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ABSTRACT: Two studies were conducted at two locations to evaluate growth performance and carcass characteristics of growing-finishing pigs fed diets containing either YieldGard Rootworm corn (MON 863), a nontransgenic genetically similar corn (RX670), or two conventional nontransgenic corn hybrids (DK647 and RX740). A randomized complete block design with a 2 × 4 factorial arrangement of treatments (two genders and four corn hybrids) was used. Study 1 used 72 barrows and 72 gilts (progeny of Danbred sires × [Danbred × NE White line] dams grown from 22.7 to 117.0 kg BW). Pigs were housed in a modified open-front building in single-gender groups of six (six pens per dietary treatment). Study 2 used 80 barrows and 80 gilts (progeny of PIC 337 sires × C22 dams) grown from 29.5 to 114.9 kg BW. Pigs were housed in an environmentally controlled finishing building in single-gender groups of five (eight pens per dietary treatment). The test corns were included at a fixed proportion of the diet in both studies. Animals had ad libitum access to feed and water. Pigs were slaughtered at the end of the growth period using standard procedures, and carcass measurements were taken. There were no diet × gender interactions for growth performance or carcass measurements in either study. In both studies, overall ADG, ADFI, and G:F were not affected by corn hybrid. There was no effect of corn hybrid on carcass or LM quality measurements in Study 1. In Study 2, LM protein content was less ($P < 0.05$) for pigs fed RX740 compared with those fed either MON 863 or RX670; however, there was no effect of corn hybrid on other LM composition measures or on quality traits. In both studies, differences between barrows and gilts for growth and carcass traits were similar to previous research. These results suggest that the YieldGard Rootworm corn (MON 863) results in equivalent growth performance and carcass quality to nontransgenic corn hybrids in growing-finishing pigs.

Key Words: Carcass, Growth, Insect-Protected Corn, Pigs

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Introduction

The development of insect-protected corn expressing the Cry 3Bbl protein from *Bacillus thuringiensis* (**Bt**) confers resistance against corn rootworm and has great potential to decrease pesticide use (Alston et al., 2002; Rice, 2004). Following a single acute exposure, Cry proteins bind to specific receptors in the midgut cells of susceptible insects and form ion-selective channels in the cell membrane (English and Slatin, 1992). The cells swell due to an influx of water, which leads to cell lysis; the insect then stops eating and dies (Knowles and Ellar, 1987). YieldGard Rootworm corn (MON 863) produces an AA sequence variant of the wild-type Cry 3Bb1 protein, which targets against feeding damage caused by corn rootworm larvae (*Diabrotica* sp.). Previous research has demonstrated that insect-protected corn containing the Bt trait expressing Cry protein (MON 810) was equivalent to the genetically related nontransgenic corn in terms of nutrient composition (Gaines et al., 2001), growth performance of weaned piglets (Piva et al., 2001), and growth performance and carcass quality in growing-finishing pigs (Weber and Richert, 2001) and broilers (Taylor et al., 2003a,b,c). There has been no research to determine the feeding value of the YieldGard Rootworm corn (MON 863) for growing-finishing pigs. The objective of this study was to evaluate growth performance and carcass quality in growing-finishing pigs when fed diets containing either

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Table 1. Chemical composition of ingredients for Studies 1 and 2, as-fed basis

	MON 863[a]		RX670[a]		DK647[a]		RX740[a]		Soybean meal		Wheat middlings
Item, %	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2	Study 2
DM	92.4	90.7	92.2	90.8	92.6	85.4	92.9	86.5	94.8	87.3	89.8
CP	8.6	8.2	8.3	7.5	8.1	6.9	8.5	8.1	47.6	47.0	15.3
Fat	3.4	3.5	5.5	3.6	3.7	3.4	4.4	4.1	3.0[b]	1.79	2.35
ADF	2.8	2.9	2.7	3.9	2.2	3.5	3.8	3.8	0.94[b]	7.04	35.6
NDF	7.9	8.7	8.7	9.3	7.8	7.5	6.9	7.4	13.3[b]	10.2	10.7
Ash	1.23	1.25	1.29	1.25	1.22	1.09	1.35	1.23	—	2.0	1.5
Ca	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.34[b]	0.36	0.11
P	0.30	0.29	0.25	0.31	0.30	0.29	0.24	0.31	0.69[b]	0.71	1.11
Arginine	0.38	0.37	0.37	0.33	0.38	0.31	0.44	0.36	3.07	3.37	0.93
Histidine	0.26	0.23	0.24	0.21	0.24	0.19	0.25	0.23	1.07	1.24	0.44
Isoleucine	0.29	0.28	0.27	0.25	0.27	0.23	0.32	0.27	1.65	2.09	0.44
Leucine	1.01	0.98	0.91	0.89	0.88	0.82	1.05	0.97	3.23	3.54	0.90
Lysine	0.26	0.26	0.26	0.23	0.25	0.22	0.27	0.25	2.63	2.92	0.59
Methionine	0.18	0.17	0.17	0.15	0.18	0.14	0.17	0.17	0.67[b]	0.65	0.23
Phenyalanine	0.41	0.39	0.37	0.35	0.35	0.32	0.41	0.38	2.03	2.31	0.57
Threonine	0.27	0.29	0.23	0.26	0.26	0.24	0.28	0.28	1.75	1.79	0.47
Tryptophan	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.65[b]	0.63	0.20
Valine	0.39	0.39	0.37	0.35	0.39	0.32	0.43	0.38	1.73	2.20	0.66

[a]MON 863 = transgenic YieldGard Rootworm corn; RX670 = nontransgenic control corn; DK647 and RX740 = conventional corn hybrids.
[b]Values from NRC (1998).

YieldGard Rootworm corn (MON 863), a genetically similar nontransgenic corn, or nontransgenic commercial corn hybrids.

Materials and Methods

Two studies were carried out at different locations. Study 1 was at the University of Nebraska (Lincoln), and Study 2 was at the University of Illinois (Urbana). Experimental protocols were approved by the respective institutional animal care and use committees before the start of the studies.

Animals and Treatments

In Study 1, 144 crossbred pigs (progeny of Danbred sire × [Danbred × NE White line] dam; 72 barrows and 72 gilts) with an initial BW of 22.7 ± 1.57 kg were used, and in Study 2, 160 pigs (progeny of PIC 337 sires × C22 dams; Franklin, KY; 80 barrows and 80 gilts) with an initial BW of 29.5 ± 1.21 kg were used.

A randomized complete block design (three and four blocks in Studies 1 and 2, respectively), with a 2 × 4 factorial arrangement of treatments, was used. Blocks were based on initial BW and pen location within the building. There were two genders (barrows and gilts) and four genetic corn hybrids (YieldGard Rootworm corn [MON 863]), the nontransgenic genetically similar control corn (RX670), and two nontransgenic commercial reference hybrids (DK647, DeKalb Seeds, DeKalb, IA; RX740, Asgrow, Des Moines, IA). The test, control, and reference corn hybrids were grown, harvested, and stored in Nebraska for Study 1 and in Illinois for Study 2.

The composition of the corns is presented in Table 1. Diets contained corn, soybean meal, and wheat middlings (Study 2), and were fortified with vitamins and minerals to meet or exceed NRC (1998) requirements for the weights of pigs used. In Study 1, there were four dietary phases (Grower I, 22.7 to 43.5 kg BW; Grower II, 43.5 to 69.3 kg BW; Finisher I, 69.3 to 98.0 kg BW; and Finisher II, 98.0 to 117.2 kg BW), and the inclusion rate of the corn was fixed within each phase (68.65, 74.79, 78.66, and 82.47% for Grower I, Grower II, Finisher I, and Finisher II, respectively; Tables 2 and 3). Within each dietary phase, diets were formulated with a fixed ingredient inclusion rate (Tables 2 and 3). In Study 2, there were three dietary phases (Grower, 29.5 to 50.2 kg BW; Finisher I, 50.2 to 77.5 kg BW; and Finisher II, 77.5 to 114.9 kg BW), and the inclusion rate of the corn hybrids was fixed within each phase (65, 72, and 76% for Grower, Finisher I, and Finisher II, respectively; Table 4). Within each phase, diets were formulated to the same (as-fed basis) ME, CP, and total lysine concentrations (Grower = 3,340 kcal of ME/kg, 17.8% CP, 1.0% total lysine; Finisher I = 3,368 kcal of ME/kg, 15.0% CP, 0.79% total lysine; Finisher II = 3,390 kcal/kg ME, 13.5% CP, 0.69% total lysine). Analyzed values were used for the lysine content of the corn. The ME values for the corn were based on the value presented in NRC (1998), adjusted to account for the differences in DM content among the different types of corn (Table 1). All other nutrient composition values used in the diet formulations were from NRC (1998). Wheat middlings and soybean oil were used in the diet formulations in Study 2 to adjust the energy content of the diets. Study 1 was carried out for a fixed time period of 104 d, with the first three phases lasting 28

Table 2. Composition of Grower I and Grower II diets: Study 1, as-fed basis

	Corn hybrid in diet[a]							
	MON 863		RX670		DK647		RX740	
	Grower I	Grower II	Grower I	Grower II	Grower I	Grower II	Grower I	Grower II
Ingredient, %								
Corn	68.65	74.79	68.65	74.79	68.65	74.79	68.65	74.79
Soybean meal	26.00	20.25	26.00	20.25	26.00	20.25	26.00	20.25
Tallow	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Dicalcium phosphate	1.25	0.85	1.25	0.85	1.25	0.85	1.25	0.85
Limestone	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin premix[b]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Trace mineral premix[c]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Lysine·HCl	0.05	0.06	0.05	0.06	0.05	0.06	0.05	0.06
Chemical composition, %								
ME, kcal/kg[d]	3,440	3,460	3,440	3,460	3,440	3,460	3,440	3,460
CP[e]	18.6	16.3	18.1	16.1	18.2	16.0	18.5	16.3
Ca[e]	0.89	0.72	0.98	0.74	0.95	0.76	0.97	0.67
P[e]	0.65	0.54	0.70	0.55	0.61	0.55	0.66	0.51
Lysine[e]	0.85	0.73	0.85	0.73	0.84	0.73	0.86	0.74

[a]MON 863 = transgenic YieldGard Rootworm corn; RX670 = nontransgenic control corn; DK647 and RX740 = conventional corn hybrids.
[b]The vitamin premix supplied per kilogram of diet: vitamin A (as retinyl acetate), 3,088 IU; vitamin D_3 (as cholecalciferol), 386 IU; vitamin E (as α-tocopherol acetate), 15 IU; vitamin K (as menadione sodium bisulfite), 2.3 mg; riboflavin, 3.9 mg; D-pantothenic acid, 15.4 mg; niacin, 23.3 mg; choline, 77.2 mg; vitamin B_{12}, 15.4 μg.
[c]The trace mineral premix supplied per kilogram of diet: Zn (as ZnO), 110 mg; Fe (as $FeSO_4 \cdot H_2O$), 110 mg; Mn (as MnO), 22 mg; Cu (as $CuSO_4 \cdot 5\ H_2O$), 11 mg; I (as $Ca(IO_3) \cdot H_2O$), 0.22 mg; Se (as Na_2SeO_3), 0.3 mg.
[d]Calculated from values from NRC (1998).
[e]Calculated values from analyzed values for the corn and soybean meal samples used.

Table 3. Composition of Finisher I and Finisher II diets: Study 1, as-fed basis

	Corn hybrid in diet[a]							
	MON 863		RX670		DK647		RX740	
	Finisher I	Finisher II	Finisher I	Finisher II	Finisher I	Finisher II	Finisher I	Finisher II
Ingredient, %								
Corn	78.66	82.47	78.66	82.47	78.66	82.47	78.66	82.47
Soybean meal	16.25	12.75	16.25	12.75	16.25	12.75	16.25	12.75
Tallow	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Dicalcium phosphate	0.93	0.75	0.93	0.75	0.93	0.75	0.93	0.75
Limestone	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin premix[b]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral premix[c]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Tylan[d]	0.13	0.00	0.13	0.00	0.13	0.00	0.13	0.00
Lysine·HCl	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Chemical composition, %								
ME, kcal/kg[e]	3,460	3,460	3,460	3,460	3,460	3,460	3,460	3,460
CP[f]	14.7	13.4	14.5	13.1	14.5	12.9	14.7	13.0
Ca[f]	0.75	0.69	0.77	0.75	0.79	0.71	0.71	0.65
P[f]	0.52	0.48	0.54	0.55	0.53	0.50	0.51	0.48
Lysine[f]	0.66	0.59	0.66	0.59	0.66	0.58	0.67	0.59

[a]MON 863 = transgenic YieldGard Rootworm corn; RX670 = nontransgenic control corn; DK647 and RX740 = conventional corn hybrids.
[b]The vitamin premix supplied per kilogram of diet: vitamin A (as retinyl acetate), 3,088 IU; vitamin D_3 (as cholecalciferol), 386 IU; vitamin E (as α-tocopherol acetate), 15 IU; vitamin K (as menadione sodium bisulfite), 2.3 mg; riboflavin, 3.9 mg; D-pantothenic acid, 15.4 mg; niacin, 23.3 mg; choline, 77.2 mg; vitamin B_{12}, 15.4 μg.
[c]The trace mineral premix supplied per kilogram of diet: Zn (as ZnO), 110 mg; Fe (as $FeSO_4 \cdot H_2O$), 110 mg; Mn (as MnO), 22 mg; Cu (as $CuSO_4 \cdot 5\ H_2O$), 11 mg; I (as $Ca(IO_3) \cdot H_2O$), 0.22 mg; Se (as Na_2SeO_3), 0.3 mg.
[d]Tylan-40 (Elanco Animal Health, Indianapolis, IN); to supply 110 g/kg of tylosin in the final feed.
[e]Calculated from values from NRC (1998).
[f]Calculated values from analyzed values for the corn and soybean meal samples used.

Table 4. Composition of the diets: Study 2, as-fed basis

	Corn hybrid in diet[a]											
	MON 863			RX670			DK647			RX740		
Ingredients, %	Grower	Finisher I	Finisher II	Grower	Finisher I	Finisher II	Grower	Finisher I	Finisher II	Grower	Finisher I	Finisher II
Corn	65.00	72.00	76.00	65.00	72.00	76.00	65.00	72.00	76.00	65.00	72.00	76.00
Soybean meal (dehulled)	24.80	17.10	13.05	25.90	18.50	14.70	28.81	21.70	17.88	26.49	18.52	14.70
Wheat middlings	6.38	7.48	7.63	6.22	6.78	6.52	0.00	0.27	0.00	2.40	3.31	3.07
Soybean oil	0.99	0.86	0.91	0.07	0.20	0.40	3.38	3.50	3.71	3.27	3.58	3.79
Dicalcium phosphate	0.84	0.63	0.50	0.82	0.62	0.50	0.93	0.75	0.65	0.90	0.70	0.55
Limestone	0.83	0.78	0.80	0.84	0.75	0.80	0.77	0.70	0.72	0.82	0.75	0.80
L-Lysine·HCl	0.09	0.08	0.09	0.07	0.05	0.05	0.02	0.00	0.00	0.06	0.06	0.06
Threonine	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01
Tryptophan	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Vitamin premix[b]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral premix[c]	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Tylan[d]	0.05	0.05	0.00	0.05	0.05	0.00	0.05	0.05	0.00	0.05	0.05	0.00
Mycotoxin binder[e]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Chemical composition, %												
ME, kcal/kg[f]	3,340	3,368	3,390	3,340	3,368	3,390	3,340	3,368	3,390	3,340	3,368	3,390
CP[g]	18.1	15.2	13.6	18.1	15.2	13.7	18.1	15.2	13.7	18.2	15.1	13.6
Ca[g]	0.60	0.51	0.47	0.60	0.50	0.47	0.61	0.51	0.48	0.61	0.51	0.48
P[g]	0.59	0.53	0.49	0.60	0.54	0.50	0.57	0.50	0.47	0.58	0.52	0.48
Lysine[g]	1.00	0.79	0.69	1.00	0.79	0.68	1.00	0.79	0.69	0.99	0.79	0.69

[a]MON 863 = transgenic YieldGard Rootworm corn; RX670 = nontransgenic control corn; DK647 and RX740 = conventional corn hybrids.

[b]The vitamin premix supplied per kilogram of diet: vitamin A (as retinyl acetate), 4,400 IU; vitamin D_3 (as cholecalciferol), 440 IU; vitamin E (as α-tocopherol acetate), 24 IU; vitamin K (as menadione sodium bisulfite), 3.5 mg; riboflavin, 8.8 mg; D-pantothenic acid, 17.5 mg; niacin, 26.4 mg; vitamin B_{12}, 26.4 μg.

[c]The trace mineral premix supplied per kilogram of diet: Zn (as ZnO), 128 mg; Fe (as $FeSO_4 \cdot H_2O$), 128 mg; Mn (as MnO), 30 mg; Cu (as $CuSO_4 \cdot 5\ H_2O$), 11 mg; I (as ($Ca(IO_3) \cdot H_2O$), 0.26 mg; Se (as Na_2SeO_3), 0.3 mg.

[d]Tylan-40 (Elanco Animal Health, Indianapolis, IN); to supply 44 g/kg of tylosin in the final feed.

[e]Sodium silicate.

[f]Based on values from NRC (1998).

[g]Calculated values from analyzed values for the corn and soybean meal samples used.

d, and the final phase lasting 20 d. Study 2 was carried out over a fixed weight range, and diets were changed between phases when the average BW of all pigs in a block reached the designated weight.

In Study 1, the pigs were housed in a modified open-front building, with 24 pens (4.8 × 1.5 m). Each single-gender pen (barrows or gilts) had six pigs, with 1.2 m^2 of floor space/pig. This gave six pens (three with barrows and three with gilts) per dietary treatment. The average temperature was 14.4 ± 5.89°C during the study. Study 2 was conducted in an environmentally controlled growing-finishing building with part-solid, part-slatted floors, and used a total of 32 single-gender pens, with five pigs per pen, giving eight pens per dietary treatment. Pen dimensions were 2.6 × 1.8 m, providing 0.94 m^2 of floor space/pig. The temperature within the building was controlled by mechanical ventilation linked to a thermostat set at 24°C during the early stages of the study and decreased to 21°C when the pigs reached an average of 50 kg BW. Temperature and humidity levels in the building were recorded on a daily basis using Hobo H8 loggers (Onset Computer Corp., Bourne, MA). The average temperature during the study was 22.2 ± 2.53°C, and the average relative humidity was 52.2 ± 12.46%.

Pigs had ad libitum access to mash feed and water throughout the experimental period. Study 1 ended after 104 d, and Study 2 ended when the average BW of all of the pens of pigs within a block reached approximately 115 kg, at which time all pigs in the block were removed from the experiment.

Data and Sample Collection

In both studies, pigs and feeders were weighed and feed intake was measured during every feeding phase throughout the study, and the amount of feed added to each feeder was recorded to determine ADG, ADFI (as-fed basis), and G:F. At the end of the experiment, all pigs were ultrasonically scanned with an Aloka model 500 B-mode ultrasound scanner fitted with a VST-5021-3 probe (Corometrics Medical Systems, Wallingford, CT). A transverse scan image was taken over the 10th rib, and backfat depth (over the middle of the LM) and LM area were measured on the scans.

At the end of the experiment, the pigs from the two studies were shipped to different commercial abattoirs and slaughtered using standard procedures. Carcass measurements were taken at 24 h postmortem in Study 1 and included midline fat depths (over the first rib, 10th rib, last rib, and last lumbar vertebra) and LM area at the 10th rib using a tracing method. In Study 2, carcass measurements were taken at 10 h postmortem and included carcass length (measured from the cranial tip of the aitch bone to the cranial edge of the first rib adjacent to the first thoracic vertebra), midline fat depths (over the first rib, last rib, and last lumbar vertebra), 10th-rib fat depth (measured over the LM at three-quarters of the distance from the midline), and LM area at the 10th rib using a plastic grid for quick measurement of LM area (Iowa State University, Ames). In Study 1, fat-free lean content (at 0% fat content) was predicted from carcass measurements using equations developed by the NPPC (2000). Initial fat-free lean content (at 0% fat content) was calculated using an equation from the NPPC (1991). In both studies, fat-free lean contents (at 0% fat content) were predicted from ultrasound measurements using the equation from the NPPC (2000).

In Study 1, muscle quality measurements were taken 24 h postmortem on the cut surface of the LM at the 10th rib and included pH, firmness, marbling scores (NPPC, 1991), and Minolta L* (lightness), a* (red-green scale), and b* (yellow-blue scale) values. In Study 2, subjective color, firmness, and marbling scores (NPPC, 1991, 2000) were taken.

In both studies, the chemical composition of the LM was determined on a sample taken at the 10th rib from a subsample of three pigs randomly selected from within each pen (18 pigs per treatment in Study 1 and 24 pigs per treatment in Study 2).

Sample Analyses

Samples from each corn hybrid were collected before the start of the experiment for nutrient analyses (Table 1). In addition, samples of soybean meal (Study 1 and 2) and wheat middlings (Study 2) were collected at the feed mill during the production of each dietary phase. These were used for the determination of CP and AA concentrations. These values for the nutrient composition of the major ingredients were used to calculate the composition of the diets fed (Tables 2, 3, and 4). Corn and soybean meal samples were ground to pass a 1-mm screen before analysis. Ingredients samples were analyzed in duplicate for CP according to AOAC (1995) procedures. Samples were hydrolyzed for 20 h using 6 *N* HCl at 107°C before separation of AA by ion-exchange HPLC. After elution, AA were quantified fluorometrically using *o*-phthalaldehyde as a derivatization reagent. Diet samples were taken after mixing, and the chemical composition of diets including CP, fat, Ca, and P was determined using the procedures of AOAC (1995). Longissimus muscle samples were homogenized and analyzed for protein, fat, and moisture using the procedures of Novakofski et al. (1989).

Statistical Analyses

Pen was the experimental unit in both studies. All growth performance, carcass, meat quality, and chemical composition data were analyzed as a randomized complete block design using PROC MIXED procedures of SAS (SAS Inst., Inc., Cary, NC). The effects included in the model were gender (barrow and gilts), corn hybrid (MON 863, RX670, DK647, and RX740), block, and gender × corn hybrid interaction. Means were evaluated using the PDIFF and STDERR options of SAS.

Table 5. Means for effects of corn line and gender on growth performance: Study 1

Item	Corn hybrid in diet[a]					Gender		
	MON 863	RX670	DK647	RX740	SEM	Barrow	Gilt	SEM
No. of pens	6	6	6	6		12	12	
Initial BW, kg	22.7	22.7	22.7	22.7	0.08	22.7	22.7	0.06
Final BW, kg	118.1	117.3	115.8	117.8	1.58	122.8[c]	111.8[d]	1.12
Grower I (23 to 44 kg)								
ADG, g	740	755	738	734	12.0	776[c]	707[d]	8.5
ADFI, kg[b]	1.46	1.47	1.45	1.46	0.021	1.52[c]	1.40[d]	0.015
G:F	0.507	0.508	0.509	0.504	0.002	0.510	0.505	0.002
Grower II (44 to 69 kg)								
ADG, g	941	917	910	928	20.6	994[c]	854[d]	14.6
ADFI, kg[b]	2.27	2.21	2.18	2.19	0.048	2.39[c]	2.04[d]	0.034
G:F	0.416	0.415	0.417	0.424	0.003	0.417	0.419	0.002
Finisher I (69 to 98 kg)								
ADG, g	1,042	1,027	1,013	1,019	23.1	1,087[c]	964[d]	16.3
ADFI, kg[b]	2.95	2.82	2.83	2.87	0.066	3.12[c]	2.61[d]	0.046
G:F	0.355	0.365	0.360	0.356	0.003	0.349[c]	0.369[d]	0.002
Finisher II (98 to 117 kg)								
ADG, g	958	952	930	1,004	25.4	1,002[c]	919[d]	18.0
ADFI, kg[b]	3.13	3.07	3.00	3.13	0.076	3.31[c]	2.85[d]	0.054
G:F	0.307	0.311	0.312	0.322	0.005	0.303[c]	0.323[d]	0.004
Overall (23 to 117 kg)								
ADG, g	918	910	895	915	15.0	962[c]	857[d]	10.9
ADFI, kg[b]	2.44	2.35	2.31	2.36	0.052	2.55[c]	2.18[d]	0.037
G:F	0.384	0.388	0.388	0.389	0.003	0.381[c]	0.394[d]	0.002

[a]MON 863 = transgenic YieldGard Rootworm corn; RX670 = nontransgenic control corn; DK647 and RX740 = conventional corn hybrids.
[b]As-fed basis.
[c,d]Within a treatment row, means without a common superscript letter differ, $P < 0.05$.

Results and Discussion

Nutrient Composition

The nutrient composition for the corn hybrids used in both studies is presented in Table 1. In Study 1, the YieldGard Rootworm corn (MON 863), and the nontransgenic corn hybrids (RX670, DK647, and RX740) were generally similar in nutrient composition. In Study 2, there was considerable variation in the composition of the corns, particularly for DM content, which was greater for MON863 and RX670 than for DK647 and RX740 (Table 1). Values for the nutrient composition of all of the corns used in the study were within the normal ranges of values for corn in the Crop Composition Database of the International Life Sciences Institute (ILSI, 2003).

Growth Performance

There was no diet × gender interaction for any growth performance measurement in either study, and only the main effects have been presented. In Study 1, ADG, ADFI, and G:F were not affected by corn hybrid during any of the four growth phases (Table 5). In Study 2, the only effect ($P < 0.05$) of corn hybrid was on ADG in Finisher I and on G:F in the Finisher I and Finisher II phases (Table 6). Pigs fed DK647 grew faster ($P < 0.05$) than those fed MON 863 and RX670 in Finisher I, with those fed RX740 being intermediate and not different from the other hybrids for growth rate in this phase. The G:F was greater ($P < 0.05$) for hybrids DK647 and RX740, than for MON 863 in Finisher I, with hybrid RX670 being intermediate (Table 6). In Finisher II, G:F was higher ($P < 0.05$) for hybrids RX670 and RX740 than for the other two hybrids; however, there was no effect ($P = 0.114$ for ADG; $P = 0.389$ for ADFI; $P = 0.208$ for G:F) of corn hybrid on overall growth performance (Table 6). Thus, in both studies, the performance by pigs fed the transgenic corn hybrid did not differ from that by those fed the nontransgenic genetically similar corn or the two conventional hybrids.

In Study 1, barrows grew faster and consumed more feed during all growth phases; however, gilts had a greater ($P < 0.01$) G:F than barrows in Finisher I, Finisher II, and overall (Table 5). In Study 2, barrows had higher ($P < 0.05$) ADG and ADFI than gilts during Finisher I, Finisher II, and overall (Table 6), but there were no significant differences ($P = 0.566$ for Grower; $P = 0.640$ for Finisher I; $P = 0.074$ for Finisher II; $P = 0.099$ for overall period) in G:F between barrows and gilts during any growth phase. The results for ADG and ADFI in both studies are similar to those of most previous research that has evaluated the growth performance of castrates and gilts (Labroue et al., 1994; Hahn and Baker, 1995; Hyun and Ellis, 2001).

Carcass and Ultrasound Measurements

There was no diet × gender interaction for any carcass and ultrasound measurement in either study. In Study

Table 6. Means for the effects of diet and gender effects on growth performance: Study 2

Item	Corn hybrid in diet[a]					Gende		
	MON 863	RX670	DK647	RX740	SEM	Barrow	Gilt	SEM
No. of pens	8	8	8	8		16	16	
Initial BW, kg	30.1	29.2	29.2	29.5	0.37	29.6	29.4	0.26
Final BW, kg	113.3	113.1	115.2	117.8	1.66	119.3	110.4	1.17
Grower (30 to 50 kg)								
ADG, g	764	718	778	776	20.6	771	746	14.6
ADFI, kg[b]	1.76	1.61	1.66	1.63	0.062	1.70	1.63	0.044
G:F	0.440	0.448	0.470	0.476	0.014	0.454	0.463	0.010
Finisher I (50 to 78 kg)								
ADG, g	840[c]	834[c]	930[b]	891[bc]	21.1	941[c]	806[d]	15.0
ADFI, kg[b]	2.50	2.30	2.38	2.36	0.082	2.55[c]	2.22[d]	0.058
G:F	0.336[c]	0.363[bc]	0.388[b]	0.378[b]	0.009	0.368	0.364	0.064
Finisher II (78 to 115 kg)								
ADG, g	959	1,001	943	1,031	26.2	1,033[c]	934[d]	18.6
ADFI, kg[b]	3.37	3.16	3.33	3.27	0.078	3.52[c]	3.04[d]	0.06
G:F	0.286[c]	0.322[b]	0.290[c]	0.318[b]	0.006	0.298	0.311	0.005
Overall (30 to 115 kg)								
ADG, g	861	855	890	913	16.4	921[c]	838[d]	11.6
ADFI, kg[b]	2.60	2.41	2.54	2.46	0.080	2.67[c]	2.34[d]	0.057
G:F	0.341	0.361	0.351	0.373	0.010	0.348	0.366	0.007

[a]MON 863 = transgenic YieldGard Rootworm corn; RX670 = nontransgenic control corn; DK647 and RX740 = conventional corn hybrids.
[b]As-fed basis.
[c,d]Within a treatment row, means without a common superscript letter differ, $P < 0.05$.

1, all carcass and ultrasound measurements did not differ for pigs fed the YieldGard Rootworm corn (MON 863) compared with the nontransgenic corn (RX670), and the nontransgenic commercial corn hybrids (DK647 and RX740) (Table 7). In Study 2 (Table 8), all carcass measurements, with the exception of carcass length and backfat thickness over the 10th-rib, did not differ (P = 0.214 and 0.349 for first rib backfat and last lumbar backfat, respectively) for pigs fed the four corn hybrids tested. Pigs fed hybrid RX670 had shorter carcass lengths ($P < 0.05$) than those fed the other three hybrids; however, the treatment differences were relatively

Table 7. Means for the carcass and ultrasound measurements: Study 1

Item	Corn hybrid in diet[a]					Gender		
	MON 863	RX670	DK647	RX740	SEM	Barrow	Gilt	SEM
No. of pens	6	6	6	6		12	12	
Hot carcass weight, kg	91.7	91.0	89.3	90.9	1.31	95.2[c]	86.3[d]	0.93
Dressing percent	77.6	77.6	77.1	77.2	0.21	77.6	77.2	0.15
Midline backfat thickness, mm								
First rib	41.6	41.9	41.1	42.1	1.06	44.6[c]	38.8[d]	0.75
Tenth rib	26.8	27.4	26.8	27.5	0.79	29.5[c]	24.8[d]	0.56
Last rib	27.1	27.7	28.5	27.2	0.62	30.2[c]	25.0[d]	0.44
Last lumbar vertebrae	22.6	22.4	22.6	24.5	0.57	25.4[c]	20.7[d]	0.41
LM area, cm^2	64.9	62.2	61.2	61.7	1.19	63.1	61.9	0.84
Predicted carcass lean measurement								
Fat-free lean, kg[b]	46.5	45.9	44.7	46.1	0.64	47.1[c]	44.5[d]	0.45
Fat-free lean, %	50.8	50.5	50.3	50.9	0.25	49.5[c]	51.7[d]	0.18
Fat-free lean gain, g/d	371.9	366.4	355.2	368.3	6.114	377.6[c]	353.3[d]	4.32
Ultrasound lean measurements								
Backfat, cm	2.22	2.24	2.17	2.30	0.129	2.48	1.98	0.129
LM area, cm^2	46.85	46.90	45.69	45.71	1.212	46.68	45.90	1.212
Fat-free lean, kg[b]	46.0	45.7	45.1	45.3	0.51	46.3[c]	44.7[d]	0.36
Fat-free lean, %	52.8	52.8	52.7	52.1	0.59	51.1[c]	54.1[d]	0.42
Fat-free lean gain, g/d	367.5	364.8	358.4	360.5	4.95	370.7[c]	354.9[d]	3.50

[a]MON 863 = transgenic YieldGard Rootworm corn; RX670 = nontransgenic control corn; DK647 and RX740 = conventional corn hybrids.
[b]Predicted fat-free lean (at 0% fat) from equation (NPPC, 2000).
[c,d]Within a treatment row, means without a common superscript letter differ, $P < 0.05$.

Table 8. Means for the effects of diet and gender on carcass measurements and ultrasound measurement: Study 2

	Corn hybrid in diet[a]					Gender		
Item	MON 863	RX670	DK647	RX740	SEM	Barrow	Gilt	SEM
No. of pens	8	8	8	8		16	16	
Slaughter weight, kg	113.3	113.1	115.2	117.8	1.67	119.2[c]	110.4[d]	1.17
Cold carcass weight, kg	80.9	81.7	83.5	85.8	1.21	86.0[c]	80.0[d]	0.86
Dressing percent	71.3	72.2	72.6	73.0	0.01	72.1	72.5	0.57
Carcass length, cm	83.2[d]	82.2[d]	83.9[c]	83.6[c]	0.281	83.1	83.3	0.20
Midline backfat thickness, mm								
First rib	45.2	47.7	44.9	48.7	1.40	49.0[c]	44.1[d]	0.99
Last rib	22.5	23.9	22.3	24.5	0.82	25.4[c]	21.2[d]	0.58
Last lumbar vertebrae	17.5	18.5	17.4	19.6	0.91	20.0[c]	16.5[d]	0.65
Tenth-rib backfat thickness, mm	18.9[cd]	19.0[cd]	17.2[d]	20.0[c]	0.51	21.3[c]	16.2[d]	0.37
LM area, cm^2	40.3	38.9	40.9	39.5	0.66	40.6	39.3	0.46
Ultrasound measurements over the 10th rib								
Backfat thickness, mm								
End of Grower	8.2	7.6	7.9	8.0	0.24	8.0	7.8	0.17
End of Finisher I	10.3	10.1	10.6	10.7	0.38	11.2[c]	9.6[d]	0.27
Final day	14.5	15.5	14.4	15.8	0.48	16.6[c]	13.5[d]	0.34
LM area, cm^2								
End of Grower	20.0	19.5	19.8	19.2	0.54	19.6	19.6	0.38
End of Finisher I	28.8	28.5	29.8	28.4	0.88	29.5	28.2	0.62
Final day	40.5	40.9	41.5	40.8	1.27	42.0	39.8	0.90
Predicted fat-free lean, kg[b]	44.5	44.3	45.4	45.5	0.95	46.0	43.9	0.67

[a]MON 863 = transgenic YieldGard Rootworm corn; RX670 = nontransgenic control corn; DK647 and RX740 = conventional corn hybrids.
[b]Predicted fat-free lean (at 0% fat) from equation (NPPC, 2000).
[c,d]Within a treatment row, means without a common superscript letter differ, $P < 0.05$.

small. In addition, pigs fed DK647 had less backfat at the 10th-rib than those fed RX740, with those fed the MON 863 and RX670 being intermediate and not different than the two conventional hybrids. This difference in fatness among the corn hybrids was unexpected, particularly given that there was no difference between the corn treatments for overall growth performance. Moreover, ultrasound measures of backfat thickness and LM area did not differ in pigs fed diets containing the different corn hybrids in either study (Tables 7 and 8).

In both studies, barrows had heavier ($P < 0.05$) carcass weights and greater ($P < 0.05$) backfat thickness than gilts; however, there was no difference ($P = 0.318$ for Study 1 and 0.079 for Study 2) between the genders for LM area (Tables 7 and 8). In Study 1, barrows had a greater weight and percentage of fat-free lean and greater fat-free lean gain than gilts (Table 7). The difference in backfat depth between barrows and gilts was similar to the results of Cromwell et al. (1993) and Hahn et al. (1995); however, in those experiments gilts had greater LM area than barrows, which is in contrast to the present results. The lack of a gender effect on LM area was likely a consequence of taking barrows and gilts off test at the same time and the resulting difference in slaughter live weight between the genders.

Longissimus Muscle Chemical Composition and Quality

There was no diet × gender interaction ($P < 0.05$) for muscle quality and chemical composition in either study. In Study 1, there was no effect of corn hybrid on any muscle quality or composition measure (Table 9). In Study 2, the only effect of corn hybrid was for LM protein content, which was greater for pigs fed RX670 than for the two conventional corns (Table 9). In addition, pigs fed the transgenic corn (MON 863) had higher muscle protein than those fed one of the conventional corn hybrids (RX740). Thus, there was no evidence from either study of any negative effect of the transgenic corn hybrid on LM quality or chemical composition measurements.

Muscle quality and chemical composition measurements did not differ between barrows and gilts in both studies (Table 9). Most previous studies have indicated that meat quality measurements, including ultimate pH, marbling, firmness, and Minolta values were similar for barrows and gilts (Unruh et al., 1996; Nold et al., 1999; Fortin et al., 2003).

There was no evidence from these two studies of any negative effect of the YieldGard Rootworm corn (MON 863) on either growth performance or carcass and pork quality measurements compared with nontransgenic corn (RX670) and conventional commercial corn hybrids (DK647 and RX740). These findings are similar to results of Stanisiewski et al. (2001) and Hyun et al. (2004) for transgenic Roundup Ready corn (GA21 and NK 603, respectively) and Gaines et al. (2001), Piva et al. (2001), and Weber and Richert (2001) for transgenic-insect–protected YieldGard Corn Borer (MON 810) compared with nontransgenic conventional corn hybrids in pigs.

Table 9. Means for the effects of diet and gender on meat quality measurements: Studies 1 and 2

	Corn hybrid in diet[a]					Gender		
Item	MON 863	RX670	DK647	RX740	SEM	Barrow	Gilt	SEM
Study 1								
LM quality								
Marbling[b]	2.67	2.44	2.28	2.28	0.136	2.48	2.36	0.096
Firmness[c]	2.95	3.08	2.86	3.08	0.104	2.91	3.07	0.074
Ultimate pH	5.58	5.57	5.57	5.56	0.027	5.58	5.55	0.019
Minolta L*[d]	47.20	46.65	46.53	46.62	0.504	46.86	46.64	0.356
Minolta a*[d]	6.99	7.21	6.72	6.84	0.148	6.96	6.93	0.105
Minolta b*[d]	2.27	2.19	1.76	1.85	0.161	2.09	1.94	0.114
Chemical composition of LM, %								
Moisture	73.11	73.62	73.34	73.37	0.167	73.31	73.41	0.118
Protein	23.43	22.94	23.20	23.02	0.229	23.15	23.15	0.162
Fat	2.30	2.22	2.03	2.27	0.144	2.28	2.13	0.102
Study 2								
LM quality								
Color[e]	2.38	2.41	2.22	2.27	0.134	2.32	2.32	0.095
Firmness[e]	2.30	2.34	2.10	2.17	0.135	2.25	2.20	0.096
Marbling[e]	2.11	1.93	1.81	1.98	0.124	2.06	1.86	0.088
Chemical composition of LM, %								
Moisture	73.86	73.68	73.75	73.39	0.146	73.58	73.76	0.103
Protein	23.14[fg]	23.48[f]	22.76[gh]	22.60[h]	0.173	22.99	23.01	0.122
Fat	2.50	2.58	2.45	3.07	0.166	2.81	2.49	0.117

[a]MON 863 = transgenic YieldGard Rootworm corn; RX670 = nontransgenic control corn; DK647 and RX740 = conventional corn hybrids.
[b]Evaluated on a scale of 1 to 4, where 1 = practically devoid of marbling and 4 = moderate to slightly abundant marbling.
[c]Evaluated on a scale of 1 to 4, where 1 = very soft and 4 = very firm.
[d]Minolta L* = lightness; a* = red-green scale; and b* = yellow-blue scale.
[e]Evaluated on a six- or five-point scale. Color: 1 = light, 6 = dark; Firmness: 1 = soft, 5 = very firm; Marbling: 1 = devoid, 6 = abundant.
[f,g,h]Within a treatment row, means without a common superscript letter differ, $P < 0.05$.

Implications

These studies demonstrated that the feeding value of YieldGard Rootworm corn (containing event MON 863 which expresses the Cry 3Bb1 protein) did not differ from that of the nontransgenic control corn and the nontransgenic commercial reference corn hybrids tested. Therefore, YieldGard Rootworm corn (MON 863), when used in diets for growing-finishing swine, would be expected to have effects on growth performance and carcass characteristics comparable to those with nontransgenic conventional corn.

Literature Cited

Alston, J. M., J. Hyde, M. C. Marra, and P. D. Mitchell. 2002. An ex ante analysis of the benefits from the adoption of corn rootworm resistant transgenic corn technology. AgBioForum 5:71–84.

AOAC. 1995. Official Methods of Analysis. 16th ed. Assoc. Off. Anal. Chem., Arlington, VA.

Cromwell, G. L., T. R. Cline, J. D. Crenshaw, T. D. Crenshaw, R. C. Ewan, C. R. Hamilton, A. J. Lewis, D. C. Mahan, E. R. Miller, J. E. Pettigrew, L. F. Tribble, and T. L. Veum. 1993. The dietary protein and(or) lysine requirement of barrows and gilts. J. Anim. Sci. 71:1510–1519.

English, L., and S. L. Slatin. 1992. Mode of action of delta-endotoxin from *Bacillus thuringiensis*: A comparison with other bacterial toxins. Insect Biochem. Molec. Biol. 22:1–7.

Fortin, A., W. M. Robertson, S. Kibite, and S. J. Landry. 2003. Growth performance, carcass and pork quality of finisher pigs fed oat-based diets containing different levels of β-glucans. J. Anim. Sci. 81:449–456.

Gaines, A. M., G. L. Allee, and B. W. Ratliff. 2001. Swine digestible energy evaluations of Bt (MON 810) and Roundup Ready corn compared with commercial varieties. J. Anim. Sci. 79(Suppl. 1):109. (Abstr.)

Hahn, J. D., and D. H. Baker. 1995. Optimum ratio to lysine of threonine, tryptophan, and sulfur amino acids for finishing swine. J. Anim. Sci. 73:482–489.

Hahn, J. D., R. R. Biehl, and D. H. Baker. 1995. Ideal digestible lysine level for early- and late-finishing swine. J. Anim. Sci. 73:773–784.

Hyun, Y., G. E. Bressner, M. Ellis, A. J. Lewis, R. Fischer, E. P. Stanisiewski, and G. F. Hartnell. 2004. Performance of growing-finishing pigs fed diets containing Roundup Ready corn (event nk603), a nontransgenic genetically similar corn, or conventional corn lines. J. Anim. Sci. 82:571–580.

Hyun, Y., and M. Ellis. 2001. Effect of group size and feeder type on growth performance and feeding patterns in growing pigs. J. Anim. Sci. 79:803–810.

ILSI. 2003. Crop Composition Database. Int. Life Sci. Inst. Available: http://www.cropcomposition.org/. Accessed Sept. 29, 2003.

Knowles, B. H., and D. J. Ellar. 1987. Colloid-osmotic lysis is a general feature of the mechanisms of action of Bacillus thuringiensis (delta)-endotoxins with different insect specificity. Biochem. Biophys. Acta 924:509–518.

Labroue, F., R. Guéblez, P. Sellier, and M. C. Meunier-Salaün. 1994. Feeding behaviour of group-housed Large White and Landrace pigs in French Central Test Stations. Livest. Prod. Sci. 40:303–312.

Nold, R. A., J. R. Romans, W. J. Costello, and G. W. Libal. 1999. Characterization of muscles from boars, barrows, and gilts slaughtered at 100 and 110 kilograms: Differences in fat, moisture, color, water-holding capacity, and collagen. J. Anim. Sci. 77:1746–1754.

Novakofski, J., S. Park, P. J. Bechtel, and F. K. McKeith. 1989. Composition of cooked pork chops: Effect of removing subcutaneous fat before cooking. J. Food Sci. 54:15–17.

NPPC. 1991. Procedures to Evaluate Market Hogs. Natl. Pork Prod. Counc., Des Moines, IA.

NPPC. 2000. Pork Composition and Quality Assessment Procedures. Natl. Pork Prod. Counc., Des Moines, IA.

NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

Rice, M. E. 2004. Transgenic rootworm corn: Assessing potential agronomic, economic, and environmental benefits. Plant Health Prog. March 1. Available: http://www.plantmanagementnetwork.org/sub/php/review/2004/rootworm. Accessed June 3, 2004.

Piva, G., M. Morlacchini, A. Pietri, A. Piva, and G. Casadei. 2001. Performance of weaned piglets fed inset-protected (MON 810) or near isogenic corn. J. Anim. Sci. 79(Suppl. 1):106. (Abstr.)

Stanisiewski, E. P., G. F. Hartnell, and D. R. Cook. 2001. Comparison of swine performance when fed diets containing Roundup Ready corn (GA21), parental line or conventional corn. J. Anim. Sci. 79(Suppl. 1):319. (Abstr.)

Taylor, M. L., G. F. Hartnell, S. G. Riordan, M. A. Nemeth, K. Karunanandaa, B. George, and J. D. Astwood. 2003a. Comparison of broiler performance when fed diets containing grain from Roundup Ready (NK603), YieldGard × Roundup Ready (MON 810 × NK603), nontransgenic control, or commercial corn. Poult. Sci. 82:443–453.

Taylor, M. L., G. F. Hartnell, S. G. Riordan, M. A. Nemeth, K. Karunanandaa, B. George, and J. D. Astwood. 2003b. Comparison of broiler performance when fed diets containing grain from YieldGard corn, YieldGard × Roundup Ready (GA21), nontransgenic control, or commercial corn. Poult. Sci. 82:823–830.

Taylor, M. L., Y. Hyun, G. F. Hartnell, S. G. Riordan, M. A. Nemeth, K. Karunanandaa, B. George, and J. D. Astwood. 2003c. Comparison of broiler performance when fed diets containing grain from YieldGard Rootworm (MON 863), YieldGard Plus (MON 810 × MON 863), nontransgenic control, or commercial reference corn hybrids. Poult. Sci. 82:1948–1956.

Unruh, J. A., K. G. Friesen, S. R. Stuewe, B. L. Dunn, J. L. Nelssen, R. D. Goodband, and M. D. Tokach. 1996. The influence of genotype, sex, and dietary lysine on pork subprimal cut yields and carcass quality of pigs fed to either 104 or 127 kilograms. J. Anim. Sci. 74:1274–1283.

Weber, T. E., and B. T. Richert. 2001. Grower-finisher growth performance and carcass characteristics including attempts to detect transgenic plant DNA and protein in muscle from pigs fed genetically modified "Bt" corn. J. Anim. Sci. 79(Suppl. 2):67. (Abstr.)