Integrated pest management of the banded sunflower moth in cultivated sunflower in North Dakota

Janet J. Knodel[1], Laurence D. Charlet[2]
[1]Department of Entomology, Hultz Hall,
North Dakota State University, Fargo, ND 58105 USA, E-mail: janet.knodel@ndsu.edu
[2]USDA, ARS, Northern Crop Science Laboratory,
1307 18th St. N, Fargo, ND 58105 USA, E-mail: larry.charlet@ars.usda.gov

ABSTRACT

Banded sunflower moth, *Cochylis hospes* Walsingham (Lepidoptera: Tortricidae), is a key insect pest of cultivated sunflowers in North Dakota. We investigated pest management strategies to reduce feeding injury caused by the banded sunflower moth in commercial oilseed and confection sunflower fields located in north central North Dakota during 2005-2006. Seed damage from banded sunflower moth was more concentrated on field edges than at 20 m, 40 m and 150 m in the field. As a result, edge spraying was as effective as whole field spraying in controlling banded sunflower moth when populations were low to moderate. Early planted sunflower had a higher percentage of seed damage than later planted sunflower regardless of sunflower type. There was a positive linear relationship between the percent of damaged seed and the subsequent number of banded sunflower moth larvae emerging from heads. The presence of sunflower in adjacent fields had a diluting effect on field densities of banded sunflower moth. In contrast, when sunflower was not present in adjacent fields, fields had a concentrating effect with higher densities of banded sunflower moth. Sixty-one percent of banded sunflower moth reared were parasitized by two species of parasitoids: *Glypta prognatha* Dasch (Hymenoptera: Ichneumonidae) and *Chelonus phaloniae* (Mason) (Hymenoptera: Braconidae). Parasitism rates were negatively impacted by insecticide spraying in field edges. Parasitoids were effective in searching from field edges to 40 m into the field and were not dependent on the presence of sunflower in the landscape.

Key words: banded sunflower moth – biological control – *Cochylis hospes* Walsingham – insecticide control – integrated pest management – sunflower.

INTRODUCTION

Banded sunflower moth, *Cochylis hospes* Walsingham (Lepidoptera: Tortricidae), is a major pest of sunflower in the northern Plains and populations have been increasing in recent years in North Dakota. Adults begin to emerge from the soil about mid-July and are present in the field until mid-August (Mundal et al., 2006). Adults tend to congregate in field margins on weeds or adjacent crops during the day and then move to 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 seeds, and also destroy mature seeds. At maturity, larvae drop to the ground and spin cocoons in the soil to overwinter (Charlet and Gross, 1990; Charlet et al., 1997). The primary management strategy for control of banded sunflower moth has been the use of insecticides, although research has also shown that delayed planting can reduce feeding damage (Knodel and Charlet, 2007). In addition, crop management programs relying primarily on insecticide usage can be detrimental to parasitoid diversity and activity. Several parasitoid species attack banded sunflower moth (Charlet, 1999, 2001). However, in most years the control exerted by parasitoids is inadequate to maintain banded sunflower moth populations below economic injury levels. Understanding the population dynamics of the pest and its natural enemies will provide valuable information that could improve control of banded sunflower moth in cultivated sunflower. The integration of different pest management strategies has the potential to provide more effective control with reduced input costs for sunflower producers.

The goal of this project was to investigate the integration of pest management strategies to reduce input costs and overall feeding injury caused by banded sunflower moth in commercial confection and oilseed sunflower fields. The effectiveness of treating only the margins of sunflower fields was evaluated for reducing economic losses from banded sunflower moth in early and late planted fields. In addition, the impacts of landscape and parasitoid complex were determined on populations of banded sunflower moth. The discovery of the most effective combination of control tactics to manage banded sunflower moth will enable producers to reduce yield loss and save money by lowering insecticide treatment costs.

Cooperation from a certified crop consultant ensured that commercial sunflower producers could readily adapt results. This helps to validate the field research in a real-life setting.

MATERIALS AND METHODS

Sunflower fields in north central North Dakota were selected in cooperation with a certified crop consultant. During 2005, eight commercial oilseed sunflower fields in Renville and Bottineau counties of ND were either treated or untreated only around the perimeter of the field with a registered sunflower insecticide, Lorsban (chlorpyrifos, Dow AgroSciences LLC, Indianapolis, IN, USA). Lorsban was applied at 1 pt per acre and 3 GPA by air when the crop was at the 10% ray petal stage. In the past several years, many fields in this region have been treated with insecticides only on the outer 61 m of the field. The influence of landscape, including sunflowers in adjacent fields, was also studied to determine the impact on abundance and field distribution of both the pest and its parasitoids. A total of eight fields were sampled on 31 August 2005. Five randomly selected sunflower heads containing mature banded sunflower moth larvae were collected from the edge, 20 m and 40 m into the field on each side of the field (a total of 60 heads per field). The heads were bagged individually, labeled, and returned to the USDA, ARS laboratory at Fargo. Banded sunflower moth larvae were extracted from the heads and reared in the laboratory to determine pest and parasitoid density, parasitoid species richness, and parasitism rates. Each head was dried, threshed, and subsamples of 100 seeds were evaluated for seed damage.

In 2006, commercial fields were selected from both confection and oilseed sunflower that were either treated or untreated, and planted early (prior to mid-May) or late (late May to mid-June). There were three replicates of the following treatments: (1) early planted, sprayed, oilseed fields; (2) late planted, sprayed, oilseed fields; (3) early planted unsprayed, oilseed fields (only two fields sampled); (4) late planted, unsprayed, oilseed fields; 5) early planted, sprayed, confection fields; (6) late planted, sprayed, confection fields; (7) early planted unsprayed, confection fields; and (8) late planted, unsprayed, confection fields. Field were aerial sprayed using 3 GPA, and the insecticide Asana (esfenvalerate, E. I. du Pont de Nemours and Co., Wilmington, DE, USA) applied at 9 fl oz per acre or the insecticide Baythroid XL (beta-cyfluthrin, Bayer Crop Sciences, RTP, North Carolina, USA) applied at 2.8 fl oz per acre. Applications were made at the 10% ray petal stage (or when early instar larvae of banded sunflower moth were present). A total of 23 fields were sampled on 25-26 September 2006. Ten randomly selected sunflower heads were collected at distances of edge (5 m), 40 m, and 150 m from two sides of each field for a total of 60 heads per field. The heads were bagged individually, labeled, and returned to the USDA, ARS laboratory at Fargo. Each head was dried, threshed and subsamples of 100 seeds were evaluated for damage by banded sunflower moth.

The effect of treated and untreated sunflower fields were compared by determining the percent of damaged seed within each sunflower field for both years. In 2005, landscape, parasitoid species richness, percent parasitism, and density of banded sunflower moth larvae also were compared. In 2006, planting date and sunflower type also were also analyzed. Data were evaluated at different sampling distances from the field edge for both years. Data were analyzed using ANOVA and Fisher's Protected LSD to separate means at the 5% significance level. Linear regression was used to determine the relationship between damaged seed in sunflower heads and the number of emerged larvae. Before analysis, banded sunflower moth data for larvae and damaged seeds were square root transformed due to non-normal distributions of residuals and non-homogeneity of variance.

RESULTS

A total of 5,242 tortricid larvae emerged from the 480 sunflower heads collected from the eight field sites in 2005. Thirty-six percent of emerged larvae were identified as *Cochylis* spp., 61 percent were parasitized and the remaining three percent died from unknown factors. Of the *Cochylis* species, 69 percent were *C. hospes* and 31 percent were *C. arthuri*. Of the parasitoids reared from *Cochylis* spp.: 53 percent were *Glypta prognatha* Dasch (Hymenoptera: Braconidae), 45 percent were *Chelonus phaloniae* (Mason) (Hymenoptera: Ichneumondiae), and 2 percent were a hyperparasitoid *Perilampus robertsoni* Crawford (Hymenoptera: Perilampidae).

In this study, untreated fields were monitored for populations of banded sunflower moths and were not treated because population levels were below the economic threshold level. There were significantly lower percent of damaged seed (F = 1.10; df = 1, 82; P = 0.2971), mean number of larvae (F = 0.37; df = 1, 82; P = 0.5033) and percent parasitism (F = 1.42; df = 1, 82; P = 0.2369) in the treated fields compared to the untreated fields in 2005 (Table 1). There were no significant differences in head diameter between untreated and treated sunflower fields. Results indicate that spraying on edges can successfully reduce moth damaged seed and mean number of banded sunflower moth larvae emerging from the seed. However, these results could vary depending on locality and year-to-year population densities of banded sunflower moth. As anticipated, insecticide spraying had a negative impact on the parasitoid complex, reducing parasitism by 6.9 percent.

Table 1. Effects of spraying edges of sunflower fields on head diameter, percent seed damaged by banded sunflower moth, mean number of larvae and percent parasitism in 2005

Location	Head diameter (cm)	% Damaged Seeds[1]	Mean number of larvae[1]	% Parasitism
Treated[2]	18.6 a	1.6 a	42.4 a	19.1 a
Untreated	17.9 a	2.5 b	74.1 b	26.0 b

Means within a column followed by the same letter are not significantly different (P< 0.05), Fisher's Protected LSD.
[1]Data transformed using square root, untransformed means presented.
[2]Lorsban applied at 1 pt per acre during 10% ray petals by air using 3 GPA, edge spray application.

For 2006, there also were significantly lower percent of banded sunflower moth damaged seed in treated fields compared to the untreated fields for both confection (F = 88.78; df = 1, 60; P =< 0.0001) and oilseed (F = 10.54; df = 1, 60; P = 0.0019) sunflower (Table 2). There were no significant differences for head diameter between untreated and treated field regardless of sunflower type. Results indicated that whole field spraying was successful in reducing damaged seed when populations of banded sunflower moth were moderate to high.

Table 2. Effects of spraying whole sunflower fields on head diameter and percent seed damaged by banded sunflower moth in confection and oilseed sunflowers in 2006

Location	Confection		Oilseed	
	Head diameter (cm)	% Damaged Seeds[1]	Head diameter (cm)	% Damaged Seeds[1]
Treated[2]	18.2 a	2.3 a	17.8 a	2.3 a
Untreated	17.6 a	10.6 b	17.7 a	3.1 b

Means within a column followed by the same letter are not significantly different (P< 0.05), Fisher's Protected LSD.
[1] Data transformed using square root, untransformed means presented.
[2] Asana (9 fl oz per acre) or Baythroid (2.8 fl oz per acre) was applied during 10% ray petals by air using 3 GPA, whole field spray application.

Comparison of early versus late-planted sunflower fields indicate that early planting dates had a significantly higher percent of damaged seed (F = 20.15, df = 1, 60, P =< 0.0001) than late planting dates for oilseed sunflower in 2006 (Table 3). There were no significant differences in head diameter between the two planting dates regardless of the sunflower type.

Table 3. Effects of early versus late planted sunflowers on head diameter and percent seed damaged by banded sunflower moth in confection and oilseed sunflowers in 2006

Location	Confection		Oilseed	
	Head diameter (cm)	% Damaged Seeds[1]	Head diameter (cm)	% Damaged Seeds[1]
Early planted	18.2 a	6.6 a	17.9 a	3.6 a
Late-planted	17.6 a	6.5 a	17.5 a	2.0 b

Means within a column followed by the same letter are not significantly different (P< 0.05), Fisher's Protected LSD.
[1] Data transformed using square root, untransformed means presented.

In 2005, the comparison of sampling locations revealed that the edge sample had significantly higher percent damaged seed (F = 8.35; df = 2, 82; P = 0.0005) and mean number of larvae emerging from heads (F = 12.24; df = 2, 82; P =< 0.0001) than the 20 m and 40 m samples (Table 4). There were no significant differences among the sampling locations for head diameter or percent parasitism. When data for treated and untreated sunflower fields were analyzed separately (results not presented), results were identical to the combined analyses. Results indicate that field edges harbor higher numbers of banded sunflower moth larvae than the samples collected at 20 m and 40 m in fields. These data validate why field edge spraying can be effective in controlling banded sunflower moth when populations are low to moderate. Parasitoids were as proficient in searching for banded sunflower moth larvae in the edge as they were in 20 m and 40 m within fields.

Table 4. Effects of sampling locations from combined (treated and untreated) sunflower fields on head diameter, percent damaged seed by banded sunflower moth, mean number of larvae and percent parasitism in 2005

Location	Head diameter (cm)	% Damaged Seeds[1]	Mean number of larvae[1]	% Parasitism
Edge	18.2 a	3.4 a	102.8 a	23.8 a
20 M	18.2 a	1.6 b	43.6 b	21.0 a
40 M	18.3 a	1.0 b	28.3 b	22.8 a

Means within a column followed by the same letter are not significantly different (P< 0.05), Fisher's Protected LSD.
[1] Data transformed using square root, untransformed mean presented.

Edge samples in 2006 had significantly higher percent damaged seed than the 40 m and 150 m samples for both confection (F = 8.12; df = 2, 60; P = 0.0008) and oilseed (F = 5.25; df = 2, 60; P = 0.0080) sunflower (Table 5). There were no significant differences among sampling locations for head diameter. When data for untreated or treated confection or oilseed sunflower fields were analyzed separately (results not presented), results were identical to the combined analyses. The 2006 results were identical to results in 2005 and further support that field edges have higher numbers of banded sunflower moth than the samples collected in the field.

Table 5. Effects of sampling locations from combined (treated and untreated) sunflower fields on head diameter and percent seed damaged by banded sunflower moth in confection and oilseed sunflowers in 2006

Location	Confection		Oilseed	
	Head diameter (cm)	% Damaged Seeds[1]	Head diameter (cm)	% Damaged Seeds[1]
Edge	18.0 a	9.5 a	17.5 a	3.5 a
40 m	17.5 a	5.7 b	17.7 b	2.0 b
150 m	18.2 a	5.3 b	18.0 a	2.6 b

Means within a column followed by the same letter are not significantly different (P< 0.05), Fisher's Protected LSD.
[1] Data transformed using square root, untransformed means presented.

Landscape effects were evaluated only for 2005 (Table 6). Fields without sunflower fields nearby had a significantly higher mean number of banded sunflower moth larvae (F = 3.61; df = 1, 82; P = 0.0611) than fields that were adjacent to sunflower fields. However, there were no significant differences for percent damaged seeds, percent parasitism or head diameter. When data were analyzed separately by treated and untreated sunflower fields (results not presented), results were identical to the combined analyses. Since fields with non-sunflower fields nearby had higher mean number of larvae, this suggests that the presence of the host plant is a density-dependent factor for banded sunflower moth populations. The opposite was observed for parasitoids with no landscape effects on parasitism, which suggests that parasitoids are not density-dependent on sunflower in the landscape.

Table 6. Landscape effects on head diameter, percent damaged seeds by banded sunflower moth, mean number of larvae and percent parasitism in 2005

Adjacent Fields	Head diameter (cm)	% Damaged Seeds[1]	Mean number of larvae[1]	% Parasitism
Sunflower	17.7a	1.3a	23.8a	17.6a
Non-sunflower	18.3a	2.1a	63.5b	23.3a

Means within a column followed by the same letter are not significantly different (P< 0.05), Fisher's Protected LSD.
[1] Data transformed using square root, untransformed means presented.

Mean number of larvae that emerged from the seed resulted in a significant parameter estimates and a significant relationship to percent damaged seeds [square root of mean number of larvae emerged from seed = 1.4870 (square root of percent damaged seeds) + 1.1415; N = 89, R^2 = 0.498, P< 0.0001] (Fig. 1). This indicates a positive relationship between the number of larvae emerging from seed and the percent of damaged seeds.

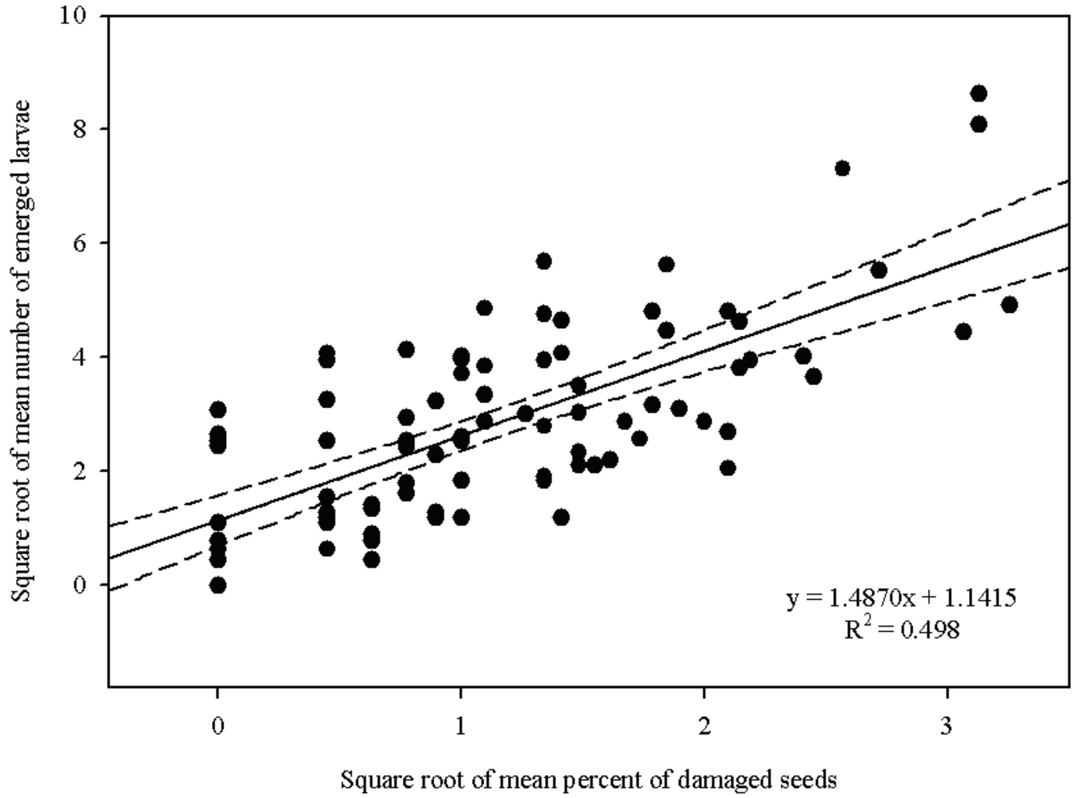

Fig. 1. Relationship between mean percent of damaged seeds and mean number of emerged larvae (n=89) across all locations and treatments. The solid line represents the best fit linear equation. Dashed lines represent 95% confidence intervals.

DISCUSSION

Since the early 1980s, cultivated sunflower fields in North Dakota, Minnesota and South Dakota have had frequent economic damage caused by banded sunflower moth (Charlet and Busacca, 1986; Charlet and Glogoza, 2004). Insecticide spraying decisions are based on sampling for eggs or adults of banded sunflower moth in fields during mid to late July (Knodel and Charlet, 2007; Knodel et al., 2008). In our study, edge spraying was effective in controlling banded sunflower moth because populations of banded sunflower moth were found to be concentrated in field edges. However, edge spraying was only effective in controlling banded sunflower moth when population levels were low to moderate. When populations of banded sunflower moth were higher in 2006, whole field spraying was required to control banded sunflower moths. A positive linear relationship was established between percent damaged seed and the subsequent number of banded sunflower moth larvae emerging from heads. Manipulating planting dates to avoid oviposition minimized damage caused by banded sunflower moth. Late planting sunflower fields into June could provide producers with a cultural control tactic to mitigate banded sunflower moth damage. Oseto et al. (1989) also reported that sunflower planted late (early June) in southeastern North Dakota had fewer damaged seeds than sunflower planted early (first week in May). The presence of sunflower in the landscape had a diluting effect on field densities of banded sunflower moth. In contrast, when sunflower was not present in the landscape, a concentrating effect was observed with higher densities of banded sunflower moths in that sunflower field.

Charlet (1999, 2001) identified several species of parasitoids attacking banded sunflower moth. Sixty-one percent of banded sunflower moth larvae reared were parasitized by two species of parasitoids: *Glypta prognatha* and *Chelonus phaloniae*. Parasitism rates were negatively impacted by insecticide spraying in field edges. Parasitoids were effective in searching from field edges to 40 m into the field and were not dependent on the presence of sunflower in the landscape.

In summary, this research supports the concept of integrating cultural control, biological control and insecticide control, which together can be used effectively to reduce banded sunflower moth damage in cultivated sunflowers in North Dakota.

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REFERENCES

Charlet, L.D. 1999. Biological control of sunflower pests: searching for new parasitoids in native *Helianthus* - challenges, constraints, and potential, p. 91-112. In: L.D. Charlet and G.J. Brewer (eds), Biological Control of Native or Indigenous Insect Pests: Challenges, Constraints, and Potential, Thomas Say Publications in Entomology, Entomol. Soc. Am., Lanham, MD, USA.

Charlet, L.D. 2001. Biology and seasonal abundance of parasitoids of the banded sunflower moth (Lepidoptera: Tortricidae) in sunflower. Biological Control 20:113-121.

Charlet, L.D., and J.D. Busacca. 1986. Insecticidal control of banded sunflower moth, *Cochylis hospes* (Lepidoptera: Cochylidae), larvae at different sunflower growth stages and dates of planting in North Dakota. J. Econ. Entomol. 79:648-650.

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., G.J. Brewer, and B. Franzmann. 1997. Insect pests, p. 183-261. In. A. A. Schneiter (ed.), Sunflower Production and Technology. Agronomy Monograph 35. ASA, CSSA and SSSA, Madison, WI, USA.

Knodel, J.J., and L.D. Charlet. 2007. IV. Pest Management – Insects. In: D.R. Berglund (ed.), Sunflower Production, NDSU Ext. Serv. A-1331 (EB-25 Revised).

Knodel, J.J., P. Beauzay, M. Boetel, and D. Markle. 2008. 2008 North Dakota Field Crop Insect Management Guide. NDSU Ext. Serv., E-1143.

Mundal, K.D., G.J. Brewer, L.D. Charlet, and J.J. Knodel. 2006. Banded Sunflower Moth. NDSU Ext. Serv. E-823 (revised), November 2006.

Oseto, C.Y., L.D. Charlet, and J.D. Busacca. 1989. Effects of planting date on damage caused by the banded sunflower moth (Lepidoptera: Cochylidae) in the northern Great Plains. J. Econ. Entomol. 82:910-912.