Pest Management Strategies for the Sunflower Stem Weevil (Coleoptera: Curculionidae) in the Northern Great Plains

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Abstract

Pest management strategies that incorporate knowledge of the insect's biology, population dynamics, economic injury levels with the use of resistant cultivars, biological and cultural controls, and the judicious use of pesticides are important in the development of sustainable agriculture. The ideal management strategy utilizes techniques that require low input costs, are cost-effective, and avoid negative impacts on the environment. The sunflower stem weevil is a serious pest of cultivated sunflower in the northern Great Plains of the U.S. Larvae feed and develop within the sunflower stalk. The construction of overwintering chambers by the larvae can severely weaken the stalk, resulting in lodging of the plant. Although chemical control can be effective in reducing larval densities in the stalk and the percentage of stalks lodged, insecticides are expensive, destroy natural enemies and may contaminate the environment. Evaluation of cultural control methods such as planting date, plant population, and stalk burial, and biological control and host-plant resistance showed promise as effective management strategies for the sunflower stem weevil in cultivated sunflower.

Key words - Sunflower, *Helianthus annuus*, pest management, *Cylindrocopturus adspersus*, biological control, cultural control

Introduction

Effective insect pest management requires a broad approach that incorporates knowledge of the insect's biology and population dynamics, determination of economic injury levels, the use of resistant cultivars, as well as biological, cultural, and chemical controls. The ideal control strategy utilizes techniques that require low input costs, are cost-effective, and avoid negative impacts on the environment.

Cultural control tactics use farming practices already associated with crop production. They are effective because they make the environment less favorable to the pest and more favorable to the plant. Cultural control tactics include the following approaches: planting date, tillage, crop spacing or plant population, trap crops, crop sanitation, and crop rotation. Cultural controls have the advantage of usually requiring no additional outlay for equipment, lack deleterious side-effects and are generally simple, effective, and inexpensive to apply. However, cultural control measures have to be applied early, the control of the pest is not always complete, and a knowledge of the pest's biology is required.

Host-plant resistance is a pest management method that utilizes the plant's own defense mechanisms against the insect to either avoid attack, destroy the insect, or tolerate the injury. The resistance is developed through plant screening and breeding. An important advantage of this strategy is that pest-resistant cultivars, once produced become a cost-effective and environmentally safe form of insect management and are compatible with other pest management approaches in sustainable agriculture. Evaluation of the plant resistance for potential adverse effects on the natural enemies of the pest is also important.

The biological control of pests by natural enemies includes importation and establishment of exotic species, augmentation of established species, and conservation of species through manipulation of the environment. The conservation of natural enemies in a crop agroecosystem is important in maintaining pests below levels that cause economic damage. The naturally occurring or indigenous natural enemies prevent many plant-feeding insects from achieving pest status. The conservation of these natural enemies allows them to operate at their full potential. Manipulating the environment to eliminate or mitigate adverse factors, such as pesticides, can effectively conserve the natural enemies present. The effective conservation of natural enemies depends on understanding the agroecosystem, the use of selective pesticides, the use of the least disruptive formulation of the chemical, application of the insecticide only when necessary and based on sound economic injury levels of the pest, and pesticide application at the least injurious time or place.

Sunflower (*Helianthus* spp.) is native to North America and thus insects associated with the plant have evolved for centuries and many have moved to the cultivated crop to feed and develop. The sunflower stem weevil has become one of the serious pests of cultivated sunflower in the northern Great Plains of the United States. Adults cause only slight feeding damage to the foliage of sunflower, but the larvae feed and develop within the sunflower stalk. The construction of overwintering chambers by the larvae can severely weaken the stalk if weevil populations are heavy, resulting in lodging of the sunflower plant prior to harvest (Rogers and Jones 1979, Charlet 1987). Although earlier research has shown that chemical control can be effective in reducing densities of weevil larvae in the stalk and the percentage of plants lodged (Charlet and Oseto 1983, Charlet et al. 1985), insecticides also destroy natural enemies of the weevil and may contaminate the environment. In addition, the number of registered insecticides available to the producer has been reduced and may decline further in the future. The goal of this research was to evaluate the impact of different cultural methods, host-plant resistance, and biological control, as economical alternatives for effective pest management of the sunflower stem weevil in cultivated sunflower as a part of a sustainable agriculture system.

Materials and Methods

Plant population. Randomized block plantings of sunflower hybrid '894' were seeded at Erie, North Dakota, on 10 May 1984. Treatments were replicated four times and included plots with 76 cm rows and plants spaced 60 cm, 30 cm, and 15 cm apart within rows for a final plant population of 22,000, 45,000, and 89,000 plants per hectare, respectively. A sunflower plant density of approximately 45,000 plants per hectare is the plant population typically used by producers in the northern growing area. After physiological maturity, the percentage of plant lodging was determined and the stalks (40 per treatment), including root crowns, were harvested and returned to the laboratory. Stalk diameter was measured and the stalk was dissected to calculate the number of larvae per stalk.

Date of planting. Block plantings of sunflower hybrid '894' were seeded at Carrington, North Dakota in 1990 and 1991. Three different dates of planting (15 and 29 May and 11 June 1990; 13 and 28 May and 10 June 1991) were replicated three times in a randomized complete block design. Plots were seeded at normal planting rates with plants 30 cm apart on 76 cm row spacings for a final plant population of approximately 45,000 plants per hectare. Intact stalks (20 per treatment) with attached root crowns were harvested at physiological maturity when stems had dried. Stalks were returned to the laboratory and held in a cold room for at least six weeks before examination to insure the breaking of larval diapause. Stalks were split and the larvae removed and counted. Larvae were held in multi-celled plastic trays until emergence of adult weevils or parasitoids. A study at Prosper, North Dakota in 1991, included three large block plantings of sunflower hybrid '894' seeded 10 May and 3 and 13 June. The procedure for harvesting and analysis was the same as the Carrington study. A total of 20 stalks from each planting were analyzed.

Host plant resistance and biological control. In 1990, 39 different sunflower lines were evaluated for resistance to the sunflower stem weevil in three tests at Prosper, North Dakota, and one at Carrington, North Dakota. The trials consisted of single 7.5 m rows planted 76 cm apart and were replicated four times in a randomized complete block design. A total of 20 stalks per accession were harvested at the end of the season and dissected to determine the density of overwintering weevil larvae within. The larvae were removed, counted, and reared to determine the species of parasitoids and percent parasitization. The rate of parasitism was calculated to evaluate the possible impact of the different accessions on natural enemies of the stem weevil.

Results and Discussion

Plant population. Plant population impacted both the diameter of sunflower stalks and percentage of lodged plants. Larval stalk population (average of 12 larvae per stalks) was not affected by the plant density within the plots. However, stalk diameter was significantly different among all three plant populations, with the thinnest stalks in the most dense plantings. Lodging was low at both the 22,000 and 45,000 plants per hectare plots. However, almost 25% of the plants were lodged when the density of sunflower stalks increased to 89,000 plants per hectare.

Larvae overwinter in stalks by constructing chambers in the stem cortex. These chambers weaken the plant and if larval numbers are high, the plant can lodge prior to harvest with a loss of the entire head. It is important to maintain the structural integrity of the sunflower stalk to prevent lodging of the plant. Results showed that with no change in insect levels in the stalk, reducing the plant population density can result in decreased damage from lodging. In areas where there have been high numbers of weevils, producers might need to reduce populations below the normal

45,000 plants per hectare to prevent lodging.

Date of planting. Stalk diameter and stem weevil larval density decreased with later planting dates. At Carrington in 1990, the stem diameter and weevil density in the stalks were significantly lower in the 11 June planting than the previous two planting dates. There was a mean of only 1 larva per stalk compared with 6.5 larvae per stalk at the 15 May planting date. Percent parasitization was highest at the second planting date. The majority of parasitoids reared from the weevils were *Nealiolus curculionis* (Fitch) (Hymenoptera: Braconidae). Although there was no difference in stalk diameter between the three planting dates in 1991 at Carrington, the number of larvae per stalk was significantly different among all three dates of planting. Density fell from a high of 21 to only 2 larvae per stalk between the first and third date of planting. Parasitism was again greatest at the second planting date with over 20% of the larvae attacked. Larval densities in the three planting dates at Prosper (1991) exhibited a similar reduction in stalk larval densities with delayed planting as was evident at Carrington in 1990 and 1991. Numbers of larvae decreased from a high of 23.4 larvae per stalk in the 10 May planting to only 2.1 larvae per stalk in the 10 June planting. Stalk diameter was also significantly reduced in the third compared with the first date of planting. The pattern of larval parasitism was similar to that observed both years at Carrington, with the highest levels at the second planting date and none detected at the third date. Although *N. curculionis* was not recovered from larvae in stalks of the third planting date, this was probably due to the extremely low number of weevil larvae present. The results revealed that the parasitoid was active and capable of attacking larvae of the sunflower stem weevil in sunflower from different planting dates.

Stem diameter is an important factor determining the ability of the sunflower plant to withstand lodging of weevil infested stalks. Although the stem diameter decreased with planting date, in all three studies, the density of larvae also decreased, thus reducing the potential for lodging. Results showed that delayed planting was a very effective cultural control method for reducing the number of larvae infesting the sunflower stalk even at very different weevil population densities. Our results confirm earlier studies by Oseto et al. (1982) in North Dakota and Rogers et al. (1983) in Texas that a reduction in stem weevil larval stalk density can be achieved with delayed planting.

Cultivation of crop residues has been shown to be another effective cultural control method with some crops. The sunflower stem weevil overwinters as a mature larva in chambers constructed by the larvae in the lower stalk or root crown. Larvae pupate within the overwintering chamber and adults then chew through the stalk epidermis and exit from the stalk (Rogers and Jones 1979). A study conducted by Charlet (1995) showed that stalk burial severely impacted emergence of adult stem weevils. Mortality may have been due to the inability of adults to move from the stalk through the soil to the surface. Earlier studies discounted the impact of tillage as a control strategy for the sunflower stem weevil. Charlet (1989) noted that larvae seemed to be protected within stalks, and unless the stalks were broken and the larvae exposed in the soil, survival would not be significantly decreased by plowing. Rogers et al. (1983) found that fall and winter disking or sweep plowing did not affect weevil mortality. Protection of the larvae in the woody portions of the stalk prevented physical injury of the larvae from the implements. However, it appears that burying stalks at least 15 cm below the soil surface decreases populations of the stem weevil the following season due to a great reduction in adult emergence (Charlet 1995). Thus, a combination of disking to break up the stalks and the use of moldboard plowing to bury the stalks and seal the soil could provide excellent control in areas that have experienced damaging populations of the sunflower stem weevil. However, because sunflower is rotated each year and infestation is based on migrating weevils, single field treatments might not protect a specific field. Only area-wide tillage would impact the number of weevils migrating into each season's new sunflower fields.

Host plant resistance and biological control. The sunflower stem weevil is attacked by both egg and larval parasitoids. The eggs of the weevil are attacked by *Anaphes pallipes* (Ashmead) (Hymenoptera: Mymaridae) (Charlet and Balsbaugh 1984). Hymenoptera recovered from overwintering larvae include: *Tetrastichus ainsliei* Gahan (Eulophidae); *Mesopolobus* sp. (Pteromalidae); and *Nealiolus curculionis* (Charlet 1983). The latter species is the most prominent of the larval parasitoids attacking the weevil. *Nealiolus curculionis* is a univoltine, solitary, endophagous larval parasitoid of the sunflower stem weevil in both cultivated and native sunflower. This parasitoid represented 96% of all parasitoids attacking the weevil in studies conducted from 1980 to 1991. Adult parasitoids are active in the field from late June to late August. Eggs are deposited in early instar weevils feeding within the sunflower stalk. The immature parasitoids overwinter within diapausing weevil larvae in the sunflower stalk (Charlet 1994). Results indicated that overall parasitization increased from levels reported in the late 1970's and early 1980's. Parasitism of stem weevil larvae by *N. curculionis* has averaged 27% since 1983, while stem weevil densities have varied from 6 to 29 larvae per stalk. The consistent rates of parasitism compared with the variable field densities of adult parasitoids suggest that *N. curculionis* effectively forages for hosts under varying host population densities. This parasitoid appears to be a consistent mortality factor in the population dynamics of the sunflower stem weevil in cultivated sunflower (Charlet, 1994).

Comparison of densities of weevil larvae from both Prosper and Carrington, North Dakota, showed significant differences among different sunflower lines. Numbers of larvae varied from 4 to 26 per stalk showing that some lines have potential resistance to infestation by the stem weevil. *Nealiolus curculionis* parasitization rates also varied among lines (6 to 41%), with high parasitism in some with low weevil numbers. The accession BSM8 had only 9 larvae per stalk, but 34% parasitism. Parasitism also varied among some lines with similar weevil densities. Some lines were very susceptible to attack by the sunflower stem weevil and also seemed to have a detrimental effect on the parasitoids of the weevil. BSM27 had an average density of 25 larvae per stalk with less than 9 percent parasitism. The mechanisms that influence parasitism of weevil larvae among different sunflower lines need to be further investigated.

Conclusion

These studies show that strategies such as host-plant resistance, biological control, and cultural control methods, such as delaying planting, varying plant population, and burying of stalks can reduce weevil densities in the plant and consequently lessen the damage from stalk lodging. Such tactics can therefore can be used effectively in an integrated pest management program for the sunflower stem weevil. These strategies are low input and therefore fit well into a sustainable approach to agricultural pest management.

References Cited

Charlet, L. D. 1983. Parasitoids of a stem weevil, *Cylindrocopturus adspersus*, in sunflower: Incidence and parasitization rates in the northern Great Plains. Environ. Entomol. 12(3): 888-890.

Charlet, L. D. 1987. Seasonal dynamics of the sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte) (Coleoptera: Curculionidae), on cultivated sunflower in the northern Great Plains.

Charlet, L. D. 1989. Overwintering survival of the sunflower stem weevil (Coleoptera: Curculionidae) and two of its parasitoids in the northern Great Plains. J. Econ. Entomol. 82: 130-133.

Charlet, L. D. 1994. Seasonal abundance and impact of the sunflower stem weevil parasitoid, *Nealiolus curculionis* (Hymenoptera: Braconidae) in the northern Great Plains. Biol. Control 4: 26-31.

Charlet, L. D. 1995. Effect of stalk burial on emergence of sunflower stem weevil adults (Coleoptera: Curculionidae). J. Kansas Entomol. Soc. 67: 288-290.

Charlet, L. D. and E. U. Balsbaugh, Jr. 1984. *Anaphes conotracheli* (Hymenoptera: Mymaridae), an egg parasitoid of *Cylindrocopturus adspersus* (Coleoptera: Curculionidae). J. Kansas Entomol. Soc. 57(3): 526-528.

Charlet, L. D. and C. Y. Oseto. 1983. Toxicity of insecticides on a stem weevil, *Cylindrocopturus adspersus* (LeConte) (Coleoptera: Curculionidae), and its parasitoids in sunflower. Environ. Entomol. 12: 959-960.

Charlet, L. D., C. Y. Oseto, and T. J. Gulya. 1985. Application of systemic insecticides at planting: effects on sunflower stem weevil (Coleoptera: Curculionidae) larvae numbers, plant lodging, and seed yield in North Dakota. J. Econ. Entomol. 78: 1347-1349.

Oseto, C. Y., W. F. Burr, and R. B. Carlson. 1982. Relationship of sunflower planting dates to damage by *Cylindrocopturus adspersus* (Coleoptera: Curculionidae) in North Dakota. J. Econ. Entomol. 75: 761-764.

Rogers, C. E. and O. R. Jones. 1979. Effects of planting date and soil water on infestation of sunflower by larvae of *Cylindrocopturus adspersus*. J. Econ. Entomol. 72: 529-531.

Rogers, C. E., P. W. Unger, T. L. Archer, and E. D. Bynum, Jr. 1983. Management of a stem weevil, *Cylindrocopturus adspersus* (LeConte) (Coleoptera: Curculionidae), in sunflower in the southern Great Plains. J. Econ. Entomol. 76: 952-956.