STEWARD™ INSECTICIDE - BEET ARMYWORM EFFICACY IN WESTERN COTTON

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Abstract

Steward™ insecticide, indoxacarb, is a new and novel insecticide from DuPont Agricultural Products. Indoxacarb is from the oxadiazine class of chemistry. Steward™ has been evaluated in western cotton for 7 years (1993-1999). In Arizona and California studies, Steward™ has consistently provided effective knockdown and residual control of beet armyworm and cabbage looper larvae in Bt and non-Bt varieties. Steward™ has also exhibited short term (2-6 days) suppression of Lygus bugs, particularly nymphs. Steward™ appears to have several advantages over older lepidopteran insecticides such as Lannate®, Lock-On®/Lorsban® and pyrethroids in terms of crop safety, beneficial arthropod safety, beet armyworm and cabbage looper control. Steward™ also appears to have advantages over pyrethroids, Larvin®, Success®/Tracer® and Alert®/Pirate® in terms of Lygus suppression. DuPont anticipates Federal Registration of Steward™ to be granted in the second quarter of 2000. Steward™ 1.25SC is expected to be labeled in western cotton at rates of 0.065 to 0.11 lbai/ac (6.7 to 11.3 floz/ac) depending on lepidoptera species and pressure.

Introduction

Beet armyworm, *Spodoptera exigua* (Hubner), is an important pest of western cotton, alfalfa, sorghum, sudangrass, tomatoes, beans, sugarbeets, lettuce and cole crops. Many weed species such as nettleleaf goosefoot, *Chenopodium murale*, common purslane, *Portulaca oleracea*, and pigweeds, *Amaranthus* spp., are also favorable hosts.

Significant populations of beet armyworm can develop early season in seedling cotton. Typical damage involves the lower epidermal layer being eaten away producing a windowed effect. Protection is usually not required as parasites and predators often keep BAW under control.

When beet armyworm are most important is during the mid to late season cotton fruiting period. Early instar larvae characteristically feed together near the egg cluster and gradually disperse on the plant as they develop. Young larvae skelotonize foliage and bracts and often spin a protective webbing over the feeding site. Later instar larvae feed singly, mostly on foliage, but also feed on squares, flowers and small bolls. They are also notorious for feeding or boring into terminals causing death of the terminal. Death of terminals can cause excessive branching and may also delay fruiting. Damage can be economic from extensive shedding or damage of squares/small bolls, or when more than 20-25 percent of the leaf surface is lost during the fruiting period.

There is not an established action threshold for beet armyworm in Arizona or California. Sampling procedures and thresholds used in New Mexico include early detection and remedial thresholds. "Early detection" refers to monitoring the presence of egg masses and newly hatching egg masses; "remedial" thresholds are for larger larvae that have dispersed from the egg masses. The early-detection threshold from early season to cutout is two hatching egg masses per 100 feet of row. For prebloom cotton, the remedial threshold is 20-30 larvae per 100 plants. The mid-season remedial threshold is 40 larvae per 100 plants (based on 50,000 plants per acre). If beet armyworm are feeding exclusively on fruit, and/or bollworms or budworms are also present, this threshold might need to be lowered.

Beet armyworm populations often develop as natural infestations if favorable hosts are adjacent to cotton and climatic conditions are right. BAW can also develop as secondary pests following intensive insecticide applications for control of Lygus bugs, *Lygus hesperus* Knight, pink bollworm, *Pectinophora gossypiella* (Saunders), tobacco budworm, *Heliothis virescens* (Fabricius), cotton bollworm, *Helicoverpa zea* (Boddie) and/or whitefly, *Bemisia tabaci* (Gennadius) a.k.a. *Bemisia argentifolii* (Bellows and Perring). Depending on the insecticide or insecticides used for these primary pests, natural enemies may be destroyed. The parasitic wasp, *Hyposoter exiguae*, is among the most important natural enemies of beet armyworm larvae. Additionally, BAW populations may often be controlled by a naturally occuring virus (nuclear polyhedrosis).

Steward™ insecticide, indoxacarb (DPX-KN128), has been evaluated in western cotton for 7 years (1993-1999). Three different formulations of indoxacarb have been evaluated during this period.

In 1993, a 0.83 lbai/gal emulsifiable concentrate (DPX-JW062 10% EC) consisting of a 50:50 ratio of the two optical isomers, DPX-KN128 and DPX-KN127 was tested. DPX-KN128 is the insecticidally active isomer, while DPX-KN127 is not insecticidally active.

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In 1994 and 1995, a 2.9 lbai/gal suspo emulsion (DPX-JW062 30% SE) was tested. This formulation was again a 50:50 ratio of DPX-KN128 and DPX-KN127.

Following a process development breakthrough that resulted in the production of an enriched isomer material, commercial development was changed to DPX-MP062, a 75:25 ratio of DPX-KN128 and DPX-KN127. From 1996 to 1999, a 1.25 lbai/gal suspension concentrate (DPX-MP062 15% SC) was tested.

Steward™ has been compared with 13 different insecticides in more than 15 Arizona and California field studies (Table 1). The main objectives in most studies has been to determine the optimum rates and timing of Steward™ to control lepidopterous pests. Impact on other primary pests, secondary pests and beneficial arthropods have also been monitored. All Arizona studies were taken to yield.

This paper summarizes a minimum of one Steward™ study per year over a 7 year time span. Due to time constraints, the oral presentation will feature primarily beet armyworm efficacy and response of Lygus bugs.

Materials and Methods

1993 Lepidoptera and Lygus Efficacy

WEC-93-012: Upland cotton, variety DPL 5415, was dry planted to 40 inch rows and furrow irrigated for the first time on 1 April. This test was conducted in Field 107 at the University of Arizona, Maricopa Agricultural Center (Pinal County). Plots were 4 rows (wide) by 50 feet (long), with a 9 foot alleyway between the ends of plots, and a skip row between adjacent plots (4x1 planting pattern). Three replications were used in a randomized complete block design. Four weekly applications of each treatment were made to fruiting cotton on 22, 30 July, 7 and 14 August. A Spirit hiboy sprayer with CO_2 as a propellant was used for all applications. A front mounted spray boom treated four rows at a time utilizing 3 nozzles per row. Hose drops with swivels were used between rows to direct side nozzles toward the upper third of the cotton plant and one nozzle over the top of each row. Nozzles used were Twinjet® TJ60 11002. Spray volume was 25 gpa and spray pressure was 35 psi. All treatments included an organosilicone surfactant (Kinetic®) at the rate of 0.125% v/v.

Insect pest and beneficial insect sampling methods consisted of taking 25 sweeps per plot, using a standard size insect sweep net. Sweep samples were taken from alternating middle rows to count adult and immature stages of each species on 26 July (4 DAT1) and 19 August (5DAT4).

Maintenance Spray: Due to heavy Lygus bug pressure, and the need to preserve squares and developing bolls for later season evaluations, all plots were treated with Vydate® C-LV at 1.0 lbai/ac on 28 July.

Seed cotton yields were taken using a two row cotton picker modified for small plot cotton picking on 23 November. The two middle rows by 50 feet were picked from each plot and weighed with an electronic scale.

1994 Lepidoptera and Lygus Efficacy

WEC-94-013: Upland cotton, variety DPL 5415, was dry planted to 40 inch rows and furrow irrigated for the first time on 21 April. This test was conducted in Field 107 at the University of Arizona, Maricopa Agricultural Center (Pinal County). Plots were 4 rows (wide) by 50 feet (long), with a 9 foot alleyway between the ends of plots, and a skip row between adjacent plots (4x1 planting pattern). Three replications were used in a randomized complete block design. Four applications of each treatment were made to fruiting cotton on 19 July, 3, 16 and 23 August. A Spirit hiboy sprayer with CO_2 as a propellant was used for all applications. A front mounted spray boom treated four rows at a time utilizing 3 nozzles per row. Hose drops with swivels were used between rows to direct side nozzles toward the upper third of the cotton plant and one nozzle over the top of each row. Nozzles used were Twinjet® TJ60 11002. Spray volume was 30 gpa and spray pressure was 35 psi. All treatments included an organosilicone surfactant (Kinetic®) at the rate of 0.125% v/v.

Insect pest and beneficial insect sampling methods consisted of taking 25 sweeps per plot, using a standard size insect sweep net. Sweep samples were taken from alternating middle rows to count adult and immature stages of each species on 22 July (3 DAT1) and 29 August (6 DAT4).

Maintenance Spray: Due to heavy Lygus pressure during the study, and the need to preserve squares and developing bolls for later season evaluations, all plots were treated with Vydate® C-LV at 1.0 lbai/ac on 1 August.

Seed cotton yields were taken using a two row cotton picker modified for small plot cotton picking on 21 October. The two middle rows by 50 feet were picked from each plot and weighed with an electronic scale.

1995 Lepidoptera and Lygus Efficacy

WEC-95-009: Upland cotton, variety DPL 5415, was planted to moisture on 28 April. Row width was 40 inches wide. This test was conducted in Field 107 at the University of Arizona, Maricopa Agricultural Center (Pinal County). Plots were 4 rows (wide) by 40 feet (long), with an 8 foot alleyway between the ends of plots, and a skip row between adjacent plots (4x1 planting pattern). Three replications were used in a randomized complete block design. Four weekly applications of each treatment were made to very late season

cotton on 29 August, 5, 12 and 19 September. A John Deere 6000 Hi-Cycle® sprayer with compressed air as a propellant was used for all applications. A rear mounted spray boom treated four rows at a time utilizing 3 nozzles per row. Hose drops with swivels were used between rows to direct side nozzles toward the upper third of the cotton plant and one nozzle over the top of each row. Nozzles used were Twinjet® TJ60 11002. Spray volume was 24 gpa and spray pressure was 35 psi. All treatments included an organosilicone surfactant (Kinetic®) at the rate of 0.125% v/v.

Insect pest and beneficial insect sampling methods consisted of taking 20 sweeps per plot, using a standard size insect sweep net. Sweep samples were taken from alternating middle rows to count adult and immature stages of each species on 1 September (3 DAT1). Pink bollworm evaluations were made by collecting 10 half-grown cotton bolls (squeezable) per plot from the center two rows. Bolls were cut open and examined for PBW larvae on 25 September (6 DAT4).

Maintenance Sprays: Due to heavy Lygus and whitefly pressure mid-season, and the need to preserve squares and developing bolls for later season evaluations, all plots were treated with Danitol® 2.4E + Orthene® 90S (0.10 + 0.25 lbai/ac) on 20 July, Danitol® 2.4E + Orthene® 90S (0.15 + 0.75 lbai/ac) on 28 July, Thiodan® 3E + Ovasyn® 1.5E (0.75 + 0.25 lbai/ac) on 7 August, and Vydate® C-LV + Orthene® 90S (0.75 + 0.75 lbai/ac) on 15 August.

Seed cotton yields were taken using a two row cotton picker modified for small plot cotton picking on 16 November. The two middle rows by 40 feet were picked from each plot and weighed with an electronic scale.

1996 Lepidoptera and Lygus Efficacy

WEC-96-008 and WEC-96-009: Upland cotton, variety DPL 5415, was dry planted to 40 inch rows on 1 May. Both tests were conducted in Field 3, Borders 75-77 at the University of Arizona, Maricopa Agricultural Center (Pinal County). Plots were 4 rows (wide) by 50 feet (long), with a 9 foot alleyway between the ends of plots, and a skip row between adjacent plots (4x1 planting pattern). Four replications were used in a randomized complete block design. Three weekly applications of each treatment were made to very late season cotton on 27 August, 3 and 10 September. A John Deere 6000 Hi-Cycle® sprayer with compressed air as a propellant was used for all applications. A rear mounted spray boom treated four rows at a time. Nozzles used were Twinjet® TJ60 11002. Spray volume was 22 gpa and spray pressure was 40 psi. No adjuvants were used in this study.

Insect pest and beneficial insect sampling methods consisted of taking 20 sweeps per plot, using a standard size insect sweep net in both tests. Sweep samples were taken from alternating middle rows to count adult and immature stages of each species on 31 August (4 DAT1), 6 September (3 DAT2) and 15 September (5 DAT3) in both tests.

Pink bollworm evaluations were made by collecting 10 half-grown cotton bolls (squeezable) per plot from the center two rows. Bolls were cut open and examined for PBW larvae on 17 September (7 DAT3) in test number WEC-96-008 only.

Maintenance Sprays: Due to heavy whitefly and Lygus pressure mid-season, and the need to preserve squares and developing bolls for later season evaluations, all plots in these two tests were treated with maintenance sprays of Knack® 0.86E at 0.054 lbai/ac on 10 July, Danitol® 2.4E + Orthene® 90S (0.20 + 0.75 lbai/ac) on 21 July, Vydate® C-LV + Orthene® 90S (0.75 + 0.75 lbai/ac) on 30 July, and Provado® 1.6F (0.047 lbai/ac) on 12 August.

Seed cotton yields were taken from both tests using a two row cotton picker modified for small plot cotton picking on 8 November. The two middle rows by 50 feet were picked from each plot and weighed with an electronic scale.

1997 Lepidoptera and Lygus Efficacy

WEC-97-013: Upland cotton, variety DPL 5690, was purposely planted late for this area. Cotton was dry planted to 40 inch rows and furrow irrigated for the first time on 15 May. This test was conducted in Field 3 at the University of Arizona, Maricopa Agricultural Center (Pinal County). Plots were 4 rows (wide) by 50 feet (long), with a 9 foot alleyway between the ends of plots, and a skip row between adjacent plots (4x1 planting pattern). Three replications were used in a randomized complete block design. Three weekly applications of each treatment were made to very late season cotton on 29 August, 4 and 12 September. A John Deere 6000 Hi-Cycle® sprayer with compressed air as a propellant was used for all applications. A rear mounted spray boom treated four rows at a time. Nozzles used were Twinjet® TJ60 11002. Spray volume was 22 gpa and spray pressure was 40 psi. All treatments included an organosilicone surfactant (Kinetic®) at the rate of 0.125% v/v and Buffer® PS at 0.125% v/v.

Insect pest and beneficial insect sampling methods consisted of taking 20 sweeps per plot, using a standard size insect sweep net. Sweep samples were taken from alternating middle rows to count adult and immature stages of each species on 3 September (5 DAT1), 8 September (4 DAT2) and 16 September (4 DAT3) in both tests.

Pink bollworm evaluations were made by collecting 10 half-grown cotton bolls (squeezable) per plot from the center two rows. Bolls were cut open and examined for PBW larvae on 22 September (4 DAT4).

Maintenance Sprays: Due to heavy whitefly and Lygus pressure mid-season, and the need to preserve squares and developing bolls for later season evaluations, all plots were treated with maintenance sprays of Vydate® C-LV + Orthene® 90S + Knack® 0.86E (0.75 + 0.75 + 0.054 lbai/ac) on 22 July, Vydate® C-LV (1.0 lbai/ac) on 21 July, Orthene® 90S (1.0 lbai/ac) on 6 August, Vydate® C-LV (1.0 lbai/ac) on 14 August, and Orthene® 90S + Applaud® 70W (1.0 + 0.35 lbai/ac) on 20 August.

Seed cotton yields were taken using a two row cotton picker modified for small plot cotton picking on 29 October. The two middle rows by 50 feet were picked from each plot and weighed with an electronic scale.

1998 Lepidoptera and Lygus Efficacy

WEC-98-010: Upland Bt cotton variety, NuCotn 33^{B}, was dry planted to 40 inch rows and furrow irrigated for the first time on 28 April. This test was conducted in Field 3, Borders 76-77 at the University of Arizona, Maricopa Agricultural Center (Pinal County). Plots were 4 rows (wide) by 50 feet (long), with a 9 foot alleyway between the ends of plots, and a skip row between adjacent plots (4x1 planting pattern). Four replications were used in a randomized complete block design. Applications of each treatment were made approximately 2 weeks apart on 15, 28 July, 10 and 24 August. A John Deere 6000 Hi-Cycle® sprayer with compressed air as a propellant was used for all applications. A rear mounted spray boom treated four rows at a time. Nozzles used were Conejet® TX-VS12. Spray volume was 21 gpa and spray pressure was 40 psi. All treatments included an organosilicone surfactant (Kinetic®) at the rate of 0.125% v/v and Buffer® PS at 0.025% v/v.

Insect pest and beneficial insect sampling methods in this study (WEC-98-010) consisted of taking 20 sweeps per plot, using a standard size insect sweep net. Sweep samples were taken from alternating middle rows to count adult and immature stages of each species. Sweep net counts were taken on 2, 7 and 10 DAT intervals following the first 3 applications to measure knockdown and residual control of each treatment.

WEC-98-013: Upland cotton variety, DPL 5415, was dry planted to 40 inch rows and furrow irrigated for the first time on 28 April. This late season test was conducted in Field 3, Borders 80-81 at the University of Arizona, Maricopa Agricultural Center (Pinal County). Plots were 4 rows (wide) by 50 feet (long), with a 9 foot alleyway between the ends of plots, and a skip row between adjacent plots (4x1 planting pattern). Four replications were used in a randomized complete block design. Four weekly applications of each treatment were made on 5, 12, 19 and 26 August. A John Deere 6000 Hi-Cycle® sprayer with compressed air as a propellant was used for all applications. A rear mounted spray boom treated four rows at a time. Nozzles used were Conejet® TX-VS12. Spray volume was 21 gpa and spray pressure was 40 psi. All treatments included an organosilicone surfactant (Kinetic®) at the rate of 0.125% v/v and Buffer® PS at 0.025% v/v.

Insect pest and beneficial insect sampling methods in this study (WEC-98-013) consisted of taking 20 sweeps per plot, using a standard size insect sweep net. Sweep samples were taken from alternating middle rows to count adult and immature stages of each species. Sweep net counts were taken on 2 and 6 DAT intervals following the first 2 applications to measure knockdown and residual control of each treatment.

Maintenance Sprays: Due to heavy Lygus pressure mid-season, and the need to preserve squares and developing bolls for later season evaluations, all plots were treated with maintenance sprays of Orthene® 90S (1.0 lbai/ac) on 15 July, Vydate® C-LV (1.0 lbai/ac) on 27 July, and Vydate® C-LV (1.0 lbai/ac) on 18 August (after sweep count evaluations in the morning).

Seed cotton yields from both studies (WEC-98-010 and WEC-98-013) were taken using a two row cotton picker modified for small plot cotton picking on 16 November. The two middle rows by 50 feet were picked from each plot and weighed with an electronic scale.

1999 Lepidoptera and Lygus Efficacy

WEI-99-018: Acala cotton variety, Royal, was planted to moisture on 2 May. Row widths were 30 inches. This trial was conducted in a grower's field in Burrell, California (Fresno County). Plots were 4 rows (wide) by 35 feet (long). Four replications were used in a randomized complete block design. A single application of each treatment was made on 4 August. Treatments were hand applied using CO_2 as a propellant. Hose drops with swivels were used between rows to direct side nozzles toward the upper third of the cotton plant and one nozzle over the top of each row. Nozzles used were Conejet® TX-VS6. Spray volume was 25 gpa and spray pressure was 40 psi. All treatments included Dyne-Amic® at the rate of 0.5% v/v.

Insect pest and beneficial insect sampling methods in this study consisted of taking 15 sweeps per plot, using a standard size insect sweep net. Sweep samples were taken from alternating middle rows to count adult and immature stages of each species. Sweep net counts were taken 2 and 6 DAT to evaluate knockdown and residual control of each treatment.

WEI-99-075: Upland cotton variety, DPL 5415^{RR}, was planted to moisture on 27 April. Row widths were 30 inches. This trial was conducted in a grower's field in Riverdale, California (Kings County). Plots were 4 rows (wide) by 35

feet (long). Four replications were used in a randomized complete block design. A single application of each treatment was made on 9 August. Treatments were hand applied using CO_2 as a propellant. Hose drops with swivels were used between rows to direct side nozzles toward the upper third of the cotton plant and one nozzle over the top of each row. Nozzles used were Conejet® TX-VS6. Spray volume was 25 gpa and spray pressure was 40 psi. All treatments included Induce® at the rate of 0.125% v/v.

Insect pest and beneficial insect sampling methods in this study consisted of taking 15 sweeps per plot, using a standard size insect sweep net. Sweep samples were taken from alternating middle rows to count adult and immature stages of each species. Sweep net counts were taken 2 and 7 DAT to evaluate knockdown and residual control of each treatment.

Data Analysis

Analysis of variance was used to determine the effects of various insecticide treatments on lepidopterous larvae and Lygus nymphs, adults, and all (nymphs & adults). It was also used for seed cotton yields. Means were separated with the Student-Newman-Keuls test for variable.

Results and Discussion

1993 Lepidoptera and Lygus Efficacy

WEC-93-012: Lepidoptera pest pressure was relatively low in this study. Lygus bugs and whitefly pressure was extremely high throughout the study. Lygus counts averaged 215 Lygus (nymphs & adults) per 100 sweeps in the untreated check on the first evaluation date 26 July (4 DAT1). Nymph counts (167 nymphs/100 sweeps) made up 79% of the population. On the last sweep count evaluation 19 August (5 DAT4) Lygus counts were still high and averaged 147 Lygus per 100 sweeps in the untreated check. Nymph counts (115 nymphs/100 sweeps) still made up 78% of the population. As the data is reviewed it should be kept in mind that action thresholds in CA/AZ cotton is considered to be 15-20 Lygus (nymphs & adults) per 100 sweeps.

Sweep count evaluations showed that the lepidoptera insecticides tested in this study were relatively weak on Lygus. Steward™ 0.83E at 0.022 to 0.067 lbai/ac did provide a rate response on Lygus, particularly on nymphs with 29-63% suppression at 4 DAT1 (Table 2), and 52-87% suppression at 5 DAT4 (Table 3).

Beet armyworm and cabbage looper larvae were effectively controlled by Steward™ at all rates tested 5 DAT4 (Table 4).

1994 Lepidoptera and Lygus Efficacy

WEC-94-013: Lygus and whitefly pressure was high throughout the study. Lygus pressure was above action threshold when this study was initiated on 19 July. Lygus counts averaged 49 Lygus (nymphs & adults) per 100 sweeps in the untreated check on the first evaluation date 22 July (3 DAT1). Nymph counts (41 nymphs/100 sweeps) made up 84% of the population. Beet armyworm and cotton leafperforator, *Bucculatrix thurberiella* (Busck), pressure was good in this study late season.

Sweep count evaluations showed that the lepidoptera insecticides tested in this study were relatively weak on Lygus long term. Steward™ 2.9SE at 0.033 to 0.055 lbai/ac again provided a rate response on Lygus nymphs with 23-48% suppression at 3 DAT1 (Table 5).

Beet armyworm larvae were effectively controlled by Steward™ at 0.055 lbai/ac 6 DAT4. Lower rates of Steward™ were not effective, particularly on smaller larvae. Baythroid® and Asana® XL were also weak on BAW.

Cotton leafperforator was controlled very effectively by Lannate® LV, while Steward™, Lorsban®, Danitol®, Asana® XL, and Baythroid® were very weak on CLP (Table 6).

1995 Lepidoptera and Lygus Efficacy

WEC-95-009: Lygus and whitefly were controlled effectively mid to late season due to maintenance sprays. Lygus pressure was still above action thresholds when this study was initiated on 29 August. Lygus counts averaged 27 Lygus (nymphs & adults) per 100 sweeps in the untreated check on the first evaluation date 1 September (3 DAT1). Nymph counts (20 nymphs/100 sweeps) made up 75% of the population. Cabbage looper, *Trichoplusia ni* (Hubner), and pink bollworm larvae pressure was moderate in this late season study.

Sweep count evaluations showed that the lepidoptera insecticides tested in this study were again relatively weak on Lygus. Steward™ 2.9SE at 0.033 to 0.067 lbai/ac provided suppression of Lygus nymphs with 58-92% control 3 DAT1 (Table 7).

Cabbage looper larvae were very effectively controlled (93-100%) by Steward™ 2.9E at 0.045 to 0.067 lbai/ac 3 DAT1. Larvin® 3.2F at 0.9 lbai/ac also gave very good control of loopers (100%). Karate® 1E at 0.04 lbai/ac provided good control (86%), while Danitol® 2.4E at 0.2 lbai/ac gave moderate control (71%). Lannate® LV at 0.675 lbai/ac gave 50% control, while Lorsban® 4E at 1.0 lbai/ac provided no control of loopers (Table 8).

Pink bollworm was not controlled effectively by Steward™ or Larvin®. Lorsban® provided 83% control, while Lannate® and Danitol® provided 92% control. Karate® gave excellent control in this study (Table 9).

By the time this late season study was initiated on 29 August the crop was basically already made. While all of the treatments yielded higher than the untreated check in this study, they were not significantly different from the untreated check. Therefore the yields did not warrant illustrating in this paper.

1996 Lepidoptera and Lygus Efficacy

WEC-96-008 and WEC-96-009: Lygus and whitefly were controlled effectively mid to late season due to maintenance sprays. Lygus pressure was still above action thresholds when these studies were initiated on 31 August. In test WEC-96-008, Lygus counts averaged 49 Lygus (nymphs & adults) per 100 sweeps in the untreated check on the first evaluation date 31 August (4 DAT1). Nymph counts (48 nymphs/100 sweeps) made up 97% of the population. Cabbage looper and pink bollworm larvae pressure was low in both of these late season studies and therefore not illustrated.

Sweep count evaluations showed that the lepidoptera insecticides tested at their highest labeled rates in this study (Lorsban® and Karate®) were relatively weak on Lygus in test WEC-96-008. Steward™ 1.25SC at 0.045 to 0.089 lbai/ac provided suppression of Lygus nymphs with 42-47% control 4 DAT1, 60-76% control 3 DAT2 and 46-64% control 5 DAT3. For comparison, Lygus insecticide Vydate® C-LV at 0.75 lbai/ac, gave very good control of Lygus nymphs with 84%, 92% and 100% control, respectively, on those same evaluation dates (Table 10).

Similar results were experienced in test WEC-96-009. Lepidoptera insecticides (Larvin®, Lock-On® and Danitol®) were relatively weak on Lygus. Of the lep insecticides tested, Lannate® and Steward™ provided the most suppression of Lygus nymphs. Steward™ 1.25SC at 0.089 lbai/ac provided 70% control 4 DAT1, 77% control 3 DAT2 and 40% control 5 DAT3. For comparison, Lygus insecticide Vydate® C-LV at 0.5 and 1.0 lbai/ac, gave very good control of Lygus nymphs with 81% and 95% control respectively at 4 DAT1, and 100% control at both rates on the next two evaluation dates 3 DAT2 and 5 DAT3 (Table 11).

By the time these two late season studies were initiated on 27 August the crop was basically made already. While most of the treatments yielded higher than the untreated checks in these two studies, they were not significantly different from the untreated check. Therefore the yields did not warrant illustrating in this paper.

1997 Lepidoptera and Lygus Efficacy

WEC-97-013: Lygus and whitefly were controlled effectively mid to late season due to maintenance sprays. Lygus pressure was still above action thresholds when this study was initiated on 29 August. Lygus counts averaged 25 Lygus (nymphs & adults) per 100 sweeps in the untreated check on the first evaluation date 3 September (5 DAT1). Nymph counts (12 nymphs/100 sweeps) made up 50% of the population. Beet armyworm and cabbage looper pressure was very low in this test. Pink bollworm pressure was very heavy late season. None of the lepidoptera insecticides tested in this study gave acceptable control. Karate® performed the best, but still had 57% of its bolls infested with PBW larvae. All other treatments had 80-100% of the bolls infested.

Sweep count evaluations showed that Pirate® and Tracer® were again very weak on Lygus. A rate response was again experienced with Steward™ 1.25SC at 0.068 to 0.111 lbai/ac following applications two and three. Steward™ suppressed Lygus nymphs 29% (5 DAT1), 50-89% (4 DAT2), and 75-92% (4 DAT3), respectively. For comparison, Lygus insecticide Vydate® C-LV at 1.0 lbai/ac, gave excellent control of Lygus nymphs (100%) on those same evaluation dates (Table 12).

By the time this late season study was initiated on 29 August the crop was basically made already. All insecticide treatments were not significantly different from the untreated check. Therefore the yields did not warrant illustrating in this paper.

1998 Lepidoptera and Lygus Efficacy

WEC-98-010: Lygus pressure was intense season long in this Bt cotton study. Following three applications (13 day spray intervals) and three evaluations at 2, 7 and 10 days after each application. Steward™ at 0.065 and 0.11 lbai/ac provided a seasonal mean of 30-43% control of Lygus nymphs at 2 DAT (Table 13) and only 14-17% control at 7 DAT (Table 14). Regent® 2.5E (0.025 and 0.05 lbai/ac), Vydate® C-LV (0.5 and 1.0 lbai/ac) and Orthene® 90S (0.5 and 1.0 lbai/ac) were far superior in providing both knockdown and residual control of Lygus nymphs.

Steward™ provided excellent control of beet armyworm, while Regent®, Vydate® C-LV and Orthene® were very weak on BAW (Table 15).

WEC-98-013: Beet armyworm pressure was moderate. Cabbage looper and budworm/bollworm pressure was relatively low, and pink bollworm pressure was non-existent.

Steward™ 1.25SC (0.065 and 0.11 lbai/ac), Pirate® 3SC (0.2 lbai/ac) and Tracer® 4F (0.089 lbai/ac) provided very effective control of beet armyworm and cabbage looper at 2 DAT1 (Table 16) and 6 DAT1 (Table 17). Lorsban® 4E (1.0 lbai/ac) was very effective on beet armyworm, but weak cabbage looper. Karate® 1E (0.04 lbai/ac) was effective on cabbage looper, but weak on beet armyworm.

Lygus were controlled effectively mid season due to maintenance sprays. Lygus pressure was still above action

thresholds when this study was initiated on 5 August. Lygus counts averaged 26 Lygus (nymphs & adults) per 100 sweeps in the untreated check on the first evaluation date 7 August (2 DAT1). Nymphs counts (5 nymphs/100 sweeps) made up 19% of the population. Lygus pressure steadily intensified and averaged 85, 111, and 123 Lygus per 100 sweeps on 11 August, 14 August and 18 August, respectively. Nymphs made up 76%, 86% and 69% of the population on those same dates.

Sweep count evaluations showed that Pirate® and Tracer® were again very weak on Lygus. A rate response was again evident with Steward™ 1.25SC at 0.065 and 0.11 lbai/ac. Steward™ suppressed Lygus nymphs an average of 56-74% following two applications and two evaluations at 2 DAT (Table 18), but provided only 17-41% at 6 DAT (Table 19). None of the other lepidoptera insecticides provided acceptable control at 6 DAT.

Steward™, Tracer®, Lannate®, Lorsban® and Karate® all had significantly higher seed cotton yields than Pirate® and the untreated check (Table 20).

1999 Lepidoptera and Lygus Efficacy

WEC-99-018: Beet armyworm pressure was extremely heavy in this study. The untreated check had 132 BAW (small & large larvae) per 100 sweeps at 2 DAT. Large larvae (3rd to 5th instar) made up 42% of the population. Success® 2SC (0.067 lbai/ac) provided 92% control of BAW at both 2 DAT and 6 DAT. Steward™ 1.25SC (0.065, 0.089 and 0.11 lbai/ac) provided 87-90% control at 2 DAT (Table 21). At the 6 DAT evaluation, Steward™ showed a rate response with 74%, 86%, and 100% control, respectively (Table 22).

Lygus pressure was above action threshold at the time of application. The untreated check had 37 Lygus (nymphs & adults) per 100 sweeps at 2 DAT. Nymph counts made up 28% of the population. While none of the treatments were significantly different from each other. Steward™ offered some numerical suppression of Lygus (nymphs & adults) with 45-68% control at 2 DAT (Table 23) and 18-58% control at 6 DAT (Table 24).

WEC-99-075: Beet armyworm pressure was extremely heavy in this study as well. The untreated check had 119 BAW (small & large larvae) per 100 sweeps at 2 DAT. Large larvae (3rd to 5th instar) made up 82% of the population. Success® 2SC (0.067 lbai/ac) provided 77% control of BAW at the 2 DAT evaluation and 81% control at the 7 DAT evaluation. The low rate of Steward™ (0.065 lbai/ac) did not perform as well as the higher rates (0.089 and 0.11 lbai/ac) at the 2 DAT evaluation, giving only 40% control of BAW versus 87% and 90%, respectively (Table 25). At the 7 DAT evaluation Steward™ provided effective control at all three rates giving 90%, 95% and 89% control, respectively (Table 26).

Conclusions

Steward™ has been evaluated in western cotton for 7 years (1993-1999). In Arizona and California studies, Steward™ has consistently provided effective knockdown and residual control of beet armyworm and cabbage looper larvae in Bt and non-Bt varieties. Steward™ has also exhibited short term (2-6 days) suppression of Lygus bugs, particularly nymphs (40-60%). Steward™ appears to have several advantages over older lepidopteran insecticides such as Lannate®, Lock-On®/Lorsban® and pyrethroids in terms of crop safety, beneficial arthropod safety, beet armyworm and cabbage looper control. Steward™ also appears to have advantages over pyrethroids, Larvin®, Success®/Tracer® and Alert®/Pirate® in terms of Lygus suppression. DuPont anticipates Federal Registration of Steward™ to be granted in the second quarter of 2000. Steward™ 1.25SC is expected to be labeled in western cotton at rates of 0.065 to 0.11 lbai/ac (6.7 to 11.3 floz/ac) depending on lepidoptera species and pressure.

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Table 1. Insecticides evaluated for lepidoptera larvae and *Lygus hesperus* efficacy 1993-1999 by chemical class, trade name, and common name.

Organo-phosphate	Carbamate	Pyrethroid	Misc.
Lock-On® Lorsban® (chlorpyrifos)	Lannate®LV (methomyl)	Asana® XL (esfenvalerate)	Alert® Pirate® (chlorfenapyr)
Orthene® (acephate)	Larvin® (thiodicarb)	Baythroid® (cyfluthrin)	Regent® (fipronil)
Penncap®M (methyl parathion)	Vydate®C-LV (oxamyl)	Danitol® (fenpropathrin)	Steward™ (indoxacarb)
		Karate® Warrior® T (lambda cyhalothrin)	Success® Tracer® (spinosad)

Table 2. Mean number of *Lygus hesperus* per 100 sweeps 4 days after treatment one (Maricopa, AZ 1993).

Non-Bt Cotton WEC-93-012 Treatments[a]	Rate lbai/ac	Mean # Lygus/100 sweeps 4 DAT1 Nymphs (% Cntrl)	Adults (% Cntrl)	All[c] (% Cntrl)
Steward 0.83E[b]	0.022	118.7 a	52.0 a	170.7 ab
		(28.8)	(-8.3)	(20.5)
Steward 0.83E	0.045	97.3 a	46.7 a	144.0 ab
		(41.6)	(2.7)	(32.9)
Steward 0.83E	0.067	61.3 a	25.3 ab	86.6 b
		(63.2)	(47.3)	(59.6)
Asana 0.66E	0.040	122.7 a	25.3 ab	148.0 ab
		(26.4)	(47.2)	(31.1)
Karate 1E	0.040	80.0 a	10.7 b	90.7 b
		(52.0)	(77.8)	(57.8)
Lannate 2.4L	0.675	68.0 a	41.3 a	109.3 ab
		(59.2)	(13.9)	(49.1)
Untreated	-	166.7 a	48.0 a	214.7 a

Means within a column with the same letter are not significantly different.
Application dates: 22, 30 July, 7 and 14 August.
[a] all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.
[b] This formulation of Steward™ 0.83E (DPX-JW062 10%E) consisted of a 50:50 ratio of the two optical isomers, DPX-KN128 and DPX-KN127.
[c] Lygus nymphs and adults combined.

Table 3. Mean number of *Lygus hesperus* per 100 sweeps 5 days after treatment four (Maricopa, AZ 1993).

Non-Bt Cotton WEC-93-012 Treatments[a]	Rate lbai/ac	Mean # Lygus/100 sweeps 5 DAT4 Nymphs (% Cntrl)	Adults (% Cntrl)	All (% Cntrl)
Steward 0.83E	0.022	54.7 abc	10.7 a	65.3 abc
		(52.3)	(66.7)	(55.5)
Steward 0.83E	0.045	38.7 bc	9.3 a	48.0 bc
		(66.3)	(70.8)	(67.3)
Steward 0.83E	0.067	14.7 c	18.7 a	33.3 bc
		(87.2)	(41.7)	(77.3)
Asana 0.66E	0.040	74.7 abc	5.3 a	80.0 abc
		(34.8)	(83.3)	(45.5)
Karate 1E	0.040	34.7 bc	1.3 a	36. bc
		(69.7)	(95.8)	(75.5)
Lannate 2.4L	0.675	16.0 c	6.7 a	22.7 c
		(86.1)	(79.2)	(84.6)
Untreated	-	114.7 a	32.0 a	146.7 a

Means within a column with the same letter are not significantly different.
Application dates: 22, 30 July, 7 and 14 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

Table 4. Mean number of lepidoptera larvae per 100 sweeps 5 days after treatment four (Maricopa, AZ 1993).

Non-Bt Cotton WEC-93-012 Treatments[a]	Rate lbai/ac	Mean # larvae/100 sweeps 5 DAT4 BAW[b] (% Cntrl)	CL[c] (% Cntrl)	Hel[d] (% Cntrl)
Steward 0.83E	0.022	1.3 a	0.0 b	0.0 a
		(93.4)	(100.0)	(100.0)
Steward 0.83E	0.045	0.0 a	0.0 b	0.0 a
		(100.0)	(100.0)	(100.0)
Steward 0.83E	0.067	0.0 a	0.0 b	0.0 a
		(100.0)	(100.0)	(100.0)
Asana 0.66E	0.040	0.0 a	0.0 b	0.0 a
		(100.0)	(100.0)	(100.0)
Karate 1E	0.040	5.3 a	0.0 b	0.0 a
		(73.3)	(100.0)	(100.0)
Lannate 2.4L	0.675	0.0 a	0.0 b	0.0 a
		(100.0)	(100.0)	(100.0)
Untreated	-	20.0 a	10.7 a	4.0 a

Means within a column with the same letter are not significantly different.
Application dates: 22, 30 July, 7 and 14 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.
[b]Beet armyworm (*Spodoptera exigua*)
[c]Cabbage looper (*Trichoplusia ni*)
[d]Budworm/bollworm (*Heliothis virescens*/*Helicoverpa zea*)

Table 5. Mean number of *Lygus hesperus* per 100 sweeps 3 days after treatment one (Maricopa, AZ 1994).

Non-Bt Cotton WEC-94-013 Treatments[a]	Rate lbai/ac	Mean # Lygus/100 sweeps 3 DAT1 Nymphs (% Cntrl)	Adults (% Cntrl)	All (% Cntrl)
Steward 2.9SE[b]	0.022	48.0 a	13.3 a	61.3 a
		(-16.1)	(-66.7)	(-24.3)
Steward 2.9SE	0.033	32.0 abc	5.3 a	37.3 abcd
		(22.6)	(33.3)	(24.3)
Steward 2.9SE	0.045	25.3 abc	10.7 a	36.0 abcd
		(38.7)	(-33.3)	(27.0)
Steward 2.9SE	0.055	21.3 abc	6.7 a	28.0 bcd
		(48.4)	(16.7)	(43.2)
Lorsban 4E	1.000	18.7 abc	12.0 a	30.7 bcd
		(54.8)	(-50.0)	(37.8)
Lannate 2.4L	0.675	4.0 c	4.0 a	8.0 d
		(90.3)	(50.0)	(83.8)
Danitol 2.4E	0.200	20.0 abc	6.7 a	26.7 bcd
		(51.6)	(16.7)	(45.9)
Asana 0.66E	0.050	21.3 abc	10.7 a	32.0 bcd
		(48.4)	(-33.3)	(35.1)
Baythroid 2E	0.040	14.7 bc	6.7 a	21.3 bcd
		(64.5)	(16.7)	(56.8)
Untreated	-	41.3 ab	8.0 a	49.3 abc

Means within a column with the same letter are not significantly different.

Application dates: 19 July, 3, 16 and 23 August

[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

[b]This formulation of Steward™ 2.9SE (DPX-JW062 30%SE) consisted of a 50:50 ratio of the two optical isomers, DPX-KN128 and DPX-KN127.

Table 6. Mean number of beet armyworm (*Spodoptera exigua*) and cotton leaf perforator larvae (*Bucculatrix thurberiella*) per 100 sweeps 6 days after treatment four (Maricopa, AZ 1994).

Non-Bt Cotton WEC-94-013 Treatments[a]	Rate lbai/ac	Mean # larvae/100 sweeps 6 DAT4 BAW (% Cntrl)	CLP (% Cntrl)
Steward 2.9SE	0.022	24.0 a	14.7 ab
		(64.7)	(21.4)
Steward 2.9SE	0.033	40.0 a	20.0 ab
		(41.2)	(-7.1)
Steward 2.9SE	0.045	29.3 a	14.7 ab
		(59.6)	(21.4)
Steward 2.9SE	0.055	1.3 a	17.3 ab
		(98.1)	(7.2)
Lorsban 4E	1.000	0.0 a	12.0 ab
		(100.0)	(35.7)
Lannate 2.4L	0.675	6.7 a	0.0 b
		(90.1)	(100.0)
Danitol 2.4E	0.200	5.3 a	14.7 ab
		(92.2)	(21.4)
Asana 0.66E	0.050	17.3 a	20.0 ab
		(74.6)	(-7.1)
Baythroid 2E	0.040	32.0 a	44.0 a
		(52.9)	(-135.7)
Untreated	-	68.0 a	18.7 ab

Means within a column with the same letter are not significantly different.

Application dates: 19 July, 3, 16 and 23 August.

[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

Table 7. Mean number of *Lygus hesperus* per 100 sweeps 3 days after treatment one (Maricopa, AZ 1995).

Non-Bt Cotton WEC-95-009 Treatments[a]	Rate lbai/ac	Mean # Lygus/100 sweeps 3 DAT1 Nymphs (% Cntrl)	Adults (% Cntrl)	All (% Cntrl)
Steward 2.9SE	0.033	5.0 a	11.7 a	16.7 a
		(75.0)	(-75.0)	(37.5)
Steward 2.9SE	0.045	1.7 a	1.7 a	3.3 a
		(91.7)	(75.0)	(87.5)
Steward 2.9SE	0.055	8.3 a	11.7 a	20.0 a
		(58.3)	(-75.0)	(25.0)
Steward 2.9SE	0.067	1.7 a	8.3 a	10.0 a
		(91.7)	(-25.0)	(62.5)
Lannate 2.4L	0.675	10.0 a	5.0 a	15.0 a
		(50.0)	(25.0)	(43.8)
Larvin 3.2F	0.900	13.3 a	5.0 a	18.3 a
		(33.3)	(25.0)	(31.3)
Lorsban 4E	1.000	5.0 a	16.7 a	21.7 a
		(75.0)	(-150.0)	(18.8)
Danitol 2.4E	0.200	10.0 a	16.7 a	26.7 a
		(50.0)	(-150.0)	(0.0)
Karate 1E	0.040	3.3 a	5.0 a	8.3 a
		(83.3)	(25.0)	(68.8)
Untreated	-	20.0 a	6.7 a	26.7 a

Means within a column with the same letter are not significantly different.

Application dates: 29 August, 5, 12 and 19 September.

[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

Table 8. Mean number of cabbage looper larvae (*Trichoplusia ni*) per 100 sweeps 3 days after treatment one (Maricopa, AZ 1995).

Non-Bt Cotton WEC-95-009 Treatments[a]	Rate lbai/ac	Mean # larvae/100 sweeps 3 DAT1 CL Sm[b] (% Cntrl)	CL Lg[c] (% Cntrl)	CL All[d] (% Cntrl)
Steward 2.9SE	0.033	1.7 a	5.0 b	6.7 b
			(78.6)	(71.4)
Steward 2.9SE	0.045	0.0 a	1.7 b	1.7 b
			(92.9)	(92.9)
Steward 2.9SE	0.055	0.0 a	1.7 b	1.7 b
			(92.9)	(92.9)
Steward 2.9SE	0.067	0.0 a	0.0 b	0.0 b
			(100.0)	(100.0)
Lannate 2.4L	0.675	0.0 a	11.7 b	11.7 b
			(50.0)	(50.0)
Larvin 3.2F	0.900	0.0 a	0.0 b	0.0 b
			(100.0)	(100.0)
Lorsban 4E	1.000	0.0 a	23.3 a	23.3 a
			(0.0)	(0.0)
Danitol 2.4E	0.200	0.0 a	6.7 b	6.7 b
			(71.4)	(71.4)
Karate 1E	0.040	0.0 a	3.3 b	3.3 b
			(85.7)	(85.7)
Untreated	-	0.0 a	23.3 a	23.3 a

Means within a column with the same letter are not significantly different.

Application dates: 29 August, 5, 12 and 19 September.

[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

[b]Small larvae (1st-2nd instar)

[c]Large larvae (3rd-5th instar)

[d]All larvae (1st-5th instar)

Table 9. Mean number of pink bollworm larvae (*Pectinophora gossypiella*) per 100 bolls examined 6 days after treatment four (Maricopa, AZ 1995).

Non-Bt Cotton WEC-95-009 Treatments[a]	Rate lbai/ac	Mean # larvae/100 bolls 6 DAT4 PBW Sm (% Cntrl)	PBW Lg (% Cntrl)	PBW All (% Cntrl)
Steward 2.9SE	0.033	23.3 a (36.4)	0.0 a (100.0)	23.3 a (41.7)
Steward 2.9SE	0.045	13.3 a (63.7)	0.0 a (100.0)	13.3 a (66.7)
Steward 2.9SE	0.055	23.3 a (36.4)	0.0 a (100.0)	23.3 a (41.7)
Steward 2.9SE	0.067	36.7 a (0.0)	0.0 a (100.0)	36.7 a (8.3)
Lannate 2.4L	0.675	3.3 a (90.9)	0.0 a (100.0)	3.3 a (91.7)
Larvin 3.2F	0.900	13.3 a (63.7)	0.0 a (100.0)	13.3 a (66.7)
Lorsban 4E	1.000	6.7 a (81.8)	0.0 a (100.0)	6.7 a (83.3)
Danitol 2.4E	0.200	3.3 a (90.9)	0.0 a (100.0)	3.3 a (91.7)
Karate 1E	0.040	0.0 a (100.0)	0.0 a (100.0)	0.0 a (100.0)
Untreated	-	36.7 a	3.3 a	40.0 a

Means within a column with the same letter are not significantly different. Application dates: 29 August, 5, 12 and 19 September.

[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

Table 10. Mean number of *Lygus hesperus* nymphs per 100 sweeps 3-5 days after each treatment (Maricopa, AZ 1996).

Non-Bt Cotton WEC-96-008 Treatments[a]	Rate lbai/ac	Mean # Lygus nymphs/100 sweeps 31 Aug 4 DAT1 (% Cntrl)	6 Sep 3 DAT2 (% Cntrl)	15 Sep 5 DAT3 (% Cntrl)
Steward 1.25SC[b]	0.045	25.0 bc (47.4)	12.5 ab (60.0)	5.0 a (63.6)
Steward 1.25SC	0.067	26.3 bc (44.7)	17.5 ab (44.0)	7.5 a (45.5)
Steward 1.25SC	0.089	27.5 bc (42.1)	7.5 ab (76.0)	6.3 a (54.6)
Vydate 3.77L	0.750	7.5 c (84.2)	2.5 b (92.0)	0.0 a (100.0)
Lorsban 4E	1.000	17.5 bc (63.2)	13.8 ab (56.0)	10.0 a (27.3)
Karate 1E	0.040	36.3 ab (23.7)	15.0 ab (52.0)	13.8 a (0.0)
Untreated	-	47.5 a	31.3 a	13.8 a

Means within a column with the same letter are not significantly different. Application dates: 27 August, 3 and 10 September.

[a]no surfactants used in this study.

[b]This formulation of Steward™ 1.25SC (DPX-MP062 15%SC) consisted of a 75:25 ratio of the two optical isomers, DPX-KN128 and DPX-KN127.

Table 11. Mean number of *Lygus hesperus* nymphs per 100 sweeps 3-5 days after each treatment (Maricopa, AZ 1996).

Non-Bt Cotton WEC-96-009 Treatments[a]	Rate lbai/ac	Mean # Lygus nymphs/100 sweeps 31 Aug 4 DAT1 (% Cntrl)	6 Sep 3 DAT2 (% Cntrl)	15 Sep 5 DAT3 (% Cntrl)
Steward 1.25SC	0.089	16.3 bc (69.8)	3.8 a (76.9)	3.8 b (40.0)
Vydate 3.77L	0.500	10.0 bc (81.4)	0.0 a (100.0)	0.0 b (100.0)
Vydate 3.77L	1.000	2.5 c (95.4)	0.0 a (100.0)	0.0 b (100.0)
Pirate 3SC	0.200	50.0 a (7.0)	12.5 a (23.1)	11.3 ab (-80.0)
Lannate 2.4L	0.675	16.3 bc (69.8)	0.0 a (100.0)	1.3 b (80.0)
Larvin 3.2F	0.900	40.0 ab (25.6)	6.3 a (61.5)	7.5 ab (-20.0)
Lock-On 2E	0.500	28.8 abc (46.5)	11.3 a (30.8)	3.8 b (40.0)
Danitol 2.4E	0.200	41.3 ab (23.3)	15.0 a (7.7)	18.8 a (-200.0)
Untreated	-	53.8 a	16.3 a	6.3 ab

Means within a column with the same letter are not significantly different. Application dates: 27 August, 3 and 10 September.

[a]no surfactants were used in this study.

Table 12. Mean number of *Lygus hesperus* nymphs per 100 sweeps 4-5 days after each treatment (Maricopa, AZ 1997).

Non-Bt Cotton WEC-97-013 Treatments[a]	Rate lbai/ac	Mean # Lygus nymphs/100 sweeps 3 Sep 5 DAT1 (% Cntrl)	8 Sep 4 DAT2 (% Cntrl)	16 Sep 4 DAT3 (% Cntrl)
Steward 1.25SC	0.068	8.3 a (28.6)	15.0 ab (50.0)	5.0 ab (75.0)
Steward 1.25SC	0.111	8.3 a (28.6)	3.3 b (88.9)	1.7 b (91.7)
Vydate 3.77L	1.000	0.0 a (100.0)	0.0 b (100.0)	0.0 b (100.0)
Pirate 3SC	0.200	16.7 a (-42.9)	15.0 ab (50.0)	23.3 a (-16.7)
Tracer 4F	0.089	18.3 a (-57.1)	26.7 a (11.1)	20.0 ab (0.0)
Lannate 2.4L	0.675	11.7 a (0.0)	1.7 b (94.4)	0.0 b (100.0)
Penncap 2F	1.000	11.7 a (0.0)	11.7 ab (61.1)	10.0 ab (50.0)
Lorsban 4E	1.000	8.3 a (28.6)	13.3 ab (55.6)	10.0 ab (50.0)
Karate 1E	0.040	5.0 a (57.1)	21.7 ab (27.8)	16.7 ab (16.7)
Untreated	-	11.7 a	30.0 a	20.0 ab

Means within a column with the same letter are not significantly different. Application dates: 29 August, 4 and 12 September.

[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

Table 13. Seasonal mean number of *Lygus hesperus* nymphs, adults and all per 100 sweeps following three applications and three evaluations 2 days after treatment (Maricopa, AZ 1998).

Bt Cotton WEC-98-010 Treatments[a]	Rate lbai/ac	Season Mean # Lyg/100 swp 2 DAT		
		Nymphs (% Cntrl)	Adults (% Cntrl)	All (% Cntrl)
Steward 1.25SC	0.065	17.5	20.8	38.3
		(30.0)	(13.8)	(22.0)
Steward 1.25SC	0.110	14.2	12.9	27.1
		(43.3)	(46.6)	(44.9)
Regent 2.5E	0.025	7.9	9.6	17.5
		(68.3)	(60.3)	(64.4)
Regent 2.5E	0.050	3.3	7.5	10.8
		(86.7)	(69.0)	(78.0)
Vydate 3.77L	0.500	1.7	10.4	12.1
		(93.3)	(56.9)	(75.4)
Vydate 3.77L	1.000	2.1	13.3	15.4
		(91.7)	(44.8)	(68.6)
Orthene 90S	0.500	5.0	13.3	18.3
		(80.0)	(44.8)	(62.7)
Orthene 90S	1.000	2.9	13.3	16.3
		(88.3)	(44.8)	(67.0)
Untreated	-	25.0	24.2	49.2

Application dates: 15, 28 July, and 10 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

Table 14. Seasonal mean number of *Lygus hesperus* nymphs, adults and all per 100 sweeps following three applications and three evaluations 7 days after treatment (Maricopa, AZ 1998).

Bt Cotton WEC-98-010 Treatments[a]	Rate lbai/ac	Season Mean # Lyg/100 swp 7 DAT		
		Nymphs (% Cntrl)	Adults (% Cntrl)	All (% Cntrl)
Steward 1.25SC	0.065	15.0	20.0	35.0
		(50.7)	(-4.4)	(29.4)
Steward 1.25SC	0.110	21.7	15.4	37.1
		(28.8)	(19.6)	(25.2)
Regent 2.5E	0.025	10.4	17.1	27.5
		(65.8)	(10.9)	(44.5)
Regent 2.5E	0.050	3.8	12.5	16.3
		(87.7)	(34.8)	(67.2)
Vydate 3.77L	0.500	7.1	13.3	20.4
		(76.7)	(30.4)	(58.8)
Vydate 3.77L	1.000	3.3	15.8	19.2
		(89.0)	(17.4)	(61.3)
Orthene 90S	0.500	2.9	14.6	17.5
		(90.4)	(23.9)	(64.7)
Orthene 90S	1.000	2.1	13.8	15.8
		(93.2)	(28.3)	(68.1)
Untreated	-	30.4	19.2	49.6

Application dates: 15, 28 July, and 10 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

Table 15. Mean number of beet armyworm larvae per 100 sweeps 10 days after each treatment (Maricopa, AZ 1998).

Bt Cotton WEC-98-010 Treatments[a]	Rate lbai/ac	Mean # BAW larvae/100 sweeps		
		10 DAT1 (% Cntrl)	10 DAT2 (% Cntrl)	10 DAT3 (% Cntrl)
Steward 1.25SC	0.065	0.0 a	3.8 ab	0.0 a
			(82.4)	(100.0)
Steward 1.25SC	0.110	0.0 a	0.0 b	1.3 a
			(100.0)	(97.1)
Regent 2.5E	0.025	2.5 a	51.3 ab	35.0 a
			(-141.2)	(20.0)
Regent 2.5E	0.050	6.3 a	56.3 a	41.3 a
			(-164.7)	(5.7)
Vydate 3.77L	0.500	3.8 a	10.0 ab	41.3 a
			(52.9)	(5.7)
Vydate 3.77L	1.000	1.3 a	12.5 ab	33.8 a
			(41.2)	(22.9)
Orthene 90S	0.500	0.0 a	35.0 ab	31.3 a
			(-64.7)	(28.6)
Orthene 90S	1.000	0.0 a	10.0 ab	18.8 a
			(52.9)	(57.1)
Untreated	-	0.0 a	21.3 ab	43.8 a

Means within a column with the same letter are not significantly different.
Application dates: 15, 28 July, and 10 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.

Table 16. Mean number of lepidoptera larvae per 100 sweeps 2 days after treatment one (Maricopa, AZ 1998).

Non-Bt Cotton WEC-98-013 Treatments[ab]	Rate lbai/ac	Mean # larvae/100 sweeps 2 DAT1		
		BAW (% Cntrl)	CL (% Cntrl)	Hel (% Cntrl)
Steward 1.25SC	0.065	0.0 a	0.0 a	0.0 a
		(100.0)	(100.0)	(100.0)
Steward 1.25SC	0.110	1.3 a	0.0 a	0.0 a
		(90.9)	(100.0)	(100.0)
Pirate 3SC	0.200	0.0 a	1.3 a	0.0 a
		(100.0)	(87.5)	(100.0)
Tracer 4F	0.089	2.5 a	0.0 a	1.3 a
		(81.8)	(100.0)	(50.0)
Lannate 2.4L	0.675	5.0 a	6.3 a	0.0 a
		(63.6)	(37.5)	(100.0)
Lorsban 4E	1.000	0.0 a	7.5 a	1.3 a
		(100.0)	(25.0)	(50.0)
Karate 1E	0.040	13.8 a	1.3 a	0.0 a
		(0.0)	(87.5)	(100.0)
Untreated	-	13.8 a	10.0 a	2.5 a

Means within a column with the same letter are not significantly different. Application date: 5 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.
[b]all plots treated previously with Orthene 90S at 1.0 lbai/ac on 15 July and Vydate C-LV at 1.0 lbai/ac on 27 July for mid season *Lygus* control.

Table 17. Mean number of lepidoptera larvae per 100 sweeps 6 days after treatment one (Maricopa, AZ 1998).

Non-Bt Cotton WEC-98-013 Treatments[ab]	Rate lbai/ac	Mean # larvae/100 sweeps 6 DAT1 BAW (% Cntrl)	CL (% Cntrl)	Hel (% Cntrl)
Steward 1.25SC	0.065	3.8 b (87.5)	0.0 b (100.0)	0.0 a
Steward 1.25SC	0.110	0.0 b (100.0)	0.0 b (100.0)	0.0 a
Pirate 3SC	0.200	0.0 b (100.0)	0.0 b (100.0)	1.3 a
Tracer 4F	0.089	2.5 b (91.7)	1.3 ab (66.7)	0.0 a
Lannate 2.4L	0.675	13.8 ab (54.1)	0.0 b (100.0)	0.0 a
Lorsban 4E	1.000	2.5 b (91.7)	2.5 ab (33.3)	0.0 a
Karate 1E	0.040	26.3 ab (12.5)	0.0 b (100.0)	0.0 a
Untreated	-	30.0 a	3.8 a	0.0 a

Means within a column with the same letter are not significantly different. Application date: 5 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.
[b]all plots treated previously with Orthene 90S at 1.0 lbai/ac on 15 July and Vydate C-LV at 1.0 lbai/ac on 27 July for mid season *Lygus* control.

Table 18. Treatment mean number of *Lygus hesperus* per 100 sweeps following two applications and two evaluations 2 days after treatment (Maricopa, AZ 1998).

Non-Bt Cotton WEC-98-013 Treatments[ab]	Rate lbai/ac	Mean # Lygus/100 sweeps 2 DAT Nymphs (% Cntrl)	Adults (% Cntrl)	All (% Cntrl)
Steward 1.25SC	0.065	21.9 (56.3)	15.6 (16.7)	37.5 (45.5)
Steward 1.25SC	0.110	13.1 (73.8)	14.4 (23.3)	27.5 (60.0)
Pirate 3SC	0.200	33.8 (32.5)	13.1 (30.0)	46.9 (31.8)
Tracer 4F	0.089	46.9 (6.3)	20.0 (-6.7)	66.9 (2.7)
Lannate 2.4L	0.675	6.9 (86.3)	10.0 (46.7)	16.9 (75.5)
Lorsban 4E	1.000	12.5 (75.0)	10.6 (43.3)	23.1 (66.4)
Karate 1E	0.040	17.5 (65.0)	6.3 (66.7)	23.8 (65.5)
Untreated	-	50.0	18.8	68.8

Application dates: 5 and 12 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.
[b]all plots treated previously with Orthene 90S at 1.0 lbai/ac on 15 July and Vydate C-LV at 1.0 lbai/ac on 27 July for mid season *Lygus* control.

Table 19. Treatment mean number of *Lygus hesperus* per 100 sweeps following two applications and two evaluations 6 days after treatment (Maricopa, AZ 1998).

Non-Bt Cotton WEC-98-013 Treatments[ab]	Rate lbai/ac	Mean # Lygus/100 sweeps 6 DAT Nymphs (% Cntrl)	Adults (% Cntrl)	All (% Cntrl)
Steward 1.25SC	0.065	60.0 (17.4)	26.9 (14.0)	86.9 (16.3)
Steward 1.25SC	0.110	42.5 (41.4)	16.3 (48.0)	58.8 (43.4)
Pirate 3SC	0.200	85.0 (-17.2)	24.4 (22.0)	109.4 (-5.4)
Tracer 4F	0.089	76.9 (-6.0)	16.9 (46.0)	93.8 (9.6)
Lannate 2.4L	0.675	47.5 (34.5)	23.1 (26.0)	70.6 (31.9)
Lorsban 4E	1.000	47.5 (34.5)	20.0 (36.0)	67.5 (34.9)
Karate 1E	0.040	41.3 (43.1)	20.6 (34.0)	61.9 (40.4)
Untreated	-	72.5	31.3	103.8

Application dates: 5 and 12 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.
[b]all plots treated previously with Orthene 90S at 1.0 lbai/ac on 15 July and Vydate C-LV at 1.0 lbai/ac on 27 July for mid season *Lygus* control.

Table 20. Cotton yields following four applications at 7 day spray intervals (Maricopa, AZ 1998).

Non-Bt Cot WEC-98-013 Treatments[ab]	Rate lbai/ac	16-Nov lb/ac Seed Cot.	% of Untreated Check	Est.[c] bales/ac Lint
Steward 1.25SC	0.065	2002 abc	127.2	1.32
Steward 1.25SC	0.110	2410 a	153.1	1.59
Pirate 3SC	0.200	1740 bc	110.6	1.15
Tracer 4F	0.089	2015 abc	128.0	1.33
Lannate 2.4L	0.675	2501 a	158.9	1.65
Lorsban 4E	1.000	2129 abc	135.3	1.41
Karate 1E	0.040	2302 ab	146.3	1.52
Untreated	-	1574 c	100.0	1.04

Means within a column with the same letter are not significantly different.
Application dates: 5, 12, 19 and 26 August.
[a]all treatments tank-mixed with Kinetic surfactant at 0.125% v/v.
[b]all plots treated previously with Orthene 90S at 1.0 lbai/ac on 15 July and Vydate C-LV at 1.0 lbai/ac on 27 July for mid season *Lygus* control.
[c]Estimated bales/acre lint assumes 33% turn-out and 500 lbs lint/bale.

Table 21. Mean number of beet armyworm larvae per 100 sweeps 2 days after treatment (Burrell, CA 1999).

Non-Bt Cotton WEI-99-018 Treatments[a]	Rate lbai/ac	Mean # larvae/100 sweeps 2 DAT		
		BAW Sm (% Cntrl)	BAW Lg (% Cntrl)	BAW All (% Cntrl)
Steward 1.25SC	0.065	6.7 b	6.7 b	13.4 b
		(91.3)	(87.8)	(89.8)
Steward 1.25SC	0.089	6.7 b	6.7 b	13.4 b
		(91.3)	(87.8)	(89.8)
Steward 1.25SC	0.110	13.4 b	3.4 b	16.8 b
		(82.5)	(92.8)	(87.2)
Success 2SC	0.067	3.3 b	6.7 b	10.0 b
		(95.7)	(87.8)	(92.4)
Untreated	-	76.7 a	55.0 a	131.7 a

Means within a column with the same letter are not significantly different.
Application date: 4 August.
[a]all treatments tank-mixed with Dyne-Amic at 0.5% v/v.

Table 22. Mean number of beet armyworm larvae per 100 sweeps 6 days after treatment (Burrell, CA 1999).

Non-Bt Cotton WEI-99-018 Treatments[a]	Rate lbai/ac	Mean # larvae/100 sweeps 6 DAT		
		BAW Sm (% Cntrl)	BAW Lg (% Cntrl)	BAW All (% Cntrl)
Steward	0.065	7.0 ab	9.0 b	16.0 b
1.25SC		(72.0)	(75.7)	(74.2)
Steward	0.089	4.0 b	5.0 b	9.0 b
1.25SC		(84.0)	(86.5)	(85.5)
Steward	0.110	0.0 b	0.0 b	0.0 b
1.25SC		(100.0)	(100.0)	(100.0)
Success 2SC	0.067	0.0 b	5.0 b	5.0 b
		(100.0)	(86.5)	(91.9)
Untreated	-	25.0 a	37.0 a	62.0 a

Means within a column with the same letter are not significantly different. Application date: 4 August.
[a]all treatments tank-mixed with Dyne-Amic at 0.5% v/v.

Table 23. Mean number of *Lygus hesperus* nymphs, adults and all per 100 sweeps 2 days after treatment (Burrell, CA 1999).

Non-Bt Cotton WEI-99-018 Treatments[a]	Rate lbai/ac	Mean # Lygus/100 sweeps 2 DAT		
		Nymphs (% Cntrl)	Adults (% Cntrl)	All (% Cntrl)
Steward	0.065	1.7 a	10.0 a	11.7 a
1.25SC		(83.0)	(62.6)	(68.1)
Steward	0.089	6.7 a	13.4 a	20.1 a
1.25SC		(33.0)	(49.8)	(45.2)
Steward	0.110	6.7 a	6.7 a	13.4 a
1.25SC		(33.0)	(74.9)	(63.5)
Success 2SC	0.067	8.4 a	16.7 a	25.1 a
		(16.0)	(37.5)	(31.6)
Untreated	-	10.0 a	26.7 a	36.7 a

Means within a column with the same letter are not significantly different. Application date: 4 August.
[a]all treatments tank-mixed with Dyne-Amic at 0.5% v/v.

Table 24. Mean number of *Lygus hesperus* nymphs, adults and all per 100 sweeps 6 days after treatment (Burrell, CA 1999).

Non-Bt Cotton WEI-99-018 Treatments[a]	Rate lbai/ac	Mean # Lygus/100 sweeps 6 DAT		
		Nymphs (% Cntrl)	Adults (% Cntrl)	All (% Cntrl)
Steward	0.065	7.0 a	7.0 a	14.0 a
1.25SC		(46.2)	(65.0)	(57.6)
Steward	0.089	5.0 a	22.0 a	27.0 a
1.25SC		(61.5)	(-10.0)	(18.2)
Steward	0.110	7.0 a	10.0 a	17.0 a
1.25SC		(46.2)	(50.0)	(48.5)
Success 2SC	0.067	15.0 a	13.0 a	28.0 a
		(-15.4)	(35.0)	(15.2)
Untreated	-	13.0 a	20.0 a	33.0 a

Means within a column with the same letter are not significantly different. Application date: 4 August.
[a]all treatments tank-mixed with Dyne-Amic at 0.5% v/v.

Table 25. Mean number of beet armyworm larvae per 100 sweeps 2 days after treatment (Riverdale, CA 1999).

		Mean # larvae/100 sweeps 2 DAT		
Non-Bt Cotton WEI-99-075 Treatments[a]	**Rate lbai/ac**	**BAW Sm (% Cntrl)**	**BAW Lg (% Cntrl)**	**BAW All (% Cntrl)**
Steward 1.25SC	0.065	30.0 a (-36.4)	42.0 ab (56.7)	72.0 ab (39.5)
Steward 1.25SC	0.089	4.0 a (81.8)	12.0 b (87.6)	16.0 b (86.6)
Steward 1.25SC	0.110	5.0 a (77.3)	7.0 b (92.8)	12.0 b (89.9)
Success 2SC	0.067	4.0 a (81.8)	24.0 b (75.3)	28.0 b (76.5)
Untreated	-	22.0 a	97.0 a	119.0 a

Means within a column with the same letter are not significantly different. Application date: 9 August.
[a]all treatments tank-mixed with Induce at 0.125% v/v.

Table 26. Mean number of beet armyworm larvae per 100 sweeps 6 days after treatment (Riverdale, CA 1999).

		Mean # larvae/100 sweeps 7 DAT		
Non-Bt Cotton WEI-99-075 Treatments[a]	**Rate lbai/ac**	**BAW Sm (% Cntrl)**	**BAW Lg (% Cntrl)**	**BAW All (% Cntrl)**
Steward 1.25SC	0.065	4.0 b (84.0)	2.0 b (94.6)	6.0 b (90.3)
Steward 1.25SC	0.089	0.0 b (100.0)	3.0 b (91.9)	3.0 b (95.2)
Steward 1.25SC	0.110	5.0 b (80.0)	2.0 b (94.6)	7.0 b (88.7)
Success 2SC	0.067	5.0 b (80.0)	7.0 b (81.1)	12.0 b (80.7)
Untreated	-	25.0 a	37.0 a	62.0 a

Means within a column with the same letter are not significantly different. Application date: 9 August.
[a]all treatments tank-mixed with Induce at 0.125% v/v.