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Stored-grain insect population commingling densities in wheat and corn from pilot-scale bucket elevator boots☆

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ABSTRACT

Grain elevator boot and pit areas facilitate the commingling of insects with the grain moving through the elevator leg. A removable boot was developed to facilitate residual grain removal and preservation in the boot and to quantify the commingling magnitude as a function of stored-product insect density. This study included two species that develop inside kernels, *Rhyzopertha dominica* and *Sitophilus oryzae*, and three species that develop outside kernels, *Tribolium castaneum*, *Oryzaephilus surinamensis* and *Cryptolestes ferrugineus*. The removable boots were loaded with infested residual grain and remained undisturbed for 0, 8, 16, or 24 weeks (wk). After each time point, uninfested grain was transferred through the infested boot. The adult beetles that commingled with the clean grain were sifted and counted. Further, the commingled lots were examined after 8 wk for adult progeny. The insect densities in the infested bucket elevator leg boots affected the insect densities transferred through the elevator leg to other locations. The insect density in clean wheat or corn transferred over infested boots was 1 insect/kg immediately after transfer, but this density doubled in 8 wk. More internally developing insects were collected by the elevator buckets when the clean grain flowed over the infested grain compared with the externally developing insects. β-Cyfluthrin application as a residual insecticide reduced the insect densities in the elevator boot, which consequently reduced the insect transfer to clean grain. Cleaning the bucket elevator boot area and applying residual insecticide monthly should minimize clean grain contamination.

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1. Introduction

Commercial grain storage facilities quickly become infested with stored-product insect pests (Reed et al., 2003; Arthur et al., 2006). Infestations of newly harvested grain are caused by previously infested grain carried over from one crop year to the next (Good, 1937). Many areas in a grain elevator, including handling equipment dead spots, collect residue or accumulate grain (Dowdy and McGaughey, 1996; Reed et al., 2003; Arthur et al., 2006), and are potential insect pest harborage sites where insects are carried over from one year to the next.

The elevator boot is an enclosed space at the bottom of a bucket elevator leg casing, where residual grain accumulates during use and is not manually cleaned on a regular basis in most grain elevators. The elevator boot is typically located in the basement or a sub-basement pit area and is an ideal habitat for insect population growth. The area surrounding the boot is also an important insect pest infestation source, especially if grain is allowed to accumulate (Good, 1937). Any infestations in the boot-pit area can spread to other locations in a facility. Arthur et al. (2006) showed that boot-pit areas have one of the two highest insect densities out of five areas surveyed over two years for nine elevators. The insect species detected in this study were the lesser grain borer, *Rhyzopertha dominica* (F.), and the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), which are common wheat pests in Kansas, and the rice weevil, *Sitophilus oryzae* (L.), which was common in the trash samples but rare in the bulk wheat storage for Kansas.

Residual insecticide sprays are often applied to floor, wall, and equipment surface areas inside grain-handling facilities to control stored-product insects. Sanitation improves the efficacy of applied residual insecticides (Ingemansen et al., 1986; Herron et al., 1996). Residual grain accumulation in the elevator boot likely contributes to insect and grain commingling or mixing through the elevator leg.

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Studies have not investigated the insect infestation dynamics for the elevator boot-pit, insect commingling, and the likely transfer of insects via elevator buckets to additional areas in the elevator grain-handling system. The objectives of this research were to (1) measure the stored-grain insect population commingling densities in wheat and corn from pilot-scale bucket elevator boots, (2) identify the dynamics that spread infestations from this area to other sections in a facility, and (3) examine the impact from a residual insecticide application to the boot-pit on insect density commingling.

2. Materials and methods

2.1. Boot hardware

Three model B-3 bucket elevator legs (Universal Industries, Cedar Falls, Iowa, USA) (Fig. 1) were retrofitted with experimental boots that could be inserted and removed with ease from the leg casing bottom. These removable boots replaced the bucket elevator leg casing standard enclosed base, where residual grain accumulates when moving grain. The boot area (29.8 by 11.4 by 6.4 cm) retained 1.9 kg of residual grain. The elevator leg function and grain flow were unaffected by the new boot, but this design permitted boots containing residual grain to be removed from the leg and incubated, while the leg was used for an additional test with a different boot installed.

2.2. Boot grain infestation

The residual hard red winter wheat (1.9 kg) in the pilot-scale elevator boot was infested with mixed ages of unsexed adults of *R. dominica*, *C. ferrugineus*, and the red flour beetle *Tribolium castaneum* (Herbst) at different insect population densities (0, 50, 100, and 200 insects/kg/species four days before testing). In contrast, yellow dent corn was infested with adults of *S. oryzae*, *T. castaneum* and the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), at the same density levels as for the wheat four days before testing. The average moisture contents of the wheat and corn treatments were 12.4% and 14.6%, respectively. Each grain type and treatment was independently tested using a pilot-scale bucket elevator boot; thus, each grain treatment used a separate removable boot. Prior to each treatment, an empty boot was installed in the bucket elevator leg to prepare for grain loading. The control treatment included insect-free grain treated as described below (Sections 2.3 and 2.4). The boot area temperature and relative humidity (r.h.) were monitored each minute throughout the test period using a HOBO® data logger (Onset Computer Corporation, Bourne, MA, USA).

2.3. Boot-loading process

Grain was acquired from a commercial grain elevator in Manhattan, Kansas, USA and stored at −13 °C for at least 4 weeks (wk) to kill any insects. Several 2 kg lots were removed from the freezer, placed in a 10 L plastic bucket, and warmed to room temperature. After re-warming for 24 h, each 2 kg lot was infested with one of four adult insect treatment densities (0, 50, 100, and 200 insects/kg/spp.). The infested lots were placed in 10 L plastic buckets and sealed with a plastic bucket lid cover; the lid cover had a hole in the center 8.25 cm in diameter covered with a 381 μm opening mesh. The infested lots in plastic buckets were held for 4 d in an environmental chamber (model CTH-811, Percival Scientific, Perry, IA, USA) at 27.5 ± 0.5 °C and 65 ± 5% r.h. prior to passing the grain through the pilot-scale elevator legs to load the boot.

The infested grain was transferred through the leg at 1.72 ton/h, which filled the boot with infested residual grain. Certain boots filled with infested grain remained installed in the bucket elevator leg, and clean grain was immediately transferred through the leg (time 0 wk). This construction simulated a recently infested boot with only the first-generation adult insects and few, if any, infested kernels that could be collected during the clean grain transfer. The grain-filled boots were covered with a 381 μm opening sieve to facilitate air diffusion but prevent insect escape; they were then incubated in the environmental growth chamber (27.5 ± 0.5 °C and 65 ± 5% r.h.) for 8, 16, and 24 wk.

Fig. 1. Pilot-scale bucket elevator leg boot arrangement.