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Field Trials of Sunflower Resistant to Bird Depredation

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It is not surprising that birds can cause extensive loss to commercial plantings of sunflower, a seed crop that many Americans associate with feeding wild birds at their backyard feeders. However, most sunflower acreage is planted with varieties processed for vegetable oil and high protein animal feeds (Beard, 1981). Damage primarily by red-winged blackbirds (*Agelaius phoeniceus* L.) to oilseed sunflower in North Dakota, South Dakota, and Minnesota can be severe (Besser, 1978), particularly near marsh roost sites. In addition to economic losses, blackbird damage to sunflower and other crops often becomes a focal point in the conflict between intensive agricultural production and the preservation of wetland habitats for waterfowl and other wildlife.

Developing a bird-resistant variety of oilseed sunflower would be an ideal resolution of the problem. Currently used bird damage control techniques involve mechanical or chemical scare devices which may be costly, labor intensive, or unreliable (e.g., Dolbeer 1981). In addition, these techniques may only serve to spread the damage to other fields. Any management that required repeated lethal control to maintain a reduced population size of blackbirds also would be costly as well as controversial. In contrast, a bird resistant sunflower is essentially without added cost if the preferred characteristics of high oil percentage, insect and disease resistance, rapid maturation and drying, and minimal shattering by wind or at harvest can be maintained.

Crop resistance to bird damage can result from morphological or chemical characteristics of the plants. Morphological features of sunflower that may increase resistance include concave heads, long bracts, head that face the soil surface, head-to-stem distance exceeding 6 inches, and seeds with tough fibrous hulls held tightly in the head (Parfitt, 1984). An analogous situation occurs in corn where long, heavy husks reduce bird damage (Dolbeer et al., 1984). Indigenous chemical compounds such as anthocyanins found in the hulls of certain sunflower varieties may act as taste repellents (Mason et al. 1985). Related compounds (tannins) may provide some resistance to bird damage in certain lines of sorghum and corn (Harris, 1969; Mason et al., 1984).

This report describes the results of a series of investigations in Ohio and North Dakota to examine bird damage to two experimental varieties of sunflower, one with possible morphological characteristics of resistant (BRS-1) and one with possible chemical characteristics (Neagra de Cluj). BRS-1 is a white-hulled, open-pollinated variety with general morphological characteristics as described above. Neagra de Cluj (NdC) is a purple-hulled, open-pollinated variety with elevated levels of anthocyanins in the hulls (Mason et al., 1985). Initial work with these varieties was described by Fox and Linz (1983a, b) and Fox et al. (1984).

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Methods

Field Evaluations - Erie County, Ohio

BRS-1, NdC, and two commercial oilseed varieties, Jacques 501 and 550, were planted 31 May 1983 in adjacent six-row by 160 yard plots. Each plot was assessed for bird damage 14 September, seven weeks after flowering, by visually estimating percent loss of seeds and surface area of damage for 60 heads (12 randomly selected subplots of five consecutive heads each) from the center four rows (Dolbeer, 1975). Concurrent with damage estimates, 10 heads were harvested from each plot on 14 September and the seeds removed by hand. Weight, volume, and size were measured for a sample of seeds.

In 1984, BRS-1, NdC, and J-550 were planted on 9 July in six-row by 160 yard plots (J-550 had 18 rows) in the same location as in 1983. On 26 October and 2 November, seven to eight weeks after flowering, bird damage was assessed for 80 heads in each plot (16 randomly selected subplots of five heads each from the middle four rows).

Field Evaluations - Lucas County, Ohio

J-550, BRS-1, and NdC were each planted 5 June 1984 in four plots in a randomized block design at Ottawa National Wildlife Refuge. Each plot was six rows by 114 yards long. The plots were located one mile south of Metzger Marsh, were up to 50,000 red-winged blackbirds roosted from August through October.

J-550 began flowering 20 August and the other two varieties by 25 August. Damage was assessed in each plot four times (30 August, 6 and 22 September, and 13 October) by examining five consecutive heads in 16 randomly selected subplots in the middle four rows. Damage data for each assessment were analyzed.

Aviary Tests, Ohio

Sunflower from the three varietal plots planted in Erie County in 1984 was also used to evaluate bird damage under aviary conditions. J-550 began flowering 2 September and the other varieties by 7 September. A 55-yard section of plots was visited at two-day intervals

starting 2 September and stems of heads with newly opened ray flowers were marked with spray paint. A different color was used each day to establish marked populations of plants of synchronous maturity.

Twenty-four adult male red-winged blackbirds caught by mist nets in July were placed, six to a cage, in four outdoor cages. Each cage had a wooden rack on the ground into which nine pieces of plastic pipe were vertically placed. On five dates from 14 September to 16 October, sunflower heads from each variety were presentd to the birds in each cage in a free-choice test. On each evaluation date, 15 heads of the same maturity class for each variety were collected from the field at 8 a.m. Three heads from each variety were randomly assigned to position on each rack and secured in a vertical position by inserting the stems into the pipes. Adjacent heads faced opposite directions and birds could not reach a head by perching on another head. After removing all food at 9 a.m., the heads were replaced in the cages at 10 a.m. and removed at 4 p.m. Percent loss of seeds and surface area seed loss were estimated for each head. The seeds from three additional heads from each variety were removed by hand, weighed, and then reweighed after drying for two weeks to obtain an estimate of percent moisture on the day of assessment.

Field Evaluations - North Dakota and Manitoba

BRS-1 or a closely related synthetic, BRS-2, was planted adjacent to one of several commercial oilseed varieties at 13 locations in North Dakota and three in Manitoba in 1983 where damage by blackbirds had been a problem in previous years. NdC was also grown at three of these locations. Plots ranged from 4 to 10 acres in size and the entries either were planted in alternating four-row strips or as adjacent blocks of 40 rows each. Plots were evaluated for bird damage six weeks after flowering by estimating percent damage for approximately 1 to 2 percent of the plants in each variety.

Yield and oil percentage were calculated for a random sample of 50 heads selected from each variety at each location. Oil percentage was determined on a dry weight basis using nuclear magnetic resonance spectroscopy.

Results

Plant Characteristics

J-501 and J-550 varieties produced uniform stands about 6 feet tall with plants, heads, and seeds all similar in appearance. The BRS-1 variety in comparison had larger, uneven-sized plants due to uneven plant spacing. BRS-1 heads were larger than the J-501 and J-550 varieties (Table 1) and had noticeably longer and thicker bracts that partially covered the outer rows of seeds. The seeds were creamy white in color and relatively long and narrow (Table 1). The most obvious BRS-1 plant characteristics was the strongly arching stalk and concave head that developed about one week after bloom. NdC had the largest and most variable heads (Table 1) although plant spacing was more uniform than in BRS-1. All NdC plants produced relatively wide seeds with dark purple seed coats.

Field Evaluations - Erie County, Ohio

In both 1983 and 1984, goldfinches (*Carduelis tristis* L.) were the predominant birds observed feeding in the plots. In 1983, 100 to 500 goldfinches began feeding daily in the plots within one week after flowering. By seven weeks after flowering, the commercial oilseed varieties (J-501 and J-550) averaged over 90 percent loss per head whereas BRS-1 and NdC averaged only 0.5 and 4.4 percent loss, respectively (Table 2).

In 1984, feeding by birds in the plots was strikingly reduced from the 1983 level. Almost no damage was noted until six weeks after flowering. Damage was assessed twice, at seven and eight weeks after flowering, and although considerably less than in 1983, the damage pattern was similar (Table 2). On the final assessment J-550 averaged 17.6 percent loss whereas BRS-1 and NdC averaged only 0.4 and 0.8 percent loss, respectively. For the two years combined, J-550, BRS-1, and NdC averaged 57.1, 0.5, and 2.6 percent loss, respectively, at the final assessment of damage.

Field Evaluations - Lucas County, Ohio

Several thousand red-winged blackbirds began feeding in the sunflower plots and adjacent fields at Ottawa National

Table 1. Mean values ± SD for selected characteristics for four varieties of sunflower grown in Erie County, Ohio, 1983-84.

Characteristic	J-501	J-550	BRS-1	NdC
Head diameter (cm, n = 60)	15 ± 3	14 ± 3	17 ± 4	20 ± 8
Area of developed seed (cm^2, n = 60)	172 ± 75	149 ± 62	233 ± 122	341 ± 260
Seed coat color	black	black	white	purple
Volume (ml) of 200 seeds	21		49	48
Weight (g) of 200 seeds	9.0		16.8	18.7
Seed length (mm, n = 5)	9		13	12
Seed width (mm, n = 5)	5		7	7
Seed thickness (mm, n = 5)	3		4	4
Percent H_2O at 35 days after flowering		51	53	54

Table 2. Bird damage primarily by goldfinches to sunflower grown in Erie County, Ohio, 1983 (4 varieties) and 1984 (3 varieties). In each year, the varieties were grown in adjacent, 6-row by 160 yd. plots with no replications.

Date of assessment	Weeks after bloom	% of seed loss to birds (cm^2 loss/head) J-501	J-550	BRS-1	NdC
14 Sept 1983	7	92.0 (158)	96.5 (144)	0.5 (1)	4.4 (15)
26 Oct 1984	7		2.5 (5)	0.1 (0)	0.3 (1)
2 Nov 1984	8		17.6 (35)	0.4 (1)	0.8 (2)
2-year $\bar{x}$ (final assessments)			57.1 (101)	0.5 (1)	2.6 (7)

Wildlife Refuge by 10 days after flowering. By 30 days after flowering, J-550 had 50 percent seed loss whereas BRS-1 had only a 3 percent loss and NdC a 15 percent loss. At the final assessment on 13 October, eight weeks after flowering, J-550 averaged 94 percent loss per head compared with 56 percent loss for NdC and 39 percent loss for BRS-1 (Fig. 1). These differences in damage among varieties were all significant.

Aviary Test, Ohio

For the five dates of evaluation from six to 35 days after flowering, J-550 averaged 25 percent loss per head, significantly more than the damage to BRS-1 or NdC (Fig. 2). Differences in damage between NdC and BRS-1 were not significant, although BRS-1 consistently averaged slightly less damage than did NdC. The maximum difference between J-550 and the two resistant varieties occurred 22 days after flowering when J-550 averaged 42 percent loss compared with 1 and 9 percent loss for BRS-1 and NdC, respectively. The three varieties had similar percent water content in the seeds on the five dates: J-550 seeds averaged

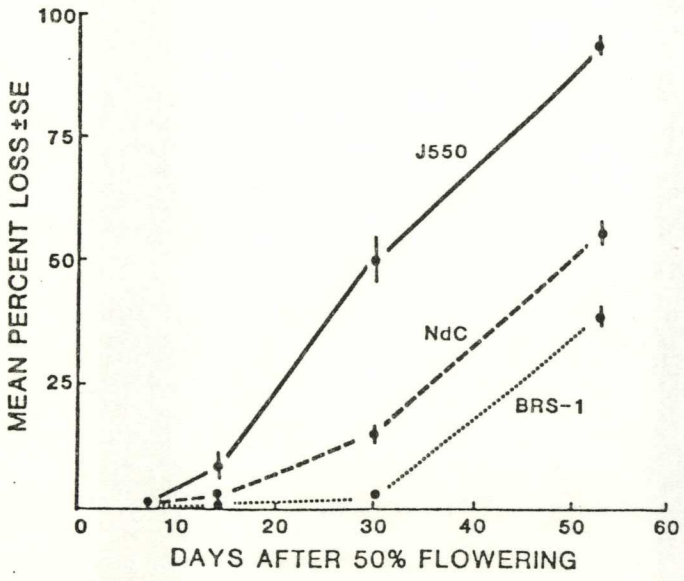

Figure 1. Mean percent of seeds eaten per head by red-winged blackbirds in four replicated plots of each of three varieties of sunflower at Ottawa National Wildlife Refuge, Ohio, 1984.

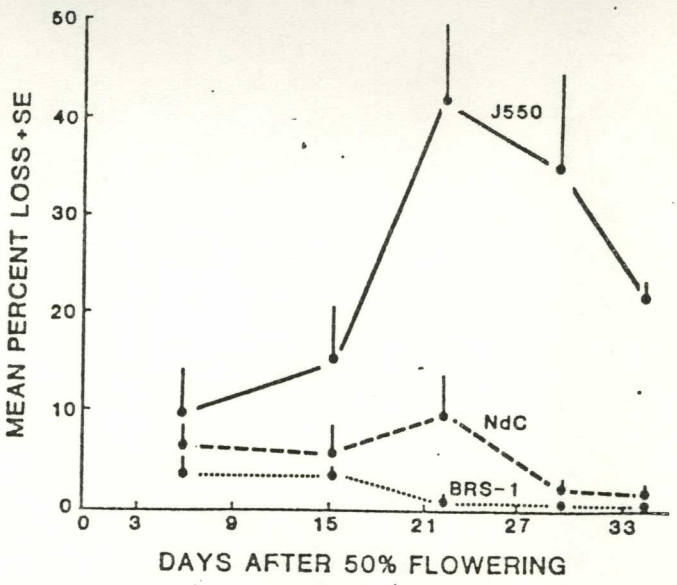

Figure 2. Percent of seeds eaten per head by red-winged blackbirds for three varieties of sunflower in free-choice tests in four cages on five dates, Ohio, 1984.

84, 82, 78, 64, and 51 percent water; NdC 84, 79, 79, 68, and 53 percent water; and BRS-1 85, 83, 73, 68, and 54 percent water at 6, 16, 22, 29, and 35 days after flowering, respectively.

Field Evaluations - North Dakota and Manitoba

BRS-1 and BRS-2 sustained less bird damage than the commercial oilseed varieties at all 16 locations (Table 3). The mean percent bird damage was 8 (range 0 to 61) for BRS varieties and 26 (range 1 to 70) for the commercial oilseed varieties. The mean percent bird damage for the 3 NdC plots was 25 (range 1 to 74).

In general, the yield of the BRS and NdC types was 50 to 67 percent of the yield of the commercial varieties. The oil percentage of the resistant types was eight to 11 percentage points lower than that of the commercial varieties.

Discussion

BRS-1 and NdC received substantially less bird damage than the commercial oilseed varieties in all evaluations, reinforcing the initial findings of Fox and Linz (1983a, b) and Fox et al. (1984). Resistance to damage by goldfinches seemed nearly complete, especially for BRS-1, because virtually no damage occurred even after over 90 percent of the seeds were eaten in the adjacent susceptible varieties in 1983. However, only partial resistance to damage by blackbirds was shown by NdC and BRS-1 in Ohio, North Dakota, and Manitoba. Resistance began to break down under severe feeding pressure when a convenient source of preferred sunflower seed was depleted. Still, damage in the resistant varieties was only 40 to 60 percent of the damage in the preferred variety.

The concept of resistance breakdown under severe feeding pressure by blackbirds is more clearly demonstrated when the data from Ohio are included with the data from

Table 3. Mean ± SD for percentage blackbird damage in 3 types of sunflower evaluated at 13 locations in North Dakota and 3 locations in Manitoba in 1983.

Location	% Bird damage		
	BRS populations white hull[a]	Oilseed hybrid black hull	Neagra de Cluj purple hull
Brinsmade, ND	0 ± 0	2 ± 4	
Churchs Ferry, ND	1 ± 2	15 ± 18	
Fingal, ND	0 ± 0	0 ± 2	1 ± 2
Kulm, ND	0 ± 0	1 ± 1	
Maddock, ND	1 ± 3	16 ± 16	
Maza, ND	0 ± 0	2 ± 2	1 ± 3
McVille, ND	0 ± 0	2 ± 3	
Page, ND	12 ± 17	79 ± 22	74 ± 27
Rugby, ND	20 ± 22	85 ± 12	
Sheldon, ND	0 ± 0	4 ± 8	
Upham 1, ND	61 ± 34	85 ± 18	
Upham 2, ND	26 ± 30	97 ± 11	
Woodworth, ND	0 ± 0	4 ± 7	
Portage 1, Man.[b]	0	1	
Portage 2, Man.[c]	0	16	
Underwood, Man.	0 ± 0	8 ± 8	
MEAN	8	26	25

[a]All locations had BRS-1 except Page, Rugby, and Sheldon with BRS-2.

[b]Goldfinch, sparrow, crow, juncos, magpie, and chickadee depredation.

[c]Goldfinch depredation.

North Dakota and Manitoba comparing damage to adjacent plots of BRS-1 and a commercial oilseed variety (Fig. 3). When feeding pressure did not exceed the point where more than 50-70 percent of the preferred oilseed variety was consumed, adjacent plots of BRS-1 received little damage. However, once feeding pressure passed a threshold of 50-70 percent loss in the preferred variety, competition for food apparently became severe enough that blackbirds began feeding on BRS-1 seed. The data for NdC are limited but suggest that the threshold is lower than for BRS-1 (Fig. 1, Table 3). Morphological characteristics such as the large, tough-hulled seeds of BRS-1 may present a more formidable barrier to the smaller goldfinches and explain the greater degree of resistance to damage by this species, even when losses in adjacent preferred varieties approach 100 percent (Fig. 3).

Although these evaluations demonstrate the potential for resistant varieties to lessen bird damage in sunflower, two avenues must be pursued before this potential can be realized in commercial seed production. First, additional studies are needed to more fully determine the important factors embuing resistance to damage by birds (e.g., Parfitt, 1984; Mason et al., 1985). Perhaps a combination of selected chemical and morphological characteristics bred into one line would be the most effective strategy for resistance. Second, our observations indicated oil percentage and yield were generally lower in BRS-1 and NdC than in commercial oilseed varieties. Thus, additional breeding will be needed to incorporate the important resistant characteristics into lines with higher yields and oil percentage. These are goals of the Bird-Resistant Project at North Dakota State University.

As a final note we emphasize that bird-damage resistance need not be absolute to useful reducing dama e. Any

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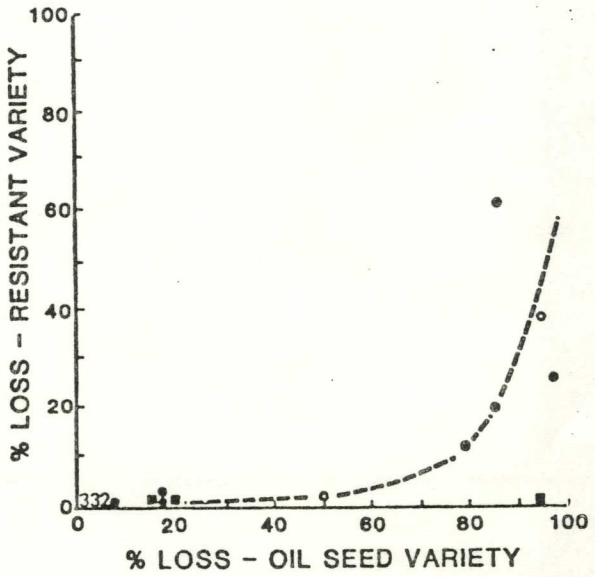

Figure 3. Relation between blackbird damage in commercial oilseed sunflower varieties and adjacent plots of bird-resistant varieties (BRS-1 or BRS-2) at 18 locations, 1983-84. Shaded circles (and numbers for superimposed data points) refer to plots in North Dakota and Manitoba (Table 3). Unshaded circles refer to damage assessments at 30 and 54 days after flowering for plots in Lucas County, Ohio (Fig. 1). Shaded squares refer to plots in Ohio and Manitoba were damage was primarily by goldfinches.

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morphological or chemical factors that can be incorporated into varieties to discourage bird feeding should prove useful in an integrated pest management program. Changes in a sunflower variety that make it less preferred or more difficult to feed upon by blackbirds should also increase the effectiveness of conventional methods of dispersing birds from the field. And for every incremental decrease achieved in sunflower seed feeding by birds, there should be a concurrent increase in feeding on insects and weed seeds, many of which are pests in agricultural crops (McNicol et al., 1982; Linz, 1984). We believe bird resistant varieties should play an important role in integrated pest management programs for sunflower in the future.

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