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Pheromone-mediated mating disruption in the millet stem borer, *Coniesta ignefusalis* (Lepidoptera: Pyralidae)

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ABSTRACT

The millet stem borer, *Coniesta ignefusalis* Hampson (Lepidoptera: Pyralidae), is a major pest of pearl millet in the Sahelian region of Africa. The female sex pheromone has been identified and synthesised, and previous research had shown that the synthetic pheromone could cause high levels of reproductive communication disruption in small plots when released at rates of 640 mg/ha/day, using PVC resin formulation renewed every seven days to maintain efficiency. In the present research, in experiments in farmers' fields in Niger, 86.8% (SE = 2.6%) communication disruption was achieved when polyethylene vials loaded with 0.5 mg pheromone at 400 dispensers/ha were used and replaced every 21 days. Polyethylene vials loaded with 80 mg pheromone gave uniform, zero-order release at approximately 0.05 mg/day at 27 °C. Experiments carried out on replicated 0.5 ha plots in farmers' fields in Niger using a single application of these dispensers at 400 dispensers/ha resulted in at least 99% suppression of pheromone trap catches of male *C. ignefusalis* moths in treated plots relative to numbers in untreated plots for up to 3 months. However, sampling the central portions of these plots before and after harvest showed no significant differences in infestation, damage or yield loss between plots treated with pheromone and untreated plots. This may have been because of small plot size and the immigration of mated female moths into the treated plots which negated any reduction of mating of females within the treated plots. Comparisons of numbers of male *C. ignefusalis* moths in traps baited with the standard 0.5 mg monitoring lures and those baited with the 80 mg disruption dispensers showed catches in the latter were only 10–20% of those in the former; indicating high level communication disruptions in traps with high dose dispensers. Implications of using insect synthetic pheromones in the development of integrated management of *C. ignefusalis* in pearl millet cropping systems in the Sahel are discussed.

1. Introduction

The millet stem borer, *Coniesta ignefusalis* Hampson (Lepidoptera: Noctuidae), is a key pest of pearl millet throughout the West African Sahelian and Sudanian zones (Harris, 1962; N'doye et al., 1984; N'doye and Gahukar, 1987; Youm et al., 1996). First generation larvae cause dead hearts and stand-loss, while the second and third generations cause lodging, disruption of the vascular system and inhibition of grain formation (Harris, 1962). In sub-Saharan Africa, where pearl millet is a major staple crop grown by subsistence farmers, yield losses due to attack by *C. ignefusalis* range from 15% to total crop failure (Harris, 1962; Ajayi, 1990), and in Niger, more than 90% of stem borer infestation and damage on millet is caused by *C. ignefusalis* (Youm and Gilstrap, 1993, 1994).

Control by chemical means has not been very effective, and repeated applications are not sustainable in subsistence agriculture systems in the Sahel (Youm, 1990). Destruction of alternative hosts and crop residues is difficult to enforce because of the importance of these materials for construction, decoration and animal bedding in the region (Harris, 1962). Manipulation of planting dates (Vercambre, 1978; Guevremont, 1983; Youm, 1990), field sanitation (Nwanze and Muller, 1989) and burning of stalks (Guevremont, 1983; Maiga, 1984) have given inconsistent results. Although some tolerance has been reported in varieties due to production of a sticky secretion in stem tunnels (N'doye, 1977) or due to increased tillering (Nwanze, 1985), there are no varieties showing useful levels of resistance. Natural enemies of *C. ignefusalis* have been described (Youm et al., 1996), but significant parasitism develops too late in the growing season (Youm, 1990).

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Female *C. ignefusalis* moths were shown to produce a sex pheromone that attracts males (Bako, 1977; ICRISAT, 1989) and this was isolated, identified and synthesized (Beevor et al., 1999). Synthetic lures were subsequently optimised and an effective, locally-made trap developed (Youm et al., 1993; Youm and Beevor, 1995). Some reduction in damage by *C. ignefusalis* was reported with mass trapping around village granaries with 25 traps/ha (ICRISAT, 1994; 1995), and initial results on use of the synthetic pheromone for control of *C. ignefusalis* by mating disruption were reported. Using a PVC resin formulation of the pheromone components, Beevor et al. (1996) showed that the attractive pheromone blend was more disruptive than two "inhibitor" compounds which only reduce the attractiveness of the attractive blend, and essentially complete communication disruption was achieved with release rates of 640 mg/ha/day. The main limiting factor was a lack of a suitable formulation, as the PVC resin had a half-life of only a few days under field conditions, frequent replacement was necessary.

This paper describes further work conducted on mating disruption of *C. ignefusalis* and the development of a longer-lasting formulation for application to stem borer management.

2. Methods and materials

2.1. Experimental sites

Experiments were carried out on-station at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Sahelian Center, Sadore, Niger and in nearby farmers' fields in the villages of Deybon and Bellare.

2.2. Pheromone traps

Pheromone traps used for the experiments consisted of locally-constructed water-oil traps with a lid and positioned 0.5 m above the ground as described by Youm and Beevor (1995). Numbers of male *C. ignefusalis* were recorded daily and discarded and trap lures were renewed every 21 days.

2.3. Pheromone dispensers

Pheromone dispensers used in field experiments were either sealed polyethylene vials (32 × 15 × 2 mm thick; Agrisense, UK) impregnated with 0.5 mg of the pheromone blend or sealed polyethylene vials (20 × 9 × 1.5 mm thick; Just Plastics, UK) containing 100 μl (80 mg) of the pheromone blend. The lids on the latter were sealed by heating or with Ethylene-vinyl acetate (EVA) hot-melt "glue-gun". Lures loaded with 0.5 mg pheromone were designed for use in monitoring traps, and the 80 mg lures were developed for use in mating disruption. The pheromone blend contained (*Z*)-7-dodecenol, (*Z*)-5-decenol and (*Z*)-7-dodecenal in a 100:5:3 mixture. Compounds were prepared at the Natural Resources Institute (NRI) as described by Beevor et al. (1999).

2.4. Mating disruption experiment 1996

Experiments were conducted in 1996 at the ICRISAT Sadore station on 40 m × 40 m plots sown with pearl millet varieties Sadore-Local and ICMV–IS–89305 on June 6 with 1 m and 0.75 m spacing between and within rows, respectively. Plots were weeded twice, manually with hoes. The experiment comprised three treatments including pheromone, insecticide and untreated (check); replicated with each variety in four randomised blocks. The pheromone treatment consisted ofstandard monitoring lures (0.5 mg loading) attached to metal stakes at 0.5 m above ground level with 5 m spacing (equivalent to 400/ha, 200 mg a.i./ha). The treatment began 21 days after sowing (DAS), and dispensers were renewed every 21 days. The insecticide plots were treated with the synthetic pyrethroid Decis® (Deltamethrin) at 21 DAS, flag leaf stage and at one third panicle exertion.

A pheromone trap with standard monitoring lure (0.5 mg loading) was placed at the centre of each plot, and numbers of male *C. ignefusalis* male moths counted and recorded daily from June 21 to September 26, then traps cleaned and moths discarded. At 40 DAS and 75 DAS, the percentage of infested hills and number of dead hearts were recorded from the 10 m × 10 m central portion of each plot. After harvest, the number of stem borer entry and exit holes and larvae were recorded from 10 randomly selected stems from each plot.

2.5. Mating disruption experiment 1997

The experiments in 1997 used a total of eight plots in farmers' fields at Sadore.Four of these of 0.5 ha area were treated with pheromone and four (0.25 ha) were untreated (check plots). Treated and untreated plots were separated by at least 500 m.All plots were planted with millet variety ICVM–IS–92222 with 1 m × 1 m spacing between hills. After emergence, hills were thinned to three plants, and two weeding operations were carried out.

In the treated plots, pheromone dispensers (80 mg loading) were placed on wire stakes at 0.5 m above ground level with 5 m spacing, to give an application rate of 400 sources/ha (32 g a.i./ha). The sources were not replaced during the season from 4 July–14 October.

A pheromone trap was placed at the centre of each plot, and numbers of male *C. ignefusalis* caught were counted each day and discarded. In the treated plots, traps were baited with the 80 mg dispensers used for mating disruption. In the untreated plots, standard monitoring lures loaded with 0.5 mg pheromone blend were used 4 July –4 August 1997, but these were then replaced by the 80 mg dispensers for the remainder of the experiment. All trap lures were renewed every 21 days.

At 40 and 75 DAS, the percentage of infested hills and number of dead hearts were recorded from the central portion of each plot (10 m × 10 m). After harvest, the number of exit holes and number of larvae were recorded from 50 stems randomly selected from the central portion of each plot (5 from each row).

2.6. Mating disruption experiment 1998

The 1998 experiments were carried out in farmers' fields at Sadore with five plots (0.5 ha) treated with pheromone and five (0.25 ha) untreated. Treated and untreated plots were separated by at least 500 m. In the treated plots, dispensers (80 mg loading) were placed on wire stakes at 0.5 m above ground level, with 5 m spacing to give an application rate of 400 sources/ha (32 g a.i./ha). The sources were not replaced during the season from 4 July–1 October 1998. A pheromone trap baited with the same 80 mg dispenser used for mating disruption and renewed every 21 days was placed at the centre of each plot, and numbers of male *C. ignefusalis* were counted each day and discarded. At 70 and 90 DAS, the numbers of hills, tillers, infested hills and dead hearts were recorded from the central portion of each plot (10 m × 10 m). At harvest, the number of exit holes and number of larvae were recorded from one stem randomly selected from each hill in the central portion of each plot.

2.7. Data analysis

The number of infested hills was expressed as a percentage of the number of hills and the number of dead hearts as a percentage