1995

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JOURNAL OF THE KANSAS ENTOMOLOGICAL SOCIETY
68(3), 1995, pp. 263–267

Description of Achene Damage by the Red Sunflower Seed Weevil, the Banded Sunflower Moth, and the Sunflower Moth

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There are four major insect pests attacking achenes of sunflower in the Great Plains of North America (Charlet et al., 1987); the red sunflower seed weevil, *Smicronyx fulvus* LeConte (Coleoptera: Curculionidae), the gray sunflower seed weevil, *S. sordidus* LeConte (Coleoptera: Curculionidae), the banded sunflower moth, *Cochylis hospes* (Walsingham) (Lepidoptera: Cochylidae), and the sunflower moth, *Homoeosoma electellum* (Hulst) (Lepidoptera: Pyralidae). Identification of achenes damaged by larvae of these species is important for assessment of yield loss caused by each species (Peng and Brewer, 1995). Achenes infested by the gray sunflower seed weevil are easily identified because they are enlarged and protrude above the surrounding achenes on intact sunflower heads and the kernel is entirely consumed (Brewer, 1991). Descriptions of achenes infested by larvae of the other three species are similar (Carlson, 1967; Oseto and Braness, 1979; McBride and Charlet, 1991) except for the location of feeding/exit holes on the surface of the achenes infested by the red sunflower seed weevil and banded sunflower moth (Charlet and Gross, 1990). The red sunflower seed weevil oviposits in the developing achenes. The larvae feed on the developing kernels and when mature chew emergence holes in the pericarp (hull) (Oseto and Braness, 1979). The banded sunflower moth and sunflower moth oviposit on the bracts and florets. Early instars feed on the pollen and florets, later instars penetrate into achenes and feed on the developing kernels (Charlet et al., 1987, Charlet and Gross, 1990). In this study, we describe achenes infested by the red sunflower seed weevil, banded sunflower moth and sunflower moth and provide characters for separation of achenes infested by each of these pest species.

Achenes from artificially infested plants were used to describe and differentiate the damage caused by each species of pest. Plants used for infestation by the red sunflower seed weevil were grown in the field. Field-collected adult weevils were used to infest sunflower heads at the plant stage of R5.4 (Schneiter & Miller, 1981), when 40% of anthesis was completed. Plants were sprayed twice with *Bacillus thuringiensis* (Acme Division/PBI-Gordon Corporation, Kansas City, KS before infestation, and were in the bud stage (R2-R4) when treated. Plants were covered with Delnet pollination bags (Applied Extrusion Technologies, Middletown, Del) after infestation to prevent infestation by other seed feeding insects. Sunflower heads used for infestation by the banded sunflower moth and the sunflower moth were grown in the greenhouse. We used newly emerged banded sunflower moth larvae (<24 hr old) and sunflower moth eggs to infest plants at the R5.2 stage (20% anthesis). The eggs and larvae were from laboratory colonies maintained on artificial diets. When plants reached physiological maturity, the heads were harvested and hand threshed. We examined pericarps of infested

Accepted for publication 12 April 1995.

Table 1. Characteristics of achenes infested by red sunflower seed weevil, banded sunflower moth and sunflower moth.

Insect	Pericarp	Kernel
Red sunflower seed weevil	An exit hole on the lateral side, ¼ to ½ of the distance from the broad, distal end to the proximal end. Edges of the holes irregular (Fig. 1a).	Part of the kernel eaten. Distal end of the kernel remaining. Frass always present on the kernel surface (Fig. 1d).
Banded sunflower moth	A feeding hole on or near the distal end. Edges of the holes smooth and the holes larger than those of the red sunflower seed weevil (Fig. 1g). Silken sheets usually around the hole (Fig. 1g).	Part or all of the kernel consumed. Distal end of the kernel always absent. If the kernel only partially consumed, frass usually absent (Fig. 1e). If the kernel entirely consumed, frass sometimes present.
Sunflower moth	A feeding crack extending from the distal to the proximal end (Fig. 1c).	Part or all of the kernel consumed. Part of the kernel consumed variable (Fig. 2c).

achenes for external damage (30 each for red sunflower seed weevil and banded sunflower moth, 13 for sunflower moth). We then split the achenes (30 each for red seed weevil and banded sunflower moth, 6 for sunflower moth) and examined the kernels for damage. Examination of pericarps and splitting of achenes were tedious and time consuming. We found that the most efficient technique was to x-ray infested achenes on a radiographic unit (Faxitron, Hewlett-Packard, McMinnville, Oreg) at 30 kv for 20 sec and to examine their radiographs for damage (Peng and Brewer, 1995). A total of 61, 66 and 7 infested achenes were x-rayed for red sunflower seed weevil, banded sunflower moth, and sunflower moth, respectively (Fig. 2).

The characteristics of achenes infested by larvae of the red sunflower seed weevil, the banded sunflower moth and the sunflower moth are listed in Table 1. Depending upon the methods used to evaluate feeding damage, different characters were used to differentiate damage caused by the three species. The shape and location of larval penetration/exit holes (Fig. 1a–c) were distinguishing characters for external examination of the achene (Table 1). However, if the red sunflower seed weevil larva has not exited the achene, a hole will not be present and the achene misidentified as uninfested.

In split achenes, the feeding site on the kernel and the appearance of frass on the surface of the kernel allowed for separation of damage by red sunflower seed weevil larvae from damage by moth larvae. However, differentiation of the damage by larvae of two moth species was not reliable when differentiation was based on examination of kernels.

Radiographs showed a clear difference between achenes infested by red sunflower seed weevil larvae and those infested by banded sunflower moth larvae (Fig. 2A, B). On radiographs, the top (broad, distal end) of kernels damaged by a red sunflower seed weevil larva was always visible (Fig. 2A). For kernels damaged by larvae of the banded sunflower moth, the top of the kernels was consumed and the area consumed was larger than that eaten by larvae of the red sunflower seed weevil (Fig. 2B). Radiographs did not show consistent characters for identifying kernels damaged by the sunflower moth (Fig. 2C). Thus, on radiographs,

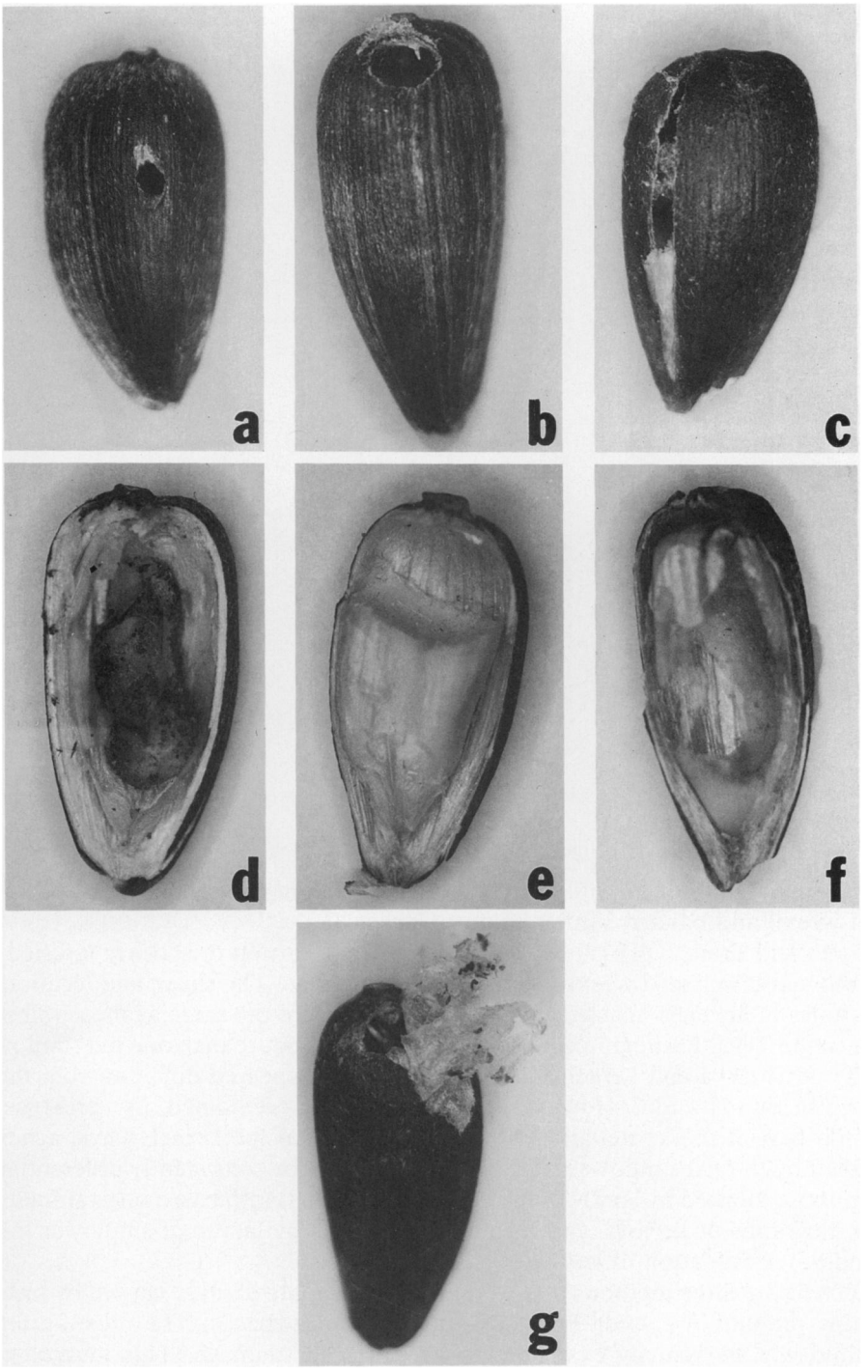

Fig. 1. Characteristics of achenes infested by red sunflower seed weevil (a and d), banded sunflower moth (b, e and g), and sunflower moth (c and f).

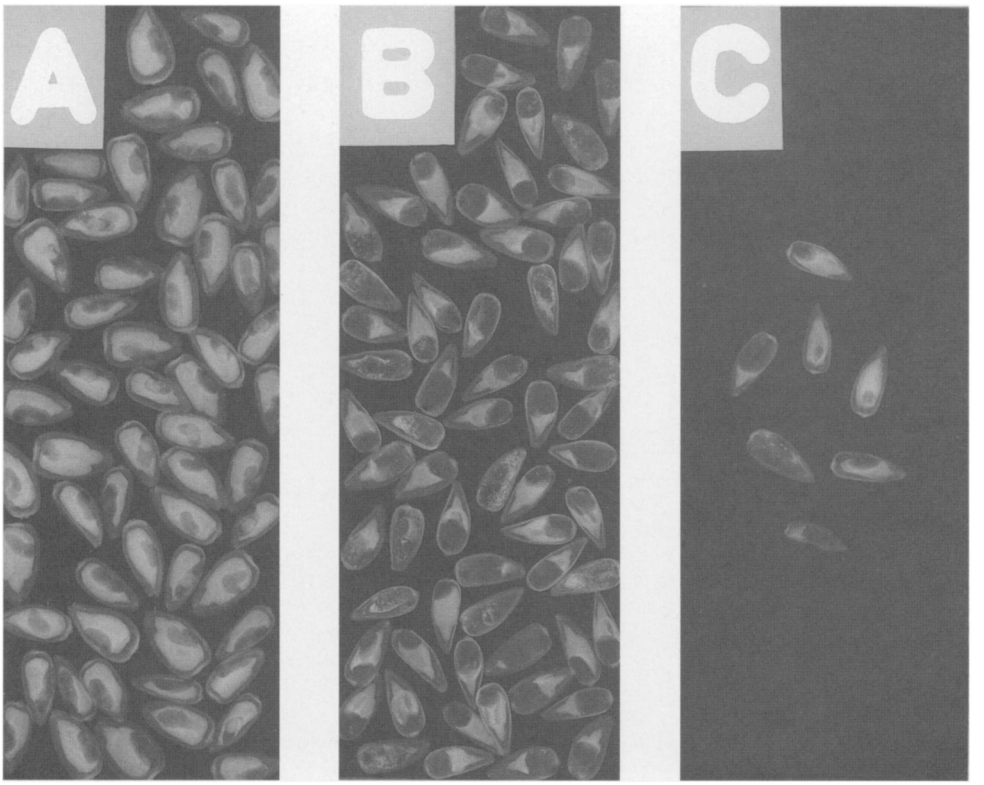

Fig. 2. Radiographs of achenes infested by red sunflower seed weevil (A), banded sunflower moth (B), and sunflower moth (C).

sunflower moth damage could be confused with damage caused by red sunflower seed weevil and banded sunflower moth larvae.

Oseto and Braness (1979) reported that a small portion of achenes infested by the red sunflower seed weevil contain multiple larvae. The shape and location of exit holes in achenes infested by multiple larvae were the same as those infested by a single larva. Radiographs of achenes infested by more than one red sunflower seed weevil larva and kernels from those achenes appeared different from those shown in Figs. 1 and 2. However, the key characters remained, i.e., presence of the top part of the kernel and frass on the surface of the kernel. Thus, achenes infested by the red sunflower seed weevil larvae can be consistently differentiated from those infested by larvae of the banded sunflower moth based on examination of radiographs or kernels, and from those infested by larvae of sunflower moth based on examination of kernels.

Each of the three methods that were used to compare damage caused by insects feeding on sunflower seed had advantages and drawbacks. The most accurate method was to visually examine the pericarps for damage. This method can distinguish infestations of all three species. However, the procedure was tedious and visual examination of pericarps did not detect red sunflower seed weevil infestations if the larvae had not exited the seeds. Examination of split achenes showed that kernels fed on by larvae of the red sunflower seed weevil were

distinguishable from those fed on by larvae of the two moth species. However, damage by the two moth species could not always be reliably separated. Radiographs provide a semi-permanent record, can be quickly read, and are advantageous if large number of entries need to be scored. However, radiographic images of sunflower moth damage were not always distinguishable from damage caused by larvae of the red sunflower seed weevil and banded sunflower moth. The particular method or combination of methods used to distinguish feeding damage should be selected based on the insect species present and the research goals.

Acknowledgments

We thank L. D. Charlet (Northern Crop Science Laboratory, USDA-ARS, Fargo, North Dakota) for review of the manuscript. Research support was provided by the USDA-CSRS, under project number 92-34133-7114.

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