## DIAMOND INSECTICIDE:BROAD SPECTRUM CONTROL OF HELIOTHINES, LOOPERS, AND ARMYWORMS IN ADDITION TO LYGUS, STINKBUGS, AND FLEAHOPPERS Gilbert W. Angle Jr. and R. Tim Weiland Chemtura Corporation Middlebury, CT

#### **Abstract**

Diamond<sup>TM</sup>, common name novaluron, is an insecticide in the benzoylphenyl urea class of chemistry. It was recently registered in the U.S.A after acceptance as an Organophosphate Replacement product for cotton. Field-tests during 2005 confirmed earlier results demonstrating activity on immature stages of *Lygus* spp., Lepidoptera (e.g. *Pseudoplusia includens, Spodoptera* spp.), stinkbugs (spp.), and *Pseudatomoscelis seriatus*. Research continues across the cottonbelt to further define insect spectrum and best use recommendations.

### **Introduction**

Novaluron is a new generation Insect Growth Regulator (IGR) in the benzoylphenyl urea chemical class. It has broad-spectrum activity against numerous insect species of the orders Lepidoptera, Coleoptera, Hemiptera and Diptera (Ishaaya et al., 1996). The basic manufacturer of novaluron is Makhteshim Agan of North America (Makhteshim Chemical Works). Chemtura Corporation is a Development and Marketing Partner. Early in 2002 U.S.E.P.A. granted novaluron Organophosphate Replacement registration status for cotton and pome fruit. These crops, including potatoes, were registered May 21, 2004. Additional crop registrations are pending. Novaluron has very low acute and chronic toxicities to mammals, low toxicities to birds and fish, low impact on beneficial organisms and it quickly degrades in water. Additionally, it can be used as a replacement for carbamates and pyrethroids.

Novaluron acts on immature stages of numerous insect species by inhibiting chitin biosynthesis causing interference with cuticle formation (Ishaaya et al., 1996). In many species novaluron works by ingestion, however contact activity has been observed. High mortality of early instar larvae occurs when treated foliage is ingested or the chemical is absorbed into the immatures through contact. Novaluron also acts as an ovicide. Weiland (2004) showed that nymph mortality of *Lygus hesperus* in a laboratory study can occur with a few days of contact to residues of Diamond. Activity on cotton pests, including the Lepidopteran heliothines, foliage feeding Lepitopterans, plant bugs, stink bugs and fleahoppers, has been published and shown to be equivalent to current standard products (Capps and Greene, 2004; Dalrymple and Hinkle, 2004; Greene and Capps, 2003; Guy and Dalrymple, 2005; Harlan and Hinkle, 2005; Johnson et al., 2004; Lopez and Latheef, 2005; Lorenz et al., 2004; Robbins and Hinkle, 2005; Smith et al., 2004; Weiland, 2004, 2005; Weiland and Whitehead, 2002, 2003). Ruberson and Fairbanks (2003) have determined Diamond has little effect on the predatory bug, *Orius insidiosus*. No cross-resistance has been determined with related benzoylphenyl compounds, pyriproxyfen and neonicotinoids (Ishaaya et al., 2003). Usage rates will depend on target species and ranges from 0.039 to 0.09 lbs ai (6 to 14 oz) per acre.

This paper presents additional results from trials conducted in 2005.

### **Materials and Methods**

### Proctor, AR 2005

Diamond 0.83EC at 6 (experimental rate) and 9 oz/A with and without 1% v/v Agridex, and Orthene 90S at 8.9 oz/A were evaluated on cotton for tarnished plant bug control. ST4892BGRR cotton was planted and test plots were 12 feet wide by 40 feet long. Treatments were arranged in a randomized complete block design (RCB) with 4 replications. The insecticides were applied on July 4 and 14 and on August 3. Infestations at 7 days after each of the first 2 applications, at 18 days after the second application and 4 days after the 3<sup>rd</sup> application were determined using a drop cloth and reported as number of nymphs per 6 row-feet of cotton.

### Kelso, AR 2005

In this study, the effects of Diamond at 9 oz/A, Diamond at 6 and 9 oz/A with Orthene 90S at 4.4 oz/A, Orthene 90S and 5.9 oz/A, and Bidrin 8 at 5.3 oz/A were investigated. Stoneville 5599 cotton was planted and test plots were 19 feet wide by 50 feet long. Treatments were arranged in an RCB design with 4 replications. Insecticides were applied

on July 27 and August 6 using a boom sprayer delivering 9.7 gallons of water per acre. Total number of nymphs shaken into a drop cloth was recorded at 3 and 6 days after the 1<sup>st</sup> treatment and 3 days after the 2<sup>nd</sup> application in 10 feet of row per plot.

# Cook County, GA 2005

Diamond at 6 and 9 oz/A was evaluated for soybean looper control at each of two farms. Cotton (Deltapine 555BR) was planted and plots were 18 rows wide by 100 feet long. The trials were each established in a randomized complete block with 3 replications (Tucker field) or 4 replications (Betts field). Larvae in 18 feet of row were determined 29 days after application (7 gallons of solution per acre with a high clearance ground sprayer) which took place on August 9.

## Tifton County, GA 2005

Diamond at 9 oz/A was evaluated for soybean looper and Southern armyworm control. The cotton variety, DP 555, was planted and plots were 6 rows by 40' in length. Results were taken from 4 replications. Application was made on August 9 with a self-propelled high clearance sprayer applying 7 gallons of solution per acre. Larvae in two 6-ft drop cloths were determined in each plot 14 and 25 days after the application.

# Corpus Christi, TX, 2005

In this trial Diamond at 4 (experimental rate) and 6 oz/A, Orthene 97at 4 oz/A, Intruder 70WP at 0.6 oz/A and Bidrin8 at 3.2 oz/A were evaluated for cotton fleahopper control. Phytogen 480 widestrike RR variety cotton was planted and plots were 4 rows by 40' in length. Treatments were replicated 4 times in a randomized complete block design. The center 2 rows of a plot were treated on May 27 (9.4 gallons of solution per acre) and 13 June (5.8 gallons of solution per acre). Nymphs of the cotton fleahopper were assessed by counting the number per 20 plant terminals per plot at various timings.

## **Results**

# Proctor, AR 2005 (Table 1)

All Diamond treatments and Orthene reduced the tarnish plant bug nymph populations starting at 5 days after the  $2^{nd}$  application in this trial, with the exception of the low 6 oz/A rate (unregistered) of Diamond at 5 days after the  $2^{nd}$  application. Note that the addition of Agridex to the 6 oz/A treatment did improve efficacy and was equivalent to all other treatments at these 2 sampling time. Populations of nymphs did increase by 18 days after the  $2^{nd}$  application, regardless of treatment, which triggered the need for the  $3^{rd}$  application. Plant bugs were still susceptible to Orthene is this area of Arkansas.

## Kelso, AR 2005 (Table 2)

At 3 days after the first application, no treatment had significantly reduced tarnish plant bug nymph populations. At 6 days after this application the nymph populations were significantly reduced over untreated plots by all treatments except Orthene. At 3 days after the  $2^{nd}$  application, all Diamond treatments equally gave the best control of nymphs. Both Orthene and Bidrin gave significant control over the untreated areas; however the level of control was not near that provided by treatments with Diamond. The addition of Orthene to either the 6 or 9 oz/A Diamond treatments did not improve efficacy over that demonstrated by Diamond at 9 oz/A. Maximum susceptibility of plant bugs to Orthene was questionable in this are of Arkansas.

## Cook County, GA 2005 (Tables 3, 4)

Both 6 and 9 oz/A treatments of Diamond significantly reduced soybean looper larval populations in Cook County GA (Table 3). However at the  $2^{nd}$  site with a much higher looper pressure (Table 4), only the higher 9 oz/A rate significantly controlled the population (Table 4).

# Tifton County, GA 2005 (Table 5, 6)

Diamond significantly reduced a high soybean looper population (Table 5) at both 14 and 25 days after treatment Southern armyworm populations (Table 6) were reduced to zero during both sampling times.

# Corpus Christi, TX, 2005 (Table 7)

Both rates of Diamond, Orthene, Intruder and Bidrin effectively controlled cotton fleahopper nymphs at 3 days after the second application. However, Bidrin failed to control the population at 6 days after the second application. The experimental rate of Diamond (4 oz/A) gave statistically similar control of nymphs at 6 days to the 6 oz/A rate of Diamond, however it was numerically higher and also significantly different to control given by Intruder.

### **Concluding Remarks**

Diamond exhibits a broad spectrum of activity on cotton pests, which includes plant bugs, stink bugs, the heliothine complex, and foliage feeding Lepidopterans. The activity is equal to or more effective than standard control products. Since it affects chitin formation/deposition, only immature stages of these pests are controlled, i.e. nymphs/larvae and eggs. Research will continue across the cottonbelt to further define insect spectrum and best use recommendations.

### **Acknowledgments**

The authors thank those institutes and consultant organizations that helped establish, monitor and provide results presented here.

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		Nymph Number per 6-row feet			
Treatment	Rate oz/A	5 DAT1	5 DAT2	18 DAT2	4 DAT3
Untreated		0.63a	2.4a	6.1a	6.7a
Diamond 0.83EC	9	0.38a	1.0bc	5.1a	0.5b
Diamond 0.83EC	9	0.25a	0.6bc	4.8 a	0.5b
+ Agridex @1%					
Diamond 0.83EC	6*	0.63a	1.6ab	5.1a	0.5b
Diamond 0.83EC	6*	0.38a	0.4c	4.9a	1.0b
+ Agridex @1%					
Orthene 90S	8.9	0.75a	0.6bc	5.1a	0.4b

Table 1. Mean number of *Lygus lineolaris* nymphs per 6-row feet at several sampling times during a 3-application period. (Proctor, AR 2005).

Means within a column followed by the same letter do not significantly differ (P=0.05, Duncan's New MRT).

\*Experimental rate.

Application dates: 4 and 14 July and 3 August.

DAT = days after treatment.

Table 2. Mean number of *Lygus lineolaris* nymphs per 10-row feet at several sampling times during a 2-application period. (Kelso, AR 2005).

		Nymph Number per 10-row feet			
Treatment	Rate — oz/A	3 DAT1	6 DAT1	3 DAT2	
Untreated		16a	18a	21a	
Diamond 0.83EC	9	15a	9bc	3c	
Diamond 0.83EC + Orthene 90S	6+4.4	15a	бс	3c	
Diamond 0.83EC + Orthene 90S	9+4.4	9a	5c	4c	
Bidrin 8	5.3	11a	10bc	14b	
Orthene 90S	5.9	21a	17ab	15b	

Means within a column followed by the same letter do not significantly differ (P=0.1, Student-Newman-Keuls).

Treatments below labeled rates are not shown.

Application dates: 27 July and 6 August.

'Franks' Field.		
Treatment	Rate (oz/A)	No. of Larvae/18 row-feet
Untreated		11.7a
Diamond 0.83EC	6	2.3b
Diamond 0.83EC	9	1.7b

Table 3. Mean number of *Pseudoplusia includens* at 29 days after application of Diamond 0.83EC (Cook County, GA 2005) in 'Franks' Field.

Means within a column followed by the same letter do not significantly differ (P=0.05, Duncan's New MRT). Application date: 9 August.

Table 4. Mean number of *Pseudoplusia includens* larvae at 29 days after application of Diamond 0.83EC (Cook County, GA 2005) in 'Betts' Field.

Treatment	Rate (oz/A)	No. of Larvae/18 row-feet
Untreated		30.5a
Diamond 0.83EC	6	22.2ab
Diamond 0.83EC	9	5.0b

Means within a column followed by the same letter do not significantly differ (P=0.05, Duncan's New MRT).

Data failed Bartlett's test of homogeneity and thus analysis was performed with transformed data [Sqrt(Count+0.5)], however actual means are shown.

Application dates: 9 August.

Table 5. Mean number of *Pseudoplusia includens* larvae at 2 assessments. (Tifton County, GA 2005).

	Rate	No. of Larvae/12-row-feet	
Treatment	oz/A	14 DAT	25 DAT
Untreated		28.5a	15.2a
Diamond 0.83EC	9	13.0b	1.8b

Means within a column followed by the same letter do not significantly differ (P=0.05, LSD).

Data at 25 DAT failed Bartlett's test of homogeneity and thus analysis was performed with transformed data (Log +1), however actual means are shown.

Application date: 9 August.

Table 6. Mean number of *Spodoptera eridania* larvae at 2 assessments. (Tifton County, GA 2005).

	Rate	No. of Larvae/12-row-feet		
Treatment	oz/A	14 DAT	25 DAT	
Untreated		28.3a	1.8a	
Diamond 0.83EC	9	0.0a	0.0a	

Means within a column followed by the same letter do not significantly differ (P=0.05, LSD).

Application date: 9 August.

Table 7. Mean number of *Pseudatomoscelis seriatus* nymphs at 2 assessments after the last of 2 applications. (Corpus Christi, TX 2005).

	Rate	Number/20 plant terminals		
Treatment	oz/A	3 DAT2	6 DAT2	
Untreated		7.5a	2.8a	
Diamond 0.83EC	4*	0.3b	1.5b	
Diamond 0.83EC	6	0.3b	0.5bc	
Orthene 97	4	0.0b	0.5bc	
Intruder 70WP	0.6	0.0b	0.0c	
Bidrin 8	3.2	0.0b	2.8a	

Means within a column followed by the same letter are not significantly different by ANOVA.

Diamond 0.83EC and Intruder 70WP included COC @ 1%.

Some treatments and sampling dates omitted for brevity.

Application dates: 27 May and 13 June.

\*Experimental rate.