

## EVALUATION OF SUNFLOWER FOR RESISTANCE TO STEM AND SEED INSECT PESTS IN NORTH AMERICA

Larry D. Charlet, Jerry F. Miller, and Gerald J. Seiler, U.S. Department of Agriculture, Agricultural Research Service, Northern Crop Science Laboratory, Fargo, ND 58105-5677 USA

E-mail: charletl@fargo.ars.usda.gov

E-mail: millerjf@fargo.ars.usda.gov

E-mail: seilerg@fargo.ars.usda.gov

### Abstract

Plant resistance is a potentially valuable management strategy to reduce damage from insects that are pests of cultivated sunflower. The sunflower stem weevil can cause lodging of the sunflower plant due to larval feeding in the stem. The banded sunflower moth, sunflower moth, and red sunflower seed weevil reduce yields because of larvae consuming the sunflower seeds. Trials were conducted in the Central and Northern Plains of the USA to screen currently available sunflower accessions, interspecific crosses, and lines for those having lower sunflower stem weevil densities in the stalks and for those that offer reduced seed damage from larval feeding by the banded sunflower moth, red sunflower seed weevil, and sunflower moth. Results from nurseries evaluating germplasm in the years 2002 and 2003 have revealed promising germplasm for all the insects studied. After each year of testing, lines, accessions, or interspecific crosses with reduced levels of damage have been selected for retesting to confirm their resistance to attack. Trials are again being conducted for all insect pest species in 2004. The isolation of resistant mechanisms may be the subject of later studies once the resistant germplasm for each insect has been determined.

### Introduction

The sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte) (Coleoptera: Curculionidae), is a pest of cultivated sunflower that has caused yield losses in North Dakota (Charlet et al., 1997). Since 1993, damage has been reported and populations have been increasing in eastern Colorado and western Kansas (Armstrong, 1996; Charlet et al., 2002). Adult sunflower stem weevils emerge from overwintered stalks in mid-to-late June. Females lay their eggs at the base of sunflower stalks. Larvae feed apically in the stems until early August and then descend to the lower portion of the stalk or root crown by late August and excavate overwintering chambers by chewing cavities into the stem cortex. If the larval population in a plant is high, the stem, weakened by tunneling, pith destruction, or overwintering chambers, will break causing a loss of the head prior to harvest. Stalk breakage due to the sunflower stem weevil is most severe during drought stress or when high winds occur as plants are drying prior to harvest (Charlet, 1987; Knodel and Charlet, 2002).

The banded sunflower moth, *Cochylis hospes* Walsingham (Lepidoptera: Tortricidae), has been a consistent pest of sunflower in the Northern Plains and also has been increasing in numbers in the Central Plains. Adults begin to emerge from the soil about mid-July and are

present in the field until mid-August. Adults tend to congregate in field margins on weeds or adjacent crops during the day, and then move into the crop in the evening. Eggs are deposited on the outside of the bracts of the sunflower head. Larvae feed in the florets and developing seed, and also destroy mature seeds. After feeding to maturity, larvae drop to the ground and spin cocoons in the soil to overwinter (Charlet and Gross, 1990; Charlet et al., 1997).

The sunflower moth, *Homoeosoma electellum* (Hulst) (Lepidoptera: Pyralidae), is a pest of cultivated sunflower and is responsible for yield losses in the Central Plains. Larvae overwinter in the soil in the Southern Plains and adults are carried on northerly winds to the Central and Northern Plains. Females deposit eggs in blooming sunflower heads. Larvae feed and develop in the sunflower head destroying seeds and reducing oil content. When mature, larvae exit the seeds and drop into the soil to overwinter (Rogers, 1978, 1992; Charlet et al., 1997).

The red sunflower stem weevil, *Smicronyx fulvus* LeConte (Coleoptera: Curculionidae), is a pest of cultivated sunflower in North Dakota. The incidence and damage from this insect has been increasing in South Dakota as shown in recent sunflower crop surveys (Charlet and Glogoza, 2004). Larvae overwinter in the soil and emerge in July, mate, and females deposit eggs in developing sunflower seeds. Larvae feed and develop in the seeds destroying a portion of the kernel and reducing oil content and when mature, exit the seeds and drop into the soil in late August or September to overwinter. There is one generation per year (Brewer, 1991; Rogers, 1992; Charlet et al., 1997).

The goal of this project was to investigate resistance as a potentially valuable management resource and to screen currently available sunflower accessions, interspecific crosses, and lines for those having lower sunflower stem weevil densities in the stalks and reduced seed damage from larval feeding by the banded sunflower moth, red sunflower seed weevil, or sunflower moth.

## Materials and Methods

Sunflower stem weevil evaluation plots were established at Akron, Colorado, and Colby, Kansas, in 2002. Field trials at Akron screened 21 selected sunflower accessions and one interspecific cross. Accessions for most studies were obtained from the USDA-ARS North Central Plant Introduction Station, Ames, Iowa. Trials at Colby included 25 interspecific crosses. In 2003 the evaluation was conducted at Colby and included 7 accessions and 16 interspecific crosses. Hybrid '894' was used as a check both years. The treatments were single-row plots replicated four times in a randomized block design. The degree of resistance or tolerance was measured by comparing the number of weevil larvae per stalk in 20 stalks per line or accession to hybrid 894 and to the line with the lowest number of weevils per stalk.

Plots for banded sunflower moth were conducted at Prosper, North Dakota, in 2002 and 2003. Trials included 30 selected sunflower lines, 20 interspecific crosses, and 47 selected accessions in 2002. In 2003, evaluations included 7 lines, 15 interspecific crosses, and 23 accessions. Hybrid 894 was used as a check both years. Treatments were single-row plots replicated four times in a randomized block design. After physiological maturity, five heads were removed from each row for evaluation. The degree of resistance or tolerance to the sunflower moth was measured by comparing the percentage of seeds damaged in the germplasm tested to hybrid '894' and to the line with the lowest level of seed damage.

Sunflower moth plots were located at Colby, Kansas, in both 2002 and 2003. Field trials in 2002 screened 25 selected sunflower lines, 13 accessions, 20 interspecific crosses, and hybrid 894. In 2003, 10 lines, 29 interspecific crosses, 14 accessions, and hybrid 894 were evaluated. Treatments were single-row plots replicated four times in a randomized block design. Five heads were removed from each row (20 per treatment) after physiological maturity. The degree of resistance or tolerance to the sunflower moth was measured by comparing the percentage of seeds damaged in the germplasm tested to hybrid '894' and to the line with the lowest level of seed damage.

Red sunflower seed weevil plots were established at Highmore, South Dakota, and Prosper, North Dakota, in 2002 and 2003. Field trials at Highmore in 2002 screened 41 selected sunflower lines, 15 accessions, and hybrid 894. Trials in 2002 at Prosper included 42 selected sunflower lines, 25 interspecific crosses and hybrid 894. In 2003, the same 20 lines, 5 accessions, 7 interspecific crosses, and hybrid 894 were evaluated at both Highmore and Prosper. Treatments were single-row plots replicated four times in a randomized block design. In both years, the degree of resistance or tolerance was measured by comparing the percentage of seeds damaged in the germplasm tested to hybrid 894 and to the line with the lowest level of seed damage.

## Results and Discussion

The sunflower stem weevil larval counts indicated very heavy stem weevil pressure in 2002 at Akron with the mean density ranging from 20 to 60 larvae per stalk among the germplasm tested. The number of weevils ranged from 1 to 184 larvae per stalk among all the stalks dissected for the study. Earlier research has shown that stems harboring 25-30 larvae are susceptible to lodging prior to harvest and therefore lead to loss of the yield for that plant (Charlet et al., 1985). Five accessions, PI 371936, PI 497939, PI 431542, PI 386230, and Ames 3454, plus hybrid 894 averaged less than 30 larvae per stalk in this trial, indicating lower susceptibility to attack by the weevil under heavy pressure. Accessions PI 431542 and PI 386230 had been tested in both 2000 and 2001 and also had some of the lowest densities of weevil larvae in those years. Accession Ames 3391 had been consistently better than most others tested in trials in 2000 and 2001, but in 2002 was about in the middle of the germplasm tested in number of larvae per stalk. The density of sunflower stem weevil larvae at Colby in 2002 was equal to the Akron location. The mean numbers occurring in the germplasm tested ranged from 17 to 59 larvae per stalk and the range in all stalks dissected varied from 0 to a high of 291 per stalk. Among the 26 lines tested, 15 were below 30 and 6 below 20 weevil larvae per stalk. The interspecific cross with the least weevils in the trial was PET-PET 1741-1 with a mean of only 17 larvae per stalk. Hybrid 894 had slightly more larvae per stalk at 37 than at the Akron location. In 2003, at Colby, densities of weevil larvae in stalks ranged from means of 5 to 44 per stalk. Seven interspecific crosses and 4 accessions had an average of less than 10 larvae per stalk. In this trial hybrid 894 had a mean of 13 larvae per stalk. Accession Ames 3454 had the lowest number of larvae per stalk in the trial and also was the lowest in the 2002 trial at Akron. The interspecific cross PET-PET 1741-1 had only 10 larvae per stalk and in 2002 at Colby was the lowest of the germplasm tested. The accessions Ames 3391 and PIs 497939 and 431542 have consistently had low numbers of larvae per stalk in the different years of testing and in 2003 had mean densities of 6, 6, and 9, respectively. The interspecific crosses showing low densities of larvae will be retested for a third year in 2004. Accessions

with consistently low numbers of weevils will be crossed and the resulting progeny field tested in 2005.

Feeding damage, based on individual heads sampled, indicated high levels of banded sunflower moth infestation within the trial at Prosper in 2002. The percentage of moth larval seed damage ranged from 0 to 99%. The mean larval seed damage varied from 1 to 42% among the germplasm tested at this location. Twenty-four of the 98 entries included in the study showed less than 4% seed damage. Among the material in the trial, those with 2% or less damage were: the line 01-4063-1; the interspecific cross PRA-HIR 437, and the accessions PI 172906, PI 291403, PI 219649, PI 170385, and PI 170388. Two of these also had lower feeding loss in another resistance study. The line 01-4063-1 sustained less than 2% damage and the interspecific cross PRA-HIR 437 less than 1% damage in the sunflower moth resistance screening in Kansas. In 2003, seed damage from banded sunflower moth larval feeding ranged from 2 to 20% among the germplasm included in the trial at Prosper. Those showing 4% or less damage in 2003 and 2002 included hybrid 894 and PIs 505651, 494859, 494861, 291403 and 170385. The interspecific crosses PRA-PRA 1142 and GIG 1616-2 which had less than 4% feeding damage in 2002 again showed low seed damage among the germplasm tested with 8 and 6% seed damage per head, respectively. Germplasm exhibiting 8% or less feeding damage will be retested in 2004.

The determination of sunflower moth feeding damage in 2002 at Colby was severe, based on damage to individual heads sampled. The percentage of moth seed damage ranged from 0 to 73% in the heads evaluated. The mean larval seed damage varied from 1 to 22% among the germplasm tested at this location. Twenty-five of the 59 germplasms included in the study had less than 2% seed damage. Among the material in the trial, those with damage levels of less than 1% were: the four lines 01-4059-1, 01-4043-1, 01-4080-1, 01-4068-2; the interspecific crosses Rf ANN 1742, PRA-HIR 437, PRA-RUN 417-1, ANO 1509-1; accession PI 486366; and hybrid 894. In 2003, damage from sunflower moth ranged from a mean of 59 to only 0.2% in the germplasm tested at Colby. Six accessions, five lines, six interspecific crosses, and hybrid 894 showed less than 4% seed damage. Of these, 11 had exhibited less than 2% damage in 2002. These were: the lines 01-4059-1, 01-4063-1, 01-4062-1, 01-4068-2, and 01-4080-1; PIs 175728 and 307946; interspecific crosses PRA-PRA 1142, STR 1622-1, and PAR 1673-1; and hybrid 894. Germplasm which sustained less than 4% damage will be retested in 2004 at the same location.

The determination of red sunflower seed weevil damage at Highmore in 2002, showed high levels of infestation occurred with a range of 8 to 55% seed damage among the germplasm tested at this location. Those with less than 10% damage included the three lines 98-1884, 98-1882, and 98-1885 and the accession PI 486366. The density of red sunflower seed weevil at Prosper in 2002 was much lower than the Highmore location, based on the amount of seed damage. Percentage damage ranged from a high of 9% in line 98-1895 to about 1% in line 98-1868. Damage to hybrid 894 was in the middle of the selected germplasm evaluated at Highmore, but was near the bottom in seed damage at Prosper. The lines, which were tested at both locations, also showed inconsistent results. However, the differences in results are likely because of the lower levels of damage that occurred at Prosper. In 2003, the same germplasm was tested at both Highmore and Prosper, but damage levels were different between the two sites. Seed weevil damage ranged from 5 to 41% at Highmore, but only 0.1 to 4% at Prosper. The interspecific crosses STR 1622-2 and TUB 1709-2 sustained less than 1% damage at Prosper, but had 15% and 32% seeds damaged per head at Highmore. Hybrid

894 had a mean of only 0.5% damage at Prosper, but averaged 26% at Highmore. The best performing germplasm as revealed in the trial at Highmore included 3 lines (98-1859, 98-1884, 98-1879-4) which averaged 10% or less damage from red sunflower seed weevil feeding. Germplasm with less than 1% damage in the Prosper trial and less than 17% in the Highmore trial will be retested at both locations in 2004.

## Conclusions

Evaluation for sunflower germplasm with resistance to four important sunflower insect pests has been conducted in the regions where these insects have caused economic losses. Nurseries for the sunflower stem weevil and sunflower moth were located in the Central Plains in Colorado and Kansas and those for the banded sunflower moth and red sunflower seed weevil were located in South and North Dakota in the Northern Plains production region. Results from 2002 and 2003 have revealed promising germplasm for all the insects studied. After each year of testing, lines, accessions, or interspecific crosses with low damage have been retested to confirm their resistance to attack. Trials are again being conducted for all insect pest species in 2004. Whether the resistance mechanisms responsible for either reduced sunflower stem weevil larval numbers in the stalk or lower percentage of seeds consumed by larvae of the banded sunflower moth, sunflower moth, or red sunflower seed weevil are antibiotic or antixenotic, have not been determined. These may be the subject of later studies once the resistant germplasm for each insect has been determined.

## References

- Armstrong, J. S. 1996. Development of a degree-day based prediction model for adult sunflower stem weevil, *Cylindrocopturus adspersus*, emergence. Proc. 18th Sunflower Research Workshop, Natl. Sunflower Assoc., Fargo, ND, 11-12 January 1996. p. 49-51.
- Brewer, G. J. 1991. Oviposition and larval bionomics of two weevils (Coleoptera: Curculionidae) on sunflower. Ann. Entomol. Soc. Am. 84:67-71.
- Charlet, L. D. 1987. Seasonal dynamics of the sunflower stem weevil, *Cylindrocopturus adspersus* LeConte (Coleoptera: Curculionidae), on cultivated sunflower in the northern Great Plains. Can. Entomol. 119: 1131-1137.
- Charlet, L. D. and P. A. Glogoza. 2004. Insect problems in the sunflower production regions based on the 2003 sunflower crop survey and comparisons with the 2002 survey. Proc. 26th Sunflower Research Workshop, Natl. Sunflower Assoc., Fargo, ND, 14-15 January 2004. <http://www.sunflowernsa.com/research/research-workshop/documents/143.pdf>
- Charlet, L. D. and T. A. Gross. 1990. Bionomics and seasonal abundance of the banded sunflower moth (Lepidoptera: Cochylidae) on cultivated sunflower in the northern Great Plains. J. Econ. Entomol. 83:135-141.
- Charlet, L. D., C. Y. Oseto, and T. J. Gulya. 1985. Application of systemic insecticides at planting: effects on sunflower stem weevil (Coleoptera: Curculionidae) larval numbers, plant lodging, and seed yield in North Dakota. J. Econ. Entomol. 78:1347-1349.
- Charlet, L. D., G. J. Brewer, and B. Franzmann. 1997. Insect pests. In: A. A. Schneiter (ed.). Sunflower Technology and Production. Agron. Ser. 35. Am. Soc. Agron., Madison, WI. p. 183-261.
- Charlet, L. D., J. S. Armstrong, and G. L. Hein. 2002. Sunflower stem weevil (Coleoptera: Curculionidae) and its larval parasitoids in the Central and Northern Plains of the USA. BioControl 47:513-523.
- Knodel, J. J. and L. D. Charlet. 2002. Biology and integrated pest management of the sunflower stem weevils in the Great Plains. North Dakota State Univ. Coop. Ext. Serv. Bull. E-821. 8p.
- Rogers, C. E. 1978. Sunflower moth: feeding behavior of the larva. Environ. Entomol. 7:763-765. E-821. 8p.
- Rogers, C. E. 1992. Insect pests and strategies for their management in cultivated sunflower. Field Crops Res. 30:301-332.