Do new corn hybrids and yield levels influence potassium fertilizer management?

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Background

The frequency of potassium (K) deficiency symptoms in corn has increased in recent years. Observations in Iowa and neighboring states have shown that the reason for these symptoms was a low soil K level in about two-thirds of the instances reported. In the rest of the instances, however, the K deficiency symptoms resulted from a variety of reasons related to limitations in root growth or water uptake and/or K uptake by plants. It is known that factors that limit root activity and growth greatly inhibit K uptake and yield because K is a relatively immobile nutrient in soils. A strong root system and continuous growth of fine roots are required to supply sufficient K to high yielding crops. However, there has not been research on K use efficiency or K fertilizer need of genetically modified modern hybrids with traits that may directly or indirectly affect the physiological needs for K or the plant capacity for K uptake. Of particular interest is the rootworm resistance trait, because a healthier root system without a need for root insecticides and higher yield could result on different root size or surface area that, in turn, can affect K uptake and the yield response to K fertilization. Therefore, a research project has been investigating since 2006 the K nutrition of corn hybrids with or without the rootworm resistance trait.

Procedures

Nine three-year field trials with continuous corn were established at Iowa State University (ISU) research farms in 2006 (4 trials) and 2007 (5 trials). All she sites had corn the previous year and were managed with chisel-plow/disk tillage. The trials were at the Central, Northern, Northeast, Southeast, and Southwest farms. Treatments replicated four times were two hybrids and several K fertilization rates. One hybrid was resistant to glyphosate and European corn borer and the other hybrid was an isoline with the addition of rootworm resistance. For the first year of the trials, the K treatments were 0, 30, 60, 120, and 180 lb K_2O/acre. For second and third years, a K rate of 180 lb K_2O/acre was applied only to plots that had received the 30-lb rate the first year. No insecticide was applied for any hybrid, and uniform high rates of N and P fertilizers were applied across all plots so these nutrients did not limit yield. Soil samples (6-inch depth) were collected each year from each site before applying the K fertilizer treatments and planting corn. Initial soil-test K across sites ranged from values borderline between Very Low and Low to Very High according to ISU soil-test Interpretations (Table 1). Measurements were grain yield, rootworm incidence, and nutrient concentration in plant tissue. For assessment of rootworm injury, corn roots from five plants were excavated in middle to late July from plots that received 0, 60, or 180 lb K_2O/acre, and injury was evaluated visually by using the continuous node-injury scale recommended by ISU (which ranges from 0 to 3). The above-ground part of the plants was weighed, chopped, and a tissue sample was collected to measure nutrient concentration by standard tissue testing methods. Also, ear leaves of corn were sampled at the same time from all plots to be analyzed for K concentration. Grain yield was harvested by hand or using plot combines, and a sample of grain was taken to determine moisture and nutrient concentration.

Summary results

In this article we summarize grain yield results from trials conducted from 2006 through 2008 (22 site-years) and results of plant tissue nutrient analyses only for the trials conducted in 2006 and 2007 (13 site-years) because tissue samples for recent years have not been analyzed or results could not be summarized yet.

The measured rootworm node injury ratings are shown in (Table 2). There was significantly higher injury for the rootworm susceptible hybrid as compared to the resistant hybrid in 19 site-years. Potassium fertilization had no effect on rootworm injury and, therefore, only averages with or without K application are shown. The root injury index ranged from 0.01 to 0.43 for the resistant hybrid and from 0.07 to 2.37 for the susceptible hybrid.

The corn hybrid with rootworm resistance usually yielded more than the susceptible hybrid. On average across all K rates, the grain yield difference was 4 bu/acre or larger in 14 of the 22-site-years. The statistically significant yield differences ranged from 4 to 32 bu/acre. Although yield differences between hybrids tended to be larger at sites or years with greater measured rootworm root injury, there was no good correlation between the yield difference and the root injury rating. Potassium fertilization had a statistically significant increasing effect on corn grain yield at six of the 22 site-years, but the increases seldom differed across the K rates. On average across all fertilizer K rates, yield was 5 bu/acre higher for one or both hybrids but large responses (9 bu/acre or larger) across both hybrids were observed only at Site 2 in 2006, Site 3 in 2008, and Site 8 in 2007 and 2008. The yield response to K fertilizer was statistically similar for both hybrids at each trial. Figure 1 shows yield averages across the sites where there was a yield response to K fertilization. Yield averages for rates of 30 and 30+180 lb K_2O/acre are not shown because these rates were not applied every year. The data suggest slightly larger yield difference between the two hybrids when K fertilizer was not applied and for the lowest K rate. Moreover, the response curves indicate that the K rate that on average maximized yield for this set of trials was smaller for the resistant hybrid even though the yield level was higher.

Plant-tissue analysis of samples collected from the first 13 site-years (in 2006 and 2007) showed that K fertilization increased the ear-leaf K concentration of corn in eight site-years and also increased both whole-plant K concentration and K uptake in 10 site-years. Data from several sites showed a significant interaction between hybrid and K rate for K uptake, which was explained by higher uptake for the resistant hybrid at low K fertilization rates but almost similar uptake for both hybrids at high K rates. Figure 2 shows whole-plant K uptake averages across all trials conducted in 2006 and 2007. The data show a clear interaction between hybrid and K fertilizer rate. Without K application the K uptake was higher for the rootworm resistant hybrid than for the susceptible hybrid but there were no consistent or large differences when K was applied. Therefore, the results clearly demonstrate that rootworm resistance results in better soil exploration or function by roots and more soil K uptake. In contrast, K fertilization had no clear effect on plant N and P concentration or uptake.

Removal of N, P, and K with grain harvest in trials for which chemical analyses were completed tended to follow the grain yield trends. The most obvious effect was that the higher yield of the rootworm resistance hybrid determined a higher nutrient removal. Data in Fig. 3 shows the relative effects of corn rootworm resistance on grain yield, K nutrient concentration, and nutrient uptake. The average N, K, and P removal differences between hybrids were 6, 2, and 2 lb of N, K_2O, or P_2O_5/acre, respectively, which corresponded to an average grain yield difference of 8 bu/acre.

Preliminary conclusions

The corn hybrid with rootworm resistance often yielded more than the susceptible hybrid, even with little root injury. Results for each site showed no consistent effect of rootworm resistance on the yield response to K fertilizer. On average across sites where K increased yield, however, the rate the maximized yield was slightly lower for the resistant hybrid even when the yield level was higher. On the other hand there was clear evidence for higher K uptake by the resistant hybrid when no K fertilizer was applied. Results for increased K uptake and higher yield levels for the resistant hybrid and a response to K fertilizer similar to the susceptible hybrid or smaller indicate higher K use efficiency with rootworm resistance. However, the higher yield levels and K removal by the resistant hybrids implies higher P and K fertilization rates needed to maintain desirable soil-test levels over time.

Acknowledgments

We recognize significant help from ISU research farms personnel Jeffrey Butler, Michael Fiscus, Kenneth Pecinovsky, David Rueber, and Kevin Van Dee. We thank Monsanto Co., especially Dr. Emilio Oyarzabal, for corn seed donation.

Table 1. Location, year, corn hybrid, and initial soil-test values for each trial.

			Hybrid		Soil-Test Values		
Site	**Region**	**Year**	**Resistant**	**Susceptible**	**K**	**pH**	**OM†**
					ppm		
1	Central	2007	DKC61-69 (VT3)	DKC61-73 (RR2/YGCB)	91	5.4	3.6
		2008	DKC61-69 (VT3)	DKC61-73 (RR2/YGCB)			
2	N. East	2007	DKC52-59 (VT3)	DKC52-63 (RR2/YGCB)	130	6.4	2.6
		2008	DKC52-59 (VT3)	DKC52-63 (RR2/YGCB)			
3	N. East	2006	DKC51-39 (YGPL)	DKC50-20 (RR2/YGCB)	123	6.1	3.3
		2007	DKC52-59 (VT3)	DKC52-63 (RR2/YGCB)			
		2008	DKC52-59 (VT3)	DKC52-63 (RR2/YGCB)			
4	North	2007	DKC52-59 (VT3)	DKC52-63 (RR2/YGCB)	191	6.1	4.5
		2008	DKC52-59 (VT3)	DKC52-63 (RR2/YGCB)			
5	North	2006	DKC51-39 (YGPL)	DKC50-20 (RR2/YGCB)	167	6.4	5.2
		2007	DKC52-59 (VT3)	DKC52-63 (RR2/YGCB)			
		2008	DKC52-59 (VT3)	DKC52-63 (RR2/YGCB)			
6	S. East	2007	DKC63-42 (VT3)	DKC63-46 (RR2/YGCB)	164	5.7	4.6
		2008	DKC63-42 (VT3)	DKC63-46 (RR2/YGCB)			
7	S. East	2006	DKC63-64 (YGPL)	DKC6381 (RR2/YGCB)	269	6.0	4.8
		2007	DKC63-42 (VT3)	DKC63-46 (RR2/YGCB)			
		2008	DKC63-42 (VT3)	DKC63-46 (RR2/YGCB)			
8	S. West	2007	DKC63-42 (VT3)	DKC63-46 (RR2/YGCB)	202	6.2	3.8
		2008	DKC63-42 (VT3)	DKC63-46 (RR2/YGCB)			
9	S. West	2006	DKC60-18 (YGPL)	DKC60-19 (RR2/YGCB)	203	6.9	2.3
		2007	DKC63-42 (VT3)	DKC63-46 (RR2/YGCB)			
		2008	DKC63-42 (VT3)	DKC63-46 (RR2/YGCB)			

† OM, organic matter.

Table 2. Rootworm root injury ratings (averages across all K application rates).

Site	Year	Resistant Hybrid	Susceptible Hybrid
		-- Root Rating Index --	
1	2007	0.08	0.61
	2008	0.22	0.22
2	2007	0.43	0.52
	2008	0.06	0.24
3	2006	0.01	0.94
	2007	0.10	1.31
	2008	0.05	0.61
4	2007	0.09	2.16
	2008	0.07	0.60
5	2006	0.02	0.69
	2007	0.10	1.81
	2008	0.04	0.21
6	2007	0.12	1.82
	2008	0.05	0.86
7	2006	0.22	2.37
	2007	0.15	0.92
	2008	0.05	1.02
8	2007	0.10	0.67
	2008	0.05	0.72
9	2006	0.01	0.07
	2007	0.09	0.52
	2008	0.05	0.20

Note: This electronic version contains an updated and corrected version of Table 2. The printed version distributed at the conference is incorrect and should be replace with this page.

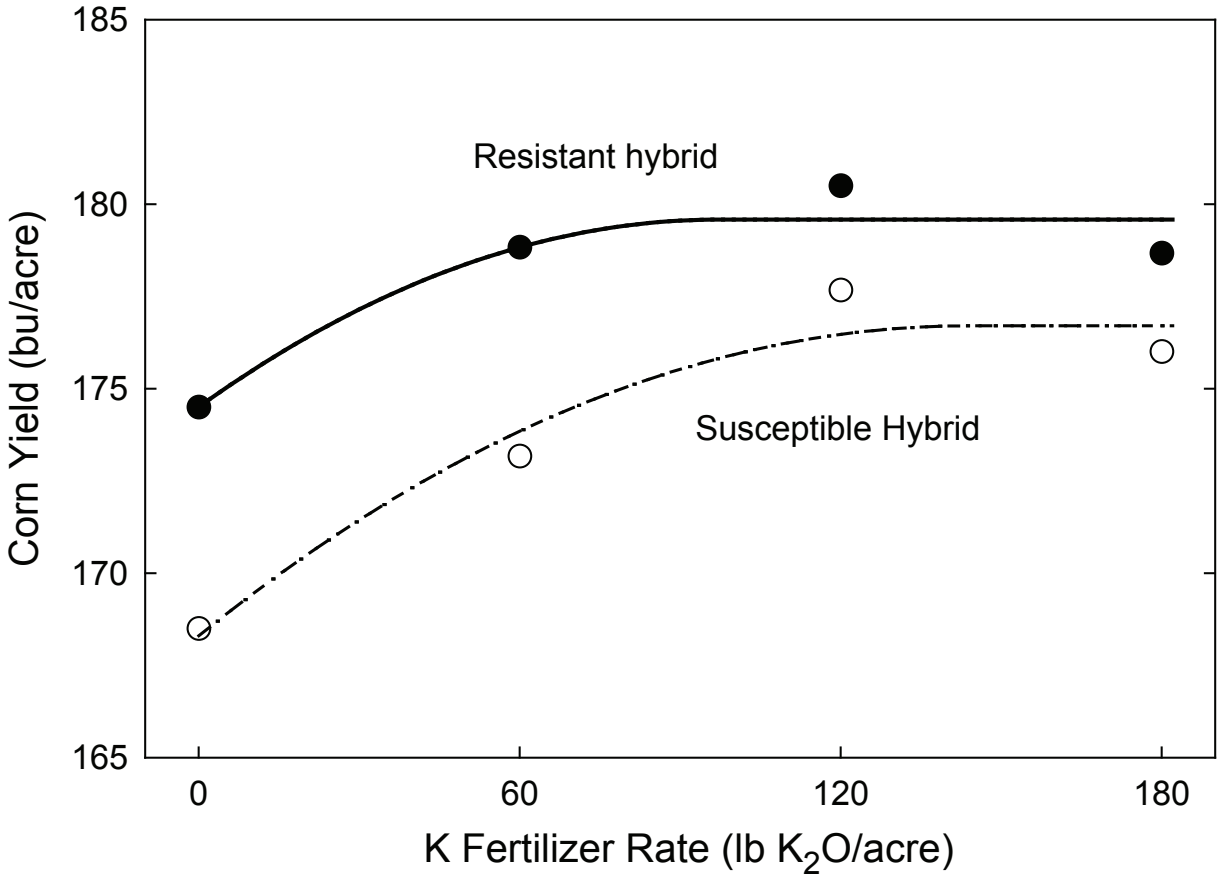

Figure 1. Corn grain yield response to K fertilizer as affected by hybrid rootworm resistance. Averages across trials that showed a significant yield response to K.

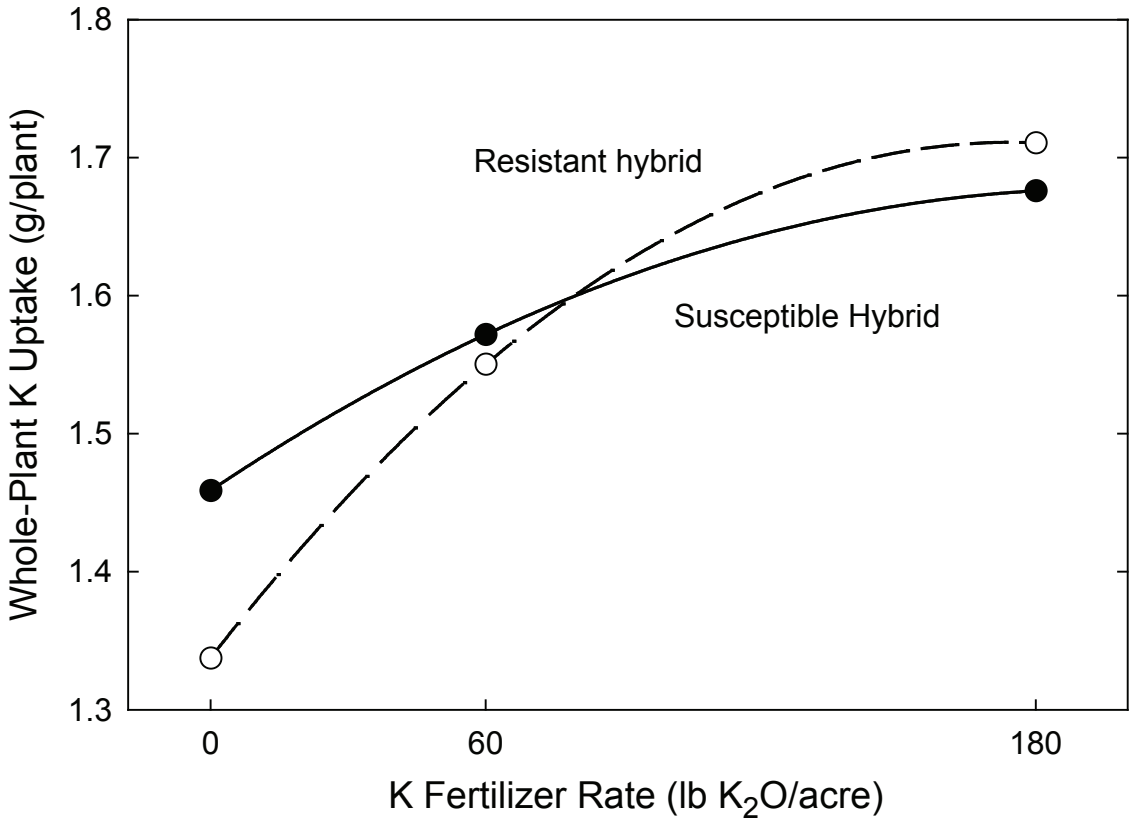

Figure 2. Corn whole-plant K uptake response (R1 growth stage) to K fertilizer as affected by hybrid rootworm resistance. Averages across trials conducted in 2006 and 2007.

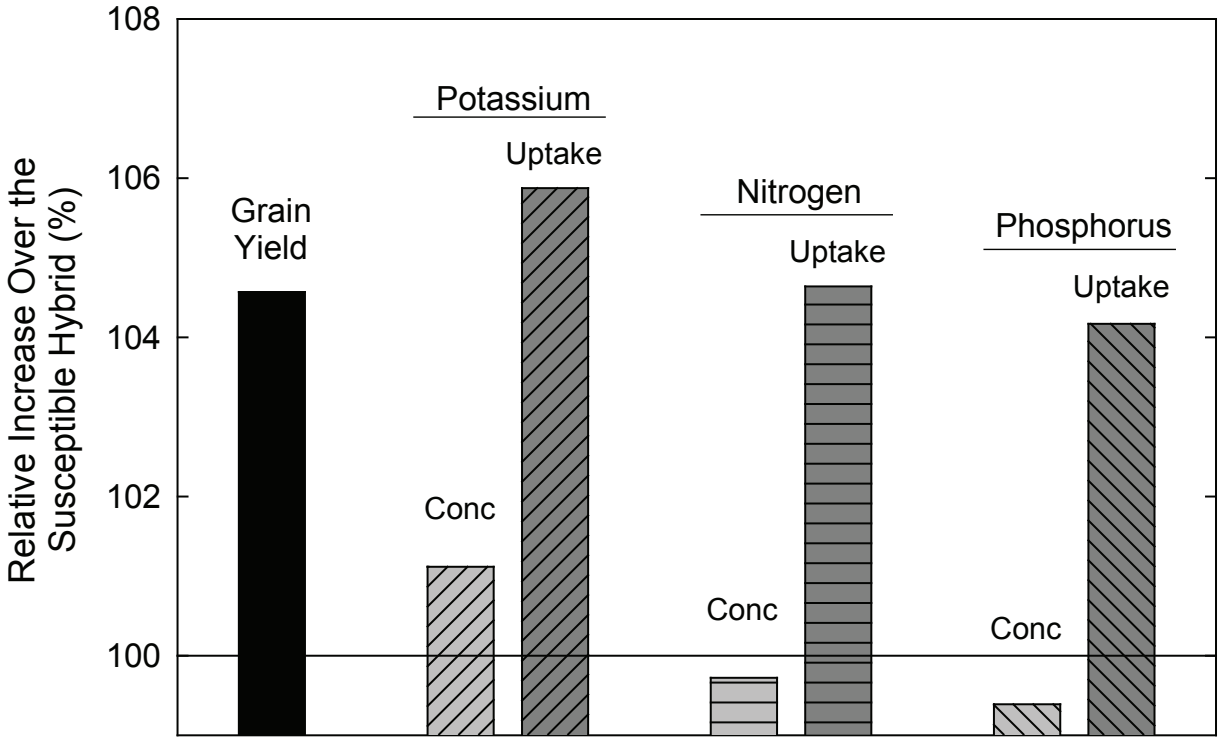

Figure 3. Effect of hybrid rootworm resistance on grain yield, grain nutrient concentration, and nutrient removal with grain harvest. Averages across all K rates for trials conducted in 2006 and 2007.