Contents

1. Type of Exemption Being Requested

This is a ***specific*** exemption for Regent® requested by the State of Arizona for mitigation of a non-routine, crisis situation with ***Lygus* plant bugs** in cotton.

2. Contact Person and Qualified Expert (166.20(a)(1))

[Name, Organization, Address and Phone]

Contact Person:	Qualified Expert:
Ed Minch, Ph.D. Environmental Specialist Arizona Department of Agriculture 1688 West Adams Phoenix, Arizona 85007 (602) 542–0954 Fax: 542–0466	Peter Ellsworth, Ph.D. Integrated Pest Management Specialist University of Arizona, Maricopa Agricultural Center 37860 W. Smith-Enke Road Maricopa, Arizona 85239 (520) 568–2273 ext. 225 FAX: 568–2556 e-mail: peterell@ag.arizona.edu

3. Description of Pesticide Requested (166.20(a)(2))

a. Common Chemical Name:	fipronil (5-amino-1-(2,6-dichloro-4-(trifluoromethyl)phenyl)-4-((1,R,S)-(trifluoromethyl)sulfinyl)-1-H-pyrazole-3-carbonitrile)
b. CAS Number:	120068-37-3
c. Trade Name and EPA Reg. No.:	Regent® 80 WG (264-570) (Fipronil, Agenda, Icon, Termidor, EXP 60720, MB46030)
d. Formulation:	80% water dispersible granule
e. % Active Ingredient:	80% active [0.8 lbs a.i. per lb]
f. Manufacturer:	Rhône-Poulenc

The product name, chemical identity, and composition is documented in an attachment as part of an application for registration of Regent 80 WG Insecticide for use in cotton (Support Document, Section A, 9 pp.). This product is currently registered on corn and rice. The technical grade of fipronil is registered (EPA Reg. No. 264-554). A history, up through submission for a cotton registration (4/97), of applications for Experimental Use Permits, Registrations, and Tolerances is contained in the attachment (Support Document, Section A, pp. 3–7). A proposed label is provided by the registrant in the attachment (Support Document, Section B, 4 pp.). The current Material Safety Data Sheet is provided (Support Document, Section C, 13 pp.). Supplemental directions for use will be provided to all individuals involved with the use of Regent through the section 18 (Arizona Attachment A). The contents of the label may be summarized as follows:

- only two, non-consecutive, uses permitted per cotton season
- the second use of Regent, if needed, may be made only after the use of an alternate insecticide for control of *Lygus hesperus*,
- applications must be based on appropriate *Lygus* thresholds & the grower or his agent (i.e., Pest Control Advisor) must document the presence of at least 4 *Lygus* **nymphs** per 100 sweeps,
- users must subscribe to local Insecticide Resistance Management and IPM strategies.
- Mixing of Regent with other *Lygus* active insecticides should be avoided, where possible,

Additional information on this product may exist in earlier documentation submitted to EPA as part of EUP efforts by the registrant since submission for registration. A crop-destruct cotton EUP was granted by the EPA for Regent in Arizona last year (264-EUP-117). Regent product identity and confidential statement of formula are available to EPA upon request. Upon expiration of the pending emergency exemption, all unused material will be disposed of according to the provisions of the emergency exemption.

4. Description of Proposed Use (166.20(a)(3)

a. Site or Sites:	Cotton Production Areas Statewide Cochise, Greenlee, Graham, La Paz, Maricopa, Mohave, Pima, Pinal, & Yuma Counties. Cotton is grown on 260,000 acres in the desert regions of Arizona, most of which is likely to be infested with *Lygus* bugs. The vast majority of the affected acreage is in the low desert (< 2000 ft) and is not proximal to any significant bodies of surface waters. Seasonal washes and rivers do flow on occasion through various parts of the desert but are often dry during the specific use period proposed. The majority of the acreage is not found near residences or other areas of high density populations. There is, however, limited acreage near significant population centers (e.g., Phoenix, Marana, Casa Grande, Yuma).
b. Method of Application:	Ground, ≥ 15 gal. spray / acre; Air: ≥ 5 GPA
c. Rate of Application (ai and product):	0.05 lb ai / A [22.68 g ai / A] or 1 oz. / A
d. Maximum Number of Applications:	two (non-consecutive uses) per cotton season

e. Total Acreage to be Treated: 260,000 Acres may be planted in 1999. Up to 30% may not require treatments for *Lygus* bugs or are otherwise not treated for this pest. At least 400,000 potential application-acres may be sprayed with this product.

f. Total Amount of Pesticide to be Used: 20,000 lbs ai

g. Use Season: The use season includes any time during the cotton production season when *Lygus* are at threshold levels (= at least 4 nymphs per 100 sweeps). Statewide for these materials, this should correspond to July 1 – September 15. Production capability of the product by the registrant is assured.

h. Additional Restrictions: Proposed labels are provided by the registrant in the attachments (Support Document, Section B). Only a licensed pest control advisor may prescribe the use of Regent through the state's 1080 process and by documenting the presence of at least 4 *Lygus* nymphs per 100 sweeps and, if used a second time, the prior use of alternative chemistry. This compound should not be mixed with any other *Lygus* insecticide, where possible. All applications must be based on appropriate *Lygus* bug thresholds. See Arizona Attachment B (& later in this document) for University guidelines for *Lygus* management.

5. Alternative Methods of Control (166.20(a)(4))

a. Registered Alternative Pesticides:

There are numerous alternative insecticides which may be used for the control of *Lygus* bugs. These products have been under intensive study in University and industrial trials for the past 7 years (Dennehy et al. 1998; Ellsworth, 1998a, 1998b, 1999; Ellsworth et al. 1998b, 1999; Pacheco 1998) with a common set of sobering conclusions:

- none of the products tested provide adequate control of *Lygus* adults,
- synthetic pyrethroids have no significant or consistent effect on *Lygus* (putative resistance)
- insecticidal mixtures have had no consistent additive, synergistic, or economic benefits in the control of *Lygus* in Arizona,
- Lygus (or other Mirids) is not a target of world-wide development of new insecticides,
- where collateral efficacy has been detected for new products, most have not been effective against our principal species of *Lygus*, *Lygus hesperus*, except for Regent (see Ellsworth 1999),
- with respect to existing products, only Orthene (acephate), Monitor (methamidophos), Vydate (oxamyl), endosulfan, and dimethoate provide any level of consistent control of

Lygus nymphs, and often only when used repeatedly at the highest labelled rates,

- of the products exhibiting activity, Orthene, Monitor and Vydate are recommended as primary products of choice against *Lygus* (see Ellsworth 1999),
- repeated use of such a limited diversity of chemistry has led to anecdotal and measurable reductions in performance in each of these products (e.g., Ellsworth 1999),
- in areas of chronic need, often due to circumstances beyond the control of the individual cotton grower (e.g., source vegetation and seed crops), multiple uses (4–8) are required to obtain acceptable, yet still compromised and not economical, yields,
- more efficacious materials with longer residual control and a greater diversity of chemistries are desperately needed to mitigate unusual invasions of a persistent nature by *Lygus* and to manage or mitigate putative resistances.

The basic biology, identification, and management options for *Lygus* are outlined in two University of Arizona publications (Diehl et al. 1998; Ellsworth & Diehl 1998). The identity of our pest *Lygus* is significant. While we have a complex of 3 species in Arizona, ***Lygus hesperus*** **constitutes the majority of *Lygus* bugs present in cotton, not *Lygus lineolaris* as is the case throughout the rest of the cotton belt east of New Mexico**. Thus, even reputed efficacy against *Lygus* or plant bugs from the mid-South or Delta regions of the cotton belt must be scrutinized carefully. The current and soon to be registered chloronicotinyls (i.e., Provado [imidacloprid] and Actara [thiomethoxam]) have documented "*Lygus*" efficacy, though they are completely inadequate for the control of *Lygus hesperus* in Arizona (Ellsworth 1999). This may be due to inherent differences among *Lygus* species that cause our species not to be a target of this chemistry, or due to multiple resistance that has developed as a result of selection by other pesticides in our system. Furthermore, the use of chloronicotinyls in our cotton system currently is not recommended by the University. This is a measure for preserving the much needed efficacy on whiteflies of imidacloprid in desert melons and vegetables (Arbogast et al. 1999; Palumbo et al. 1999). Of the newer chemistries, only Regent has shown consistent efficacy against *Lygus hesperus* in Arizona.

The following registered products have had some efficacy against *Lygus* in Arizona:

- **Orthene** (*acephate*): This product is widely used as the standard in screening trials and the product of choice among practitioners and is still a key synergist for Stage III whitefly control (Ellsworth & Watson 1996; Ellsworth et al. 1996). The key feature of acephate is that it is cheaper than any other alternative. Because our overall IRM instructs growers not to use any active ingredient more than twice per season (Arbogast et al. 1999), Orthene should not be relied upon exclusively for *Lygus* control. Unfortunately, some PCAs have reported up to 6 or 7 sprays of Orthene against *Lygus* in fields of chronic need. The efficacy of this product is notably declined after such a use pattern. In one study (Ellsworth 1999), 5 repeated uses of Orthene led to the best control and yield response possible; however, it is estimated that at least one third of a bale was still lost to *Lygus* bugs and Orthene efficacy may have been compromised by the end of the regime. Also, mite resurgence was becoming apparent within this very harsh regime.

- **Monitor** (*methamidophos*): As experienced by the insect biochemically, this product is similar to Orthene. The same set of limitations exist as above, except Monitor has an even higher toxicity rating. Because of its high toxicity, concomitant added WPS requirements, and higher cost, Monitor is not often used by growers. Furthermore, it is a poor choice for sensitive areas near our urban centers. Control of *Lygus* has been less consistent among trials suggesting efficacy, tolerance, and/or resistance problems (Ellsworth et al. 1998b).

- **Vydate C-LV** (*oxamyl*): As our only efficacious carbamate, Vydate is a valuable product for the control of *Lygus* and other sucking pests. It is our key insecticide used for the control of Cotton Leafperforator with good efficacy against Pink Bollworm moths also. Vydate has performed well in most trials against *Lygus*; however, the maximum labelled rate is usually needed and at this rate, it is substantially more expensive than Orthene ($21 vs. $12/A). Indications of reduced performance against *Lygus* can be seen in Fig. 1. Where Vydate was used more than once, response in terms of percentage kill of nymphs declined. In fact, after the fourth spray of Vydate, nymph levels increased significantly. Vydate used sparingly in a rotational program with Orthene and Regent provided for outstanding control of nymphs through the same period (Ellsworth 1999).
- **endosulfan**: As our only cyclodiene, endosulfan is a critical part of our IRM program in Arizona agriculture. The loss of efficacy of endosulfan in this or other targets could have disastrous effects on the cotton and melon and vegetable industries of this state. Endosulfan is a key product and synergist in our whitefly IRM program (Ellsworth & Watson 1996). It is also not quite as effective against *Lygus* as the above three compounds, and it is best used at its maximum labelled rate (1.5 lbs ai/A) where it is more expensive than Orthene ($18.50 vs $12/A). At this rate, the seasonal limitation on use of this product is reached with just 2 sprays. For all these reasons, endosulfan is a secondary choice for *Lygus* control, and we suggest strongly to growers to consider reserving its use for Stage II control of whiteflies (Ellsworth et al. 1996). As the sole member of its own chemical class, we cannot afford the overuse of endosulfan in this state. Pesticide use reports suggest that endosulfan increased dramatically last year, in part because of the need for maximum rates to accomplish any control of *Lygus*. Data from Dennehy et al. (1999) would suggest that, as a result, collateral susceptibilities in *Bemisia* to endosulfan in some areas declined in 1998.
- **dimethoate**: Dimethoate is an old organophosphate with systemic properties that make it useful for early season control of thrips, fleahoppers and *Lygus*. It is a fairly toxic and broad-spectrum OP with many restrictions on its use. While very cheap, it is a tertiary choice for *Lygus* control. It is only partially effective (Ellsworth et al. 1998b), and the window during the season when it would be most useful is too early for most *Lygus* invasions.
- **others**: **There is no appreciable or economically significant level of control with any other product alone or in combination including the remaining organophosphates, carbamates, pyrethroids and newer chemistries** (Ellsworth et al. 1998b; Ellsworth 1999). This fact, in itself, might suggest the presence of serious multiple resistances in this insect. No natural products or biorationals have been proven effective against *Lygus* in Arizona.

In short, there are no viable, registered insecticide alternatives that will provide season-long suppression of non-routine, yet continual, invasions of *Lygus* in cotton. Furthermore, continued use and overuse of our key organophosphate (Orthene), carbamate (Vydate), and cyclodiene (endosulfan) will likely lead to more severe expressions of resistance in *Lygus* and to further problems with secondary pest outbreaks (e.g., mites, whiteflies, aphids) and pest resistance (e.g., in *Bemisia*). Currently, our system is delicately balanced through the striking efficacy and use of Bt cotton for Pink Bollworm and of IGRs for *Bemisia* whiteflies. Cold weather in April resulted in either delayed planting or re-planting. Thus, progress of the crop is very late, like last year when the crop was exposed to abnormally severe *Lygus* damage. Should unusually unceasing invasions of *Lygus* persist like last year, our entire control, IPM, and IRM systems could fail. Furthermore, this is a pest that attacks the yield component directly and results in dramatic losses of yield (i.e., even up to 2 bales lost per A). Finally, with cotton lint prices hovering in the $0.50–0.60 / lb. range, it is unlikely that growers will be able to achieve adequate **and** economical control of *Lygus* this year. **Growers are in desperate financial straits and are in need of a low-cost, effective, and longer-lasting product like Regent to address this emergency need.**

b. Alternative Control Practices:

Management of this pest is currently outlined in several publications (Diehl & Ellsworth 1998; Ellsworth & Diehl 1998). *Lygus* is an indigenous pest with a very broad host range and a considerable capacity to move. This has made the management of this pest on a field-to-field basis difficult. **However, severe problems with *Lygus* of a non-routine and emergency nature have been fostered by a combination of crop ecological, meteorological, economic, and pest control changes in our system**. Given these changes (detailed elsewhere), there is little a grower can do to protect his/her own cotton than to follow the basics of pest management (see Ellsworth 1998a,b). Below is an accounting of the variety of alternative tactics that are available:

- Alternate Host Management (weeds): The Arizona low desert ecosystem is governed by the availability of water and the cultivation of hosts. During winters and springs of excess moisture, desert vegetation flourishes as well as weeds in association with agriculture. These serve as important overwintering and spring build-up hosts for *Lygus*. While wholesale removal of the desert flora is impossible, management of proximate sources of *Lygus* hosts is helpful. This includes weed control and other host plant sanitation techniques. Especially in preparation for planting cotton, virtually all growers practice a clean cultivation strategy that eliminates most of these marginal weedy host sources. Ditchbank sanitation is also widely practiced. These practices, while helpful, cannot mitigate the overwhelming sources of natural vegetation or cultivated crops (see below).
- Alt. Host Management (alfalfa hay): Unfortunately, cultivated crop hosts are not so easily eliminated from our agroecosystem. Forage alfalfa hay is an excellent nursery crop for *Lygus* which carries

this pest into the cotton season each year. With each cyclic cutting, more *Lygus* are flushed into less preferred cotton hosts. Through management of cuttings via strip- or block-cutting, a grower can limit *Lygus* movement by providing for lush, preferred alfalfa as a host at all times. (*Lygus* is not an economic pest of forage hay, so this presents no particular threat to the grower but also results in populations that increase unabated there). This tactic is not completely effective, but can substantially reduce the number of *Lygus* invading cotton. However, management of alfalfa host availability requires 1) enough alfalfa owned and/or controlled by the grower himself, 2) an appropriate geometry of fields in alfalfa relative to cotton, 3) the ability to time and manage water, and 4) control over the alfalfa harvest operation. These are not trivial challenges. Many growers do not have enough alfalfa or do not own or control the alfalfa that is adjacent to their own cotton acreage. Water management is difficult and at times costly to the grower. Most of all, many alfalfa growers are serviced by custom-harvest operations which cannot accommodate this selective cutting regime.

- Alt. Host Management (alfalfa seed): Alfalfa grown for its seed is a crop that has been re-introduced to Central Arizona during the last 2 growing seasons. It differs dramatically from forage alfalfa because of the longer grower season and the elimination of periodic cuttings. Alternate or strip-cutting therefore is not even an option. [Cuttings would help to destroy a portion of the *Lygus* population each time.] Thus, the longer seed-alfalfa season produces an ideal nursery for *Lygus* to grow unchecked except for chemical control. *Lygus* is a significant pest of seed alfalfa, and these growers do attempt to chemically control their *Lygus*. Unfortunately, this crisis is further exacerbated by the relative dearth of effective insecticides available to these growers. This, in turn, leads to excessive chemical practices which condition our shared *Lygus* populations to resistances to many of our chemistries. Furthermore, seed-alfalfa production utterly depends on pollination by bees (*Apis* & *Megachile* spp.) for an extended period of time. During this period, only very short residual insecticides may be used, and all are only marginally efficacious on *Lygus*. The result is seed-alfalfa, even under best management practices, with a tremendous capacity to supply our agroecosystem with an overabundance of *Lygus* preconditioned to overcome many of our key insecticides. In most cases, too, our cotton growers are different individuals from our seed-alfalfa growers, so little progress can be made in isolation. The presence of seed-alfalfa in a region may well effect cotton fields miles away (Silvertooth 1999).

- Alt. Host Management (safflower): Safflower is another host which is grown in AZ for its seed. It, too, is a prolific *Lygus* producer, but unlike seed-alfalfa, it is not affected economically by this pest. Thus, no measures are taken to mitigate the movement of *Lygus* from this nursery crop. As with seed-alfalfa, safflower growers tend to be different individuals from the cotton growers of an area. Recommendations do exist for the grower of both crops for timing one spray strategically in safflower to prevent *Lygus* movement out to cotton. With little economic incentive for the safflower grower, however, this tactic is not widely practiced. Even if it were, the list of *Lygus* active insecticides for safflower is extremely limited and it is further limited by PHI restrictions. Furthermore, even if an insecticide is well-selected and well-timed, control is incomplete and a migration of *Lygus* will still occur at some level. Safflower acreage ebbs and flows; however, acreage has increased in geographic distribution in the last 2 years affecting more cotton growers than in the past. This is in part due to the poor economic return of the alternatives.
- Resistant Varieties: Resistant varieties, *per se*, are not available in our current commercial or experimental germplasm. There is some suggestion that leaf hairiness may lead to some minor reduction in *Lygus* numbers. Unfortunately, however, whiteflies prefer varieties with leaf hair. A rather decided shift has occurred in the last 5 years to smooth-leafed varieties for this very reason.
- Cotton Management (cultural): One practice has been identified for crop management that constitutes cultural control for *Lygus*. "Early" planting in order to produce the crop before the onset of mid-season *Lygus* problems is the major tactic. Growers almost universally seek out the earliest agronomic window in which to plant. This advances the fruiting cycle relative to the normal onset of *Lygus* infestations. Note, however, 1998 and **1999 planting**

seasons are on record as 2 of the 3 worst years since 1987 meteorologically for planting cotton in AZ (Brown 1999). This is a primary factor in initiating this request. Another impractical tactic for limiting *Lygus* populations is through crop-water stress. *Lygus* tend to re-distribute to areas of lush, unstressed cotton growth. Unfortunately, this tactic is incompatible with the production of cotton in the irrigated desert. **Growers attempt to practice these cultural/crop management suggestions, but are still faced with uncontrollable, damaging levels of *Lygus*, especially when there are sufficient non-cotton sources of *Lygus* and poor planting conditions.**

- Crop Rotation — There is no apparent benefit of crop rotation to avoid or mitigate *Lygus* populations.
- Seed Treatments (Preventatives) — At or near planting treatments with various soil insecticides have been inadequate to prevent, substantially delay, or reduce *Lygus* infestations in cotton. In general these prophylactics (e.g., aldicarb, imidacloprid, disulfoton) have dissipated by the time of *Lygus* invasion usually 2–3 months later. This delay in onset of *Lygus* has led others to the spurious conclusion that these treatments "control" *Lygus*.
- Biological/Natural Controls — Natural controls in our current cotton (& seed crop systems) have been inadequate to control *Lygus*, especially in the context of repeated use of broad spectrum insecticides. Cotton is often the recipient of *Lygus* populations from prior crops, weeds or desert sources and as such is unlikely to be protected by indigenous or introduced biological control agents. Hagler and others prior to him have tried to use *Anaphes iole*, an egg-parasitoid, to control *Lygus*. Their work at this point is to better understand the movement potential of this parasitoid and the reasons why *Anaphes* does not readily forage in cotton. Mycoinsecticides have been field tested extensively in AZ while searching for *Bemisia* control agents. There are no consistent report of efficacy against *Lygus*. Our low humidity environment is not conducive to the efficacy of mycoinsecticides. Regent, especially at its relatively reduced rates, is far more selective against pest species than the compounds it may displace (e.g., Orthene, Vydate, Monitor).
- Insecticide Resistance Management — IRM plans have been proposed (Ellsworth 1998a); but they are dependent primarily on the various non-

chemical and chemical optimization tactics that are common to all IPM plans. That is, growers must avoid infestations whereever possible through various cultural means, and then sample and time effective chemistry according to well-established thresholds. Compound and rate selection is critical. Ellsworth (1998a,b) stated that "in most situations [routine], no more than two sprays should be used [i.e., necessary] against *Lygus* per season." This statement is among our most powerful evidence that we are currently suffering under a non-routine and emergency condition. Ellsworth (1999) treated *Lygus* 5 times last year in experimental plots. While even more distant from a seed-alfalfa source, Dittmar et al. (1999) showed that under commercial conditions and scale utilizing all available University recommendations and expertise, they had to spray 3 times against *Lygus* and still suffered increasing populations and yield loss (Fig. 2). The themes specific to chemical use and selection of our cotton IRM include limiting all active ingredients to no more than 2 uses per season, no mixtures and no pyrethroids for *Lygus* control, and reservation of key active ingredients for late season use (i.e., Orthene and endosulfan). **Unfortunately, these basic recommendations and practices are inadequate for mitigating unusual and non-routine levels of constantly invading *Lygus*.**

- Integrated Pest Management

IPM recommendations entail all of the above tactics and the observance of appropriate action thresholds for chemical use (Ellsworth & Diehl 1998). These recommendations have been implemented over the majority of Arizona cotton acreage in 1998. Though helpful in limiting insecticide use to the lowest practical limits, these thresholds were routinely surpassed in virtually all fields from July 15 to September 15 resulting in economic losses in yield and even threats to quality (Fig. 3). The Maricopa Agricultural Center's research farm cultivates 500 A of diverse crops (250 A in cotton) and endeavors to manage pests so as to limit influences on experiments. In 1998, the farm-wide average yield was ca. 1 bale/A, easily 1 bale below our historical and rather consistent farm average of 2–2.5 bales/A (Roth, pers. comm.). **The addition of Regent to our IPM arsenal will create opportunities to reduce risk of environmental expo-**

sure to other neuro-toxic insecticides, capitalize on natural controls, prevent secondary pest outbreaks, and maximize IPM and IRM benefits in cotton. Furthermore, it will provide growers with a longer-lasting, more effective, and more economical means for controlling *Lygus*.

In conclusion, there are no single, stand-alone, registered products which can control *Lygus* in cotton that is faced with unusual and non-routine invasions of this pest from external sources. Furthermore, putative multiple resistances may be further exacerbated by control measures taken against this pest outside the cotton crop (i.e., seed-alfalfa). Regent has been shown to be effective against multiple-resistant *Lygus* populations elsewhere (RP Cotton Reg. Subm., Sect. E, Table 13, pg. 9). With the addition of this GABA-inhibiting agent, we will have potentially three modes of action (Regent, Orthene/Vydate, endosulfan) that could be strategically deployed in a sustainable system of limited use of all three. Arizona has been on the forefront of IPM and IRM deployment in cotton, and this addition to our arsenal may well be the keystone to a more stable, multidimensional solution to a complex multiple-pest system. Even without Regent, we have a very successful *Bemisia* IRM and IPM strategy in place and widely practiced; however in spite of this, **there are no feasible, non-chemical or chemical tactics which can alleviate this emergency condition**.

6. Efficacy of Use Proposed Under Section 18 (166.20(a)(5))

Under the Section 18, we propose to limit the use of Regent to just two, non-consecutive, uses per season (total ≤ 0.1 lbs ai/A). This is well below the registrant residue-supported seasonal limit of 0.3 lbs ai/A, and signals the progressive thinking of our growers with respect to resistance management. It would do little good to our growers to receive unlimited access to Regent if only to suffer performance problems in the near future due to resistance. Furthermore, by specifying non-consecutive uses, we are assuring the usage of alternative chemistry to Regent against chronic *Lygus* problems. This will help conserve susceptibilities in *Lygus* to all chemistries. The two-use limit formalizes our attempts to limit all active ingredients to no more than 2 uses per season as part of our cotton IRM program. We further stipulate that the grower or his/her agent (i.e., Pest Control Advisor) must document the presence of at least 4 *Lygus* nymphs per 100 sweeps. This is supported by dozens of site-years worth of research that shows that economic control of *Lygus* is governed primarily by control of the nymphs. Our current *Lygus* threshold is 15-20 total *Lygus* per 100 sweeps; nymphs must be present with economic control assured when at least 30% of the total are nymphs. By requiring the PCA to document the presence of at least 4 *Lygus* nymphs per 100 sweeps (on our state's 1080 form), we are assuring that an active, reproducing, and economically significant population is present.

This proposed use pattern, the Section 18, and the IRM plan will be disseminated to growers and PCAs in a series of Cooperative Extension workshops to be conducted around the cotton-producing areas of the state:

- 17 June Yuma Co.
- 23 June LaPaz Co.

- 23 June Mohave Co.
- 29 June Pinal Co.
- 6 July Maricopa Co.
- 7 July Graham Co.
- 13 July Pima Co.

These workshops have been proven as effective tools of dissemination and teaching. Arizona cotton has an outstanding recent history in gaining compliance to Section 18 requirements as demonstrated in the successful Section 18 educational campaigns associated with the introduction of pyriproxyfen (Knack) and buprofezin (Applaud) starting in 1996 for cotton and buprofezin in 1998 for melons (ref.).

Fipronil has been in development by Rhône-Poulenc since 1989. The evidence for its efficacy is voluminous and well-documented in their cotton registration submission (see RP Cotton Reg. Subm., Sect. E., 23 pp.). In addition to *Lygus*, fipronil has proven efficacy against thrips, boll weevil, and fleahoppers. Of most importance given the unusual control dynamics of our *Lygus* species is the documentation of efficacy of our proposed use in Arizona. These studies are summarized below (Ellsworth et al. 1998b, 1999; Ellsworth 1999).

Briefly, Ellsworth and his colleagues have demonstrated through a series of small plot and commercial-scale replicated studies that Regent is, in fact, very effective against *Lygus hesperus* in Arizona. Furthermore, they showed that a rotational program that incorporated one use each of Orthene, Vydate and Regent provided for control and yield protection that was superior to 5 repeated uses of an array of registered and new chemistries both alone or in mixtures. These experiments were conducted over two seasons under completely different production scenarios. In 1997, production of cotton was very early and summer conditions were ideal for boll set. Under these conditions, *Lygus* tend to arrive later relative to the fruiting cycle and therefore have a smaller damage potential. In spite of this asynchrony, Ellsworth et al. (1998b) was able to detect significant and economic differences in yield and *Lygus* control where Regent was used three times compared to an array of new and registered chemistries. **Regent at the full rate had the highest yield in this test**. In addition, even the half rate of Regent was not significantly lower in yield than the more costly full rate of Orthene (Fig. 4). In 1998, however, plantings and plant growth were delayed by a cool, wet spring. The fruiting cycle was displaced towards a much later period and exposed to a more protracted, continuous invasion of *Lygus* from seed-alfalfa and other sources (much like is expected in 1999). Now instead of the 1 or 2 sprays that were considered typical for the control of *Lygus* in 1997 (Ellsworth 1998a,b), 5 or more sprays were required to “control” *Lygus*. The repeated regime of Regent controlled *Lygus* very well; however, yield was just below that of Vydate or Orthene regimes. This, however, is a case in point for avoiding repeated use. Ellsworth (1999) noted that this reduction was due to the premature defoliation caused by mite resurgence that became apparent in the excessive Regent regime. The rotated “program” using only 1 Regent spray showed no signs of mite resurgence. Evidence of Regent’s superior level of *Lygus* control relative to our current standards is found in examination of lint turnouts and seed index (=weight of 100 ginned seeds) for the same test. **The Regent regime had the highest % lint turnout (Fig. 5) and the smallest seeds (Fig. 6) indicating that carbohydrates were apportioned to more fruiting forms than in the other treatments**. Ellsworth (1998) concluded that these were indirect measurements of *Lygus* control, and this suggests that Regent performed even better than the Orthene or Vydate repeated regimes.

In a commercial-scale, replicated, EUP trial, Ellsworth et al. (1999) found that Regent used only twice performed better than Vydate and at least as good as Orthene, both used three times and at their highest labelled rates. This would suggest that the residual of Regent is substantially greater than the existing alternatives, in spite of excessive *Lygus* pressure in this test. Furthermore, Regent yields were not lower than the other two treatments and significantly higher than the untreated check. They also concluded that Regent's efficacy against adults is better than either other compound.

Yield and efficacy data from 1997 and 1998 as well as collateral data in 1998 on lint turnouts and seed indices suggest that Regent is not only superior in effect than our current chemistry, but superior to all the new, unregistered chemistries that were also tested. **Regent is truly the only hope for Arizona cotton growers to mitigate this crisis situation that has developed as a result of a myriad of changes in our crop ecological and pest control systems over which is laid a very late, poor spring meteorologically and a bleak economic forecast**. This combination of factors will likely give rise to the production of cotton (square and boll set) during a period in which we will see huge invasions of *Lygus* from non-cotton sources. Growers cannot currently control *Lygus* economically without the use of Regent (see B5).

7. Expected Residue Levels in Food (166.20(a)(6))

Residue data were developed for Regent 80 WG, and petitions for tolerances on cotton and other crops are on file with EPA. The proposed maximum residue limits for fipronil (and its metabolites) are 0.05 ppm in cotton seed and 3.0 ppm in ginning by-products (RP Cotton Reg. Subm., Sect. D-3, pg. 11). The residues and environmental fate of this compound are well understood and should pose no problem for the use pattern that is proposed.

8. Risk Information (166.20(a)(7))

a. Description of Application Sites: All proposed uses will be on cotton acreage afflicted by *Lygus* bugs. These areas are generally not associated with sensitive areas, riparian habitat, or endangered species, but are routinely sprayed with neurotoxic insecticides.

b. Possible Risks Posed by Use: The use of Regent will likely result in **reduced risk** to human health, endangered or threatened species, beneficial organisms, and the environment relative to current insecticide use patterns. Regent has differential toxicity to avian species and is essentially nontoxic to some species. Galliformes are particularly sensitive to this compound; however, fipronil has been shown to be significantly repellent to members of this order. This would seem to mitigate any risk of ingestion in these sensitive species. No significant mammalian effects have been found. Regent is not nor contains any probable or suspected human carcinogens. It is not mutagenic or teratogenic. Regent should not prove to be mobile in the environment. Eco-toxicology data are summarized in Support Document, Section C. Acute toxicity of the active ingredient, fipronil, is moderate: Category II for acute dermal, oral, and inhalation. Fipronil is highly toxic to some aquatic invertebrates. Regent is apparently no more toxic to beneficial arthropods common to the cotton system than the uses we seek to replace (Ellsworth, unpubl. data).

c. Proposals To Mitigate Risks: Appropriate protective clothing is listed in the proposed labelling provided by the registrants (see Support Document, Section B, pg. 2). Regent has a 12 hr. re-entry period. Risk of exposure to neurotoxic insecticides (especially pyrethroids, organophosphates and carbamates) will be reduced through the use of this product. We see this as an excellent opportunity to reduce the overall pesticide load on cotton while selectively reducing neurotoxic broad-spectrum insecticide use, due to the relative specificity and efficacy of this product.

9. Coordination with Other Affected Agencies (166.20(a)(8))

Please see separate sheet for list of endangered or threatened species.

10. Notification of Registrant (166.20(a)(9))

Please see attached letter located in Support Document, Attachment D.

11. Enforcement Program (166.20(a)(10))

The Arizona Department of Agriculture is the lead agency in the state for enforcement of pesticide use within the state except for structural uses (ARS 3-361 et. seq.). Concerning tracking the number of applications of Regent, the Arizona Department of Agriculture and the Arizona Cotton Research & Protection Council would combine their data on pesticide use reports and statewide field map information to randomly monitor fields.

Monitoring and enforcement will be accomplished through the state's 1080 system of reporting/tracking pesticide use and permitting system for unregistered compounds. The Arizona Department of Agriculture (ADA) currently monitors and enforces other pesticide regulations in this way. The Arizona Cotton Research & Protection Council currently oversees the usage of the IGRs on over 250,000 A of Arizona cotton. Their system of recording and tracking 1080s and of mapping the entire state's cotton acreage (for plowdown compliance and other boll weevil measures) will be used to track field-by-field Regent use. ADA will then monitor compliance with the two uses (non-consecutive) per season limitation.

We would further bolster this effort through an educational campaign supported by the growers of this state (Arizona Cotton Growers Association and Cotton Research & Protection Council), state regulators (Arizona Department of Agriculture), the registrant, and The University of Arizona Cooperative Extension system. A Cotton Monitoring & Management Workshop series will serve as the vehicle for rapid dissemination of Section 18 and Regent use requirements as well as *Lygus* management education. This will ensure that users are fully aware of the IPM, IRM, and regulatory issues surrounding the use of this compound. Our educational effort will focus on indications of first use (i.e., thresholds for nymphs and adults), alternate chemistry requirements, and resistance and pest management. Lastly, we will provide for thorough discussion of resistance risk, our responsibility as product stewards, and presentation of our recommended IRM plan which will include the use of registered materials as well.

A combination of educational programs, a system of PCA training and regulatory safeguards should result in the use of no more than two, non-consecutive applications of Regent per season in any given field. This plan is endorsed by the AZ Cotton Growers Association, AZ Cotton Research & Protection Council, AZ Department of Agriculture, USDA, University of Arizona, Cotton Incorporated, and the registrant. Furthermore, our opportunity and flexibility to manage *Lygus* populations effectively, efficiently and with reduced environmental hazard should be greatly enhanced while minimizing risk of resistance to this compound and perhaps resurrect the efficacy of other compromised chemistries through a reduced use strategy.

12. Repeat Uses (166.20(a)(11))

No previous use requested.

13. Progress Towards Registration (166.25(b)(2)(ii))

The registrant has submitted a full cotton registration package as of 4/22/97 and this, along with their letter of support (Support Document D), serves as evidence towards registration.

B1. Name of Pest (166.20(b)(1))

a. Scientific Name: *Lygus hesperus* Knight

b. Common Name: Western Tarnished Plant Bug (a.k.a. *Lygus* bug)

B2. Circumstances that Caused the Emergency (166.20(b)(2))

Lygus is not a new pest to our region; however, a complex of crop ecological, meteorological, economic, and pest control factors have led to its increase in prominence, especially during years of delayed planting. Ellsworth (1999) documents many of the factors which have led to this change in impact of this otherwise perennial pest. Briefly, they are

1) Pest Control, the introduction &widespread adoption of selective pest control technologies:
•'Bt' transgenic cotton for Pink Bollworm control (1996), and
• the insect growth regulators, pyriproxyfen and buprofezin, for whitefly control (1996).
2) Crop Ecology, the introduction and/or increase in distribution of ideal *Lygus* nursery crops:
• alfalfa production for seed in central Arizona (1997), and
• production of safflower for seed in the Yuma Valley (1998).
3) Weather, 1998 and now 1999 are the number 2 and number 3 'worst' planting years
• which delays planting (see Brown 1999), and
• places a greater portion of the fruiting cycle in synchrony with *Lygus* invasions.
4) Economy, cotton prices at a historical all time low around $0.50–0.60 / lb lint:
• inadequate to support the currently deficient *Lygus* control program,
• creates even greater hardship on growers who will suffer significant collateral losses.

A summary of inputs and crops losses to this insect are documented in Table 1. The losses and costs of control attributed to *Lygus* are masked in some years by the control practices and losses associated with other pests. However, it should be noted that during the 3 "worst" planting years in the last 13 (1991, 1998, 1999) (sensu Brown 1999), we have experienced some of our most severe *Lygus* pressures. In 1991, we sprayed a statewide average of 3.3 times against *Lygus* but sustained only a moderate amount of damage (1.64%). In 1998, we had the second highest number of sprays against *Lygus* in the decade (2.76) and the highest control costs (55.20$/A) and largest yield reductions as a result (7.00%)! **Furthermore, there were individual fields that received in excess of 6 sprays against *Lygus* and suffered more than a 20% loss**. This suggests two things. Meteorological assessments of spring weather provide some predictive capability as to the risk of exposure of our fruiting cycle to damaging pests. Second, control measures escalated dramatically in 1998 without a concomitant protection against yield loss. In Brown's (1999) analysis, he projects that 1999 is a similarly "bad" spring weather year. Thus, our weather conditions which have in fact resulted in a protracted and much delayed planting are setting our crop up for high risk of exposure to damaging pests, like *Lygus*. This coupled with the significant changes in crop ecology in Arizona (seed-alfalfa and safflower acreage) and the unusually dire economic climate, we believe that *Lygus* will pose a serious, non-routine, crisis threat to our production.

B3. Additional Benefits Information

Fipronil belongs to the novel class of chemistry, phenylpyrazoles, which was discovered by Rhône-Poulenc. Fipronil's mode of action is unique. It affects GABA neurotransmission via contact or ingestion. Its low use rates (0.05 lbs ai/A) are well below those of our primary *Lygus* insecticides (0.75–1.0 lbs ai/A for Orthene, Monitor, or Vydate, and 1.0–1.5 lbs ai/A for endosulfan). This provides storage and worker safety benefits over our older, broadly toxic compounds. Benefits to resistance management are clear and cannot be overstated (see below). Regent use would lower the overall number of treatments and therefore exposures of our *Lygus* populations. The impact on pest resistance is not limited to *Lygus*, because Regent use would help us limit the use of strategic *Bemisia* insecticides which still constitute key active ingredients in Stage II and Stage III of our IRM program (i.e., Orthene and endosulfan) (Ellsworth et al. 1996; Ellsworth & Watson 1996). It is a safer chemistry to key beneficials, especially in comparison to the uses it serves to replace or limit (e.g., Orthene, Vydate, Monitor, and high rates of endosulfan). The addition of this one unique and effective mode of action will significantly affect the stability of our IRM for all chemistry and pests. Arizona is innovating programs for pest and resistance management (e.g., Palumbo et al. 1999); however, growers faced with a devastating pest problem, such as relentlessly invading *Lygus*, will be forced to abandon the many chemical use practices that we currently recommend if this request is not granted. No significant risk should be associated with the proposed use.

Resistance Management

Ample evidence exists in our local literature that *Lygus* has the propensity to overcome insecticides through resistance (Dennehy & Russell 1996, Russell et al. 1997, Dennehy et al. 1998). Furthermore, this resistance appears as a mosaic across and within regions suggestive of a phenomenon that is reflective of field-level practices. PCAs were forced in some cases last year to treat fields as many as 6–10 times for *Lygus* using as much as 7 lbs of Orthene over the course of the season. There is only a limited diversity of chemistry available: potentially only two functional classes (organophosphate/carbamate or cyclodiene). Under conditions of synchrony of the fruiting cycle with large and persistent invasions of *Lygus*, there is no way a producer can select or rotate chemistry rationally to avoid overuse of any one active ingredient. Our current IRM for all chemistry and all pests of cotton recommends a limit of no more than two uses of each active ingredient with the whole pyrethroid class treated as a single active ingredient.

Sustainable resistance management is an explicit goal of our grower community in AZ. Their progressive thinking and cooperation with the scientific and industrial communities has led to an innovative program for limiting the usage of two valuable active ingredients, buprofezin and pyriproxyfen. This program has led to the preservation of all *Bemisia* chemistry in the control of this pest. Bt cotton, too, has drastically changed the cotton landscape in AZ. Many of the harsh adulticidal programs directed at PBW moths are no longer needed except on a very limited acreage of non-Bt cotton. Together these two sets of technologies, Bt cotton and IGRs, have led us to a system that has the potential of foregoing **any** broad-spectrum conventional insecticides on a vast number of acres. However, one pest now stands in our way, *Lygus hesperus*. Due to limitations of its biology, taxonomy, and feeding habits, we do not have active development of insecticidal technologies for plant bugs. Consequently, we have had to over rely on just a few, old, active compounds which are very broad-spectrum in nature. This overreliance has contributed to the crisis that we now face. Even in years of ostensible resistance recovery and lower *Lygus* pressures, Russell et al. (1997) found that “Central Arizona *Lygus* are some of the most refractory to insecticides in the State.”

Lygus may have been sustainably managed through alternate host management and strategic chemical control at one time. In this system, as suggested by Ellsworth (1998), the vast majority of infestations could be controlled through the use of active products just 1 or 2 times. Unfortunately a significant shift in our crop ecology has reduced our ability to manage non-cotton sources of *Lygus* and at the same time vastly increased the reproductive potential of this pest. This combined with the unfortunate timing of the last 2 year’s planting season will likely lead to a repeat of 1998. That is, the production imperative of 4–8 applications targeted against *Lygus*. **There is virtually no combination of existing chemistry used this frequently that will mitigate or prevent resistance, let alone control the pest adequately.**

New insecticide chemistry, with a new mode of action, is needed in Arizona cotton to help prevent the further buildup of resistance to current insecticide chemistry. Also, there is a strong possibility that the current chemistry available to cotton growers at this time will not be adequate for the 1999 season, as happened locally in 1998. **Fipronil offers a new mode of action to control *Lygus hesperus*, has proven to be effective in tests conducted in AZ, and is a product that could help formulation of a sustainable IRM and IPM program for all chemistries and all pests of AZ cotton**.

Other Benefits

Ellsworth (1999) identified a suite of benefits associated with *Lygus* control specifically associated with Regent use. Better *Lygus* control reduces or potentially eliminates the need for the chemical input, Pix® or other plant growth regulators (see Economic Analysis). This, in turn, leads to a more efficient, "once-over," clean defoliation. This eliminates the need for additional chemical defoliants limiting environmental risks further. The cleaner defoliation reduces leaf trash and dust (additional environmental contaminants), and a higher lint turnout can be expected. Ellsworth & Naranjo (1999) also showed that lint contamination (Fig. 3), either through green leaf trash directly or through the additional production of *Bemisia* honeydew on rank cotton, was reduced by 71% where *Lygus* were effectively controlled. Alternatively, if *Lygus* persist and control is lost, AZ could suffer huge market penalties for producing "sticky" cotton that is normally associated with whiteflies. While it remains unknown and unmeasured, it is conceivable that high *Lygus* pressure, which can wound small bolls, could elevate aflatoxin levels in cotton seed. This has a drastic impact on the cost and marketability of seed for the dairy industry and itself represents another environmental hazard. Ellsworth (1999) measured as much as a five-fold increase in cotton yields where *Lygus* were controlled best even though losses were still evident. Increased yield, reduced chemical inputs (and concomitant environmental and health risks) in the form of plant growth regulators and defoliants, higher lint turnouts, and less leaf trash and lint contamination significantly enhance the profitability of cotton in AZ. Furthermore, with Regent's superior activity on adults, its longer residual, and competitive pricing, growers will be able to realize a significant savings over our existing deficient program for *Lygus* control.

B4. Discussion of Economic Loss (166.20(b)(4)

Economic losses to *Lygus* bugs in 1998 are well-documented (Table 1) (Ellsworth 1999; Ellsworth & Naranjo 1999; Dittmar et al. 1999). *Lygus* attack the yield component directly and have the capacity, if left unchecked, to remove virtually all fruiting sites on the plant. In 8 years of insecticide testing on the Maricopa Agricultural Center's research farm, the untreated checks in dozens of site-years commonly yielded at least 1.5 to 2.0 bales / A, in spite of heavy damage by whiteflies and other pests including *Lygus* (Ellsworth, unpubl. data). However, in 1998, the UTC in studies reported in Ellsworth (1999) yielded as low as 0.4–0.5 bales/A. These reductions in yield are completely attributed to *Lygus*. Sadly, economic loss is not limited only to the elimination of fruiting sites (i.e., lower seedcotton weights). A whole host of factors are also negatively affected and are documented in the previous section. **Based on control costs and yields alone, *Lygus* have a greater capacity to reduce profitability in cotton in AZ than any other pest**.

Regent use would significantly lower overall control costs, limit repeated uses of all chemistry, extend the residual control of *Lygus* nymphs and adults, and reduce the direct and collateral losses associated with *Lygus*. A complete economic analysis is provided in the Arizona Attachment D.

B5. Estimated Revenues for the Site (166.20(b)(4)(ii) and (iii)

a. With Next Best Available Control — See Arizona Attachment D, #3&5
   Gross Revenue: 876.00 per Acre
   Net Revenue: [50.00] per Acre

b. With Requested Chemicals — See Arizona Attachment D, #6&8
   Gross Revenue: 908.00 per Acre
   Net Revenue: 53.00 per Acre

List of References ('C' denotes copy included in Arizona Attachement E)

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Table 1. *Arizona statewide average* Lygus *control and loss statistics (1990–1998).* Columns in order are: the number of foliar sprays made to control *Lygus*; the costs of the *Lygus* foliar spray program; the percentage of the total foliar insect control costs that were dedicated to *Lygus* control; the loss associated with *Lygus* averaged over the entire state and in spite of controls; the percentage of the total insect losses that were as a result of *Lygus*; the amount of money lost in production alone to *Lygus* statewide (adapted from Head 1991–1993; Williams 1994–1999). From Ellsworth, 1999.

Year	Applications (No. / A)	Cost of Control ($/A)	% of Total Insect Control	Yield Reduction (%)	% of Total Insect Losses	Crop Loss ($ millions)
1990	1.90	17.10	15.0	0.95	15.8	2.9
1991	3.30	33.00	31.4	1.64	51.6	5.8
1992	0.50	5.00	4.1	0.12	1.2	0.3
1993	0.20	2.60	3.7	0.50	11.3	1.3
1994	1.20	14.40	10.4	4.81	45.5	10.6
1995	2.30	27.60	12.8	6.08	70.1	17.4
1996	1.26	25.25	22.7	4.75	47.5	16.2
1997	2.10	37.67	35.0	2.63	41.4	8.4
1998	2.76	55.20	53.4	7.00	78.3	16.4

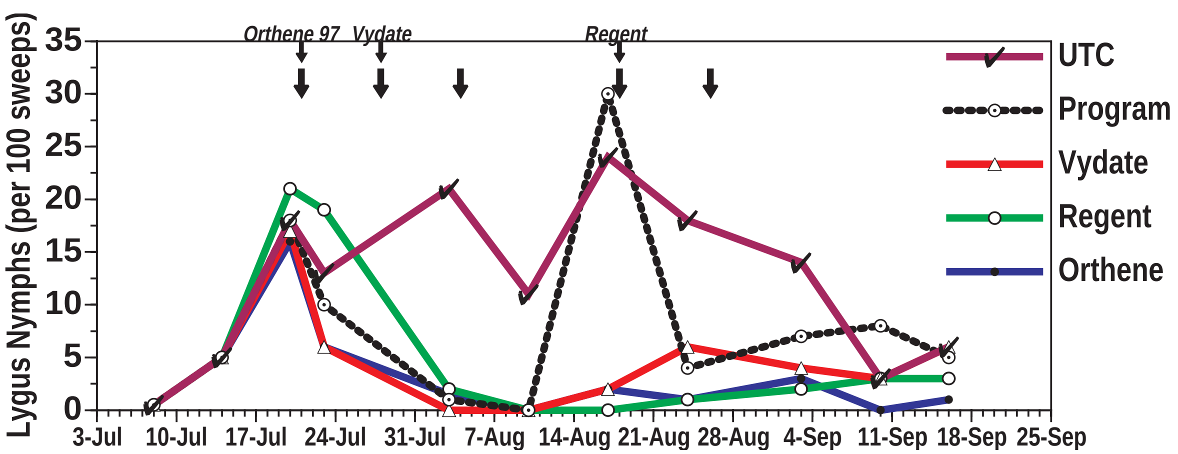

Figure 1. *Number of* Lygus *nymphs per 100 sweeps (± SE) in response to selected insecticides in a small plot trial, Maricopa, AZ.* Sprays for the 3 repeated treatments (Orthene, Regent, Vydate) are indicated with large arrows. Sprays for the 'Program' (Orthene fb Vydate fb Regent) are indicated with small arrows. Note the large increase in nymph levels in the Program when no sprays had been made for 21 days. Then, note the subsequent, excellent activity of the Program (Regent spray) in suppressing nymphs relative to the static and even increasing levels after the fourth sprays of the repeated regimes. Most disturbing is the dramatic increase after the fourth Vydate spray, especially when considering that the UTC was declining at that time. UTC=Untreated Check. From Ellsworth, 1999.

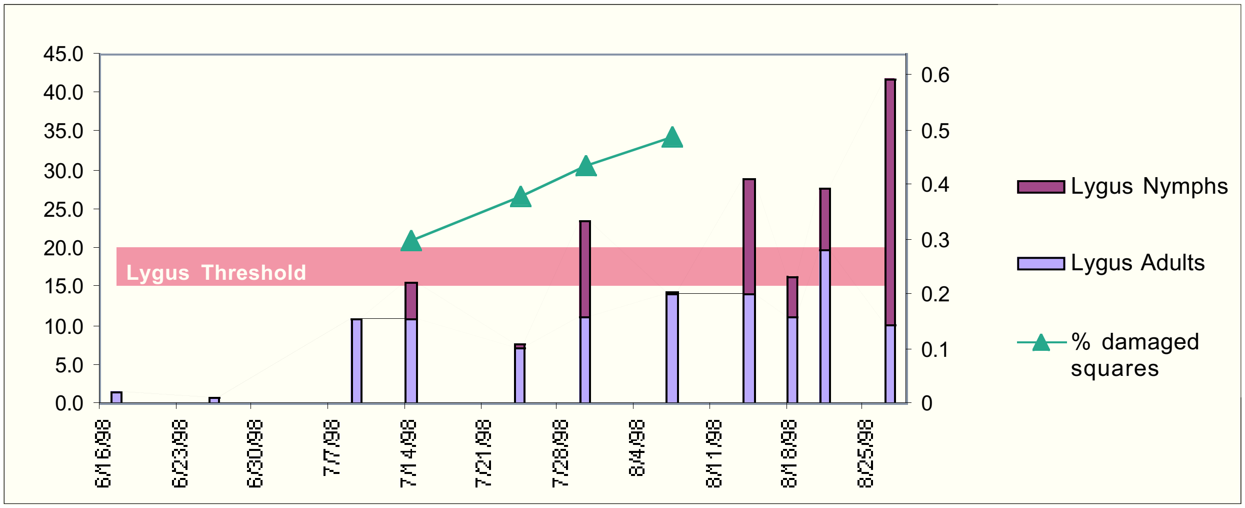

Figure 2. *Number of* Lygus *per 100 sweeps and percentage damaged squares in a 51 A Demonstration of University recommended Integrated Crop Management practices*. In spite of following the best available IPM and ICM recommendations, the field still had to be sprayed three times with full rates of insecticides for *Lygus* control. In spite of the bi-weekly regime, *Lygus* numbers continued to increase never returning below threshold after 14 July. Furthermore, the levels of damaged squares increased each sampling period in spite of the *Lygus* management program. Sprays were finally discontinued, because they were deemed uneconomical. From Dittmar et al., 1999.

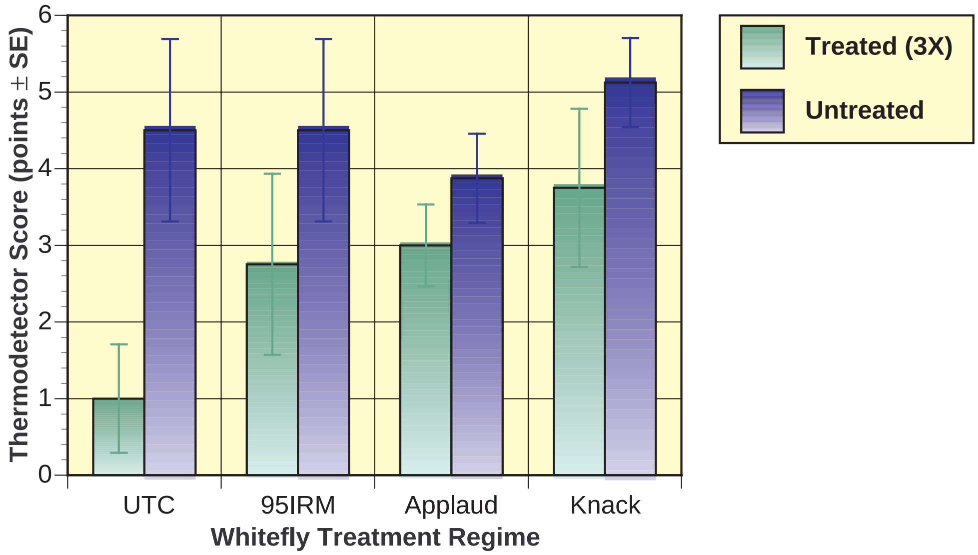

Figure 3. *Manual thermodetector (TD) scores (no. of sticking points ± SE) in response to SWF treatment regime and* Lygus *control, MAC 1998.* Only one spray against SWF was made season long. '95IRM' was sprayed with endosulfan (0.75 lb ai/A) + Ovasyn (0.25 lb ai/A). *Lygus* bugs were sprayed 3 times (Vydate C-LV, Orthene, Vydate C-LV; each at 1 lb ai/A) or not at all. TD scores were not significantly different among SWF regimes (P>0.10). However, TD scores were ca. 71% higher in *Lygus*-untreated versus treated regimes (P=0.03). The average difference was < 2 points and could have been related to the increased trash in the *Lygus*-untreated regimes or increased whitefly harborage due to the excessive vegetative condition of these plots. From Ellsworth & Naranjo (1999).

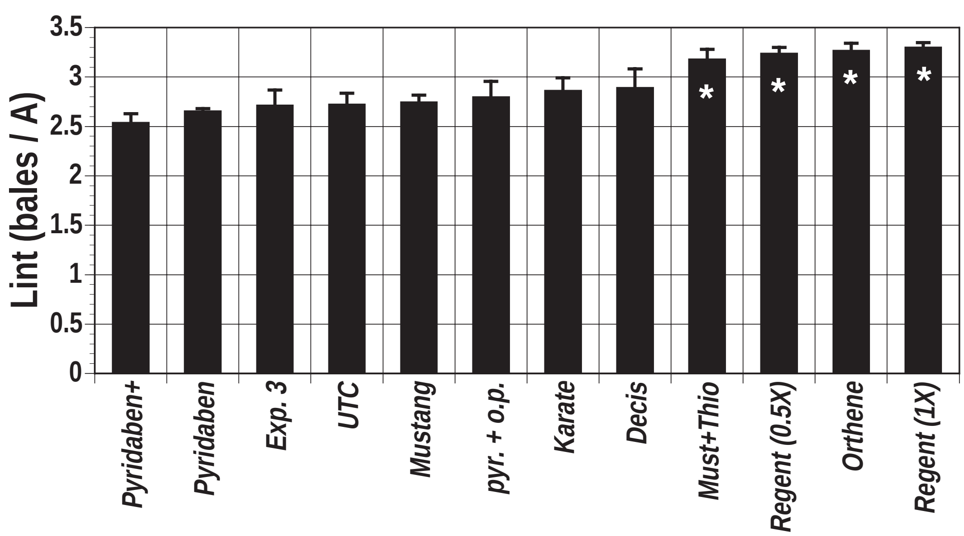

Figure 4. *Yield responses to experimental & pyrethroid* Lygus *chemical controls, MAC 1997.* * = significantly different from the untreated check (Dunnett's Test, P < 0.05). All others are not significantly different from each other or the check. Regent at the full rate outyielded all other treatments. Abbreviations: Pyridaben+=Pyridaben+surfactant, Must=Mustang, Thio=Thiodan, pyr+o.p.=experimental pyrethroid + organophosphate premix. From Ellsworth et al. 1998b.

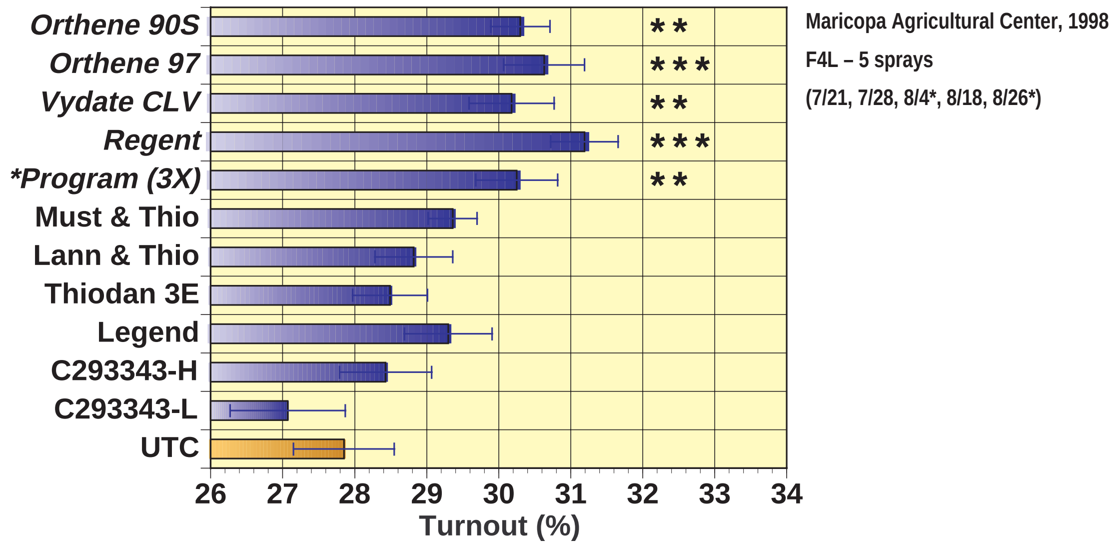

Figure 5. *Lint turnout (% ± SE) in response to various insecticides in a small plot trial, Maricopa, AZ.* Five sprays were made against *Lygus* except for the 'Program' which was skipped on two dates ('*'), but sprayed with a rotation of products (Orthene 97 fb Vydate, fb Regent). Treatments indicated ('*') are significantly different from the UTC by orthogonal contrasts (*=P<0.05; **=P<0.01; ***=P<0.001). Turnouts were highest where *Lygus* control was best. The average difference between the top five treatments and the remaining treatments was ca. 2% with Regent having the highest turnout (over 3% higher than UTC). UTC=Untreated Check. From Ellsworth, 1999.

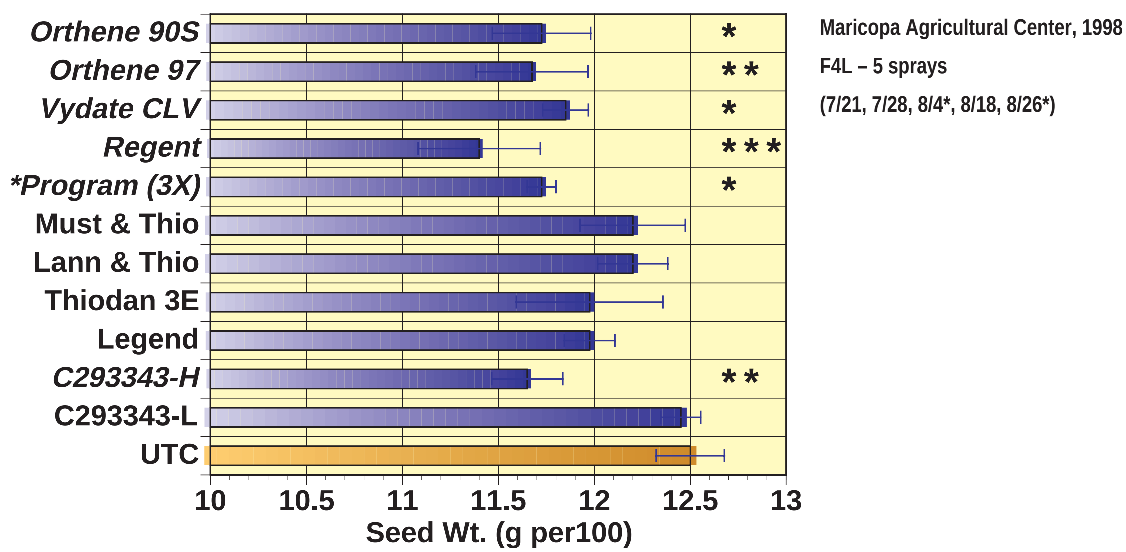

Figure 6. *Seed index (g per 100 ginned seed ± SE) in response to various insecticides in a small plot trial, Maricopa, AZ.* Sprays and statistics were as described above (Fig. 5). The top five treatments had ca. 4% lighter seeds than the remaining treatments. With more boll sinks to fill in the best performing *Lygus* treatments, carbohydrates were more evenly distributed among more, smaller-sized seeds. The Regent treatment had the smallest seed index (ca. 9% lighter than the UTC), indicating the best level of control. UTC=Untreated Check. From Ellsworth, 1999.