Protection of Stored Corn From Insect Pests, Using a Two-Component Biological Control Method Consisting of a Hymenopteran Parasitoid, *Theocolax elegans*, and Transgenic Avidin Corn Powder

Paul W. Flinn, Karl J. Kramer, James E. Throne, and Thomas D. Morgan

USDA,ARS, Grain Marketing and Production Research Center, Manhattan KS

Introduction

Theocolax elegans is a small pteromalid wasp (1-2 mm) that attacks primary grain pests, such as the maize weevil, *Sitophilus zeamais*, whose larvae develop inside the grain kernels. However, *T. elegans* does not parasitize species that are secondary grain pests, including the flour beetles, *Tribolium* spp., and the rusty grain beetle, *Cryptolestes ferrugineus*, whose larvae develop outside of the grain kernel. A candidate biological material that could be used in combination with parasitoids to control grain pests is transgenic avidin corn powder. Avidin has been shown to cause mortality in many different species of stored-product insects by preventing the absorption of dietary biotin. The avidin gene has been incorporated into corn plants and avidin corn kernels are resistant to insects, especially after the kernels are ground into a powder. We tested a biopesticide that might be used to supplement the species-specific activity of the parasitoid, which, when used in combination with the parasitoid, would protect grain from both internally and externally developing pests, and be

Small parasitic wasps *Theocolax elegans* (Pteromalidae), attack beetle larvae inside grain kernels (shown here on wheat).

Sitophilus zeamais, can cause severe damage to stored grain. Eggs are laid inside the kernel and larvae develop inside the kernel. Photo courtesy of Agri-Canada (Winnipeg).

Objectives

1. Determine if powdered avidin corn added to stored corn interfered with the parasitoid's ability to find and parasitize maize weevil.
2. Determine if a two-component approach using powdered avidin corn and a parasitoid wasp could suppress both primary and secondary insect pests on stored corn.

Methods

Avidin corn powder from ProdiGene, Inc., (College Station, TX) contained approximately 850 ppm avidin. The avidin corn powder was added at an application rate of 0.3% to the test corn samples (Asgrow RX877).

Plastic jars (3.8 L) were filled with corn (3 kg). Thirty g of ground corn was added to each jar and the contents were thoroughly mixed. The ground corn was added to ensure that the secondary feeders, *T. castaneum* and *C. ferrugineus,* would have enough food during the experiment. Plastic lids with a 3 cm diameter opening covered with silkscreen were used to allow air movement and prevent insects from leaving the jars. There were six treatments: corn, corn + 0.3% powdered corn, parasitoid, parasitoid + 0.3% powdered corn, 0.3% powdered avidin corn, and parasitoid + 0.3% powdered avidin corn. Each treatment was replicated four times.

Three liter jar filled with corn (left). Red flour beetle (right) is a secondary pest of corn, and feeds on fine material in the grain.

The three beetle species were combined in each test. One pair each of sexed 2- to 3-week-old *S. zeamais*, *T. castaneum*, and *C. ferrugineus* was added to each jar. The jars were held in an environmental chamber maintained at 27±1°C and 65±5% RH. Twenty days after beetle release, two pairs of sexed 1- to 4-day-old *T. elegans* were added to the parasitoid treatment jars. A second introduction of *T. elegans* was also made 27 days after beetle release. After 8 weeks from initial beetle release, the insects were removed from the corn using a motorized inclined sieve. The numbers of live and dead adults of each species of insect were recorded.

Results

Neither the avidin maize powder nor the control with 0.3% powdered maize had an effect on either the wasp's host finding ability or its mortality.

The total number of beetles of all three species in the avidin corn powder treatment was significantly less than that in the control treatment (Figure 1).

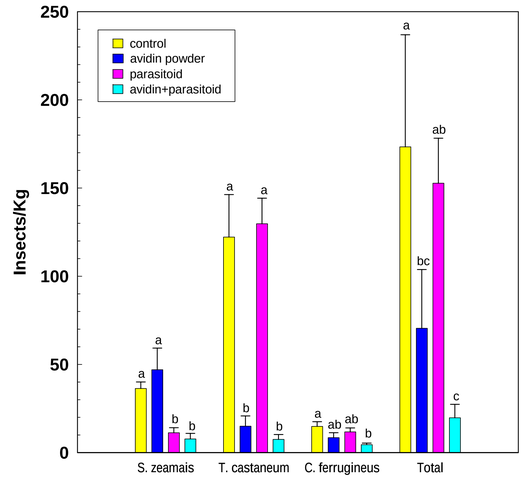

Fig. 1. Effect of 0.3% avidin corn powder, parasitoids, or the combination of 0.3% avidin corn powder + parasitoids on adult insect densities of *T. castaneum*, *S. zeamais*, and *C. ferrugineus*. Vertical bars indicate standard error of the mean (n=4). Bars designated by the same letter, within a species, were not significantly different (P>0.05; Tukey's Studentized Range (HSD) Test.

The parasitoid treatment, on the other hand, was not significantly different from the control treatment for the total number of beetles. However, the total number of beetles was significantly less in the combination treatment (parasitoid + avidin corn powder) than in the control or in the parasitoid treatment.

The combination treatment had the greatest percentage reduction for all of the insect species. It resulted in 78, 94, and 70% reductions of *S. zeamais*, *T. castaneum*, and *C. ferrugineus*, respectively, when compared to the control treatment.

The percentage reductions for the parasitoid treatment alone resulted in 70, 8, and 20% reductions of *S. zeamais*, *T. castaneum*, and *C. ferrugineus*, respectively.

For the avidin corn powder treatment, populations of *S. zeamais*, *T. castaneum*, and *C. ferrugineus* were reduced by 10, 85, and 40%, respectively.

Conclusions

The combination treatment of avidin corn powder plus the release of parasitoid wasps was superior to either treatment alone when tested against mixed populations of the internal feeder, *S. zeamais*, and the external feeders, *T. castaneum*, and *C. ferrugineus*. Normally, multiple beetle species that are both external and internal feeders are found in stored grain. While avidin corn powder is fairly effective as an insecticide against the external feeders, it is not very effective against the internal feeders. By using the combination treatment, stored grain managers would be assured of protection from both internal and external feeders. The advantage of using this particular beneficial species is that by releasing only *T. elegans*, it would control most of the beetle species that are internal feeders in stored grain (*R. dominica* and all three *Sitophilus* species). Avidin corn powder could then be used in a combination treatment to suppress most of the insects that are external feeders, such as *C. ferrugineus*, *T. castaneum* and *O. surinamensis*.

Acknowledgments

We thank Ken Friesen and Ann Redmon for superb technical support during this project. We also thank Dr. John Howard (ProdiGene, Inc.) for the sample of avidin corn powder and for his comments and encouragement.