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Field assessment of novaluron for sugarcane borer, *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae), management in Louisiana sugarcane

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ABSTRACT

On-farm field experiments were conducted in 2004 and 2007 to assess the suitability of novaluron, a chitin synthesis inhibitor, for sugarcane borer, *Diatraea saccharalis* (F.), management in Louisiana sugarcane (*Saccharum* spp. hybrids). Aerial insecticide applications reproducing commercial production practices were made when *D. saccharalis* infestation levels exceeded a recommended action threshold. In addition to decreased *D. saccharalis* infestations, 6.3 – 14.5-fold reductions in end of season injury, expressed as the percentage of bored sugarcane internodes, were observed in plots treated with novaluron. *D. saccharalis* control in novaluron plots was equivalent to ($P > 0.05$) or better ($P < 0.05$) than that achieved with tebufenozide, an ecdysone agonist that has been extensively used for over a decade on sugarcane. With a numerical trend of a 3.1-fold decrease in percent bored internodes, the pyrethroid gamma-cyhalothrin seemed less effective than the biorational insecticides in protecting sugarcane against *D. saccharalis*. Using continuous pitfall trap sampling, no measurable ($P > 0.05$) decreases in predaceous and non-predaceous soil-dwelling non-target arthropods were associated with insecticides. However, numerical trends for decreases in immature crickets associated with novaluron and gamma-cyhalothrin were recorded in 2007. Our data suggest that novaluron will fit well in Louisiana sugarcane integrated pest management.

1. Introduction

The sugarcane borer, *Diatraea saccharalis* (F.), is a lepidopteran pest that has historically been the most damaging arthropod in Louisiana sugarcane (hybrids of *Saccharum* L. spp.) (Reagan et al., 1972; Reagan, 2001). Management recommendations for *D. saccharalis* emphasize the importance of cultivar resistance, scouting, properly timed insecticide applications, and conservation of beneficial arthropods (Reagan and Posey, 2001; Posey et al., 2006). However, resistant cultivars have been underexploited for the past decade due to widespread use of susceptible high-yielding cultivars, and adequate *D. saccharalis* control with narrow-range insecticides and associated conservation of natural enemies (Reay-Jones et al., 2005).

The red imported fire ant, *Solenopsis invicta* Buren, is the dominant natural enemy of *D. saccharalis* in Louisiana sugarcane (Reagan, 1986), contributing an estimated savings of as much as two insecticide applications per year for *D. saccharalis* management (Sauer et al., 1982). Spiders (Araneae) are the primary *D. saccharalis* egg predators and are probably second in importance in the natural enemy complex (Negm and Hensley, 1969; Ali and Reagan, 1986). Ground beetles (Coleoptera: Carabidae), tiger beetles (Coleoptera: Carabidae: Cicindelinae), rove beetles (Coleoptera: Staphylinidae), click beetles (Coleoptera: Elateridae), and earwigs (Dermaptera) have also been cited as important components of the *D. saccharalis* natural enemy complex in Louisiana (Negm and Hensley, 1967, 1969).

Natural enemies of *D. saccharalis* are largely protected in Louisiana sugarcane by the widespread use of tebufenozide, which represented 90% of the foliar applications in 2007 (Pollet, 2008). This biorational insecticide belonging to the diacylhydrazine class is an ecdysone agonist that causes larvae to produce a malformed cuticle (Dhadialla et al., 1998). This compound is very specific to certain lepidopterans (Dhadialla et al., 1998) and has shown little to no toxicity to *D. saccharalis* natural enemies (Reagan and Posey, 2001). In addition to tebufenozide, the pyrethroids esfenvalerate, cyfluthrin, zeta-cypermethrin, lambda-cyhalothrin, and gamma-cyhalothrin are labeled but seldom used (Pollet, 2008). Because the development of resistance to different classes of insecticides in *D. saccharalis* populations has been a recurring problem in Louisiana

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sugarcane (Vines et al., 1984; Akbar et al., 2008), over-reliance on tebufenozide has raised concerns. Depending on cultivar and agricultural consultant recommendations, growers apply insecticides when the level of stalks infested with at least one live larva feeding in the leaf sheaths exceeds a 5–10% threshold (Schexnayder et al., 2001; Posey et al., 2006). After field management failures were reported, Reay-Jones et al. (2005) documented reductions in susceptibility to tebufenozide among *D. saccharalis* populations in Louisiana. Akbar et al. (2008) obtained a 27.1-fold increase in LC_{50} after 12 generations of selection with tebufenozide in the laboratory. Appropriate insecticide resistance management strategies are therefore needed to preserve a balance of *D. saccharalis* control tactics for the Louisiana sugarcane industry.

Among potential alternatives to tebufenozide, novaluron is a biorational insecticide belonging to the benzoylphenyl urea class that was initially registered in the USA in 2001 (Ishaaya and Horowitz, 1998; US EPA, 2001). Benzoylphenyl ureas inhibit chitin polymerization, thus disrupting cuticle formation in immature insects (Oberlander and Silhacek, 1998). Novaluron is therefore not directly toxic to adult insects, but exerts insecticidal activity on egg and larval stages (Barzani, 2001). By 2008, this insecticide had been granted permanent federal labels in the USA for use on cotton, potato, apple, *Brassica* vegetables, and ornamentals to control or suppress caterpillars (Lepidoptera: Gracillariidae, Noctuidae, Plutellidae, Pyralidae, Tortricidae), hemipterans (Hemiptera: Aleyrodidae, Miridae, Pentatomidae), beetles (Coleoptera: Chrysomelidae, Curculionidae), thrips (Thysanoptera: Thripidae), and leafminers (Diptera: Agromyzidae) (CPR, 2008; T&OR, 2008). Additionally, novaluron has a relatively low mammalian toxicity (Barzani, 2001).

In sugarcane, preliminary small-plot studies showed that novaluron reduced *D. saccharalis* infestations below economic levels (Posey et al., 2003; Akbar et al., 2004). Targeting immature stages, novaluron is expected to have limited non-target effects on adult natural enemies that are present in the sugarcane agroecosystem (Ishaaya et al., 2001, 2002). Thus, this biorational pesticide has the potential to become a major component of Louisiana sugarcane integrated pest management (IPM). In addition, having a different mode of action from other labeled insecticides, novaluron represents an alternative that would reduce the selection pressure on *D. saccharalis* from other classes of insecticides, mitigating the potential development of insecticide resistance. Before novaluron was granted a permanent federal label in 2009 for use on sugarcane in the USA (www.greenbook.net, 2009), two aerial application field studies were conducted in 2004 and 2007. These studies reported in this paper were conducted on commercial farms to assess the efficacy and non-target arthropod impacts of novaluron for *D. saccharalis* management in Louisiana sugarcane.

2. Material and methods

2.1. Experimental plots and *D. saccharalis* pest severity assessment – 2004

A study was conducted during the summer of 2004 near Cheneyville, Rapides Parish, LA (N 31.019°, W 92.302°) in commercial fields planted during the summer of 2003 with sugarcane cultivar LCP 85-384. Portions of fields were divided into 16 plots of 2 ha (30 rows, 1.83-m row spacing) in a randomized complete block design arrangement with four blocks. Each plot was assigned one of four treatments. In addition to an untreated control, insecticide treatments were tebufenozide (Confirm® 2F) at 140 g(AI)/ha, and novaluron (Diamond® 0.83EC) at 58 g(AI)/ha and 87 g(AI)/ha. From mid-June, pre-treatment *D. saccharalis* infestation levels were determined by weekly examinations of 25 randomly selected stalks from each block, observing for live larvae (1st–3rd instars) infesting leaf sheaths. The 5% threshold was exceeded on July 15 when 10% of the stalks were infested and the first insecticide application was made on July 16. All insecticide treatments were applied in water with the surfactant Latron® CS-7 at the rate of 0.25% vol/vol. A Turbo Thrush Commander aircraft equipped with 38 CP-09-3P nozzles (0.125 orifice, 30° deflector, 275.8 kPa pressure, CP Products Inc., Tempe, AZ) and delivering 46.7 L per hectare of finished formulation was used to spray swaths of 18.3 m at a speed of approximately 210 km/h. Subsequently, post-treatment infestation levels were assessed in each plot on July 25, 30, August 5, 13, 21, 26, and September 2. All insecticides were applied again on August 13 when a 10% threshold was exceeded in the high rate novaluron plots. Later infestation levels did not warrant a third insecticide application. At the end of the growing season, *D. saccharalis* injury (no. bored internodes/total no. internodes) and moth production (no. adult emergence holes) were recorded from 25 stalks randomly selected in each plot on September 16.

2.2. Non-target arthropod pitfall trap sampling – 2004

Three pitfall traps were used to determine relative soil-associated arthropod abundance in each plot. Traps consisted of wide mouth 0.47-L glass jars (Ball Corp., Broomfield, CO) filled with 150 ml of ethylene glycol and 2 ml of liquid soap to reduce surface tension. Traps were placed on the 15th, 16th, and 15th row of each plot, respectively 30, 60, and 90 m from the unplowed front. Pitfall traps were imbedded to the soil surface and were covered by a 15 by 15 cm metal plate, which was supported by a tripod and elevated 3 cm above the jar to exclude rain, debris, and larger animals. Pitfall traps were initially placed in the experimental plots on June 11. For pre-treatment sampling, traps were collected and replaced on July 2 (21 days) and July 20 (18 days). For treatment assessment, traps were collected and replaced on August 4 (15 days) and August 17 (13 days). All traps were collected after a fifth sampling period on September 2 (16 days). For each sampling period, the non-target arthropods collected were counted after being sorted to the following 13 groups: *S. invicta*, spiders, earwigs (Dermaptera: Anisolabididae, Forficulidae), ground beetles, tiger beetles, click beetles, rove beetles, scarab beetles (Coleoptera: Scarabaeidae), other Coleoptera, field crickets (Orthoptera: Gryllidae), Orthoptera other than field crickets (Orthoptera: Gryllotalpidae, Tridactylidae), leafhoppers (Hemiptera: Cicadellidae), and other ground-dwelling arthropods. Predator abundance was determined considering four groups of predators: *S. invicta*, spiders, pooled predaceous beetles (ground, tiger, click, and rove), and earwigs. Non-predator abundance was determined considering four groups: field crickets, pooled non-predaceous beetles (scarab and others), leafhoppers, and pooled other arthropods (Orthoptera other than field crickets and other ground-dwelling arthropods).

2.3. Experimental plots and *D. saccharalis* pest severity assessment – 2007

A study was conducted during the summer of 2007, near Broussard, Iberia Parish, LA (N 30.068°, W 91.905°) in commercial fields planted during the summer of 2006 with sugarcane cultivar HoCP 96-540. Portions of fields were divided into 20 plots of 0.4 ha (12 rows, 1.83-m row spacing) in a randomized complete block design arrangement with five blocks. Each plot was assigned one of four treatments. In addition to an untreated control, insecticide treatments were tebufenozide (Confirm® 2F) at 140 g(AI)/ha, novaluron (Diamond® 0.83EC) at 65 g(AI)/ha, and gamma-cyhalothrin (Prolex® 1.25EC) at 20 g(AI)/ha. From mid-June, weekly examinations of 20 stalks per block indicated that the 5% threshold