N O T E

Evaluation of a New Formulation of Grandlure for the Boll Weevil (Coleoptera: Curculionidae)[1]

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Grandlure, the synthesized pheromone of boll weevils (*Anthonomus grandis* Boheman), consists of 2 terpene alcohols (components I and II; (+)-cis-2-isopropenyl-1-methyl cyclobutaneethanol and cis-3,3-dimethyl-$\Delta^{1,\beta}$-cyclohexaneethanol, respectively) and 2 terpene aldehydes (components III and IV; cis-3,3-dimethyl-$\Delta^{1,\alpha}$-cyclohexaneacetaldehyde and trans-3,3-dimethyl-$\Delta^{1,\alpha}$-cyclohexaneacetaldehyde) (Tumlinson et al. 1969; Science 166: 1010 - 1012). The ratio of these 4 components in grandlure is ≈ 30:40:15:15 (component I:II:III:IV, respectively). However, Spurgeon and Suh (2007; J. Entomol. Sci. 42: 250 - 260) and Westbrook and Suh (2010; pp. 994 - 998, *In* Proc., Beltwide Cotton Conf.) examined the composition of pheromone released from boll weevils and reported the ratio of these 4 components in boll weevil pheromone was ≈ 45:42:3:10. Thus, the existing commercial formulation of grandlure may not be the most effective blend for attracting boll weevils to traps. Because active and posteradication programs rely on pheromone traps to detect incipient boll weevils and to indicate the need for insecticide treatments, optimizing detection of boll weevils with traps is critically important. The objective of our study was to evaluate the attraction of boll weevils to a new experimental formulation of grandlure which matches the component ratio of pheromone produced by boll weevils.

The experimental and standard formulations of grandlure were prepared by ISP Fine Chemicals (Columbus, OH). Both formulations were incorporated into lure dispensers manufactured by Plato Industries Inc. (Houston, TX) at a requested dosage of ≈ 10 mg of pheromone per lure. The residual pheromone contents of new (0 d) and field-aged lures (1, 4, 7, 10, and 14 d) were quantified by gas chromatography (GC)

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to confirm that both lure types were similarly dosed, possessed the specified component ratio, and released pheromone at comparable rates. Lures were aged and evaluated during the 3 periods of April 5 - 19, June 7 - 21, and Aug. 2 - 16 in College Station, TX, using procedures described by Westbrook and Suh (2010; pp. 994 - 998, *In* Proc., Beltwide Cotton Conf.). In brief, 10 lures were evaluated for each lure type-by-field age combination during each period. Average residual pheromone values within and across all 3 periods were obtained for each age class of lures using the PROC MEANS statement of SAS (2008; SAS 9.2 Help and Documentation, SAS Institute, Cary, NC).

The attraction of boll weevils to the experimental and standard formulations of grandlure was assessed at 3 locations in Mexico (Durango, Ojinaga and Tamaulipas) and at 2 locations in Texas (near Jourdanton and Weslaco). Twenty-five to 80 paired pheromone traps were established in multiple lines along brush lines at each location. Traps were supported ≈ 1 m above ground on metal conduit or wooden stakes, and each line of traps was oriented perpendicular to the area's prevailing wind direction. Traps within a pair were separated by ≈25 m and pairs of traps within a line were separated by ≥ 50 m. One trap in each pair was baited with a standard pheromone lure and the other trap was baited with the experimental formulation of grandlure. Traps were serviced weekly for 4 - 8 wks (Table 1), and the lures were replaced and treatments switched within pairs every 2 wks. Weekly counts of boll weevils captured in paired traps were omitted from subsequent analyses if one or both traps were missing a part, knocked down, or displayed evidence of cone obstruction (e.g., spider webbing or plugged arthropods) or substantial weevil predation. The mean weekly numbers of captured weevils were obtained using the PROC MEANS statement of SAS (2008; SAS 9.2 Help and Documentation, SAS Institute, Cary, NC), and the weekly numbers of captured boll weevils were compared between the 2 lure types using the PROC TTEST and PAIRED statements of SAS (2008; SAS 9.2 Help and Documentation, SAS Institute, Cary, NC). Data collected at each of the 5 geographical locations were analyzed separately.

Overall, the initial grandlure dose of the experimental and standard lures averaged 10.4 and 10.9 mg $lure^{-1}$, respectively. The average component ratio of the experimental grandlure was 44:43:3:10 (components I:II:III:IV, respectively), which closely matched the targeted ratio of 45:42:3:10. In comparison, the component ratio of standard grandlure averaged 32:38:15:15. Based on the initial and residual grandlure content of lures aged for 7 and 14 d, experimental lures released pheromone at an average of 0.59 and 0.41 mg day^{-1} during the 1st and 2nd wks of aging, respectively. In comparison, standard lures released pheromone at an average of 0.69 and 0.43 mg day^{-1} during the respective weeks of aging.

Statistical differences in the numbers of boll weevils captured in traps were not detected between the standard and experimental formulations of grandlure at any of the test locations (Table 1). Consequently, we found no evidence that boll weevils were more attracted to the experimental blend than standard formulation of grandlure. An unexpected, but enlightening finding was the increased attraction of milkweed weevils, *Rhyssomatus* spp., to the experimental grandlure formulation (2012; Suh and Westbrook; Southwest. Entomol. 36: 375 - 376). Traps baited with the experimental formulation captured nearly 4x more *Rhyssomatus* weevils than traps baited with standard lures. This occurrence suggests the lack of difference in boll weevil captures between grandlure formulations was not a result of our experimental design or approach. Instead, the lack of difference likely resulted from a combination of factors including the relatively low boll weevil population levels encountered at most sites and the inherent attraction of boll weevils to a dynamic range of pheromone

Table 1. Comparisons of mean weekly captures of boll weevils in pheromone traps baited with standard and experimental formulations of grandlure.

Location	Trapping dates	Trap pairs	Grandlure formulation		*t-value*	df	*P-value*
			Experimental	Standard			
Durango, MX	26 April - 31 May 2010	25	0.38	0.49	–0.38	19	0.711
Ojinaga, MX	26 April - 24 May 2010	60	0.06	0.03	1.45	13	0.254
Ojinaga, MX	8 Oct. - 5 Nov. 2010	60	0.17	0.15	0.21	20	0.833
Tamaulipas, MX	24 Aug. - 19 Oct. 2010	40	91.63	92.25	0.03	285	0.978
Jourdanton, TX	27 April - 15 June 2010	80	0.14	0.13	0.55	84	0.581
Weslaco, TX	24 Aug. - 5 Oct. 2010	50	1.06	0.87	0.89	122	0.376

blends. Indeed, Hardee et al. (1974; Environ. Entomol. 3: 135 - 138) reported boll weevils responded to a wide range of ratios, but also indicated some component ratios were more attractive than others to boll weevils. Considering the relative production cost of each component, especially the 1st component, those authors concluded the most promising ratios (components I:II:III and IV combined) for commercialization were 20:60:20, 30:50:20, and 40:30:30. Consequently, these earlier findings are likely responsible for the existing formulation of grandlure used in contemporary eradication programs.

Although the manufacturing cost of the experimental grandlure cannot be disclosed, we can state the experimental formulation was more expensive than the standard formulation. Considering the increased production cost of the experimental grandlure and lack of difference in the numbers of weevils captured in traps, we found no justification for altering the existing commercial formulation of grandlure – at least no benefit of matching the component ratio of pheromone produced by weevils. In light of these findings, we suggest research efforts and eradication programs focus on other lure attributes (e.g., pheromone dose, lure replacement interval, and lure dispenser technologies) to improve detection of incipient boll weevil populations with pheromone traps.

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