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Resistance of Sweet Corn to Damage by Blackbirds and Starlings

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Abstract. **Twenty-five cultivars of sweet corn were evaluated for resistance to bird damage in an aviary during 1983 and 1984. A free-choice test was used in which red-winged blackbirds (*Agelaius phoeniceus* L.), common grackles (*Quiscalus quiscula* L.), and starlings (*Sturnus vulgaris* L.) could select from among 8 cultivars at a time. In addition, no-choice conditions in which red-wings were presented with only one cultivar at a time were tested. In the free-choice test, there were significant differences among bird species and corn cultivars in the amount of damage. The most damaged cultivar had 4.8 times the damage of the least damaged cultivar. Starlings did the most damage and grackles the least, but all bird species damaged the cultivars in the same approximate order. Differences in damage among cultivars were diminished in the no-choice tests; however, the damage ranking of cultivars was similar to that of the free-choice test. Husk weight, length of husk beyond kernels, and weight of husk extension were the best correlates (all negative) with damage. The incorporation of these characteristics into sweet corn lines should increase cultivar resistance to damage by birds.**

Blackbird (Icterinae) damage to maturing sweet corn is a serious economic problem in localized areas of North America. Bird-damaged ears usually are lost completely for fresh-market sales. For cannery corn, bird damage not only reduces yield but also increases labor costs for culling and trimming. The amount of bird damage to sweet corn is not as well documented as it is for field corn (7, 12). Nonetheless, studies in one- to 3-county areas of Idaho, Wisconsin, New York, Ohio, and Maryland in 1974 revealed mean losses ranging from 4.5% to 23.5% of the ears damaged per field (1, 8, 11). About 25% of the 115 fields sampled in these states had more than 10% of the ears damaged by birds. In Ontario, 55 sweet corn fields averaged 2.4% (range 0–13%) ear damage by blackbirds in 1965 (5). Farmers surveyed in Connecticut in 1974 reported that 33% of the sweet corn fields were damaged by blackbirds, resulting in a mean loss of $430/ha (6). In some instances farmers have resorted to illegal poisoning of birds to reduce damage (13).

Damage is inflicted primarily by the red-winged blackbird, although damage by common grackles has been reported (1, 6). There also is evidence that starlings, a species of the family Sturnide that was introduced in North America, cause losses (6, 16).

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In localities where blackbird populations are high, one promising means of reducing damage is through the use of cultivars resistant to bird attack. No formal evaluations of resistance to bird damage have been done in sweet corn; however, several studies of resistance in field corn hybrids have indicated that use of resistant cultivars may be particularly suited for sweet corn. Maturing sweet corn has only a short period of vulnerability to birds. Damage begins at about 14 days after silking (DAS), and harvest usually occurs 16–20 DAS (4, 15). In contrast, the period of vulnerability for field corn extends to 50 or more DAS (4, 15). Dolbeer et al. (2, 3) found in aviary tests that bird damage varied considerably among field corn hybrids and was correlated strongly with certain husk characteristics 14–25 DAS. However, these differences in damage among hybrids and the correlations with characteristics were less pronounced past 25 DAS. Thus, if similar patterns were to hold true for sweet corn, there would be an increased potential for exploitation of resistance to reduce damage.

The objectives were to a) determine the relative resistance of a sample of sweet corn cultivars to damage by 3 species of birds in a controlled aviary environment and b) establish the relationship between ear and husk characteristics of the cultivars and the amount of bird damage received.

Materials and Methods

Thirteen cultivars of sweet corn (Table 1) were planted on 28 May 1983 in 3-row × 60-m plots in Erie County, Ohio. Row spacing was 0.75 m and plant spacing averaged 20 cm. Starting 18 July and at 2-day intervals until 5 August, all plants with newly silked top ears in each plot were marked with spray paint. A different color was used each day. This practice allowed the use of ears of the same silking date in the evaluations. For each cultivar, only ears from the peak 2 or 3 silking dates (covering 4–6 days) were used.

In early July, 50 to 100 each of red-wings, grackles, and starlings were captured in mist nets. Birds from this population were placed, 6 to a cage, in twenty 1.5 × 1.0 × 0.5-m cages in an outdoor pavilion isolated from human activity. Male red-wings were placed in 8 cages. Female red-wings, grackles (4 males, 2 females), and starlings (unknown sex ratio) were placed in 4 cages each. Male and female red-wings were separated because of their size difference (female weight is about 65% that of males) and because of evidence from feeding habit studies that corn is a more important food for males than for females (10). Cages were identical in perches, water, grit, cracked corn, sunflower seeds, and millet, and poultry pellets (starlings only). The birds also were provided with fresh ears of sweet corn during the week before the experiment began for acclimation to test conditions.

The 13 cultivars were evaluated for bird damage in a free-choice test in which birds could select from 8 cultivars at a time and in a no-choice test in which birds were presented with one cultivar at a time. For the free-choice test, the cultivars were divided into 2 groups of 8 cultivars each (based on maturity)

Table 1. Selected characteristics of the 25 sweet corn cultivars evaluated for resistance to bird damage in an aviary in 1983 (varieties 1–13) and 1984 (varieties 5, 6, 11, 13, and 14–25).

Cultivar no.[y]	Cultivar name	Means values[z] Days to 50% silking	Husk extension (mm)[x]	Husk wt (g)	Husk extension wt (g)[w]	Pericarp strength (g/mm²)	Cob length (mm)	Total husk length (mm)
1	Merit	61	50	12.7	2.4	155	213	263
2	Paramount	58	25	10.7	1.1	95	226	251
3	Platinum Lady	57	30	8.9	1.1	160	203	233
4	Terrific	59	41	12.0	2.0	135	208	250
5	121 Harmony	55	57	9.1	2.2	230	179	236
6	133 Silver Prince	67	27	14.5	1.6	180	214	242
7	BX 9660	59	21	9.6	0.9	150	196	217
8	Kandy Korn	63	6	10.5	0.3	90	202	208
9	Peaches & Cream	55	42	8.3	1.5	165	187	229
10	Sterling	63	34	9.2	1.4	120	193	227
11	Honeycomb	57	59	10.8	2.3	170	218	276
12	Sugarloaf	61	46	7.9	1.6	175	188	234
13	Trigold	63	42	7.0	1.3	200	185	226
14	S. Delicious	65	62	12.5	2.7	140	220	282
15	Miracle	58	25	9.1	1.0	95	192	217
16	Cr 8028	54	41	9.3	1.7	125	183	224
17	Crisp'n Sweet 710	57	42	8.4	1.6	180	182	224
18	Stardust	49	79	10.2	3.2	150	171	251
19	Pearl White	54	56	13.0	3.1	140	177	233
20	Gold Dust	54	90	16.5	5.4	150	182	271
21	Jazz	49	46	9.8	1.9	135	192	238
22	Honey & Frost	58	44	17.6	3.2	140	201	244
23	Crusader	57	44	12.8	2.3	115	197	241
24	Celebrity	60	36	14.0	2.1	110	206	242
25	Advance	59	63	14.0	3.4	130	185	248

[z]See text for details of measurements; N = 10 ears (1983) and 12 ears (1984).
[y]Seed Company. Cultivars: 1 Asgrow; 2–4, 14–17 Crookham; 5–7 Harris; 8, 9, 24 and 25 Musser; 10 and 21 Roger Bros.; 11–13 Sun; 18–20 Agway; 22 and 23 Seedway.
[x]From tip of cob to tip of husk.
[w]Husk extension length/total husk length) × husk weight.

with 3 intermediate cultivars (4, 7, 12) belonging to both groups. Each group was evaluated on 2 maturity dates (16 and 20 DAS) by placing one ear freshly picked at 0800 HR from each cultivar, with husk and shank intact, in each of the cages (excluding 4 cages of the male red-wings) for 6 hr (0900–1500 HR). The ears were skewered to nails on a board at 20-cm intervals at an angle of 30° from vertical and with the same orientation as on the plants. Ears were assigned randomly to positions on the board at each evaluation. For 1 hr before and during the 6-hr test, all other food, but not water and grit, was removed from the cages. Upon removing the ears from the cages at 1500 HR, the maximum length (mm) of damage down a corn row (hereafter referred to as damage length) was measured for each ear. Mean damage length and percent of ears damaged/cultivar were the 2 measures of damage used in the analyses.

The no-choice test used only the 8 cages of male red-wings. Each cultivar was evaluated on one maturity date (18 DAS) by placing 8 ears in each of 4 randomly assigned cages for the 6-hr period. All other conditions were as in the free-choice test. The free- and no-choice tests were scheduled so that all birds had at least one day without corn between evaluations. The tests were from 7 to 20 Aug.

Characteristics of each cultivar were measured for 10 additional ears picked on the day of the no-choice test. The shank and cob stem were separated from each ear by sawing through the husk precisely at the butt of the cob. The maximum and minimum husk lengths (mm) were measured from butt to tip. The force (to the nearest 5 g) required to penetrate the husk was measured at 4 points located 3 cm below the cob tip using a 500-g penetrometer with a 0.66-mm-diameter plunger. The husk was then removed, placed in a paper sack, dried at 30°C for 8 weeks, and weighed to the nearest 0.1 g. The maximum and minimum kernel row length, cob length, and maximum ear circumference were then measured. The penetrometer (with a 0.81-mm-diameter plunger) was used to measure pericarp strength by puncturing 2 randomly selected kernels, 4 kernels down from the end of the kernel row. Finally, the 10 ears were weighed together, dried for 8 weeks, and reweighed to obtain moisture content.

In 1984, 16 cultivars (Table 1), including 4 evaluated in 1983, were planted on 5 June in 6-row × 50-m plots. Ears were marked at silking and cages were set up as in 1983, except that 24 cages, each with 4 male red-wings, were used. Four birds were used instead of 6, because the 1983 results indicated that 6 birds feeding on 8 ears may have been too much feeding pressure. Each cultivar was evaluated in a no-choice test at 18 DAS as in 1983 by placing 8 ears in each of 6 randomly assigned cages for 6 hr. Cultivar characteristics were measured on a sample of 12 ears. The tests were from 9 to 25 Aug.

In 1984, a one-day, free-choice test was run using ears of 2 cultivars at 19 DAS with the husks removed. Four husked ears of each cultivar were randomly assigned to positions within each of 4 cages. The ears were removed after 6 hr, and the number of damaged kernels was determined per ear.

To determine if differences in damage among cultivars, bird classes, and maturity dates were significant in the 1983 free-choice test, a 3-way analysis of variance (ANOVA) with repeated measures for dates was run for each group of 8 varieties. In the no-choice tests, one-way ANOVAs were run to test for differences in damage among cultivars. Stepwise regression was used to determine which cultivar characteristics were best correlated with mean damage levels in the no-choice tests.

Results

Free-choice tests, 1983. Both groups of 8 cultivars had highly significant ($P \leq 0.01$) differences in mean damage length and percent of ears damaged among cultivars and bird classes, but no significant ($P > 0.20$) differences were found in damage between the 2 maturity dates. To determine if the 2 groups of cultivars could be combined to obtain an approximate ranking of all 13 cultivars for damage, the damage received by the 3 cultivars common to both groups was examined. There were no significant ($P > 0.10$) differences between the damage received by any of these 3 cultivars when they were a part of the first and 2nd group of cultivars (t tests, paired comparisons of mean damage by cage for first and 2nd groups of tests, df = 15). Thus, we felt justified in combining the 2 groups to obtain an approximate ranking (Table 2).

The ranking of the 13 cultivars for mean damage length was significantly correlated ($P \leq 0.05$) among all 6 pairwise combinations of the 4 bird classes (Spearman's rank tests, $r = 0.64$–0.87). This correlation indicated that all 4 bird classes damaged the 13 cultivars in the same approximate order. Cultivar 6 had the least damage for 3 of the 4 bird classes (and was 2nd in the 4th class) and cultivar 13 had the most damage for all 4 classes. For the 4 classes of birds combined, cultivar 6 averaged 23 mm damage/ear, 71% less than the 100 mm/ear for cultivar 13 (Table 2). Percent of ears damaged ranged from 44% for cultivar 6 to 94% for cultivar 13 for all bird classes combined.

Starlings did the most damage of the 4 bird classes, averaging 96 mm damage/ear (57% of the maximum kernel row length). Starlings damaged 98% of the ears. Starlings were followed by male red-wings, female red-wings, and grackles in the amount of damage done (Table 2).

No-choice test, 1983. The ranking of cultivars for mean damage length by male red-wings in the no-choice test was significantly correlated ($P \leq 0.05$) with the rankings for damage by both male red-wings ($r = 0.74$) and by all birds ($r = 0.69$) in the free-choice test. Thus both tests indicated the same pattern of cultivar selection by the birds (Table 2). However, the differences in damage among cultivars in the no-choice test were not nearly as great as in the free-choice test. Mean damage length/ear, ranging from 59 mm for cultivar 9 to 86 mm for cultivar 13, was not signficantly different ($P = 0.18$) among cultivars. There was a highly significant difference ($P \leq 0.01$) among cultivars in percent of ears damaged; however most of this difference was attributed to cultivar 6. Cultivar 6 had 47% of the ears damaged whereas the remaining 12 cultivars ranged from 75 to 100% of the ears damaged.

None of the cultivar characteristics was significantly correlated ($P > 0.15$) with mean length of damage (Table 3). Three characteristics were significantly correlated ($P \leq 0.05$) with percent of ears damaged (Table 3). However, husk weight was the only variable entered into the stepwise regression equation, explaining 53% of the variation in damage among the 13 cultivars (Fig. 1).

No-choice test, 1984. There were significant differences ($P \leq 0.01$) among the 16 cultivars in both mean damage length/ear and percent of ears damaged. Mean damage length/ear ranged from 29 mm for cultivar 20 to 68 mm for cultivar 14. Percent of ears damaged ranged from 29% in cultivar 20 to 84% in cultivar 22 (Table 4).

Three of the cultivar characteristics were significantly correlated with mean length of damage (Table 3). Husk extension weight was entered first into the stepwise regression equation, explaining 48% of the variation in damage among the 16 cul-

Table 2. Ranking for 13 cultivars of sweet corn for mean length (mm) of damage/ear by 4 classes of birds in a free-choice test and by male red-winged blackbirds in a no-choice test in an aviary, 1983.

	Free-choice test rank										No-choice test rank	
	Male red-wing		Female red-wing		Grackle		Starling		All birds		Male red-wing	
Rank	cv. no.	damage (mm)	cv. no.	damage (mm)	cv. no.	damage (mm)	cv. no.	damage (mm)	cv. no.	damage (mm)	cv. no.	damage (mm)
1	6	11	6	2	6	13	2	61	6	23 (44)[z]	9	59 a[y] (88)
2	10	30	5	28	5	16	6	64	11	43 (59)	5	60 a (91)
3	11	43	11	36	11	24	11	70	5	45 (59)	11	65 ab (78)
4	2	53	10	38	7	33	10	73	10	46 (66)	2	70 ab (75)
5	9	54	8	45	9	39	5	81	2	54 (78)	6	70 ab (47)
6	5	56	1	45	8	42	8	86	8	60 (88)	1	71 ab (91)
7	7	65	2	45	10	44	7	87	7	63 (78)	7	72 ab (88)
8	8	66	12	55	12	45	4	92	9	65 (75)	10	73 ab (88)
9	1	73	9	61	2	55	9	107	12	74 (78)	8	75 ab (94)
10	12	81	7	67	3	55	12	116	1	79 (81)	4	76 ab (81)
11	4	96	4	79	1	77	1	121	4	87 (92)	3	79 ab (78)
12	3	108	3	81	4	82	3	132	3	94 (78)	12	79 ab (78)
13	13	115	13	90	13	89	13	145	13	110 (94)	13	86 b (100)
$\bar{X}$		68 (81)		55 (77)		48 (49)		96 (98)		67 (76)		72 (84)

[z]Values in parentheses are percent of ears damaged.
[y]Mean separation within no-choice test by Duncan's multiple range test, $P < 0.05$.

Table 3. Simple correlation coefficients between mean bird damage and mean values for various characteristics of 13 (1983) and 16 (1984) cultivars of sweet corn evaluated in an aviary.

	No-choice test 1983		No-choice test 1984	
Cultivar characteristics[z]	Mean damage length ear	Percent of ears damaged	Mean damage length/ear	Percent of ears damaged
Husk weight	−0.21	−0.73**	−0.35	−0.23
Husk extension weight	−0.39	−0.10	−0.69**	−0.51*
Maximum husk extension beyond cob	−0.32	0.18	−0.61*	−0.54*
Maximum husk extension beyond kernels	0.00	0.33	−0.44	−0.59*
Maximum kernel row length	−0.11	−0.61*	0.43	0.09
Cob length	−0.02	−0.61*	0.63**	0.12

[z]The characteristics ear circumference, maximum husk length, percent H_2O at 18 days after silking, husk strength, and pericarp strength showed no significant correlations with damage and are not presented.
$*P < 0.05$, $**P < 0.01$.

tivars (Fig. 2). Cob length was the only other variable entered into the equation, increasing the R^2 value to 74%. Length of the husk extension beyond the kernels explained 45% of the variation in percent of ears damaged (Table 3) and was the only variable entered into this stepwise regression equation.

Free-choice test with husks removed, 1984. The birds consistently ate more kernels from husked ears of cultivar 21 than from cultivar 20 in each of the 4 cages. Overall, the birds consumed 136 kernels/ear for cultivar 21, almost double the 73 kernels/ear for cultivar 20 ($P \leq 0.02$, paired difference t test, 3 df).

Discussion

This study demonstrated that given a free-choice of 8 sweet corn cultivars, 3 species of birds (and each sex for one species) similarly selected certain cultivars more than others. The most damaged cultivar received 4.8 times as much damage/ear as did the least damaged cultivar. Furthermore, in the 1983 no-choice test, the ranking of cultivars for damage by red-wings was similar to that in the free-choice test. This result indicated that the cultivar selection process by the birds was the same, even when alternate cultivar ears or other foods were not available under a situation of heavy feeding pressure. However, the differences in damage among cultivars were diminished compared with the free-choice test. The most damaged cultivar received 1.4 times the damage of the least damaged cultivar.

The 1984 no-choice test showed greater differences among cultivars than did the 1983 no-choice test. The most damaged cultivar had 2.3 times the damage of the least damaged cultivar. These greater differences in damage among cultivars in 1984 were probably related to reduced feeding pressure in the cages (from 6 to 4 birds/cage) and to the inclusion of cultivars in 1984 with heavier and long husk extensions.

For example, husk extension weight had the best correlation with mean damage length/ear in 1984. This characteristic explained little of the variation in damage among cultivars in 1983, probably because none of the cultivars evaluated in 1983 had a very long or heavy husk extension (Table 1 and Fig. 2). Only

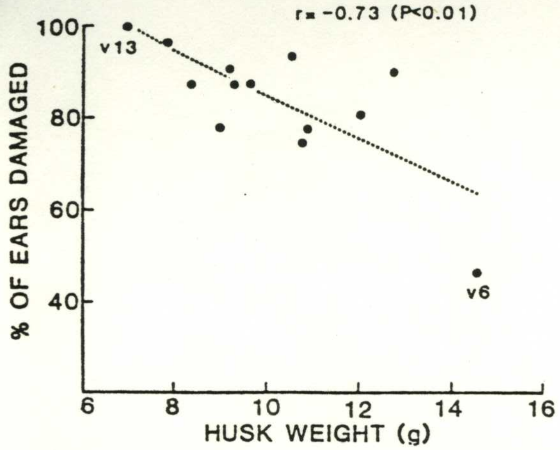

Fig. 1. Relationship of mean husk weight to percent of ears damaged by red-winged blackbirds for 13 cultivars of sweet corn in a no-choice test, 1983. The data points for cultivars 6 (v6) and 13 (v13) are identified.

Table 4. Rank of 16 cultivars of sweet corn for damage by male red-winged blackbirds in a no-choice aviary test, 1984.

Rank	Cultivar no.	Mean damage length (mm)/ear	Mean percentage of ears damaged
1	20	29 a[z]	29
2	25	38 ab	42
3	18	42 abc	58
4	5	48 bcd	83
5	19	50 bcd	79
6	24	53 bcd	60
7	23	54 bcd	65
8	16	54 bcd	75
9	11	58 cd	71
10	17	59 cde	73
11	22	59 cde	84
12	21	60 cde	83
13	13	61 cde	83
14	6	62 de	56
15	15	62 de	77
16	14	68 e	77

[z]Mean separation for damage length by Duncan's multiple range test, $P < 0.05$.

after husk extension weight had passed a threshold of about 3 g was a significant relationship expressed. Total husk weight (1983) and length of husk extension beyond the kernels (1984) were the best predictors of percent of ears damaged/cultivar. Previous studies with field corn (2, 3) have shown also that husk weight and husk extension were correlated negatively with bird damage.

Cultivar 14 was the major outlier in the relationship between husk extension weight and damage in 1984 (Fig. 2). This cultivar was heavily damaged by birds in spite of having an above average husk extension and weight of husk extension. The one exceptional characteristic of this cultivar was its ear size; the mean cob length (220 mm) was longer than that for any of the other varieties, except cultivar 2. Previous studies with field corn (2, 14) have suggested birds prefer long ears which might help explain the susceptibility of this cultivar. As noted above, cob length was entered into the stepwise regression as a second

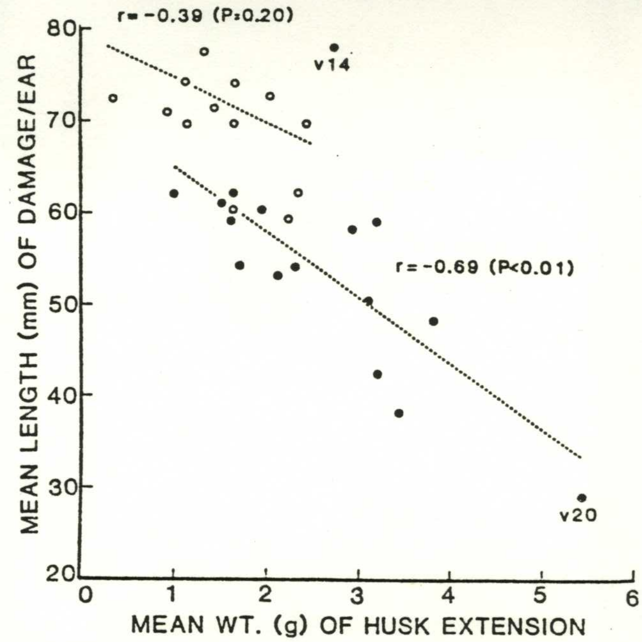

Fig. 2. Relationship of mean weight of husk extension to mean damage length/ear by red-winged blackbirds for 13 and 16 sweet corn cultivars evaluated in no-choice tests in 1983 (○) and 1984 (●), respectively. Damage values were higher in 1983 than in 1984 because 6 birds/cage were used in 1983 compared with 4 birds/cage in 1984. The data points for cultivars 14 (v14) and 20 (v20) are identified.

independent variable after husk weight extension in explaining a significant amount of the variation in mean damage length/ear among cultivars in 1984.

Factors only briefly examined in this study that might help explain variation in damage among cultivars were taste and texture of the kernels. One small test indicated that birds had a definite preference for kernels of cultivar 21 compared with 20. A previous study of red-wings feeding on cracked-corn particles from various field-corn hybrids revealed the birds had a preference for corn with low tannin content (9). Additional research is needed to determine the basis of taste preference of birds for sweet corn and the relative importance of taste compared with husk and ear characteristics in determining susceptibility of cultivars to damage by birds.

The development of a system for rating the relative bird resistance of currently marketed sweet corn cultivars appears possible. In addition, plant breeders can use husk characteristics to select sweet corn lines with reduced susceptibility to bird damage. The tests showed that under conditions with high bird pressure, birds of 3 species consistently damaged certain cultivars more than others when given a free choice. Although these differences in damage were reduced when the birds were offered a single cultivar at a time with no alternative food, the performance of several cultivars indicated that by increasing husk weight and husk extension, a certain degree of true resistance might be developed. Furthermore, the no-choice tests were more severe than field situations where the birds always have more ears of corn and alternative food sources (weed seeds and insects). Even if truly resistant cultivars are not commercially achievable, the use of relatively tolerant cultivars, such as cultivar 20, integrated with other control procedures (4), should help significantly in reducing damage. Conventional bird damage control procedures should be more effective in fields of less-susceptible cultivars than in fields of highly susceptible cultivars.

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