Resistance Among Cultivated Sunflower Germplasm to Stem-Infesting Pests in the Central Great Plains

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ABSTRACT A 7-yr field study evaluated 61 oilseed sunflower, *Helianthus annuus* L., accessions and 31 interspecific crosses for resistance to attack by naturally occurring populations of three stem-infesting pests, the sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte) (Coleoptera: Curculionidae); a longhorned beetle, *Dectes texanus* LeConte (Coleoptera: Cerambycidae); and a root boring moth, *Pelochrista womonana* (Kearfott) (Lepidoptera: Tortricidae), at two locations in the central Great Plains. Germplasm with potential sources of resistance to attack from all three stem-infesting species were revealed. Accessions PI 650558, PI 386230, and PI 431516 were consistent in averaging low densities of stem weevil larvae per stalk among lines tested, and PI 497939 exceeded 25 weevil larvae per stalk in only 1 yr of 5 yr of trials. Several interspecific crosses also had consistently low densities of *C. adspersus* larvae per stalk. Populations of both *D. texanus* and P. *womonana* were variable over years, but differences among the lines tested were evident in many trials, revealing potential for developing resistant germplasm. Four accessions (PI 386230, PI 431542, PI 650497, and PI 650558) had low larval densities of *C. adspersus* and *P. womonana* in addition to reduced percentage infestation by *D. texanus.* Results showed potential for developing resistant genotypes for these pests. The prospect of adding host plant resistance as an integrated pest management (IPM) tactic would provide another tool for reducing economic losses from stem-infesting insect pests of sunflower in the central Great Plains.

KEY WORDS sunflower, host plant resistance, *Cylindrocopturus adspersus*, *Dectes texanus*, *Pelochrista womonana*

The sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte), is an economic pest of cultivated sunflower, *Helianthus annuus* L., in the United States (Rogers and Jones 1979; Charlet 1987; Charlet et al. 1997, 2002; Armstrong et al. 2004). Sunflower stem weevil eggs are deposited at the base of the sunflower stalk and larvae feed, develop, and overwinter within the stem. Larvae excavate overwintering chambers in the stem cortex (Charlet 1983). If the larval population in a plant is high (>25–30 larvae), the stem, weakened by tunneling, pith destruction, or overwintering chambers, will break, causing a loss of the entire capitula before harvest (Rogers and Serda 1982; Charlet et al. 1985, 1997). Yield loss is chiefly due to lodging of plants weakened by larval feeding and construction of overwintering chambers (Rogers and Jones 1979, Charlet 1987). The sunflower stem weevil also has been implicated in the epidemiology of sunflower pathogens, such as Phoma black stem (*Phoma macdonaldii* Boerma), that contribute to the premature ripening syndrome in the northern Plains. The weevil also may predispose plants to infection by *Macrophomina phaseolina* (Tassi) Goid, the causative agent of charcoal stem rot in the southern Plains (Gaudet and Schulz 1981, Yang et al. 1983). Phoma has been implicated as one of the major biotic causes of premature ripening syndrome (early dry down) of sunflower in North Dakota (Gulya and Charlet 1984). In the 1970s in Texas, a longhorned beetle, *Dectes texanus* LeConte (Coleoptera: Cerambycidae), was recognized as a pest of sunflower (Rogers 1977, 1985b), but it also is an important pest of soybean (Hatchett et al. 1975, Michaud and Grant 2005, Niide et al. 2006). High densities of *D. texanus* were present in sunflower stalks in 2003 from the central Great Plains to South Dakota (Charlet and Glogoza 2004). Larvae feed and tunnel in the petioles, then into stem pith, and finally move to the base of the plant in late summer. Mature larvae girdle the inside of the lower stalk or root crown, move below the girdle, and pack frass into the tunnels and overwinter in the stem. Although stalks frequently break at the point of girdling, the larva remains protected during the winter in its frass-packed tunnel (Rogers 1985b, Charlet et al. 1997, Michaud et al. 2007a).

In the past few years, the incidence of a root boring moth, *Pelochrista womonana* (Kearfott) (Lepidoptera:

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Tortricidae), also has increased, based on recovery of larvae from the lower stalk and root area in sunflower within the central Great Plains (Charlet et al. 2007). This insect previously was cited as a sunflower pest in Texas, but neither an economic impact nor an injury threshold has been determined (Rogers 1979, Rogers 1985a).

In many native sunflower species resistance to feeding, oviposition, and larval development in the sunflower stem weevil has been observed in greenhouse and field experiments (Rogers and Seiler 1985). Barker (1991) found that the reduced feeding by adults on some native sunflower species was not associated with high trichome density. Comparison of numbers of weevil larvae in stalks from Prosper and Carrington, ND, between 1989 and 1991 showed significant differences among sunflower lines (Charlet and Brewer 1992, Charlet 1996). However, research into the development of resistant sunflower for the sunflower stem weevil has been hampered by reduced field populations in the northern Great Plains for screening of potentially useful lines. Recently, nurseries in Colorado and Kansas, where stem weevils have become a consistent problem, have identified promising germplasm (Charlet et al. 2004, 2006).

Plant resistance offers an alternative management strategy that would decrease economic losses from stem-infesting sunflower pests while reducing input costs. Studies were initiated in 1999, in the central Great Plains to evaluate sunflower for potential resistance to attack by stem pests. Sunflower germplasm was exposed to naturally occurring infestations to determine larval densities of *C. adspersus* and *P. womanana* within stems and incidence of attack by *D. texanus.*

Materials and Methods

During the 1999–2006 growing seasons, 61 oilseed sunflower accessions and 31 interspecific crosses were evaluated for resistance to infestation by naturally occurring populations of the sunflower stem weevil. The lines also were compared for resistance to attack by two other stem-infesting pests: a longhorned beetle, *D. texanus,* and a root-boring moth, *P. womonana.* Each year, USDA sunflower hybrid '894' was included in the trials because of its historical use as a standard check. The sunflower accessions were obtained from the USDA Plant Introduction Station, Ames, IA. Interspecific crosses were provided by one of the authors (G.J.S.). Trials were conducted at two locations: 1) the USDA–ARS Central Great Plains Research Station, Akron, CO, from 1999 to 2002; and 2) the Northwest Research Extension Center, Kansas State University, Colby, KS, from 2002 to 2006. Eleven to 28 entries were evaluated annually (two locations in 2002) in single row plots 8 m in length, with rows 76 cm apart, and plants spaced 30.5 cm apart within rows; ≈54,000 plants per ha. Entries with relatively low densities of weevil larvae were retested in subsequent years and some susceptible lines were also selected for continued evaluation. Plots were planted between 8 and 23 May each year (6 June in 2001) in a randomized block design with four replicates, except from 2004 to 2006 when only three replicates were used. Plots received a preplant application of fertilizer and herbicide, but no other chemical treatments were used.

The degree of infestation was measured by comparing the number of larvae per stalk in the case of *C. adspersus* and *P. womonana.* However, because stalks infested by multiple larvae of *D. texanus* are reduced through competition to one, or in rare cases two surviving overwintering larvae per stalk (Charlet et al. 1997, Michaud and Grant 2005), comparison among germplasm was based on percentage of stalks infested. Five stalks (≈50 cm of basal length plus the root crown) per row (total of 15–20 per treatment) were removed after plants had senesced. Lodging notes were made in 1999 before collection of stalks. Sunflower stalks were harvested from October to November each year and sent to Fargo, ND. Stalks were stored at 5 °C until evaluated and then split longitudinally, and the number of *C. adspersus, D. texanus,* and *P. womonana* larvae in each stem was counted.

The analysis of variance (ANOVA) option of the GLM procedure was used to compare larval numbers of the three stem-infesting pests in sunflower stalks among the different treatments for each study year. Means were separated using the Fisher protected least significant difference (LSD) test (Carmer and Walker 1985) at $P < 0.05$. Percentage of stalks infested by *D. texanus* was transformed to the square root of the arcsine before analysis (SAS Institute 2001).

Results

Between the two locations and 8 yr of testing, there were significant differences in densities of *C. adspersus* larvae in stalks among the germplasm tested with six of nine location years with >50 larvae per stalk in the most susceptible lines (Tables 1–9). In 1999, a few tested accessions had 50% fewer weevil larvae per stalk than PI 297475, the most susceptible line evaluated (Table 1). Stalk diameters at the plant base were measured and the mean among all accessions varied only from 1.5 to 1.7 cm. PI 297475, which had the highest density of weevil larvae, and hybrid 894 had the same average stalk diameter of 1.7 cm but half as many larvae per stalk. PI 650350 and PI 650497 were selected for further testing based on significantly lower weevil numbers. A comparison of lodging and stem weevil density in the trial showed inconsistent results with accessions having higher densities of *C. adspersus* larvae similar to those with 50% less larvae. For example, PI 297475, which averaged 44.3 larvae per stalk, had 18.1% lodged plants, and PI650375, with a mean of 20.3 larvae per stalk, showed an average of 16.3% lodged plants. A regression analysis of lodging and stem weevil density also showed a poor relationship, with an R^2 of 0.08. The variables influencing lodging are complex and likely a combination of many factors including stalk diameter, weevil density, the location of weevil overwintering chambers, stalk dryness, cortex thickness, and other insects in the stalk.

Table 1. Mean number of *C. adspersus* and *P. womonana* larvae per stalk in selected sunflower accessions evaluated at Akron, CO, 1999

Accession	No. larvae per stalk (mean ± SE)	
	C. adspersus	*P. womonana*
PI 297475	44.3 ± 4.1a	7.9 ± 0.7a
Ames 3081	43.9 ± 10.5a	6.6 ± 1.0abc
PI 175723	34.0 ± 3.6ab	7.3 ± 0.7ab
PI 650534	30.7 ± 4.3bc	5.5 ± 0.7bcd
PI 219649	28.8 ± 4.3bc	4.4 ± 0.6d
PI 650350	26.5 ± 3.2bc	6.5 ± 0.5abc
PI 431537	25.5 ± 2.8bc	5.7 ± 0.7bcd
PI 650368	25.2 ± 5.1bc	5.0 ± 0.8cd
PI 650497	21.7 ± 3.4bc	5.8 ± 0.5bcd
PI 650375	20.3 ± 3.6c	6.5 ± 0.6abc
Hybrid '894' (standard check)	20.1 ± 5.2c	5.2 ± 0.9cd
Mean	29.2 ± 1.6	6.0 ± 0.2

Means followed by the same letter in a column are not significantly different ($P < 0.05$; LSD).

Because of these results, insect density was used as an indicator of resistance among the lines tested and lodging notes were not included in subsequent years. Hybrid 894, which was the most resistant of those tested, had been shown to be more susceptible to attack in earlier trials in North Dakota compared with other lines evaluated (Charlet and Brewer 1992).

The determination of weevil larvae within the stalks in 2000 indicated very heavy stem weevil pressure at this location with large differences among the accessions evaluated (Table 2). Stalks of PI 369358 averaged almost 80 larvae, whereas PI 431542 only contained nine larvae per stalk. Stems harboring 25–30 or more larvae are frequently susceptible to lodging (Charlet et al. 1985). PI 650497, which seemed to be resistance in the 1999 trial, also had some of the lowest numbers of weevil larvae in the 2000 trial.

Sunflower stem weevil pressure was much lower in the 2001 trial, but PI 650497 did again show significantly lower larval densities in the stalk compared with the five most infested lines and PI 431513 only averaged one larva per stalk (Table 3). In 2002, at the Akron location, *C. adspersus* numbers were much higher than in the previous year, with a range in the mean density from 20 to 61 larvae per stalk among the lines evaluated in the trial (Table 4). Five accessions (PI 371936, PI 497939, PI 431542, PI 386230, and PI 650558) averaged <30 weevil larvae per stalk in this trial, showing lower susceptibility to attack by the weevil under heavy pressure. PI 431542 and PI 386230 also had some of the lowest densities of weevil larvae in both 2000 and 2001. PI 650497 also had lower numbers of *C. adspersus* larvae per stalk than most other entries in 2000 and 2001 but averaged 38 weevil larvae per stalk in 2002. Results also were inconsistent for another accession (PI 431513), which although the most resistant in 2001 was heavily infested in 2002 with a mean of 47 weevil larvae per stalk. However, population pressure was substantially lower in 2001. An additional trial in 2002 at Colby, KS, included selected interspecific crosses and the range of infestation in the location averaged 17–59 larvae per stalk (Table 5). Ten of the 25 lines evaluated had <25 larvae per stalk with Pet Pet 1741-1 having the lowest average of only 17 *C. adspersus* larvae per stalk.

The 2003 trial at Colby, KS, included germplasm that had previously been tested at Akron and Colby, plus some new lines. However, there was reduced pressure from the sunflower stem weevil with the most susceptible line averaging only 24 larvae per stalk (Table 6). The line with the best performance was PI 650558 with an average of only five larvae per stalk, significantly lower than 10 other lines tested. This line also had the lowest weevil density in the 2002 trial at Akron. PI 497939 also showed reduced weevil larval numbers per stalk as it had in the 2002 trial at Akron. Pet-Pet 1741-1 averaged only ten larvae per stalk in the 2003 trial and had the lowest weevil density in the 2002 trial at Colby.

The mean number of sunflower stem weevil larvae occurring in the germplasm tested in 2004 at Colby, ranged from 7 to 56 weevil larvae per stalk (Table 7).

Table 2. Mean number of *C. adspersus*, *D. texanus*, and *P. womonana* larvae per stalk in selected sunflower accessions evaluated at Akron, CO, 2000

Accession	*C. adspersus* larvae/stalk (mean ± SE)	*D. texanus* % infested stalks (mean ± SE)	*P. womonana* larvae/stalk (mean ± SE)
PI 369358	79.8 ± 11.0a	5.0 ± 5.0ab	3.4 ± 0.6a
PI 480472	66.3 ± 8.3ab	5.0 ± 5.0ab	1.6 ± 0.3bc
PI 372175	56.3 ± 8.8bc	0b	2.1 ± 0.4b
PI 600721	51.7 ± 4.9bcd	5.0 ± 5.0ab	1.2 ± 0.3bcd
PI 265099	47.1 ± 6.0cde	15.0 ± 5.0a	1.8 ± 0.4b
PI 650741	36.2 ± 10.5def	10.0 ± 10.0ab	0.6 ± 0.2de
PI 650350[a]	29.4 ± 5.6efg	5.0 ± 5.0ab	0.8 ± 0.3cde
PI 371935	28.5 ± 3.3efg	5.0 ± 5.0ab	0.8 ± 0.3cde
Hybrid '894'[a] (standard check)	25.8 ± 4.5fgh	10.0 ± 5.0ab	0.7 ± 0.2cde
PI 650413	19.8 ± 2.6fgh	5.0 ± 5.0ab	0.4 ± 0.2de
PI 386230	12.7 ± 4.1gh	0b	1.3 ± 0.3bcd
PI 650497	11.5 ± 5.2gh	0b	0.3 ± 0.1e
PI 431542	9.4 ± 2.0h	10.0 ± 10.0ab	0.5 ± 0.1de
Mean	37.8 ± 2.3	5.9 ± 1.6	1.2 ± 0.1

Means followed by the same letter in a column are not significantly different ($P < 0.05$; LSD); percentages transformed to square root of the arcsine before analysis; 13–20 stalks examined per accession.

[a] Retested from previous year.

Table 3. Mean number of *C. adspersus*, *D. texanus*, and *P. womonana* larvae per stalk in selected sunflower accessions evaluated at Akron, CO, 2001

Accession	*C. adspersus* larvae/stalk (mean ± SE)	*D. texanus* % infested stalks (mean ± SE)	*P. womonana* larvae/stalk (mean ± SE)
PI 343809	11.5 ± 2.9a	0b	0.4 ± 0.1abcd
PI 431506	11.0 ± 2.6ab	0b	0.5 ± 0.1ab
PI 431532	8.0 ± 1.6abcd	0b	0.5 ± 0.2abc
PI 253417	7.8 ± 1.4abcd	5.0 ± 5.0a	0.2 ± 0.1bcde
PI 431542[a]	7.4 ± 1.5bcd	0b	0.2 ± 0.1cde
PI 650350[a]	6.8 ± 1.2cde	0b	0.2 ± 0.1bcde
PI 307936	6.1 ± 1.1cde	0b	0.2 ± 0.1cde
PI 343799	6.0 ± 0.9cde	0b	0.5 ± 0.2ab
Hybrid '894'[a] (standard check)	6.0 ± 1.3cde	0b	0.1 ± 0.1de
PI 343802	5.5 ± 1.0de	0b	0.2 ± 0.1bcde
PI 431545	5.3 ± 1.2de	0b	0.1 ± 0.1e
PI 307946	4.9 ± 1.3def	0b	0.2 ± 0.1bcde
PI 371934	4.5 ± 1.2def	0b	0.7 ± 0.2a
PI 386230[a]	4.2 ± 1.1def	0b	0.1 ± 0.1de
PI 650497[a]	3.4 ± 0.6ef	0b	0.1 ± 0.1de
PI 431513	1.1 ± 0.2f	0b	0.1 ± 0.1de
Mean	6.4 ± 0.4	0.3 ± 0.3	0.3 ± 0.0

Means followed by the same letter in a column are not significantly different ($P < 0.05$; LSD); percentages transformed to square root of the arcsine before analysis; 20 stalks examined per accession.
[a] Retested from previous year.

Among the 27 lines tested, 17 were below 20 and three below nine weevil larvae per stalk. The line with the best performance in the trial was interspecific cross Gig 1616-1, with a mean of only 6.8 weevil larvae per stalk. This cross had only nine weevil larvae per stalk in the 2003 trial. Two other interspecific crosses, Hir 828-2 and Hir 828-3, also had low densities of weevil larvae per stalk. Accession PI 497939, which had only six larvae per stalk in 2003, contained an average of 12 weevil larvae per stalk in 2004. The interspecific cross Pet-Pet 1741-1 had an average of only 12 weevil larvae per stalk in this trial, only 10 in 2003, and it was the lowest in the 2002 trial at Colby.

The mean number of sunflower stem weevil larvae occurring in the germplasm tested in 2005 ranged from 7 to 61 larvae per stalk (Table 8). Among the 21 lines tested, 12 were below 25 and five were below 10 weevil larvae per stalk. The accession with the fewest weevil larvae in the trial was PI 431516, with a mean of 6.6 larvae per stalk, significantly lower compared with most other lines in this trial. This was the first year in which this line was tested. Gig

Table 4. Mean number of *C. adspersus*, *D. texanus*, and *P. womonana* larvae per stalk in selected sunflower accessions evaluated at Akron, CO, 2002

Accession	*C. adspersus* larvae/stalk (mean ± SE)	*D. texanus* % infested stalks (mean ± SE)	*P. womonana* larvae/stalk (mean ± SE)
PI 650467	60.9 ± 16.0a	31.7 ± 9.3ab	0.4 ± 0.2ab
PI 431513[a]	47.3 ± 7.9ab	16.7 ± 16.7abc	0.5 ± 0.3ab
Pet Pet 1741-2	44.4 ± 8.0abc	0c	0.3 ± 0.2ab
PI 650438	43.5 ± 6.0abc	5.0 ± 5.0bc	0.9 ± 0.4a
PI 307934	43.0 ± 8.9abc	30.0 ± 17.3abc	0.6 ± 0.3ab
PI 650472	41.4 ± 7.2bc	14.5 ± 8.5abc	0.7 ± 0.3ab
PI 650413	39.6 ± 7.3bc	11.0 ± 11.0abc	0.7 ± 0.3ab
PI 386323	38.5 ± 7.0bcd	22.5 ± 13.1abc	0.4 ± 0.2ab
PI 650370	38.1 ± 8.5bcd	24.5 ± 8.7abc	0.2 ± 0.2b
PI 650497[a]	37.7 ± 5.8bcd	0c	0.7 ± 0.2ab
PI 650362	37.7 ± 4.4bcd	30.0 ± 12.9abc	0.3 ± 0.2ab
PI 505839	36.6 ± 6.7bcd	5.0 ± 5.0bc	0.3 ± 0.2ab
PI 487194	35.3 ± 6.0bcd	35.0 ± 22.2ab	0.7 ± 0.3ab
PI 476659	33.4 ± 4.2bcd	38.8 ± 13.0a	0.5 ± 0.2ab
PI 307942	32.1 ± 6.4bcd	22.5 ± 10.3abc	0.5 ± 0.2ab
PI 432519	31.6 ± 4.0bcd	16.8 ± 16.8abc	0.2 ± 0.1b
Hybrid '894'[a] (standard check)	29.9 ± 5.8bcd	20.0 ± 11.5abc	0.5 ± 0.3ab
PI 371936	28.2 ± 5.0cd	15.0 ± 9.6abc	0.7 ± 0.3ab
PI 497939	28.0 ± 5.0cd	10.0 ± 10.0abc	0.3 ± 0.1ab
PI 431542[a]	26.4 ± 6.3cd	0c	0.5 ± 0.2ab
PI 386230[a]	20.2 ± 4.8d	8.3 ± 8.3abc	0.1 ± 0.1b
PI 650558	19.8 ± 4.7d	6.7 ± 6.7abc	0.3 ± 0.2ab
Mean	35.5 ± 1.4	16.8 ± 2.5	0.5 ± 0.0

Means followed by the same letter in a column are not significantly different ($P < 0.05$; LSD); percentages transformed to square root of the arcsine before analysis; 10–20 stalks examined per accession.
[a] Retested from previous year.

Table 5. Mean number of *C. adspersus*, *D. texanus*, and *P. womonana* larvae per stalk in selected sunflower accessions evaluated at Colby, KS, 2002

Accession	*C. adspersus* larvae/stalk (mean ± SE)	*D. texanus* % infested stalks (mean ± SE)	*P. womonana* larvae/stalk (mean ± SE)
Hir 1734-1	59.3 ± 14.0a	20.0 ± 14.1abc	4.1 ± 0.9ab
Hir 1734-3	56.8 ± 8.2a	20.0 ± 8.2abc	4.9 ± 1.1a
Tub 1789	46.8 ± 9.5ab	35.0 ± 12.6abc	3.7 ± 0.8abcd
Hybrid '894'[a] (standard check)	36.9 ± 2.5bc	43.0 ± 5.5ab	3.8 ± 0.4abc
Tub 1709-2	36.2 ± 7.1bcd	40.0 ± 0.0ab	2.3 ± 0.6bcdefgh
Pet Pet 1741-2	34.5 ± 6.9bcde	31.3 ± 5.2ab	1.7 ± 0.5defgh
Gig 1616-2	33.0 ± 9.3bcdef	16.3 ± 9.9bc	1.3 ± 0.5gh
Rf Tub 346	32.1 ± 8.0bcdef	25.0 ± 9.6abc	3.3 ± 1.0abcdef
Tub 1709-1	31.5 ± 8.5bcdef	10.0 ± 5.8bc	2.5 ± 0.6bcdefgh
Str 1622-1	31.1 ± 5.4bcdef	30.0 ± 12.9abc	3.3 ± 0.8abcdef
Tub 825-2	30.6 ± 5.3bcdef	35.0 ± 9.6ab	2.6 ± 0.5bcdefgh
Res 834-2	28.6 ± 4.9cdef	5.0 ± 5.0c	1.4 ± 0.3efgh
Tub 346	28.3 ± 5.9cdef	15.0 ± 5.0abc	1.1 ± 0.3gh
Tub 365	27.9 ± 5.4cdef	35.0 ± 9.6ab	3.4 ± 1.0abcde
Res 834-3	26.6 ± 7.2cdef	28.8 ± 16.1abc	2.7 ± 0.8bcdefgh
Tub 1709-3	25.6 ± 7.3cdef	20.0 ± 14.1abc	2.6 ± 0.8bcdefgh
Str 1622-2	24.8 ± 3.3cdef	40.0 ± 8.2ab	2.8 ± 0.7bcdefg
Hir 828-3	24.5 ± 4.9cdef	20.0 ± 14.1abc	2.1 ± 0.6cdefgh
Gig 1616-1	22.8 ± 5.7cdef	21.3 ± 8.3abc	2.3 ± 0.8bcdefgh
Res 834-1	20.8 ± 4.2cdef	15.0 ± 9.6bc	1.5 ± 0.7efgh
Tub 825-1	19.5 ± 3.4def	35.0 ± 17.1abc	0.8 ± 0.2h
Hir 828-2	19.5 ± 4.1def	30.0 ± 19.1abc	1.4 ± 0.4fgh
Hir 828-1	19.3 ± 3.6def	45.0 ± 17.1ab	3.7 ± 1.0abcd
Hir 828-4	18.6 ± 3.6ef	45.0 ± 18.9a	1.9 ± 0.5cdefgh
Hir 1734-2	18.2 ± 2.6ef	15.0 ± 5.0abc	2.0 ± 0.6cdefgh
Pet Pet 1741-1	16.6 ± 3.8f	17.5 ± 6.0abc	1.2 ± 0.7gh
Mean	32.6 ± 2.6	2.8 ± 2.2	3.3 ± 0.4

Means followed by the same letter in a column are not significantly different ($P < 0.05$; LSD); percentages transformed to square root of the arcsine before analysis; 17–20 stalks examined per accession (100 stalks of hybrid 894).
[a] Retested from previous year.

1616-1 with a mean of only 6.8 weevil larvae per stalk in 2004 had >32 larvae in 2005. This cross had only nine weevil larvae per stalk in 2003. However, three other interspecific crosses Str 1622-2, Hir 828-2, and Hir 828-3 had <20 weevil larvae per stalk. PI 497939 only had nine larvae in 2005, 12 in 2004, and only six in 2003. The accession PI 386230 had only nine larvae and was among the ten lowest in 2004. Hybrid 894, which had only an average of 16 weevil larvae per stalk in 2004, had >30 weevil larvae per stalk in 2005.

The mean number of sunflower stem weevil larvae occurring in the germplasm tested in 2006 ranged from five to 51 larvae per stalk (Table 9). Among the 22 lines or hybrids tested, 16 were <25 and three were <10 weevil larvae per stalk. One of the two accessions with the best performance in the trial was accession PI 431516, with a mean of only 6.5 larvae per stalk. This was the second year in which this line was tested. In 2005, it had the lowest number of larvae in the trial. The line with the lowest number of larvae in 2006 was PI 386230 with a mean of five weevil larvae per stalk; in 2005, it was among those with the lowest larvae density per stalk and was among the 10 lowest in 2004. PI 650558 averaged only nine weevil larvae per stalk, again showing low densities as it had in previous years of testing.

Populations of *D. texanus* were too low at Akron in 1999 to be detected in the stalks. Five to 15% of stalks were infested in 2000 (Table 2), with an average of 6% for the trial, but no larvae were found in three accessions, two of which (PI 386230 and PI 650497) also had low densities of stem weevil larvae. Incidence of *D. texanus* at Akron in 2001 was too low to make meaningful comparisons (Table 3). In 2002, the incidence of *D. texanus* ranged from 0 to 39% of stalks infested in the Akron trial (Table 4). Those with no larvae detected in the stalks included the interspecific cross Pet Pet 1741-2 and the accessions PI 431542 and PI 650497. The latter accession also had no longhorned beetle larvae detected in stalks in 2000. The mean percent of stalks infested by *D. texanus* larvae at Colby in 2002 was similar to densities that occurred at Akron and ranged from a high of 45 to only 5% per stalk (Table 5). None of the germplasm tested was immune to attack by *D. texanus*, although Res 834-2 had only 5% of stalks infested.

In 2003, although there was little significant difference among lines tested, three of the 24 lines tested sustained 5% or less stalks attacked (Table 6). PI 386230, in which there were no *D. texanus* detected, also had low densities of weevil larvae and PI 650558 had the lowest number of *C. adspersus* in the trial and only 5% of stalks infested by longhorned beetle larvae. However, 2004 populations of *D. texanus* were extremely high, and both PI 650558 and PI 386230 had >50% of the stalks infested by longhorned beetle larvae (Table 7). The most susceptible line in the trial was an interspecific cross, Hir 828-2, with 80% of stalks containing larvae of *D. texanus.* The accession with the lowest incidence was PI 650519 with 27% of stalks containing longhorned beetle larvae.

Table 6. Mean number of *C. adspersus*, *D. texanus*, and *P. womonana* larvae per stalk in selected sunflower accessions evaluated at Colby, KS, 2003

Accession	*C. adspersus* larvae/stalk (mean ± SE)	*D. texanus* % infested stalks (mean ± SE)	*P. womonana* larvae/stalk (mean ± SE)
Hir 1734-1 [2]	23.9 ± 4.6a	20.0 ± 11.5abc	0.2 ± 0.1cdef
PI 650467[a]	20.6 ± 3.5ab	20.0 ± 20.0abc	0.6 ± 0.2bcde
PI 371936[a]	19.2 ± 2.9abc	15.0 ± 9.6abc	0.3 ± 0.1cdef
Res 834-1[2]	18.7 ± 3.8abc	5.0 ± 5.0bc	0.4 ± 0.2bcdef
Hir 828-1[a]	17.6 ± 3.4abcd	25.3 ± 12.5ab	0.2 ± 0.1def
Rf Ann 1742	15.7 ± 3.4bcde	12.5 ± 12.5abc	0.7 ± 0.3bc
Hir 1734-2[2]	15.1 ± 5.0bcdef	10.0 ± 10.0abc	0.2 ± 0.1cdef
Par 1673-1	14.2 ± 3.0bcdefg	5.0 ± 5.0bc	0.3 ± 0.1bcdef
Hybrid '894'[a] (standard check)	13.4 ± 1.8cdefg	21.8 ± 6.3abc	0.6 ± 0.2bcd
Rf Arg 420	13.4 ± 1.9cdefg	10.0 ± 5.8abc	0.4 ± 0.1bcdef
Pra Run 417-1	10.5 ± 2.1defgh	20.0 ± 11.5abc	0.3 ± 0.1cdef
PI 386230[a]	10.5 ± 2.0defgh	0c	0.4 ± 0.2bcdef
Pet Pet 1741-1[a]	10.4 ± 3.2efgh	11.3 ± 6.6abc	0.2 ± 0.1cdef
Str 1622-2[a]	9.7 ± 2.4efgh	15.0 ± 5.0abc	0.3 ± 0.1cdef
Arg 1575-2	9.7 ± 1.2efgh	30.0 ± 5.8a	0.1 ± 0.1ef
Gig 1616-1[a]	9.3 ± 1.9efgh	20.0 ± 8.2abc	0.2 ± 0.1def
Hir 828-3[a]	9.2 ± 1.6efgh	20.0 ± 11.5abc	0.5 ± 0.3bcdef
Tub 825-1[a]	8.7 ± 1.8efgh	10.0 ± 5.8abc	0.2 ± 0.1def
PI 431542[a]	8.6 ± 1.5fgh	15.0 ± 9.6abc	0.4 ± 0.1bcdef
Hir 828-2[a]	8.0 ± 1.3gh	25.0 ± 9.6ab	1.2 ± 0.4a
Hir 828-4[a]	7.7 ± 1.5gh	25.0 ± 5.0ab	0.8 ± 0.3ab
PI 650497[a]	6.2 ± 0.9h	15.0 ± 5.0abc	0.2 ± 0.1cdef
PI 497939[a]	5.9 ± 1.1h	15.0 ± 9.6abc	0.1 ± 0.1f
PI 650558[a]	4.9 ± 1.8h	5.0 ± 5.0bc	0.1 ± 0.1ef
Mean	12.2 ± 0.6	15.9 ± 1.8	0.4 ± 0.0

Means followed by the same letter in a column are not significantly different ($P < 0.05$; LSD); percentages transformed to square root of the arcsine before analysis; 17–20 stalks examined per accession (55 stalks of hybrid '894').

[a] Retested from previous year.

In 2005 at Colby, the mean percentage of infested stalks among the selected lines varied from 0 to 53%, with Hir 828-2 again the most susceptible line. PI 650497 stalks were not infested with *D. texanus,* although the previous year 73% of the stalks had been infested. PI 650558 had <7% infested stalks and PI 386230 had 13% stalks infested, and both had low densities of weevil larvae, which was the same pattern observed in 2003. In 2006, PI 386230 had no long-horned beetle larvae detected in the stalks and the lowest density of stem weevil larvae (Table 9). PI 650558 also had very low numbers of *C. adspersus* larvae per stalk and only 11% of stalks infested by *D. texanus* in 2006.

In 1999 at Akron, densities of *P. womonana* larvae in the selected accessions evaluated ranged from a mean of four to eight larvae per stalk (Table 1). PI 297475 had both the highest level of weevil larvae and root moth larvae in the stalks. The numbers of the root boring moth larvae were reduced in 2000 (trial mean, 1.2 larvae per stalk) compared with the densities in 1999, where the average for the accessions was 6.0 larvae per stalk (Table 2). The accession with the highest density of weevil larvae per stalk (PI 369358) also had the greatest number of moth larvae per stalk and some of the accessions with the lowest numbers of weevil larvae per stalk (PI 650413, PI 650497, and PI 431542) also had the lowest density of *P. womonana* larvae per stalk. In both 2001 and 2002 at Akron, numbers of root moth larvae fell to levels less than one per stalk making comparisons among accessions difficult (Tables 3 and 4).

At Colby in 2002, stalk densities of *P. womonana* ranged from one to five larvae per stalk (Table 5). Some of the interspecific crosses with the highest densities of weevil larvae also had high numbers of root moth larvae (Hir 1734-1 and Hir 1734-3) and some of the interspecific crosses with reduced numbers of weevil larvae also had lower numbers of *P. womonana* larvae (Tub 825-1, Pet-Pet 1741-1, and Tub 365). Comparisons of evaluated germplasm in 2003 and 2004 again were difficult because *P. womonana* populations fell to very low levels averaging one or less larvae per stalk (Tables 6 and 7).

Levels of root boring moth larvae were somewhat higher in 2005 than in 2004, with a range of 0.7–7.3 larvae per stalk (Table 8). The line with the highest number of moth larvae (Hir 1734-1) was also heavily infested with weevil larvae, and 20% of stalks were also infested with *D. texanus.* Those with very low numbers of weevils per stalk did, in some cases, have less than two *P. womonana* larvae per stalk (PI 650558, PI 386230, and PI 497939). Levels of root boring moth larvae in 2006 were lower than 2005, with a range of zero to 3.7 larvae per stalk (Table 9). The three lines with no *P. womonana* larvae detected in the stalks (PI 497939, PI 650558, and PI 386230) include one line (PI 386230) that had both the lowest level of stem weevil larvae and no *Dectes* larvae.

Discussion

This study identified germplasm with potential new sources of resistance to attack by three stem-infesting

Table 7. Mean number of *C. adspersus*, *D. texanus*, and *P. womonana* larvae per stalk in selected sunflower accessions evaluated at Colby, KS, 2004

Accession	*C. adspersus* larvae/stalk (mean ± SE)	*D. texanus* % infested stalks (mean ± SE)	*P. womonana* larvae/stalk (mean ± SE)
PI 372259	55.9 ± 13.1a	40.0 ± 23.1bcd	1.4 ± 0.5a
Hir 1734-1[a]	45.4 ± 7.8ab	46.7 ± 24.0abcd	1.1 ± 0.3abc
PI 531351	39.1 ± 7.8b	73.3 ± 13.3ab	0.5 ± 0.2defg
Res 834-2	33.6 ± 5.7bc	60.0 ± 0.0abcd	0.5 ± 0.2defg
Res 834-3	33.2 ± 3.6bc	66.7 ± 13.3abcd	0.8 ± 0.3abcdef
Arg 1575-2[a]	23.5 ± 5.4cd	53.3 ± 13.3abcd	0.7 ± 0.2bcdefg
PI 170414	23.4 ± 5.6cd	46.7 ± 6.7abcd	0.2 ± 0.1fg
PI 650558[a]	22.5 ± 4.9cd	53.3 ± 13.3abcd	0.3 ± 0.2defg
PI 650441	21.6 ± 2.7cd	46.7 ± 17.6abcd	0.3 ± 0.1efg
PI 650519	21.5 ± 3.9cd	26.7 ± 17.6d	0.1 ± 0.1g
PI 431542[a]	20.5 ± 3.5cde	53.3 ± 6.7abcd	0.9 ± 0.3abcd
PI 650497[a]	19.1 ± 5.0def	73.3 ± 6.7abc	0.5 ± 0.2defg
PI 650437	17.9 ± 3.3def	53.3 ± 6.7abcd	0.5 ± 0.2defg
Str 1622-2[a]	17.2 ± 5.7def	40.0 ± 20.0bcd	0.6 ± 0.2cdefg
Pra Run 417-1[a]	16.9 ± 2.9def	33.3 ± 17.6cd	0.4 ± 0.2defg
Hybrid ‘894’[a] (standard check)	16.4 ± 1.9def	55.6 ± 5.6abcd	0.8 ± 0.2abcde
Tub 365	14.7 ± 3.0def	53.3 ± 24.0abcd	0.3 ± 0.1efg
PI 386230[a]	14.2 ± 2.8def	53.3 ± 29.1abcd	1.3 ± 0.3ab
Tub 825-1[a]	14.2 ± 2.6def	46.7 ± 17.6abcd	0.2 ± 0.1fg
Hir 828-4[a]	13.9 ± 2.3def	71.7 ± 6.0abcd	0.7 ± 0.2bcdefg
Tub 1709-3	12.6 ± 2.3def	33.3 ± 13.3bcd	0.3 ± 0.2defg
Tub 346	12.3 ± 2.9def	40.0 ± 23.1bcd	0.6 ± 0.2cdefg
PI 497939[a]	11.9 ± 2.5def	40.0 ± 11.5abcd	0.4 ± 0.2defg
Pet Pet 1741-1[a]	11.9 ± 2.8def	73.3 ± 17.6ab	0.3 ± 0.2defg
Hir 828-3[a]	8.2 ± 3.6ef	73.3 ± 6.7abc	0.5 ± 0.2cdefg
Hir 828-2[a]	8.1 ± 3.2ef	80.0 ± 11.5a	0.5 ± 0.2cdefg
Gig 1616-1[a]	6.8 ± 1.9f	53.3 ± 17.6abcd	0.4 ± 0.2defg
Mean	20.2 ± 1.0	53.7 ± 2.7	0.6 ± 0.0

Means followed by the same letter in a column are not significantly different ($P < 0.05$; LSD); percentages transformed to square root of the arcsine before analysis; 15 stalks examined per accession (45 stalks of hybrid ‘894’).

[a] Retested from previous year.

insect species. Many of the lines evaluated in *C. adspersus* trials seemed to offer resistance in 1 or 2 yr and then would show heavy infestation by larvae in the stalks in another year. PI 431513 was the lowest in the trial at Akron in 2001 but was among the highest in mean number of larvae per stalk in 2002. In 7 yr of

Table 8. Mean number of *C adspersus*, *D. texanus*, and *P. womonana* larvae per stalk in selected sunflower accessions evaluated at Colby, KS, 2005

Accession	*C. adspersus* larvae/stalk (mean ± SE)	*D. texanus* % infested stalks (mean ± SE)	*P. womonana* larvae/stalk (mean ± SE)
PI 372259[a]	61.3 ± 11.7a	33.3 ± 17.6abc	2.4 ± 0.9cd
Hir 1734-1[a]	43.7 ± 6.6b	20.0 ± 0.0abcd	7.3 ± 2.2a
PI 431542[a]	34.8 ± 11.8bc	27.8 ± 14.7abcd	1.8 ± 0.7cd
Tub 365[a]	33.6 ± 8.4bcd	26.7 ± 6.7abc	3.7 ± 1.4bc
Tub 346[a]	33.2 ± 7.4bcd	13.3 ± 13.3bcd	2.4 ± 0.7cd
Gig 1616-1[a]	32.5 ± 6.6bcde	26.7 ± 6.7abc	4.0 ± 1.4bc
Tub 1709-3[a]	31.3 ± 6.5bcde	13.3 ± 13.3bcd	2.2 ± 1.1cd
Hybrid ‘894’[a] (standard check)	30.6 ± 2.9bcde	25.0 ± 5.5abcd	3.5 ± 0.6bcd
Tub 825-1[a]	26.0 ± 5.5cdef	13.3 ± 6.7bcd	2.5 ± 0.7cd
Pra Run 417-1[a]	24.9 ± 5.4cdefg	30.0 ± 5.3abc	3.3 ± 0.9bcd
Hir 828-4[a]	24.0 ± 2.4cdefg	20.0 ± 11.5abcd	4.3 ± 0.9bc
PI 650437[a]	23.2 ± 5.2cdefg	6.7 ± 6.7cd	0.7 ± 03d
Pet Pet 1741-1[a]	23.1 ± 5.8cdefg	24.4 ± 12.4abcd	3.6 ± 1.4bc
Hir 828-2[a]	18.1 ± 3.4defgh	53.3 ± 17.6a	5.6 ± 1.2ab
Hir 828-3[a]	16.4 ± 3.0efgh	40.0 ± 11.5ab	3.3 ± 0.9bcd
Str 1622-2[a]	13.2 ± 3.2fgh	10.0 ± 10.0bcd	2.4 ± 1.0cd
PI 650497[a]	9.7 ± 2.2gh	0d	2.3 ± 1.2cd
PI 650558[a]	9.3 ± 4.2gh	6.7 ± 6.7cd	1.5 ± 0.8cd
PI 386230[a]	9.3 ± 2.3gh	13.3 ± 13.3bcd	1.7 ± 0.5cd
PI 497939[a]	8.8 ± 2.5gh	20.0 ± 0.0abcd	1.6 ± 0.5cd
PI 431516	6.6 ± 2.5h	17.8 ± 9.7abcd	2.6 ± 0.9cd
Mean	25.4 ± 1.4	21.5 ± 2.4	3.1 ± 0.2

Means followed by the same letter in a column are not significantly different ($P < 0.05$; LSD); 10–15 stalks examined per accession (44 stalks of hybrid ‘894’).

Retested from previous year.

Table 9. Mean number of *C. adspersus*, *D. texanus*, and *P. womonana* larvae per stalk in selected sunflower accessions evaluated at Colby, KS, 2006

Accession	*C. adspersus* larvae/stalk (mean ± SE)	*D. texanus* % infested stalks (mean ± SE)	*P. womonana* larvae/stalk (mean ± SE)
PI 193775	51.0 ± 10.0a	11.1 ± 11.1bcd	0.8 ± 0.5b
PI 372259[a]	41.2 ± 6.4ab	34.4 ± 8.7abc	1.5 ± 0.6ab
Hir 1734-1[a]	33.6 ± 6.5bc	21.7 ± 1.7abcd	1.0 ± 0.5b
PI 170401	29.2 ± 5.9bcd	33.3 ± 17.6abcd	2.1 ± 0.9ab
PI 175728	28.0 ± 6.9bcd	52.2 ± 7.8a	1.2 ± 0.6ab
PI 265503	27.7 ± 3.5bcd	28.3 ± 6.0abc	1.0 ± 0.4b
PI 251902	24.0 ± 4.1cde	30.0 ± 10.0abc	3.4 ± 2.7a
Pra Pra 1142	23.4 ± 7.0cde	6.7 ± 6.7cd	0.6 ± 0.5b
PI 497939[a]	23.3 ± 6.8cde	40.0 ± 30.6abc	0b
PI 170391	23.1 ± 4.4cdef	38.3 ± 7.3abc	1.1 ± 0.9ab
Hybrid '894'[a] (standard check)	23.0 ± 2.8cdef	15.4 ± 5.3abcd	0.2 ± 0.1b
PI 162453	23.0 ± 3.6cdef	41.7 ± 19.2abc	0.4 ± 0.2b
Gig 1616-1[a]	22.0 ± 5.3cdef	36.7 ± 8.8abc	1.0 ± 0.3b
PI 431542[a]	21.4 ± 5.1cdef	16.7 ± 16.7abcd	0.4 ± 0.4b
Tub 346[a]	18.9 ± 7.1defg	0d	0.9 ± 0.6b
Hir 828-2[a]	15.5 ± 2.5defg	0d	0.7 ± 0.6b
Hir 828-3[a]	15.3 ± 4.4defg	44.4 ± 29.4ab	0.2 ± 0.2b
PI 170405	12.4 ± 3.5efg	16.7 ± 16.7abcd	2.2 ± 1.5ab
Tub 365[a]	10.9 ± 2.7efg	6.7 ± 6.7cd	1.1 ± 0.6ab
PI 650558[a]	8.9 ± 4.8fg	11.1 ± 11.1bcd	0b
PI 431516[a]	6.5 ± 1.7g	6.7 ± 6.7cd	0.2 ± 0.2b
PI 386230[a]	5.0 ± 2.1g	0d	0d
Mean	22.2 ± 1.2	21.8 ± 2.9	0.9 ± 0.2

Means followed by the same letter in a column are not significantly different ($P < 0.05$; LSD); 7–15 stalks examined per accession (33 stalks of hybrid '894').
[a] Retested from previous year.

testing, PI 650497 and PI 431542 were among the lowest of the lines in a trial in numbers of weevil larvae per stalk, but in one or two of those years the mean density exceeded 25 larvae per stalk. Rogers and Seiler (1985) also noted inconsistent results among years in field testing of wild and cultivated sunflower to sunflower stem weevil in Texas. However, PI 650558, PI 386230, and PI 431516 had consistently low densities of weevil larvae per stalk, among the lines tested two or more years. PI 497939 exceeded 25 weevil larvae per stalk in only one of the 5 yr tested. Interspecific crosses that had showed consistently low levels of *C. adspersus* larvae per stalks included Hir 1734-2, Hir 828-1, Hir 828-2, Hir 828-3, Hir 828-4, Pet-Pet 1741-1, Pra-Run 417-1, and Str 1622-2. In all these crosses, the mean numbers of stem weevil larvae never exceed 25 per stalk revealing the potential of these lines as sources of resistance. Our results are in contract to those of Rogers and Seiler (1985) who commented that in their studies crosses seemed to lose the resistance they had noted in the wild sunflower parent.

There was some variation in stalk diameter among the lines tested each year. In some years, those with the largest average stem diameter did have a greater density of weevil larvae per stalk and those with the smallest diameter lower numbers of *C. adspersus* larvae per stalk. The size of the stalk and density of larvae within can impact the ability of the plant to resist lodging. However, within years it was not consistent among the different lines tested. Often, lines that had the same average stalk diameter varied greatly in number of weevil larvae per stalk; differences were often in the range of 50–70%. For example in 2006, stalks of PI 372259 averaged 2.6 cm in diameter, and the mean number of larvae per stalk was 41.2. In contrast, stalks of PI 431542 had an average stalk diameter of 2.4 cm, but only a mean of 21.4 larvae per stalk. To offer resistance to lodging, the density of larvae needs to be <25–30 per stalk (Charlet et al. 1985). And as noted, variables that can influence lodging are complex and likely a combination of many factors, including stalk diameter, weevil density, the location of weevil overwintering chambers, stalk dryness, cortex thickness, and other insects in the stalk. Plant spacing and plant population and environmental conditions can influence stalk diameter, thickness of the stem cortex, and degree of plant desiccation. The addition of these factors plus wind speed and head size also can impact lodging (Charlet et al. 1985). Thus, the ability of the plant to be resistant over a variety of conditions is dependent on harboring consistently low densities of *C. adspersus* larvae in the stalk. Further detailed studies would be required to determine whether antixenosis or antibiosis are the mechanisms responsible for the resistance shown by the lines and crosses that showed consistently lower numbers of sunflower stem weevils over the years of the study.

Populations of *D. texanus* were quite variable and in some years were too low to detect differences among the lines tested. In addition, as was noted in the stem weevil trials, results were inconsistent among years. PI 650497 had a very low incidence of beetle larvae in most years of testing, but in 2004, 73% of stalks were infested by *D. texanus.* Overall, PI 386230, PI 431542, PI 650497, and PI 650558 had the lowest incidence of longhorned beetle larvae per stalk. These accessions also were among those that offered resistance to stem weevil as evidenced by consistently lower densities of larvae per stalk. There has been little work conducted on resistance of *D. texanus* in sunflower, although Rogers (1985b) noted that none of the commercial varieties or hybrids tested showed an acceptable level of resistance based on percentage of infested stalks. Rogers further mentioned that wild perennial sunflowers seemed to be immune to attack although F1 progeny from hybrid × perennial crosses were as susceptible as the hybrid parents. Michaud et al. (2007b) also noted that cultivated sunflower is strongly preferred by *D. texanus* over wild *Helianthus.* Girdling of stalks by the longhorned beetle larvae resulting in stalk lodging is dependent on stalk diameter and a lower internal moisture condition of the stalk (Michaud et al. 2007a). They commented that in addition to reducing plant population to increase stalk diameter another potential measure to reduce losses from this pest include development of cultivars with stalks possessing a "stay-green" characteristic to delay the girdling behavior of the *D. texanus* larvae within the stalk.

Populations of *P. womonana* were at low levels through most of the years of testing, but differences among the lines tested were evident in many of the trials revealing the potential for developing resistant germplasm. A couple of the interspecific crosses evaluated (Tub 825-1 and Pet-Pet 1741-1) and one accession (PI 497939) showed resistance to infestation from both *P. womonana* and the sunflower stem weevil. Four accessions (PI 386230, PI 431542, PI 650497, and PI 650558) also had low larval densities of these species in addition to reduced percentage infestation by *D. texanus.* Little effort has been devoted to the study of this insect although its status as a potential pest of sunflower was noted a number of years ago (Rogers 1979). At that time, some preliminary studies did show breeding lines differed significantly in susceptibility to this root moth.

Although chemical control has shown to be effective in managing the sunflower stem weevil (Rogers et al. 1983, Charlet et al. 2007) and delayed planting has been shown to reduce densities of *C. adspersus, D. texanus,* and *P. womonana* in sunflower stalks (Rogers 1985a, 1985b; Rogers and Seiler 1985; Charlet and Aiken 2005), the prospect of adding host-plant resistance as an IPM tactic would provide the producer with another tool to reduce economic losses from insect pests, provide flexibility in planting windows, and reduced input costs. Based on the results from this study there is the potential for developing resistant genotypes for these stem-infesting insect pests of sunflower and further effort is anticipated to use the identified lines and interspecific crosses to introgress resistance genes into cultivated sunflower through both conventional breeding, and facilitated by the use of molecular markers.

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