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Influence of Planting Date on Sunflower Stem Weevil (Coleoptera: Curculionidae) Larval Density and Parasitism in Oilseed and Confection Sunflower in Western Kansas

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Abstract

The sunflower stem weevil infests stalks of cultivated sunflower and can cause lodging resulting in loss of the head prior to harvest. Our objective was to determine whether altered planting periods could reduce weevil densities in confection and oilseed sunflower in the central High Plains production region. We evaluated impact of planting date by measuring larval density within sunflower stalks, larval parasitoid species present, and parasitization rates. Trials were conducted at Colby, KS from 1999 to 2001, with plots seeded in four planting periods. Results, although inconsistent over years and between the two sunflower types, showed that later planting dates reduced weevil density in stalks. Weevil numbers in stalks from the first seeding period until the last had decreased by 10% to 50%. The third planting date in each year coincided with cumulative degree-days (581) for the predicted emergence of 90% of adult sunflower stem weevils. Yields were not reduced as planting was delayed. Fewer weevils were observed in oilseed than in confection hybrids. Lower densities of sunflower stem weevils in the stalk can reduce losses from lodged plants. Seven hymenopteran parasitoid species were reared from sunflower stem weevil larvae. *Nealiolus curculionis* (Fitch) and *Neocatolaccus tylodermae* (Ashmead) were the most common species. Parasitization rates were low, but wasps actively attacked the weevil throughout the growing season. Research showed that delaying planting until after the early and later May planting periods reduced weevil densities in western Kansas.

Introduction

The sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte) (Coleoptera: Curculionidae), is a pest of cultivated sunflower that has caused yields losses in North Dakota (8,13). Since the early 1990s, damage has been reported and population densities of stem weevils have been increasing in the central High Plains sunflower production region of eastern Colorado, western Kansas, and southwestern Nebraska (1,7,9). Adult sunflower stem weevils emerge from overwintered stalks in May to June, and females lay their eggs at the base of sunflower stalks. Larvae feed apically within the stems, 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 densities of larvae in a plant are large, the stem, weakened by tunneling, pith destruction, or overwintering chambers, may break, causing a loss of the entire plant prior to harvest. In the central Great Plains, studies by Armstrong and Koch (1) showed that 90% of adult stem weevils had emerged by 581 degree-days with a delay of 10 to 14 days for mating and the start of egg laying from the time of emergence. Research by Charlet et al. (10) revealed that average densities of 37 larvae per stalk resulted in 28% plant lodging prior to harvest.

Stalk breakage or lodging due to the sunflower stem weevil is most severe during drought stress or when high winds occur as plants are drying prior to harvest (3,19). Natural control of the sunflower stem weevil has been reported in cultivated sunflower, and several species of parasitic wasps attack sunflower stem weevil larvae, with a greater species richness reported in the central High Plains than in the northern Plains (4,9).

The primary tactic to manage sunflower stem weevil populations and prevent yield loss in cultivated sunflower has been the use of insecticides; however, the frequent application of insecticides increases the risk of development of insecticide resistance and kills natural enemies. Cultural control, as part of an integrated pest management program, can be used to modify the cropping environment to reduce pest densities and enhance, or at least not interfere with, the activity of natural enemies (14). When information about pest emergence patterns is available, planting periods can sometimes be established to avoid attack by most of the pest population (12). Part of the basis for this tactic is the influence of plant phenological stage on colonization of the crop and how factors such as oviposition behavior of the pest can change through plant maturation (11,15). Manipulating planting periods has been shown to effectively reduce damage from a number of sunflower pests, including the banded sunflower moth, *Cochylis hospes* Walsingham; the red sunflower seed weevil, *Smicronyx fulvus* LeConte; and the sunflower beetle, *Zygogramma exclamationis* Fabricius, without appreciable loss in seed weight or oil content (5,6,16,17). Early studies on the sunflower stem weevil in North Dakota and Texas indicated that date of planting could result in reduced numbers of larvae in sunflower stems (18,19,20).

Our objective was to determine whether altering planting dates could reduce densities of sunflower stem weevils in cultivated sunflower in the central High Plains production region. We evaluated the impact of planting date on both confection and oilseed sunflower by measuring the overwintering population density of larvae within the sunflower stalk. We also determined the parasitoid species present and rates of parasitization of the overwintering larvae to measure the impact of planting dates on biological control of the weevil.

Experimental Procedures

The trials were conducted at Kansas State University Northwest Research Extension Center plots in Colby, KS, 1999–2001. Plots were planted with 17,000 seeds per acre at four intervals to range from an early to late planting period. The planting dates were 10 and 24 May and 7 and 21 June, 1999; 5 and 19 May and 1 and 15 June, 2000; and 11 and 24 May and 8 and 22 June, 2001. In all three years, the confection hybrid was Sigco 954 and the oilseed hybrid was Cargill 187 (= Mycogen SF187). In 1999, a randomized block design with four replicates was used, with each hybrid in a separate plot. Plots in both 2000 and 2001 were planted using a split block design with four replicates. Planting date was the main plot, with hybrid type as the sub-plots. Plots were 12 rows wide by 18 m long, with rows 76 cm apart and plants spaced 30.5 cm apart within rows. The plots received a preplant application of fertilizer and herbicide, but no other chemical treatments were used. Plots were not irrigated.

Five (10 in 2000) randomly selected stalks (lower 45- to 50-cm section plus the root crown) per plot (total of 20 [40 in 2000] per treatment) were removed after plants had reached the R9 stage (22) and senesced (usually in October of each year), and were sent to the first author's laboratory in Fargo, ND, for evaluation. Yield was determined in 2000 and 2001 by harvesting heads at physiological maturity from two 5.5-m rows per plot and compared as seed weight in kg/ha. Stalks were stored at 5°C for a minimum of 6 weeks to break diapause of the weevils. The diameter of each stalk was measured, the stalks were then split, and the weevils were extracted from their chambers. The number of weevil larvae in each stem was determined. Larvae were reared individually in small, multi-chambered plastic units at 24 ± 2°C, 50 to 60% RH, and a photoperiod of 15:9 (L:D) h for emergence of adults or parasitoids (2). Larvae were held until eclosion of adult weevils, emergence of parasitoids, or death. Dead larvae were not dissected to examine for the presence of parasitoids.

Percentage parasitization was determined from the number of parasitoids recovered relative to the total number of sunflower stem weevil larvae reared. Parasitoid identifications were verified by examining specimens previously determined by specialists at the USDA-ARS Systematic Entomology Laboratory (Beltsville, MD), Canadian National Collection of Insects (Ottawa, Ontario, Canada), or Texas A&M University. Voucher specimens were placed in the first author's sunflower insect collection (USDA-ARS Northern Crop Science Laboratory, Fargo, ND) and in the North Dakota State Insect Reference Collection, Department of Entomology, North Dakota State University, Fargo, ND.

The analysis of variance option of the GLM procedure (21) was used to compare stem diameter, weevil number, yield, and rates of parasitization among the four planting periods for each study year and across years. Significantly different means were separated using least significant difference (LSD) ($P < 0.05$). Percentages were transformed using arc sine before analysis (21).

Results from 1999

In 1999, weevil densities in oilseed sunflower from the first three planting dates were equivalent ($F = 6.76$; df = 3, 73; $P = 0.0004$) (Table 1). But, in the confection hybrid, there was a significant reduction at each progressively later planting date, with numbers of weevils per stalk declining by one fourth from the first (10 May) to the last (21 June) planting date ($F = 30.00$; df = 3, 73; $P < 0.0001$) (Table 2). Weevil densities in the stalks were two to three times greater in the confection hybrids than in the oilseed hybrids within each planting date. Planting date did not have an effect on stem diameter in oilseed sunflower (Table 1), but confection sunflower stalks were thicker in the first planting date than in the other three dates (Table 2). Rates of parasitization were low overall, but were greater at the later planting dates in both the oilseed ($F = 3.74$; df = 3, 73; $P = 0.0148$) and confection hybrids ($F = 5.00$; df = 3, 73; $P = 0.0033$) (Tables 1 and 2). Five species of parasitoids were reared from sunflower stem weevil larvae during 1999. All were Hymenoptera and included: *Nealiolus curculionis* (Fitch) (Braconidae); *Neocatolaccus tylodermae* (Ashmead), *Chlorocytus* sp., *Quadrastichus ainsliei* Gahan (Eulophidae); and *Eurytoma tylodermatis* Ashmead (Eurytomidae). *Nealiolus curculionis* represented over 77% of the identified parasitoids. With the exception of *E. tylodermatis* (only one specimen was recovered), the wasps were reared from weevil larvae from both oilseed and confection sunflower.

Table 1. Mean number of sunflower stem weevil larvae in stalks of oilseed type sunflower at four planting dates, Colby, KS, 1999–2001.

Year	Planting date	No. stalks	Stem diameter	No. weevil larvae per stalk	% parasit-ization	Cumul-ative degree-days[x]
			(mean±SE)			
1999	10 May	20	2.4±0.1a	27.8±2.9a	2.2±0.7ab	297
	24 May	20	2.3±0.1a	25.1±2.6a	0.8±0.6a	428
	7 June	20	2.4±0.1a	21.8±2.6a	4.3±1.4bc	610
	21 June	20	2.2±0.1a	13.1±1.8b	8.5±3.2c	793
	LSD	--	0.2	6.9	5.0	--
2000	5 May	40	2.1±0.0c	22.5±2.8a	4.0±1.0a	241
	19 May	40	2.8±0.1a	8.9±0.9b	0.9±0.5b	373
	1 June	40	2.7±0.1ab	13.9±2.2b	1.3±0.4b	551
	15 June	40	2.6±0.1b	9.8±0.9b	1.1±0.7b	765
	LSD	--	0.2	5.4	1.9	--
2001	11 May	20	2.3±0.1a	53.8±6.6a	7.7±1.3a	293
	24 May	20	2.5±0.1a	55.0±5.0a	9.3±1.3ab	440
	8 June	20	2.3±0.1a	26.6±3.8b	10.4±1.7ab	596
	22 June	20	2.3±0.1a	20.8±7.4b	24.8±8.4b	789
	LSD	--	0.3	16.4	15.6	--
Combined	1st	80	2.2±0.0a	31.6±2.7a	4.5±0.6a	--
	2nd	80	2.6±0.0a	24.5±2.6a	3.0±0.6a	--
	3rd	80	2.5±0.0a	19.0±1.7a	4.3±0.7a	--
	4th	80	2.4±0.0a	13.3±2.0a	8.2±2.3a	--

Means followed by the same letter in a column within each year are not significantly different ($P < 0.05$) using LSD. Percentages transformed using arc sine before analysis.

[x] Calculated from 1 January using base of 6°C with 32°C upper limit

Table 2. Mean number of sunflower stem weevil larvae in stalks of confection type sunflower at four planting dates, Colby, KS, 1999–2001.

Year	Planting date	No. stalks	Stem diameter	No. weevil larvae per stalk	% parasit-ization	Cumul-ative degree-days[x]
			(mean±SE)			
1999	10 May	20	3.3±0.1a	80.3±6.5a	0.6±0.4a	297
	24 May	20	3.0±0.1b	62.7±6.3b	2.3±0.6bc	428
	7 June	20	2.8±0.1b	37.8±3.7c	2.0±0.6ab	610
	21 June	20	2.7±0.1b	20.6±1.9d	5.3±1.3c	793
	LSD	--	0.3	13.6	2.1	--
2000	5 May	35	2.6±0.1b	36.3±5.3a	1.5±0.6a	241
	19 May	39	2.7±0.1b	15.6±2.0c	0.5±0.4a	373
	1 June	40	3.0±0.1a	26.5±4.0b	1.5±0.7a	551
	15 June	39	2.5±0.1b	19.7±2.1bc	0.8±0.3a	765
	LSD	--	0.2	9.6	1.4	--
2001	11 May	20	2.5±0.1ab	84.3±9.5a	5.5±1.1a	293
	24 May	20	2.2±0.1a	44.8±8.5b	5.9±1.0a	440
	8 June	20	2.4±0.1ab	37.4±4.6b	10.3±1.8a	596
	22 June	20	2.6±0.2b	8.2±2.2c	10.0±3.0a	789
	LSD	--	0.3	19.1	4.6	--
Combined	1st	75	2.8±0.1a	60.8±4.7a	2.3±0.5a	--
	2nd	79	2.6±0.1a	34.9±3.6ab	2.2±0.4a	--
	3rd	80	2.8±0.1a	32.0±2.5ab	3.9±0.7a	--
	4th	79	2.6±0.1a	17.0±1.4b	3.8±0.8a	--
	LSD	--	--	24.4	--	--

Means followed by the same letter in a column within each year are not significantly different (P < 0.05) using LSD. Percentages transformed using arc sine before analysis.

[x] Calculated from 1 January using base of 6°C with 32°C upper limit

Results from 2000

Population densities of weevil larvae in the stalks from the first planting date in 2000 (5 May) in the oilseed sunflower were similar to densities in the first planting in 1999 (10 May), but densities declined significantly in 2000 from the first to the second planting date (19 May) (F = 10.40; df = 3, 153; P < 0.0001) (Table 1). Densities were statistically equal in the second (19 May), third (1 June), and fourth (15 June) planting dates. In the confection sunflower, weevil numbers also decreased from the first (5 May) to the second planting date (19 May), but increased from the second to the third (1 June) planting date (F = 6.82; df = 3, 146; P = 0.0002). However, densities remained smaller than the mean density from the first planting date. Population densities were lower in the confection sunflowers in 2000 than in 1999. There was some variation in stem diameter among planting dates from both oilseed and confection sunflower, with stalk diameter increasing in as planting date was delayed (Tables 1 and 2). In both the oilseed and confection sunflowers there was no difference in seed yield among the second, third, and fourth planting dates (Table 3). Overall, percentage parasitization of weevil larvae was less in 2000 than in 1999 in both the oilseed and confection sunflower plots. In the oilseed sunflower plots, percentage parasitization from the first planting date was greater than from the three later planting dates (F = 5.18; df = 3, 148; P = 0.002) (Table 1). There was no difference in parasitization among any planting dates in the confection sunflower plots (F = 1.72; df = 3, 141; P = 0.1664) (Table 2). Two additional species of Hymenoptera were recovered in 2000, *Nealiolus collaris* (Brues) (Braconidae) and *Pteromalus anthonomi* (Ashmead) (Pteromalidae), but were represented by only three individuals. *Nealiolus curculionis* and *Neocatolaccus tylodermae* were the most common species recovered and together represented more than 50% of the parasitoids reared from weevils in the sunflower stalks.

Table 3. Sunflower yield (kg/ha) for oilseed and confection type sunflower at four planting dates, Colby, KS, 2000–2001.

		Yield (kg/ha)	
Year	**Planting date**	**Oilseed**	**Confection**
2000	5 May	939.7a	635.0a
	19 May	1864.8b	1329.4b
	1 June	2178.4b	1559.0b
	15 June	1905.1b	1275.7b
	SE	159.0	199.4
	LSD	359.5	451.4
2001	11 May	103.0a	294.6a
	24 May	953.1b	834.4bc
	8 June	1080.8b	759.4b
	22 June	1397.8b	1223.0c
	SE	315.8	172.5
	LSD	713.4	390.9

Means followed by the same letter in a column within each year are not significantly different (P < 0.05) using LSD.

Results from 2001

In 2001, weevil densities in the oilseed sunflower plots (F = 9.49; df = 3, 73; P < 0.0001) were the greatest of the three study years (Table 1). The last two planting dates (8 and 22 June) had similar numbers of weevils in the stalks and were half of the levels of the first two planting dates (11 and 24 May). Sunflower stem weevil larvae also were abundant in the confection sunflower plots, with numbers again much higher than in the oilseed sunflower plots (F = 21.34; df = 3, 73; P < 0.0001) (Table 2). There was a significant decrease in density of sunflower stem weevil larvae from the first (11 May) to the second (24 May) planting date, and also from the second and third (8 June) to the fourth (22 June) planting date. Numbers dropped by 90% from the first to the last planting date in the confection sunflower plots. Stem diameter in oilseed sunflower were similar among all four planting dates (Table 1), but some variation was evident in the confection sunflower among the dates of planting (Table 2). In the oilseed sunflowers, as in 2002, seed yield was statistically equal in the second, third, and fourth planting dates (Table 3). Sunflower seed yield showed a trend for higher weights as planting date was delayed (Table 3). Rates of parasitization were at their highest in 2001 among the three study years, ranging from 8 to 25% in the oilseed sunflower plots (F = 4.00; df = 3, 68; P = 0.011) and from 6 to 10% in the confection sunflower plots (F = 1.60; df = 3, 64; P = 0.1986) (Table 1 and 2). The most prevalent species of parasitoids reared from weevils were *N. curculionis* and *N. tylodermae*, representing 44 and 23% of those collected.

Summary

For the hybrids evaluated in this study, densities of weevils in confection sunflower appeared to be greater than in oilseed sunflower during each of the years of the trial. A paired comparison of the stem weevil densities per stalk between the oilseed and confection hybrids combined for the study years 2000 and 2001 revealed that the numbers of larvae were significantly greater in the confection sunflower stalks (t = -4.18, df = 329, $P < 0.0001$).

In general, results were similar among individual years and between the two sunflower types, showing that as planting date was delayed, weevil density in the stalks was reduced. Sunflower stem weevil numbers in the stalks declined from the first planting date until the last planting date by at least 50%. Over the three study years (Tables 1 and 2), cumulative degree-days at the time sunflowers were seeded on the third planting date coincided with the accumulation of 581 degree-days when 90% emergence of adult sunflower stem weevil is predicted (1). These findings, therefore, provide some validity for the use of degree-day emergence models to assist in sunflower planting recommendations. Based on the data collected in years in which seed weight was evaluated, delayed planting was not detrimental to yield, so would not be a trade-off for the producer in managing sunflower stem weevil.

When comparisons were made across years, however, results were somewhat inconsistent. The non-significant planting date effect (df = 3, 6; $F = 2.99$; $P = 0.12$) combined with the significant planting date by year interaction (df = 2, 299; $F = 7.23$; $P < 0.0001$) indicated that planting date was not consistent across years in reducing stem weevil density in oilseed sunflowers. In confection sunflowers, there was a significant planting date effect (df = 3, 6; $F = 5.30$; $P = 0.04$) combined with a significant date by year interaction (df = 2, 292; $F = 10.43$; $P < 0.0001$), showing that planting date was consistent in reducing weevil numbers in the stalks. Analysis of stem diameter for oilseed (df = 3,6; $F = 0.64$; $P = 0.62$) and confection (df = 3,6; $F = 0.45$; $P = 0.73$) across years showed no significant planting date effect. Thus, it seems that delayed planting would be reliable every year in reducing weevil numbers in confection stalks. However, delayed planting might not effectively lower stem weevil densities in oilseed sunflowers in some years. These findings confirm research conducted previously in North Dakota (18) and Texas (19,20) that revealed that delayed planting was effective in reducing numbers of weevils overwintering in sunflower stalks. Yield losses due to lodging are reduced when densities of sunflower stem weevils are smaller.

Several species of parasitoids were recovered during the three years of the study. Analysis across years showed no significant planting date effect on larval parasitism in either oilseed (df = 3,6; $F = 1.22$; $P = 0.38$) or confection sunflowers (df = 3,6; $F = 0.83$; $P = 0.52$). Although parasitization rates were low, the wasps actively oviposited in the sunflower stem weevil in both sunflower types and in all planting periods. Based on the research from this three-year study, sunflower growers in the central Plains production region where sunflower stem weevil is a problem would benefit from delaying planting until June in most years to reduce losses in oilseed and confection sunflower caused by high densities of this insect pest.

Acknowledgments and Disclaimer

Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

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