Stress Impacts on Corn Root Distribution

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Introduction

The resilience of an agricultural system to climatic variability is influenced by many interactions that occur between the soil and plant systems. Changes in either system can produce long-term ramifications.

Two of the most critical components in managing stress are: 1) the impact on root development and 2) assessing how stress impacts soil quality.

Objectives

1) To determine the influence of corn hybrid on root distribution; and

2) To compare the measured non-harvested biomass with the estimated non-harvested biomass returned to soil

Materials & Methods

The experimental design was a randomized complete block design with 4 replications. The plot size was 3 m x 10 m and each plot was 4 rows wide.

Root distributions, leaf area, and root crowns were measured at silking, while grain, cobs, and leaves and stalks yields were measured at physiological maturity.

For corn roots, 4-cm wide soil cores from four locations in each plot were collected. Two samples were collected adjacent to a corn plant and two samples were collected half-way between the two rows. The samples depths were 0-15, 15-30, 30-60, and 60-76 cm. The soil and root mixture was washed with a hydropneumatic elutriator (Smucker et al., 1982) to separate roots from soil.

Grain and stover sub-samples were analyzed for total N, δ15 N, total C, and δ13C, which was used to calculate yield losses due to N (YLNS) and water stress (YLWS).

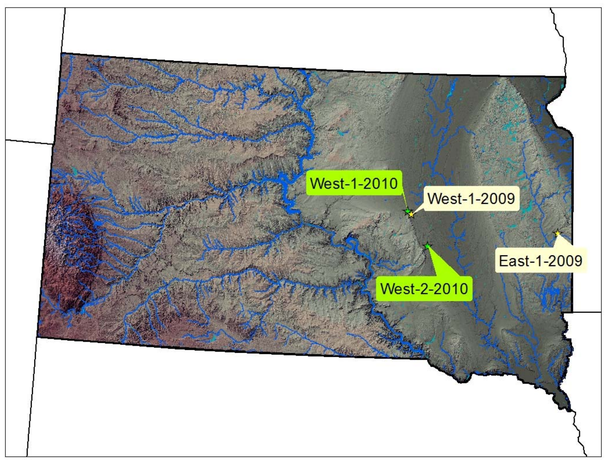

Fig. 1: Study sites in 2009 and 2010.

Results

Table 1: Correlation matrix of root biomass, above ground biomass, and yield reduction in 2009.

Root zone	Stover	Cob	Grain	NHB	YLNS	YLWS
0-15 cm	-0.101	0.069	0.355**	0.813**	0.000	0.068
15-30 cm	0.219*	-0.063	-0.135	0.366**	-0.025	-0.053
30-60 cm	-0.050	-0.050	-0.026	0.344**	0.045	0.200*
60-75 cm	-0.097	0.032	-0.042	0.132	-0.071	0.141
Root crown	-0.231**	0.062	0.376**	0.470**	0.006	0.271**
R/S ratio	-0.323**	-0.204*	0.029	0.722**	0.153	0.355**

NHB: Non-harvested biomass
YLNS: Yield loss due to N stress
YLWS: Yield loss due to water stress

*Significant in 95% level
**Significant in 99% level

Table 2: The influence of hybrid and location on root distribution, above ground biomass, and yield reduction data in 2009.

		Roots + exudates in soil zone (cm)				Root				Root/shoot		
		0-15	15-30	30-60	60-75	crown	Stover	Grain	Cob	ratio	YLNS	YLWS
		Mg/ha									Mg/ha	
Hybrid	ND4903NRR1	4.6	1.5	1.7	0.6	1.6	7.2	10.0	1.5	0.54	1.0	2.0
	ND4903MQK1	4.4	1.6	1.4	0.5	1.6	7.3	9.5	1.5	0.53	1.1	2.4
	TXP151-DA	4.8	1.5	1.2	0.5	2.0	7.1	10.1	1.4	0.55	1.0	2.0
	TXP151MQK2	4.9	1.6	1.1	0.5	1.7	7.0	9.8	1.4	0.54	1.3	2.0
	DKC50-47	4.4	1.3	1.3	0.5	1.8	6.9	9.9	1.5	0.51	1.2	1.9
	NB5101MQK1	5.1	1.4	1.1	0.4	1.6	7.6	10.3	1.5	0.49	1.0	1.7
	NC5607NRR1	4.3	1.6	1.5	0.5	2.0	7.8	8.9	1.3	0.55	2.0	2.3
	NC5607MQK1	6.4	1.6	1.7	0.6	1.9	8.0	8.9	1.3	0.67	1.8	2.3
	p	*0.038*	*0.890*	*0.025*	*0.471*	*0.276*	*0.059*	*0.064*	*0.004*	*0.040*	*0.075*	*0.832*
Location	East-1-2009	4.0	1.6	1.3	0.5	1.4	7.9	9.0	1.4	0.48	1.2	1.7
	West-1-2009	5.7	1.4	1.5	0.5	2.2	6.9	10.3	1.5	0.61	1.4	2.4
	p	*<.0001*	*0.120*	*0.121*	*0.585*	*<.0001*	*<.0001*	*<.0001*	*0.362*	*<.0001*	*0.575*	*0.003*

Table 3: The influence of hybrid and location on root distribution, above ground biomass, and yield reduction data in 2010.

		Roots + exudates in soil zone (cm)				Root				Root/shoot		
		0-15	15-30	30-60	60-75	crown	Stover	Grain	Cob	ratio	YLNS	YLWS
		Mg/ha									Mg/ha	
Hybrid	ND4903NRR1	2.9	1.1	0.4	0.1	2.7	5.7	9.4	1.2	0.45	1.2	1.2
	NC5607MQK1	2.7	1.3	0.5	0.1	3.2	6.0	9.1	1.2	0.49	1.5	2.1
	p	*0.969*	*0.141*	*0.497*	*0.778*	*0.323*	*0.630*	*0.619*	*0.422*	*0.616*	*0.401*	*0.894*
Location	West-1-2010	3.4	1.5			3.4	5.8	10.6	1.4	0.47	1.3	1.9
	West-2-2010	2.2	0.8	0.9	0.3	2.5	5.9	7.9	1.0	0.46	1.4	2.3
	p	*0.068*	*0.007*			*0.109*	*0.977*	*0.015*	*0.013*	*0.715*	*0.840*	*0.752*

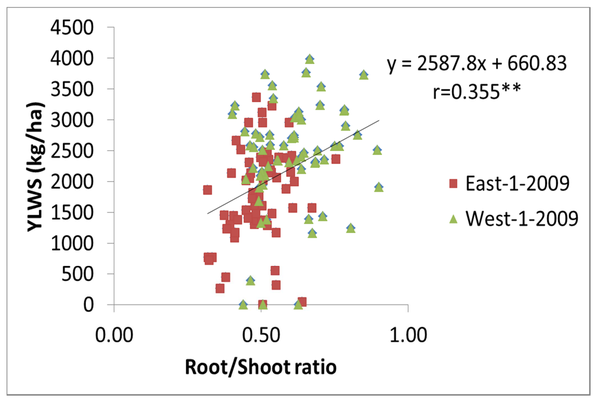

Fig. 2: These results suggest that in response to mild water stress, corn may increase root development at the expense of shoot production.

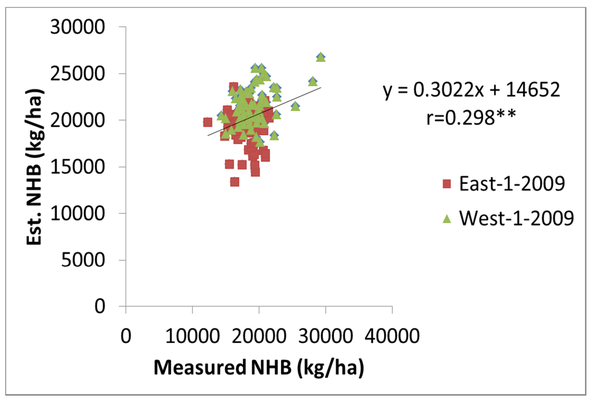

Fig. 3: When 0.55 and 0.5 are used for R/S ratio and harvest index, the measured NHB was correlated with the estimated NHB significantly.

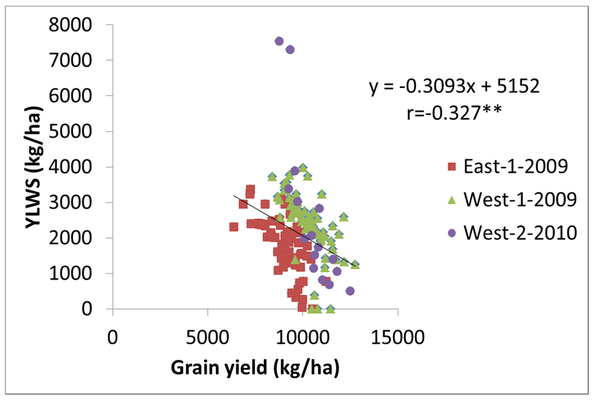

Fig. 4: These relationship showed that there was significant yield reduction with mild water stress conditions.

References

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- Clay, D.E. et al. 2010. J. Environ. Qual.39:783-790
- Smucker, A.J.M. et al. 1982. Agron. J. 74:500-503.