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Source: Journal of Economic Entomology, 100(5) : 1555-1559

Published By: Entomological Society of America

URL: https://doi.org/10.1603/0022-0493(2007)100[1555:IOIOLD]2.0.CO;2

Impact of Irrigation on Larval Density of Stem-Infesting Pests of Cultivated Sunflower in Kansas

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J. Econ. Entomol. 100(5): 1555–1559 (2007)

ABSTRACT The guild of stem-infesting insect pests of cultivated sunflower, *Helianthus annuus* L., within the central Plains is a concern to producers, chiefly due to losses caused by plant lodging from the sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte) (Coleoptera: Curculionidae), and *Dectes texanus texanus* LeConte (Coleoptera: Cerambycidae). The incidence of a root boring moth, *Pelochrista womonana* (Kearfott) (Lepidoptera: Tortricidae), also has increased. Experiments were conducted in Kansas during 2000–2001 to investigate the effect of irrigation timing and intensity on densities of *C. adspersus*, *D. texanus*, and *P. womonana* larvae within cultivated sunflower stalks. Supplemental soil moisture provided by irrigation during the growing season increased both seed yield and oil content, and it reduced insect densities of the sunflower stem weevil and *P. womonana* in the sunflower stalk. Results showed that ensuring adequate moisture during the growing season can assist in reducing stem-infesting insect densities, revealing an additional advantage of crop irrigation beyond improved sunflower productivity.

KEY WORDS sunflower, *Cylindrocopturus adspersus*, *Pelochrista womonana*, *Dectes texanus*, pest management

The sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte) (Coleoptera: Curculionidae), has caused economic damage to cultivated sunflower, *Helianthus annuus* L., in Texas, North Dakota, South Dakota, and Minnesota (Rogers and Jones 1979, Charlet et al. 1997, Knodel and Charlet 2002). The weevil was first noted as a pest of sunflower by Newton (1921) who observed severely wilted plants in fields grown for silage in Colorado. Recently, damage has been reported from the central Plains production region, including Colorado, Kansas, and Nebraska (Armstrong 1996, Charlet et al. 2002, Charlet and Glogoza 2004). The sunflower stem weevil also has been implicated in the epidemiology of sunflower fungal pathogens, and diseases that contribute to stalk rot and may predispose plants to lodging (Phoma black stem [*Phoma macdonaldii* Boerma] and charcoal rot (*Macrophomina phaseolina* [Tassi] Goid) (Gaudet and Schulz 1981, Yang et al. 1983, Charlet et al. 1997). In addition to cultivated sunflower, the sunflower stem weevil also occurs in different species of native sunflowers, including *H. annuus*, *Helianthus pauciflorus* Nuttall, *Helianthus petiolaris* Nuttall, *Helianthus tuberosus* L., and *Helianthus maximiliani* Schrader (Charlet 1983, Charlet et al. 1992), and it has been found on ragweed (*Ambrosia* spp.), pigweed (*Amaranthus* spp.), Russian knapweed (*Centaurea repens* L.), lambsquarter (*Chenopodium album* L.), golden ragwort (*Senecio aureus* L.), perennial sowthistle (*Sonchus arvensis* L.), red clover (*Trifolium pratense* L.), cocklebur (*Xanthium strumarium* L.), kochia [*Kochia scoparia* (L.)], and sugar beets (*Beta vulgaris* L.) (Mitchell and Pierce 1911; Pierce 1916; Goeden and Ricker 1975, 1976; Casals-Bustos 1976; Schulz 1978). Adult sunflower stem weevils emerge from overwintered stalks from April to June, depending on latitude, and females deposit eggs at the base of the sunflower stem. Weevil larvae feed and develop in the sunflower stem, and they tunnel to the base of the stalk or root crown at the end of the growing season. They overwinter inside chambers chewed into the cortex of the stalk. 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 percentage of stalks lodging is related to the number of stem weevil larvae per stalk, although other factors such as wind speed and stem thickness also may contribute (Charlet et al. 1985).

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A longhorned beetle, *Dectes texanus texanus* LeConte (Coleoptera: Cerambycidae), has been recognized as a pest of sunflower since the early 1970s when it caused considerable damage in south central Texas (Rogers 1977, 1985b), but it is also an important pest of soybean (Hatchett et al. 1975, Michaud and Grant 2005, Niide et al. 2006). High numbers of *D. texanus* were present in sunflower stalks in 2003 from the central Plains extending north into South Dakota (Charlet and Glogoza 2004). Larvae feed and tunnel in the petioles, then into stem pith, and finally they move to the base of the plant in late summer to overwinter. Mature larvae girdle the inside of the lower stalk or root crown, move below the girdle, and pack frass into the tunnels. Stalks frequently break at the point of girdling, leaving the larva protected during the winter in its frass-packed tunnel (Rogers 1985b, Charlet et al. 1997).

The incidence of a root boring moth, *Pelochrista womonana* (Kearfott) (Lepidoptera: Tortricidae), also has increased in the past few years based on recovery of larvae from the lower stalk and root area in sunflower within the central Plains (L.D.C., unpublished data). This insect previously was mentioned as a sunflower pest in Texas, but an injury threshold has not been determined (Rogers 1979, 1985a).

Available soil water frequently limits grain productivity in rain-fed semiarid cropping systems of the central Great Plains (Aiken 2002). Sunflower water use can exceed that of other summer crops, due to higher transpiration rates, greater rooting depth and extraction of soil water (Hattendorf et al. 1988, Stone et al. 2001). Available soil water can limit sunflower productivity by direct effects on canopy function and by indirect effects on canopy and seed development (Villalobos et al. 1996). Seed number and size together with oil content are the principal components of yield in sunflower (Connor and Hall 1997). Water stress can impact the sunflower plant before anthesis in determining floret primordia; during anthesis, influencing the proportion of florets setting seed; and after anthesis during the seed-filling period (Connor and Sadras 1992, Connor and Hall 1997). Knowledge of these effects can guide management decisions to sustain or improve water management for sunflower productivity. Improving the productive use of water by sunflower cultivars would enhance the array of management alternatives for farmers seeking profitable crops for rain-fed and limited irrigation cropping systems in this region (Aiken 2002).

The primary tactic for managing sunflower stem weevil populations and preventing yield loss in cultivated sunflower has been the use of insecticides; however, the frequent application of pesticides can potentially risk the development of insecticide resistance and negatively impact beneficial insects. Cultural control, as part of an integrated pest management (IPM) program, can potentially be used to modify cropping environments to reduce pest densities. This study investigated the impact of irrigation timing and intensity on populations of stem-infesting pests in sunflower. We evaluated the density of *C. adspersus, P. womonana,* and *D. texanus,* within the sunflower stalks at the end of the season to determine whether irrigation could serve as a tactic in the management insect pests attacking the stems of cultivated sunflower.

Materials and Methods

This trial was conducted at Kansas State University Northwest Research Extension Center plots in Colby, KS, in 2000 and 2001. Plots were planted on 9 June 2000 and 11 June 2001 in a randomized block design with four replicates. In both years, the oilseed sunflower hybrid Cargill 187 (=Mycogen SF187) was planted in plots eight rows wide by 26 m long with rows 76 cm apart. Plants were spaced 30.5 cm within rows. The plots received a preplant application of fertilizer and herbicide, but no other chemical treatments were used. Supplemental water treatments were 1) no supplemental water, 2) water during plant reproduction development and seed fill (growth stage R1 to R9; Schneiter and Miller 1981), 3) water during seed fill (growth stage R6 to R9), 4) water during reproductive development (R1 to R5), and 5) water throughout most of the growing season (V12 to R9). The amount of supplemental water provided was based on rainfall and for each treatment, millimeters of water for 2000 and 2001, respectively, was 1) 0, 0; 2) 254.0, 177.8; 3) 152.4, 127.0; 4) 152.4, 50.8; and 5) 330.2, 165.1. Treatment 2 is representative of a full irrigation practice, whereas treatment four is more representative of a limited irrigation practice. Yield was determined at physiological maturity (R9 stage). Two 5.3-m rows from each of four replicated plots were machine-harvested when seed moisture was <12%. Seed was analyzed for moisture content, seed number, seed weight, and oil content.

Variation among treatments in stalk insect infestation was compared by counting the number of sunflower stem weevil, *P. womonana,* and *D. texanus* larvae per stalk. Five randomly selected stalks (≈50 cm of basal length plus the root crown) per plot (total of 20 per treatment) were removed after plants had reached the R9 growth stage and senesced and sent to the first author's laboratory in Fargo, ND. Stalks were stored at 5°C until they were split, and the number of larvae in each stem was determined. The analysis of variance (ANOVA) option of the SAS-GLM procedure was used to compare larval numbers among the different irrigation schedules for each study year. Significantly different means were separated using Fisher protected least significant difference (LSD) ($P < 0.05$) (SAS Institute 2001).

Results

Irrigation at Colby had a significant impact on weevil densities within sunflower stalks in both 2000 and 2001 (Table 1). In addition to supplemental water from irrigation, moisture received by the plots from June through August rainfall was higher in 2000 (153.9 mm) than in 2001 (132.1 mm). The early season (June) amount was very low in 2001 (10.4 mm) com-

Table 1. Mean number of sunflower stem weevil larvae in stalks of sunflower at five irrigation schedules, Colby, KS, 2000–2001

Irrigation schedule	No. weevil larvae per stalk (mean ± SE)		
	2000	2001	Mean
No supplemental water	11.1 ± 0.8a	3.4 ± 0.8a	8.5 ± 0.8a
R1 to R9	7.7 ± 0.7bc	2.3 ± 0.6ab	5.9 ± 0.6b
R6 to R9	10.8 ± 0.7a	3.0 ± 0.8ab	8.8 ± 0.7a
R1 to R5	9.1 ± 1.0ab	2.2 ± 0.5ab	6.8 ± 0.8ab
V12 to R9	6.7 ± 0.6c	1.6 ± 0.4b	5.0 ± 0.5b

Means followed by the same letter in a column are not significantly different ($P < 0.05$) by using LSD; 20–40 stalks examined per treatment each year.

pared with 2000 (53.2 mm), but similar in July both years. In contrast, August rainfall was actually higher in 2001 (43.4 mm) than 2000 (22.4 mm). In 2000, compared with treatments where no supplemental water was provided, those receiving water either for the majority of the vegetative stage (beginning when plants were at the 12-leaf stage) until the plants were physiologically mature (R9) or when plants were in the reproductive stage of early bud to physiological maturity (R1 to R9) had significantly fewer weevils. In 2001, weevil densities were lower than the previous year, but treatments receiving water throughout the season (V12 to R9) again had significantly lower weevil densities than the plots with no supplemental water. There was no treatment by year interaction. The combined data were consistent, showing a significant effect of irrigation on numbers of stem weevil larvae per stalk ($F = 6.09$; df = 1, 4; $P = 0.05$). Supplemental water from R1 to R9 and from V12 to R9 significantly reduced weevil numbers per stalk.

The density of *P. womonana* larvae in the stalks was similar in all treatments in 2000, indicating no impact of irrigation (Table 2). However, in 2001 numbers were higher and the plots receiving water throughout the season (V12 to R9) had significantly fewer larvae per stalk. There was no treatment by year interaction, and when combined over years, treatment effect ($F = 1.47$; df = 1, 4; $P = 0.36$) was not significant. Although only conducted over 2 yr, results did indicate in some years irrigation could reduce *P. womonana* densities in sunflower stalks.

In both 2000 and 2001, larval densities of *D. texanus* were higher in some treatments than others, but the differences were not significant (Table 3). As with *P. womonana*, there was no treatment by year interaction, and when combined over years, treatment effect was not significant ($F = 0.43$; df = 1, 4; $P = 0.79$).

Irrigated yields in 2001 were ≈28% lower than yields in 2000 (Table 4). Yield reductions were partly due to a severe sunflower moth, *Homoeosoma electellum* (Hulst), infestation, which also reduced number of seeds per plant. Although rainfall was lower in 2001, due to faulty readings of soil water, insufficient irrigation amounts were applied that year, which also could have impacted yield. However, results did show that supplemental irrigation in some treatments increased seed yields by ≈500 ka/ha each year and also contributed to a higher oil percentage.

Table 2. Mean number of *P. womonana* larvae in stalks of sunflower at five irrigation schedules, Colby, KS, 2000–2001

Irrigation schedule	No. larvae per stalk (mean ± SE)		
	2000	2001	Mean
No supplemental water	0.2 ± 0.1a	1.4 ± 0.5a	0.6 ± 0.2a
R1 to R9	0.2 ± 0.1a	1.1 ± 0.3ab	0.5 ± 0.1a
R6 to R9	0.3 ± 0.1a	1.2 ± 0.2ab	0.6 ± 0.1a
R1 to R5	0.2 ± 0.1a	0.9 ± 0.3ab	0.4 ± 0.1a
V12 to R9	0.1 ± 0.0a	0.5 ± 0.2b	0.2 ± 0.1a

Means followed by the same letter in a column are not significantly different ($P < 0.05$) by using LSD; 20–40 stalks examined per treatment each year.

Table 3. Mean number of *D. texanus* larvae in stalks of sunflower at five irrigation schedules, Colby, KS, 2000–2001

Irrigation schedule	No. larvae per stalk (mean ± SE)		
	2000	2001	Mean
No supplemental water	0.4 ± 0.1a	0.3 ± 0.1a	0.3 ± 0.1a
R1 to R9	0.5 ± 0.1a	0.4 ± 0.2a	0.4 ± 0.1a
R6 to R9	0.5 ± 0.1a	0.3 ± 0.1a	0.4 ± 0.1a
R1 to R5	0.4 ± 0.1a	0.4 ± 0.1a	0.4 ± 0.1a
V12 to R9	0.3 ± 0.0a	0.5 ± 0.1a	0.4 ± 0.1a

Means followed by the same letter in a column are not significantly different ($P < 0.05$) by using LSD; 20–40 stalks examined per treatment each year.

Discussion

Supplemental water reduced densities of sunflower stem weevil larvae within plant stalks in sunflower receiving irrigation over much of the growing season. Sunflower yield was more likely influenced by moisture than numbers of larvae per stalk. Rogers and Jones (1979) showed that yield and oil content in the seed was only reduced in plots averaging 81 larvae per plant. Rainfall probably did not impact larval densities per stalk, because weevil levels were lower in 2001 than 2000, when seasonal rainfall amounts, especially

Table 4. Sunflower yield components at five irrigation schedules, Colby, KS, 2000–2001

Yr	Irrigation schedule	Yield		
		Seeds/plant	kg/ha	% Oil
2000	No supplemental water	1,834 ± 248a	2,368 ± 143c	37.7 ± 04b
	R1 to R9	1,718 ± 244a	2,875 ± 112ab	40.0 ± 0.7a
	R6 to R9	1,811 ± 166a	3,026 ± 148a	40.6 ± 0.5a
	R1 to R5	1,778 ± 107a	2,843 ± 128ab	38.3 ± 0.2b
	V12 to R9	1,784 ± 158a	2,554 ± 121bc	40.2 ± 0.5a
2001	No supplemental water	874 ± 37b	1,610 ± 143b	36.8 ± 0.5b
	R1 to R9	1,001 ± 99ab	2,515 ± 273a	38.3 ± 0.2a
	R6 to R9	964 ± 46ab	2,266 ± 162ab	39.0 ± 0.4a
	R1 to R5	984 ± 64ab	2,072 ± 138ab	36.6 ± 0.4b
	V12 to R9	1,062 ± 61a	2,536 ± 154a	37.2 ± 0.3b

Means followed by the same letter in a column for each year are not significantly different ($P < 0.05$) by using LSD; yield is adjusted to 10% seed moisture.

those occurring early season, were lower. Results were not as conclusive with *P. womonana,* likely because populations were very low in one of the study years, but there was evidence that irrigation produced plants with stems that provided some resistance against root moth larvae. Densities of *D. texanus* were likely too low during the 2 yr of the study to show any effect of supplemental water. An added benefit was an increase in seed yield and seed oil content in plots receiving supplemental irrigation. However, an irrigation study conducted in Texas revealed slightly higher densities of stem weevils in irrigated than in dryland sunflower (Rogers and Jones 1979). However, the plots in that trial only received preplant irrigation. Studies at Hay, KS, also have provided evidence of sunflower resistance to the stem weevil based on plant moisture availability. Populations were greater in the same sunflower varieties planted on similar dates in years of drought-stress compared with those in years having adequate moisture throughout the growing season (J. P. Michaud, personal communication). Additional studies are necessary to determine how environmental factors, especially soil moisture, can impact the guild of stem insects and related mechanisms in the plant that may be responsible for resistance.

The guild of stem-infesting insect pests of cultivated sunflower are a concern to sunflower producers in the central Plains due chiefly to crop losses from plant lodging, caused mainly by the sunflower stem weevil and *D. texanus* (Armstrong et al. 2004, Charlet and Glogoza 2004, Charlet and Aiken 2005). High densities of the latter pest also can result in crop losses to soybean, *Glycine max* (L.) Merr., especially when harvesting is delayed for any reason (Michaud and Grant 2005, Niide et al. 2006). Effective insect management strategies to ensure crop standability and seed protection are critical to sustained sunflower production in this region. Results from this study revealed that ensuring adequate moisture during the growing season can assist in reducing insect densities in the stalk, pointing to an additional crop irrigation advantage beyond that of improved sunflower productivity.

Acknowledgments

We thank Larry Campbell for advice on data analysis, and Theresa Gross for assistance in the laboratory (USDA–ARS, Fargo, ND), Larry Dible for planting and plot maintenance, and Ralph Wolf (Kansas State University, Colby) for field sampling and data collection. The High Plains Committee of the National Sunflower Association provided a portion of the financial support for this project.

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Received 9 March 2007; accepted 9 June 2007.