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EVALUATION OF CORN BORER RESISTANCE AND GRAIN YIELD FOR BT AND NON-BT CORN HYBRIDS[1]

by

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SUMMARY

Twenty-six corn hybrids (15 Bt- and 11 non-Bt-corn) were evaluated for corn borer resistance and grain yield performance. The yield losses to girdling by southwestern corn borers averaged 30 bu/a for the unsprayed non-Bt hybrids, 2.9 bu/a for sprayed non-Bt hybrids, and 19.4 bu/a for hybrids with event 176. Hybrids with Bt11, MON810, and CBH351 had virtually no yield losses. A yield loss of 20.9 bu/a was associated with spider mite leaf damage. Grain yields averaged 187.9 bu/a across all hybrids in the sprayed block and 165.0 bu/a in the unsprayed block.

PROCEDURES

Corn plots were machine-planted on 13 May at 30,000 seeds/a at the Southwest Research-Extension Center near Garden City, KS. Spot replanting was done as necessary. Across hybrids, the number of plants with ears at harvest varied from 91 to 117 plants per 60 row-ft. Preplant herbicides applied on 10 April were 2 qt Milo-Pro, 1 qt 2,4-D and 1 pt Roundup/a. Postemergence herbicides applied on 2 June were 7 oz. Accent and 0.5 pt Banvel with 0.2 qt surfactant/a. The soil was a saline-Richfield silt-loam with a pH of 7.5 to 8.0. The field was furrow irrigated on 18 June, 2 July, 18 July, and 24 Aug. with 4.6, 4.1, 4.2, and 4.1 inches of water, respectively. Monthly rainfalls for April through Aug. were 0.9, 2.7, 0.9, 6.61, and 3.1 inches. The plots were four rows wide (10 ft) by 30 ft long. Two border rows (5 ft) of Bt corn were planted between the plots, and 10-ft alleyways at the end of each plot were left bare. The border rows and alleyways were included to reduce larval migration between plots. The experimental design was a split-plot with four replications. The main plots were insecticide-protected versus insecticide unprotected, and the sub-plots were the corn hybrids. The protected blocks were sprayed on 17 July with Capture (bifenthrin) at 0.08 lb. AI/a. We used 26 hybrids with relative maturity ratings of 110 to 118 days. An attempt was made to pair each non-Bt hybrid with its Bt sister line or with another related hybrid. Pioneer 3162IR was included as the standard commonly used hybrid.

On 22 and again on 29 June, 25 to 30 neonate European corn borers (ECB) were placed in the whorls of 10 plants in each plot to supplement the native first generation infestation. However, shot-hole damage was minimal, so no data were collected on first generation corn borers. In Sept., spider mite damage was evaluated by examining three leaves (the ear-leaf and the second leaf above and below it) on six plants in each plot. The percentage of each leaf having spider mite damage was recorded and averaged for each plot. Second generation corn borer infestations were entirely native. Data for second generation corn borers were taken from five consecutive plants in one of the two center rows of each plot. The plants were dissected to record corn borers and corn borer tunneling. Kernel damage was recorded as the estimated percentage of kernels damaged at the tip (mostly corn earworm) and at the base or side of the ear (mostly corn borer damage). In addition, lodged plants in the middle two rows were counted and separated into those girdled by southwestern corn borer (SWCB) and those that lodged from European corn borer tunneling or stalk rot. Yield was determined by separately harvesting ears from standing plants and from fallen plants. The lodged corn was harvested by hand, and the standing corn was machine harvested. The two middle rows of each plot were harvested in late October. Grain yield was calculated separately for standing and fallen corn and corrected to 15.5% moisture.

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The data were analyzed both as a two-factor experiment (including both sprayed and unsprayed plots) and as two single-factor experiments (sprayed and unsprayed plots analyzed separately). To simplify the discussion, results are averaged across the four Bt events and the sprayed and unsprayed non-Bt hybrids.

RESULTS AND DISCUSSION

First generation corn borer pressure was light, and no data were collected. Second generation ECB and SWCB pressures averaged 0.13 and 0.35 larvae per plant, respectively, in the unsprayed non-Bt plots (Tables 1 & 2). In hybrids with Bt11, MON810, CBH351, and Bt176 and the insecticide treatment, second generation ECB larvae were reduced by 100, 100, 100, 61, and 76%, respectively; second generation SWCB larvae were reduced by 100, 100, 100, 22, and 86% (Fig. 1); girdled plants were reduced by 100, 98, 99, 38, and 90%; corn borer tunneling was reduced by 100, 99, 98, 50, and 87% (Fig. 2); and yield losses from SWCB lodged plants were reduced by 100, 97, 99, 35, and 90%. The yield losses to girdling by SWCB averaged 30.0 bu/a for the unsprayed non-Bt hybrids, 2.9 bu/a for sprayed non-Bt hybrids, and 19.4 bu/a for hybrids with event 176 (Fig.3). Hybrids with Bt11, MON810, and CBH351 had virtually no yield loss.

Fig. 1. Second generation SWCB larvae per plant at Garden City, KS, 1998.

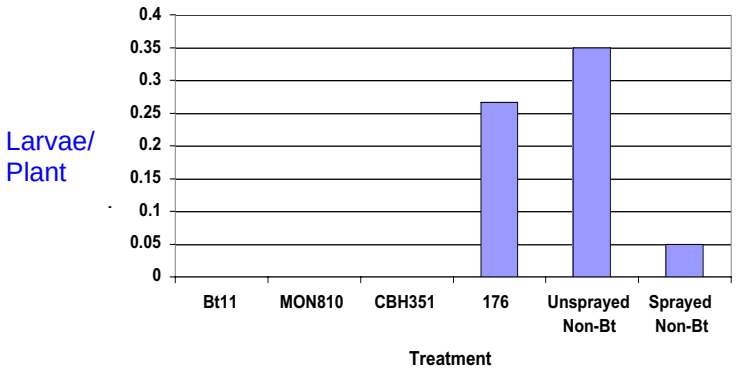


Fig. 2. Second generation SWCB tunneling at Garden City, KS, 1998.

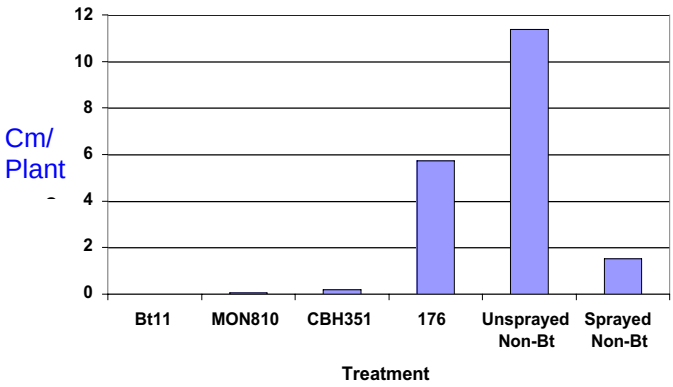
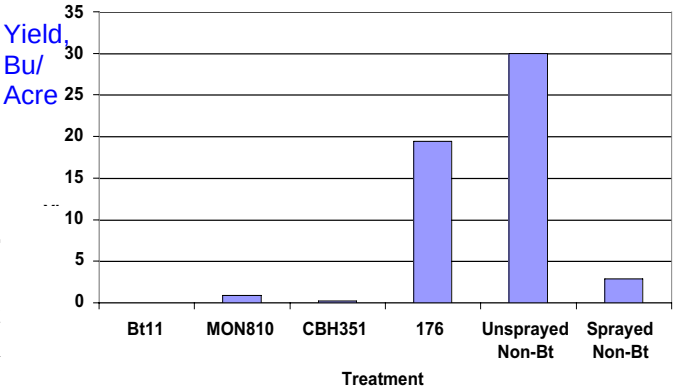


Fig. 3. Grain yield losses caused by SWCB at Garden City, KS, 1998.



Spider mite pressure was high during the hot dry spell in August (Fig. 4). In the unsprayed block, spider mite leaf damage averaged 59.1%, and in the Capture-sprayed block, it averaged 27.1%. Capture is a good miticide that apparently was able to suppress the spider mite damage during the hot dry period in August. Across the Bt hybrids (with no corn borer damage), the yield difference between sprayed and unsprayed was 20.9 bu/a. This yield loss appeared to be associated with a 24% difference in spider mite leaf damage.

Corn earworm damage to kernels in the ear tip was relatively light, averaging only 1.5% in the unsprayed non-Bt (Tables 1 & 2). Hybrids with Bt11

and Mon810 averaged 51 and 30% reductions in kernel damage, respectively (Fig. 5). Hybrids with Bt176 or CBH351 and sprayed non-Bt hybrids had small reductions in kernel damage. Damage at the ear base was minor and did not differ significantly across the hybrids.

Grain yields averaged 187.9 bu/a across all hybrids in the sprayed block and 165.0 bu/a in the unsprayed block (Tables 1 & 2, Fig. 6). The standard hybrid, Pioneer 3162IR, yielded 203.0 bu/a in the sprayed block, but only 159.1 bu/a in the unsprayed block. A number of Bt and non-Bt hybrids were among the top yielders.

When the plants were at the pretassel stage, a windstorm on 2 July caused significant stalk breakage in some of the hybrids. The hybrids with the highest breakage (plants broken per 60 row-ft) were as follows: DeKalb 621 (11.0), DeKalb 621BtY (8.3), Novartis 4494 (6.0), Garst 8325Bt (5.3) Novartis Max454 (4.8) and Garst 8325 (4.3). The other hybrids had 4 or fewer plants broken per 60 row-ft.

Fig. 4. Percent of ear zone leaves with spider mite damage at Garden City, KS, 1998.

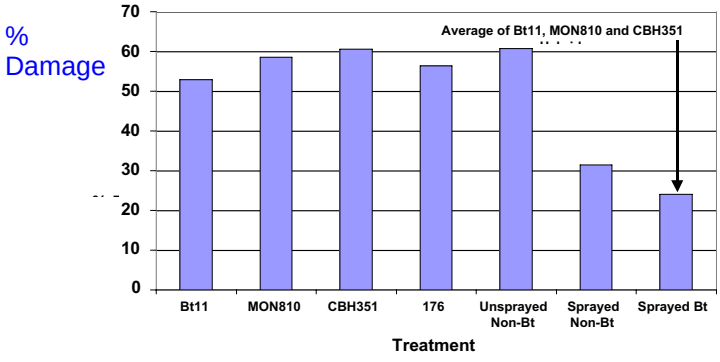


Fig. 5. Percent of ear tip kernel damage at Garden City, KS, 1998.

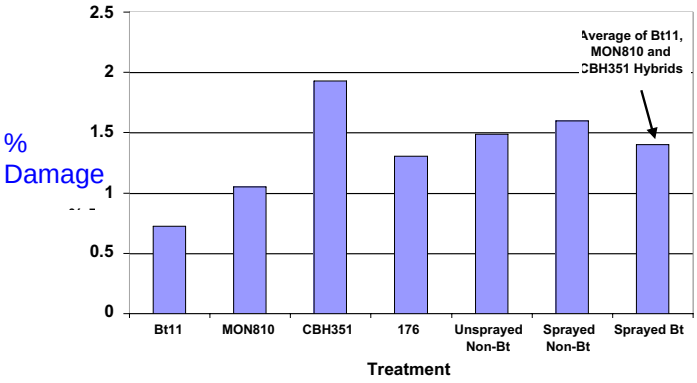


Fig. 6. Grain yield from standing and fallen plants at Garden City, KS, 1998.

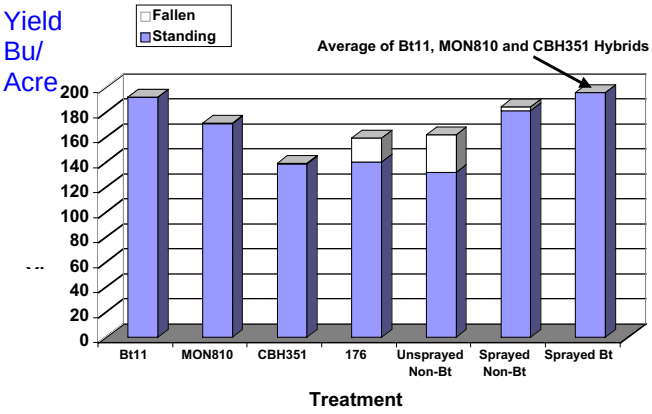
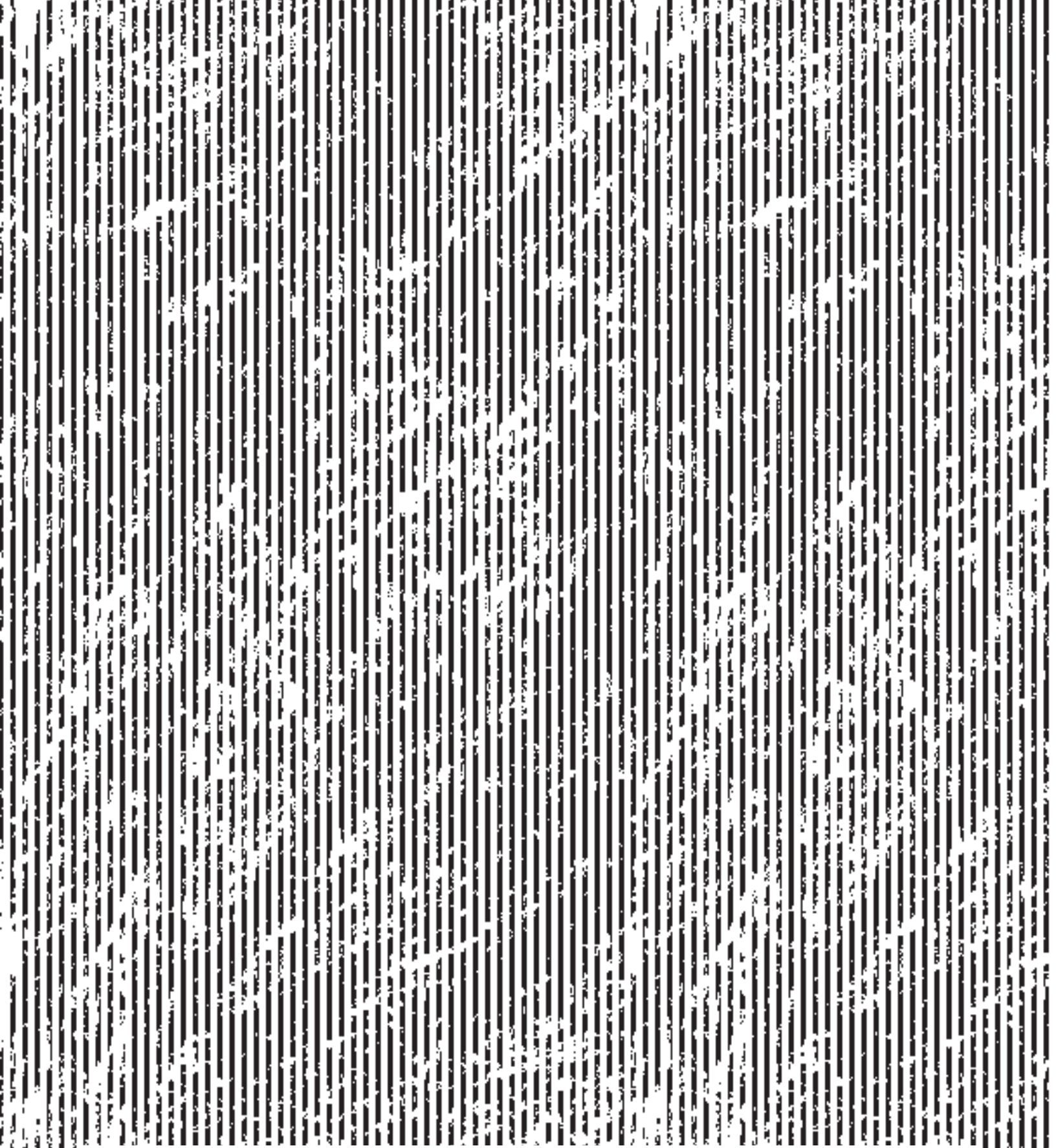


Table 1. Evaluation of corn borer resistance of Bt and non-Bt corn hybrids, unsprayed block at Garden City, KS, 1998.

Hybrid	Bt Event	Company	2nd Gen. Corn Borer: ECB Larvae per Plant	2nd Gen. Corn Borer: SWCB Larvae per Plant	2nd Gen. Corn Borer: % SWCB Girdled Plants/Plot	2nd Gen. Corn Borer: Cm of Tunneling per Plant	Ear Tip Damage (% kernels)	Yield Standing (Plts. bu/a)	Yield Fallen Plts. (bu/a)	Total Yield (bu/a)
4494		Novartis Seeds	0.20	0.50 b	25.75 ab	17.35 abc	1.55 b-f	120.3 lmn	43.2 b	163.6 c-h
MAX454	176	Novartis Seeds	0.00	0.40 bc	11.50 ef	7.00 e-h	1.49 b-g	146.1 f-k	18.1 fgh	164.1b-h
7590Bt	Bt11	Novartis Seeds	0.00	0.00 e	0.00 h	0.00 h	0.85 d-i	189.7 ab	0.0 i	189.7 ab
7590		Novartis Seeds	0.05	0.15 cde	11.50 ef	3.80 gh	1.37 b-h	157.4 e-j	21.5 efg	179.0 a-e
7639Bt	Bt11	Novartis Seeds	0.00	0.00 e	0.00 h	0.00 h	0.60 hi	193.8 a	0.0 i	193.8 a
H-2530Bt	MON810	Golden Harvest	0.00	0.00 e	0.00 h	0.25 h	2.05 ab	155.6 e-j	0.0 i	155.6 e-i
H-2530		Golden Harvest	0.20	0.35 bcd	15.75 cde	10.15 c-g	1.66 a-d	138.1 h-m	22.4 efg	160.5 d-h
3162IR		Pioneer	0.20	0.35 bcd	21.00 bcd	15.33 a-d	1.39 b-h	129.6 k-n	29.6 c-f	159.1 e-i
31B13	MON810	Pioneer	0.00	0.00 e	0.25 h	0.00 h	0.99 d-i	173.8 a-e	0.1 i	173.9 a-f
32J55		Pioneer	0.05	0.15 cde	12.25 ef	5.3 fgh	1.69 a-d	155.6 e-j	19.7 e-h	175.3 a-f
33A14	MON810	Pioneer	0.00	0.00 e	0.00 h	0.00 h	1.44 b-h	186.3 a-d	0.0 i	186.3 a-d
8325		Garst	0.15	0.45 b	9.00 efg	20.02 ab	1.42 b-h	161.5 d-h	12.6 ghi	174.1 a-f
8325Bt	MON810	Garst	0.00	0.00 e	0.00 h	0.03 h	1.51 b-g	169.4 a-f	0.0 i	169.4 a-g
8342Bt	MON810	Garst	0.00	0.00 e	0.00 h	0.00 h	0.85 d-i	186.9 abc	0.0 i	186.9 abc
7997		Cargill	0.30	0.80 a	15.25 def	20.46 a	1.60 a-e	136.8 h-m	24.9 d-g	161.7 c-h
7821BT	MON810	Cargill	0.00	0.00 e	0.25 h	0.00 h	0.78 e-i	169.3 a-f	0.4 i	169.7 a-f
8021BT	MON810	Cargill	0.00	0.00 e	0.00 h	0.00 h	0.66 ghi	168.8 b-f	0.0 i	168.8 a-g
580		DeKalb	0.10	0.10 de	14.00 ef	3.70 gh	0.68 ghi	121.5 k-n	19.8 e-h	141.3 hi
580BtY	MON810	DeKalb	0.00	0.00 e	0.00 h	0.15 h	0.74 f-i	159.1 e-i	0.0 i	159.1 e-i
621		DeKalb	0.00	0.30 bcd	30.50 a	12.90 b-e	1.35 b-h	108.2 n	56.9 a	165.0 b-h
621BtY	MON810	DeKalb	0.00	0.00 e	2.75 gh	0.00 h	0.45 i	164.6 c-g	7.5 hi	172.1 a-f
7250		Mycogen	0.15	0.30 bcd	23.25 b	6.95 e-h	1.33 b-h	126.8 k-n	40.5 bc	167.2 b-h
2787	176	Mycogen	0.10	0.25 b-e	14.75 def	6.60 e-h	1.12 c-i	136.4 i-m	18.2 fgh	154.6 e-i
2801	176	Mycogen	0.05	0.15 cde	8.50 fg	3.55 gh	1.29 b-i	136.9 h-m	21.9 efg	158.9 e-i
8366IT		Garst	0.00	0.35 bcd	24.00 ab	8.55 d-g	1.89 abc	106.5 n	36.9 bcd	143.5 ghi
8366Bt/LL	CBH351	Garst	0.00	0.00 e	0.00 h	0.40 h	1.42 b-h	143.4 g-l	0.0 i	143.4 ghi
8366IT		Garst	0.15	0.40 bc	22.50 bc	12.00 c-f	1.96 abc	118.2 mn	31.4 b-e	149.6 f-i
8366Bt/LL	CBH351	Garst	0.00	0.00 e	0.25 h	0.00 h	2.44 a	133.7 j-m	0.4 i	134.1 i
LSD value p=0.05			0.20	0.27	6.95	7.52	0.86	24.9	12.9	26.0
F-test Prob.			0.1193	<0.0001	<0.0001	<0.0001	0.0007	<0.0001	<0.0001	0.0006

Table 2. Evaluation of corn borer resistance of Bt and non-Bt corn hybrids, sprayed block at Garden City, KS, 1998.

Hybrid	Bt Event	Company	2nd Gen. Corn Borer ECB Larvae per Plant	2nd Gen. Corn Borer SWCB Larvae per Plant	2nd Gen. Corn Borer % SWCB Girdled Plants/Plot	2nd Gen. Corn Borer Cm of Tunneling per Plant	Ear Tip Damage (% kernels)	Yield Standing Plts (bu/a)	Yield Fallen Plts (bu/a)	Total Yield (bu/a)
4494		Norvartis Seeds	0.00	0.00	0.7 cd	1.0 b	1.67 c-g	196.3 a-f	1.3 def	197.6 a-g
MAX454	176	Novartis Seeds	0.00	0.00	0.5 d	0.0 b	1.65 c-g	205.1 a-d	1.0 ef	206.1 a-d
7590Bt	Bt11	Novartis Seeds	0.00	0.00	0.0 d	0.0 b	0.89 ghi	218.0 a	0.0 f	218.0
7590		Novartis Seeds	0.00	0.00	2.5 b	0.1 b	1.22 e-i	204.9 a-d	4.5 abc	209.3 ab
7639Bt	Bt11	Novartis Seeds	0.00	0.00	0.0 d	0.0 b	0.69 hi	207.9 abc	0.0 f	207.9 abc
H-2530Bt	MON810	Golden Harvest	0.00	0.00	0.0 d	0.0 b	1.37 d-i	185.0 b-i	0.0 f	185.0 b-j
H-2530		Golden Harvest	0.00	0.05	0.7 cd	1.4 b	1.45 c-h	162.9 hij	1.1 def	164.0 ijk
3162IR		Pioneer	0.10	0.00	1.5 bcd	1.2 b	1.22 e-i	200.4 a-e	2.6 b-f	203.0 a-e
31B13	MON810	Pioneer	0.00	0.00	0.0 d	0.0 b	1.91 c-f	195.6 a-g	0.0 f	195.6 a-h
32J55		Pioneer	0.05	0.00	2.3 bc	0.3 b	1.27 e-i	216.5 a	4.0 a-d	220.5 a
33A14	MON810	Pioneer	0.00	0.00	0.0 d	0.0 b	0.94 ghi	210.0 ab	0.0 f	210.0 ab
8325		Garst	0.00	0.10	0.0 d	1.5 b	2.05 a-e	188.4 b-h	0.0 f	188.4 b-i
8325Bt	MON810	Garst	0.00	0.00	0.0 d	0.0 b	1.33 d-i	201.0 a-e	0.0 f	201.0 a-g
8342Bt	MON810	Garst	0.00	0.00	0.0 d	0.1 b	0.98 ghi	187.3 b-i	0.0 f	187.3 b-j
7997		Cargill	0.00	0.00	5.3 a	1.9 b	1.52 c-h	149.1 j	5.5 ab	154.5 k
7821BT	MON810	Cargill	0.00	0.00	0.0 d	0.0 b	1.40 d-i	202.0 a-e	0.0 f	202.0 a-f
8021BT	MON810	Cargill	0.00	0.00	0.3 d	0.0 b	0.97 ghi	187.4 b-i	0.5 f	187.9 b-j
580		DeKalb	0.05	0.00	1.3 bcd	0.2 b	1.05 f-i	176.5 e-i	2.8 b-f	179.3 e-k
580BtY	MON810	DeKalb	0.00	0.00	0.0 d	0.0 b	0.49 i	180.9 d-i	0.0 f	180.9 d-k
621		DeKalb	0.20	0.25	4.7 a	8.7 a	1.19 e-i	171.2 f-j	5.9 a	177.1 e-k
621BtY	MON810	DeKalb	0.00	0.00	0.0 d	0.0 b	0.85 ghi	175.1 e-j	0.0 f	175.1 g-k
7250		Mycogen	0.00	0.10	2.3 bc	0.7 b	1.40 d-i	176.9 e-i	4.6 abc	181.1 c-j
2787	176	Mycogen	0.05	0.00	0.3 d	0.5 b	1.25 e-i	181.2 c-i	1.4 def	182.6 c-j
2801	176	Mycogen	0.00	0.05	1.3 bcd	0.7 b	2.22 a-d	171.9 f-j	3.5 a-e	175.4 f-k
8366IT		Garst	0.00	0.10	0.5 d	1.3 b	2.84 ab	168.9 g-j	0.9 ef	169.9 h-k
8366Bt/LL	CBH351	Garst	0.00	0.00	0.0 d	0.0 b	1.98 b-f	177.1 e-i	0.0 f	177.1 e-k
8366IT		Garst	0.00	0.00	1.5 bcd	0.0 b	2.36 abc	160.6 ij	1.7 c-f	162.3 ijk
8366Bt/LL	CBH351	Garst	0.00	0.00	0.3 d	0.1 b	2.97 a	161.1 ij	0.3 f	161.4 jk
LSD value p=0.05			0.12	0.13	1.7	3.4	0.93	27.0	2.9	26.6
F-test Prob.			0.4305	0.0993	<0.0001	0.0130	<0.0001	<0.0001	<0.0001	<0.0001



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