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2001 UPDATE ON PESTICIDE USE IN ARIZONA COTTON

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Abstract

Environmental and public health policies protecting Arizona's groundwater have generated statewide pesticide use reporting systems, while offering opportunities for pesticide research. Since 1996, Arizona Agricultural Statistics Service (AASS), under cooperative agreement with Arizona Department of Agriculture (ADA) Environmental Services Division, has provided data to The University of Arizona Pesticide Information and Training Office in support of research objectives. Since 1995, Arizona has seen a downward trend in agricultural pesticide usage. Preliminary results show a 50% decrease in application acres in Arizona since 1998, adjusted for planting acreage. Analysis of ADA data from 22,425 reports indicated 6,199 (27.6%) of pesticide applications occurred on cotton and 16,226 (63.4%) occurred on other crops. Field size of pesticide applications in 2001 varied widely, ranging from 0.5 to 700 acres per application. *Lygus* remained the most frequently reported treated pest on cotton, followed by whitefly and pink bollworm. Of active ingredients reported as pesticide application components, 19,423 (54.8%) were applied to cotton. Development and adaptation of the State's pesticide use reporting system are discussed. Modifications to the database structure are presented. Year-end 2001 statistics are presented summarizing frequencies of applications and reported target pest species in Arizona cotton production. Chemical usage trends and confounding variables are discussed in light of regulatory changes affecting pest management options.

Introduction

Since 1991, Arizona has monitored use of agricultural chemicals to prevent contamination of the state's groundwater supply. Historical concerns about groundwater quality, heightened by addition of Arizona to the Environmental Protection Agency (EPA) National Priorities List in the 1980's, have prompted environmental health legislation and policies to preserve this natural resource. In 1992, the Arizona State legislature enacted laws to monitor agricultural pesticide usage. Since that time, Arizona Administrative Code has expanded to encompass a broader range of environmental concerns related to chemicals, including 152 compounds listed as potential groundwater contaminants. Enforcement of label requirements is assigned to the Arizona Department of Agriculture (ADA), with directives for monitoring relegated to the auspices of the ADA's Environmental Services Division. Since 1995, Arizona has seen a downward trend in agricultural pesticide usage. These legislated reporting requirements provide a systematic process to track and quantify the statewide decline in pesticide use. Understanding the database structure promotes improved methods in utilizing this source of information for research. This report summarizes pesticide use in Arizona cotton production for 2001.

Methods

In 1991, the ADA began developing a process for data collection on 152 chemical compounds listed under State law. Specified categories of chemical users were identified, and a systematic process constructed for collection of information. The *ADA L1080* form was designed by the Arizona Department of Agriculture to record information submitted by users of agricultural chemicals, and monitors their use (Figure 1). Collected data include active ingredient (AI), EPA Registration number, quantity, crop, acres treated, harvest date, re-entry intervals, wind velocity during aerial applications, equipment codes, and license/permit ID numbers for regulated sellers, applicators, and growers.

Between 1991 and 2001, the record keeping system underwent several revisions, and continued to evolve as new uses for information were identified (Figure 2). Initially implemented as a monitoring tool to track specific chemical uses, subsequent modifications incorporated data on aerial applications, licensing, and materials registered under Section 18. Later, reporting requirements were expanded to include other chemical applications. In 1993, chemicals on the Arizona Department of Environmental Quality (ADEQ) Groundwater Protection List (GPL) were incorporated into the reporting process. At present, chemicals subject to ADA monitoring include custom applications, chemicals on the ADEQ Groundwater Protection List (GPL), and Section 18 (A.R.S. §§ 3-341 et seq. and 3-3101 et seq.).

In 1996, collaborative agreements were formed with USDA-NASS in Arizona. Drawing from the expertise of State statisticians, several levels of quality control and process improvements were instituted, including numerous enhancements to preserve integrity of data. Arizona Agricultural Statistics Service (USDA-NASS) re-configured the database structure as a relational database in Standard Query Language (SQL) to execute in Microsoft FoxPro™ Sherman, 1999). Modification of the system resulted in splitting of data fields from the *ADA L1080* form into four separate tables, linked by a common but unique *Sequence Number*. Relationships between data fields were defined to permit appropriate links between tables for retrieval of data. The tables were designed for subsequent use of queries to extract information, and to reduce the total size of the database. In 1998, a new data field was created for *Pest Name*, to allow for listings of up to three target pests per pesticide application. Target pest listings were included in data collection, offering additional opportunities to examine pest management practices. Further assessments continued through 2001 to examine feasibility of integrating the pesticide data with The University of Arizona College of Agriculture and Life Sciences web site, and increase its utilization by extension agents, growers, and researchers. Because this database consists of all crops in Arizona, we are reporting on cotton pesticide use as a subset of the entire database. In order to simplify the data, we have separated our Results and Discussion into sections addressing the various issues.

Results and Discussion

Pesticide Applications

Pesticide usage summaries of active ingredient applications on cotton and non-cotton crops are presented in Table 1. During 2001, a total of 22,425 Pesticide Applications on all crops were reported to the Arizona Department of Agriculture - Environmental Services Division. A completed ADA Form L1080 that has been accepted by the Arizona Department of Agriculture, and assigned a unique Sequence Number, verified in data entry by the Arizona Agricultural Statistics Service (AASS), represents each *Pesticide Application*. Analysis of ADA data from the 22,425 reports indicated 6,199 (27.6%) of Pesticide Applications occurred on cotton and 16,226 (63.4%) occurred on all other crops.

Field Applications

A *Field Application* is defined as a pesticide application on an individual planting of a single crop, delineated by range, township, and section, and for which the size of the planting area has been specified in acres on the *ADA Form L1080* corresponding to the application. Data analysis showed a total of 38,491 pesticide Field Applications on all crops, of which 12,214 (31.7%) occurred on cotton fields.

Despite a 7% increase in planted acreage since 1998, the number of pesticide applications declined this year. Analysis of data from the last three years indicates a 50% decrease in pesticide usage since 1998, when 2.1 million application acres were reported on 265,900 acres of cotton. These preliminary results indicate a continuation of the downward trend described in previous publications, and point to a dramatic change in pesticide use patterns statewide. (Agnew and Baker, 2000; United States Department of Agriculture, 1999). USDA-NASS estimated year 2001 planted cotton acreage in Arizona at 286,000 acres. Total estimated area was 1,032,188 Field-Application acres. The implication is that each field received 3.6 applications of pesticides, however, this variation could range from zero to 7 applications/field. The data suggest continued decrease in application acres in Arizona from previous years, adjusted for planting acreage.

Frequency distribution data on field size per application showed 57% of applications occurred on cotton fields 50 acres or smaller in total area (Figure 3). Field size of pesticide applications varied widely, ranging from 0.5 to 700 acres per application. Data analysis determined the average field size was 84.5 ± 79 acres per field pesticide application in Arizona cotton. The variation could be determined by data analysis, showing the average pesticide application encompassed 1.89 ± 1.05 acres.

Active Ingredient (AI) Applications

An *Active Ingredient (AI)-Application* represents application of a product identified by a single active ingredient (AI), and which bears a unique EPA-Registration Number. Reported listings of active ingredients applied to all Arizona crops totaled 35,426. Of active ingredients reported as pesticide application components, 19,423 (54.8%) were applied to cotton. These active ingredient applications (AI-Applications) consisted of 33,020 Field Applications on cotton, representing 53.6% of the 61,537 (AI-Field-Applications) on all crops statewide in 2001. This represents a disproportionate frequency of AI-Applications on cotton relative to other crops, and may be explained in part by the greater number of products available for use on cotton. In addition, a switch to alternative compounds could be an outcome of mid-year changes in registration status of several pesticides that occurred, restrictions on numbers of applications permitted under SLN, or implementation of specific IPM protocols, such as for whitefly control (Ellsworth, et.al 1999; Ellsworth et.al, 1996; Naranjo et.al, 1998; Palumbo et al. 1999). In addition to the advent of Bt cotton, numerous changes occurred in 2001 in the status of products registered for use in Arizona, and may help to explain these trends. In July 2001, Actara™ (Syngenta) was registered for whitefly and aphid control in cotton. Harpin protein, Messenger™ (Eden Bioscience), was registered as a growth regulator for cotton plant growth and yield. Other new products registered for use on cotton in Arizona include: Intrepid™ 2F Agricultural Insecticide (Rhome and Haas) for beet armyworm, Indoxacarb (Avaunt™ insecticide, KB/Steward® insecticide, and Steward® 1.25SC insecticide. In addition, SLN (24c) was granted for Staple® and Staple Plus® Herbicides, for glyphosate tank mixtures for annual morningglory and broadleaf weed control in glyphosate tolerant cotton.

Active Ingredient (AI)-Field-Applications

Data analysis show the number of active ingredients per application declined this year, although there was a greater diversity of compounds applied to cotton than other crops. An *Active Ingredient Field Application* (AI-Field-Application) denotes a Field-Application of a pesticide comprised of a single active ingredient (AI), and which bears a unique EPA-Registration Number. AI-Field-Applications were computed in data analysis to include single chemical agents, as well as separate components of mixtures utilized as a single application. Number of active ingredients per application averaged 3.1 AI on cotton, versus 1.58 on all crops (Mean = 1.58 AI/Application). At the field level, the number of active ingredients per application was higher, with 2.70 AI/field application on cotton, compared with 1.6 AI/field application on all crops. Further analysis is needed to distinguish AI's applied individually as part of an IPM program to vary modes of action, versus those AIs applied as tank mixtures. Regardless, these results mark a notable decrease from 1995 levels, which peaked at an estimated 14.9 applications per acre statewide.

Despite EPA cancellations of several registrations, preliminary data suggest acephate, endosulfan and chlorpyrifos were widely used in 2001. Several factors influence the reliability of information on active ingredients (AI's). These include accuracy in calculating application rates, and appropriate use of conversion factors to standardize concentrations. Chemical summaries organized by active ingredient (AI) permit calculation of application rates, provided formulation data are obtainable. Estimates of application rates and frequencies must incorporate chemical information to accurately quantify field conditions. Despite demand for user-friendly summaries, EPA risk assessments underscore the inseparability of the chemistries from the formulations and product characteristics that impact their exposure and environmental fate.

Insecticide Applications

The data show the vast majority of reports are generated from insecticide applications. Aerial applications represent more than 90% of insecticide applications in number of reports and acres applied. This is consistent with data from previous years, showing the majority of reports were generated from aerial insecticide applications. Since 1991, the data have shown a fairly consistent pattern in ground applications of insecticides, comprising approximately 5% of the insecticides reported annually.

Between 1999 and 2000, total insecticide-applied acres decreased by 16% statewide. Even prior to their cancellations, reported use of several compounds dropped dramatically last year from previous years. Three of the most historically and widely used insecticides, chlorpyrifos (Lorsban®), endosulfan (Thiodan®), and acephate (Orthene®) fell 15, 17, and 30 percent, respectively. Of the fifteen most frequently reported pesticides last year (2000), only three active ingredients were associated with increased application-acreage: Applications increased 75 percent for the insect growth regulator (IGR) pyriproxyfen (Knack®), as well as two pyrethroids: fenpropathrin (Danitol®), and cyfluthrin (Baythroid®), which increased 64 and 124 percent, respectively. These changes are believed to be due at least in part to the large proportion of planted acreage of transgenic cotton. In 2001, roughly 62,920 acres (22%) of planted acreage was Bt cotton, with another 140,140 acres (49%) representing stacked gene variety (Silvertooth, 2001). With the benefits of this shift, are concerns about overuse of newly registered IGR's, potentially resulting in reduced susceptibility and cross-resistance (Dennehy and Williams, 1997).

Target Pests

In 2001, a total of 33,377 target pest reports were generated for all crops in Arizona. Of this number, 22,544 (67.54%) represented Insects; and 10,833 (32.46%) represented Non-Insects. Stratification of the Non-Insect reports showed frequencies in the following target pest categories: Weeds- 5,816 (17.45%); Diseases- 2,221 (6.65%); Plant Growth Regulators (PGR's)- 2,730 (8.18%); and Nematodes- 66 (<1%). As with the crude data on total crops, target pest reports on cotton alone were separated into Insect/Non-insect groupings, and categorized by pest species. Of target pests on cotton, 9,497 (60.21%) were reported as Insect pests, and 6,277 (39.80%) as Non-Insect pests.

Of 33,377 total pest reports for the year 2001 in Arizona, 15,774 (47.26%) represented pests targeted for pesticide applications on cotton. Reported target pests and their frequencies are summarized in Table 2. The chi-square test of observed and expected frequencies showed the relationship between reporting of insect pests and cotton is highly significant ($p < 0.001$). Chi-square tests on contingency tables (df=1) show that of the 15,774 target pests on cotton, the expected frequencies of insects were 10,654.31 and 5,119.68 non-insect pests. Similarly, among the 17,603 pests on non-cotton, expected frequencies were 11,889.7 for insect pests, and 5,713.3 for non-insect pests.

Analysis of 22,425 *ADA L1080* reports showed an average of 1.48 target pests/pesticide application. Tabulation of crude active ingredient frequencies demonstrated a mean of 1.23 AI-Applications/target pest on cotton, compared with 1.06 AI-Applications/target pest for all crops. At the field level, this was higher, with a mean of 2.09 AI-Field Applications/pest on cotton, compared to 1.84 AI-Field Applications/pest on other crops. Active Ingredients appeared non-specific in relation to corresponding target pests, averaging 1.06/target pest (Mean=1.06 AI-Applications/Pest).

Lygus remained the most frequently reported target pest on all Arizona crops in 2001 (Figure 4). In cotton production, results showed 3,124 listings for *Lygus* out of 15,774 (19.80%) total pesticide application reports. This was followed by sweet potato whitefly with 2,711 (17.19%), and pink bollworm with 1,218 (7.72%). The remaining 26% of cotton pest frequencies were distributed across categories of aphid, (3.5%), budworm/bollworm (3.47%), silverleaf whitefly (3.42%), armyworm (2.60%), thrip (0.86%), and cotton leaf perforator (0.86%).

Assessing insecticide effectiveness on insects such as *Lygus*, requires critical considerations beyond the scope of usage statistics (Antilla, et al. 1998). The newly added data field for *Pest Name*, allows for listings of up to three target pests per pesticide application, and offers understanding of field practices that influence pest management decision-making. Currently, reporting of pests is neither contingent upon sampling nor threshold values, and may not reflect population levels of relevant species. Target pest reports are not linked to chemical label data or other flagging mechanisms that might serve to verify integrity of the data. Pest listings may suggest economic or operational incentives driving the choice of products that are unrelated to field conditions. The target pest data field holds promise for elucidating plant-pest-chemical interactions, however its vigor requires accuracy in identification of pest species. Additional criteria to guide pest identification will strengthen future investigations.

Insect Growth Regulators (IGRs)

In 1996, an Environmental Protection Agency (EPA) Section 18 exemption was granted to two insect growth regulators (IGRs) for whitefly control. Full reporting of IGRs, including use by non-custom applicators was also required. Pyriproxyfen (Knack®) received a regular Section 3 registration before the 1999 season. Buprofezin (Applaud®) was registered under Section 18.

Analysis of year 2001 data shows a considerable increase in the number of applications of IGR's since last year. Table 4 shows IGR data from 1996-2001, including number of applications, frequencies adjusted by planted cotton acreage estimates (%PA), and percent change adjusted annually. Pyriproxyfen (Knack) applications increased 45.1% since last year, from 303 applications to 552. Adjusting for planted acreage, this represents a one-year increase from 17.6% to 37.2% application acres/planted acres (intensity). Similarly, buprofezin (Applaud) usage increased dramatically, from 89 applications to 191 this year – more than doubling the number of applications since last reported (Agnew and Baker, 2001). This corresponds to a five-fold increase in application acres/planted acres (intensity) from the previous twelve months. IGR effectiveness is vital to continuation of the downward trend in insecticide use in Arizona cotton (Ellsworth and Jones 2001). Findings of reduced susceptibility in Arizona whiteflies last year highlight concerns about overuse of IGRs, and pyriproxyfen in particular (Li et.al, 2000; Dennehy and Williams, 1997; Ellsworth et.al, 2001).

The increased use of both pyriproxyfen and fenpropathrin are explained by increased whitefly pressure. As expected, growers focused on sweet potato whitefly control. In fact, in 2000, grower (non-custom) IGR application acres averaged 5.7% of total IGR application acres. Reportable custom ground applications comprised 2.1 percent of IGR and 2.4 percent of non-IGR applications. The synergized pyrethroid mix of fenpropathrin and acephate has been widely used for whitefly control since 1995. In 2000, fenpropathrin, acephate, and pyriproxyfen were the most frequently reported mixtures for whitefly control.

Estimates of the shortfall in the ADA database may be weakened by incorrect assumptions of full reporting of grower applications of IGRs (Agnew et. al., 2000; Frisvold, et. al 2001). Individual growers may be less likely to report IGR applications than licensed custom applicators. Lack of grower familiarity with the reporting process is a source of potential bias and may introduce error. Acreage estimates for IGRs based on sales data from the IGR registrants may provide insight into upper bound estimates.

Non-Insecticide Applications

Herbicides

The magnitude of non-insecticidal pesticide applications in 2001 is noteworthy. Of the 22,436 reported pesticide applications, weeds comprise 5,816 (17.42%) of 33,377 pest reports filed on all crops. Of 15,771 pesticide applications on cotton, 1,403 (8.89%) list weeds as a target pest. Last year revealed a continued increase in glyphosate (Roundup®) use. Resistant varieties of cotton genetically modified to withstand high exposure levels to glyphosate are implicated in the twenty-fold increase in glyphosate-treated acres since 1995. This immense increase cannot be explained entirely by availability of resistant varieties of cotton, as use of the herbicide is highly disproportionate to glyphosate-planted acreage, represented by only 14% of planted acres in 1999. Of particular note is the alarming frequency of 899 out of 1,403 (64.1%) of ADA-1080 reports that list target pest as "Weeds, unknown".

Defoliants
In 2000, there was increased reporting of defoliant application acres relative to previous years. The plant growth regulator (PGR), ethephon (Super Boll®) increased almost three-fold while use of mepiquat chloride (Pix®) fell for the first time in six years. Controlling for confounding variables of soil applications (fungicides, nematicides, 1,3-dichloropropene (Telone®) versus aerial applications (mancozeb (Ridomil®), several defoliants and PGRs) may provide understanding of shortfalls in further analyses.

Section 24C Registrations; *Special Local Need*
Figure 5 depicts regulated criteria for pesticide reporting, with frequencies of pesticide applications reported for the year 2001. There were 25,866 regulated pesticide applications reported for the year – 3,441 more than the 22,425 total applications. The greater number of *regulated* applications than *total* pesticide applications is explained by the applications that must be reported under multiple regulations. Table 5 presents yearly data on aerial and ground applications for registrations of Special Local Need (SLN). In addition, frequencies are presented for SLN applications that similarly require reporting due to their inclusion on ADEQ's Groundwater Protection List. Of the total 268 ground applications of pesticides with SLN status, 219 (81.7%) were similarly regulated under ADEQ. Table 6 shows applications of potential groundwater contaminants covered by ADEQ. There were 2,259 pesticide applications reported for ADEQ active ingredients on the groundwater protection list (GPL). Ground applications accounted for 1,693 (83%) of the 2,040 ADEQ applications without SLN status. The remaining 347 (17%) were aerial applications. Of 22,425 pesticide applications, 1,183 were reported for Special Local Need (SLN). Of these, 915 (77.3%) were aerial applications and 268 (22.7%) were ground applications. Of the 915 SLN aerial applications reported, 145 (15.8%) also fell within ADEQ mandated reporting requirements due to active ingredients specified on the Groundwater Protection List. All 145 of the aforementioned SLN-aerial-GPL applications occurred between September and November 2001. SLN status varies widely according to county, with several Arizona counties reporting no SNL applications. County-specific data on SLN air and ground applications in Yuma, Maricopa, LaPaz, Pinal, and Cochise counties revealed that of 770 SLN aerial applications exempt from ADEQ groundwater protection list reporting requirements, 611 (79%) were from Yuma County, Arizona (Table 7). Comparing statewide data, usage of agricultural chemicals is unevenly distributed across Arizona. Figure 6 further illustrates this contrast in annual application acres reported for all counties statewide. Data from 2001 showed application acres on all crops were relatively proportional to agricultural production in local areas. Stratified by county, SLN applications were disproportionately represented in Yuma County, with 944 applications (80.0%) of the total 1,183 reported statewide in 2001. Of the 944 SLN applications in Yuma County, 755 (79.9%) were aerial, and 189 (21.1%) were ground applications. Other counties reporting SLN applications were Maricopa County: 10.3% [(n=122), 95 aerial vs. 27 ground]; Pinal County: 3.9% [(n=46) 29 aerial vs. 17 ground]; LaPaz County: 5.7% [(n=67) 32 aerial vs. 35 ground]; and Cochise: <1% [(n=4) 4 aerial vs. 0 ground]. There were no SLN applications reported from Apache, Coconino, Gila, Graham, Greenlee, Mohave, Pima, Santa Cruz, or Yavapai counties.

Measurement Error, Confounding, and Reporting Bias
Caution is urged in attempts to derive too great an association between frequencies of reported pests and applications of active ingredients (AI). Previous attempts to generate a "top ten" list of chemicals potentially misclassify data into opposing statistical categories, resulting in crossover measurements of exposure and outcome. In the absence of pest sampling data or other direct measures, misclassification is more likely. Estimating pesticide effectiveness on the basis of reported application frequencies may create artifacts of association and result in confused outcome measures. For example, rather than effectiveness, a product's high rate of usage may, alternatively, indicate its ineffectiveness. Multiple applications at higher concentrations, separated by shorter intervals could be an indicator of poor effect, but may be associated with very high probability of reporting.

Combining several active ingredients into tank mixtures that are then utilized as a single pesticide application complicates both evaluation of effectiveness, as well as analysis of additive or synergistic effects. While effective combinations of active ingredients may be realized in field practice, additional data analysis of interactions and/or effect modification may be necessary to measure association. Previous yearly reports document examples of high application frequencies for pesticides with no biologically plausible relationship. Compounds comprising tank mixes may have no relationship to the target pest species but may be added with intent to control secondary pests, unlisted or unidentified species. The impact of differential and non-differential error may exist in early data summaries, and include measurement error of both binary and continuous variables (Greenland, 1980). The effects of an imperfectly measured exposure or outcome can induce effect modifications. Unrelated chemicals combined as tank mixes require stratification by active ingredient. Thus, further analysis will be required to substantiate previously published summaries.

The frequency of pesticide use reporting is a function of pesticide category and mode of application, with aerial application associated with very high probability of reporting. Applicator status is a confounding variable that calls for adjustment by stratifying the records according to licensing categories, and performing separate data analysis on each subset. With reporting frequencies driven by the regulatory process, pesticide usage across all categories will be skewed toward higher reporting frequencies by custom applicators. Stratifying the data set by applicator status will adjust for this confounding effect. Characterization of reporting and selection bias, with identification of measurement error will increase reliability and lend power to the data set.

With an estimated 30,000 records added annually, growth of the database potentially challenges a user-friendly interface and accessibility of pertinent data. While size favors condensing information into manageable summaries, consolidating data potentially masks vital information or renders it less retrievable. Report generation can be easily automated for production of weekly-updated charts and other summaries, however serious problems may result from reliance on oversimplified levels of information. To date, the system has been prized for speed in producing easy-to-read reports. The need for current, accurate information is high, as is the demand for quick turn-around of summaries in user-friendly format. As demand and accessibility of data increase, so will the need for optimal ways to depict this information. More work is needed to ascertain the loss of information in data consolidation, determine the impact, and produce the level of summary statistics appropriate to the need.

Summary

The Arizona Department of Agriculture Pesticide Use Reporting system provides understanding of agricultural chemical use and cotton pest management practices. The availability of standardized data on agricultural chemicals affords numerous enhancements to research endeavors, linking growers, regulators, and stakeholders toward common pest management solutions. Statistical analysis of data collected between 1998 and 2001 indicates a 50% reduction in pesticide usage in the last three-year period. Preliminary results indicate 27.6% of all reported pesticide applications in Arizona occur on cotton. Field sizes receiving applications average 84.5 acres, but vary widely from 0.5 to 700 acres. Fifty-seven percent of applications occurred on cotton fields 50 acres or smaller, with the average application covering 1.89 acres. Field applications on cotton represented 53.6% of reported active ingredient field applications on all crops statewide. Number of active ingredients averaged 3.1 on cotton, compared to 1.58 on all crops. The association between reporting of insect pests versus non-insect pests and cotton is highly significant. Forty-seven percent of target pest reports are from pesticide applications on cotton. *Lygus* remained the most frequently reported target pest, followed by whitefly and pink bollworm. Despite EPA cancellations of several registrations, preliminary data suggest acephate, endosulfan and chlorpyrifos were widely used in 2001. IGR usage continued to increase in 2001, suggesting directions for research and extension activities. Preliminary data analysis indicates that EPA cancellations of several products in 2001 will have notable impact on reported usage statistics next year.

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Table 1. Pesticide applications reported on ADA form L1080, Arizona Dept. Agriculture, 2001.

		CROP			
		COTTON		NON-COTTON	
Total Pesticide Applications N=22,425	**TOTAL**	**Number of Reports**	**Relative Frequency (%)**	**Number of Reports**	**Relative Frequency (%)**
Field-Applications	38,491	12,214	0.32	26,277	0.68
AI-Applications	35,426	19,423	0.55	16,003	0.45
AI-Field-Applications	61,537	33,020	0.54	28,517	0.46

Source: United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS) Cotton Area Planted, AZ (2001) = 286,000 Acres.

Table 2. Pesticide Applications in Arizona, by County, 2001 (N=22,425).

COUNTY	Number of Applications	SLN (n=1,183)	Ground (n=268)	Air (n=915)
Cochise	315	4	0	4
Graham	79	0	0	0
Greelee	2	0	0	0
LaPaz	1,460	67	35	32
Maricopa	2,494	122	27	95
Mohave	45	0	0	0
Pima	308	0	0	0
Pinal	3,908	46	17	29
Yuma	13,809	944	189	755

Table 3. Observed contingency table of target pest reports on Arizona cotton with chi-square (χ^2) test results (df=1).

	CROP		
PEST REPORTS	COTTON	NON-COTTON	TOTAL
INSECT	9,744	12,800	22,544
NON-INSECT	6,030	4,803	10,833
TOTAL	15,774	17,603	33,377

χ^2= 453.80 ($P < 0.001$).

Table 4. Change in IGR Usage in Arizona, Adjusted for Planted Cotton Acreage, 1995-2001.

IGR	YEAR	1995	1996	1997	1998	1999	2000	2001
	Planted Acres Cotton (x1000)	***413.6***	***357.0***	***347.0***	***265.9***	***279.0***	***286.0***	***286.0***
Pyriproxifen (Knack®)								
	Number of Applications	-	-	-	-	192	303	552
	Application-Acres (x1000)	0	143.8	101.8	115.6	28.7	50.3	106.6
	%PA*	0	40.3%	29.3%	43.5%	10.3%	17.6%	37.2%
	Annual change (%)		+40.3%	-11.0%	+14.2%	-33.2%	+7.3%	+19.6%
Buprofezin (Applaud®)								
	Number of Applications	0				107	89	191
	Application-Acres (x1000)	0	55.8	68.0	34.3	17.9	5.7	29.6
	%PA*	0	15.6%	19.6%	12.9%	6.4%	2.0%	10.3%
	Annual change (%)	0	+15.6%	+4.0%	-6.7%	-6.5%	-4.4%	+8.3%

* %PA = Application-Acres/Planted Cotton Acres.

Table 5. Special Local Need and Aerial Applications in Arizona*, 2001.

MODE OF APPLICATION	SLN, % (n=1,183)	ADEQ-GPL, Yes % (n=219)	ADEQ-GPL, No % (n=964)
AERIAL	77.3 (915)	66.2 (145)	79.9 (770)
GROUND	22.6 (268)	33.8 (74)	20.1 (194)

Arizona Department of Agriculture, *ADA Form L1080*; Arizona Agricultural Statistics Service.

Table 6. Department of Environmental Quality-Groundwater Protection List; Regulated Pesticide Applications, Arizona Department of Agriculture *L1080*, 2001.

PESTICIDE APPLICATIONS (N=22,425)	SPECIAL LOCAL NEED (SLN)	
DEQ GPL-Regulated	Yes	No
Yes (n=2,259)	219	2,040
No (n=20,166)	964	19,202
TOTAL	1,183	21,242

Table 7. County-Specific *Special Local Need (SLN)*, Aerial and Ground Applications in Arizona (%)*, 2001.

COUNTY	AIR, % (n=915)	GROUND, % (n=268)	TOTAL SLN APPLICATIONS (n=1,183)
Yuma	755 (79%)	189 (21.1%)	944
Maricopa	95 (79%)	27 (21.1%)	122
LaPaz	32 (47.7%)	35 (52.2%)	67
Pinal	29 (63.1%)	17 (36.9%)	46
Cochise	4 (100%)	0 (0%)	4

*Arizona Department of Agriculture, *ADA Form L1080*; Arizona Agricultural Statistics Service.

ADA-OFFICE-USE-ONLY **18155** **99-18155**

Seller ____________________ PSP ____ Date ____________

Grower ____________________ PGP ____ County ____________

PEST CONDITIONS ______________________________ PMA AREA (Y/N)

HARVEST DATE ________ LBL REENTRY INTERVAL ________ WS REENTRY INTERVAL ________ LABEL DAYS TO HARVEST ________ DATE TO BE APPLIED ________

CROP	SEC	TWN	RGE	ACRES	CROP	SEC	TWN	RGE	ACRES

ADDITIONAL FIELD DESCRIPTION: ____

____

PRODUCT/BRAND NAME	EPA REGISTRATION NO	RATE & UNIT OF MEASURE/ACRE	DILUTION/ 100 GAL	TOTAL CHEMICAL

TOTAL ACRES _____ TOTAL VOLUME PER ACRE ______ DEQ SOIL APPLIED YES _____ NO ______ SUPPLEMENTAL REQ'D Yes _____ No ____ LABEL AIR ____ GROUND ___

LABEL-RESTRICTIONS/SPECIAL INSTRUCTIONS: ____

APPLICATOR ______________________ DELIVERY-LOCATION ______________________

THE UNDERSIGNED CERTIFIES THAT THE ABOVE INSTRUCTIONS COMPLY WITH ALL LAWS AND RULES.

____

GROWER/AGENT'S SIGNATURE OR ADVISOR'S SIGNATURE PGP/PCA NO.

PESTICIDE APPLICATION REPORT

I, the undersigned, certify that an application of pesticides was made by the designated applicator in strict compliance with the above written recommendation-instructions on the date and under the conditions specified below:

EQUIP. TAG NO. _______ TOTAL TIMES __________ WIND DIRECTION & VELOCITY _____________ DATE APPLIED _____________

DEVIATION FROM INSTRUCTIONS:____

____

COMPANY NAME: ______________________________________ PGP/CA NO: ______

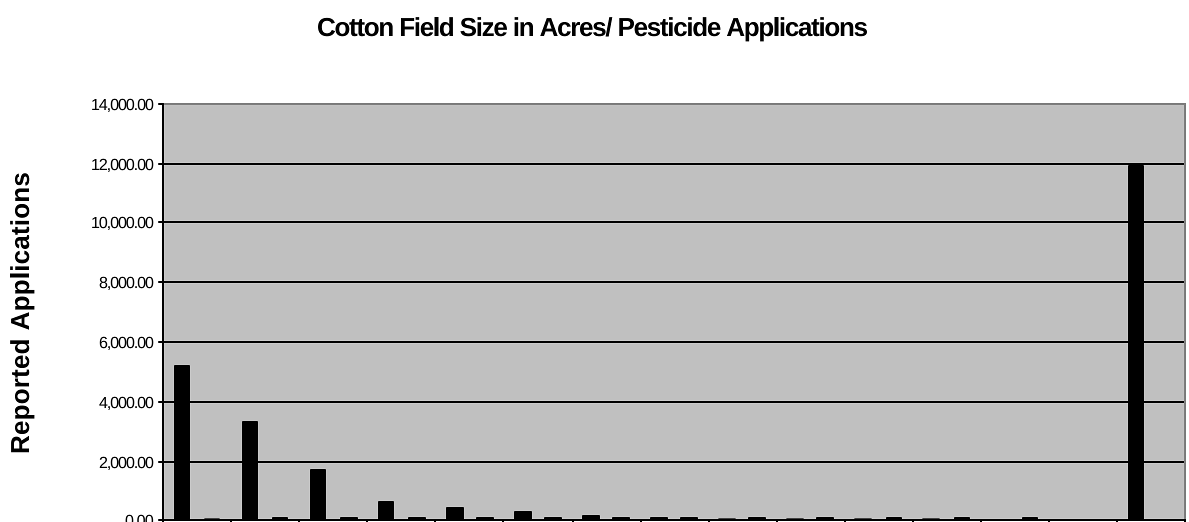
GROWER/APPLICATOR SIGNATURE: ______________________________PUP/PUC NO.:_____

UNIT OPERATOR/ILOT NAME ______________________________ AAP NO.: ________

Figure 1. Arizona Department of Agriculture, Form L1080.

1991	First full year of pesticide use reporting under Arizona Revised Statutes
1992	Enactment of House Bill R-3-302
1993	Arizona Dept. of Environmental Quality's Groundwater Protection List added to reporting requirements
1996	Agreements formed between NASS and ADA to satisfy their survey requirements
1997	Change over from ADA to NASS in processing requests
1998	Edit procedures rewritten in Standard Query Language (SQL) to execute in Microsoft FoxPro™
1999	Procedures developed to flag abnormal application rates of chemicals using 2-year averages; first year of reporting using *Target Pest* data field

Figure 2. Chronology of Arizona Department of Agriculture's Pesticide Usage Reporting System.



	< 49.9	50-99.9	100-149.9	150-199.9	200-249.9	250-299.9	300-349.9	350-399.9	400-449.9	450-499.9	500-599.9	600-649.9	650-699.9	> 700	TOTAL
Acres/Application	5225	3344	1687	617	442	296	130	70	48	31	22	15	5	1	11933
Frequency (%)	0.437861	0.280231	0.141373	0.051705	0.03704	0.024805	0.010894	0.005866	0.004022	0.002598	0.001844	0.001257	0.000419	8.38E-05	1
Cumulative %	43.8	71.8	85.95	91.1	94.8	97.3	98.4	98.9	99.38	99.6	99.8	99.9	99.9		

Figure 3. Field Size Distribution in Arizona cotton applications, 2001.

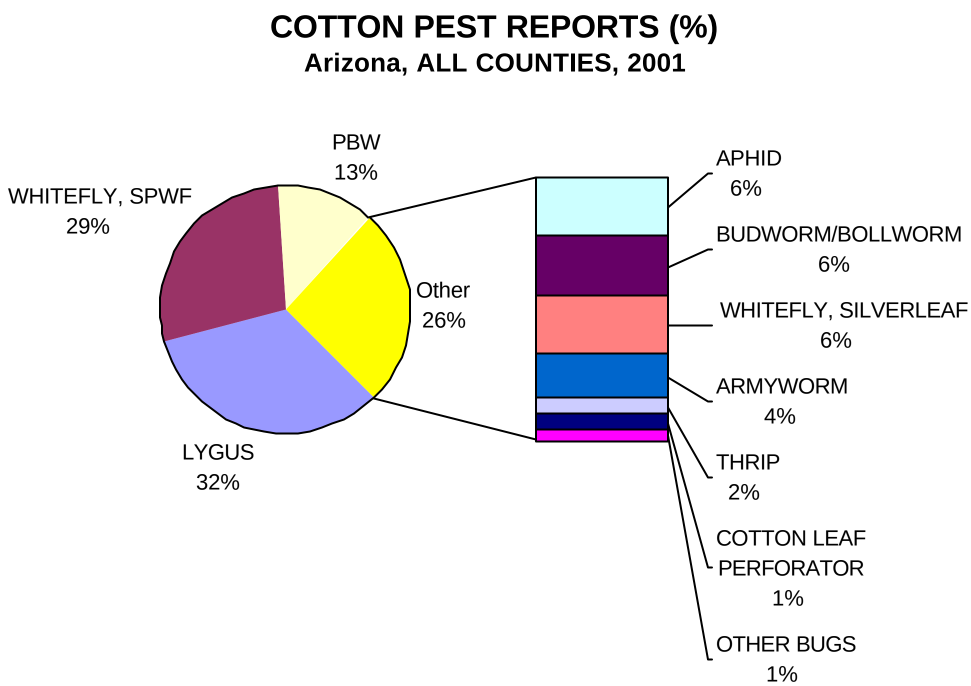
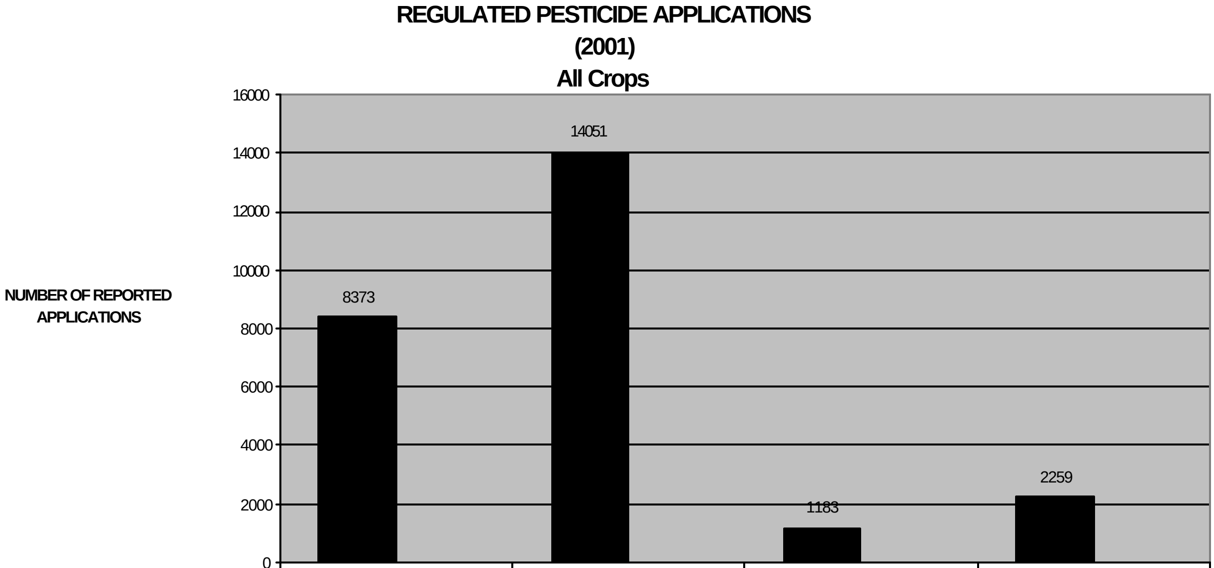


Figure 4. Target pest percentages reported on Arizona cotton, all counties, 2001.



	GROUND	AIR	SLN	DEQ
Number of Reports	8373	14051	1183	2259
Percent*	37.34%	62.66%	5.28%	10.07%

Figure 5. Frequency of Pesticide Applications in Arizona by regulated criteria, 2001. Arizona Department of Agriculture, *Form L1080*.

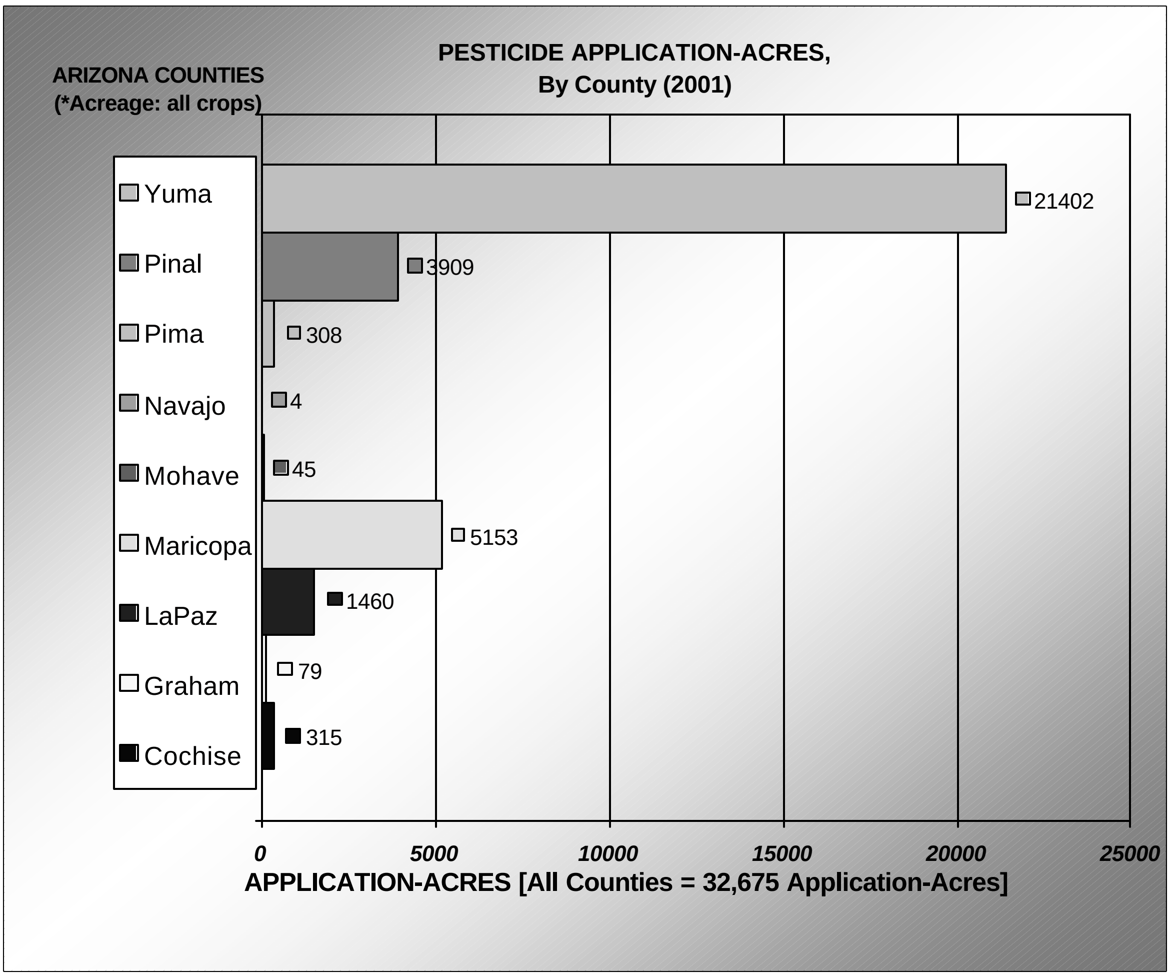


Figure 6. Pesticide Application-Acres in Arizona, by County, 2001.