NOVALURON - A REGISTRATION AND PERFORMANCE UPDATE R. Tim Weiland Uniroyal Chemical Company, a subsidiary of Crompton Corporation Middlebury, CT James Whitehead Makhteshim-Agan of North America, Inc. Oxford, MS

Abstract

Novaluron is an insect growth regulator in the benzoylphenyl urea class of chemistry. It was recently registered in the U.S.A. as PedestalTM for control of a variety of insect pests on container-grown ornamentals as a Reduced Risk pesticide. U.S.E.P.A. is currently reviewing novaluron after acceptance as an Organophosphate Replacement product for cotton and pome fruit (DiamondTM). The potato grouping also was recently included. Sales of Diamond on these crops are expected for the 2004 season. Field-tests during 2001with cotton confirmed earlier results demonstrating activity on whitefly (*Bemisia* spp.), Lepidoptera (*Heliocoverpa virescens*, *H. zea*, and *Bucculartrix thurberiella*) and *Lygus* spp. Research continues across the cottonbelt to further define rates and insect spectrum.

Introduction

Novaluron is a new generation Insect Growth Regulator (IGR) in the benzoylphenyl urea chemical class. It has broadspectrum 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). Uniroyal Chemical Company is a Development and Marketing Partner. During the last quarter of 2001 novaluron was registered in the U.S.A. for use on ornamentals as a reduced risk pesticide and currently is being marketed as Pedestal[™]. Early in 2002 U.S.E.P.A. granted novaluron Organophosphate Replacement status for cotton and pome fruit and initial sales as Diamond[™] in these areas, including potatoes, is anticipated for 2004. 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.

Several formulations of novaluron have been developed for the U.S.A. These include Diamond 0.83EC for use on field crops and vegetables, Diamond 7.5WG for use on pome fruits, and Pedestal 0.83SC for use on ornamentals.

Novaluron acts on immature stages of numerous insect species of the orders Lepidoptera, Coleoptera, Hemiptera and Diptera by inhibiting chitin biosynthesis causing interference with cuticle formation (Ishaaya et al., 1996). Novaluron works primarily by ingestion, however limited contact activity has been observed. High mortality of early instar larvae occurs when treated foliage is ingested. Novaluron also acts as an ovicide. Activity on cotton pests, including whiteflies, the Lepidopteran heliothines and plant bugs has been published and shown to be equivalent to current standard products (Weiland and Whitehead, 2002). Usage rates will depend on target species and ranges from 0.02 to 0.09 lbs ai/acre.

This paper presents additional results from trials conducted in 2001.

Materials and Methods

Uvalde, TX 2001

Insecticides evaluated on immature nymph populations of *Bemisia tobacii* were Diamond 0.83EC at 0.013, 0.026 and 0.052 lbs. a.i./acre and Applaud 70WP at 0.35 lbs. a.i./acre. Suregrow 125 cotton was planted and test plots were 23.3 feet wide by 40 feet long. Treatments were arranged in a randomized complete block (RCB) design with 4 replications. The insecticides were applied on 26 July, 2 August and 9 August. Ten leaf samples were taken 0 and 6 days after the first application, 4 days after the second application, and 6 days after the third application, and mean number of immatures were determined. Nineteen days after the third application visual leaf damage due to a late infestation of cotton leaf perforator (*Bucculatrix thurberiella*) was estimated by scoring plot plants from 0 (no damage) to 10 (100% defoliation).

Somerton, AZ 2001

In this study, Diamond 0.83EC at 0.013 and 0.026 lbs. a.i./acre and Applaud 70WP at 0.35 lbs. a.i./acre were tested on cotton for *Bemisia argentifolii* control. Plots were 4-rows wide by 30 feet long. Treatments were arranged in a RCB design with 4 replications. The insecticides were applied on 20 August. Ten 5^{th} node mainstem leaves were collected from each plot. Nymph counts were taken in a 1-cm² area for each leaf at 0, 3, 7, 14, 21, and 28 days after application.

Elko, SC 2001

Products evaluated for *Helicoverpa zea* control were Diamond 0.83EC at 0.023, 0.045 and 0.068 lbs. a.i./acre, Steward 1.25SC at 0.09 lbs. a.i./acre, and Tracer 4SC at 0.08 lbs. a.i./acre. D.P. 436 cotton was planted and test plots were 4-row (40 inch centers) wide by 40 feet long. The experimental design was a RCB with 4 replications. Insecticide applications were made on 20 and 28 July and 4 August. One hundred bolls were evaluated for larval damage 3 and 7 days after each of the 3 applications, and 10 and 14 days after the last application.

Prattville, AL 2001

In this study, Diamond 0.83EC at 0.023, 0.045, 0.068 and 0.091 lbs. a.i./acre, Tracer 4SC at 0.063 lbs. a.i./acre, Steward 1.25SC at 0.09 lbs. a.i./acre, Intrepid 2SC at 0.15 lbs. a.i./acre, Denim 0.16 at at 0.01 lbs. a.i./acre and S-1812 35 WP at 0.15 lbs. a.i./acre were evaluated on Delta Pearl cotton for heliothine Lepidoptera control. Test plots were 4 rows by 50 feet long. A RCB study design with 4 replicates was used. The insecticides were applied on 23 July, 30 July, 13 August and 21 August. One hundred bolls were evaluated for larval feeding 9 days after the second application, 10 days after the third application and 9 days after the fourth application.

Quitman County, MS 2001

Insecticides evaluated in this trial included 3 rates of Diamond 0.83EC (0.019, 0.039, 0.059 lbs. a.i./acre), Orthene 90SC at 0.5 lbs. a.i./acre, 0.25 lbs. a.i./acre of Orthene plus 0.019 lbs. a.i./acre of Diamond 0.83EC, Provado 1.6F at 0.047 lbs. a.i./acre, Assail 70WP at 0.05 lbs. a.i./acre, Calypso 4SC at 0.047 lbs. a.i./acre and Centric 40WG at 0.047 lbs. a.i./acre. These treatments were established on PM 1218 cotton with plots 12.5 by 50 feet to evaluate activity on *Lygus lineolaris*. A RCB experimental design with 4 replications was used. Applications were made on 8 and 15 August, and nymph population counts (number per 20 plants per plot) were taken 2 and 5 days after the first application and 2 and 6 days after the second application.

Macon Ridge, LA 2001

Insecticides tested for control of *Lygus lineolaris* were 3 rates of Diamond 0.83EC (0.019, 0.039, 0.059 lbs. a.i./acre), Orthene 90SC at 0.75 lbs. a.i./acre, Capture 2EC at 0.06 lbs. a.i./acre, Steward 1.25SC at 0.1 lbs. a.i./acre, and Vydate L at 0.25 lbs. a.i./acre. Suregrow 747 cotton was planted and test plots were 13.3 wide by 50 feet long. The experimental design was a RCB with 4 replications. The insecticides were applied on 13 and 20 June. The mean number of nymphs plus adults was determined in 25 sweep net passes per plot at 2 and 6 days after the first application and at 2 and 9 days after the second application.

Headland, AL 2001

Products evaluated for Southern green stink bug (*Nezara viridula*) activity included Diamond 0.83EC at 0.059 lbs. a.i./acre, Orthene 97PE at 0.5 lbs. a.i./acre, Capture 2EC at 0.05 lbs. a.i./acre, Steward 1.25SC at 0.11 lbs. a.i./acre, Vydate L at 0.25 lbs. a.i./acre, Provado 1.6F at 0.047 lbs. a.i./acre, Assail 70WP at 0.1 lbs. a.i./acre, Calypso 4SC at 0.094 lbs. a.i./acre, and Centric 40WG at 0.062 lbs. a.i./acre. Test plots were 8 rows x 400 feet long in SG 125 BR cotton. Within each treatment block a drop cloth was used to sample 6 row feet of plants at 5 randomly selected sites. Nymph population assessment was at 4 days after the 13 September application.

Results

Uvalde, TX 2001 (Table 1)

Starting at 4 days after the second application through 6 days after the third application both of the chemical treatments resulted in immature populations of *Bemisia tobaci* that were significantly lower than the untreated control (Table 1). Control was equal and no rate response with Diamond 0.83EC was demonstrated. All three rates of Diamond equally controlled the *Bucculatrix thurberiella* population.

Somerton, AZ 2001 (Table 2)

Treatments were made to a heavy growing population of *Bemisia argentifolii* (Table 2). Treatments demonstrated efficacy starting at 7 days after application. The higher rate (0.026 lbs. a.i./acre) of Diamond 0.83EC significantly lowered the population more so than Applaud 70WP at that time. The higher rate of Diamond numerically exhibited better control of this whitefly in contrast to the lower rate.

Elko, SC 2001 (Table 3)

Under low bollworm pressure Diamond 0.83EC controlled potential boll damage similarly to Tracer and Steward starting 3 days after the second application (Table 3). The 0.023 lbs. a.i./acre rate of Diamond 0.83EC failed to control this heliothine to the extent of the other treatments at 7 days after the second application. The higher 3 rates of Diamond (0.045 to 0.091 lbs. a.i./acre) exhibited similar control.

Prattville, AL 2001 (Table 4)

Of the treatments illustrated only S-1812 35WP at 9 days after the second application and the low rate of Diamond 0.83EC (0.023 lbs. a.i./acre) did not significantly reduce square damage due to heliothine Lepidoptera in contrast to the untreated area. Intrepid 2SC and Denim 0.16 did not statistically lessen pressure at 10 days after the third application (Table 4). The higher 3 rates of Diamond (0.045 to 0.091 lbs. a.i./acre) exhibited similar control throughout the 3 sampling times.

Quitman County, MS 2001 (Table 5)

Treatment differences occurred starting at 5 days after the first application (Table 5). Only the low rate of Diamond 0.83EC (0.019 lbs. a.i./acre), Assail 70WP and Calypso 4SC did not significantly lower *Lygus lineolaris* nymph numbers. At 2 days after the second application, only Calypso 4SC did not significantly lower nymph numbers. All treatments had lower numbers by 6 days after the second application. A rate of 0.019 lbs. a.i./acre of Diamond 0.83EC was not as efficacious as the higher rates in this study, unless it was combined with Orthene at 0.25 lbs. a.i./acre.

Macon Ridge, LA 2001 (Table 6)

Both Orthene 90SC and Capture 2EC exhibited *Lygus lineolaris* activity starting 2 days after the first application (Table 6). The high rate of Diamond 083EC (0.059 lbs. a.i./acre), Steward 1.25SC and Vydate L also demonstrated activity by 6 days after the first application. All treatments had lowered populations by 2 days after the second application. The high rate of Diamond 0.83EC demonstrated quicker activity on the tarnish plant bug in this study. A differentiation between adult and nymph populations may have indicated early control of Lygus with Diamond 0.83EC since any direct effects are only on immature insect stages due to its mode of activity.

Headland, AL 2001 (Table 7)

In this study all insecticide treatments demonstrated *Nezara viridula* activity on the nymphal population of *Nezara viridula*. Calypso 4SC only reduced the population 50% at the rate applied.

Concluding Remarks

Cotton trials in the U.S.A. indicate Diamond 0.83EC has activity on *Bemisia argentifoli* and *B. tabaci* immatures, heliothine, and *Lygus* (spp.) immatures. A rate of 0.04 lbs. a.i./acre or more appears to be needed for heliothine and *Lygus* control. It appears a lower rate will control *Bemisia* populations. Additional research is needed to identify control rate ranges for stinkbugs and foliage feeding Lepidoptera. Future studies will address them, including novaluron's minimal activity on the beneficial insect complex.

Acknowledgments

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

References

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Table 1. Mean number of *Bemisi tabaci* immatures per 10 leaves during the 3-application period and leaf damage (0= no damage, 10=100% defoliation) from *Bucculatrix thurberiella*, 19 days after the last of the 3 applications (Uvalde, TX 2001).

	Rate	Ir	nmatures	Defoliation Rating		
Treatment	lbs. a.i./A	0 DAA1	6 DAA1	4 DAA2	6 DAA3	19 DAA3
Untreated		0.5a	3.0	3.5a	4.5a	6.5a
Diamond 0.83EC	0.013	1.3a	0.8a	1.3b	0.8b	2.6c
Diamond 0.83EC	0.026	1.3a	1.3a	0.0b	0.5b	2.4c
Diamond 0.83EC	0.052	1.0a	1.0a	0.3b	1.0b	2.2c
Applaud 70WP	0.35	1.0a	0.5a	0.3b	0.8b	5.2b

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

Application dates: 26 July, 2 August, 9 August.

Table 2. Mean number of *Bemisia agrentifolii* immatures in 1^2 cm of 10 leaves at 0, 3, 7,14, 21 and 28 days after application (Somerton, AZ 2001).

	Rate	Immatures per 1 ² cm				m		
Treatment	lbs. a.i./A	0 DAA	3 DAA	7 DAA	14 DAA	21 DAA	28 DAA	
Untreated		1.5a	3.2a	17.5a	23.8a	31a	16.2a	
Diamond 0.83EC	0.013	2a	2.5a	10.2bc	17.8ab	16.8b	11.2b	
Diamond 0.83EC	0.026	1.5a	2.2a	7.8c	9.8b	12.2b	8.5b	
Applaud 70WP	0.35	1.8a	2.2a	12.5b	9b	18.8b	11.2b	

Means within a column followed by the same letter do not significantly differ (P=0.1, Duncan's MRT).

Application date: 20 August.

Table 3. Bolls damaged by Helicoverpa zea per 100 sampled at various days after each of 3 applications (Elko, SC 2001).

	Rate	Damaged bolls							
Treatment	lbs. a.i./A	3 DAA1	7 DAA1	3 DAA2	7 DAA2	3 DAA3	7 DAA3	10 DAA3	14 DAA3
Untreated		1.5a	1.5a	2.8a	4.3a	6.0a	4.5a	4.0a	2.8a
Diamond 0.83EC	0.023	0.5a	1.0a	1.0b	3.0a	2.0b	1.8b	1.3bc	0.5b
Diamond 0.83EC	0.045	0.8a	0.8a	1.0b	1.3b	1.3b	1.0b	1.3bc	0.3b
Diamond 0.83EC	0.068	0.5a	1.5a	0.5b	0.5b	1.0b	0.8bc	1.8b	0.3b
Diamond 0.83EC	0.091	0.5a	0.3a	0.5b	0.3b	1.0b	1.0bc	0.5bc	0.0b
Tracer 4SC	0.08	0.5a	0.3a	0.3b	0.0b	0.3b	0.3bc	0.3c	0.0b
Steward 1.25SC	0.09	0.3a	0.0a	0.8b	0.0b	0.0b	0.0c	0.5bc	0.3b

Means within a column with the same letter do not significantly differ (P=0.05, Student-Newman-Keuls). Application dates: 20 July, 28 July, 4 August.

Table 4. Squares and bolls damaged by heliothine Lepidoptera per 100 sampled at 3 assessments during a 4-application treatment evaluation (Prattville, AL 2001).

<u></u>	Rate	Damaged Squares/Bolls				
Treatment	lbs. a.i./A	9 DAA2	10 DAA3	9 DAA4		
Untreated		27a	13a	25a		
Diamond 0.83EC	0.023	9b	9ab	8b		
Diamond 0.83EC	0.045	1b	3b	5b		
Diamond 0.83EC	0.068	2b	5b	8b		
Diamond 0.83EC	0.091	3b	3b	4b		
Tracer 4SC	0.063	2b	3b	3b		
Steward 1.25SC	0.09	0b	2b	1b		
Intrepid 2SC	0.15	4b	8ab	3b		
Denim 0.16	0.01	3b	7ab	3b		
S-1812 35WP	0.15	11ab	2b	3b		

Means within a column followed by the same letter do not significantly differ (P=0.05, Duncan's MRT). Additional treatments have been omitted from the table for simplicity.

Application dates: 23 July, 30 July, 13 August, 21 August.

Table 5. Mean number of *Lygus lineolaris* nymphs per 20 plants at various days after each of 2 applications (Quitman County, MS 2001).

	Rate	Mean number per 20 plants				
Treatment	lbs. a.i./A	2 DAA1	5 DAA1	2 DAA2	6 DAA2	
Water		15a	19a	15.5a	21.9a	
Diamond 0.83EC	0.019	13.9a	15.7abc	4.8bcd	4.8bc	
Diamond 0.83EC	0.039	11.7a	6.8de	5.6bc	1.2d	
Diamond 0.83EC	0.058	14.6a	5.5e	3.2cd	3.1bcd	
Diamond 0.83EC	0.019	9.3a	6.1e	2.3cd	1.2d	
+ Orthene 90SC	0.25					
Orthene 90SC	0.5	7.2a	4.8e	1.9d	1.6cd	
Provado 1.6F	0.047	10.6a	9.2be	4.9bc	2.2cd	
Assail 70WP	0.05	15.4a	17ab	4.9bc	4.5bc	
Calypso 4SC	0.047	11.8a	12.9a-d	8.7ab	8.2b	
Centric 40WG	0.047	7.7a	8.3cde	0.4e	1.1d	

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

Application dates: 8 and 15 August.

Table 6. Mean number of *Lygus lineolaris* nymphs + adults per 25 net sweeps at various days after each of 2 applications (Macon Ridge, LA 2001).

	Rate	Mean number of Lygus per 25 sweeps				
Treatment	lbs. a.i./A	2 DAA1	6 DAA1	2 DAA2	9 DAA2	
Untreated		7.3a	8.5a	3.3a	3.3a	
Diamond 0.83EC	0.019	5abc	5.5ab	1.3b	0.8ab	
Diamond 0.83EC	0.039	4abc	4.3ab	1.0b	0.5a	
Diamond 0.83EC	0.059	5.3ab	3.5bc	0.5b	1ab	
Capture 2EC	0.06	2.3bc	3.5bc	0.8b	0.8ab	
Orthene 90SC	0.75	1c	1.3c	0.0b	0.5b	
Steward 1.25SC	0.1	4.8abc	4.0bc	1.0b	2.8ab	
Vydate L	0.25	6.8a	4.5bc	0.8b	1ab	

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

Application dates: 13 and 20 June.

	Rate lbs.	Mean number per 100 feet
Treatment	a.i./A	4 DAA
Untreated		40
Diamond 0.83EC	0.059	3
Capture 2EC	0.5	0
Orthene 97PE	0.5	0
Steward 1.25SC	0.11	0
Vydate 3.77L	0.25	0
Provado 1.6F	0.047	3
Assail 70WP	0.1	0
Calypso 4SC	0.094	20
Centric 40WG	0.062	0

Table 7. Mean number of *Nezara viridula* nymphs per 100 feet of row 4 days after application (Head-land, AL 2001).

Additional Treatments have been omitted from the table for simplicity.

Application date: 13 September.