Management of grape colaspis, Colaspis brunnea (Coleoptera: Chrysomelidae), in seed corn production

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Management of grape colaspis, *Colaspis brunnea* (Coleoptera: Chrysomelidae), in seed corn production

by

Benjamin Carl Kaeb

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Entomology

Program of Study Committee:
Jon J. Tollefson, Major Professor
Marlin E. Rice
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Iowa State University

Ames, Iowa

2006

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CHAPTER 1. GENERAL INTRODUCTION

Organization

This thesis is organized into five chapters. Chapter 1 includes the introduction and a literature review of the grape colaspis. Chapter 2 is a study of using neonicotinoid seed treatments and a soil insecticide to protect seed corn from colaspis larvae. Chapter 3 reports the evaluations of insecticides to reduce oviposition in soybeans by reducing adult populations, thereby reducing the larval population that threatens seed corn the following year. Chapter 4 is a review and discussion of sampling methods used in the study of the grape colaspis. The final chapter contains the general conclusions and discussion of this project.

Introduction

The grape colaspis, *Colaspis brunnea* (F.), is a native beetle in the family Chrysomelidae. Grape colaspis adults are small (≈5mm in length) bronze-colored beetles. The adults feed on a wide variety of plants including various crops and weeds in Iowa. The larvae are small (5.0–6.5mm in length at 10th instar), scarabaeiform, cream-colored grubs that injure crops by feeding on the surface of the root, denuding it of root hairs (Lindsay 1943). This causes plant stress by interfering with the water and nutrient uptake.

*Colaspis brunnea* Injury and damage to seed corn and commercial corn has been reported across the Midwest in recent years (Bailey et al. 1997, Gray 2000, Obermeyer et al. 2000, Ratcliffe and Steffey 2001, Rice 2003, Steffey 2003). Corn injury that is most often associated with *C. brunnea* is stunting, wilting, purpling, and
death of seedlings (Lindsay 1943, Edwards et al. 2000, Steffey and Ratcliffe 2001, Rice 2003, Steffey 2003). The damage has been most prevalent in inbred seed corn, which is planted into rotations favoring *C. brunnea* and lacks the vigor to cope with the injury. The value of the crop to growers and seed corn companies has caused concern, which resulted in financial support to carry out this project.

In Iowa, *C. brunnea* is a univoltine species. The adults emerge during mid summer and are present in the field from late June through August. Oviposition occurs in July and August. Eggs hatch within two weeks of oviposition. The larvae develop to the 5th–8th instar before moving below the frost line to winter. In the spring, the larvae move into the root zone, where they feed on the seedling plants (Lindsay 1943).

One of the frustrations faced by corn producers in dealing with this pest is the lack of research in modern cropping systems where *C. brunnea* is injuring crops. Research on *C. brunnea* has not taken place in the modern era of the corn–soybean rotation and reduced tillage cropping systems. This project is a start to correct this problem.

**Objectives:**
1. Test the efficacy of commercially available insecticides, specifically the neonicotinoid seed treatments, in protecting commercial seed corn from *C. brunnea* larval injury.
2. Develop and test a method of using foliar-applied insecticides to reduce adult *C. brunnea* populations to lower the subsequent larval population.
Literature Review:

Colaspis name. The literature on the grape colaspis, *Colaspis brunnea* (F.), has been confused by the use of two scientific names. The following describes the controversy and confusion that has surrounded the scientific name of the grape colaspis over the years. This is not intended to be a complete literature review of the taxonomy of the grape colaspis. For that, look to the Blake (1974) revision of the *Colaspis* genus, which discusses the systematics and taxonomy of the grape colaspis in detail.

Fabricius (1798) described the grape colaspis as *Galleruca brunnea*. In 1801 he moved it to the genus *Colaspis* (Blake 1974). The name *Colaspis brunnea* has been in use since. In 1825, Thomas Say described the grape colaspis as *Eumolpus flavida* (Say 1825). By rule of precedence, *Colaspis brunnea* (F.) should have been considered the proper name and *Colaspis flavida* (Say) a synonym. In the mid 1860’s the grape colaspis was identified as a pest of grapes (Fitch 1866, Walsh 1866). In an 1866 article, in addition to discussing the grape colaspis as a pest, Benjamin Walsh advocated the use of the name *Colaspis flavida* (Walsh 1866). This was a common practice of his as he strongly encouraged the use of what he considered ‘modern’ scientific names (Walsh 1866, Lockwood 2004). The names *Colaspis brunnea* (F.) and *Colaspis flavida* (Say) were then used in literature from 1866 into the 1970’s. There were various works in between that advocated one name or the other (Riley 1870, Schaeffer 1933, Barber 1936, Lindsay 1943), however, none of those works offered a satisfactory resolution. Blake (1974) published a revision of the *Colaspis* genus in which she writes in detail on the
taxonomy and name of the grape colaspis. On the scientific name of the grape colaspis, she wrote “From Say’s description of *Eumolpus flavida* it appears that he had *C. brunnea* before him” (Blake 1974). In 2003, the Catalog of the Leaf Beetles of America North of Mexico was published where it is stated that the *Colaspis flavida* (Say) is a “name of uncertain application” (Riley et al. 2003). The name grape colaspis is recognized by the Entomological Society of America as a common name for the *Colaspis brunnea* (F.) in the database Common Names of Insects & Related Organisms (ESA 2006).

From the literature it is apparent that the works cited in this thesis that use *Colaspis brunnea* (F.) and *Colaspis flavida* (Say) involve the same species of insect, which is commonly known as the grape colaspis.

**Life History.** The initial description contains little information on the life history (Fabricius 1798, Blake 1974). Say (1825) states that it inhabits the United States, and is common in Pennsylvania.

Little was written on *C. brunnea* until it appeared as a crop pest in the 1860's; then its life history was studied as it pertained to the crops it infested. Walsh (1866) reported rearing a *C. brunnea* from a pupa found at the base of a peach tree. At that time, he speculated that it lived above ground as a larva and adult and went underground to pupate. In 1870, it was reported that, in Missouri, the larva of *C. brunnea* was a soil insect that fed on strawberry roots and could be found in the soil in fall, winter, and spring. It was noted that *C. brunnea* pupated in June and adults emerged from July into the fall (Riley 1870). Forbes (1883) speculated that the absence of *C. brunnea* in the fall meant that it was single brooded. Garman (1890)
reported that the damage to strawberries on new land indicated that *C. brunnea* larvae were not dependent on strawberries. Bigger (1928) reported observations of *C. brunnea* in Illinois through the winter of the larval lifecycle. This study found that *C. brunnea* wintered as larvae, and that the majority of the larvae moved under the line of heaviest frost in the soil.

Lindsay (1943) wrote a dissertation on the biology of *C. brunnea* in Iowa, which reported that *C. brunnea* is univoltine in Iowa. Adult emergence phenology was shown to vary, most likely the result of weather conditions. Mating was observed to occur soon after emergence. Oviposition was reported to occur 10 to 18 days after emergence in laboratory studies; however, it was noted that field observations suggested a shorter time. Eggs were shown to hatch between one and two weeks after being laid. The larval stages were determined using head capsule width measurements. Ten separate larval stages were reported with some larvae having several extra supernumerary molts. Most larvae wintered between the fifth and eighth instars. Pupation began in mid June and continued through the season. *Colaspis brunnea* spends six to nine days as a pupa.

Rolston and Rouse (1965) demonstrated that, in Arkansas, *C. brunnea* was bivoltine with two separate broods of adults during the summer months. Eaton (1978) found that, in North Carolina, *C. brunnea* has a single generation and that there was evidence of a small partial generation in the fall.

*Colaspis brunnea* adults as a crop pest. The adult stage of *C. brunnea* has been reported as a crop pest since the mid 1860s. It was first reported as a foliar feeder on grape; resulting in the common name of grape colaspis (Fitch 1866; Walsh 1866,
1867; Riley 1870, 1872). Additionally, adult *C. brunnea* have been observed feeding on a variety of crops and weeds including alfalfa, apple, soybean, red clover, cowpea, corn, timothy, strawberry, barnyard grass, and smartweed (Rolston and Rouse 1965). Kogan and Turnipseed (1987) listed *C. brunnea* adults as incidental insects in soybeans but did not mention the larvae. The Handbook of Soybean Insect Pests states that *C. brunnea* adults and larvae are common in soybean fields, but are seldom economically damaging (Lambert 1994). Recently, *C. brunnea* was reported to vector bean pod mottle virus, which may make adult feeding in soybean of greater concern (Giesler et al. 2002). Baur et al. (2000) reported that peak populations of colaspis (combination of *C. louisanae* Blake and *C. brunnea*) coincided with the first peak of the bean leaf beetle, *Cerotoma trifurcata* (Forster), and that the combined feeding approached the threshold for feeding by *C. trifurcata* and *Diabrotica balteata* (LeConte) in locations in Texas and Lousiana. In corn, *C. brunnea* have been reported feeding on the silks (Webster and Mally 1899). Tonhasca (1994) found that *C. brunnea* adult populations are higher in no-till cropping systems than in conventional cropping systems.

**Colaspis brunnea larvae as a crop pest.** The first report of root feeding and description of *C. brunnea* larvae was in strawberries by Riley (1870). Forbes (1900) reported that *C. brunnea* had been found feeding on the roots of timothy and Indian corn in central Illinois. In 1900, severe damage was reported in a number of cornfields in central Illinois; with stunting and stand loss occurring (Forbes 1903). Forbes (1903) also described colaspis injury to the corn root as feeding on the soft
tissue on the surface of the root. This report also listed clover and two prairie grasses as larval hosts.

Bigger (1928) reported severe injury and damage from *C. brunnea* larvae in Illinois from 1924–1926 on corn that was planted in a rotation following clover. *Colaspis brunnea* larvae were found to be most numerous in second-year red clover, though he found larvae in sweet clover and timothy and a single larva in soybeans. The single larva that was reported in soybeans is the first report of *C. brunnea* larvae in soybeans. Bigger (1931) described the colaspis as a pest that "regularly causes a small amount of damage but which occasionally occurs in outbreak form...". This report is the first to report damage in corn following soybeans. Lindsay (1943) reported damage to corn by *C. brunnea* in eastern and central Iowa. The infestations and damage were most severe on the higher locations with lighter soils. *Colaspis brunnea* injury to corn was reported to be manifested in three different ways: 1) death of the plant, 2) stunting and retardation of plant development, and 3) plant stunting and leaf discoloration. The leaf discoloration was reported to be the result of phosphorus deficiency. The degree of stunting was reported to be dependent on moisture availability to the plant. This article also states that feeding, which damaged the taproot, generally led to damage symptoms being apparent. Injury in this study was quantified using counts of hills of corn damaged. Bigger and Petty (1965) found that ten percent of cornfields surveyed over the course of a ten-year study in Illinois where infested by *C. brunnea*. This included 30% of cornfields following clover, 16% following grass, 14% following alfalfa, 11% following soybeans, and 0% following small grains. Steffey (1999) describes *C. brunnea* as a sporadic pest of corn planted
after mammoth clover or red clover, occasionally occurring in corn planted after
sweet clover, alfalfa, or soybeans. He further states that the injury is more severe
when conditions retard plant growth. Injury symptoms listed included stunting,
purpling of leaves, browning of leaf tips and margins, and, in severe cases, death
and reduced plant populations.

Rolston and Rouse (1965) reported damage to dry-seeded rice in Arkansas
grown in rotations following lespedeza, soybeans, and “weedy fallow.” A reduction of
nearly one plant per square foot was noted for each increase of two *C. brunnea* per
square foot of soil. This paper also reports that soybeans support a smaller over­
wintering population of *C. brunnea* than lespedeza. Experiments reported in this
paper suggested that lespedeza and soybeans were not great hosts for *C. brunnea*,
and that larvae did very well on crab grass. This caused the author to speculate that
infestations of grass were a reason for the heavy *C. brunnea* populations found in
those crops. Winter grains and rice were reported as hosts on which *C. brunnea*
could not reproduce. A list of adult and larval hosts is also included in this work.
Mayse and Tugwell (1980) found that two larvae per core (10 cm diameter) in rice
accounted for 6% yield reduction.

In the early 1940s, *C. brunnea* larvae damaged soybeans in Illinois and
eastern Iowa (Flint 1941, Keilholz 1941, Cooper 1942). Eaton (1978) studied *C.
brunnea* and found *C. brunnea* populations in soybean fields to be randomly
distributed across a field though the damage from larvae was localized in areas of
the fields. Soils that were loose, friable, and with high moisture holding capacity
were found to be associated with high *C. brunnea* “production.” These were thought
to be factors of egg and larval survivability. Kogan and Turnipseed (1987) list *C. brunnea* adults as incidental insects in soybeans and do not mention the larvae. Lambert (1994) states that *C. brunnea* adults and larvae are common in soybean fields, but are seldom economically damaging.

Reports of *C. brunnea* injury and damage to corn became widespread in the late 1990s with reports of injury in Missouri in 1997, Illinois in 1998, Indiana in 2000, and Iowa in 2003 (Bailey et al. 1997, Steffey and Gray 1998, Obermeyer et al. 2000, Rice 2003). Obermeyer et al. (2000) reported the first significant *C. brunnea* damage in Indiana since 1988. Rice (2003) reported injury in Iowa, however an agronomist quoted in the article stated that they had seen the problem for three years. Iowa, Illinois, and Missouri have had sporadic reports of damage since the initial reports. With the exception of the first report from Missouri in 1997, the damage reported is in corn planted after soybeans.

**Managing *C. brunnea***. Management techniques for *C. brunnea* have been discussed since the first reports of adults feeding on grape foliage. Fitch (1866) recommended dusting the leaves with ashes, soot, or some other powder to make the leaves of grapes less palatable to adults. Riley (1870) recommended the use of ashes, soot, lime, or salt to “ward off” *C. brunnea* in strawberries if access to the plants could not be prevented. In this article, he acknowledged that this was not based on experimental data. Forbes (1884) discussed using Paris green (copper acetoarsenite) to kill adults that occurred during July to prevent oviposition in strawberries. Forbes (1884) also includes the first discussion of soil insecticides; bisulphide of carbon and carbolic acid as soil fumigants targeting soil pests of
strawberries included *C. brunnea*. Garman (1890) discussed managing three root-feeding pests of strawberries and recommended the use of London purple (calcium arsenite) to kill the adults, protect the foliage, and reduce the number of larvae the next season; or occasional application of Paris green (copper acetoarsenite) as a preventive. Transplanting plants to new locations was also mentioned as a possible management technique. Gossard (1911) recommended spraying arsenical insecticides to control the adults feeding on grapes and raised doubts that fall plowing would control this insect.

In the late 1920’s and early 1930’s J.H. Bigger showed that the timing of plowing and crop rotation had an effect on *C. brunnea* populations. Fall plowing reduced the level of *C. brunnea* infestation and correlated to a higher yield. Early spring plowing also was shown to lower the *C. brunnea* infestation, though with less effect on the infestation level than fall plowing. Studies of *C. brunnea* larval populations found more *C. brunnea* larvae in red clover than in sweet clover, soybeans, or timothy. As a result, recommendations were made to adjust crop rotation and “timely plowing of sod land where corn is to be planted.” Crop rotation changes suggested using soybeans or sweet clover in place of red clover for soil-building (Bigger 1928, 1931).

In the early 1940s a number of cultural control methods were recommended for managing *C. brunnea* damage to soybeans and corn in farm magazines and extension bulletins. Keilholz (1941), in an article in Country Gentleman, recommended early spring plowing and then heavy disking of land that is to be planted to corn and soybeans. Failure of fall plowing to control *C. brunnea* in some
cases is noted (Keilholz 1941). Flint (1941), in an article in Soybean Digest, recommended the use of fall or early spring plowing, "as many diskings as seems practical," and to delay as long as possible the planting of corn or soybeans to reduce *C. brunnea* risks. Cooper (1942), in an article in Country Gentlemen, reported that there were no dependable controls, stated that late fall or early spring plowing reduced infestations and recommended applying phosphorus at planting to help the crops overcome some of the damage. In a bulletin on using lespedeza in Illinois, it was noted that corn planted following lespedeza was at risk for colaspis damage. It recommended only growing legumes for a single year prior to planting corn, plowing the field in March or April, and ensuring phosphorous was well supplied in the soil when planting corn following lespedeza (Sears and Burlison 1943).

Lindsay (1943), as part of studies on *C. brunnea* biology, looked at cultural practices. Corn on well-fertilized and limed ground was able to withstand heavy populations of *C. brunnea* larvae. Additional recommendations were the addition of phosphate when corn was planted following red clover or soybeans, planting in a well-prepared seedbed late enough to ensure quick germination, which would allow the plant to grow more vigorously and escape severe damage. Plowing in the spring or fall was not supported by this study. Late summer plowing was reported to reduce populations; however, it was felt that this would be objectionable from the standpoint of encouraging erosion. The commonly used crop rotation of oats, red clover, and corn placed corn at risk. However, it was felt that agronomic advantages of that rotation outweighed changing the rotation to reduce risk of injury by *C. brunnea*. 


The first insecticide trial specifically targeting *C. brunnea* was carried out in 1945 and 1946 using DDT, results of which were never published (Bigger and Decker 1966). The first published studies were conducted in the 1950s and evaluated organochlorine insecticides (Bigger and Blanchard 1959). Bigger and Blanchard (1959) and Bigger and Decker (1966) reported on 5 and 10 years of insecticide trials for corn insects in Illinois. In these trials of soil-applied insecticides, a number of fields contained *C. brunnea* larvae. Where *C. brunnea* was present, aldrin or heptachlor gave an average of 71% control. This study also showed that the application method considerably influenced *C. brunnea* control: broadcasting insecticides provided 83% control of *C. brunnea* versus 60% for insecticides placed in the row. This study also presented an evaluation of organochlorine seed treatments, which gave 56% control compared to 92% for soil-applied insecticides in three tests.

Rolston and Rouse (1960) found that both soil-applied and seed-applied treatments of aldrin could provide adequate protection of rice from *C. brunnea* injury. The seed treatment of aldrin was recommended, as it was the most economical.

Rolston and Rouse (1965) discuss various methods, including cultural and chemical, for managing *C. brunnea* in Arkansas rice production. They mention that seed treatments were a commonly used method for managing *C. brunnea* in rice at the time. Water-seeded rice was reported to be protected from injury, except on levees where it is not flooded. Flushing of drilled rice (which cannot be flooded for prolonged periods) was reported not to provide control. An experiment in which containers of soil containing *C. brunnea* larvae were flooded for three days resulted
in 34% mortality. Removing lespedeza from the crop rotation was reported not to be a satisfactory solution. An experiment looking at the host suitability of varieties of lespedeza was reported. This showed that the most commonly grown varieties of lespedeza in the rice growing region of Arkansas, which often had damage to rice following it in rotation, was one of the least suitable hosts of the varieties of lespedeza tested.

Mayse and Tugwell (1980) note that the after aldrin was banned there was no known replacement insecticide for managing C. brunnea in rice. In the late 1990s, a fipronil-based seed treatment (Icon®) was found to be effective for controlling C. brunnea in rice (Anonymous 2001). The fipronil seed treatment was used on 30% of the rice acres grown in Arkansas in 2003. In 2004, it was voluntarily removed from the market (Bennet 2004).

In the late 1990s, damage to corn in a corn and soybean rotation from C. brunnea resulted in renewed interest in managing this pest in the Midwest. An emphasis has been placed on chemical control of C. brunnea larvae using soil insecticides in the recent studies. No soil insecticides for use on corn included C. brunnea on the label until 2001 when a number of insecticide efficacy trials were reported (Bailey 1999, Steffey 2000, Steffey and Ratcliffe 2001). The Illinois Natural History Survey and University of Illinois carried out a series of insecticide efficacy trials in 2000 and 2001. The 2000 trials consisted of two locations. At one of the locations, most of the insecticides tested significantly reduced the number of C. brunnea larvae when compared to the control. The other location did not show a significant reduction in colaspis populations. Plant stands did not differ significantly
for most treatments (Shaw et al. 2000). In 2001, the results were similar, with most of the insecticides reducing the number of *C. brunnea*. Again, the plant stands among treatments did not differ significantly (Shaw 2001). In 2004, Iowa State University conducted insecticide efficacy testing on *C. brunnea* in inbred and hybrid corn. Plant stand and height did not differ significantly among treatments in the hybrid corn. In the inbred corn, plant stand did not differ significantly, however tebupirimphos and cyfluthrin (Aztec®) soil insecticide treatments resulted in plants that were significantly taller than the untreated control (Oleson and Tollefson 2004). Also during this time, a number of insecticides were labeled for use on *C. brunnea* (Hest 2001, 2004, Andersch and Schwarz 2003).

A number of recent extension publications on insecticides have chemicals listed for control of *C. brunnea* adults. The Louisiana Agricultural Center Research and Extension Guide on managing corn and grain sorghum pest lists methyl parathion for managing *C. brunnea* adults feeding on corn silks (Baldwin et al. 2005). North Carolina Cooperative Extension Service lists several insecticides for control of *C. brunnea*, along with a number of other foliage feeding insects of soybeans (Van Duyn and Bacheler 2005).

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CHAPTER 2. EFFICACY OF COMMERCIAL AVAILABLE SEED TREATMENTS AND A SOIL INSECTICIDE IN PROTECTING SEEDCORN FROM COLASPIS BRUNNEA (COLEOPTERA: CHRYSOMELIDAE)

A paper to be submitted to Journal of Economic Entomology

Benjamin C. Kaeb and Jon J. Tollefson

Abstract

In recent years, grape colaspis, Colaspis brunnea (F.), larvae have caused significant injury to seed corn by feeding on the surface of the root, denuding it of root hairs. The objective of this study was to test the efficacy of commercially available seed treatments and a soil insecticide to protect the roots of inbred corn seedlings. Treatments consisted of two seed treatments, Poncho® (clothianidin) and Cruiser® (thiamethoxam), at two rates, a soil applied insecticide, Aztec® (tebupirimphos and cyfluthrin), and an untreated check. The experiment was repeated in five commercial seed production fields near Reinbeck, Iowa; three fields in 2004 and two fields in 2005. The experimental design was a Latin square with six replications. The effectiveness of the treatments was compared using plant health traits as indirect response variables and C. brunnea population as a direct response variable. Measures of the plant health included stand, plant height, and yield. Measures of the C. brunnea population included adult emergence and larval counts. The stand and yield data did not show significant treatment effects. There were significant differences among plant heights in 2004 and 2005. Plant height means were analyzed with Dunnet’s means separation technique. The plants in the insecticide treated plots (Aztec, Poncho, and Cruiser) were, in general, significantly
taller than the untreated. There were no consistent differences in plants heights between the insecticide treatments or rates of treatments. Insecticide treatments did not affect *C. brunnea* adult emergence or larval numbers. These results suggest that the insecticides offer protection to the seedling corn.

**Introduction**

Larvae of the grape colaspis beetle, *Colaspis brunnea* (F.), are a root-feeding pest on a wide variety of plants. Damage to seed corn and commercial corn, *Zea mays* L. has been reported across the Midwest in recent years (Bailey et al. 1997, Gray 2000, Obermeyer et al. 2000, Ratcliffe and Steffey 2001, Rice 2003, Steffey 2003). Corn seedlings are injured in the spring by late-instar *C. brunnea* feeding on roots, causing stunting or stand loss. Agronomists managing seed corn planted in rotation following soybeans, *Glycine max* (L.) have estimated yield losses of up to 40% occur in localized areas of infested fields (J. Webster, Pioneer Hi-bred Inc, personal communication). A number of fields in Iowa have had a consistent history of damage when growing seed corn.

Injury from *C. brunnea* larvae occurs early in the growing season; this suggests that an application of an insecticide at planting as a seed treatment or granular insecticide applied to the soil should protect the crop from *C. brunnea* damage. Soil insecticides have been tested against *C. brunnea* in corn several times with various degrees of success. Bigger and Decker (1966) showed organochlorine insecticides reduced *C. brunnea* numbers. Shaw (2001) showed a reduction in *C. brunnea* larval population using various insecticides including Poncho® (clothianidin)
seed treatment, but did not see a difference in plant height. The Icon® (fipronil) seed treatment was the only recommended control for *C. brunnea* in rice, *Oryza sativa* L., production (Bernhardt 2001) until it was withdrawn from the market in 2004 (Bennett 2004).

In this experiment, the ability of commercially available seed treatments and a soil insecticide to protect seed corn plants from *C. brunnea* larvae were tested.

**Materials and Methods**

Seed corn production fields near Reinbeck in central Iowa with a history of *C. brunnea* damage were selected for this experiment. Three fields were used in 2004 and two in 2005. The experimental plots were embedded within a larger field. Inbred seed corn varieties that matched the surrounding field were planted within two days of the surrounding corn to ensure proper pollination. The same production practices were used in the plots as in the remainder of the field. The planting configuration was a 1:4:1 seed production configuration with four female rows and a male row on each side. All fields were planted with 76 cm rows. Treatments were applied only to the female rows. Each treatment unit was 9.1 meters long by four rows arranged in a Latin square design. Between each replication, a one-meter alley was left to facilitate data collection in the plot. The plots were planted with a four-row integral planter (John Deere Max Emerge™ 7100, Deere & Company, Moline, Ill). The seed treatments were tested at the labeled rate for secondary pests and at the higher labeled rate recommended for corn rootworm, *Diabrotica* spp., control. The six treatments were: 1) an untreated control, 2) tebupirimphos and cyfluthrin, *Aztec*®
2.1G, Bayer Crop Science, Monheim, Germany) soil insecticide at the rate of 0.62 mg/1 m row (6.7 oz/1000 row feet), 3) thiamethoxam (Cruiser®, Syngenta Crop Protection, Greensboro, NC) seed treatment at a rate of 0.25 mg ai/seed, 4) thiamethoxam at a rate of 1.25 mg ai/seed, 5) clothianidin (Poncho®, Bayer Crop Science, Monheim, Germany) seed treatment at a rate of 0.25 mg ai/seed (250 rate), and 6) clothianidin at a rate of 1.25 mg ai/seed (1250 rate). Employees of Pioneer Hi-bred International (Johnston, IA) applied the seed treatments to the seeds. The soil insecticide was applied in-furrow at planting using mechanical metering units (Noble®, Royal Industries, Sac City, IA). In each experimental unit, only the center two rows were used for data collection. One row was used for destructive sampling and the other preserved for yield.

**Sampling.** Indicators of plant health were used to assess damage to the seed corn by C. brunnea. Plant height, stand, and yield were measured. Plant heights were measured as extended leaf heights. The heights of 20 plants were measured in the two center rows and averaged. The measurements were taken from 10 consecutive plants, starting 5 plants from the end of the row. In 2004, measurements were taken twice during the growing season, 10 June and 14 July. In 2005, measurements were taken each week for 5 weeks from 13 June until 14 July at which time plants were detasseled. Plant-stand counts were taken the first time plant height was recorded and again at harvest each year. This was done by counting the number of plants in 5.31 m of row. One of the center two rows in each plot was randomly selected for use in collecting yield data. Yield data were collected by hand harvesting the ears from 5.31 m of row; the ears of corn were dried to 12.5±1% moisture, shelled, and
the grain weighed. All data collection was done at least one meter from the alley between treatment plots.

*Colaspis brunnea* activity and abundance within the plot was assessed using emergence cages and soil sampling. Emergence cages similar to the type described by Hein et al. (1985) were used in both 2004 and 2005. The emergence cages were positioned in the fields before the first adult *C. brunnea* emerged and remained in the fields through the month of August when the number of adults emerging declined. Two cages were placed in the center row that would not be used for yield of every plot in one field each year; cages were placed only in the untreated plots in the remaining fields to compare populations. The emergence cages were 76.2 cm long and 35.6 cm wide. The 76.2 cm length allows the cage to reach from the center one row to the center of the next. The cages were centered over a plant which was cut off 15 to 25 cm above the ground, which meant that they covered 35.6 cm of row length. The cages were checked twice a week until beetle emergence began, then checked once a week through the remainder of the emergence period. In the fields that had emergence cages placed in all plots, one cage was moved to a new plant at the end of July to determine if death of the roots under the cages effected *C. brunnea* survival and emergence.

In 2005, plants were dug and the number of *C. brunnea* larvae was counted. This was done in two different ways. The first method used a shovel and hand sorting. Starting five plants from the end of the plot, five consecutive plants per row were dug and, using a dark plastic surface, the soil was broken up and *C. brunnea* larvae counted. The second method was used the following week to dig five more
plants. A golf-cup cutter (Par Aide Products Co., Lino Lakes, MN) was used to remove a 10.8 cm diameter by 17 cm deep soil core that included the plant and surrounding soil. Samples were placed into bags, stored in a 4° C cooler, and processed within one week. *Colaspis brunnea* larvae were removed from the samples using a modification of the processes described in Mayse and Tugwell (1980) and Eaton (1978). The soil was soaked in water for at least 15 min. Then the soil and water was washed through a 61 by 61 cm, 40-mesh (380 μm) sieve screen. Debris remaining on the surface of the sieve was then washed into a 48-mesh (300 μm) sieve (W.S. Tyler Inc., Mentor, OH) which was partially submerged in a saturated salt solution. The larvae that floated to the surface where they were recovered.

**Analysis.** The data on stand, plant height, and yield were analyzed across the field locations for each year. This allowed for greater statistical power and took full advantage of the multiple Latin-square design. The treatment by field interaction was tested for each response variable. PROC MIXED in SAS 9.1 was used for the analysis (SAS Institute 2003). This resulted in two random effects; the row within field, and column within field. Dunnett’s method was used to compare seed treatments to the controls with the untreated as a negative control and Aztec 2.1G as a positive control (SAS Institute 2003). Contrasts were used to make comparisons among the seed treatments. The data on beetle emergence and larval populations were analyzed with ANOVA by field. The beetle emergence was analyzed as total emergence for the year (SAS Institute 2003).
Voucher Specimens. A series of adult male and female C. brunnea collected while carrying out this study have been placed in the Iowa State University Insect Collection.

Results

Indirect measures. Plant stands did not differ in 2004 or 2005 (Table 1) and the treatments did not significantly affect seed corn yield in 2004 and 2005 (Table 2). The plant heights had consistent, significant differences in 2004 and 2005 (Table 3). The results of the insecticides compared to the untreated negative control and Aztec 2.1G positive control are shown in Tables 4 and 5. In 2004, all treatments were significantly taller than the untreated check with the exception of the Cruiser 0.25 on 10 June. In 2005, all treatments were significantly taller than untreated with the exception of the Poncho 1250 on 28 June and Aztec 2.1G on 5 July. When the seed treatments were compared to Aztec 2.1G as a positive control the only significant difference was on 10 June, 2004 when Cruiser 0.25 was significantly shorter. In comparisons made among the seed treatments on 10 June 2004, Cruiser 1.25 was significantly taller than Cruiser 0.25, and on 20 and 28 June, 2005 Poncho 250 was significantly taller than Poncho 1250. There was not a significant effect for the treatment by field interaction for any of the response variables.

Direct measures. Few C. brunnea adults were found in the emergence cages in 2004 and 2005. In 2004, there were 0.29 beetles per cage and in 2005, 0.39 beetles were collected per cage. Treatment did not significantly affect the number of beetles caught in the emergence cages in either 2004 or 2005 (Table 6). The number of C.
brunnea larvae collected from corn seedlings was not significantly affected by insecticide treatments. No significant differences were observed for either extraction method (Table 7).

Discussion

In this experiment, the ability of seed treatments and a soil insecticide to protect the roots of seedling inbred seed corn was examined. The results for most of the response variables were not significant. There were consistent differences in plant heights over the growing seasons due to insecticides treatment; this suggests that they offer protection to the roots of the seedling corn. However, the current data does not separate the insecticide treatments.

The lack of significance in the yield and stand was the result of more than adequate moisture available to the plants during the early part of the growing season when C. brunnea injury occurred. Had either season been dry early in the growing season there may have been reduced stand, yield loss, and more severe stunting. These damage symptoms would have occurred because the root systems compromised by C. brunnea injury would have been impaired in their ability to take up water and nutrients. Weather data in 2005 showed that in the week prior to the 20 June sample date had just 0.5 mm rain. The greatest difference in plant height was observed in this sample date. In both seasons, the first measurement date of plant height occurred while C brunnea was still actively feeding. This, as well as the lack of rain, is likely the reason that the greatest differences in plant heights were measured in late June in 2005.
The direct measures were not significant due to the variability of the distribution of *C. brunnea* in the soil. It is not uncommon to find a plant with a number of larvae feeding on it between two plants with none. A larger sample size would compensate for the uneven distribution. The emergence cages were designed for corn rootworms, which have higher populations per plant than were observed with *C. brunnea* in Iowa. To use emergence as a response variable for studies of this type, a greater area of the field would need to be monitored.

For seed corn production in fields where there is a history of damaging *C. brunnea* populations growers should consider using a soil insecticide or seed treatment as a management option. This experiment shows that seed corn fields treated with any of the insecticide treatments were consistently taller than the untreated control, however none of the products tested consistently performed better than the others. In a situation where conditions allow severe damage to occur there may be differences in efficacy of the products that was not evident in this experiment.

**Literature Cited**


Webster, J. 2003. Personal communications
**Table 1.** Mean plant stand in plots treated with insecticides to protect seed corn from *C. brunnea* larval feeding

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2004</th>
<th>2005</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 June&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10 Sept&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13 June&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12 Sept&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Poncho 250</td>
<td>66.6</td>
<td>66.6</td>
<td>62.5</td>
<td>62.0</td>
</tr>
<tr>
<td>Poncho 1250</td>
<td>67.1</td>
<td>64.1</td>
<td>59.3</td>
<td>60.7</td>
</tr>
<tr>
<td>Cruiser 0.25</td>
<td>65.8</td>
<td>67.8</td>
<td>60.5</td>
<td>62.0</td>
</tr>
<tr>
<td>Cruiser 1.25</td>
<td>66.0</td>
<td>65.2</td>
<td>61.5</td>
<td>61.0</td>
</tr>
<tr>
<td>Aztec</td>
<td>67.2</td>
<td>67.2</td>
<td>61.2</td>
<td>62.0</td>
</tr>
<tr>
<td>Untreated</td>
<td>66.3</td>
<td>63.0</td>
<td>63.3</td>
<td>63.4</td>
</tr>
</tbody>
</table>

<sup>a</sup>n.s.  $F=0.38$ df=5,60  $P=0.86$

<sup>b</sup>n.s.  $F=2.04$ df=5,60  $P=0.09$

<sup>c</sup>n.s.  $F=1.62$ df=5,40  $P=0.18$

<sup>d</sup>n.s.  $F=0.39$ df=5,40  $P=0.85$

**Table 2.** Mean yield in plots treated with insecticides to protect seed corn from *C. brunnea* larval feeding

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2004&lt;sup&gt;a&lt;/sup&gt;</th>
<th>2005&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poncho 250</td>
<td>1235</td>
<td>841</td>
</tr>
<tr>
<td>Poncho 1250</td>
<td>1199</td>
<td>828</td>
</tr>
<tr>
<td>Cruiser 0.25</td>
<td>1221</td>
<td>827</td>
</tr>
<tr>
<td>Cruiser 1.25</td>
<td>1211</td>
<td>815</td>
</tr>
<tr>
<td>Aztec</td>
<td>1201</td>
<td>786</td>
</tr>
<tr>
<td>Untreated</td>
<td>1140</td>
<td>784</td>
</tr>
</tbody>
</table>

<sup>a</sup>n.s.  $F=0.40$ df=5,60  $P=0.85$

<sup>b</sup>n.s.  $F=0.39$ df=5,40  $P=0.85$
Table 3. ANOVA of treatment main effects for plant height means in seed corn treated with insecticide to protect seed corn from *C. brunnea* larval feeding

<table>
<thead>
<tr>
<th>Date</th>
<th>F</th>
<th>df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 June 2004</td>
<td>5.21</td>
<td>5,75</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>14 July 2004</td>
<td>5.58</td>
<td>5,60</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>13 June 2005</td>
<td>0.55</td>
<td>5,40</td>
<td>0.738</td>
</tr>
<tr>
<td>20 June 2005</td>
<td>7.50</td>
<td>5,40</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>28 June 2005</td>
<td>5.78</td>
<td>5,40</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>5 July 2005</td>
<td>4.58</td>
<td>5,40</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>14 July 2005</td>
<td>4.42</td>
<td>5,40</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Table 4. Mean plant heights for plots treated with insecticides to protect seed corn from *C. brunnea* larval feeding in 2004

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean Plant Height (cm)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10 June</td>
<td>14 July</td>
</tr>
<tr>
<td>Poncho 250</td>
<td>39.3*</td>
<td>173.6*</td>
<td></td>
</tr>
<tr>
<td>Poncho 1250</td>
<td>38.7*</td>
<td>174.6*</td>
<td></td>
</tr>
<tr>
<td>Cruiser 0.25</td>
<td>37.7**</td>
<td>173.5*</td>
<td></td>
</tr>
<tr>
<td>Cruiser 1.25</td>
<td>39.3*</td>
<td>174.3*</td>
<td></td>
</tr>
<tr>
<td>Aztec</td>
<td>39.3*</td>
<td>174.7*</td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>37.3</td>
<td>170.0</td>
<td></td>
</tr>
<tr>
<td>% difference&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.8</td>
<td>2.8</td>
<td></td>
</tr>
</tbody>
</table>

* indicates treatment is significantly different than the untreated.

** indicates significantly different than Aztec.

<sup>a</sup>% difference indicates the percent of reduction in height of untreated compared to the insecticide treatments.
Table 5. Mean plant heights for plots treated with insecticides to protect seed corn from *C. brunnea* larval feeding in 2005

<table>
<thead>
<tr>
<th>Treatment</th>
<th>13 June</th>
<th>20 June</th>
<th>28 June</th>
<th>5 July</th>
<th>14 July</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poncho 250</td>
<td>32.5</td>
<td>55.2*</td>
<td>87.2*</td>
<td>110.9*</td>
<td>153.5*</td>
</tr>
<tr>
<td>Poncho 1250</td>
<td>33.1</td>
<td>52.7*</td>
<td>84.4</td>
<td>108.5*</td>
<td>151.8*</td>
</tr>
<tr>
<td>Cruiser 0.25</td>
<td>32.6</td>
<td>53.8*</td>
<td>85.2*</td>
<td>108.6*</td>
<td>151.3*</td>
</tr>
<tr>
<td>Cruiser 1.25</td>
<td>33.1</td>
<td>54.0*</td>
<td>85.9*</td>
<td>109.0*</td>
<td>151.6*</td>
</tr>
<tr>
<td>Aztec</td>
<td>33.4</td>
<td>53.6*</td>
<td>85.2*</td>
<td>108.6*</td>
<td>150.5</td>
</tr>
<tr>
<td>Untreated</td>
<td>32.4</td>
<td>50.5</td>
<td>81.9</td>
<td>104.5</td>
<td>146.5</td>
</tr>
</tbody>
</table>

% difference\(^a\) 1.6  6.5  5.2  3.5  4.3

* indicates treatment is significantly different than the untreated.

\(^a\) % difference indicates the percent of reduction in height of untreated compared to the insecticide treatments.
Table 6. Adult *C. brunnea* collected in emergence cages from plants treated with insecticides targeting *C. brunnea* larvae

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2004&lt;sup&gt;a&lt;/sup&gt;</th>
<th>2005&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poncho 250</td>
<td>0.33</td>
<td>0.42</td>
</tr>
<tr>
<td>Poncho 1250</td>
<td>0.25</td>
<td>0.00</td>
</tr>
<tr>
<td>Cruiser 0.25</td>
<td>0.17</td>
<td>0.67</td>
</tr>
<tr>
<td>Cruiser 1.25</td>
<td>0.42</td>
<td>0.42</td>
</tr>
<tr>
<td>Aztec</td>
<td>0.33</td>
<td>0.25</td>
</tr>
</tbody>
</table>

<sup>a</sup>*F*=0.33; df=5,20; *P*=0.89  
<sup>b</sup>*F*=1.80, df=5,20; *P*=0.16

Table 7. *C. brunnea* larvae collected using two different extraction methods from seedling plants that had been treated with insecticides

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Visual&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Wash&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poncho 250</td>
<td>0.17</td>
<td>1.47</td>
</tr>
<tr>
<td>Poncho 1250</td>
<td>0.93</td>
<td>0.33</td>
</tr>
<tr>
<td>Cruiser 0.25</td>
<td>0.67</td>
<td>1.13</td>
</tr>
<tr>
<td>Cruiser 1.25</td>
<td>0.83</td>
<td>0.40</td>
</tr>
<tr>
<td>Aztec</td>
<td>0.50</td>
<td>0.87</td>
</tr>
<tr>
<td>Untreated</td>
<td>0.50</td>
<td>1.33</td>
</tr>
</tbody>
</table>

<sup>a</sup>*F*=1.95; df=5,20; *P*=0.13  
<sup>b</sup>*F*=2.30 df=5,20; *P*=0.08
CHAPTER 3. FEASIBILITY OF APPLYING INSECTICIDES TO SOYBEANS TO REDUCE *COLASPIS BRUNNEA* (COLEOPTERA: CHRYSOMELIDAE) POPULATION IN A SOYBEAN–SEED CORN ROTATION

A paper to be submitted to Journal of the Kansas Entomological Society

Benjamin C. Kaeb and Jon J. Tollefson

**Abstract**

In recent years, grape colaspis, *Colaspis brunnea* (F.), larvae have caused significant injury to seed corn by feeding on the surface of the root, denuding it of root hairs. The objective of this study was to test the feasibility of reducing the population of larvae attacking seed corn by applying an insecticide to soybeans when adult *C. brunnea* are present the previous year. Three treatments were evaluated: 1) untreated check, 2) one application of zeta-cypermethrin, and 3) two applications of zeta-cypermethrin. Treatments were applied on 5 and 19 July 2005.

The experiment was conducted in three fields near Reinbeck, IA that had a history of high *C. brunnea* populations. The experiment was a randomized complete block design. The population of adult *C. brunnea* was measured using weekly sweep net samples from 28 June through 1 September. The larval population in the fall was measured using two 5.7 l soil samples per treatment plot. Both one and two applications of zeta-cypermethrin significantly reduced the adult *C. brunnea* population. When the data from both insecticide treatments were combined and contrasted against the untreated, the larval population in the fall soil samples was reduced in plots receiving zeta-cypermethrin. This result indicates that an insecticide
applied to control adult *C. brunnea* could reduce the risk of damage to seed corn the following growing season.

**Introduction**

The grape colaspis, *Colaspis brunnea* (F.), is a native beetle that can cause damage to corn, *Zea mays* L. *Colaspis brunnea* larvae injure crops by feeding on the surface of the root denuding it of root hairs (Lindsay 1943). In Iowa, *C. brunnea* is univoltine. Adult emergence, oviposition, and egg hatch occur during summer. Late in the summer, larvae develop to the 5th–8th instar of 10 instars before wintering below the frost line (Lindsay 1943). The following spring, later instars (5th–10th) are present early in the season when the crops are small and most vulnerable. In corn, damage that is most often associated with larval injury is stunting, wilting, and purpling of seedlings (Lindsay 1943, Edwards et al. 2000, Steffey and Ratcliffe 2001, Rice 2003, Steffey 2003). Damage to seed corn and commercial corn has been reported across the Midwest in recent years (Bailey et al. 1997, Gray 2000, Obermeyer et al. 2000, Ratcliffe and Steffey 2001, Rice 2003, Steffey 2003). Damage to seed corn is of the greatest concern because of lower vigor and higher economic returns, Agronomists managing seed corn production have estimated that yield losses of up to 40% occur in localized areas of infested fields (J. Webster, personal communication).

Preliminary data on adult *C. brunnea* populations from sweep net samples in 2004 indicated that 85% of adult *C. brunnea* were present in soybean, *Glycine max* (L.), fields between 1 and 21 July. This three-week period is a window of opportunity
to reduce *C. brunnea* population within a soybean field. The study presented here was designed to determine if controlling *C. brunnea* adults with insecticide applications is a feasible management option to reduce larval populations in fields being rotated to seed corn the following year. A reduced *C. brunnea* larval population could reduce the risk of injury to the seed corn.

Insecticide applications have been recommended to protect corn silks (Baldwin et al. 2005) and bean foliage from adult *C. brunnea* (Van Duyn and Bacheler 2005). However, there have not been any studies published reporting the effects of an adult *C. brunnea* insecticide application on subsequent larval populations.

**Methods and materials**

This experiment was conducted during the summer of 2005 in three soybean fields near Reinbeck, Iowa that were to be rotated to seed corn in 2006. The fields each had a history of high populations of *C. brunnea*. The growers planted and maintained the fields using standard commercial techniques. Two fields (referred to as fields A and B) were planted with 76 cm rows, and one field (referred to as field C) was planted with 18 cm rows.

Treatment plots were 54.9 m squares with 3.0 m buffers of unsprayed soybeans between plots, arranged in a randomized complete block design with four replications. The three treatments compared in this study, were: 1) an untreated control, 2) one application of zeta-cypermethrin, (Mustang Max,® FMC Corporation, Philadelphia, PA), on 5 July, and 3) two applications of zeta-cypermethrin on 5 and
19 July. The zeta-cypermethrin was applied at the labeled rate of 293 ml/hectare (4.0 oz/acre). A commercial RoGator® (AGCO Corporation, Duluth, GA) applicator with 27.4 m spray booms with flat fan nozzles was used for the insecticide applications. The carrier rate used was 141 liter/hectare (15 gallons/acre).

**Adult population sampling.** Sweep net samples taken one or two times per week in two locations in each plot were used as a relative measure of the adult *C. brunnea* populations. Samples were taken twice during weeks in which insecticide applications were made and during the first week after application; all other samples were taken on weekly intervals. Twenty-five sweeps were done at each sampling location. In fields A and B, which had 76 cm row widths, sweeps were done across one row. In field C, which had 18 cm row widths, sweeps were done across four rows to sample a similar area. Care was taken to sample at least 18 m from either edge of the plot. When possible, sweep net sampling was conducted between 1000 and 1700 hours to reduce sample variation due to diel fluctuation reported in sweep net samples for *C. brunnea* (Eaton 1978). Sampling began on 30 June and continued to 1 September for fields A and B; in field C sampling was discontinued after 4 August when the field was sprayed with an insecticide for soybean aphid, *Aphis glycines* Matsumura, control. Sampling on 5 and 19 July was done before insecticides were applied.

**Laval population sampling.** *Colaspis brunnea* larval populations in the soil were measured at the end of the growing season. Field A was sampled on 22 September and B was sampled on 23 September. Field C was not sampled because it had been sprayed with insecticide for soybean aphids, which confounded the insecticide
treatments applied for *C. brunnea* control. Soil samples were dug using a 16 cm wide shovel to a depth of 17 cm, making each sample 5.7 l of soil. Samples were placed into bags, stored in a 4°C cooler, and processed within three weeks. *Colaspis brunnea* larvae were removed from the samples using a modification of the processes described in Mayse and Tugwell (1980) and Eaton (1978). The soil was soaked in buckets for at least 15 minutes then washed through a 61 by 61 cm 40-mesh (380 μm) sieve. Debris remaining on the surface of the sieve was then washed into a 48-mesh (300 μm) sieve (W.S. Tyler Inc., Mentor, OH) which was partially submerged in a concentrated salt solution. The larvae floated to the surface where they were recovered.

**Analysis.** Adult *C. brunnea* sampling data were analyzed using the Proc Mixed procedure in SAS (SAS Institute 2003). Analysis was done as a repeated measure of sampling dates after the first insecticide application had occurred (7 July to 1 September) using Toeplitz covariance structure (SAS Institute 2003). Comparisons were made between treatments using least square means with Tukey adjustment (SAS Institute 2003).

The larval sampling data were analyzed across the two fields that were sampled. The data were normalized using a log transformation (ln+1) prior to analysis. A contrast was used to compare the treatments with one or two insecticide applications to the untreated control (SAS Institute 2003).

**Voucher Specimens.** A series of adult male and female *C. brunnea* collected while carrying out this study have been placed in the Iowa State University Insect Collection.
**Results**

**Adult population.** In all three locations both one and two insecticide applications significantly reduced adult *C. brunnea* population when compared to the untreated locations (Field A: $F=7.50$; $df=2,9$; $P=0.0121$; Field B: $F=10.15$; $df=2,9$; $P=0.0049$; Field C: $F=5.86$; $df=2,9$; $P=0.0234$) (Fig. 1-3). There was no significant difference between one and two applications in any of the locations.

**Larval population.** Insecticide treatments to soybeans to reduce adult numbers resulted in significant differences in the larval populations of *C. brunnea* ($F=4.5$; $df=3,21$; $P=0.014$, Table 1). A contrast comparing the insecticide treatments to the untreated showed a significant reduction in the number of larvae ($F=5.0$; $df=1$; $P=0.036$).

**Discussion**

This experiment demonstrated that it is possible to significantly reduce adult *C. brunnea* population using one or two insecticide treatments. It further showed that this reduction carried over to the larval population. The reduction in larval numbers indicates that the oviposition of *C. brunnea* in the treated plot was reduced. With a better understanding of *C. brunnea* biology, managing *C. brunnea* adults in soybeans in the year prior to seed corn could be developed as a means to allow seed corn growers to reduce the risk of *C. brunnea* damage.

The low number of larvae found limited the larval *C. brunnea* population analysis. However, the way they were distributed between the treatments with twenty–four in the untreated area, three in the areas sprayed one time, and five in
the areas sprayed twice suggested that the treatments were having an effect. Had the numbers of larvae recovered been larger it is likely that the trends observed in the samples would have had a greater separation and there would have been significant differences between the untreated and each of the insecticide treatments.

The timing of the insecticide application is critical to the success of this management technique and needs to be refined prior to adoption by seed-corn growers. In this study, the timing of insecticide applications was based on the phenology of the prior year. Two areas that need to be clarified to improve the timing for optimal control are the periods of emergence and oviposition.

Prior studies on *C. brunnea* have shown that the emergence of *C. brunnea* is dependent on weather conditions and soil temperature and may vary from year to year and field to field (Lindsay 1943, Rolston and Rouse 1965, Eaton 1978). From the variation in emergence given by these studies, the optimal timing of an insecticide may vary as well. Understanding the factors that control the emergence of *C. brunnea* would greatly benefit a management strategy of this type. It would allow the insecticide timings to be more precisely related to *C. brunnea* phenology.

The preoviposition period of *C. brunnea* is not well understood. The two studies that have looked at *C. brunnea* preoviposition period reported that it is most likely between three and ten days. Lindsay (1943) observed the preoviposition period for reared *C. brunnea* to be between ten and eighteen days in the laboratory. However, this same manuscript states field observations suggest that it may be considerably less. Rolston and Rouse (1965) reported the preoviposition period could be as short as three days; and possibly as long as ten for field collected *C.*
brunnea specimens in Arkansas. Research clarifying timing of oviposition of C. brunnea would clearly define the window of opportunity for successful management.

In this study, histories of infestation were used to select fields which were thought to be at risk for C. brunnea damage. Currently this is the only prediction method that is available with this pest. A method of predicting the populations of C. brunnea would allow this management technique to be of greater value. Sweep net sampling is useful for measuring the population; however, by the time the population reaches its peak in sweep net samples, the optimal timing of an insecticide application has likely been missed.

This study has demonstrated that C. brunnea can be controlled as an adult. This management technique, when fully developed, will give commercial growers another option to manage this pest.

**Literature Cited**


Fig 1. Adult *C. brunnea* populations in plots treated with zeta-cypermethrin in field A. Bars show standard error (n=4)

- ■ Untreated
- ● - ● One Application (5 July)
- ▲ - ▲ Two Applications (5, 19 July)
Fig 2. Adult *C. brunnea* populations in plots treated with zeta-cypermethrin in field B. Bars show standard error (n=4)
Fig 3. Adult *C. brunnea* populations plots treated with zeta-cypermethrin in field C. Bars show standard error (n=4).
Table 1. *C. brunnea* larval population in September soil samples in plots treated in
July with zeta-cypermethrin targeting *C. brunnea* adults (n = 8)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>(larvae / l soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>0.26</td>
</tr>
<tr>
<td>One Application (5 July)</td>
<td>0.03</td>
</tr>
<tr>
<td>Two Applications (5,19 July)</td>
<td>0.05</td>
</tr>
</tbody>
</table>
CHAPTER 4. REVIEW AND DISCUSSION OF SAMPLING METHODS FOR

COLASPIS BRUNNEA

Introduction

Researchers working on C. brunnea have used a variety of sampling methods to sample it at various life stages. This chapter includes a review and discussion of these sampling methods. Also included are the methods used in carrying out this project. Some of methods used in this project, particularly those that did not work well, which are not included elsewhere in this thesis are included here. This chapter is meant to be used as a resource for further research with C. brunnea.

Soil sampling for Colaspis brunnea larvae

Review. The challenge of sampling C. brunnea larvae was approached in different ways by previous research projects. Lindsay (1943) recommended using a cubic foot soil sample and locating C. brunnea larvae by sorting through the soil by hand. This is a labor intensive and tedious process, which was reported to take two or three hours per sample. Shaw (2001) dug and visually examined one meter of row to examine the efficacy of insecticides against C. brunnea. Rolston and Rouse (1965) dug and visually examined soil cores that were four inches in diameter (no depth given) at the rate of thirty per field. Eaton (1978) sampled with a commercial golf cup cutter to a depth of 15.2 cm. Larvae were extracted from the soil by washing samples through sieves with openings varying between 0.425 mm and 0.841 mm depending on the size of larvae being located, then floating the debris from the sieve in water and examining the surface and sunken debris for colaspis larvae. Mayse
and Tugwell (1980) described two methods for recovering *C. brunnea* larvae from soil. The first was a dry screening method in which a 0.5 l sample is worked through a framed screen onto a dark piece of plywood; when no larvae were found in four samples, a low risk of colaspis damage to rice was indicated. The second method used washing and flotation. This method used a garden hose to wash the sample through a soil screen (10 strands of wire per cm) then placing the remaining debris in a saturated salt solution and using an aspirator to collect the larvae floating on the surface. A study done in Illinois in 2000 and 2001 reported that a baiting system similar to that used for wireworms was unsuccessful for *C. brunnea* (Holmberg 2002).

**Sampling Corn.** When scouting a corn field for *C. brunnea* larvae, using a trenching shovel and a putty knife worked well. With the trenching shovel, the seedling plant is dug up, keeping the root system intact around it, thereby reducing the amount of soil that must be searched for larvae. A putty knife was then used to remove the soil a layer at a time to reveal *C. brunnea* larvae. If *C. brunnea* damage is suspected in a field, an observant person can make a determination within a few minutes whether *C. brunnea* is present at the site or not. This method is limited in that it can be used only after the crop has emerged. Prior to seedling emergence, the larvae are spread out too much to be found in random samples, and are below the depth that can be sampled easily. The number of larvae found using this method is too variable to be adequate for systematic, research sampling.

Golf-cup cutters (Par Aide Products Co., Lino Lakes, MN) were used in sampling seed corn as they allowed the taking of consistent samples that contained
most of the root systems of the corn. Each soil core taken was 10.8 cm in diameter and 17 cm deep. The golf-cup cutter samples were processed using a wash-flotation method. Even in areas with high populations the number of *C. brunnea* larvae per plant vary considerably so the number of samples must be relatively high. In seed corn, the sampling was most effective in late May and June when *C. brunnea* larvae were feeding and causing injury. Soil sampling prior to crop emergence was difficult, as the larvae were randomly distributed in the field and were located deeper in the soil, which resulted in low numbers in samples.

The depth and scarcity larvae in the spring is demonstrated by sampling done in late April and early May of 2004. The 28 April sample was taken prior to planting of corn, and the 11 May sample prior to crop emergence. In these samples, a second golf cup core was taken in the hole of the first to give a deeper sample. The two cores from each location were processed separately, a 0–17 cm deep core and a 17–34 cm depth. Twenty–four locations were sampled each time. Sampling on 28 April 2004 yielded just one larva in a 17–34 cm core and none in the 0–17 cm cores. Sampling on 11 May 2004 yielded four larvae at 17–34 cm depth and none in the 0–17 cm cores. Prior studies have reported that the majority of *C. brunnea* are found at depth greater than 20 cm in fall samples taken in October through December (Bigger 1928, Easton 1978, Lindsay 1943). The larvae concentrate around the roots as they move into the root zone to feed.

Another method used to sample larvae feeding on corn was to use a shovel to remove the seedling and root system from the ground, then placing the sample onto a dark piece of plastic where the soil was carefully pulled back and spread out
so colaspis larvae could easily be seen. The number of larvae found by this method differed considerably among personnel processing the samples. Once the crop had emerged, *C. brunnea* larvae begin feeding and can be found concentrated in the area near the roots of the crops.

**Sampling Soybeans.** Sampling for *C. brunnea* larvae in soybean fields was done in the fall. The samples taken consisted of a 17.7 cm (7 in) soil cube containing the mature root system of the soybean. These samples were centered over one plant, but often contained more than one plant. When sampling in the fall the sampling was completed no later than mid September because once the plants senesce the number of larvae in the area sampled drops as the larvae move deeper for the winter. Soil samples from soybeans were all processed using the wash-flotation method described below.

**Extraction Methods.** The wash-flotation method of soil sample processing in this project primarily used a modification of the methods described in Mayse and Tugwell (1980) and Eaton (1978). The samples were stored for less than a month in a 4°C cooler until processed. The first step in sample processing was to soak the soil samples in water for at least 15 minutes. The sample was placed in a bucket and the bucket filled with water using a nozzle to produce a pressurized stream to break up soil clumps. The surface of the water was checked for colaspis larvae as occasionally a few would be found floating. In soil with higher levels of clay, it was important to ensure that the sample soaked through.

The samples were then washed through a 40-mesh (380 µm) sieve. A 0.69 m x 0.69 m (2 ft by 2 ft) screen was built for this purpose. Samples were washed
through the screen using a garden hose and nozzle. Care had to be taken not to use excessive water pressure, which could destroy *C. brunnea* larvae. After most of the soil had been washed through the screen, the remaining soil (aggregates and gravel) and debris (roots, stubble, etc.) was washed onto a smaller, 48-mesh (300 μm) standard sieve (W.S. Tyler, Inc., Mentor, OH), which was then partially submerged into a concentrated salt (MgSO₄) solution. This caused the colaspis larvae and light debris to float to the surface. If there was a large amount of debris, the sample was split into sub samples to facilitate sorting the larvae from the debris. In samples with a large amount of aggregates or gravel which did not wash through the sieve, the sample was stirred to make sure that the colaspis larvae were not trapped under the gravel and could float to the surface. Two people (one washing, the other soaking and searching washed samples) could process a golf-cup cutter sized sample at the rate of one sample per 10 minutes. A larger seven-inch soil cube sample took longer to wash and could be processed at the rate of one sample per 15 minutes.

Tullgren funnels were utilized in an attempt to reduce the labor in locating *C. brunnea* larvae in soil samples. The Tullgren funnel was of the type described by Eastman (1980). Golf-cup core size soil samples were taken from corn and placed into the Tullgren funnels for 96 hours. The funnels were checked every 24 hours for *C. brunnea* larvae. A variety of soil arthropods were found in the samples, however, in over 30 samples, not a single *C. brunnea* larva was extracted. The technique was varied by adding heat and breaking up the samples without success. Eight samples were paired to a wash-flotation sample. In the samples processed by the wash-
flotation method, three had a single *C. brunnea* larvae present and one had two; this compared to none in the eight samples placed into the Tullgren funnels. The samples that had been placed in the Tullgren funnels were subsequently processed using the wash-flotation method and a larva was found in one sample. From these results, it is apparent that Tullgren funnels are not a viable option for separating *C. brunnea* larvae from soil.

**Emergence sampling**

**Emergence in corn.** Emergence cages, similar to the type described in Hein et al. (1985), were used in the seed-treatment study to examine the effects of the treatments on emerging *C. brunnea* beetles. In 2004, the cages used had “live capture cups”. The live capture cups are a cylinder capped on one end with a removable top. The other end of the cylinder has a funnel set into it that beetles climb through and are unable to escape. The capture cups are mounted on the top of the cage and require beetles to climb to the top of the cage to be captured. In 2005, cages with a zipper opening were used without a capture device; beetles were collected by hand from the cages.

The emergence cages collected few *C. brunnea* adults (less than two beetles per cage in the field with the highest population) in both 2004 and 2005. These numbers are due to several factors. First, they are designed to collect corn rootworm beetles which usually are more abundant. The number of larvae found around each plant in the soil samples was rarely more than five. Another factor that may have been responsible for the low numbers is that the plants under the cages were cut off
and that may have reduced the quality of roots that *C. brunnea* larvae had to feed on. On several occasions in 2004 beetles were observed in cages below the capture units, but no beetles were found in the capture units during subsequent inspections. In 2005, the beetles were found in the cage as long as there was green foliage on the plant where they could feed. Once the plant had died the number of beetles found in the cages dropped to zero. In 2004, beetles had been located in the cages throughout the growing season. In both 2004 and 2005, a number of cages were moved mid-season to see if there was an effect of the quality of roots under an emergence cage. Not enough beetles emerged late in the season to form a definitive conclusion on whether moving the cages made a difference.

**Emergence in soybeans.** In soybeans 1.82 m x 1.82 m (6 ft x 6 ft) tent-type cages were used to get an idea of the emergence phenology. Tents similar to this type were successfully used in prior work on *C. brunnea* emerging in soybeans with up to 25.6 beetles/m² being collected in a season (Eaton 1978). Two emergence tents were placed in the center of untreated plots in each field location of the adult control study in 2005. The tents were checked once or twice a week for the presence of adults. The beans in the tent were cut back to a single trifoliate every two weeks to facilitate locating *C. brunnea* within the tent. In the three field locations, beetles were found in tents at the rates of 2.6, 1.5, and 0.2 beetles/m². *Colaspis brunnea* collected in the tent seemed to follow the activity recorded in sweep samples. The reason for low populations emerging in the tents in 2005 is not entirely clear. It may be an accurate reflection of the population or perhaps some other factor of the tent sampling. In putting the cages in and checking the cages, the soil under the cage
may have been compacted by foot traffic, resulting in *C. brunnea* being unable to emerge. There were also a number of tiger beetles (Coleoptera: Cicindelidae) observed in the tents. It is not known if these feed on *C. brunnea*.

Even with the low numbers of emerging *C. brunnea* adults, the number found in emergence cages peaked sharply near the beginning of the emergence period in all fields sampled (Fig. 1). This is similar to emergence phenology reported for soybeans in North Carolina (Eaton 1978).

**Adult sampling**

**Review.** Sweep sampling has been reported to work successfully to track the populations of *C. brunnea* in clover, alfalfa, soybeans, and lespedeza (Forbes 1900, Bigger 1928, Lindsay 1943, Rolston and Rouse 1965, Rudd and Jensen 1977, Eaton 1978). Rudd and Jensen (1977) showed a correlation in soybeans between the number of *C. brunnea* in sweep samples compared to the number collected shaking plants over a ground cloth. However, this work was carried out in Louisiana, and in 1979 it was reported that a majority of the colaspis beetles in Louisiana were *Colaspis louisanae* Blake (Chapin 1979). Eaton (1978) demonstrated a diel fluctuation in colaspis beetles caught in sweep samples in soybeans; as the canopy warmed the beetles moved away from the top of the canopy where sweep-net sampling is most effective.

**Sweep-net sampling.** The sweep net is an economical way to sample *C. brunnea* beetles over the course of the season. *Colaspis brunnea* tends not to fly when the sweep net is opened. This allowed the samples to be counted in the field, even
when the numbers were at their highest. The beetles were also easily transferred from the net to a collection cup by simply grabbing the beetles. Very few beetles are lost in the transfer process. If collected beetles are to be kept alive, they need to be stored in a cooler; just a few minutes in a warm vehicle will kill most beetles in a container. In the experiments conducted in this study, sweep net sampling was carried out between 1000 and 1700 hours to minimize the effect of the time of day on the sample that was reported by Eaton (1978).

In the sweep sampling carried out in this experiment, it was noted that C. brunnea populations in each soybean field peaked sharply for less than a week in one of the first three weeks of July. The timing of the peak C. brunnea population varied between fields by as much as two weeks within a growing season. This complicates developing a threshold for predicting C. brunnea in seed corn from sweep samples in soybeans as sampling would need to be carried out repeatedly to insure that peak populations are included.

Yellow sticky traps. As part of the adult control study, yellow sticky card traps were evaluated as a possible measure of the activity of colaspis beetles in soybean fields. Yellow sticky traps are normally used to sample for other beetles in soybeans, including the western corn rootworm (Diabrotica virgifera LeConte) (Cook et al. 2005). The sharp peak in the number of colaspis beetles caught by sweep samples, the time of which varied from field-to-field and year-to-year, means that sampling would have to be conducted over several weeks to get an accurate population estimate. The yellow sticky card was viewed as an alternative that could be cheaper, less variable, and was more likely to be adopted by producers as a sampling
method. It was tried in Illinois without success, however the researchers questioned whether enough sticky cards had been used (Holmberg 2002). In this study, as part of the adult control experiment in soybeans, a Pherocon AM® yellow sticky trap (Trece Salinas, CA) was placed on a stake at canopy level at each sweep-sampling location. There were 72 locations in three fields. The traps were moved up each week to keep the card at canopy height. Cards were changed on a three-week interval. Over the course of the colaspis emergence period two beetles were caught on 19 July; they were both on cards that had slipped down the stake into the soybean canopy. The beetles had probably crawled onto them by chance.

Similar results were observed in corn with a similar number of sticky cards. In corn, the cards were placed on stakes between corn plants until the corn was strong enough to support the cards. *Colaspis brunnea* beetles were not found on the cards as long as they were on the stakes. Once the cards were attached to the plants a number of *C. brunnea* beetles were caught. However, it also became apparent that personnel checking the traps were also mistaking teneral northern corn rootworms (*Diabrotica barberi* Smith and Lawrence) for *C. brunnea* beetles; which inflated the numbers for several weeks.

**Egg sampling**

Eaton (1978) reported on *C. brunnea* egg sampling. In a laboratory study reported in that manuscript, 707 cm³ soil were washed carefully through a sieve with 0.180 mm openings and examined under a microscope for *C. brunnea* eggs. Eaton (1978) further reports that a variety of less labor intensive methods of extracting eggs from
soil samples did not provide satisfactory results. Recovery rates were reported to be low and *C. brunnea* eggs were often damaged by agitation or the salt solutions used.

**Damage and injury sampling in corn**

**Review.** Commonly reported injury to corn attributed to *C. brunnea* includes stunting, wilting, purpling, and death of seedlings (Forbes 1900, Bigger 1928, Lindsay 1943, Obermeyer et al. 2000, Steffey and Ratcliffe 2001, Rice 2003, Steffey 2003). Yield was the first factor used to quantify *C. brunnea* damage to corn. Variation in yield attributed to *C. brunnea* was reported in 1931 (Bigger 1931). Lindsay (1943) was the first to utilize stand loss to quantify *C. brunnea* injury in corn. This was done by counting the number of stunted or missing hills of corn along a row of 50 hills. The hills were groups of 2–4 corn plants planted with a check-type planter. During the 1950s and 1960s, a series of insecticide trials some of which included *C. brunnea* as well as other secondary pests, were carried out in Illinois. In these trials, plant-stand and yield were reported as response variables (Bigger and Decker 1966). More recent insecticide trials have begun to include plant heights as a way of gauging stunting due to *C. brunnea* damage (Shaw 2001, Oleson and Tollefson 2004). In one insecticide trial, unevenness of plant height due to *C. brunnea* injury was reported as “plants needing manual detasseling.” This was done by counting seed corn plants missed by a mechanical detasseler (Andersch and Schwarz 2003).
**Injury Sampling.** For the seed-treatment trials carried out as part of this study, plant stand and plant height were used as indicators of *C. brunnea* injury and to quantify the root protection provided by the insecticides (seed treatments and granular). Damage to the seed corn was quantified using yield. It should be noted that in the two years that these trials were carried out the injury from *C. brunnea* was not apparent in visual observations of the field even though *C. brunnea* larvae were present and larval injury occurred. This was a small-plot study with four 9.1 m (30 in) rows in each treatment plot. Plant stand was measured in mid-June and at harvest in 5.31 m (17 ft 5 in) of row. The 17 ft 5 in is the equivalent of 1/1,000 of an acre in 72 cm (30 in) row spacing. No stand loss was noted in this study. However judging from photographs of *C. brunnea* damage in conditions where severe damage was occurring, it would quantify the injury quite well. Plant height was measured in the center two rows, starting five plants from the end of a row and measuring ten consecutive plants. The height data were then averaged over the twenty plants. Height on the individual plants was measured using “extended leaf height” where the distance from the ground to the highest extended leaf was measured. In 2004, the plant heights were measured in mid-June and mid-July. Application of insecticides resulted in small but significant differences in height. In 2005, the heights were measured once a week for five weeks from 13 June to 14 July in an effort to see how plant height varied over time. It appears that rainfall was the controlling factor. In the week prior to 20 June, there was 0.5 mm (0.02 in) of rain recorded, and this was the week in which the differences were greatest.
to the 28 June sample date, there was 142.2 mm (5.60 in) of rain recorded, and the differences between the treatments were smaller.

When this study began, a method for directly rating or quantifying *C. brunnea* feeding injury did not exist. The way that the injury had been reported was larval feeding on the surface of roots, which related mostly to the root hairs. An observation in late July of 2005 demonstrated that sampling and quantifying direct injury to the roots from *C. brunnea* feeding would have been far less time consuming and less subjective than thought. Several roots from *C. brunnea* seed treatment study locations were washed and rated for corn rootworm damage. There was no rootworm damage on the plants, however, there was clearly visible scarring that ran along the surface of the roots. This was not noticed until the roots were cleaned of all dirt and debris. The scarring was suspected to be *C. brunnea* injury. The pattern of the scarring was similar to how feeding injury from *C. brunnea* larvae had been described in the past (Forbes 1903, Bigger 1931, Lindsay 1943). What had not been mentioned in any prior work was how visible the scarring was. There have been no reported attempts to directly quantifying the feeding injury. If a method to quantify the feeding injury were developed, it would be a useful tool, especially for insecticide control studies during years in which colaspis feeding occurs but environmental conditions prevent significant injury symptoms from being observed in above ground plant parts. A reasonable scale may simply be the number or portion of roots on a given plant that is affected.
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Fig 1. Total *C. brunnea* emergence in 6; 1.82 m x 1.82 m tent type emergence cages in soybeans in 2005.
CHAPTER 5. GENERAL CONCLUSIONS AND SUMMARY

The grape colaspis (Colaspis brunnea) is an insect pest that is damaging seed corn and commercial corn in the Midwest. The larvae injure crops by feeding on the surface of the root, which removes root hairs and interferes with water and nutrient uptake. The damage that has been reported in seed corn in recent years has caused concern among seed corn producers. Prior to the studies reported in this thesis, management of C. brunnea was based on studies carried out in obsolete cropping systems. This study's objective was developing and testing the efficacy of management techniques for C. brunnea in seed corn production. This research provides agricultural producers in the Midwest strategies to manage C. brunnea in modern cropping systems.

In the first study, seed treatments and a soil insecticide were tested; examining their ability to protect the seedling inbred seed corn from the effects of the C. brunnea feeding. It was found that the seed treatments resulted in significantly taller seed corn than the untreated checks. However, there was not consistent differentiation among the insecticides used. From this test, it is concluded that the seed treatments and soil insecticide tested offer some protection from C. brunnea larvae. However, none of the products or rates of treatment were shown to be significantly more effective than the others. In situations were a grower is at risk from C. brunnea injury they would lessen the risk with the soil insecticide or seed treatments tested in this trial.

The second study in this project is an adult control study. In this study, the feasibility of applying foliar insecticides to control C. brunnea as adults in soybeans
to lower the population of larvae in a field to reduce the risk of injury to seed corn planted the following year was evaluated. Both one and two applications of a foliar applied insecticide significantly reduced the adult *C. brunnea* population. Fall soil sampling found a significant reduction in the population of *C. brunnea* larvae in areas where foliar insecticides had been applied. This study provides another method of managing *C. brunnea* that, when fully developed, will give seed corn producers another option. More data is needed on some biological aspects of *C. brunnea* to fully develop controlling *C. brunnea* as adults to reduce the risk to seed corn. This includes knowing what affects the emergence of the adults and when oviposition occurs.
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