Economic Impact of Lygus in Arizona Cotton: A Comparative Approach

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Abstract

In the Western U.S., Lygus *spp. (Hemiptera: Miridae) can cause major losses to cotton, vegetables, seed crops, and a variety of other crops. However, the economic impact of this pest remains largely undocumented in most crops. Two major data sources were used to quantify the economic impact of* Lygus *in low-desert upland cotton production in Arizona: a statewide Pesticide Use Reporting ("1080") database and an annual "Cotton Insect Losses" (CIL) survey of cotton Pest Control Advisors (PCAs). Both data sources include information on the target pest for insecticide applications, making it possible to single out* Lygus *control efforts. PUR data, based on information submitted by applicators to the Arizona Department of Agriculture, provides quantitative information on a high proportion of* Lygus *applications in cotton, but is incomplete, since not all types of applications require reporting. These data are complemented by information from the CIL survey to provide a more complete picture, based on direct responses from PCAs about their pest management practices. While the 1080 database is very useful in documenting a high proportion of* Lygus *insecticide use in cotton, by definition, these data on their own cannot provide good estimates of statewide behaviors with respect to* Lygus *management. In contrast, this is exactly what the Cotton Insect Losses survey is designed to do.*

As indicated by 1080 data and CIL data from 2001 to 2005, Lygus *is the most important pest in Arizona cotton most years, based on application*acres of all foliar insecticides. Other key pests by this measure are sweetpotato whitefly, Bemisia tabaci Genn., and to a lesser extent pink bollworm, Pectinophora gossypiella (Saunders). Whitefly is the most important* Lygus *co-target, when applications are aimed at controlling more than one pest. The most commonly used foliar materials against* Lygus *in Arizona cotton are acephate, endosulfan and oxamyl, and they are typically used at about 90% of maximum label rates. About 80% of* Lygus *applications occur between mid-July and late-August.*

Average spray intensity (based on average sprays per acre) was calculated independently using the CIL and 1080 data sets and compared. For every year except for 2004, the CIL data estimates a somewhat higher insecticide use against Lygus *. Several reasons for this discrepancy were identified, including less than 100% pesticide use reporting on 1080s; differences in the insecticides included in the estimates (top three active ingredients only for 1080 estimate, all insecticides for CIL estimate); and differences between how the two datasets apportion a single spray event among multiple pest targets.*

The intensity of Lygus *management varies by county, based on 1080 data and county-level information on cotton acreages. Pinal county, which has the most*

cotton acres, shows the highest sprays / acre of the top three active ingredients to control Lygus *. Analysis of 2005 1080 data at the section level indicates a relationship between the proportion of sections where cotton is grown in a Township - Range and spray intensity for* Lygus *control. Growers in Township - Ranges with a low proportion of cotton sections (10–15%) tend to make more sprays per field to control* Lygus *. However, Township – Ranges with the lowest and highest proportions of cotton sections (<10% and >90%) tend to show trends of lower spray requirements for* Lygus *control. These data suggest the possibility that landscape factors can influence* Lygus *populations at the local level, although more research in this area is needed.*

Lygus *is perhaps the most significant economic pest of Arizona cotton. Cotton Insect Losses survey data indicate that a high proportion of cotton insect pest management efforts are directed toward* Lygus *control. Up to 40% of foliar insecticide sprays target* Lygus *, for about one third of the foliar insecticide budget for growers most years. Despite these control efforts and associated costs,* Lygus *are consistently listed in the CIL by survey respondents as the most damaging insect pest of cotton, accounting for more than 50% of insect-related yield loss most years.*

These two different and complementary data sets provide important baseline information on the current status and economic impact of Lygus *in Arizona cotton, which will be useful for measuring changes in* Lygus *impact and control practices over time. A number of factors could potentially impact these practices in the future including (1) the introduction of new selective chemistry for* Lygus *control; (2) the introduction of transgenic control options for* Lygus *; and (3) landscape-level changes that can have area-wide impact on* Lygus *management in cotton and other crops. These data underscore the need for continued research to develop effective, selective tools for improved* Lygus *management in cotton, and to integrate these into effective IPM programs. Data documenting a pest's economic impact provides a rationale for funding to support critical IPM research and education. There is a need to similarly document the economics of* Lygus *management in other crops including vegetables, seed crops, and alfalfa, and the impact of landscape-level factors on* Lygus *management in a variety of crops.*

Methods

Our analysis throughout this paper is based on two data sources: Pesticide Use Reporting (PUR) data originally collected by the Arizona Department of Agriculture (hereafter referred to as "1080 data"), and a "Cotton Insect Losses" (CIL) survey of PCAs, Extension personnel and other end-users of pesticides. The 1080 database and CIL survey provide two different but complementary data sources for measuring pest management practices. Drawing on these two data sources, we provide an analysis of insecticide use for *Lygus* control in cotton and the economic impact of this pest.

Pesticide Use Reporting Database ("1080 data")

These analyses were made possible by the existence of a statewide Pesticide Use Reporting database, available as a result of state reporting requirements. The Arizona Department of Agriculture (ADA) requires applicators to report all pesticides that are applied for hire (i.e., custom), applied by air, that are under Section 18 and 24c exemptions, or that are listed on Arizona's Department of Environmental Quality's Groundwater Protection List, as well as all restricted use and certain odoriferous pesticides. These data are submitted (on form L1080) and entered into a pesticide use reporting (PUR) database by the Arizona office of the National Agricultural Statistics Service (AZ-NASS), processed, and then sent to the Arizona Pest Management Center (APMC) of the University of Arizona for post-processing and use in research and education. We have verified and refined the resulting "1080 data" for 2001 to 2005. Variables incorporated into the 1080 database include location of application (township, range and section), target crop, product applied, rates, and target pest(s) for an application. The geographic component makes it possible to integrate 1080 data with GIS cotton field maps to generate statistics on landscape impacts on spray intensity. Although certain kinds of applications may not be included in the data (e.g., non-custom, ground applications), our initial estimate for *Lygus* was that at least 70-90% of statewide applications in cotton are represented. (Percentages for other pests varies greatly, e.g., such as herbicide use for weed control). This estimate, based on timing of *Lygus* applications, compounds used, and relationships to the CIL survey data, has been confirmed through this analysis (see Discussion). While the 1080 database is very useful in documenting a high proportion of *Lygus* insecticide use in cotton, by definition, these data on their own do not directly estimate statewide behaviors with respect to *Lygus* management. In contrast, this is exactly what the Cotton Insect Losses survey is designed to do.

Cotton Insect Losses Survey

The Crop Insect Losses and Impact Assessment Working Group (CILIAWG), a collaboration of Extension scientists funded by the Western IPM Center, strives to develop "real world" data on insecticide use patterns, costs, target pests, and yield/quality losses due to key insect pests for a variety of crops in Arizona and adjacent low desert regions of California. This is done through a series of interactive, face-to-face stakeholder workshops involving Pest Control Advisors (PCAs), growers, industry representatives and Extension professionals. We enlist the participation of representative PCAs from throughout the appropriate growing regions, and follow-up with mail surveys to those who cannot attend, to develop the most sound data possible. Currently, the group develops data on cotton, head lettuce and melons, and is developing a pilot instrument for alfalfa. These data allow us to build relevant databases for measuring user behaviors and adoption of new IPM technologies and are our most objective tools for assessing change in our systems. Our CIL questionnaire has been adapted from the National Cotton Council Annual Beltwide Cotton Insect Losses Survey (established in 1979) and expanded to include additional questions on insecticide use patterns and target pests (Ellsworth & Jones 2000, 2001a).

Value and Constraints of the Analysis

While the 1080 database and the CIL survey provide rich information for understanding user *Lygus* management practices and the economic impact of this pest, there are some important data constraints that affect our analysis. First, we have limited our analysis to foliar insecticide sprays and do not include seed treatments, soil-applied materials, biotechnologies or associated user fees.

Both the 1080 database and the CIL survey provide information about the target pest for an application, but these data are recorded in significantly different ways that make direct comparisons difficult. The L1080 form completed by users allows them to list multiple pest targets for a single application. Up to four pest targets per application are entered into the 1080 database, but there is no way to determine or apportion the spray *intention* appropriately among the listed pests. For example, a single application of endosulfan may, in the mind of the user, be primarily applied to control *Lygus*, but he or she may also list sweetpotato whitefly and aphids as co-target pests. Should this application be counted as one application against *Lygus*, one against whitefly, and one against aphids, or should it be counted as 33.3% of an application against each pest? How applications are "apportioned" among co-target pests will affect the analysis. We have chosen in our approach to count each application against each pest as a full application, meaning that any application that included *Lygus* as a target pest was counted as one application against *Lygus*, and one application against each additional co-target pest, meaning that the applications shown against the various pest are not additive.

In contrast the CIL survey asks respondents to apportion a single application (including mixtures) targeting multiple pests based on their *intentions*. For example, one flight over a field of chlorpyrifos + acephate (e.g., Lorsban® + Orthene®) may reflect a PCA's desire to control two different pests, each with one of these compounds (in this case, Lorsban against pink bollworm and Orthene against Lygus). As such, it is no different than flying twice over the field or 2 sprays, 1 against pink bollworm and 1 against Lygus. Or a single application of one insecticide, for example, endosulfan, may be counted 0.75 against *Lygus* and 0.25 against aphids. So insecticide use against specific pests is measured more directly based on user intentions, making these applications additive, unlike the 1080 data. These differences make it challenging to make direct comparisons between the datasets.

Another limitation of the 1080 data is that field-level data are not recorded in the database. The best resolution possible is section-level analysis. It is impossible to directly calculate number of sprays per field, for example. In order to determine the relative importance of pests (Figure 1) we used (application*acres) as a proxy for sprays per field. This would be the total number of acres treated with a given compound (or set of compounds) accumulated for a section over an entire season. When tallied over an area of known cotton density (i.e., statewide or by county), one can infer the number of sprays that were made per acre against a specific pest target or with an individual compound, etc.

Results and Discussion

Top Pests in Cotton

Lygus, sweetpotato whitefly *Bemisia tabaci* Genn., and pink bollworm *Pectinophora gossypiella* (Saunders) consistently represent the top three insect pests of Arizona cotton, based on application*acres, according to both 1080 data (Figure 1) and Cotton Insect Loss surveys (Figure 2). These are the pests that drive the system in terms of pesticide applications.

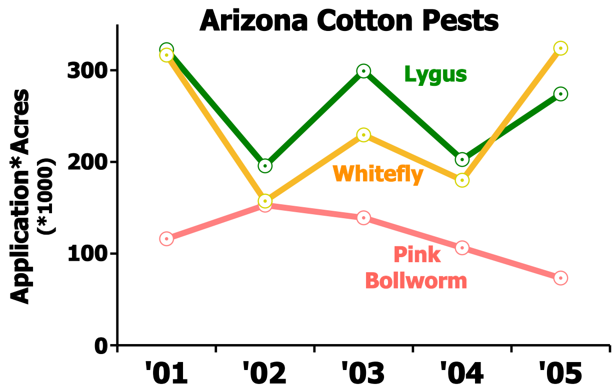

Figure 1. *According to 1080 data,* Lygus *is the most important pest in Arizona cotton, in terms of insecticide application*acres. Sweetpotato whitefly,* Bemisia tabaci *Genn., ranks as a close second, and pink bollworm,* Pectinophora gossypiella *(Saunders), third. Targeted applications for other pests (not shown) drop off dramatically.*

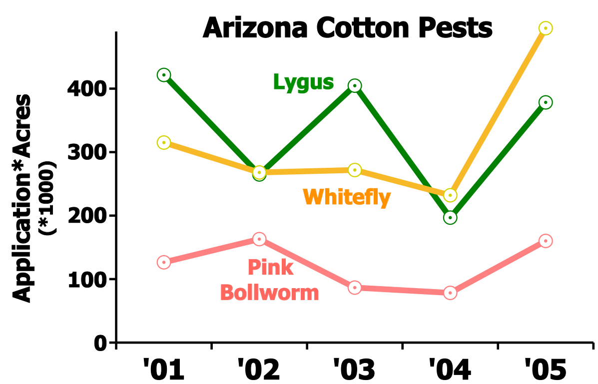

Figure 2. *Generally,* Lygus *accounts for more insecticide use than any other insect pest of Arizona cotton, according to CIL survey data (2001-2005). A similar acreage is sprayed for whitefly. Targeted applications for other pests (not shown) drop off dramatically.*

While information from the two data sources is fairly consistent, there are some differences. CIL data generally indicates higher application*acres compared to 1080 data for both *Lygus* and whitefly, while PBW levels remain relatively consistent with PUR data. Application*acres for *Lygus* based on 1080 data range from about 72% (2005) to 100% (2004) of CIL estimates. This is fairly consistent with our preliminary estimate of the percentage of foliar *Lygus* applications represented in the 1080 database. As stated earlier, CIL data represent statewide estimates by end-users of all foliar applications, whereas some foliar applications are excluded from the 1080 data (i.e., where reporting is not required).

Pink bollworm sprays tend to be more targeted, i.e., lepidopteran-active insecticides with little to no collateral effects on whitefly or *Lygus.* So the CIL data for this pest is easier to estimate by users. Whereas some *Lygus* insecticides are also specifically targeted at whiteflies (especially endosulfan, a very popular a.i.) such that CIL users have to "estimate" the fraction of the spray dedicated to whitefly control versus *Lygus* control. Also, pink bollworm sprays generally occur later in the season, and therefore are almost exclusively aerial (custom), while *Lygus* and/or whitefly insecticides might have some early season, grower applied sprays (not reported in 1080s). Also, *Lygus* and whitefly spraying is likely more coincident in time and also complicates the CIL survey user's estimate of the relative apportioning of a spray to these two targets.

For applications that target *Lygus* along with additional pests, whitefly is the most important co-target (Figure 3). Pink bollworm and heliothines were the second and third most common co-targets, respectively, but accounted for a much smaller proportion of applications. This system is essentially driven by two insect pests. Widespread adoption of Bt cotton has greatly reduced the need for foliar applications against pink bollworm areawide (Carriere et al. 2003), because Bt cotton is fully effective against pink bollworm and therefore requires no oversprays for this pest (Ellsworth et al. 2002). Timing is also a factor. *Lygus* and whitefly are more coincident in the field, and proportionally more sprays are made later in the season with pink bollworm, when Lygus sprays are greatly diminishing.

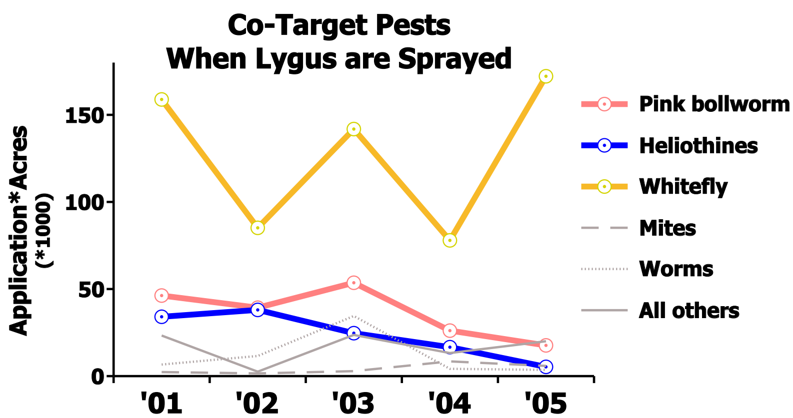

Figure 3. *Based on 1080 data, whitefly stands out as the most important co-target pest when users spray for* Lygus. *Pink bollworm and heliothines (bollworm/ budworm) are a distant second and third, respectively, due to about 80% deployment of Bt cotton statewide over this period.*

Insecticide Use Patterns for Lygus Control

Based on the 1080 database, acephate, endosulfan and oxamyl are the most commonly used active ingredients for *Lygus* control in Arizona cotton (Figure 4). These materials ranked highest for single-product applications targeting *Lygus*. These materials are typically used on average at about 90% of full label rates when applied alone and at somewhat lower rates in mixtures (Figure 5). When mixtures were used, chlorpyrifos outpaced oxamyl as the third most common important active ingredient. Chlorpyrifos is probably chosen in mixtures, because it also provides Lepidopteran control presumably. When mixed in a *Lygus* application, it is likely used against various lepidopteran pests on non-bt cotton (e.g., pink bollworm, armyworm complex, bollworm/budworm complex) and even on bt cotton (for armyworm control). Data indicate that chlorpyrifos is never used alone for *Lygus* control, which reflects user's attitudes about its efficacy for this purpose. Thiamethoxam was introduced in 2001 and most of the applications cited here are as a result of the initial pulse in usage during 2001-2002, as practitioners tried to use it for *Lygus* and whitefly control. Usage against *Lygus* has since declined dramatically, dropping to zero acres in 2005.