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# Efficacies of Selected Insecticides on Cabbage Looper and Diamondback Moth on Cabbage in South Texas

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## ABSTRACT

**The efficacies of several novel insecticides, Alert (chlorfenapyr), Avaunt (indoxacarb), Confirm (tebufenozide), Proclaim (emamectin benzoate), and SpinTor (spinosad) were tested under field conditions against cabbage looper (*Trichoplusia ni* Hübner) and diamondback moth (*Plutella xylostella* L.) on cabbage in south Texas. A pyrethroid, Karate (lambda-cyhalothrin), was used as the standard for comparison in most trials. Results from 4 field studies indicated that Alert, Avaunt, and SpinTor provided the best control of cabbage looper and diamondback moth larvae on cabbage, followed by Proclaim and Confirm. The pyrethroid, Karate, was still effective against the two lepidopterous species on cabbage, and no evidence of resistance was found.**

## RESUMEN

**Se probó la eficacia de varios insecticidas de aparición reciente, Alert (chlorfenapyr), Avaunt (indoxacarb), Confirm (tebufenozide), Proclaim (benzoato de emamectin) y SpinTor (spinosad) contra el gusano medidor de la col (*Trichoplusia ni* Hübner) y la palomilla de dorso de diamante (*Plutella xylostella* L.) en col bajo condiciones de campo en el sur de Texas. Un piretroide, karate (lambda-cyhalothrin), se utilizó como modelo para comparación en la mayoría de los ensayos. Los resultados de 4 estudios de campo indicaron que Alert, Avaunt y SpinTor proporcionaron el mejor control de las larvas del gusano medidor y de la palomilla de dorso de diamante en la col, seguidos por Proclaim y Confirm. El piretroide, karate, continuó siendo efectivo en contra de las dos especies de lepidopteros en la col y no se encontró ninguna evidencia de resistencia.**

*Additional Index Words: Spinosad, biorational insecticide, cabbage looper, Trichoplusia ni, cabbage*

Cabbage looper, *Trichoplusia ni* Hübner, and diamondback moth, *Plutella xylostella* (L.), have been the two most important pests on cole crops in south Texas since the 1950's (Schuster 1959, Cartwright et al. 1987, Liu et al. 1999) and are the most important production limitations for these crops (Edelson et al. 1993). Control of these pests is becoming increasingly difficult due to resistance to many common synthetic insecticides and the imposed quality restrictions on fresh market vegetables. Management recommendations for these lepidopterous pests in cole crops have been based on either a low economic threshold (1 larva per 3 plants) (Cartwright et al. 1987) or scheduled weekly sprays. Because of frequent applications of insecticides and the resulting insecticide resistance, failure to control *P. xylostella* has been reported in south Texas since 1986 (Magaro and Edelson 1990). Prior to the recent registration of SpinTor (spinosad; Dow AgroSciences, Indianapolis, IN), insecticidal control of cabbage loopers had relied heavily on pyrethroid insecticides for a decade. The continued reliance on pyrethroid and other synthetic insecticides enhances the potential for development of insecticide resistance and is detrimental to management of beneficial arthropods. With implementation of the Food Quality Protection Act (FQPA) which will likely limit the applications of some organic chemical insecticides and the potential resistance to *Bacillus thuringiensis* (Berliner) (Bt) products by these lepidopterous pests, scientists and growers are seeking alternative materials that are effective against the pests while safe to humans and the environment.

Several new insecticides with novel modes of action against the lepidopterous complex on cabbage and other cole crops are becoming available to the growers. Alert (chlorfenapyr; American Cyanamid, Princeton, NJ) is both an insecticide and a miticide, with a novel mode of action of blocking the production of energy. Avaunt (indoxacarb; Du Pont, Wilmington, DE) is a relatively broad spectrum insecticide, with activity against most major lepidopterous pests on cotton and vegetables. Confirm and Intrepid (tebufenozide and methoxyfenozide, respectively; Rohm and Haas, Philadelphia, PA) are insect growth regulators (IGRs) that imitate the natural insect molting hormone by strongly binding to the ecdysone receptor protein, which when activated, initiates the molting process. SpinTor is a fermentation by-product based compound derived from a naturally occurring soil actinomycete bacterium, *Saccharopolyspora spinosa* (Thompson et al. 1997). Proclaim (emamectin benzoate; Novartis, Greensboro, NC) is a semi-synthetic avermectin insecticide derived from the fermentation product avermectin $B_1$ (abamectin).

These studies were initiated to determine the efficacies of selected novel insecticides, including Avaunt, Alert, Confirm, Proclaim, and SpinTor, against cabbage looper and diamondback moth field larval populations on cabbage under field conditions in south Texas.

## MATERIALS AND METHODS

Four field trials were conducted at the Texas Agricultural Research and Extension Center, Texas A&M University System, in Weslaco, TX. Cabbage (*Brassica oleracea capitata* L. variety 'Grand Slam') was used in all trials, and the standard culture protocols developed by the Texas Agricultural Experiment Station at Weslaco were followed.

**Insecticides.** The insecticides tested with the rates and manufacturers are listed in Table 1. The pyrethroid, Karate (lambda-cyhalothrin; Zeneca, Wilmington, DE), was used as a standard for comparison in most trials. A non-treated check was included in all trials. Dyne-Amic (Helena Chemical Company, Memphis, TN), a methylated vegetable oil plus nonionic organosilicone surfactant, was used as a tank mix in some trials. Addition of this product or similar products was recommended by the manufacturer of some insecticides.

**Experimental Design, Sampling and Material Application.** Plot size, and arrangement were consistent within each trial but varied between trials. Generally, each plot (5-10 m long) consisted of 1 or 2 rows of cabbage on 1 m (40 in.) beds with 30 cm (12 in.) within-row plant spacing. Plots were 1 or 2 beds wide. All plots were separated with sorghum wind breaks and a 0.6 to 1.3 m (2 to 5 ft) alleyway. All treatments were arranged in a randomized complete block design (RCBD) with 4 replications. Plants were scouted 1 to 3 times weekly by visual inspection of 5 or 10 randomly selected plants per plot. Insecticide applications were initiated as larval densities exceeded the threshold level of 0.3 larvae per plant as determined in south Texas (Cartwright et al. 1987). Insecticides were applied using a tractor-mounted sprayer or a $CO_2$ pressurized backpack sprayer. The tractor mounted sprayer was equipped with 3 ceramic hollow cone nozzles per row (TX6-red, 1 over the plant, and one on each side of the row directed into the plant) with a spray pressure of 689.5 kPa (100 psi) and a delivery rate of 280 - 374 l/ha (30-40 gal/acre) at 4.8 km/h (3 mph). Tests treated with the $CO_2$ pressurized backpack sprayer varied in application methodology from 93.5 to 280.6 liter/ha (10 to 30 gal/ac) and 206.9 to 275.8 kPa (30 to 40 psi). All $CO_2$ pressurized backpack treated plots used a nozzle arrangement of three nozzles per row (1 over the plant, and 1 on each side of the row directed into the plant) with either TX5 or TX10 hollow cone nozzles.

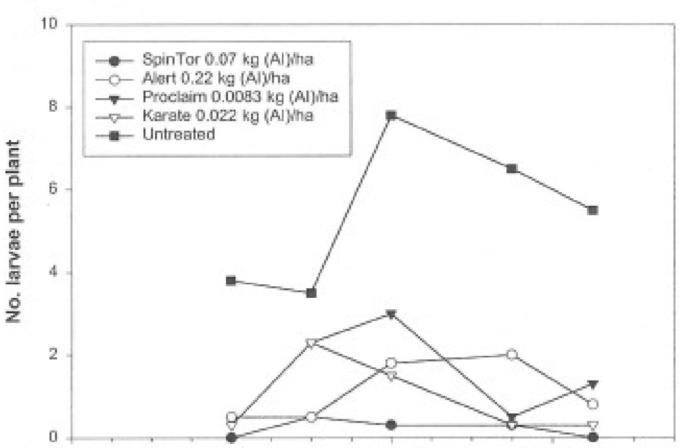


**Fig. 1.** Efficacy of several new insecticides on cabbage looper on cabbage in south Texas (Weslaco 1996).

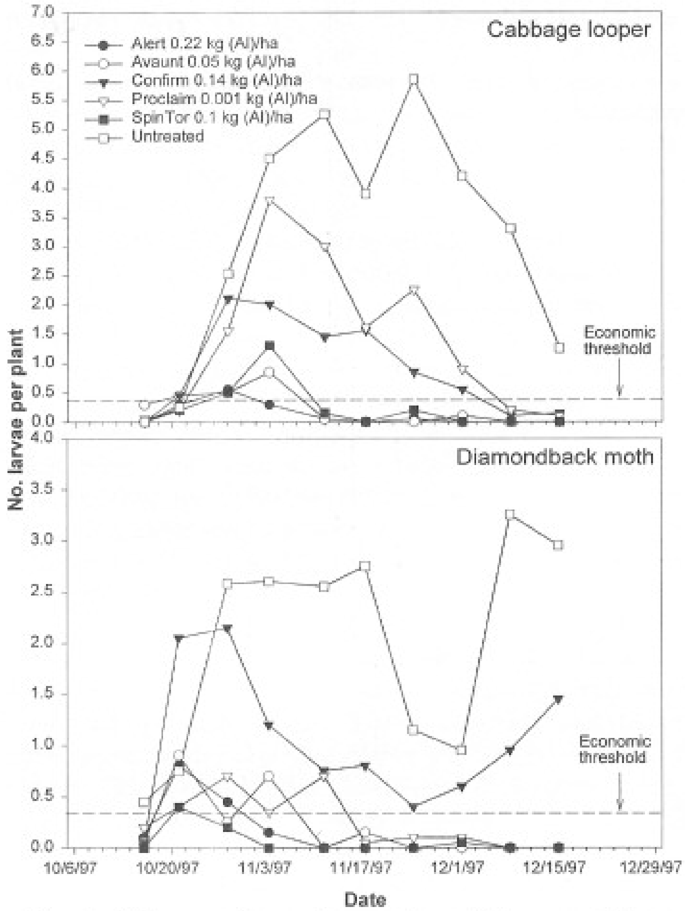


**Fig. 2.** Efficacy of several new insecticides on cabbage looper on cabbage and diamondback moth in south Texas (Weslaco 1997).

**Trial 1 (Fall, 1996).** New products tested included Alert (0.22 kg [AI]/ha), Proclaim (0.0084 kg [AI]/ha), and SpinTor 2SC (0.078 kg [AI]/ha). Karate (0.022 kg [AI]/ha) was included for standard comparison. Insecticides were applied with a $CO_2$ pressurized backpack sprayer (280.6 l/ha; 275.8 kPa; TX10 nozzles) on Dec. 7 and 14, 1996. In addition to larval counts, a visual damage rating was conducted at termination of the experiment (Dec. 18). Plots were rated on a 1 to 5 scale, with 1 representing no damage and a 4 or 5 representing commercially unacceptable levels of damage.

**Trial 2 (Fall, 1997).** Avaunt (0.05 and 0.072 kg [AI]/ha),Alert (0.22 kg [AI]/ha), Confirm (0.14 kg [AI]/ha), Proclaim (0.009 kg [AI]/ha), and SpinTor (0.1 kg [AI]/ha) were tested. The insecticides were applied with the tractor-mounted sprayer on Oct. 23, 30, Nov. 6, 14, and 25. Confirm was applied

applied an additional time on Nov. 22 when the larval population exceeded the action threshold. The trial was terminated on Dec. 15 with a final evaluation of larval population and foliage damage. The damage/quality evaluation was made on ten plants per plot based on the following 6 categories as described in Greene et al. (1969): 0 - no apparent damage, 1-minor feeding damage on wrapper outer leaves, or 1% leaf area eaten;, 2 - minor-moderate feeding damage, or 2-5% leaf area eaten; 3 - moderate damage, or 6-10% leaf area eaten, but no head damage; 4 - moderate-heavy damage on wrapper and outer leaves with minor damage on head, or 11-30% leaf area eaten; and 5 - heavy damage on wrapper and head, or >30% leaf area eaten.

**Trial 3 (Fall, 1997).** Insecticides tested were Confirm (0.14 kg [AI]/ha), SpinTor (0.069 kg[AI]/ha), Alert (0.22 kg[AI]/ha), Proclaim (0.0084 and 0.012 kg [AI]/ha), and Karate (0.022 kg[AI]/ha). Applications were made with a $CO_2$ pressurized backpack sprayer (93.5 l/ha; 275.8 kPa; TX5 nozzles) on Oct. 24 and Nov. 5, 1997. Dyne-Amic (0.5% v:v) was tank-mixed with all insecticide treatments.

**Trial 4 (Fall, 1998).** The insecticides evaluated included Alert (0.22 kg[AI]/ha), Avaunt (0.05 kg[AI]/ha), Confirm (0.14 kg[AI]/ha), Proclaim (0.0112 kg[AI]/ha), SpinTor (0.01 kg[AI]/ha), and Karate (0.028 kg[AI]/ha). Insecticides were applied with a $CO_2$ pressurized backpack sprayer (280.6 l/ha; 206.9 kPa; TX10 nozzles) on Oct. 21. Dyne-Amic (0.5%, v:v) was tank-mixed with all insecticides.

**Data Analysis.** Field counts of numbers of cabbage looper and diamondback moth larvae and damage (ranks) from each plant were analyzed using analysis of variance (ANOVA), and the means were separated using the least significant difference test (LSD) after a significant *F*-test at $P = 0.05$ (SAS Institute 1996).

## RESULTS

**Trial 1.** Cabbage looper populations were relatively low, but above threshold in the check throughout this study (Fig. 1). Populations in all treatments were significantly lower than the untreated check on all sampling dates. All insecticides tested reduced and maintained populations below the threshold throughout the study, with the exceptions of Proclaim and Karate which allowed populations to reach the threshold on Dec. 11 and 13, and Alert on Dec. 13 and 16. Damage ratings taken on Dec. 18 also showed that all treatments resulted in significantly lower feeding damage than the untreated check, with no significant differences among treatments.

**Trial 2.** Cabbage looper larval populations were low at the beginning of the season, increased rapidly 2 weeks after the first application, then exceeded the economic threshold in the untreated check throughout the reminder of the test period (Fig. 2). Alert, Avaunt and SpinTor significantly reduced the larval population after 3 applications, and maintained populations below threshold throughout the season. On the other hand, Confirm and Proclaim provided significant reductions in cabbage looper densities, but did not reduce the populations below threshold until the end of the season when overall densities were declining.

Populations of diamondback moth larvae were high at the beginning of the season, and remained above threshold in the untreated plots throughout the season. Confirm provided some reduction in larval densities but did not reduce larval populations below threshold at any point in the study. All other insecticides significantly reduced larval populations, but required multiple applications to reduce populations below the economic threshold.

Damage ratings showed that plants treated with SpinTor, Avaunt, and Alert had the least damage and were marketable, with damage ratings of 0.25-1.25. Although the plants treated with Proclaim and Confirm had significantly less damage than the untreated control, they were still not marketable, with damage ratings of 3.0 for Proclaim, 2.5 for Confirm, and 5.5 for the untreated plants.

**Trial 3.** Cabbage looper populations remained above the economic threshold level in the untreated control plots throughout the trial period (Fig. 3). With few exceptions, all insecticides tested significantly reduced the larval populations compared with the untreated control. Alert, SpinTor and Proclaim provided the greatest reduction, with populations below the economic threshold. Confirm and Karate generally provided reduction in cabbage looper densities as compared to the untreated check, but did not reduce populations to levels below the economic threshold.

For diamondback moth, all insecticides provided significant reduction of larval populations compared with the untreated control, which had extremely high populations in the early and middle season. Among the insecticides, Confirm consistently had the greatest populations, with significantly higher populations on four sampling dates. However, the populations of diamondback moth larvae in all insecticide treatments were below the economic threshold from Nov. 6 to the end of the season.

Although damage was not numerically evaluated in this trial, plants in the untreated control were heavily damaged, and

**Table 1.** Insecticides used for management of cabbage looper and diamondback moth on cabbage in the field trials during 1996-1998 (Weslaco).

| Common Name | Chemical Name | Formulation | lb (AI)/a | kg (AI)/ha | Manufacturer |
|---|---|---|---|---|---|
| Alert | chlorfenapyr | 2SC | 0.20 | 0.22 | American Cyanamid, Princeton, NJ |
| Avaunt | indoxacarb | 30WG | 0.045 | 0.05 | Du Pont Agricultural Products, Wilmington, DE |
| Confirm | tebufenozide | 2F | 0.125 | 0.14 | Rohm & Hass Company, Philadelphia, PA |
| Karate | lambda-cyhalothrin | 1EC | 0.02, 0.025 | 0.022, 0.028 | Zeneca Agricultural Products, Inc., Wilmington, DE |
| Proclaim | emamectin benzoate | 5SG | 0.0075, 0.01 | 0.0084, 0.0122 | Novartis Crop Protection, Inc., Greensboro, NC |
| SpinTor (Tracer) | spinosad | 2SC | 0.045-0.09 | 0.05-0.10 | Dow AgroSciences, Indianapolis, IN |

easily distinguished from other treatments. Plants in Karate and Confirm treated plots had less damage than those in the untreated control, but could also be easily distinguished from the damage level in other insecticide treatments that showed relatively little or no damage.

**Trial 4.** The cabbage looper populations were far above the economic threshold when the trial was initiated. All insecticides significantly reduced the larval populations compared with the untreated control, although Confirm showed a delay in achieving control (Fig. 4). Cabbage looper densities were below threshold by 1 week after application in all treatments. A single application of Proclaim, SpinTor, Avaunt or Alert maintained populations below threshold through 20 days after treatment, compared with 9 and 12 days for Confirm and Karate, respectively.

In this trial, diamondback moth larval populations were relatively low, with below threshold densities through most of the test. All insecticide treatments significantly reduced larval densities compared with the untreated check by 1 week after application. A decline in pest pressure after this time prevented evaluation of product longevity against this pest.

## DISCUSSION

Alert, Avaunt, Confirm, Proclaim and SpinTor are highly active against a range of lepidopterous species, including most destructive pests of vegetables and other field crops (Dybas and Babu 1988, Dybas et al. 1989, Harder et al. 1996, Bret et al. 1997, Wing et al. 1998). These materials act through ingestion and topical exposure, however, ingestion is the primary method of lethal dose accumulation. Although most of these materials are not systemic, some are reported to penetrate the plant cuticle to form a reservoir that extends their residual activity in target crops. All of these novel products have unique modes of action compared with older insecticide chemistries and to each other. While several of these products can cause rapid mortality, some are relatively slow acting with mortality often not occurring for several days. This could result in a poor performance ratings based on numbers of larvae present despite the insecticide providing protection of the crop. The best example of this is Confirm which may require four or more days to result in larval mortality but stops larvae from feeding within 12 h of ingestion (Sparks, unpublished data). Thus, for evaluation of these new products with unique modes of action, a proper protocol would include both larval counts over an extended period and larval counts in conjunction with plant damage analyses.

Based on both larval densities and plant damage evaluations, Alert, Avaunt and SpinTor were the most effective insecticides against cabbage looper and diamondback moth on cabbage in our studies. Both Proclaim and Confirm significantly reduced larval densities below the untreated check,

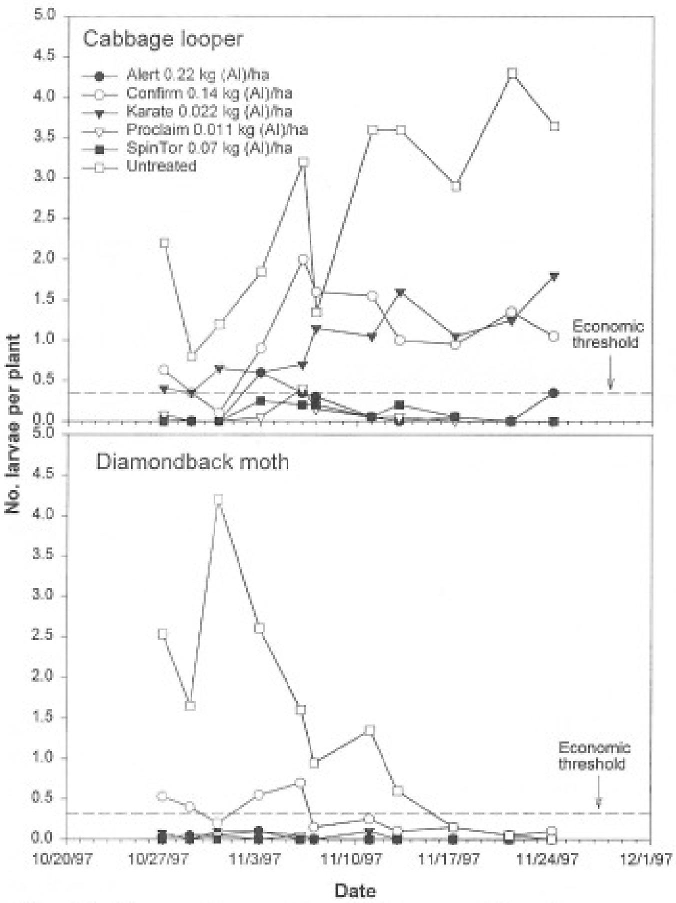


**Fig. 3.** Efficacy of several insecticides on cabbage looper on cabbage and diamondback moth in south Texas (Weslaco 1997).

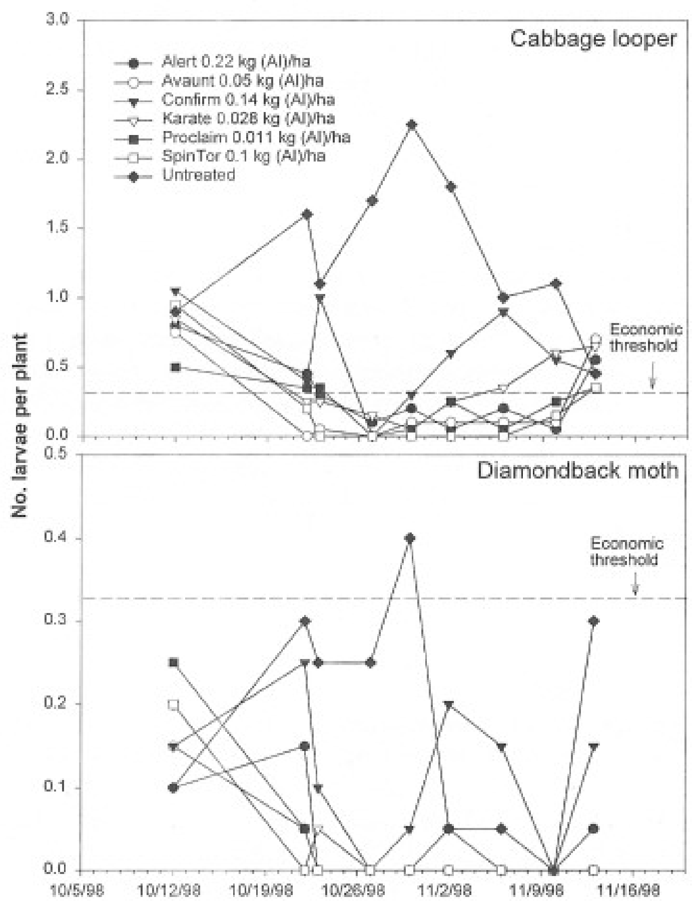


**Fig. 4.** Efficacy of several insecticides on cabbage looper amd diamondback moth on cabbage in south Texas (Weslaco 1998).

but often did not perform as well as the other new products being evaluated. Confirm was consistently less efficacious on diamondback moth larvae compared with the other insecticides tested.

The performance of Proclaim appeared to vary the most among tests, with the best performance in tests 3 and 4. In these two tests, all products were mixed with Dyne-Amic. The addition of this spray adjuvant appears to have increased efficacy or residual activity of this product. Similar results have been obtained with SpinTor in other field and laboratory studies (Liu and Sparks, unpublished data). In an early study on cotton, Larson (1997) did not find any significant response with several adjuvants, including Silwet (silicon super wetter), Sunspray oil, Agridex oil, Intac (blend of polymer and copolymer), and Kinetic (surfactant); however, with both new insecticide chemistries and adjuvant chemistries, further studies to evaluate the effects of spray adjuvants are warranted.

The insecticides evaluated in our trials represent valuable new chemical control tools which provide growers with alternatives to the currently used insecticides. The pyrethroid insecticides have served as a standard for cabbage looper control for more than a decade in south Texas. Our results and recent field experiences (Liu and Sparks, unpublished data) suggest that resistance to these insecticides may be developing within the cabbage looper. Incorporation of these novel insecticides with new modes of action into an integrated pest management program should help delay additional resistance within cabbage looper populations as well as within diamondback moth populations which have shown resistance to all of the older insecticide classes.

All these materials should be used judiciously to avoid selection for resistance. In south Texas, we recommend rotation or alternation of these materials with Bt products, pyrethroids and other conventional chemistries, and other new biorational insecticides. Each of these new insecticides has different performance characteristics, such as speed of activity, length of residual control, and selectivity against beneficial organisms, and will need to be utilized differently within an integrated management program. Good coverage, proper rates and timing, and appropriate application equipment are also critical components to be considered when using these insecticides. These novel insecticides represent valuable new chemical control tools, provide growers alternatives to the current used insecticides, and could be fully incorporated in integrated pest management programs.

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