

**IMPROVED PHEROMONE AND INSECTICIDE DELIVERY  
SYSTEMS FOR USE IN ACTIVE AND POST ERADICATION PROGRAMS**  
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**Abstract**

In five separate, replicated field trials, slow-release pheromone dispensers containing various combinations of Grandlure, eugenol, and DDVP (dichlorvos) were compared to separate Grandlure and DDVP dispensers for efficacy to attract boll weevil (*Anthonomus grandis* Boh.) adults to the Plato Boll Weevil Trap<sup>®</sup>. Release studies with GC analyses for Grandlure content were conducted with various dispensers to aid in understanding field trial results. Dispensers containing Grandlure and eugenol did not perform significantly or consistently better in attracting boll weevils than Grandlure dispensers without eugenol. Dispensers combining Grandlure and DDVP or Grandlure, DDVP and eugenol into a single dispenser demonstrated performance equivalent to separate Grandlure and DDVP dispensers. The inclusion of eugenol did not appear to alter the release rate of Grandlure in the Plato Industries polyvinyl-chloride dispenser system but the inclusion of DDVP tended to accelerate the release of Grandlure. The use of “Combo” dispensers combining Grandlure and DDVP or Grandlure, eugenol, and DDVP are a viable approach to reducing costs associated with boll weevil eradication programs in “active or post-eradication” stages.

**Introduction**

The use of monitoring traps is an important component of boll weevil management and is a key component of boll weevil eradication programs (BWEPs). Data obtained from trap captures trigger spray and other management decisions. Boll weevil traps use the synthetic aggregation pheromone, Grandlure, to attract boll weevils into traps for accurate population monitoring and the DDVP insecticide dispensers are used to kill the trapped weevils to prevent them from crawling out of the “trap capture cylinder”. At present, separate dispensers of Grandlure and DDVP are used in eradication programs. The most commonly used dispensers contain either 10-mg of Grandlure or 60 or 90-mg of DDVP. However, in post eradication programs, there are operational reasons for using a dispenser system that will last longer than two weeks and will have an improved Grandlure liberation rate with equal or superior attraction power for weevils. Currently, a large portion of the Southeast Boll Weevil Eradication Foundation’s Program (SEBWEF) is already in a post-eradication program and an extended duration dispenser containing both 25-mg of Grandlure and 30-mg of eugenol is used plus a separate 60 or 90-mg DDVP dispenser. Eugenol has been reported to increase the effectiveness of Grandlure (G. H. McKibben, 2000) in attracting boll weevils.

Much of the delta and southwest growing regions will soon be in post-eradication programs and eventually, all of the U.S. will be in such programs. As the boll weevil eradication programs evolve into post-eradication status, researchers are investigating new compounds to improve the effectiveness of Grandlure and program managers are interested in longer lasting dispensers to minimize program labor and operational costs by reducing the frequency of servicing large numbers of deployed traps.

We developed a series of polyvinyl chloride-based slow-release dispensers containing various combinations and amounts of Grandlure, eugenol, and/or DDVP. Field trails with Plato Industries Dispensers (PIDs) and the Hercon “Super Lure” (samples from the SEBWEF) were conducted in the northern Blacklands and the Rio Grande Valley regions of Texas. Both of these regions are outside of active eradication programs. We also conducted release studies using GC analyses of the active ingredient to further understand the performance of the dispensers in the field.

**Materials and Methods**

**Field Study 1 (Willacy County, TX)**

This study was initiated on August 22, 2003; it included two treatments and lasted for 35 days. Treatment 1 was the standard 10-mg Plato Industries Grandlure Dispenser used with a separate 90-mg DDVP dispenser (Plato Industries Insecticide Strip, EPA Reg. No. 65458-5) referred to as the PI-IS. Treatment 2 was a single dispenser containing both 10-mg of Grandlure and 60-mg of DDVP. The 60-mg DDVP rate was used because it is quite adequate for the 7 and 14 day “dispenser change out programs” that are used with the 10-mg pheromone dispensers by the various BWEPs. The experimental design consisted of 10 cotton fields with five traps of each treatment deployed at each field. The traps within a field were arranged along a field

edge in a straight line with 100 feet between traps. Traps were randomized within the trap line and a “dummy or non-data” trap was also placed at the beginning and end of each trap line. Traps were baited with treatments as follows:

- for Treatment 1, the 90-mg DDVP dispenser was placed in the capture cylinder on day 0 and was not replaced during the 35-day trial duration. A 10-mg Grandlure dispenser was loaded on day 0 followed by a second dispenser on day 7. The first Grandlure dispenser was replaced on day 14 while the second dispenser was replaced in day 21 and so on.
- for Treatment 2 the first combination dispenser was loaded on day 0 followed by a second dispenser on day 7. The first combination dispenser was replaced on day 14 while the second dispenser was replaced on day 21 and so on. Weevils were counted and emptied from the trap on days 7, 14, 21, 28 and 35.

### **Field Study 2 (Willacy County, TX)**

This study “with extended duration lures” was conducted in late November and early December 2003. Three dispensers containing 25-mg of Grandlure and one dispenser containing 17.5-mg of Grandlure with or without combinations of eugenol and DDVP were evaluated for attracting weevils into boll weevil traps (Table 1). Each treatment was replicated 10 times in a randomized complete block design. Traps were deployed on November 14, 2003 along a cotton field edge with 100 feet separating each trap. A dummy trap loaded with 10-mg Grandlure and a PI-IS was placed at the ends and middle of each trap line. Traps were inspected every seven days when weevils were counted and removed from each trap. Treatment dispensers were not replaced during the study but “dummy” lures were replaced at day 14. The traps were checked for weevils on days 7, 14, 21 and 28.

### **Field Study 3 (North Texas Blacklands)**

The standard treatment in this study consisted of the standard 10-mg Plato Industries Grandlure Dispenser with a separate 90-mg DDVP dispenser (PI-IS). The two other experimental materials from PIL included in the trial were a dispenser loaded with 10-mg Grandlure + 60-mg DDVP and a dispenser loaded with 10-mg Grandlure + 30-mg eugenol + 60-mg DDVP (Table 2). The study was initiated on October 4, 2003 and lasted for 30 days. Ten fields were included in the study with five traps of each treatment placed in each field along a field border at 100-foot intervals. “Dummy” traps were placed at the end of each trap line. A completely randomized scheme was used within each field. The replacement of dispensers was each 7 days, the same schedule as used in Field Study 1.

### **Field Study 4 (North Texas Blacklands)**

Four treatments containing 25-mg of Grandlure were evaluated for attraction of boll weevil in boll weevil traps (Table 3). Separate dispensers of 25-mg Grandlure and 90-mg DDVP were compared to other combination dispensers containing Grandlure plus eugenol and/or DDVP. Ten fields were included in the study with five traps of each treatment placed in each field along a field border at 100-foot intervals. “Dummy” traps were placed at the end of each trap line. A completely randomized scheme was used within each field. Dispensers were placed in the trap capture cylinders on day 0 and were not replaced for the duration of the 30-day trial.

### **Release Study**

On August 8, samples from various treatments used in Field Studies 1 and 3 were placed in Plato Traps and exposed to ambient temperatures outside the Plato Industries Plant facility in Houston, TX. At pre-determined dates, three dispensers of each treatment were removed from the traps, placed into sealed, foil bags and stored in a freezer for later GC analysis of chemical content. Samples were then analyzed for Grandlure content with a protocol utilizing gas chromatography (GC). 10-mg Grandlure dispensers from Hercon (sample obtained from the LBWEP) and Scentry (sample obtained from the TxBWEF) were included in the release study but they were not included in field trials. Most of the BWEFs do not differentiate between the Plato, Hercon and Scentry 10-mg dispensers in their respective capacity to capture boll weevil.

## **Results**

### **Field Study 1 (Willacy County, TX)**

Traps containing the combo dispenser loaded with both 10-mg of Grandlure and 60 mg of DDVP captured an average of 3.92 weevils per trap per day. This represented a 17.3% increase over the 3.34 weevils per trap per day captured in traps containing separate 10-mg Grandlure and 90-mg DDVP dispensers (Figure 1). The difference in captures was not statistically significant. The largest numerical difference occurred in the fourth week. Week three counts were reduced following several days of continuous rain.

### **Field Study 2 (Willacy County, TX)**

Weevil capture results in Field Study 2 ranged from a low of 2.51 weevils per trap per day with treatment of the combo lure containing 25-mg Grandlure/30-mg eugenol/90-mg DDVP to a high of 3.39 weevils per trap per day in the treatment containing a combo lure of 25-mg Grandlure/30-mg eugenol plus a separate 90-mg PI-IS (Figure 2). The treatment containing sepa-

rate dispensers of 25-mg Grandlure and 90-mg DDVP captured an average of 3.32 weevils per trap per day. GC analysis of Grandlure content between the 25-mg dispensers indicated greater differences in initial loadings than anticipated. Dispensers intended to contain 25-mg of Grandlure ranged from a low of 21.7-mg of Grandlure in the Grandlure/eugenol/DDVP combo to a high of 31.4-mg in the Grandlure alone lure (Figure 5). The weevil capture data is positively correlated with initial Grandlure loadings to offset the capture differences. There was no indication that the inclusion of eugenol was beneficial to increasing weevil captures.

### **Field Study 3 (Northeast Blacklands)**

Trap captures ranged from a low of 4.37 weevils per trap per day in the 10-mg Grandlure/60-mg DDVP combo treatment to a high of 5.52 weevils per trap per day in the separate 10-mg Grandlure and 90-mg DDVP dispenser treatment. The three component dispenser containing 10-mg Grandlure plus 30-mg eugenol and 60-mg DDVP was intermediate in capturing an average of 5.22 weevils per trap per day (Figure 3). Treatments 1 and 2 performed almost identically over the four-week study whereas Treatment 3 captured fewer weevils than the other treatments in weeks one and three and the same number in weeks two and four. There was no increase in weevil capture due to the addition of eugenol to Grandlure dispensers. Release studies (Figures 7 and 8) indicate that dispensers containing DDVP generally released more Grandlure per day in the initial three days than dispensers containing Grandlure alone.

### **Field Study 4 (Northeast Blacklands)**

Treatments in Field Study 4 were similar to those in Field Study 2; the main difference being the substitution of the Plato 17.5-mg combo dispenser with the Hercon “Superlure” (Lot #3EUG0340, labeled to contain 25-mg Grandlure + 30-mg eugenol) plus a separate 90-mg PI-IS. Trap captures of all four treatments declined during the duration of the trial (Figure 4A). As seen in Field Study 2, the most effective treatment was a PIL combo dispenser of 25-mg Grandlure/30-mg eugenol plus a 90-mg PI-IS (6.00 weevils per trap per day) that was only slightly more effective than a 25-mg Grandlure dispenser plus a 90-mg PI-IS (5.65 weevils per trap per day). The fewest weevils, 4.21 per trap per day, were captured in traps baited with the Hercon “Superlure”. The PIL combo dispenser containing 25-mg Grandlure/30-mg eugenol/90-mg DDVP caught fewer weevils, 4.31 per trap per day, than other PIL treatments. Trap captures with PIL dispensers were correlated with initial Grandlure content that ranged from 21.7 to 31.1 mg (Figure 5). On average, the Plato Industries “Combo Lure” containing both 25 mg Grandlure and 30 mg eugenol captured 42.5% more weevils than did the comparable Hercon “Super Lure” but this difference may be due, at least partly, to variation in Grandlure loading in the different dispensers (Figures 5 and 6). In order to evaluate the effect of initial Grandlure content on weevil capture, the trap data were adjusted by a factor equal to the difference between each treatment’s initial Grandlure content and the 25-mg target. Those data (Figure 4B) tend to reduce treatment differences in weevil capture among the four treatments. Over the four-week trial, the Plato Combo Dispenser containing 25-mg Grandlure and 30-mg eugenol captured 28% more weevils than the comparable Hercon “Superlure”.

### **Release Studies**

Analysis of Grandlure content indicated that the commercial PIL 10-mg Grandlure dispenser provided a more constant release than either the Hercon or Scentry dispensers (Figure 8). Both PIL combo dispensers (10/60 and 10/30/60) containing DDVP released more Grandlure in the initial 3-day exposure period than did the PIL 10-mg commercial dispenser. The Scentry 10-mg dispenser behaved similar to the PIL 10/60 combo dispenser. The PIL dispenser containing only 25-mg Grandlure demonstrated an initial high release the first seven days of exposure followed by a more consistent release during the next 21 days (Figure 6). Both PIL combo dispensers demonstrated a declining release rate over the 28-day exposure period while the Hercon “Superlure” demonstrated a slower and lower release rate over much of the 28-day period.

## **Discussion and Conclusions**

### **Trap Captures**

Results from the initial set of 2003 field studies investigating the utility of various dispensers combining Grandlure and DDVP indicate an excellent potential to develop a “Combo Lure” that combines Grandlure and DDVP to significantly reduce labor requirements in BWEPS. Trap catches with Plato Combo Dispensers containing 10-mg of Grandlure and 60-mg of DDVP were similar to traps loaded with separate lures of equivalent contents. Excellent results were also obtained with Plato Combo Dispensers containing 25-mg Grandlure, 90-mg DDVP and with or without 30-mg eugenol. The Plato Combo dispenser containing 25-mg of Grandlure and 30-mg eugenol was numerically more effective than the Hercon “Superlure” with similar ingredients in attracting 28% more boll weevils over a four week period. Combination dispensers would significantly reduce the costs to BWEPS by reducing the labor involved with preparing, labeling, dating and loading traps with two separate dispensers. In addition, the cost of disposal of depleted dispensers would be significantly reduced.

The addition of eugenol did not appear to improve trap catches in either 10-mg or 25-mg Plato dispensers. The addition of DDVP in Plato Industries dispensers tended to slightly increase the initial release rate of Grandlure in 10-mg dispensers. Plato Industries dispensers formulated with 25-mg Grandlure released a more effective amount of Grandlure on a per day basis than did the Hercon “Superlure”. The Plato Industries 10-mg Grandlure dispenser system released a consistent and more effective amount of Grandlure per day than the Hercon 10-mg laminated “sandwich”.

## References

McKibben, G. H. 2001. U.S. Patent Number 6,183,733. Compositions and Methods of Attracting Overwintering Boll Weevils.

## Acknowledgements

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Table 1. Treatments evaluated for attraction of boll weevils in boll weevil traps in the Field.

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<b>Study 2 – Willacy County, Texas</b>
PIL-Separate Grandlure 25 mg/eugenol 30 mg + 90 mg DDVP PI-IS
PIL-Combination Grandlure 25 mg/eugenol 30 mg/DDVP 90 mg
PIL-Separate Grandlure 17.5 mg/eugenol 21 mg + 90 mg DDVP PI-IS
PIL-Separate Grandlure 25 mg and 90 mg DDVP PI-IS

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Table 2. Treatments evaluated for attraction of boll weevils in boll weevil traps in the Field.

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<b>Study 3 – North Texas Blacklands</b>
PIL-Separate 10 mg Grandlure and 90 mg PI-IS DDVP dispensers
PIL-Combo 10 mg Grandlure + 30 mg eugenol + 60 mg DDVP dispenser
PIL-Combo 10 mg Grandlure + 60 mg DDVP dispenser

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Table 3. Treatments evaluated for attraction of boll weevils in boll weevil traps in the Field.

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<b>Study 4 – North Texas Blacklands</b>
PIL-Combo 25 mg Grandlure + 30 mg eugenol “Super Lure” and a separate 90 mg PI-IS DDVP dispenser
PIL-Separate 25 mg Grandlure and 90 mg PI-IS DDVP dispensers
PIL-Combo 25 mg Grandlure + 30 mg eugenol + 90 mg DDVP dispenser
Hercon Super Lure – a combo 25 mg Grandlure + 30 mg eugenol and a separate 90 mg
PI-IS DDVP dispenser

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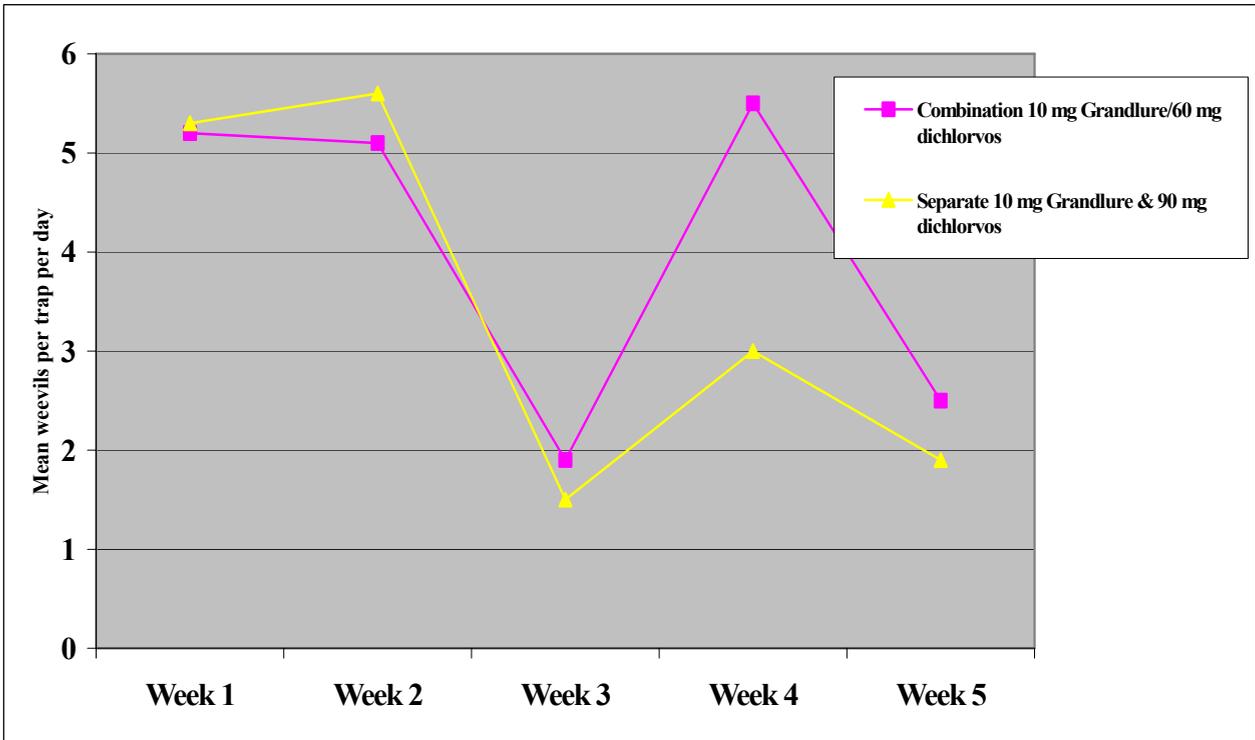


Figure 1. Boll weevil captures per trap per day in Field Study 1 in Willacy County Texas.

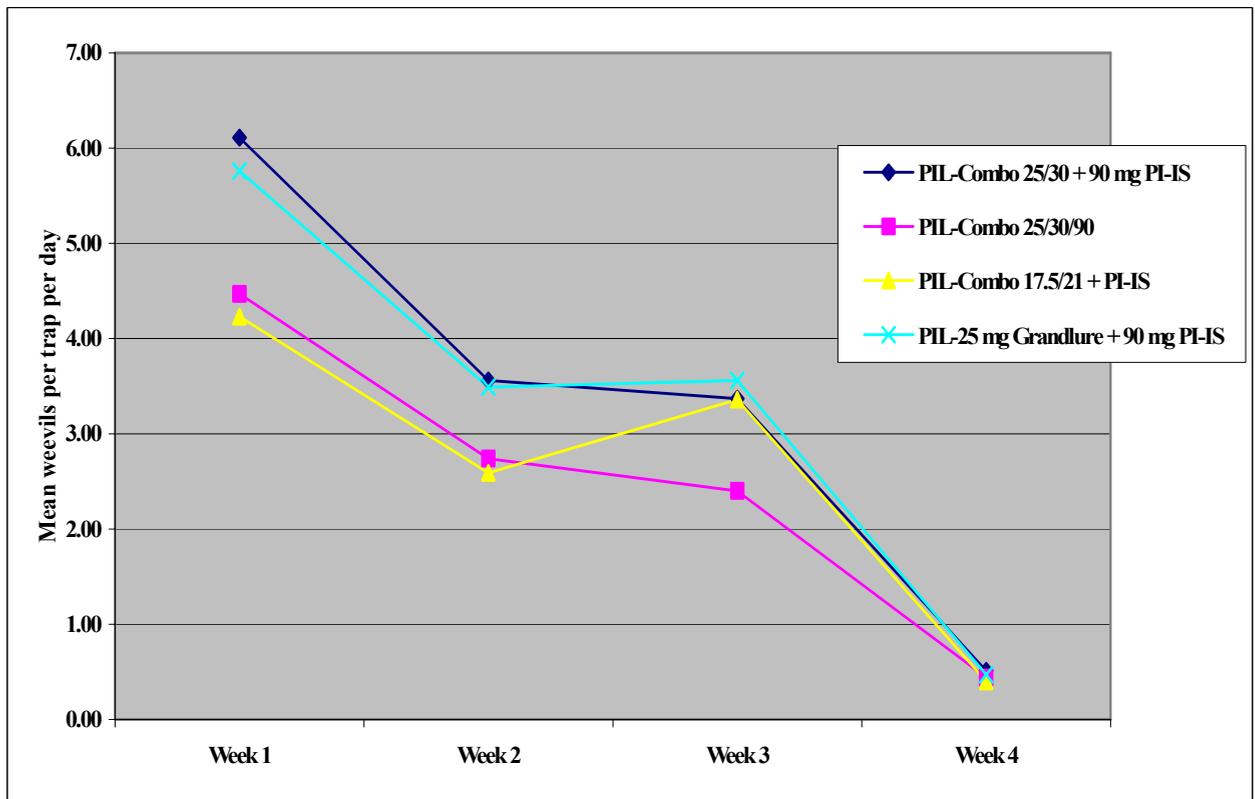


Figure 2. Boll weevil captures per trap per day in Field Study 2 in Willacy County Texas.

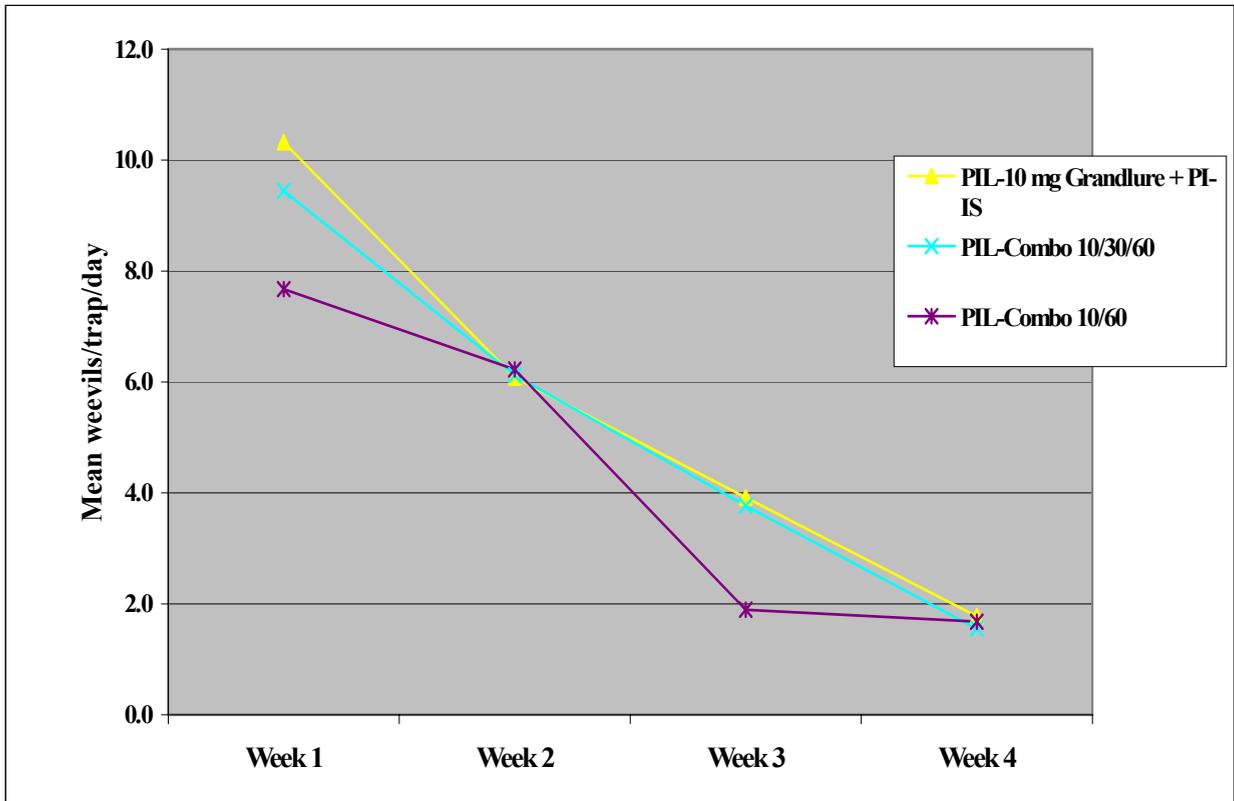


Figure 3. Boll weevil trap captures in Field Study 3 in North Texas Blacklands.

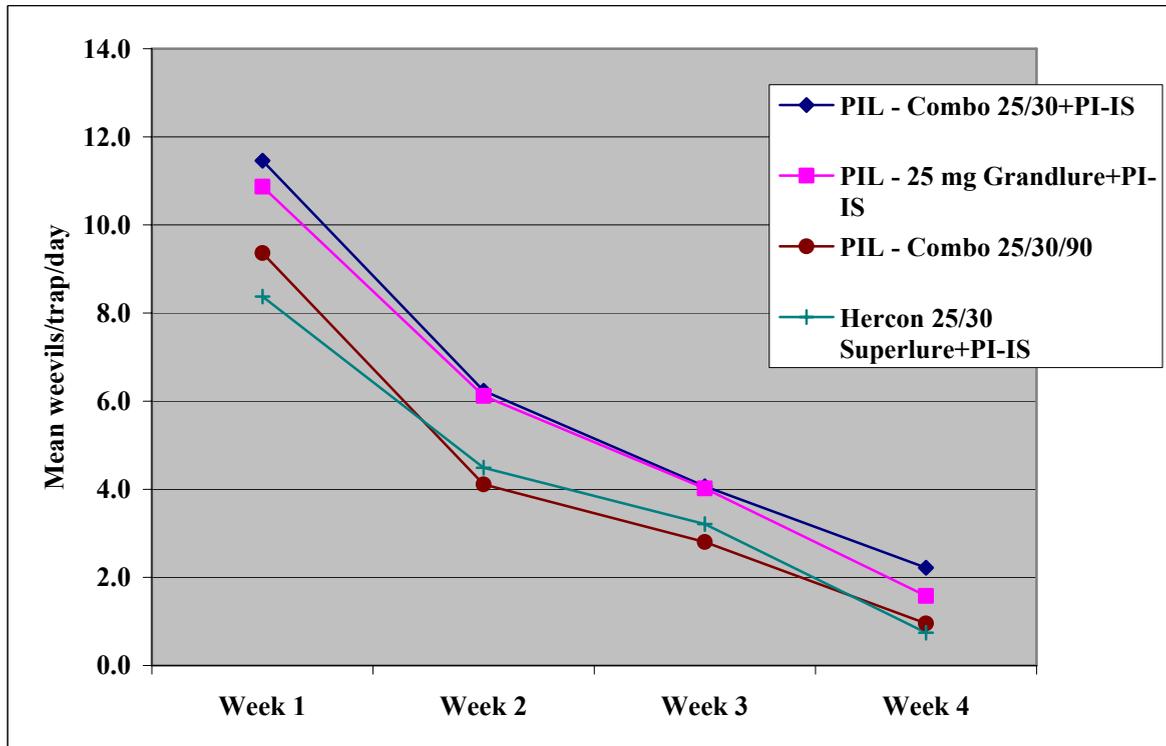


Figure 4A. Boll weevil trap capture in Field Study 4 in North Texas Blacklands.

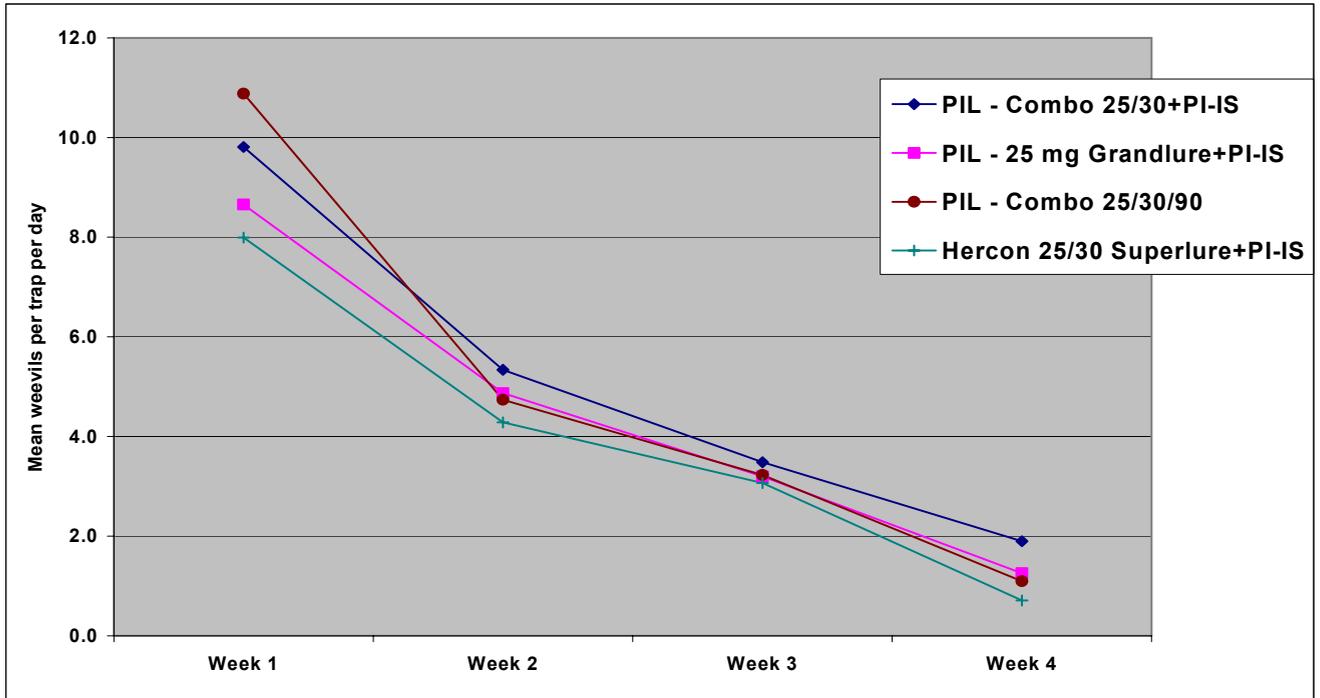


Figure 4B. Mean boll weevil captures using adjusted data (North Texas Blacklands).

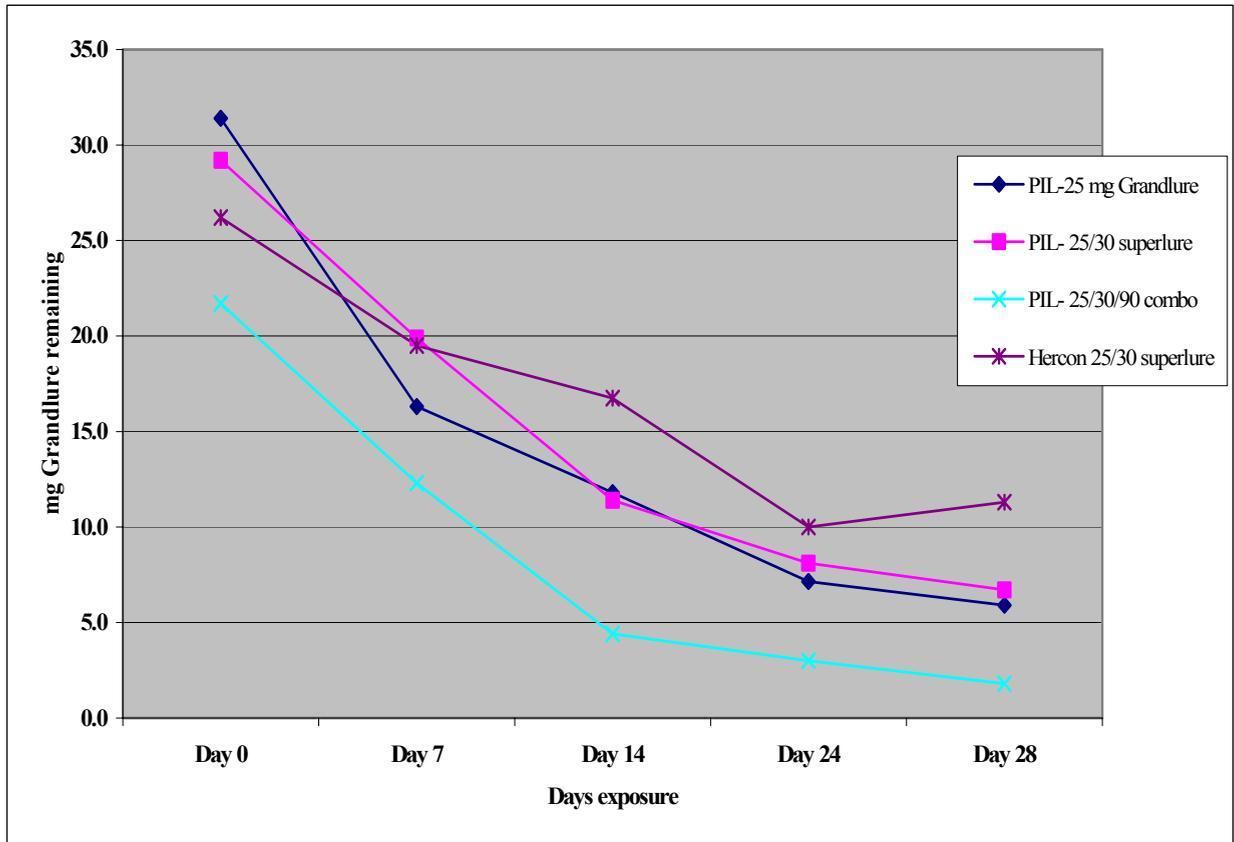


Figure 5. Grandlure remaining in 25-mg dispensers of a 28-day period.

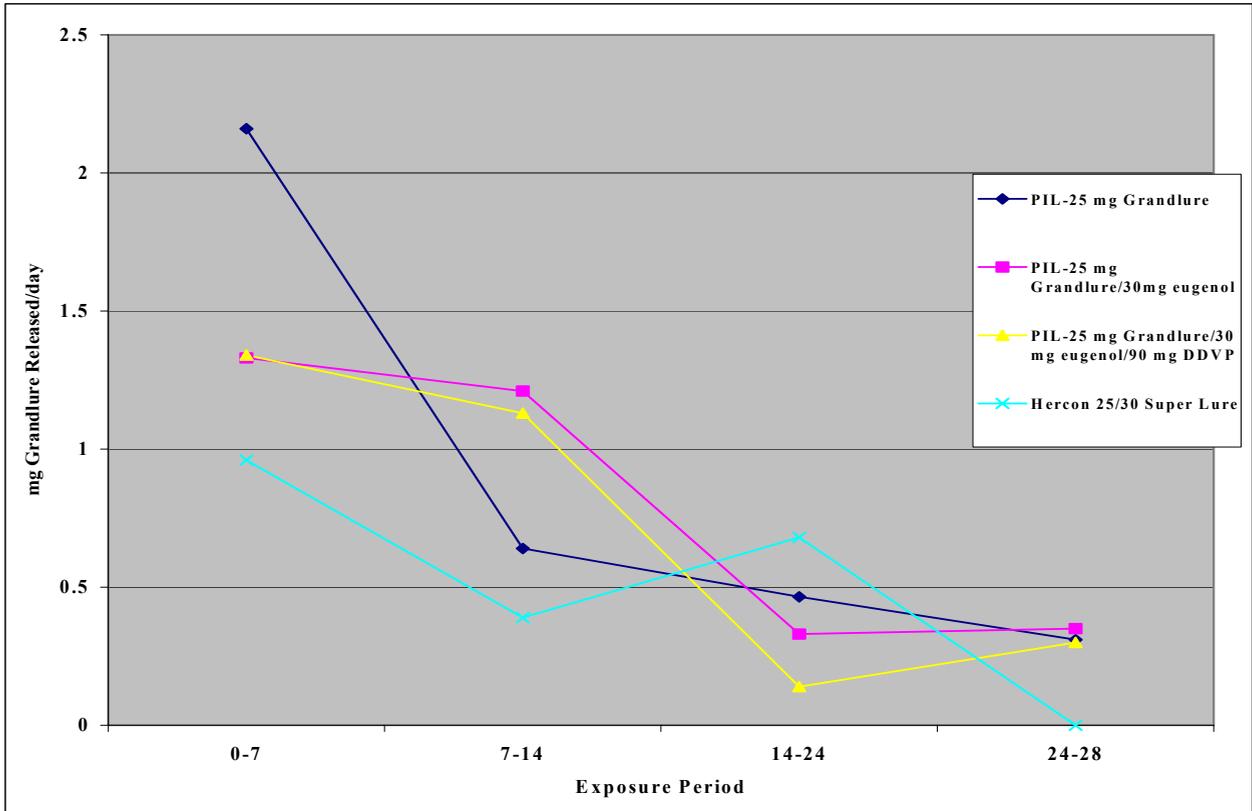


Figure 6. Average Grandlure released per day in 25-mg dispensers over a 28-day period.

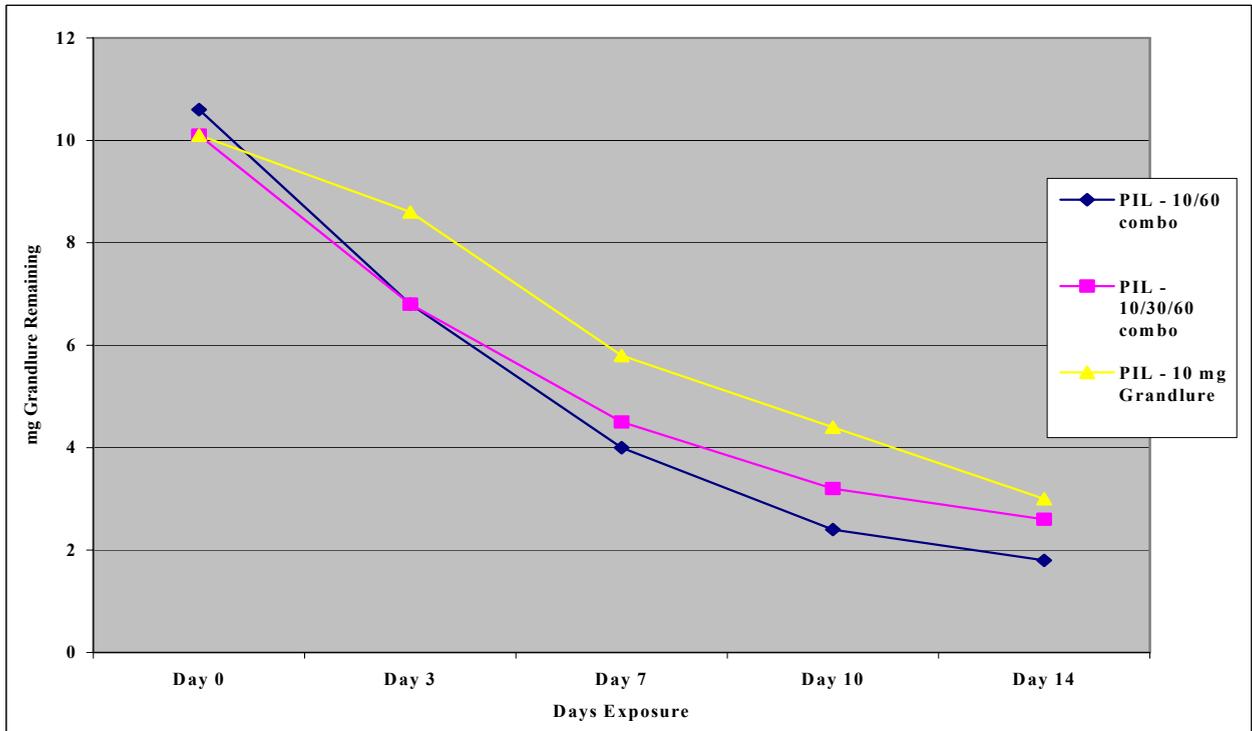


Figure 7. Grandlure remaining in 10-mg dispensers over a 14-day exposure period.

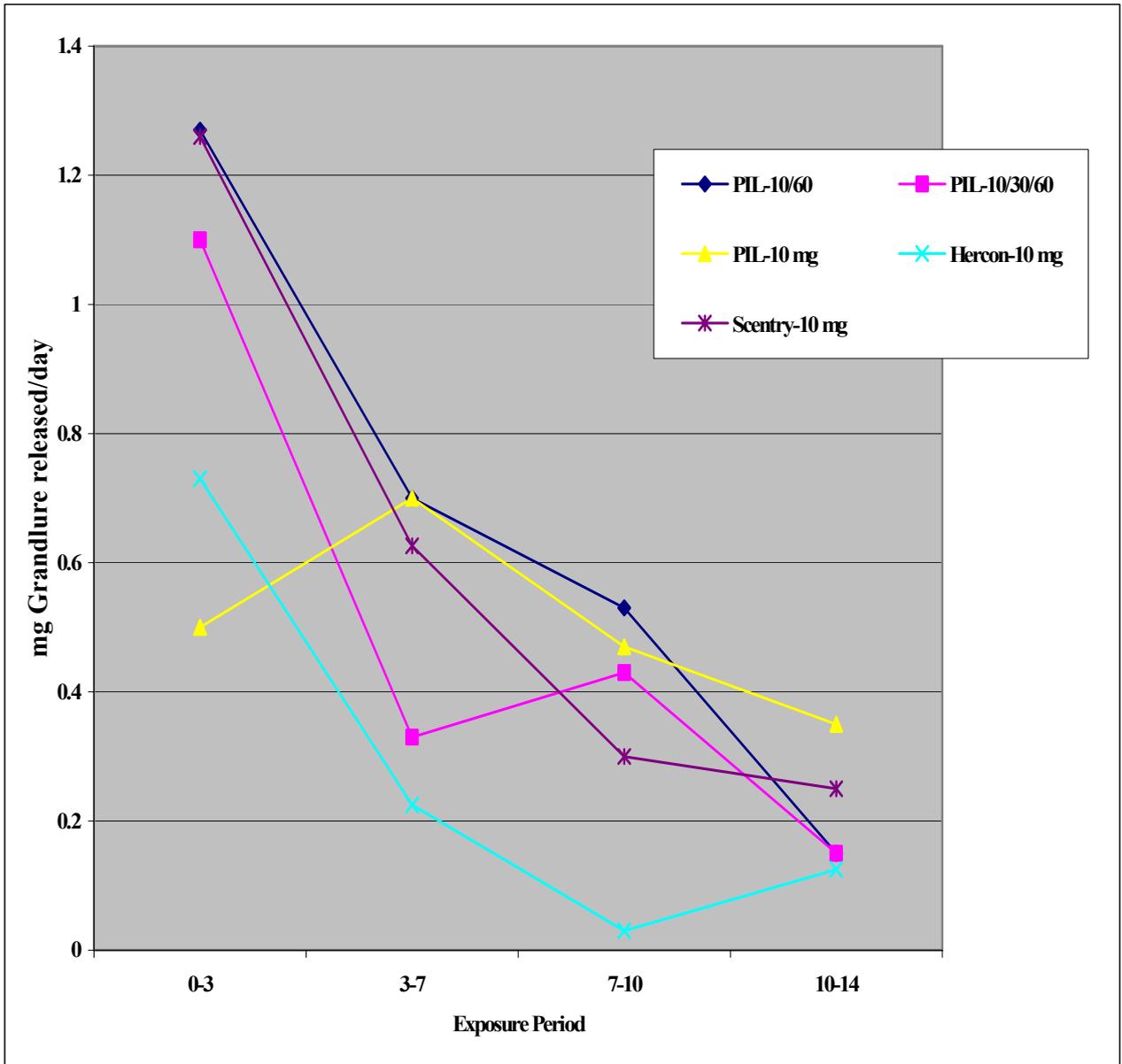


Figure 8. Average release of Grandlure in 10-mg dispensers over a 14-day period.