COMPARISON OF THE NITROGEN USE EFFICIENCY AND NITROGEN NEEDS OF CORN HYBRIDS WITH AND WITHOUT TRANSGENIC CORN ROOTWORM RESISTANCE

Carrie A.M. Laboski, T.W. Andraski, and J.G. Lauer
University of Wisconsin-Madison, Dep. Soil Science and Agronomy

BACKGROUND

The number of acres planted to corn rootworm (*Diabrotica* spp.) (CRW) resistant corn (*Zea mays* L.) hybrids has increased over the past few years. It is expected that the root systems of CRW resistant hybrids are larger because of reduced larval feeding. Many agronomists feel that CRW resistant hybrids have a greater yield potential, because of reduced stress from CRW larval feeding, and may require more N fertilizer to realize this greater yield potential. However, it is possible that larger root systems of CRW resistant hybrids may actually have greater N use efficiency and perhaps a reduced N fertilizer need, or at least a similar N need, compared to non-CRW resistant hybrids. If differences in N need do exist, then the University of Wisconsin N response database will need to be updated in order to provide recommendations for CRW resistant hybrids.

There is no record in the published literature of research focusing on the N use efficiency and N need of CRW resistant vs. non-resistant corn hybrids. Research on the integration of corn hybrid traits, including CRW resistance, with various N management systems is in the preliminary stages at the University of Minnesota (Gyles Randall, personal communication). There has been some research conducted on the influence of N fertilizer on corn rootworm CRW larval feeding. Riedell et al. (1996) concluded that banded split N applications, compared to broadcast preplant applications, would result in greater tolerance to CRW larval feeding damage because of a larger root system and reduced lodging. However, Roth et al. (1995) found that N fertilizer timing (at planting, sidedress, or split) did not affect root damage ratings.

The objectives of this study were: 1) to determine if corn hybrids with a transgenic corn rootworm resistant gene vary in their N use efficiency and N need compared to non-resistant hybrids; and 2) tp obtain additional N response information to add to Wisconsin's database upon which corn N rate recommendations are made.

MATERIALS AND METHODS

A field research study was conducted in 2008 at the University of Wisconsin Agricultural Research Station at Arlington on a Plano silt loam soil (fine-silty, mixed, superactive, mesic Typic Argiudoll). Corn was grown on this site using standard management practices (chisel plow, no manure, inorganic-N fertilizer, harvested for grain) for several years prior to 2008. The continuous corn history was selected in order to increase the probability of moderate to severe corn rootworm pressure.

Treatments consisted of eight corn hybrids and six nitrogen rates in a factorial of corn hybrid and N rate in a randomized complete block design with four replications. A description of selected corn hybrids is provided in Table 1. The corn hybrids included two pairs of hybrid isolines with and without the corn rootworm resistance gene (hybrids 1 and 2; hybrids 3 and 4), two of the overall best non-rootworm resistant hybrids available in Wisconsin (hybrids 5 and 6), and two of the overall best rootworm resistant hybrids available in Wisconsin (hybrids 7 and 8). The hybrid selection was designed to reflect isoline differences as well as real-world choices that growers make when selecting a hybrid. Nitrogen fertilizer (as NH_4NO_3) rates ranged from 0 to 200 lb N/acre in 40 lb N/acre increments.

Routine soil analysis of 0-6" samples were 107 ppm P, 347 ppm K, 4.1% organic matter, and a pH of 7.1. The soil profile (0-3 ft) contained 69 lb/acre NO_3-N con obtained on 9 May, resulting in a potential preplant soil nitrate test N credit of 19 lb N/a (69 lb NO_3-N/a measured – 50 lb N/a background level). The site was chisel plowed and the seedbed was prepared for planting using a soil finisher on 30 April and 1 May, respectively. Corn was planted on 5 May with 30-inch row spacing at 33,600 seeds/acre with 3 gal/acre of 10-34-0 pop-up starter fertilizer in the furrow and 4.4 lb/acre of soil insecticide (Force 3G) in a T-band. Nitrogen fertilizer treatments were surface broadcast applied on 16 May prior to corn emergence. Initial plot size was four-rows wide (10 ft.) and 25-ft long. Plot lengths were trimmed to 20-ft and corn plants within each plot were counted and thinned to a uniform stand density of 30,500 plants/acre at the V4 to V5 corn growth stage. Weed control was accomplished with Calisto (5 oz./a) and Surpass EC (2.5 pt/a) applied preemerge on 10 May. Accent was applied postemerge on 7 June and cultivation took place on 23 June. Corn rootworm ratings were determined by digging 20 roots of the standard nontransgenic hybrid (#6; Pioneer 35A30) in a border area that did not have soil insecticide applied. The average rating was 1.12 using the 0 to 3 node-injury scale (Oleson et al., 2005).

At physiological maturity (29-30 September), nine corn plants were hand harvested from each plot to determine total biomass yield, N uptake, and silage quality (NIR). Corn grain yield was determined by harvesting all ears from the middle two rows from each plot using a plot combine on 11 November. A grain subsample was retained for analysis of total N, NIR grain protein, oil, starch, and ethanol traits. All tissue samples were ground to pass a 1-mm mesh screen, and will be analyzed for total N as described by Nelson and Sommers (1973) using automated analysis. Corn grain yields are reported at 15.5% moisture and corn silage yields are reported on a dry matter basis.

Silage and grain yield response to N were modeled with linear plateau, quadratic plateau, and quadratic models and the model with the best R^2 was chose for each hybrid (PROC REG or PROC NLIN). Economic optimum N rate (EONR) for grain and silage were calculated for several N:corn price ratios using \$0.20/lb N, \$0.40/lb N, \$0.60/lb N, and \$0.80/lb N with \$4.00/bu grain and \$86/ton dry silage.

RESULTS AND DISCUSSION

Climatic conditions for the 2008 growing season consisted of below-average air temperatures and below-average precipitation with the exception of June when total rainfall amounts were nearly 10 in. above average (Table 2).

The effect of corn hybrid and N rate on total corn biomass (silage) and grain yield was significant (Figs. 1 and 2). Silage yields among hybrids ranged from 7.38 to 9.04 tons/a at the 0 lb N/a rate and 10.33 to 11.97 tons/a at the 200 lb N/a rate. Corn grain yields among hybrids ranged from 142 to 175 bu/a at the 0 lb N/a rate and 216 to 252 bu/a at the 200 lb N/a rate. The relative grain yield at 0 lb N/a was 67, 71, 68, 73, 66, 60, 69, and 64 % for hybrids 1 through 8 respectively and for silage yield was 76, 80, 77, 77, 78, 68, 74, 70 % for hybrids 1 through 8 respectively. There was no distinction between CRW resistant and nonresistant hybrids with regard the amount of yield that could be obtained with the soil's supply of N only.

The EONR for silage and grain yield with various N:corn price ratios are given in Table 3. For each price ratio the EONR for silage and grain yield varied with hybrid and is likely a result of the efficiency of each hybrid to take up N. The EONR for grain at the 0.05 price ratio ranged from as 119 to 175 lb N/a with an average of 141 lb N/a for individual hybrids. When all hybrids are combined to create an average response model the EONR for grain is 167 lb N/a at the 0.05 price ratio. When a maximum return to N (MRTN) analysis approach (Sawyer et al., 2006) was taken using the individual hybrid N response models the MRTN for the 0.05 price ratio was 154 lb N/a with 143 to 165 lb N/a being the profitable range (within in $1/a of the return at the MRTN). It is interesting to note that using an averaging process, either MRTN or the average response model, results in an EONR or MRTN that is greater than the simple average EONR. This observation holds true for all N:corn price ratios for both grain and silage. The MRTN at each price ratio is greater than the EONR for most hybrids and suggests that if N rate recommendations are made using the MRTN approach, most of the time the recommended N rate will be greater than the actual economic amount of N needed.

The MRTN for grain and silage were similar for all price ratios. This was also true for the EONR based on the average response model. However, when evaluating individual hybrids the EONR for the 0.05 (grain) and 0.002 (silage) price ratios (same price of N with silage price indexed off of the grain price) results in silage requiring from 36 lb N/a less to 32 lb N/a more N than grain. There was no trend for CRW resistant hybrids, whether comparing near isolines or traits in general, to have higher or lower grain or silage EONR; or for silage from CRW resistant hybrids to require more or less N than grain. McLeod and Butzen (2008) recently reported that CRW resistant hybrids and near isolines (with insecticide) had similar yields at adequate N rates, while CRW resistant hybrids had greater yield when no N was applied.

Corn tissue total N, protein, oil, starch, and/or ethanol traits have not yet been analyzed but will be evaluated to determine the effect of CRW traits on these properties.

CONCLUSION

Based on one year's data, it is not possible to say that there is a difference in N requirement of CRW resistant vs. nonresistant corn hybrids when soil applied insecticide is used.

REFERENCES

McLeod, M. and S. Butzen. 2008. Planting date and nitrogen rate effects on performance of Pioneer brand hybrids with Herculex RW or Herculex XTRA technologies. Crop Insights. 18(18):1-4. Pioneer Agronomy Science.

Oleson, J.D., Y.L. Park, T.M. Nowatzki, and J.J. Tollefson. 2005. Node-injury scale to evaluate root injury by corn rootworms (Coleopter: Chrysomelidae). J. Econ. Entomol. 98:1-8.

Riedell, W.E., T.E. Schumacher, and P.D. Evenson. 1996. Nitrogen fertilizer management to improve crop tolerance to corn rootworm larval feeding damage. Agron. J. 88:27-32.

Roth, G.W., D.D. Calvin, and S.M. Lueloff. 1995. Tillage, Nitrogen Timing, And Planting Date Effects On Western Corn-Rootworm Injury To Corn. Agron. J. 87:189-193.

SAS Institute. 2002. SAS release 9.1. SAS Inst., Cary, NC.

Sawyer, J., E. Nafziger, G. Randall, L. Bundy, G. Rehm, B. Joern, C. Laboski, R. Hoeft, R. Mullen, R. Killorn, and S. Brouder. 2006. Concepts and rationale for regional nitrogen rate guidelines for corn. Iowa State University, University Extension Publ. PM2015.

Table 1. Description of corn hybrid treatments used in the Bt corn hybrid x N response study at Arlington, 2008. The corn hybrids include two pairs of hybrid isolines with and without the corn rootworm resistance gene (hybrids 1 and 2; hybrids 3 and 4), two of the overall best non-rootworm resistant hybrids available in Wisconsin (hybrids 5 and 6), and two of the overall best rootworm resistant hybrids available in Wisconsin (hybrids 7 and 8).

Hybrid no.	Hybrid i.d.	Brand	Hybrid	Relative maturity (CRM)	Traits
1	Bt-CR 1	Pioneer	P35F44	105	Herculex Xtra, Roundup Ready 2, Liberty Link
2	Isoline 1	Pioneer	P35F37	105	Roundup Ready 2
3	Bt-CR 2	DeKalb	DKC52-59	102	Yield Guard VT Triple, Roundup Ready
4	Isoline 2	DeKalb	DKC52-62	102	Roundup Ready 2
5	Standard Bt-CB	Northrup King	N58-D1	107	Yield Guard Corn Borer
6	Standard nontransgenic	Pioneer	35A30	106	None
7	Bt-CR (Mon863) 1	Renk	R698RRYGRW	104	Roundup Ready, CRW
8	Bt-CR (Mon863) 2	Dairyland	ST400	106	Roundup Ready, CRW

Table 2. Monthly precipitation, average air temperature, and growing degree days (GDD) for Arlington, 2008. Source WI-MN Cooperative Extension Agricultural Weather.

Month	Precipitation	Average air temperature
	inches	^{o}F
May	3.2 (-0.2) †	53.2 (-3.9)
June	13.7 (9.6)	65.8 (-0.8)
July	4.9 (1.0)	69.6 (-0.9)
August	1.7 (-2.6)	66.9 (-1.6)
September	1.5 (-2.2)	61.4 (0.9)

† Numbers in parentheses are the departure from the 30-year average (NOAA).

Table 3. Plateau (maximum) yield and N needed to obtain plateau yield, economic optimum N rate (EONR), grain and silage yield at EONR, and maximum return to N (MRTN) and the profitable range of N rates at several N:corn price ratios for eight corn hybrids individually and the combined average response of hybrids at Arlington, 2008.

			N:Corn price ratio (grain or silage) †							
	Plateau yield		0.05 or 0.002		0.10 or 0.005		0.15 or 0.007		0.20 or 0.009	
Hybrid	N rate	Yield	EONR	Yield	EONR	Yield	EONR	Yield	EONR	Yield
	lb/a	bu/a	lb/a	bu/a	lb/a	bu/a	lb/a	bu/a	lb/a	bu/a
Grain										
1	164	227	155	227	146	226	137	225	128	223
2	131	234	131	234	131	234	131	234	131	234
3	128	250	128	250	128	250	128	250	128	250
4	175	227	163	227	150	226	138	225	126	222
5	130	212	124	211	118	211	112	210	107	209
6	119	239	119	239	119	239	119	239	119	239
7	130	230	130	230	130	230	130	230	130	230
8	185	234	175	234	165	233	155	232	145	230
Ave.	177	233	167	233	157	232	147	231	138	229
	MRTN, lb/a		154		141		137		132	
	Range ≤ $1/a		143 - 165		134 - 148		130 - 143		125 - 139	
Silage										
1	119	10.55	119	10.55	119	10.55	119	10.55	119	10.55
2	133	10.86	133	10.86	133	10.86	133	10.86	133	10.86
3	160	11.49	160	11.49	160	11.49	160	11.49	160	11.49
4	143	10.49	143	10.49	143	10.49	143	10.49	143	10.49
5	144	10.12	132	10.11	119	10.06	110	10.01	100	9.93
6	129	11.83	129	11.83	129	11.83	129	11.83	129	11.83
7	124	10.68	124	10.68	124	10.68	124	10.68	124	10.68
8	154	10.64	142	10.53	131	10.50	124	10.45	117	10.40
Ave.	189	10.89	177	10.88	158	10.82	146	10.74	133	10.64
	MRTN, lb/a		156		145		137		131	
	Range ≤ $1/a		141 - 170		137 - 154		129 - 145		123 - 139	

† Example of N:corn price ratio: $4.00/bu corn grain or $86/ton dry silage, and $0.20/lb N (0.05 or 0.002), $0.40/lb N (0.10 or 0.005), $0.60/lb N (0.15 or 0.007), or $0.80/lb N (0.20 or 0.009).

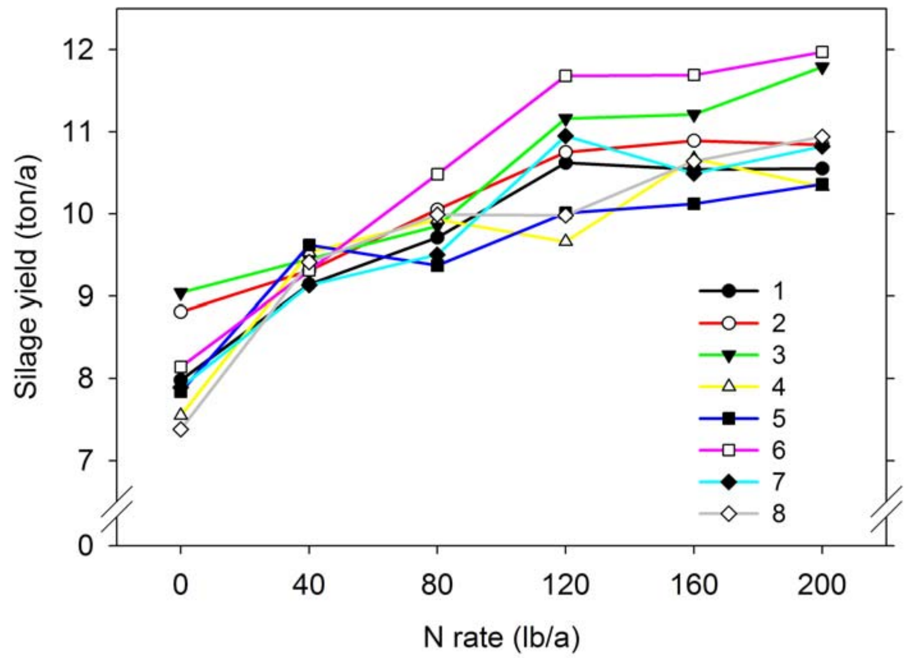

Figure 1. Relationship between N rate and corn silage yield for eight corn hybrids at Arlington, WI in 2008.

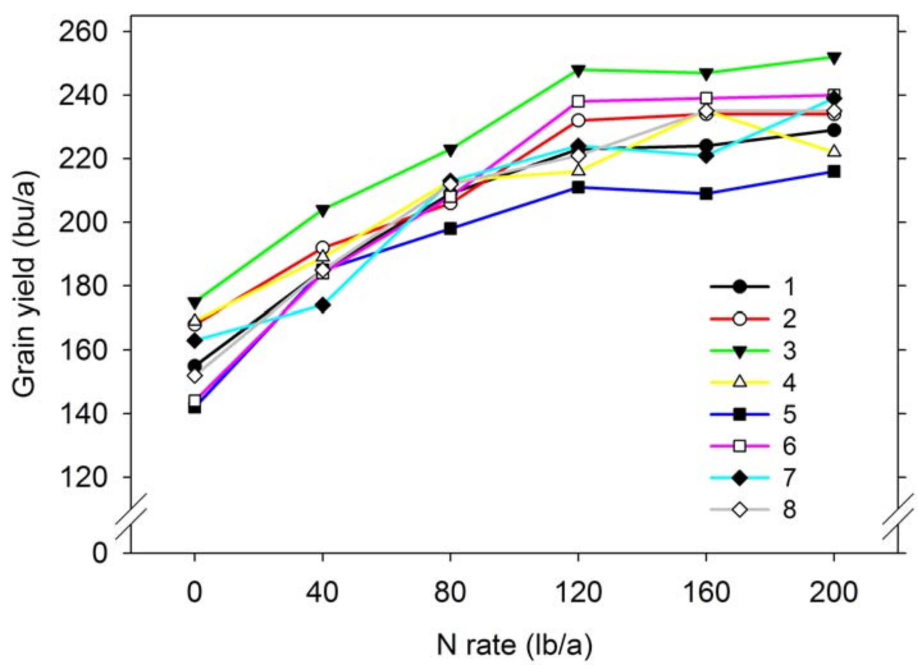

Figure 2. Relationship between N rate and corn grain yield for eight corn hybrids at Arlington, WI in 2008.