

EUP Evaluation of a Novel Insecticide for *Lygus* Control

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Abstract

Lygus became the number one pest of cotton in 1998 with statewide losses of over \$16 million in spite of individual costs to the grower of over \$55/A for control. Selective technologies for whitefly and pink bollworm control reduce the number of broad spectrum sprays that incidentally control *Lygus*. Control of *Lygus* depends mainly on just two related chemical classes of insecticides, organophosphates and carbamates. Over reliance on such a limited diversity of chemical controls increases the risk of resistance. Further, FQPA threatens the future availability of many of our main stay chemical controls. The study reported here sought to investigate the commercial suitability of a new compound, Regent[®], for the control of *Lygus*. This novel mode of action represents one of the few potential new tools under development for *Lygus* management. Under a federal Emergency Use Permit (EUP), Regent was tested against two standards of *Lygus* control (Orthene[®] and Vydate[®]) and an untreated check. In a test of unusually high *Lygus* densities, Regent provided excellent control of small (instars 1–3) and large (instars 4–5) *Lygus* nymphs and may provide marginally better control of adults than current standards. None of the tested agents provided quick control or knock-down of adults. Rather, adult levels were reduced over time, most likely as a result of prevention of the development of new adults via nymphal control. All three materials protected cotton producing yields significantly higher than the check. The Orthene treatment had the highest yield, though not significantly higher than the Regent treatment which was effectively sprayed one less time than the other compounds.

Introduction

Control of *Lygus* in Arizona currently depends on just two chemical classes, organophosphates and carbamates (Ellsworth & Diehl, 1998; Ellsworth 1998a, b; Pacheco 1998; Ellsworth 1999, *this volume*). Within these two classes, only two compounds, Orthene[®] and Vydate C-LV[®], are regularly used for *Lygus* control in cotton. Clearly, growers need access to new chemistries with new modes of action for *Lygus* control. The threat of loss of our existing organophosphates to regulatory action heightens this need (i.e., FQPA). Over reliance on too few insecticides for the control of a pest may quickly lead to resistance.

Fipronil is a new chemistry with significant *Lygus* activity and a novel mode of action (Ellsworth et al., 1998b). Rhône-Poulenc will market this compound as Regent[®], but fipronil is not currently registered for use in cotton. In April 1998, EPA approved a crop-destruct Emergency Use Permit (EUP) on up to 20 acres of cotton in Arizona. The goal of this project is to evaluate the effectiveness of this new insecticide under commercial-scale conditions for the control of *Lygus*. This information will be critical to the registration and ultimate availability of this new product for

Arizona cotton growers. Our objectives were to evaluate the effectiveness of Regent for *Lygus* control on large acreages and to compare its efficacy relative to currently registered insecticides in a replicated, large-scale design. These evaluations will provide information necessary for the successful use and introduction of this valuable chemistry in the future.

Lygus is a serious pest of Arizona cotton and is gaining in prominence with the advent of selective pest control technologies like Bt cotton and insect growth regulators (Ellsworth et al., 1998a, b; Ellsworth 1998c). Also, the local crop ecology in several regions of Arizona is undergoing a change to include crop hosts which can foster large numbers of *Lygus* bugs if not properly managed (e.g., safflower, alfalfa seed) (Diehl et al., 1998). With only a limited number of effective products currently available, the *Lygus* control dilemma could escalate to crisis dimensions, if new compounds are not identified and registered for use. Already in 1998, *Lygus* became the number one pest of cotton. Statewide, growers averaged 2.76 sprays / A at a cost of \$55.20/A. Further, in spite of the increase in the frequency and costs of spraying for *Lygus*, losses to this pest have skyrocketed with an estimated statewide loss of over \$16 million (Williams 1999).

In 1997, we initiated evaluations of Regent for *Lygus* control under small plot conditions (Ellsworth et al., 1998b). This product showed great promise as an alternative to currently registered insecticides. With the approval of an Arizona EUP, we have a unique opportunity to evaluate the efficacy and proper use of this product in a commercial grower's field. Because this product was initially identified for the control of boll weevils, very little information on its *Lygus* efficacy exists. Further, new products are slow to be developed for *Lygus* control, because Miridae, as a group, are not a target for world-wide development of insecticides. In addition, once promising materials are identified, information on their efficacy against *Lygus* in cotton tends to reflect these properties for a different species of *Lygus*. *Lygus lineolaris* is the major species that threatens cotton in the mid-South and Southeast. The West has a different species, *Lygus hesperus* (Diehl et al., 1998), which often responds much differently to insecticides than the eastern species (Ellsworth, *this volume*). Also, the low desert environment challenges the action of our insecticides due to high temperatures, solar radiation, and arid conditions. For these reasons, it is crucial that evaluations of *Lygus* control chemistry be conducted here in the West, where there is a unique combination of environment, pest species, and crop ecology.

Materials and Methods

A field in Stanfield, AZ (P. Ollerton) was chosen, because it was very late planted and was surely to experience *Lygus* problems at some point. In addition, the variety chosen, DP20B, allowed us to ignore any potential confounding affects of pink bollworm or most other lepidopterans. The site was approximately 41 A in size and was planted in the first week of June. The field was defoliated twice and later harvested on 16 December.

Row spacing constraints (32 in.) dictated that we work with a dedicated spray rig. The Arizona Cotton Research and Protection Council graciously volunteered their staff's time and the use of their Spray Coupe. Prior spray history included an Orthene® spray in late July and a Knack® + Lorsban® spray on 19 August. Samples taken in early August indicated sub-threshold levels of *Lygus* at that time (< 15–20 total *Lygus* / 100 sweeps).

By 18 August, *Lygus* numbers increased sharply to 27.3 and 30 / 100 sweeps. Most nymphs present were very young at this time. The trial was scheduled to start the following Monday, 24 August; however, an irrigation was required and applied before application. The soils there were heavy and required at least 10 days of drying. The resulting pressure from *Lygus* bugs due to the delay in application was extraordinary. During this same time, about 200 A of Pima was shredded just to the south of the test and served to concentrate even more *Lygus* on this late maturing field. The general vicinity was populated with *Lygus* in part as a result of the close proximity of seed alfalfa fields just to the southeast (0.5 miles).

The field was divided into 16 plots as part of a randomized complete block design with 4 treatments. Each plot was 66 rows X 800 ft, except for the untreated check which was 36 rows X 800 ft. This helped to reduce the exposure of the grower to whom we are very grateful for his permission to establish these much needed checks. All plots were flagged twice in two locations to facilitate spraying and crop destruction in the Regent-treated areas.

The four treatments and rates were Orthene 90S (1 lb ai/A), Vydate C-LV® (1 lb ai/A), Regent (0.05 lb ai/A) and the untreated check. Flat fan 8002 nozzles were spaced every 20 inches. The spray coupe was equipped with 3 separate reservoirs and injectors for direct injection of the a.i. into the water stream. Each injector was controlled by an on-board Raven computer controller system for delivery of ca. 15 GPA. Orthene was mixed to a 1 gallon per acre supply volume. Vydate C-LV was not mixed, but delivered at a 34 fl. oz. per acre supply volume. Regent was mixed to a 16 fl. oz. per acre supply volume. Applications were made on 4, 14, and 28 September. Applaud® was sprayed on all plots on 14 September for whitefly control.

Calibration and logistical problems led to a poorly made second application. The Vydate treatment was underdosed on the first day and a follow-up application was made the second day. The Regent application was severely underdosed by almost a factor of 10. This fact disadvantages the Regent treatment which should be considered as having received only two applications. This was particularly unfortunate because of the intense *Lygus* pressure that was present then.

Samples were taken from each plot, 4 subsamples of 25 sweeps / plot for a total of 100 sweeps per plot. There were a total of 3 precount sample dates (18, 24 & 31 August) and 7 post-application counts (9, 14, 18, 23, 28 September; 1 & 5 October). Only a partial sample was taken on 18 September because of irrigation water. Due to the lateness of the season and the growth habit of the plants, late September and October sweep samples were very difficult to take consistently. All samples were placed on ice in the field, then frozen, and held for later processing. Processing included an enumeration of all *Lygus* and other arthropod abundance. *Lygus* were divided among small nymphs (instars 1–3), large nymphs (instars 4–5), and adults.

Yields were estimated from commercially-picked strips. One round (10-rows) was harvested from near the centers of each plot and weighed in a boll buggy. Regent plots were harvested last, weighed, bulked in a truck and discharged back into the Regent-treated areas for crop destruction as required by the EUP.

Analyses were conducted by ANOVA with orthogonal contrasts ($P < 0.05$) for small, large, and total nymphs, adults and total *Lygus* per 100 sweeps, as well as yield. All data were normalized where appropriate with raw means (\pm SE) presented for interpretation.

Results and Discussion

Current recommendations for timing of *Lygus* control in Arizona are 15–20 total *Lygus* per 100 sweeps with nymphs present. Also, nymph levels of around 30% of the total sample indicate that treatment with appropriate materials should provide a positive economic return (Ellsworth 1998a, b; Diehl et al., 1998; Ellsworth, *this volume*). A limited 18 August sample indicated pre-spray levels of *Lygus* around 30 per 100 sweeps with 17% nymphs. Most nymphs were very young and probably less able to damage squares directly. The grower elected to spray for other pests on 19 August. Precount samples taken over the entire field on 24 August showed *Lygus* levels of ca. 21 per 100 sweeps with ca. 15% nymphs. Irrigation on this date prevented the timely application of *Lygus* materials and delayed spraying for an additional 10 days. One week later (8/31), *Lygus* levels including nymphs rose sharply (ca. 67 / 100 sweeps with over 50% nymphs). Thus, applications made on 4 September were not optimally timed for efficient *Lygus* control.

Past experience with this pest in Arizona has shown that adult *Lygus* are less responsive to treatments than nymphs (Ellsworth et al., 1998b; Pacheco 1998; Ellsworth, *this volume*). Adult numbers in this test were no exception (Fig. 1). There were no significant treatment differences 5 and 10 days after the first treatment (DAT). Adult abundance was being influenced by several crop ecological changes in the area. Seed alfalfa fields in the vicinity had been drying down, and large numbers of adults were seeking new hosts. Also, about 200 A of Pima cotton production between the seed alfalfa fields and our test site was discontinued and shredded. Adult *Lygus*, therefore, were being driven from other hosts. Our test site provided peak flowering cotton that was attractive and preferred over much earlier planted fields in the vicinity.

By the second treatment (9DAT2), adult levels began to decline significantly relative to the check. By the last evaluation (7 DAT3), all three treatments had significantly fewer adults than the check in spite of an overall lowering in

densities across the field. This delay in response of adult levels to treatments is likely due to the consistent reductions in nymphs. These reductions then resulted in the production of fewer adults in the treated areas. Adults develop from eggs in about 21 days under summer conditions (Diehl et al., 1998). The first reductions noted occurred 19 days after the initial treatment (Fig 1; see Vydate, 9DAT2). Thus, reductions in adult numbers appear to be less related to direct mortality and more related to population control via the nymphs (Fig. 2). Nevertheless, only 2 sprays of Regent were equivalent in effect on adults as 3 sprays of the other two materials 3 and 7 DAT (Fig. 1). The refractory nature of adults to treatments was even more pronounced in another study in Maricopa (Ellsworth, *this volume*). There, adults only declined after repeated applications and time, indicating the generational reduction of adults via nymphal control. Furthermore, the yield response was impressive, nearly 5-fold increase over the check, indicating that nymphs are responsible for substantial levels of yield loss, while adult control may be less important (Ellsworth, *this volume*).

The response of *Lygus* nymphs to treatments was quicker and much more dramatic (Fig. 2). All three products significantly lowered total nymph numbers relative to the check. Examination of the pattern of reductions would suggest that this effect may be observed for up to 10–14 DAT with each product and that Regent and Orthene may have slightly longer residual activity than Vydate (Fig. 2; 10 DAT). While an error of the protocol, it was interesting to see the impact of omitting the second spray of Regent (Fig. 2; 9 & 14 DAT2). There appeared to be a decided resurgence in nymphal numbers relative to the check. This phenomenon could be due to the elimination of certain key natural enemies or through some other direct effect on *Lygus* nymphs. Arthropod densities including natural enemy abundance are still being processed and analyzed. Once the second application of Regent was made (Fig. 2; 3 & 7 DAT3), nymph levels declined dramatically indicating excellent efficacy of the product. By the third spray, Orthene and Vydate were both highly effective against nymphs driving populations close to zero.

Lygus sweep samples tend to be adult-biased, and therefore, adults tend to drive general population censuses of total numbers (Fig. 3). This has the unfortunate consequence of misuing growers about the potential efficacy, or lack thereof, of various treatments. For example 5 and 10 DAT (Fig. 3), the insecticides did not appear to lower overall *Lygus* numbers from precount levels (31 August) in spite of significant treatment differences. This fact results in lack of confidence in our *Lygus* chemistry and sometimes leads to a trial and error type of searching by growers for better materials. This experimentation may lead to less effective and more expensive alternatives. Based on total *Lygus* numbers, populations in this test may have been at 3.5 to 4.5 times threshold at the time of first spraying. These types of densities can be associated with population growth rates which mask the gains made by spraying. It took two applications of Orthene or Vydate before total levels returned to near threshold levels (< 23/100) with nymphs comprising a minor portion (8%) of the population (Fig. 3; 9 & 14 DAT2). A second application with Regent also drove total levels well below threshold (3 & 7 DAT3), though nymphs remained a much larger portion of the total. This would suggest that Regent may be relatively more effective against adults than the other materials.

Small nymphs may be overlooked in sweep net samples; however, changes in their density in relation to treatments can help explain efficacy (Fig. 4). These nymphs (instars 1–3) are less able to damage the plant and take about 7 days to develop into larger, more damaging nymphs (Diehl et al., 1998). All three materials reduced small nymph densities relative to the check. The resurgence noted earlier in the Regent treatment is most pronounced for the small nymphs (Fig. 4) and may indicate the presence of a key, small nymphal or egg predator in the system. Orthene and Vydate reduced small nymph levels to zero after the third spray (Fig. 4; 3 & 7 DAT3).

Large nymphs, which begin to occur about 7 days after hatching, constituted just a small fraction (<1 / 100 sweeps) of the population on the first precount date (Fig. 5; 24 August). This indicated a relatively new invasion of *Lygus* to the field. Seven days later, however, large nymph numbers exploded (>30 / 100 sweeps) and revealed the potential for much damage. All three materials significantly lowered large nymph numbers after just one spray. After two sprays, Orthene and Vydate reduced large nymph levels to close to early precount numbers (<2 / 100 sweeps; Fig. 5; 9 & 14 DAT2). Even more impressively, both compounds lowered large nymph numbers to zero after 3 sprays. The relatively good efficacy of these compounds on this stage may be in part a result of the large nymphs' active feeding status and the penetration of these insecticides into plant tissues. Similar efficacy on large and small nymphs was also observed in another trial in Maricopa (Ellsworth, *this volume*).

Yield Response to *Lygus* Controls

The yield potential of this field was not very high due to a variety of agronomic (e.g., late planting, short-season

variety) and entomological (e.g., late initiation of *Lygus* controls, large source populations in the vicinity) factors. When potentials are naturally low, the ability to detect differences in treatment regimes is diminished. Nevertheless, a significant yield effect was seen in this experiment (Fig. 6). The UTC yielded significantly less than the sprayed treatments and almost half that of the Orthene treatment. Orthene was highest but not significantly different from Regent, in spite of the one fewer sprays that the Regent plots received. The Vydate yields were significantly lower than the Orthene yields, but not the Regent yields. The commercial field site was 41 A in size and noticeably variable. The Vydate plots may have been positioned at random in less productive portions of the field which biased yield estimates negatively.

Regent and other chemistry was studied in a separate small plot experiment at the Maricopa Agricultural Center in 1998 (Ellsworth, *this volume*). Regent was a top performer in a variety of *Lygus* control parameters, and produced one of the highest yields. Though slightly lower yielding than the Orthene or Vydate treatments, this difference was attributed to the premature defoliation by mites observed in the Regent plots. The lint turnouts for Regent were higher than any other treatment including Orthene and Vydate and may be indicative of the outstanding *Lygus* control (see Ellsworth, *this volume*). The higher lint turnouts are at least partially related to reduced seed size where *Lygus* control is good. Ellsworth & Naranjo (*this volume*) also measured significantly heavier seed where *Lygus* control was poor and the source-sink relationship of the plant's photosynthate to bolls is disrupted.

Regent, as a new mode of action with significant *Lygus* activity, represents a new potential tool for *Lygus* management. With it, we will have three classes of chemistry, plus endosulfan, that are effective *Lygus* control products. This provides additional benefits to resistance management, if growers properly time and rotate among the available effective classes. However, Regent is not a panacea for *Lygus* control. *Lygus* management ultimately still depends on the fundamentals of sampling and properly-timed applications of effective chemistry and avoidance of the problem from the start, especially in this case, by pest source reduction.

Acknowledgments

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Disclaimer

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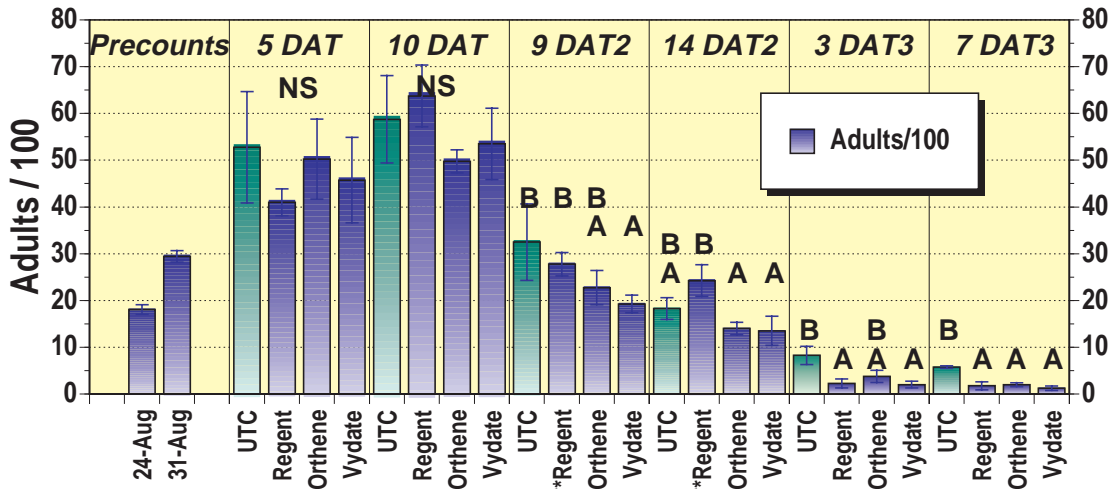


Figure 1. Number of *Lygus* adults per 100 sweeps (\pm SE) in response to insecticides at a commercial location in Stanfield, AZ. Sprays were made 10 days after reaching threshold (24 August) on 4, 14, and 28 September except for Regent which was skipped on the second spray. Evaluations were made twice prior to and twice after each spray (DAT=days after treatment). Within an evaluation, treatments sharing the same letter are not significantly different by orthogonal contrasts ($P>0.05$). All treatments had relatively minor direct impact on adult levels. Adults eventually declined significantly probably as a result of the reduction of the nymphal generation. UTC=Untreated Check.

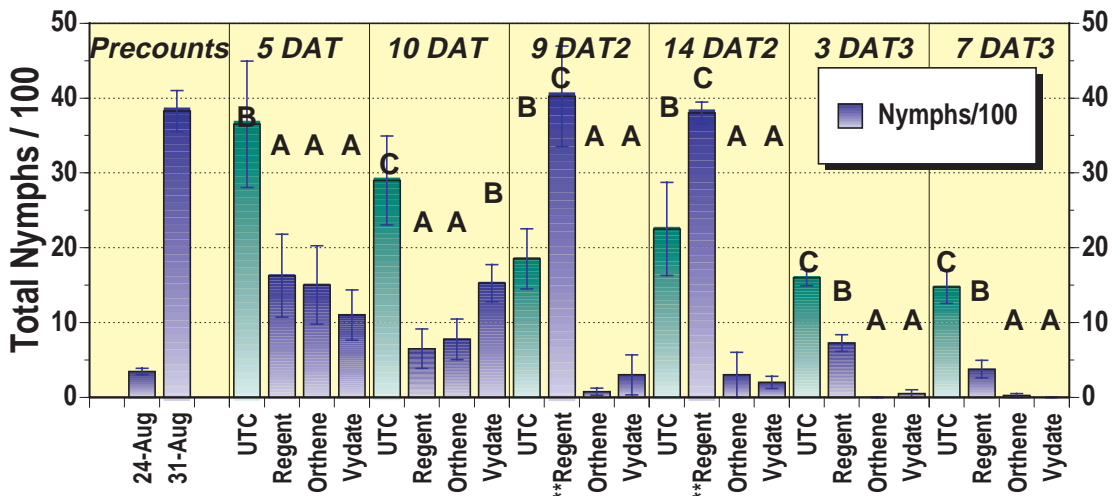


Figure 2. Number of *Lygus* nymphs per 100 sweeps (\pm SE) in response to insecticides at a commercial location in Stanfield, AZ. Sprays were made 10 days after reaching threshold (24 August) on 4, 14, and 28 September except for Regent which was skipped on the second spray. Evaluations were made twice prior to and twice after each spray (DAT=days after treatment). Within an evaluation, treatments sharing the same letter are not significantly different by orthogonal contrasts ($P>0.05$). Each treatment significantly reduced nymphal levels relative to the UTC. When Regent was skipped during the second spray, nymphs resurged to levels higher than the UTC (9 & 14DAT2). Orthene and Vydate sprays reduced nymphal levels to near zero. UTC=Untreated Check.

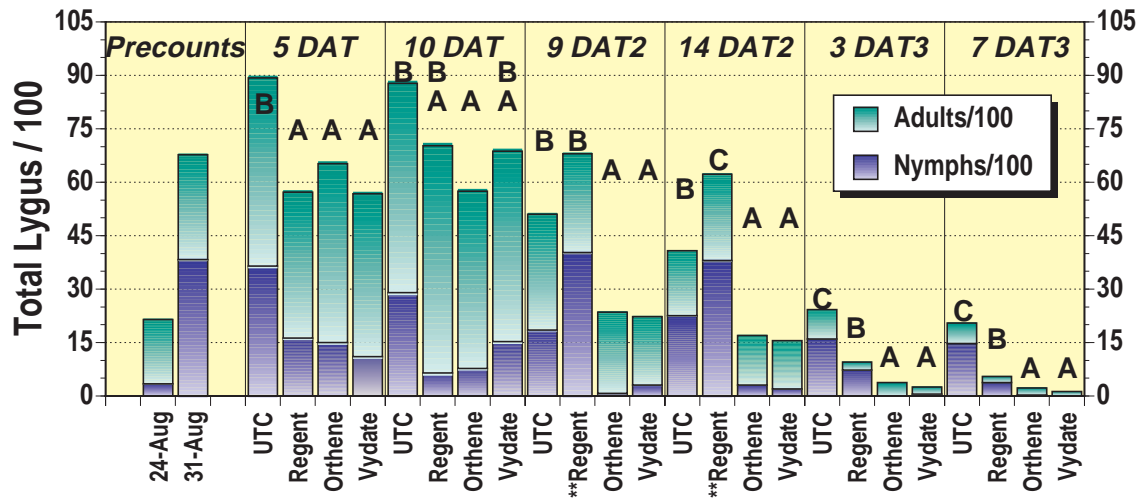


Figure 3. Total number of *Lygus* bugs per 100 sweeps in response to insecticides at a commercial location in Stanfield, AZ. Sprays were made 10 days after reaching threshold (24 August) on 4, 14, and 28 September except for Regent which was skipped on the second spray. Evaluations were made twice prior to and twice after each spray (DAT=days after treatment). Within an evaluation, treatments sharing the same letter are not significantly different by orthogonal contrasts ($P>0.05$). The first spray lowered total numbers significantly, though not below the threshold of 15–20 total *Lygus* / 100 sweeps or precount levels. The second spray of Orthene or Vydate reduced totals to near threshold 14 DAT2 (ca. 23/100). The second spray of Regent (3 & 7DAT3) also lowered numbers below threshold, though not as low as after 3 sprays of either Orthene or Vydate. UTC=Untreated Check.

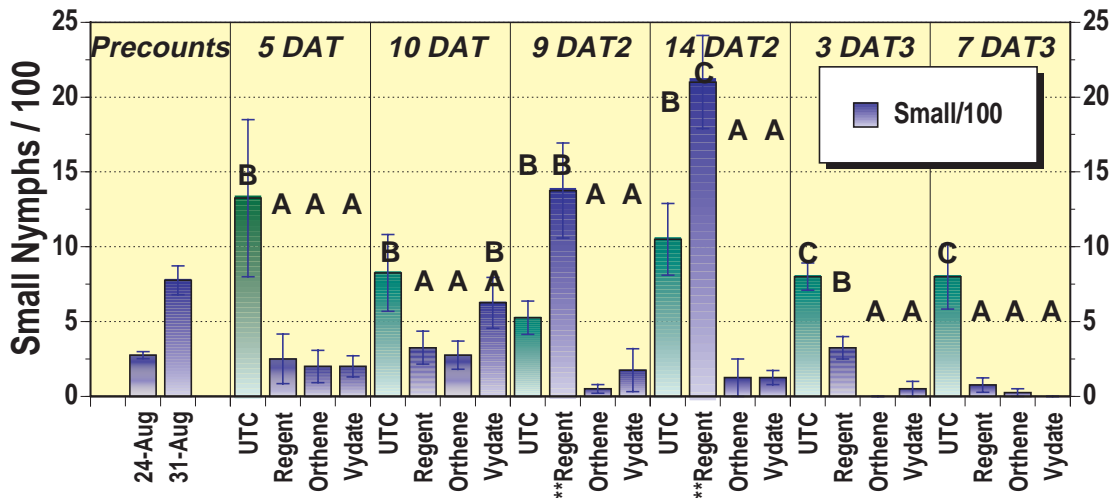


Figure 4. Number of *Lygus* small nymphs (instars 1–3) per 100 sweeps (\pm SE) in response to insecticides at a commercial location in Stanfield, AZ. Sprays were made 10 days after reaching threshold (24 August) on 4, 14, and 28 September except for Regent which was skipped on the second spray. Evaluations were made twice prior to and twice after each spray (DAT=days after treatment). Within an evaluation, treatments sharing the same letter are not significantly different by orthogonal contrasts ($P>0.05$). Populations of small nymphs were doubling almost weekly since (24 August) indicating a substantial egg-lay prior to the first treatments. Each treatment significantly reduced small nymph levels relative to the UTC. When Regent was skipped during the second spray, small nymphs resurged to levels higher than the UTC (14DAT2); however, 2 sprays of Regent were equivalent to 3 sprays of the other two compounds (7DAT3). Orthene and Vydate sprays reduced small nymph levels to near zero. UTC=Untreated Check.

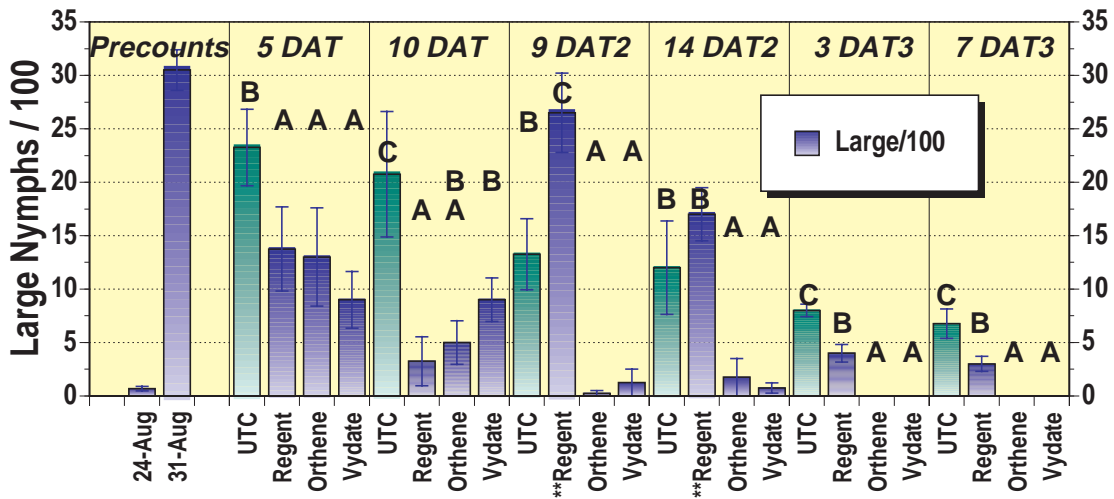


Figure 5. Number of *Lygus* large nymphs (instars 4–5) per 100 sweeps (\pm SE) in response to insecticides at a commercial location in Stanfield, AZ. Sprays were made 10 days after reaching threshold (24 August) on 4, 14, and 28 September except for Regent which was skipped on the second spray. Evaluations were made twice prior to and twice after each spray (DAT=days after treatment). Within an evaluation, treatments sharing the same letter are not significantly different by orthogonal contrasts ($P>0.05$). The post-threshold period, prior to spraying (31 August), revealed an aggressively growing large nymph population. Each treatment significantly reduced large nymph levels relative to the UTC. When Regent was skipped during the second spray, large nymphs resurged to levels higher than the UTC (9DAT2). Orthene and Vydate were extremely effective in reducing large nymph levels. UTC=Untreated Check.

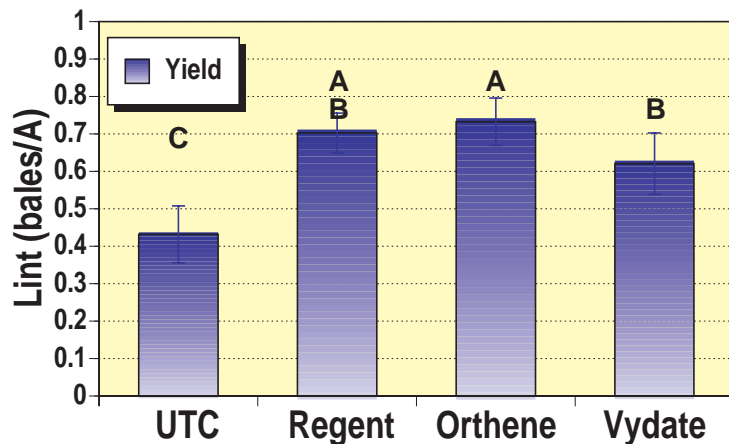


Figure 6. Yield (bales/A \pm SE) response to *Lygus* treatments at a commercial location in Stanfield, AZ. A 31% lint turnout was assumed. A total of two (Regent) or three (Orthene or Vydate) sprays were made against *Lygus*. The cotton (DP20B) was planted late (early June) and treatments were initiated late, 10 days after reaching the *Lygus* threshold. Populations were aggressively migrating into the field from external sources. Treatments sharing the same letter are not significantly different by orthogonal contrasts ($P>0.05$). Each treatment yielded significantly more than the UTC. The Orthene treatment yielded the most and significantly more than the Vydate treatment but not significantly more than Regent which was sprayed 1 fewer times. UTC=Untreated Check.