Relationships among Yield, Canopy Temperature, and Root Architecture in Hard Winter Wheat

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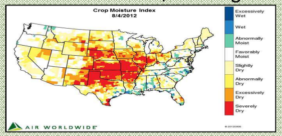
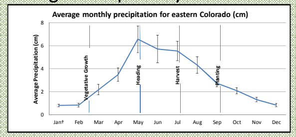
Introduction and Background

- Drought is one of the most important environmental challenges farmers face around the globe and water stress is the main cause for grain loss.
- As a consequence of climate change, water stress will likely lead to further losses, creating more hunger and poverty.



US crop moisture index shows that the Great Plains suffer from severe drought stress (2012)



Average monthly rainfall across 10 locations in eastern Colorado from 1950-1999 (NOAA, 2011)

- The development of a deep and extensive root system is a drought adaptation strategy that could efficiently acquire water and nutrients from deep soil (Palta *et al.*, 2011).
- Due to its labor intensive and destructive nature, the majority of root studies have relied on artificial conditions.
- The overall goal of this project is to use phenotypic and genotypic data from Great Plains winter wheat germplasm to discover alleles that improve yield under drought stress.

Objectives

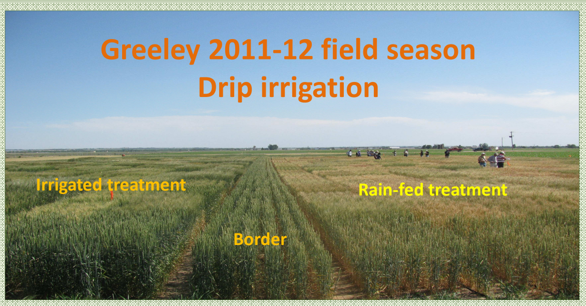
- Evaluate an association mapping population in multiple environments for yield and drought tolerance related traits (roots, canopy temperature (CT), etc.)
- Investigate the relationship among yield, canopy temperature, and root architecture.

Materials & Methods

Plant Materials

- Thirty winter wheat genotypes adapted to Colorado, and consisting of released cultivars and advanced breeding lines as part of a 300 hard winter wheat association mapping population.

Field study



Field study

- **2011-12**: Greeley, CO, USDA-Agricultural Research Service, drip irrigation.
- **2012-2013**: ARDEC, Fort Collins, CO, sprinkler irrigation.

Experimental design

- The trials were designed as a modified augmented design with one replicate and incorporating multiple repeated checks.
- Two moisture levels: fully irrigated and partially irrigated.

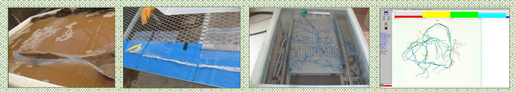
Phenotyping

- Genotypes were evaluated for a wide range of physiological, morphological, maturity, and yield traits.
- Canopy temperature: Using an infrared thermometer, around noon and at different growth stages.
- Root traits: Soil cores of 23 entries were collected using a 1 m X 5 cm hydraulic probe, 3 reps per plot.

Greenhouse study

- Genotypes were evaluated in 1 m X 10 cm plastic tubes filled with fritted clay.
- Design was RCBD, with 4 reps.

- Root masses were separated, washed, scanned, and analyzed with WinRhizo software, as shown in the photos.



Statistical analysis

- Spatial variation was accounted for by using the best-fit of six different SAS spatial models to calculate BLUPs based on performance of repeated checks.
- Statistical methods (proc corr, proc mixed, and proc GLM) were performed by SAS 9.3, SAS Institute, 2011.

Yield results

- Genotypes differed significantly for yield under drought stress ($P<0.05$) in both years.
- Yield ranged from 2.035 to 3.117 t/ha with an overall mean of 2.600 t/ha in 2011-12 and from 2.449 to 2.936 t/ha with an overall mean of 2.674 t/h in 2012-13.

Acknowledgments

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Canopy temperature

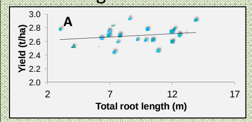
- Canopy temperature differed significantly among genotypes and ranged from 31.8 to 35.1 °C with an overall mean of 33.5 °C in 2011-12 and from 32.5 to 39.7 °C with an overall mean of 35.3 °C in 2012-13.

Root traits with significant genotype effect

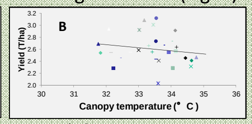
Variable	P-value
I. Root traits from the greenhouse:	
Top section diameter	0.0086
Bottom section diameter	0.0151
Top section length	0.0009
Middle section length	0.0449
Bottom section length	0.0075
Overall average diameter	0.0380
Total length	0.0007
Top section biomass	0.0005
Bottom section biomass	0.0232
II. Root traits from soil cores:	
Bottom section diameter	0.0070
Top section length	0.0478
Middle section length	0.0017

Correlations among traits

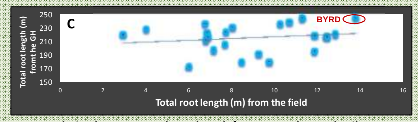
- There was a positive but non-significant correlation between yield and soil cores total root length (Fig. A).
- A negative but non-significant correlation was observed between yield (from 2011-12, and 2012-13) and canopy temperature (Fig. B).
- A positive correlation was observed between total root length from the field and the greenhouse (Fig. C).



Scatter plot between total root length (soil cores) and yield (ARDEC 2012-13)



Scatter plot between Canopy temperature and yield (Greeley 2011-12)



Correlation between total root length from root tubes and soil cores

Conclusion

Results demonstrate variability for CT, yield, and root traits among Great Plains genotypes, but additional study is needed to confirm the relationship among these traits.

Key Reference

'Palta et al., 2011' Large root systems: are they useful in adapting wheat to dry environments? Funct. Plant Biol. 38:3