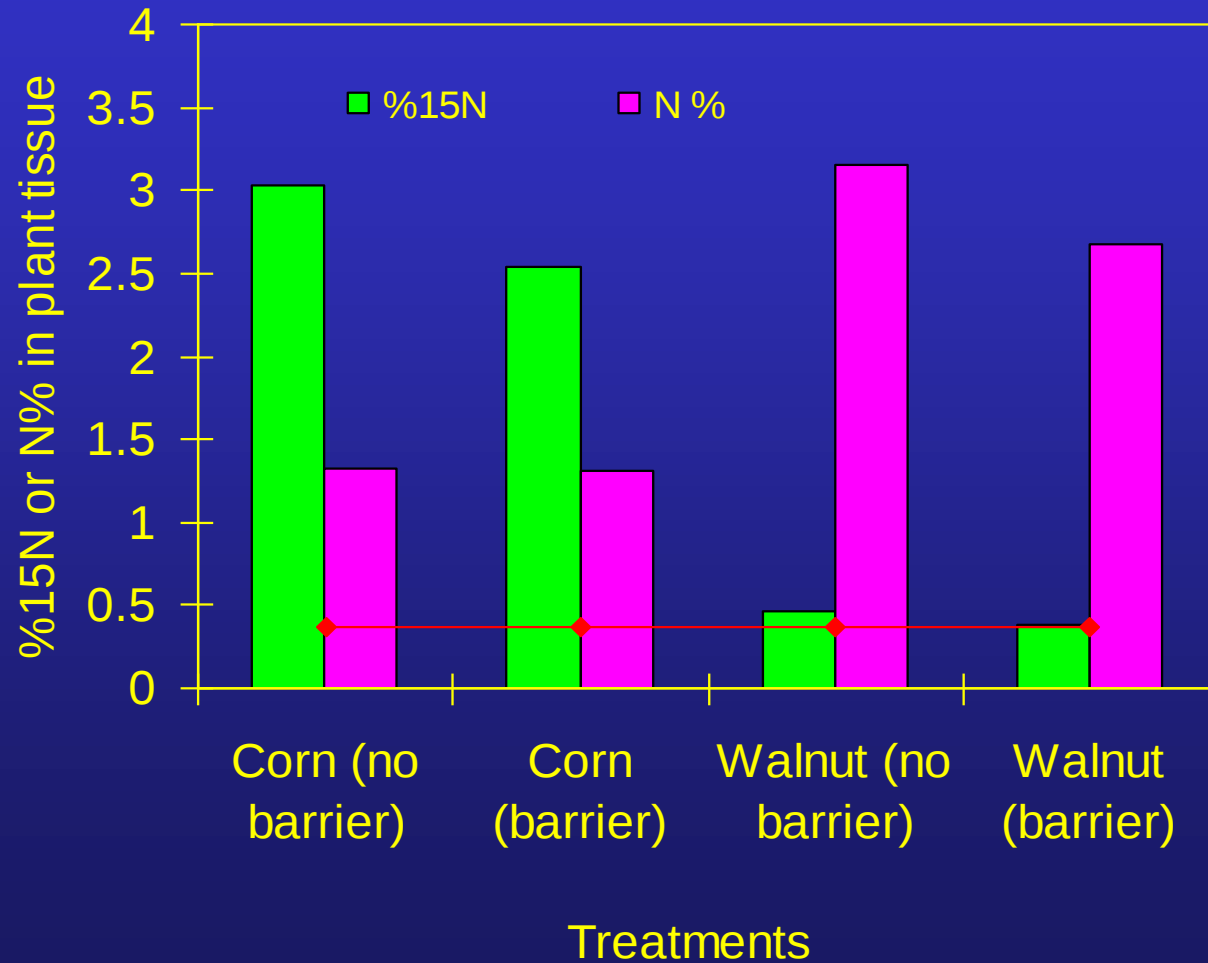


Growing season total

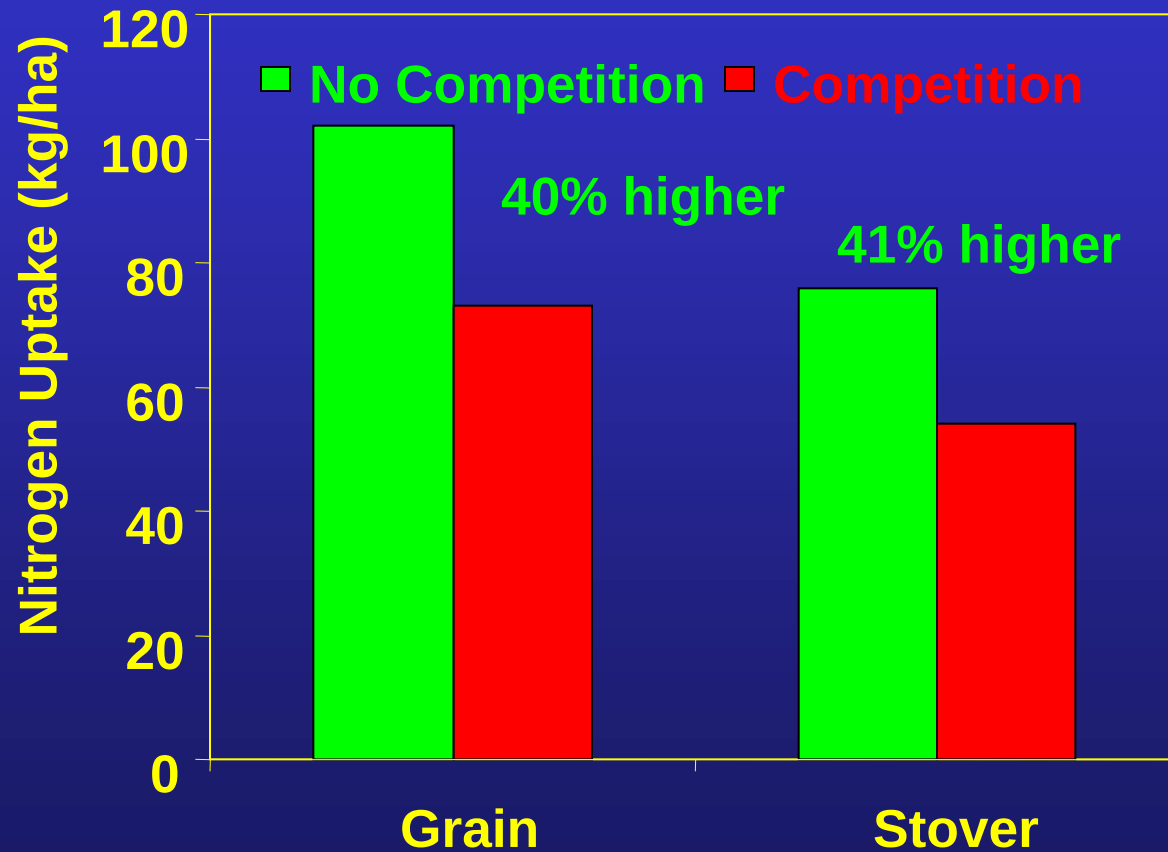


12.9% reduction

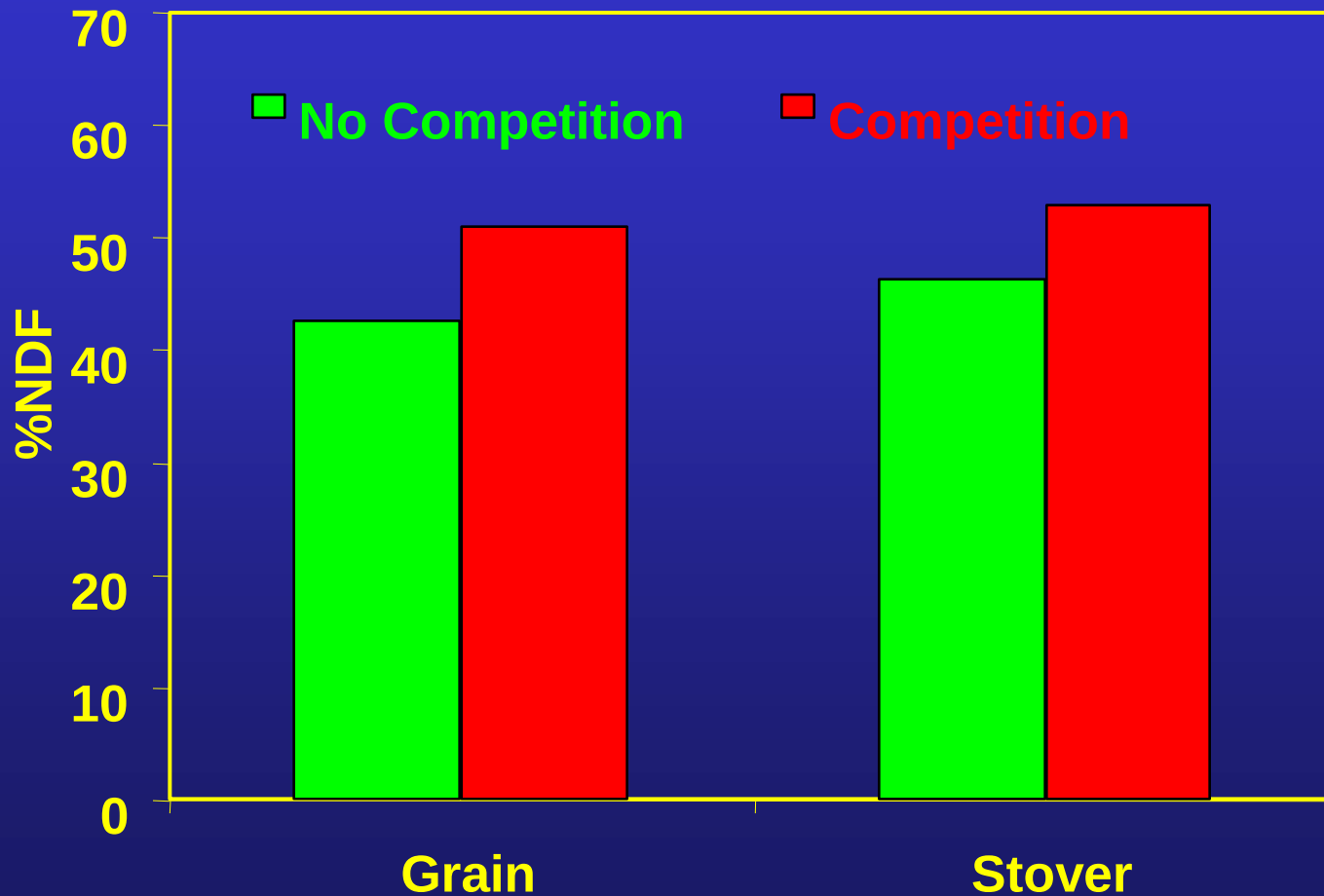
Competition for Nitrogen



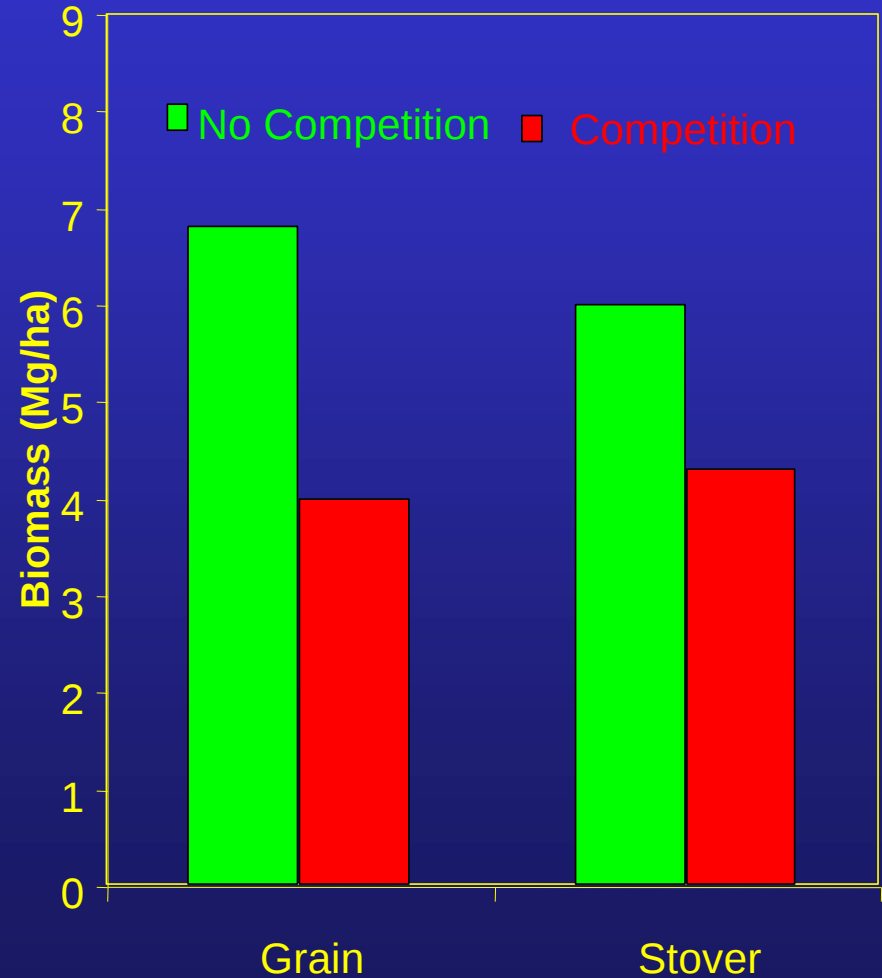
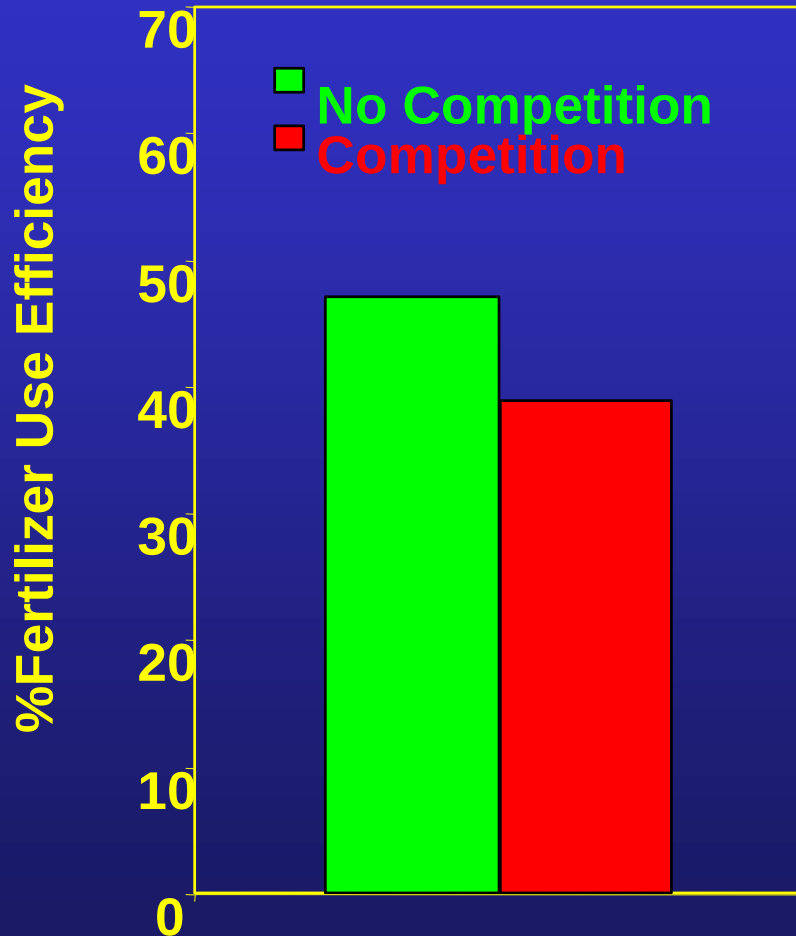
Total Nitrogen Uptake



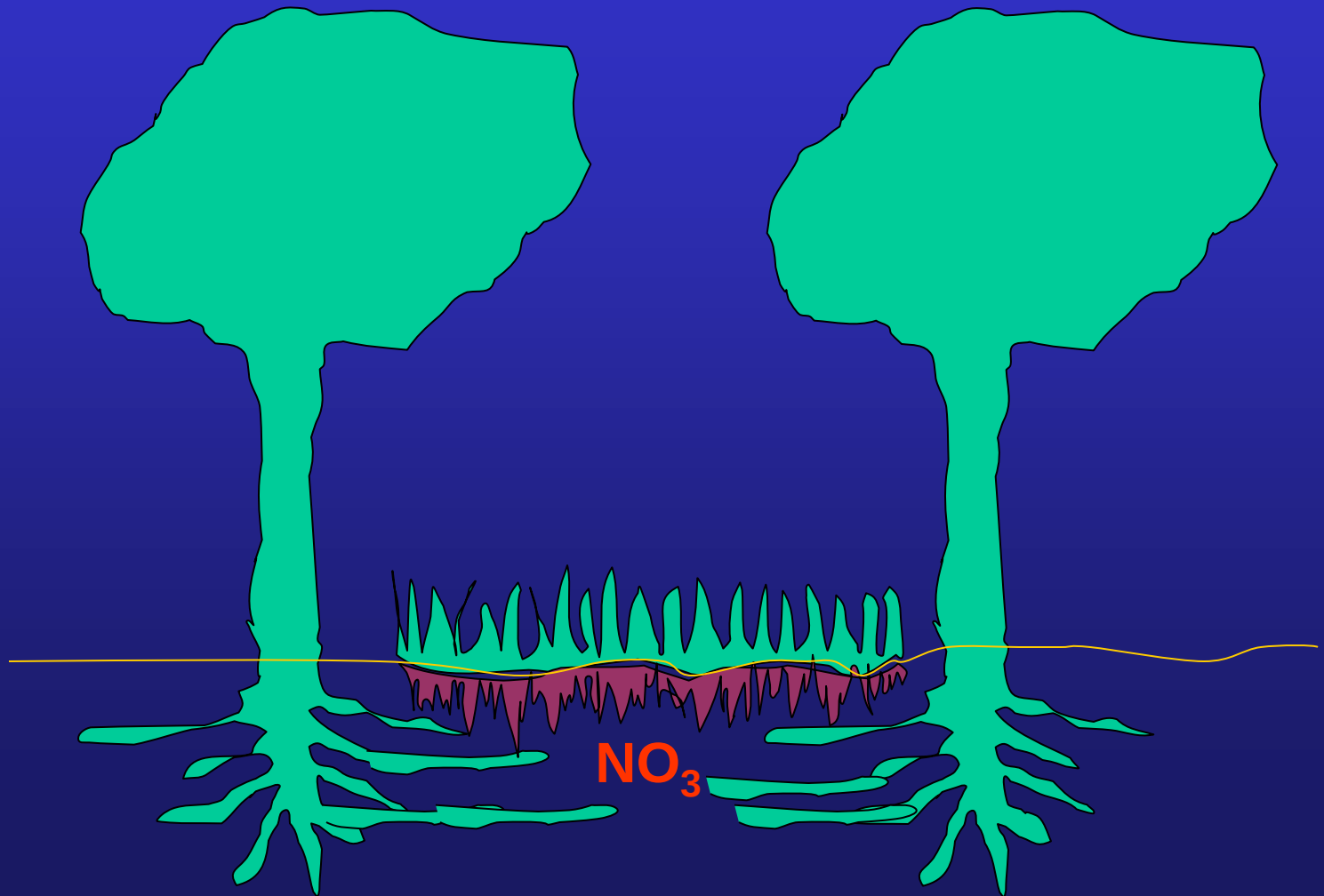
Nitrogen derived from Fertilizer



Fertilizer Use Efficiency

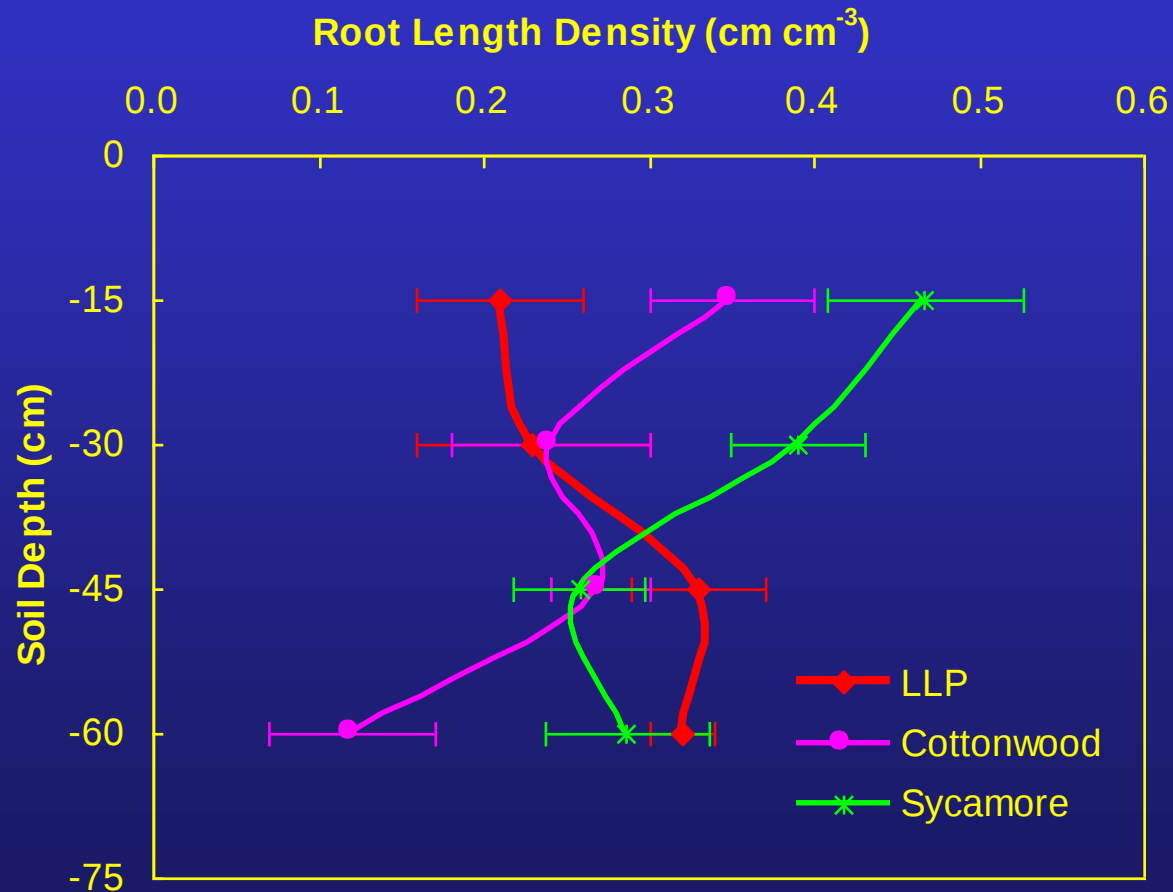


Safety net role of tree roots



Safety net in nature?

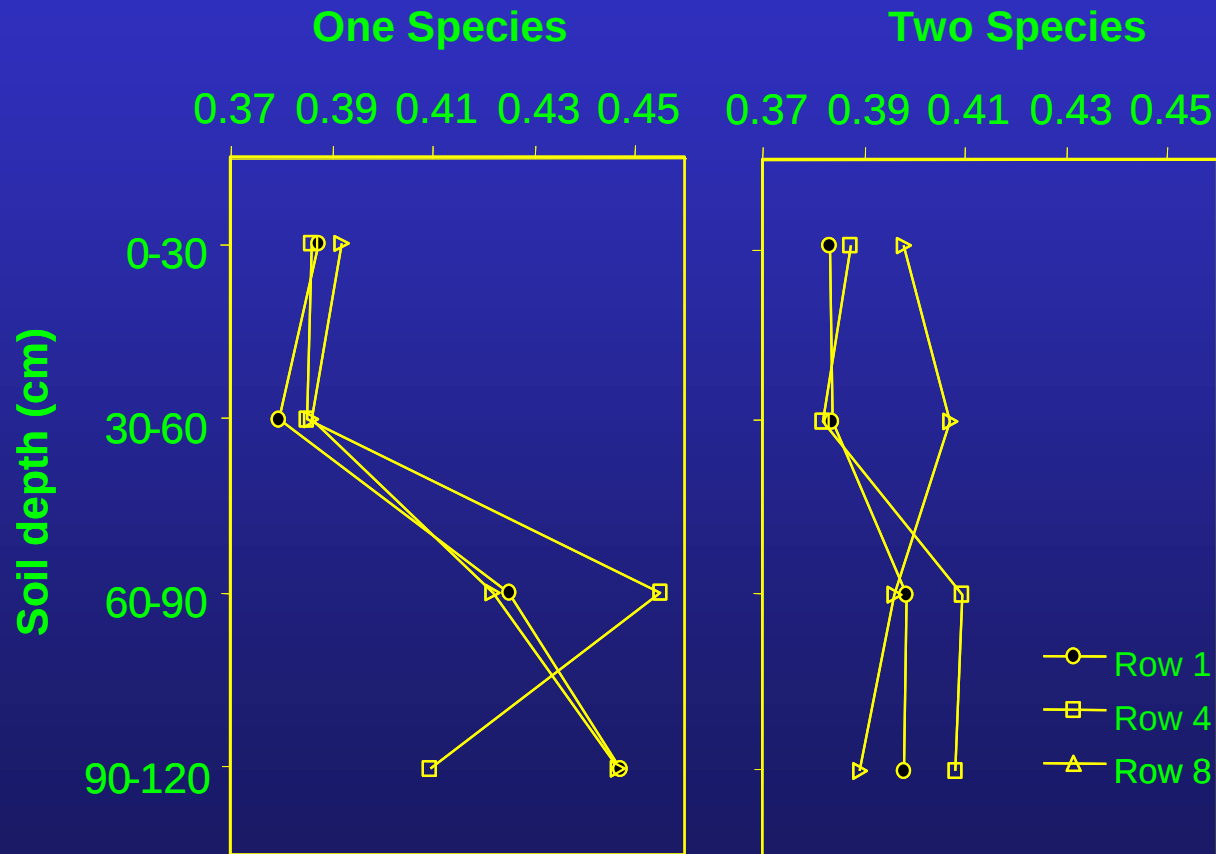
Belowground Niche separation in mixed species forests



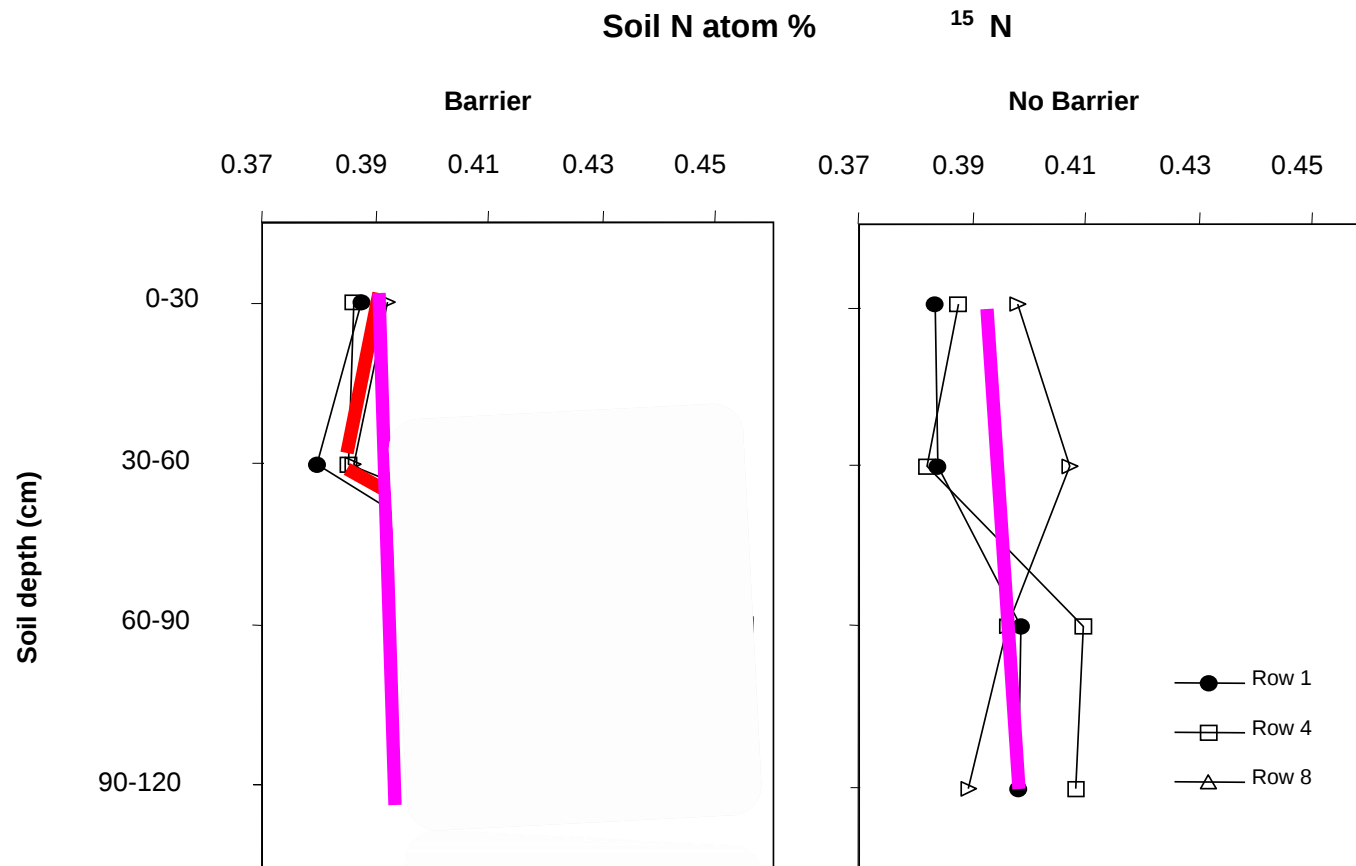


Safety net role: Evidence?

Soil N atom % ^{15}N



^{15}N in the soil profile: Safety net



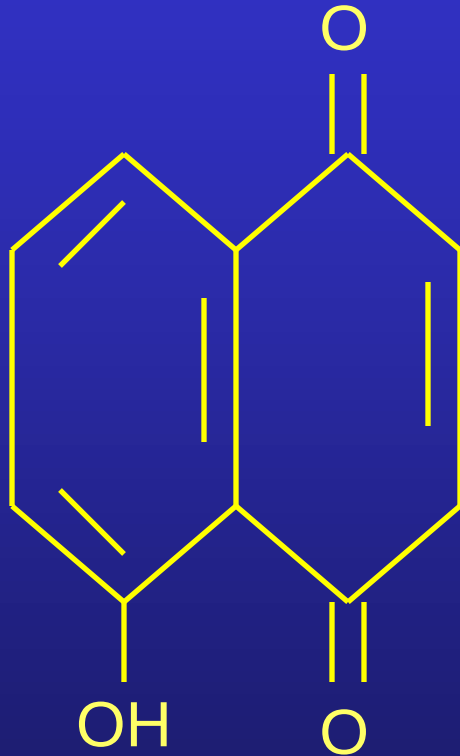
Net Retention Index

0 = No Retention

1= Total Retention

Observation Period	NO ₃ -N	
	0.3 m	0.9 m
2001 Growing Season (June-November)	0.64	0.55
2002 Growing Season (May-August)	0.45	0.97
Whole Study Period (June 2001-August 2002)	0.57	0.66

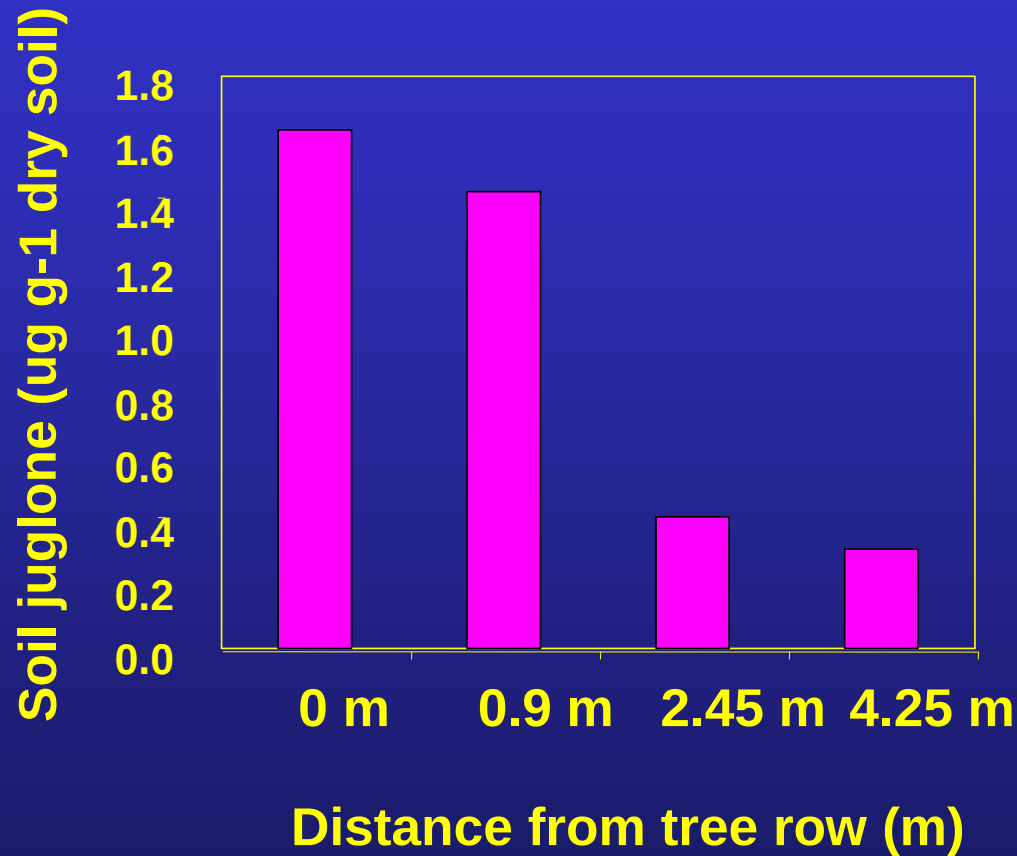
Phytotoxicity / Allelopathy



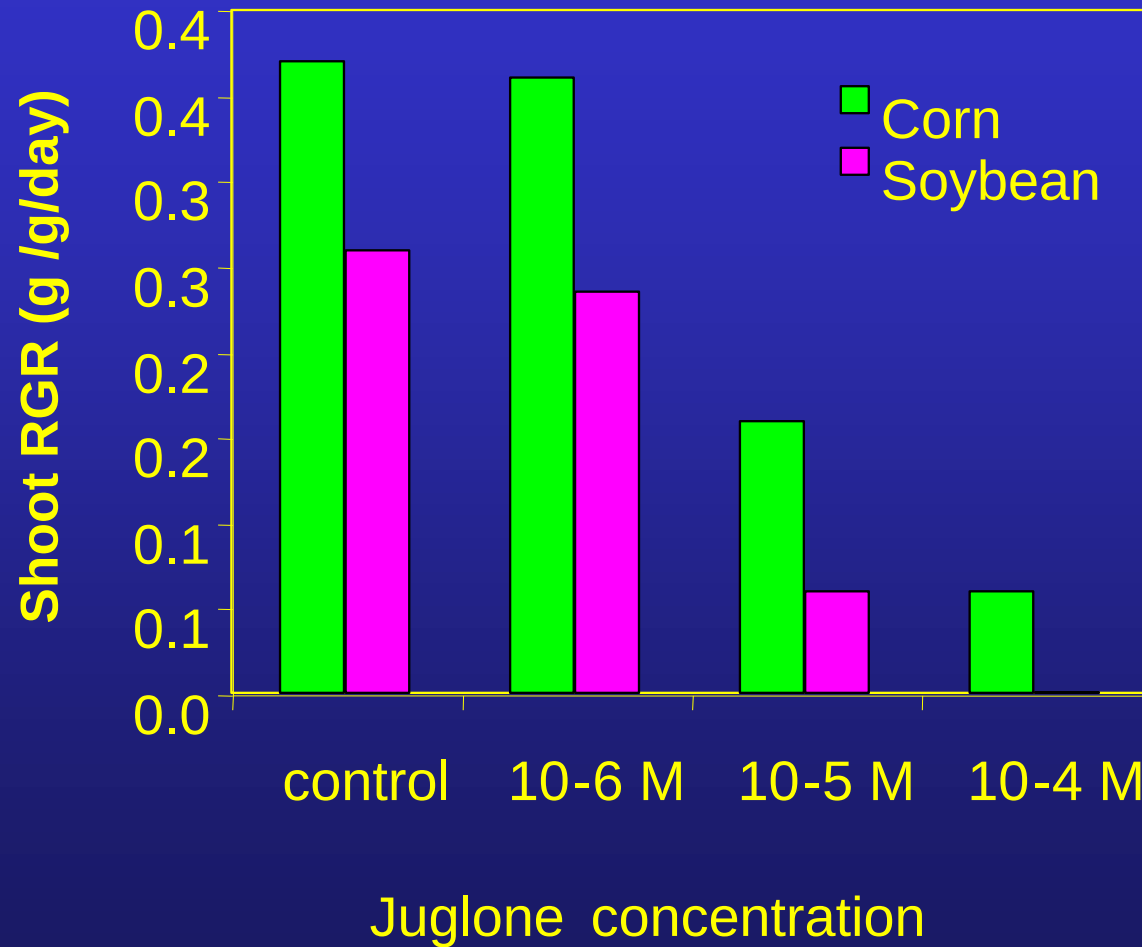
Juglone:

5-hydroxy-1,4-naphthoquinone

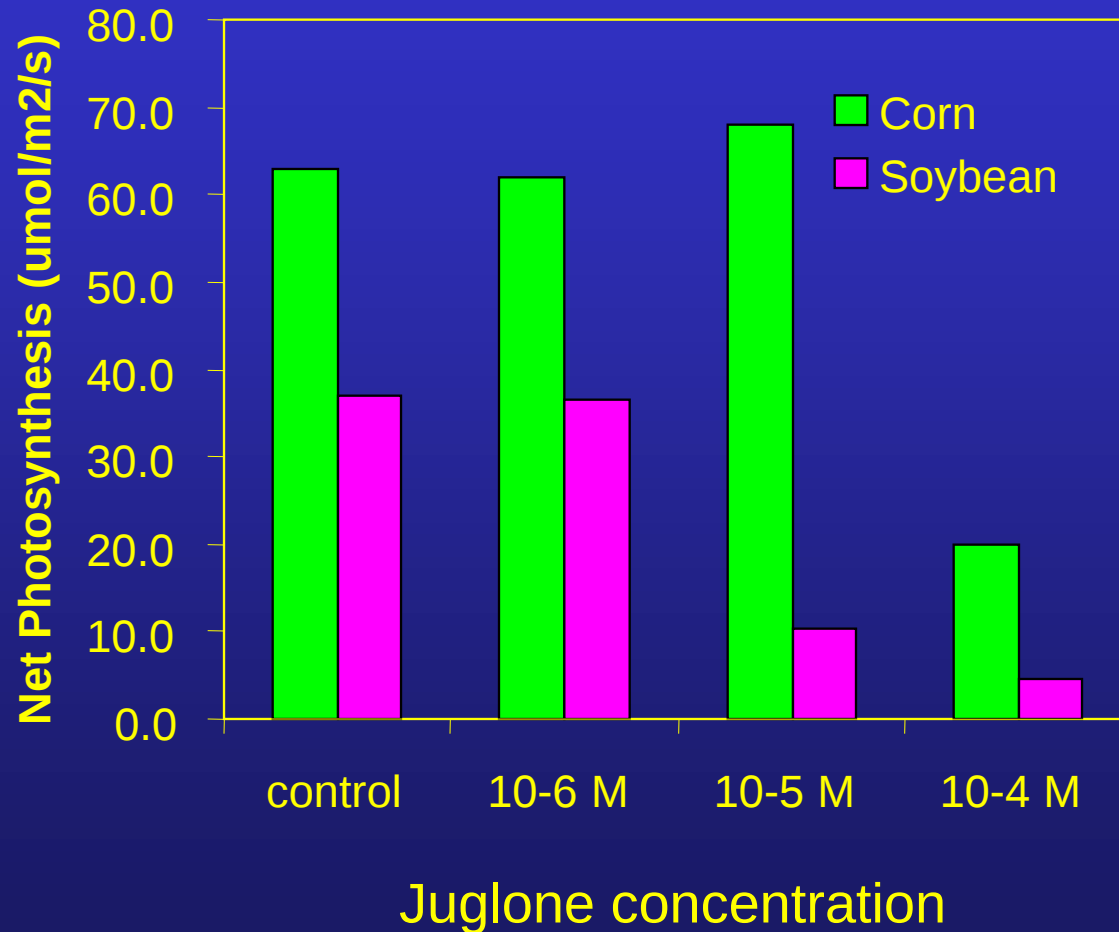
Soil Juglone: Spatial variation



Juglone: Effects on crop growth



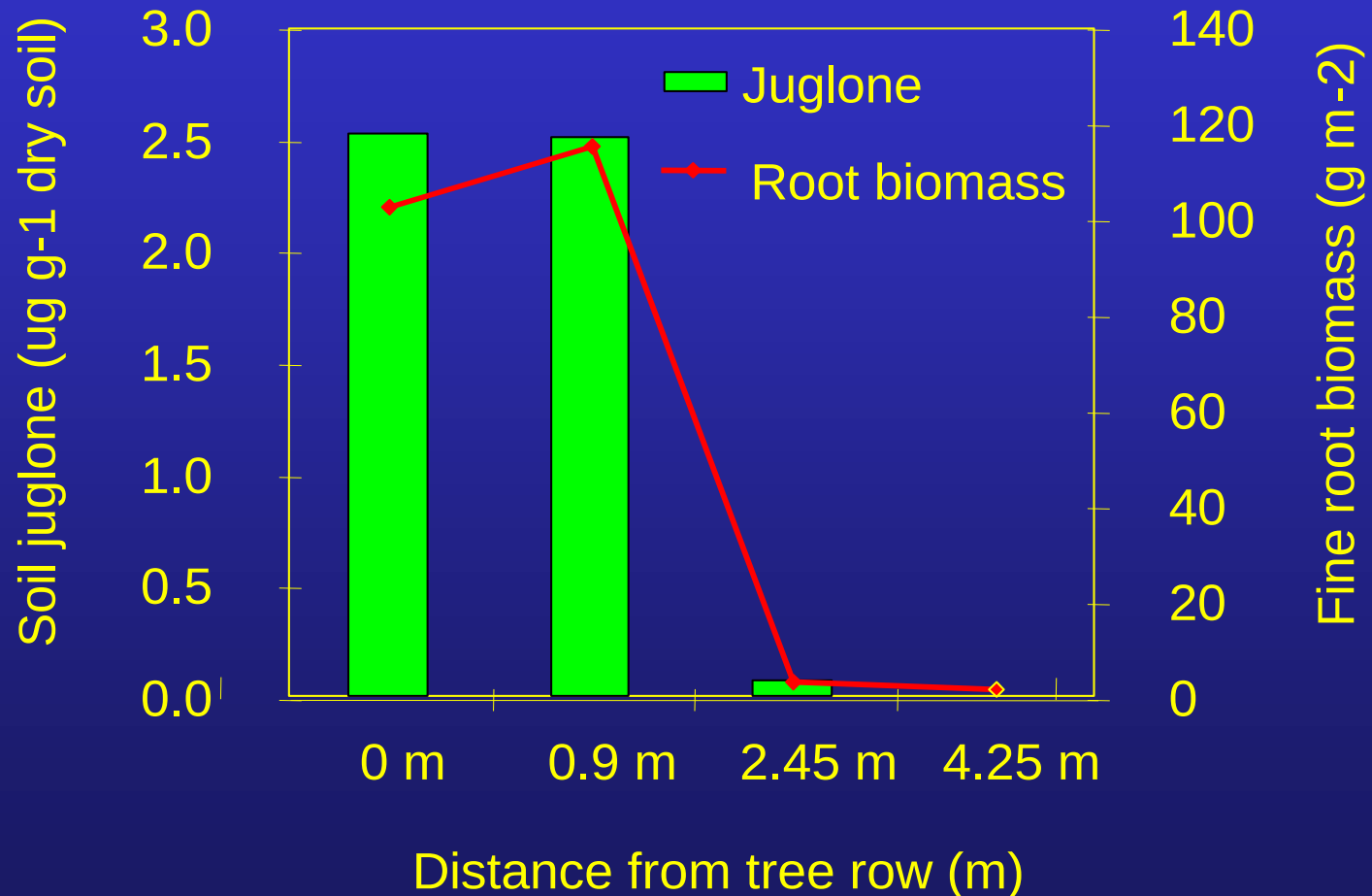
Juglone: Effects on crop physiology







Allelopathy: Management intervention





References:

- Jose and Gillespie 1998. *Plant Soil* 203: 191-197
- Jose and Gillespie 1998. *Plant Soil* 203: 199-205
- Gillespie et al. 2000. *Agrofor Syst* 48: 25-40
- Jose et al. 2000. *Agrofor Syst* 48: 41-59
- Jose et al. 2000. *Agrofor Syst* 48: 61-77
- Jose et al. 2001. *Agrofor Syst* 52: 161-168
- Jose 2002. *Chem Ecol Plants (Birkhauser-Verlag)* 149-172
- Lee and Jose 2003. *Agrofor Syst* 58:45-54
- Wanvestraut et al. 2004. *Agrofor Syst* 60:167-179
- Allen et al. 2004. *For Ecol Manage* 192:395-407
- Jose et al. 2004. *Agrofor Syst* 61:237-255
- Allen et al. 2004. *Plant Soil* 263: 151-164
- Allen et al. 2005. *Biol Fert Soil* 41: 28-37
- Lee and Jose 2005. *Agric Ecosys Environ* 105:615-623
- Jose et al. 2006. *For Ecol Manage* 233-231-239
- Zamora et al. 2007. *Agrofor Syst* 69:107-116