Silicon Nutrition and European Corn Borer Resistance in Two Maize Hybrid Isolines

J.R. Heckman, J. Ingerson-Mahar, and M. Provance-Bowley
Department of Plant Biology and Pathology, 59 Dudley Road - Foran Hall, Cook College, New Brunswick, NJ 08901-8520

RUTGERS New Jersey Agricultural Experiment Station

Abstract

Increasing the concentration of Si in plant tissue may provide a mechanical barrier against insect larval boring and feeding activity. Amending Si deficient soils may serve as a valuable component of integrated insect pest management as it leaves no insecticide residues. Field experiments were conducted on a Quakertown silt loam soil near Pittstown, NJ using Bt and non-Bt corn (*Zea mays* L.) hybrid isolines to study the effects of Si amendment of soil on management of European corn borer (ECB) (*Ostrinia nubilalis* Hubner). The plots were treated with two different liming materials as CaCO3 or CaSiO3 at the rate of 7840 kg/ha of calcium carbonate equivalent. Non-Bt isoline stem tissue Si increased from 1.3 to 1.7 g/kg in 2002 and 1.8 to 3.3 in 2003 in Si amended compared to CaCO3 plots. Grain yield did not respond to the calcium silicate amendment in either year, but isoline type influenced yield in both years . The Bt isoline produced a greater yield than the non-Bt isoline by 4% in 2002 and by 16% in 2003. European corn borer damage was greater in the non-Bt isoline than in the Bt isoline both years which may have been responsible for some grain yield suppression in the non-Bt isoline relative to the Bt isoline. The calcium silicate amendment tended to decrease the amount of damage to the stem both years but this protection from European corn borer did not translate into a grain yield benefit. In 2002, the protective effect of calcium silicate soil amendment from European corn borer damage was primarily exhibited as fewer tunnels per plant while in 2003 as a decrease in tunnel

Materials and Methods

A 2-yr continuous corn experiment evaluating Si amendment of soil on grain yield and ECB was planted in the spring of 2002 and 2003 on a Quakertown silt loam soil in previously established plots near Pittstown, NJ. These field plots were amended in June 2000 with a single application of different liming materials as CaCO3 or CaSiO3 at the rate of 7840 kg/ha of calcium carbonate equivalent. The site was cropped to pumpkin (*Cucurbita pepo* L.) in 2000 and 2002 (Heckman et al., 2003). Soil and plant analysis for Si were performed by Logan Labs, LLC. Liming material treatment plots were split between corn isolines (4 rows of each), with and without the Bt gene, 'Pioneer Brand 33B50-N001' and 'Pioneer Brand 33B51-N001,' respectively. Corn was planted in all plots on May 17, 2002 and May 1, 2003 at a row spacing of 0.76 m and a planting rate of 75,500 plants/ha. When corn plants were about 15 cm tall, sidedress N was applied at a rate of 190 kg N/ha. When plants were mature, 7.6 m of row length of each hybrid was harvested from the center of each plot. After grain harvest, ten corn stalks of each hybrid were collected at random from each plot and were stripped of leaves. The stalks were evaluated for ECB damage by splitting them lengthwise

Objective

To study the influence of enhanced Si nutrition of conventional and Bt hybrid isolines by evaluating injury from European corn borer infestation and grain yield.

Injury from ECB tunneling influences mature corn stem strength, standability, and ease of harvest.

Table 1. Effect of soil amendment and hybrid on European corn borer tunnels at harvest, grain yield, and stem Si concentration in 2002 and 2003.

Hybrid	Amendment	No. tunnels/plant	Tunnel length/plant	Mean tunnel length	Grain yield	Stem Si
			cm		Mg/ha	g/kg
			2002			
Non-Bt	$CaCO_3$	1.511	5.878	3.422	11.5	1.3
	$CaSiO_3$	0.800	4.922	6.100	11.0	1.7
Bt	$CaCO_3$	0.089	0.211	0.978	12.1	1.4
	$CaSiO_3$	0.100	0.311	1.667	11.4	1.7
			F-tests (P > F)			
Amendment		0.024	0.60	0.015	0.25	0.0001
Hybrid		0.0001	0.0001	0.0002	0.054	0.51
Amendment*Hybrid		0.032	0.52	0.18	0.76	0.27
			2003			
Non-Bt	$CaCO_3$	0.86	4.09	4.81	9.9	1.8
	$CaSiO_3$	0.72	2.89	4.04	10.6	3.3
Bt	$CaCO_3$	0.16	0.39	2.07	11.8	1.9
	$CaSiO_3$	0.14	0.32	1.32	12.1	3.8
			F-tests (P > F)			
Amendment		0.2180	0.0598	0.1001	0.3427	0.0005
Hybrid		0.0001	0.0001	0.0001	0.0021	0.6599
Amendment*Hybrid		0.3904	0.0925	0.9856	0.6282	0.3503

Results

Non-Bt isoline stem tissue Si increased from 1.3 to 1.7 g/kg in 2002 and 1.8 to 3.3 in 2003 with Si amended as compared with CaCO3 plots (Table 1). Soil test by acetic acid extract was 251 mg/kg in the Si amended plots and 114 mg/kg in the CaCO3 plots. Grain yield did not respond to the calcium silicate amendment in either year, but isoline type influenced yield in both years. The Bt isoline produced a greater yield than the non-Bt isoline by 4% in 2002 and by 16% in 2003. European corn borer damage was greater in the non-Bt isoline than in the Bt-isoline which may have been responsible for some the grain yield suppression in the non-Bt isoline relative to the Bt isoline. The calcium silicate amendment tended to decrease the amount of damage to the stem both years but this protection from ECB did not translate into a grain yield benefit. In 2002, the protective effect of calcium silicate from ECB damage was primarily exhibited as fewer tunnels per plant while in 2003 as a decrease in tunnel length.

Fig. 1. Measuring corn borer tunnel length in corn stem tissue

References

Andow, D.A. and K.R. Ostlie. 1990. First generation European corn borer (Lepidopera: Pyralidae) response to three conservation tillage systems in Minnesota. J. Econ. Entomol. 83:2455-2461.
Deay, H.O., L.H. Patch, and R.O. Snelling. 1949. Loss in yield of dent corn infested with the August generation of the European corn borer. J. Econ. Entomol. 42:81-87.
Godfrey, L.D., T.O. Holtzer, S.M. Spomer, and J.M. Norman. 1991. European corn borer tunneling and drought stress: Effects on corn yield. J Econ. Entomol. 84:1850:1860.
Phenal, P.L., J.F. Mason, and B.R. Stinner. 1995. Soil fertility management and host preference by European corn borer, *Ostrinia nibilalis* (Hübner), on *Zea mays* L.: A comparison of organic and conventional chemical farming. Agric. Ecosystems Environ. 56:1-8.
Phenal, P.L., K.H. Norris, and J.F. Mason. 1996. Soil-management history and host preference by *Ostrinia nibilalis*: Evidence for plant mineral balance mediating insect-plant interactions, Environ. Entomol. 25:1329-1336.
Epstein, E., A.J. Bloom. 2005. Mineral Nutrition of Plants: Principles and Perspectives. Sinauer, Sunderland, MA, 2nd Ed.
Fauteux, F., F. Chain, F. Belzile, J.G. Menzies, and R.R. Belanger. 2006. The Protective Role of Silicon in the *Arabidopsis*-Powdery Mildew Pathosystem. PNAS 103: 17554-17559.
Heckman, J.R., S. Johnston, and W. Cowgill. 2003. Pumpkin Yield and Disease Response to Amending Soil with Silicon. HortScience. 38(4):552-554.
Korndorfer, G.H. G. H. Snyder, M. Ulloa, G. Powell, and L.E. Datnoff. 2001. Calibration of Soil and Plant Silicon Analysis for Rice Production. Journal of Plant Nutrition 24(7): 1071-1084.
Sommer, M., D. Kaczorek, Y. Kuzyakov, and J. Breuer. 2006. Silicon Pools and Fluxes in Soils and Landscapes – A Review. J. Plant Nutr. Soil Sci. 169: 310-329.
Wang, Jim. J., Syam K. Dodla, and Rodney E. Henderson. 2004. Soil Silicon Extractability with Seven Selected Extractants in Relation to Colorimetric and ICP Determination. Soil Science: 169 (12): 861-870.