Biology of Sunflower Seed Maggot (*Neotephritis finalis*) (Diptera: Tephritidae):

Results from 2008 field studies

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Introduction

Sunflower (*Helianthus annuus* L.) is one of only a very few domesticated crops native to North America. It is commercially cultivated on a large scale in the United States in the northern Plains (North Dakota and South Dakota) and the southern High Plains (western Nebraska and Kansas, plus areas of Colorado and Texas) where the growing season is often too dry and/or too short for profitable soybean and corn production (Tatta, 2001). North Dakota ranks first in sunflower production in the United States (Berglund, 2007).

Sunflowers are subjected to attack by an extensive number of insect species (Charlet et al. 1997). The major insect pests of sunflower in the northern Great Plains include banded sunflower moth, sunflower beetle, sunflower stem weevil, red sunflower seed weevil, and sunflower midge (Charlet et al. 1997). High insect pest densities have reduced yields and have led to reduction in hectares planted in some production areas. Among the insect species associated with sunflower, the most important and damaging pests are head-feeding insects (Charlet et al. 1997).
The sunflower seed maggot, *Neotephritis finalis* (Loew), can be a serious pest of sunflower and is distributed throughout North America. It ranges in southern Canada from Alberta to Manitoba south to Virginia and Georgia and west to California and into northern Mexico (Arthur and Campbell 1979). In the early 1970s, the sunflower seed maggot was described as potentially the most destructive pest of sunflower seed in north Georgia and was reported to infest plants throughout the growing season (Beckham and Tippins 1972). Recent field observations have revealed that *N. finalis* is widely distributed throughout North Dakota and can cause substantial damage to sunflower heads (NSA sunflower surveys).

Sunflower seed maggot appears to be a polyphagous insect. It is also reported to attack cultivated sunflower, wild sunflower and many other species of the family Asteraceae (Goeden et al. 1987). Many of the hosts are members of the subtribe Verbesininae of the tribe Heliantheae. Other hosts of the family Asteraceae include *Balsamorhiza deltoidea* (deltoid balsamroot), *Encelia frutescens* (bush encelia), *Encelia virginensis* (virgin river brittle bush), *Encelia californica* (Coast Sunflower), *Geraea canescens* (desert sunflower), *Helianthus gracilentus* (slender sunflower), *Helianthus niveus* (snowy sunflower), *Viguierra deltoidea* (triangle goldeneye), and *Wyethia ovata* (southern mule ears). Additional hosts of sunflower seed maggot include *Aster spinosus* (Mexican devil-weed), *Balsamorhiza sagittata* (arrowleaf balsamroot), *Eriophyllum lanatum* (Common woolly sunflower), *Gaillardia aristata* (common gaillardia), *Helianthella uniflora* (oneflower helianthella) and *Verbesina* sp. (crownbeard) (Goeden et al. 1987).
The biology and behavior of *N. finalis* were described from California and Saskatchewan Canada (Goeden et al. 1987, Arthur and Mason 1989). However, no studies have been reported on the biology of this species in the northern Great Plains especially in North Dakota. Therefore, the objectives of the present study were to elucidate the biological and behavioral aspects of *N. finalis* in the northern Plains sunflower production region.

**Materials and Methods**

**Biological Studies**

Field studies on the biology of sunflower seed maggot were carried out at location about 15 miles from Fargo, ND, at the NDSU, Prosper Agricultural Research Farm and in the NDSU Entomology Department and the USDA-ARS Northern Crop Science laboratory. Studies were made at a 30 x 30 m study plot during the months of May to October. Sunflower seeds of Advanta-Pacific 6111 treated with Apron fungicide was sown on 15 May 2008. When plants were in the VE stage, six yellow sticky traps were set up in “M” manner and were replaced in every Tuesday and Thursday in order to monitor the populations of adult *N. finalis* to determine the number of generations per year. Sticky traps were carefully placed inside the polythene plastic bags and brought back to the laboratory for insect identification and counting. In the laboratory, yellow sticky traps were observed under a magnifying lenses and the number of *N. finalis* adults in each trap was recorded. The plant stage was also recorded during each visit.

Adult males and females of the sunflower seed maggot were collected from the field using sweep nets and brought into the laboratory. Males and females were kept in a wooden cage measuring 30 cm x 30 cm with glass top and a door to insert plant materials
and insects into the cage. Insects were fed with a 10% sugar solutions as a source of food and water. Mated females were exposed to excised sunflower heads, which were not infested by other insects. The cut end of the sunflower stem was placed in a water filled glass flask. Once the females started to lay eggs on a sunflower head, it was replaced with a new head.

The incubation period was studied under laboratory conditions. Sunflower heads were exposed to females for 24 hours and were carefully observed under light microscope for the presence of eggs. If eggs were present on the head, the number of eggs was counted and the sunflower head was kept in small aluminum container (12 cm diameter x 10 cm high) with moist cotton to prevent it from drying. Eggs were observed daily until hatching. After recording the incubation period, larvae were allowed to develop on the same sunflower head. However, the old sunflower head was replaced by new head if necessary. Larvae were observed daily until pupation to determine the developmental period. After pupation, pupal cocoons were removed from the sunflower head and kept on moist filter paper placed in small glass disk covered with a lid to determine the length of the pupal period. A sub sample of eggs (n=4), larvae (n=3), and pupae (n=14) were measured to determine their size.

In a separate experiment, newly emerged adult males (n=20) and females (20) were collected from the rearing cages and from the field collected pupae and were placed separately in rearing jars. A 10% sugar solution was provided as needed as a source of food and water. Insects in the cages were monitored daily until all the insects died in order to calculate the adult longevity.
Behavioral observations

Behavioral studies of resting, mating, and oviposition were observed in the field as well as in the laboratory. Focal animal sampling was used to observe these studies, i.e. observing the same individual until the end of its certain behavior (Martin and Bateson 1993).

Oviposition Choice Test

Seeds of sunflower were grown in greenhouse under control conditions. Excised sunflower heads of R2, R3, R4 and R5 stage were placed in water filled glass flask at a uniform height in a circular manner in 30 cm x 30 cm x 30 cm wooden cages. Two separate experiments were conducted. For each cage, approximately about 10 mated 20 days old females were introduced at 10:00 AM. Heads were removed after 24 hours and the number of eggs on each head counted.

Natural enemies

Field collected pupal cocoons were kept on moist filter paper placed in small glass disk covered with a lid to determine the length of the pupal period. Number of adults and parasitoids emerged from the cocoons were recorded and any parasitoids were identified by the NDSU taxonomist (P. Beauzay).

Results and Discussion

Biological Studies

It appears that the sunflower seed maggot has two generations per year in North Dakota (Figure 1). Adults of the first generation started to emerge the late June when plants were at V-12 to R1 stage and the second generation started to emerge the mid-
August. During the day, adult maggots were observed on sunflower heads either resting or mating. Oviposition was hard to observe in field or laboratory.

The adult sunflower seed maggot is a fly about 6 mm long and a wing span of approximately 7 mm. The wings have a brown lacelike appearance. Females can be distinguished from males by the shape of their abdomen. The tip of the abdomen is pointed in females (Figure 2) and rounded in males (Figure 3).

Eggs are elongate, tapered at both ends, and white in color. They are about 1.2 mm long. One end has a nipple-like projection, and the other end is rounded smoothly (Figure 3). Eggs hatched 4 days after oviposition (n=17). Total larval period ranged from 14-16 days (n=15) and larvae pupated in the developing sunflower head. The total development period of the pupa ranged from 8-9 days (n=12). Pupae are barrel shaped, brown in color and about 4 mm long (n=14). In the present study it was observed that development from eggs to adult emergence takes about 26-29 days. The longevity of the adults ranged from 64-87 days.

**Behavioral observations**

Behavioral observations have indicated that mating occurred during 7:45 AM to 10:20 AM (n=8) and lasted about 10 min to 5 hours (n=8). Multiple mating occurred in a 24 hour period.

**Oviposition Choice Test**

There were no significant differences between the numbers of eggs on the different flowering stages (R2-R5). In addition, oviposition occurred 5-7 days after exposing to the heads. However, this is not the exact pre-oviposition period as field collected adult females with an unknown age were used.
**Natural enemies**

In 2008, one pupal parasitoid was observed in field-collected cocoons. It was identified as *Pteromalus* spp. (Hymenoptera: Pteromalidae). Percentage parasitism was ranged from 50-90% in four separate occasions.

It was reported that, *Neotephritis finalis* was reported as a multivoltine pest in southern California and adults were observed throughout the year (Goerden et al. 1987). During the winter, reproduction occurred in low desert areas on *Helianthus niveus*. In summer, reproduction occurred on native hosts in mountain areas and then adults migrated to fall blooming species of *Helianthus* in the fall (Goerden et al. 1987). Arthur and Mason (1989) reported that larvae of the second generation drop to soil and overwintes as puparia.

**Future Research Directions**

There is currently no laboratory technique to rear this insect. It was difficult to observe the pre-oviposition and post-oviposition periods of *N. finalis* as well as total fecundity. As a result, 2009 studies will be expanded to develop a laboratory method to culture the sunflower seed maggot to investigate these life history parameters.

Susceptible seeds of sunflower will be grown in the greenhouse. Seeds will be planted every 3-4 days in order to provide a continuous supply of plants for use in different studies. Adult males and females will be collected from the field and reared under laboratory condition using 10% sugar solutions. Mated females will be exposed to fresh sunflower heads and pupae will be collected. Collected pupae will be placed in separate rearing containers until adults emerge. Adult males and females will be collected from the rearing cages within 24h of last molt. Batches of 3 males and 1 female will be placed
in 10 rearing cages with 10% sugar solutions. A new sunflower seed head (R3 or R4 stage) will be placed inside the cage for oviposition. Sunflower heads will be observed every day and the number of eggs recorded.

Even though, it is reported that this insect is overwinters as a pupa in the soil, in the present study, there is no evidence to support this statement. Therefore, during 2009, field-collected pupal cocoons will be chilled for different intervals and remove to a rearing room to monitor adult emergence.

References


Figure 1. Emergence of adult sunflower seed maggots from the study plot at Prosper (NDSU Agricultural Research Farm) starting from VE stage to R7 stage of sunflowers.
Figure: 2. Sunflower seed maggot female (Pointed abdomen tip)

Figure: 3. Sunflower seed maggot male (Rounded abdomen tip)
Figure: 4. Sunflower seed maggot-eggs

Figure: 5. Sunflower seed maggot- mature larva
Figure: 6. Sunflower seed maggot- pupa