EVALUATION OF FERTILIZER PLACEMENT FOR CORN WITH CONTRASTING ROOTING SYSTEM

D.A. Ruiz Diaz, A.T. Rosa, and E.W. King
Kansas State University, Manhattan, KS
ruizdiaz@ksu.edu

INTRODUCTION

Corn genetic improvements in recent year's generated hybrids adapted for water limited conditions (drought tolerant-DT). Drought tolerant hybrids were developed with conventional breeding selection process, and therefore selected based on certain characteristics such as growth habits and root system. New transgenic DT corn hybrids are also becoming available to producers. A previous study demonstrated that corn response to starter fertilizer application can vary by hybrid (Gordon et al, 1997). These differences may be related to different genetic factors including growth habits and differences in root system that may also be associated with current DT corn hybrids. Commercially generated data has suggested that DT corn from conventional breeding should have a deeper rooting system with potentially higher capability for access to subsoil water. A selection process targeting different rooting systems may also affect overall nutrient uptake, particularly the uptake of immobile nutrients (Mengel, 1995). A hybrid with greater root growth, root biomass and ability to take up nitrogen and phosphorus may also show a different response to fertilizer placement including starters (Mengel, 1995). Is possible that the response to starter fertilizer may be expected of a hybrid having a slower rate of root growth and/or low nutrient uptake rate (Rhoads and Wright, 1998).

Gordon et al (1998) evaluated the effects of starter fertilizer on six corn hybrids with maturities ranging from 2530 to 2850 growing degree units (GDD) grown under no-tillage and dryland conditions. Results showed significant differences in the amount of nitrogen and phosphorus uptake at the V6 growth stage. Differences in nitrogen and phosphorus concentrations among hybrids also were found in ear leaf tissue at VT (Gordon et al, 1998). They suggested that differences in rooting system among corn hybrids may contribute to the significant differences in nutrient uptake from fertilizer and soil phosphorus. However, the study evaluated specific commercial hybrids available at that time that were not categorized based on drought tolerance. Furthermore, these field studies would require matching studies under controlled environment for detailed evaluation and measurement of the different root parameters. The objective of this study was to evaluate corn response and phosphorus uptake for DT and conventional corn hybrids with contrasting root system; and to describe differences in root growth characteristics of these hybrids.

MATERIALS AND METHODS

Two studies were conducted, including a greenhouse and field plot research at multiple locations. The greenhouse study compared two corn hybrids with contrasting root systems using large columns and image analysis. The two hybrids of corn used were P1151 AM drought tolerant (DT), and P1105 AM, a conventional hybrid (CT). A blend of macro and micronutrients was mixed with the growing media at the same rate for all columns. Irrigation was provided daily. Temperature was set for day and night and photoperiod was constant. Plant shoots and roots samples were collected at the V6, V10 and VT growth stage. Roots were scanned and processed with the WinRHIZO software to get information about root length, surface area, average diameter and root volume. Shoots and roots were dried and weighted to record biomass data. Samples were ground and sent to the Kansas State University Soil Testing Lab for analysis, including total N, P, K, S, Mn and Zn. The experimental design was a completely randomized design with three replications.

A field study was established using the same two hybrids to evaluate corn response to fertilizer and soil phosphorus. The study was established at seven locations during two years (2011 and 2012). Four locations were rain fed and three locations were irrigated. Fertilizer treatments included starter and broadcast phosphorus application, with 100 lbs/acre P2O5 broadcast and 20 lbs/acre P2O5 starter. The experimental design was a factorial and in a randomized complete block with four replications. The factors were four fertilizer treatments and two hybrid combinations for a total of eight treatments. Early growth biomass was evaluated at the V6 growth stage, including whole plant tissue phosphorus concentrations. Ear leaf tissue was collected at the VT-R1 growth stage and analyzed for phosphorus concentration. Grain yield was evaluated at the end of the growing season.

RESULTS AND DISCUSSION

The root system characteristics of the two hybrids evaluated in this study showed significant differences (Table 1 and Figure 1). The DT hybrid showed higher values for shoot and root biomass compared to the CT hybrid (Table 2 and 3). However, the nutrient concentration in the shoot and root system are similar for both hybrids, except for some nutrients such as Mn in the root (Table 3), and some tendencies for N and Zn. The uptake of nutrients therefore are primarily affected by biomass (Figure 2). The DT hybrid showed some key differences in root characteristics such as root length, surface area and root volume (Table 4). Higher values in these characteristics for the DT hybrid suggest an overall bigger root system that would likely explore a larger volume of soil during the growing season.

The same hybrids were used for the field study, results showed significant differences in early growth and P uptake, ear leaf phosphorus concentration, and grain yield response between hybrids as affected by the main effects of hybrid and fertilizer treatments. Several locations showed lower early P uptake for the DT hybrid compared to the conventional hybrid (Table 5). However, by mid-season the DT hybrid showed a higher ear leaf P concentration (Table 6). Grain yield was also higher for the DT hybrid across locations and with various yield potential (Table 7). Overall, there were no interaction effects between hybrids and fertilizer phosphorus treatments. Therefore, these hybrids seem to show similar response to fertilizer P. This would suggest that there is no need to change the P fertility management for DT hybrids compared to conventional hybrids. However, fertilizer recommendations need to be adjusted to yield potential and P removal with the grain.

REFERENCES

Gordon W.B., D.A. Whitney, and D.L. Fjell. 1998. Starter Fertilizer Interactions with Corn and Grain Sorghum Hybrids. Better Crops. 82:16-19.

Gordon W.B., D.L. Fjell, and D.A. Whitney. 1997. Corn hybrid response to starter fertilizer in a no-tillage, dryland environment. J. Prod. Ag. 10:401-404.

Mengel D.B. 1995. Roots, Growth and Nutrient Uptake, AGRY-95-08. Purdue University, Department of Agronomy, West Lafayette, IN.

Rhoads F. and D. Wright. 1998. Starter Fertilizer: Nitrogen, Phosphorus, Corn Hybrid Response, and Root Mass. Better Crops. 82:20-24.

Table 1. Level of significance (p-values) for root characteristics in corn.

Parameters	Hybrid (H)	Stage (S)	H x S
	----------- p > F -----------		
Length	<0.001	<0.001	<0.001
Surface area	0.008	<0.001	0.075
Average diameter	0.661	<0.001	0.543
Root volume	0.002	<0.001	0.010

Table 2. Corn shoot dry weight (SDW) and nutrient concentration as affected by hybrid and growth stage.

Variables		SDW	N	P	K	SO4-S	Mn	Zn
		g	- - - - - - - - - - - % - - - - - - - - - - -				- - - - - - ppm - - - - -	
DT	V6	9.4 e	2.7	0.30	4.5	0.19	246 a	37.9
CT	V6	7.6 e	3.0	0.31	4.8	0.20	197 b	36.4
DT	V10	52.6 c	2.0	0.25	3.6	0.14	147 cd	25.4
CT	V10	44.3 d	2.2	0.25	3.9	0.16	162 c	21.8
DT	VT	121.7 a	1.7	0.23	2.4	0.10	133 d	22.2
CT	VT	109.4 b	1.7	0.22	2.8	0.13	125 d	20.0

† Numbers followed by different letters between rows represent statistically significant differences at $p \leq 0.10$.

Table 3. Corn root dry weight (RDW) and nutrient concentration as affected by hybrid and growth stage.

Variables		RDW	N	P	K	S	Mn	Zn
		g	- - - - - - - - - - - % - - - - - - - - - - -				- - - - - - ppm - - - -	
DT	V6	3.3 d	1.4	0.16	2.8	0.51	278	34.9
CT	V6	4.0 d	1.5	0.16	3.4	0.54	352	35.4
DT	V10	9.1 c	1.0	0.11	1.3	0.47	338	32.5
CT	V10	8.0 c	1.2	0.13	1.4	0.46	377	42.2
DT	VT	20.8 a	1.0	0.12	1.4	0.37	280	27.4
CT	VT	17.7 b	1.1	0.13	1.8	0.45	230	26.1

† Numbers followed by different letters between rows represent statistically significant differences at $p \leq 0.10$.

Table 4. Corn root length, surface area, average diameter and root volume based on scanned images.

Variables		Length	Surface Area	Average Diam.	Root Vol.
		cm	cm^2	mm	cm^3
DT	V6	25,735 e	2851 d	0.37	25 d
CT	V6	22,844 f	2641 d	0.39	25 d
DT	V10	68,399 c	6169 c	0.29	45 c
CT	V10	51,454 d	4768 c	0.29	35 cd
DT	VT	134,124 a	14338 a	0.35	127 a
CT	VT	103,489 b	10827 b	0.34	92 b

Table 5. Phosphorus uptake of each treatment by location and across locations.

	Hybrid		Fertilizer			
Location	Drought Tolerant	Conventional	Control	Starter (S)	Broadcast (B)	S + B
	- - - - - - - - - - - - - - - - - - - mg $plant^{-1}$ -					
1	15.1 b†	17.0 a	12.0 c	17.8 b	14.0 c	20.4 a
2	39.9	42.1	30.3 b	43.2 a	43.9 a	46.7 a
3	25.8 b	29.1 a	27.8	27.8	26.5	27.7
4	26.9	27.1	24.0 c	25.3 bc	28.3 ab	30.3 a
5	40.2	40.5	36.6	39.8	39.5	45.7
6	25.3	26.7	14.7 b	20.5 b	31.4 a	37.4 a
7	39.9 a	33.4 b	29.1 b	30.9 b	42.5 a	44.1 a
All loc.	30.4	30.9	24.9 d	29.3 c	32.3 b	36.2 a

† Numbers in each row followed by different letters within each effect are statistically significant at the 0.05 probability level.

Table 6. Ear leaf concentration of each treatment by location and across locations.

	Hybrid		Fertilizer			
Location	Drought Tolerant	Conventional	Control	Starter (S)	Broadcast (B)	S + B
	- P Concentration g kg^{-1} -					
1	4.3	4.1	4.0	4.4	4.3	4.1
2	4.9	4.8	4.8	4.8	4.9	5.0
3	2.9	2.7	2.8 ab†	2.5 b	2.9 a	3.0 a
4	2.8	2.5	2.3 b	2.5 ab	2.9 a	2.8 a
5	3.0 a	2.5 b	2.4 c	2.5 bc	2.9 ab	3.3 a
6	3.3	3.1	2.9 b	2.9 b	3.5 a	3.5 a
7	3.1 a	2.6 b	2.4 b	2.4 b	3.3 a	3.2 a
All loc.	3.5 a	3.2 b	3.1 b	3.1 b	3.5 a	3.6 a

† Numbers in each row followed by different letters within each effect are statistically significant at the 0.05 probability level.

Table 7.Average grain yield of each treatment by location and across locations.

Location	Hybrid		Fertilizer			
	Drought Tolerant	Conventional	Control	Starter (S)	Broadcast (B)	S + B
	- - - - - - - - - - - - - - - - - - - -	- - - - - - - Mg ha^{-1}	- - - - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - -
1	209 a	192 b	191 b	199 ab	210 a	201 ab
2	117 a	90 b	95	104	111	104
3	95 a	55 b	74	81	81	63
4	30 a	12 b	22	21	18	23
5	152 a	140 b	146	145	147	145
6	201	209	189 b	200 b	216 a	216 a
7	216 a	196 b	196 b	204 ab	214 a	210 a
All loc.	146 a	128 b	130 b	136 ab	142 a	138 a

† Numbers in each row followed by different letters within each effect are statistically significant at the 0.05 probability level.

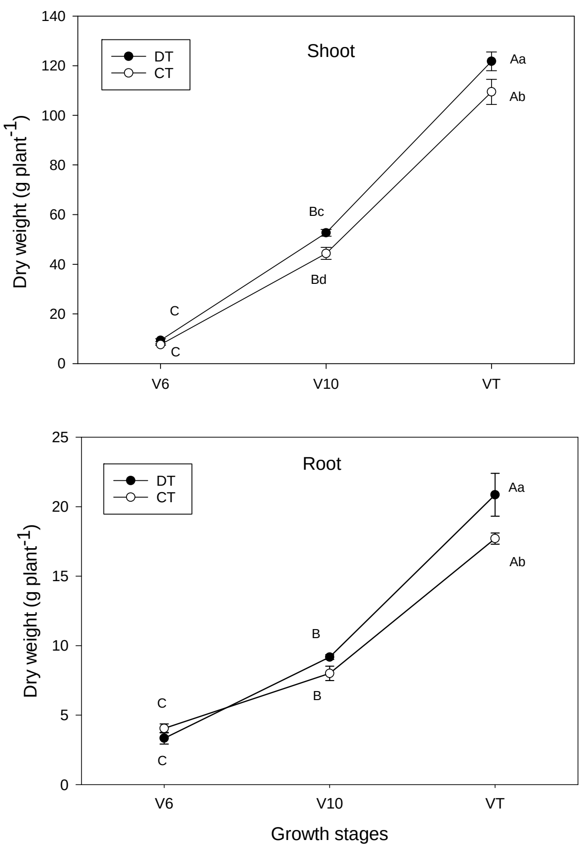

Figure 1. Corn shoots and roots biomass at V6, V10 and VT growth stages. Upper case letters indicate statistically significant differences between growth stages, and lower case letters between hybrids at $p \leq 0.10$.

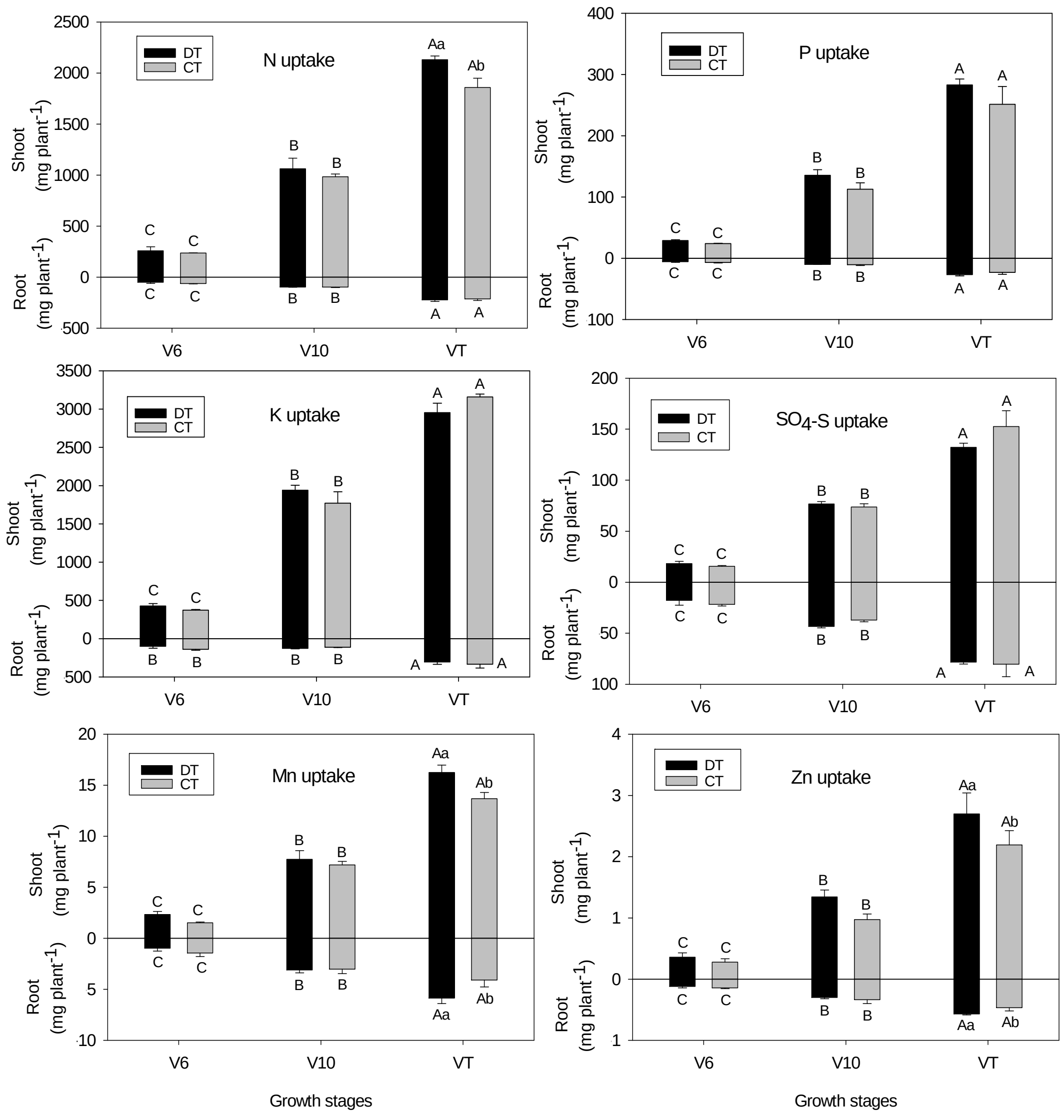

Figure 2. Nutrient uptake by shoots and roots in corn at V6, V10 and VT growth stages. Upper case letters indicate statistically significant differences between growth stages, and lower case letters between hybrids at $p \leq 0.10$.

PROCEEDINGS OF THE

45th

NORTH CENTRAL EXTENSION-INDUSTRY SOIL FERTILITY CONFERENCE

Volume 31

November 4-5, 2015
Holiday Inn Airport
Des Moines, IA

PROGRAM CHAIR:

John E. Sawyer
Iowa State Univ
Ames, IA 50011
(515) 294-7078
jsawyer@iastate.edu

PUBLISHED BY:

International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
Web page**: www.IPNI.net**

ON-LINE PROCEEDINGS:

http://extension.agron.iastate.edu/NCE/