Competition for Water Among Plants:
Resolving the Root System

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Introduction

Competition for water and nutrients by plants plays a major role in controlling growth and the level of reactive forms of nutrients and their availability for off-site leakage.

Root competition for water and other soil resources has been scarcely quantified, particularly in multi-species pastures.

Objectives

Our goal is to develop a mechanistic model of plant competition applicable to multi-species pastures. This work will improve capabilities of the simulation models *CropSyst* and *Cycles.*

Methodology

Growth in controlled conditions, without competition for light

Root boxes (rhizotrons) in the greenhouse

Measured variables:

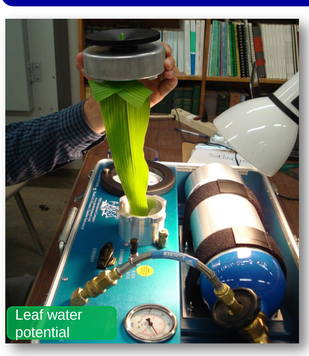
Solar radiation | Temperature | Irrigation | Relative humidity

Water Stress Phase

Measured variables

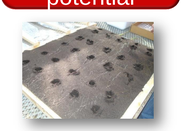
Daily water loss | Conductance | Leaf temperature

Plant and Soil Sampling



Measured variables

Leaf water potential | Soil moisture and water potential | Leaf area | Root count



Treatments


Maize/Maize


Maize

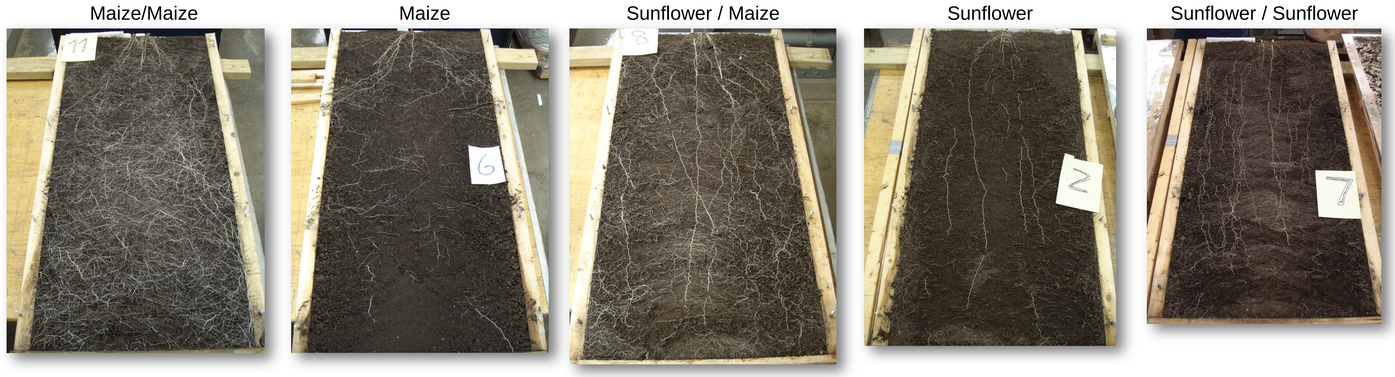

Sunflower/Maize


Sunflower

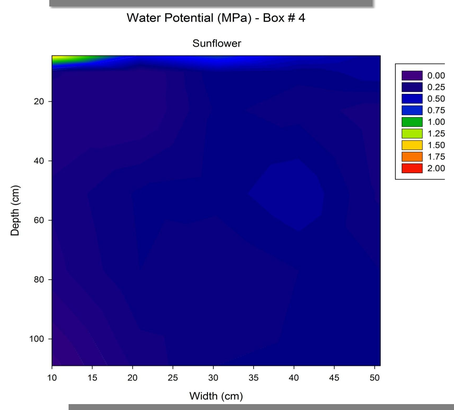

Sunflower/Sunflower

Results

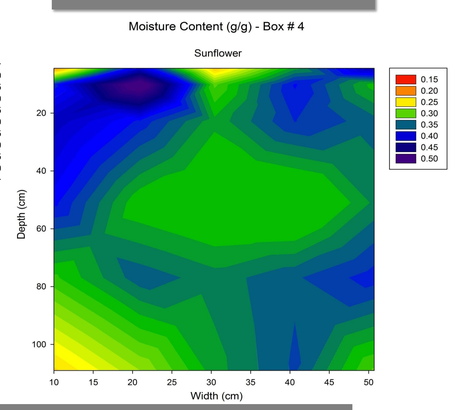
Root density



Water Potential



Water Content

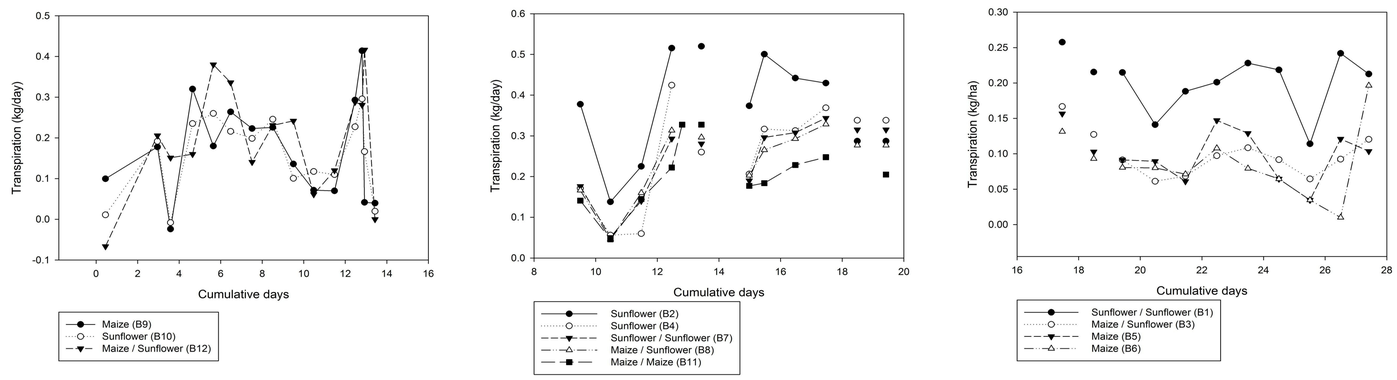


Soil + Plant Resistance

Box species	Transpiration (kg/m²/s)*	Mean Leaf Water Potential (J/kg)	Mean Soil Water Potential (J/kg)	Total Soil + Plant Resistance (m⁴/kg/s)
Sunflower / Sunflower (B1)	1.36×10^{-4}	950	349	4.43×10^{6}
Sunflower / Sunflower (B7)	8.17×10^{-5}	1260	334	1.13×10^{7}
Sunflower (B2)	6.95×10^{-5}	1570	1147	6.09×10^{6}
Sunflower (B4)	8.51×10^{-5}	1300	339	1.13×10^{7}
Maize (B5)	7.98×10^{-5}	860	77	9.81×10^{6}
Maize (B6)	8.32×10^{-5}	940	95	1.02×10^{7}
Maize / Maize (B11)	3.34×10^{-5}	995	515	1.43×10^{7}

* Maximum transpiration per square meter of leaf area.

Water transpiration



Discussion

In this study we were able to generate competition in the soil without competition for light. The total water loss of two plants was higher than that of one plant of the same species (but not twice as large). Sunflower had, as expected, a much higher conductance, transpiration, and leaf temperature depression. Combined with the root density measurements, we expect to quantify the extent to which the location of the roots control the access to water.

The work with models plants such as maize and sunflower, is the first step toward integrating this model into perennial and annual pastures.

Conclusions / Future work

The proposed systems seems to be optimal to monitor water use and compute parameters needed to understand and simulate water use by multi-species communities.

References

CropSyst available at: www.bsyse.wsu.edu/cropsyst

Cycles available at: www.ecologicalmodels.psu.edu/agroecology

Acknowledgements

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