PEST AND PESTICIDE USAGE PATTERNS IN ARIZONA COTTON

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Abstract

Arizona's pesticide use reporting (PUR) database is used to track and quantify the general decline in pesticide use in the state. A full summary of the 2000 growing season pesticide usage is included. The database also enables tracking of changing usage patterns. For two years, target pest information has been included in the Arizona PUR database. Limitations in the PUR database are discussed. The reporting coverage shortfall for insecticide reports in the PUR database is estimated and found to be reasonable relative to sample based approaches to pesticide use reporting.

Introduction

The downward trend in pesticide usage in Arizona cotton since 1995 has been dramatic. Effective pest management options for whiteflies and pink bollworm combined with historically low lint prices are generally credited for the decline. Arizona Department of Agriculture's pesticide use reporting (PUR) system makes it possible to track and quantify the general decline in pesticide use in the state. The database also enables tracking of changing usage patterns. For two years, target pest information has been included in the Arizona PUR offering opportunities for tracking pest population dynamics. Examples are provided of how near real-time data can be displayed on a weekly basis to assist researchers and growers in understanding the course of the present growing season. Finally, the reporting coverage shortfall for insecticide reports in the ADA PUR is estimated and found to be reasonable relative to sample based approaches to pesticide use reporting.

Methods

Pesticide use statistics are usually summarized in oversimplified terms. Pesticide formulations are diverse, application methods are varied and area-, year- and crop-specific permutations too numerous to list. A PUR database facilitates the reporting of use patterns in a variety of different forms. This allows a richer picture of the pest management practices over time and across different growing regions. The target pest data makes it possible to establish a stronger cause and effect relationship between specific pests and pesticide use.

A general summary of pesticide use data should be organized by pesticide product active ingredients (AIs). Formulation specifics are less important for a general summary. Acres applied and rate of application are the most important statistics. Supplying the number of reports from which these numbers are generated allows the reader to make a determination as to the robustness of the numbers to data error. Normalizing application acres by the relevant cotton acreage, producing a mean intensity measure, facilitates comparisons across time. Pesticide use in cotton can be conveniently divided into categories: insecticides, herbicides, defoliant, plant growth regulators, fungicides, Nematicides and fumigants. There are a few AIs (aldicarb (Temik), sulfur, dichloropropene (TeloneII)) that have multiple uses but they are not widely used in Arizona cotton production.

The ADA database is best suited for summarizing insecticide usage. The vast majority of reports come from aerial applications (Table 1) and the majority of these reports record applications of insecticides (Table 2). With a few minor exceptions, all insecticides can be applied aerially. Aerial application is extremely common in Arizona and it is assumed that this data, primarily from aerial applications of insecticides, is representative of usage pattern in general. Only approximately 5% of the insecticide applications reported are ground applications.

Pesticides are frequently applied with multiple AIs. Usage summaries rarely report this kind of information. For producers, PCAs and Extension scientists this information is of great importance. Under some circumstances AIs are more effective when used in combination. Under other circumstances there is no economical increase in efficacy. Summarizing use data on AI combinations provides a better picture of use patterns.

Target pest data makes it possible to better understand the pest problems being treated. Pesticide applications can be summarized by pest providing quantitative evidence of the magnitude of pest infestation problems. Recording multiple target pests is necessary as it reflects actual practice in the field. Unfortunately, reporting multiple pests complicates analysis significantly. Target pests may or may not have differing priorities. Secondary pests may or may not be reported.

Target pest data combined with tankmix information makes it possible to explore usage patterns in their full complexity. The number of permutations of AIs and pests is large. This type of summary is primarily useful for better understanding more general summaries which are based on simplifying assumptions regarding AIs or pests or both. The data presently does not indicate which AI in a combination application is intended for which reported pest. AIs and pests can be linked by database logic in ways that defy pest management logic. The best example of this involves plant growth regulators applied with an insecticide application. The database will summarize plant growth regulators by the target pests indicated for the insecticidal AIs with which they are applied. This example makes it clear that despite the substantial increase of data on pesticide application available from the ADA PUR system, an extensive knowledge of production practices is essential to fully utilize the data.

Perhaps the most impressive characteristic of ADA's PUR system is the alacrity with which it is available for analysis. No other reporting system can provide the raw data to researchers within at most 3 weeks of the application date. This process is as close to real-time data as pesticide reporting gets. Weekly charts of insecticide usage and pest reporting have been developed to keep research abreast of developments through the growing season. The further possibilities for taking advantage of this near real-time data for modeling pest population dynamic are being explored.

Pesticide use summaries are only as good as the data from which they are produced. The limitations in coverage of the ADA PUR Database do raise concerns over the usefulness of the summaries derived therein. The ADA PUR database records pesticide use reports from a number of different kinds of applicators some of which must report completely and others who do not necessarily need to report at all. An ongoing challenge with this database has been estimating the shortfall in coverage.

A simple procedure is used to estimate the shortfall in insecticide applications. With minimal assumptions, the data on certain fully reported AIs from different classes of applicators is used to estimate the under-reported AIs. Independent data is utilized to determine an upper bound of potential under-reporting.

Data

Database Contents

The data reported in the ADA PUR database include AI, amount of product, acres treated, date, section, target pest and ID numbers for all parties

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involved from the seller to the applicator to the grower. Field level application rate estimates for AIs should be quite accurate with a reasonable number of reports. With the data on AI combinations it is possible to go beyond overall average rate and compare rates under different usage scenarios. Date and section information allow for plotting data both through time and spatially. ID numbers provide valuable information on whether applications are voluntary grower applications or mandatory reports from custom applicators.

The target pest field has been present on the report form from the outset but has only been entered into the database for two years. The potential for this data field is immense. Previous to explicit reporting of target pest, the intent of the applicator had to be inferred based on application composition. Only in a few cases, like synergized pyrethroid mixes for whiteflies, was this feasible. Recording the target pest makes it possible to track true usage patterns even when they might go contrary to expectations. It will take time and education to increase the accuracy and consistency of the target pest field to allow it to be utilized to its full potential.

The efficiency of the ADA - Arizona Agricultural Statistics Service collaboration on the 1080 PUR makes it possible to report on the most recent year's pesticide use. All year 2000 data, however, will go through a series of data validations once the year is complete. Thus, summaries of year 2000 usage in this paper are all preliminary. No significant changes are foreseen.

Regulatory Statutes

The Arizona Department of Agriculture PUR database does not cover all pesticide use in Arizona agriculture. The database results from three different regulatory policies. These policies cover custom applications, Section 18 products and Arizona Department of Environmental Quality (DEQ) Groundwater Protection List (GPL) AIs. The nature of these policies and the means of regulation determine the coverage within the database.

Arizona statute R3-3-302 requires custom applications of pesticides to be reported. A custom applicator is "any person who applies pesticides: a.) For hire; or b.) By aircraft whether or not for hire (R3-3-101)." Licenses are required for all Arizona custom applicators. Failure to report usage properly can result in the loss of the applicator's license so compliance is assumed to be high.

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

The final regulatory policy that affects the PUR system is state statute R18-6-303 which states that all soil applied pesticides on the Arizona DEQ GPL must be reported. R18-6-101 in the Arizona Administrative Code defines a soil-applied pesticide as "a pesticide which is intended to be applied to or injected into the soil by ground-based application equipment or by chemigation, or the label of the pesticide requires or recommends that the application be followed within 72 hours by flood or furrow irrigation." The list of AIs included in this regulation (http://www.sosaz.com/public_services/Title_18/18-06.htm) is over ten years old but still includes many widely used pesticides. Proper reporting of these AIs would dramatically improve the coverage of this database.

Regulatory Policies and Database Coverage

These different regulatory policies have different effects on coverage of the ADA PUR database. Full reporting of aerially applied pesticides is the primary strength of the database. Under certain circumstances, aerially applied pesticides are a specific category of interest, and in this case, the Arizona PUR database offers the full advantages of complete reporting. An example is the EPA risk assessment. With respect to exposure potential, aerial application has unique characteristics and thus is treated separately with respect to risk assessment.

The extent of coverage of the ADA PUR database varies across different types of pesticides largely because it is dominated by aerial applications (Tables 1 and 2). Cotton insecticides appear to be well covered in the database. Anecdotal evidence indicates that in many areas all insecticide applications are done aerially. In some areas irrigation schedules combine with soil characteristics to make field entry with ground equipment impossible. Furthermore, ground application equipment that can treat cotton through the growing season is specialized and expensive. There is some evidence that on the boundaries of Arizona's rapidly expanding urban areas, ground application may be increasingly considered a cost effective alternative to public concern over aerial applications. Elsewhere in Arizona, the picture is less clear.

There is some independent evidence that applications recorded in the ADA PUR database do not drastically underestimate actual applications. University of Arizona IPM specialist Peter Ellsworth estimates the Cotton Council's Beltwide Cotton Insect Losses Survey for Arizona (http://ag.arizona.edu/cotton/cil/cil.html). Ellsworth estimated statewide average 1999 insecticide usage at 1.91 applications per acre. These estimates reflect "PCA responses to a standardized survey, and/or expert opinion". Ellsworth's 1999 estimate is actually slightly below the average insecticide usage estimate of 2.15 applications per acre derived from ADA database. Earlier Cotton Insect Loss estimates were substantially above ADA 1080 average applications but this could reflect the greater usage of combination applications and multiple target pests. The similarity of the 1999 estimates indicate that the ADA database may record a large percent of the cotton insecticide applications.

Unfortunately, the same cannot be said for herbicide applications, even those that are on the DEQ GPL. There is no evidence that these AIs are consistently reported as they should be. Part of the problem is the high ratio of usage by non-custom applicators who otherwise do not have to report. The report field for GPL AIs is checked in an extremely inconsistent manner. While this field is checked for less 50% of the acres for a number of GPL AIs, it is checked for more than 80% of the acres for some non- GPL AIs. Much of the confusion surrounding GPL status appears to be among both aerial and ground custom applicators. These custom applicators must report all applications so this doesn't necessarily indicate under-reporting. But if custom applicators are unclear about what constitutes a GPL AI, there is likely greater confusion among the non-custom ground applicators. As expected, where non-custom applicators are reporting herbicide applications, the GPL field is almost always checked regardless of whether it is on the GPL list or not. With only 58 and 64 percent of cotton acreage reported as treated by herbicide in the last two years, it is clear herbicide applications are drastically under-counted. USDA recently estimated that nationwide herbicide application acreage is 139% of planted cotton acreage (Padgitt, et al. 2000).

GPL list applications will always be a difficult policy to promote. Different usage patterns of the same product might warrant different regulatory consideration. The definition of "soil-applied" appears to rule out foliar applications. Whether post-directed applications are included is less clear. However, at present it is clear that the limitations of GPL list reporting go beyond this level of confusion. If this reporting requirement is to be taken seriously, education of grower and custom applicators must take place.

Results

Data Summary

Preliminary data from the 2000 growing season indicates that usage of most insecticides continued to drop in Arizona cotton production. Total insecticide applied acres dropped by 16% despite a small projected increase in planted acreage. Acephate (Orthene), endosulfan (Thiodan) and chlorpyrifos (Lorsban), the three most widely used insecticides for many years, fell 17, 30 and 15 percent, respectively (Table 3). Acephate and chlorpyrifos are organophosphates and endosulfan is an organochlorine. The only AIs in the top 15 that increased in acreage were pyriproxyfen (Knack), fenpropathrin (Danitol) and cyfluthrin (Baythroid). These three AIs increased 75, 64 and 129 percent respectively but the acreage increases were small relative to the top three above. Pyriproxyfen is an insect growth regulator (IGR) and fenpropathrin and cyfluthrin are pyrethroids. Both of these categories of insecticides are considered preferable to either organophosphates or organochlorines. Application rates are the mean of field level rates and stayed approximately the same between 1999 and 2000. State and county cotton acreages come from the Arizona Agricultural Statistics Service (AASS. 1999).

Lygus continued to be the most treated pest problem in Arizona cotton production though pressure was down in 2000 (Table 4). The lower pressure may in part be explained by an extremely dry intervening winter that limited alternative non-agricultural hosts for lygus populations. Meanwhile, whitefly pressure returned after a relatively low-pressure season in 1999 and pink bollworm applications dropped slightly.

The new target pest field in the ADA PUR database helps document and explain these trends. It is important to look at summaries organized both by AI and Pest combinations (Tables 5 and 6) and by single AIs and pests (Tables 7, 8 and 9). The fully disaggregated tables 5 and 6 provide the most specific information but are overwhelming in the number of permutations. In 2000, the lowest insecticide application year in the last ten (Agnew and Baker, 2000), there were 740 different AI/Target insect combinations. The single AI/single pest tables simplify the data but lose important information in the process. The three AIs that increased in usage in 2000 are good example of how both tables are necessary.

The increased use of both pyriproxyfen and fenpropathrin in 2000 are a result of the increased whitefly pressure. Pyriproxyfen is one of the two insect growth regulators available for whitefly control. Fenpropathrin combined with acephate has been the most used synergized pyrethroid combination for whitefly control since 1995. As expected, these AIs are on top of the whitefly usage summary. Interestingly, however, both pyriproxyfen and fenpropathrin are also on the lygus list. Neither AI is recommended for lygus, while pyriproxyfen has no activity at all against lygus. Both find places on the lygus list because they are commonly tank mixed with acephate which was the most common lygus treatment in 2000.

Cyfluthrin increased between 1999 and 2000 because alone and combined with chlorpyrifos it is considered effective on the bollworm/budworm complex. Cyfluthrin's presence on the lygus top ten AI list is also unexpected. It does not make the list by combining with a popular lygus AI. To the contrary, cyfluthrin is on the lygus list as a result of numerous oddball combinations that all include lygus along with some other pest. The most common cyfluthrin combination targeting lygus is 52nd on the AI combination list and cyfluthrin alone is never reported targeted for lygus alone. Without the single AI/single pest tables none of these peculiar results would be easily explained.

Table 10 shows the general downward trend in application acres over the last six years. Table 11 shows the downward trend remains even when decreasing cotton acreage is factored in. The percentage of planted acres measures are also called application intensity. Figures 1 to 6 show application intensity in one county, Maricopa, from 1995 to 1999. These time plots were developed to provide a simple, visually-oriented way of reporting the weekly data received from Arizona Agricultural Statistics Service, the office that does the actual data entry. County level, weekly charts can provide researchers, county agents and growers with useful information on developments at the county level. Comparison of time plots across counties and through time provides and new perspective on pest control in Arizona over the last 6 years.

Table 12 shows herbicide usage in Arizona cotton production for the years 1999 and 2000. As noted, reporting coverage for herbicides is not as good. The list does indicate what AIs are used for weed control in Arizona. The list may even provide an indication of the relative popularity of different AIs. If an herbicidal AI is more likely to be applied by a custom applicator then it will be over represented in the ADA database.

One trend that has been clear both from the database and anecdotal evidence is the increasing popularity of glyphosate (Roundup. With the availability of cotton genetically modified to tolerate over-the-top applications of glyphosate early in the season, usage and reporting of this AI has increased dramatically. Since 1995, reported acres have increased twenty-fold. The fact that glyphosate acres still only represent 14% of planted acres (based on 1999 acres) in 2000 is an indication of the limitations of herbicide reporting in the database.

Table 13 shows the usage of defoliants, fungicides, Nematicides and plant growth regulators (PGRs). ADA PUR database coverage of these categories of pesticides is difficult to determine. Both defoliants and PGRs are frequently applied aerially so will be well represented in the database. For the fungicides and Nematicides, 1,3-dichloropropene (Telone) is only applied by ground while mancozeb (Ridomil) is only applied aerially.

Table 13 documents a dramatic increase in reported defoliant application acres in 2000 relative to previous years. Also the use of ethephon (Super Boll) as a PGR increased almost three-fold while use of mepiquat chloride (Pix) fell for the first time in six years.

Coverage Estimation

The unknown extent of under-reporting in the ADA PUR database is its single greatest weakness. Data from within the database can be used to estimate the magnitude of the shortfall.

In the database, aerial applications represent more than 90% of insecticide applications both in terms of the number of reports and acres applied. The small percentage of reports that are ground applications of insecticides can be split into two groups: Custom applicators who must report and grower (non-custom) applicators who report voluntarily. The shortfall in reporting comes as a result of grower applicators who choose not to report. Fortunately, we do have an indication of this shortfall as a result of the Section 18 registration for the IGRs. Full reporting of usage of these two AIs was required during the years the Section 18 was in force even for grower applicators.

Grower (non-custom), IGR application acres averaged 5.7% of total IGR application acres for the years Section 18 requirements remained in place. This is substantially higher than the 1.2% average for grower applications of the top 15 non-IGR insecticides. This increased percentage for IGR applications should represent the increase of grower applications to full reporting. Furthermore, looking at custom ground applications, where all applications must be reported, the percentages of IGR and non-IGR applications were 2.1 and 2.4 percent respectively. According the complete custom reporting, IGRs are a lower percentage of overall usage relative to non-IGRs. Projecting this custom usage ratio onto the grower IGR acreage percentage provides a rough estimate of a grower non-IGR acreage percentage.

grower non-IGR %= grower IGR%*custom non-IGR%/custom IGR%

With full reporting, grower non-IGR application acres should be 6.6% of overall acreage. This is an average 5.5 time increase for all non-IGR grower applications. This sounds significant until one remembers that grower applications represent only 1.2 % of total application acres over the six year span. The effect of multiplying grower applications by 5.5 only increases overall applications of the top 16 non-IGR AIs by 5.0%. For the over 670,000 acres reported of the top 16 non-IGR AIs in 2000 the increase is under 15,000 acres or only 2.1%.

This simple approach to estimating the shortfall in the ADA PUR database has one major weakness. It assumes that all grower applications of IGRs were in fact reported. However, an individual grower making a single ground application of an IGR would have less incentive to comply with regulations than a licensed custom applicator. Furthermore, if a grower is not familiar with the 1080 reports and how to fill them out properly, the possibility of lost data due to reporting error increases.

Fortunately, there is an alternative source of data on IGR applications that allows us to create a conservative, upper-bound estimate of the under-reporting in the 1080 database. Peter Ellsworth has acreage estimates for the IGRs that are based on sales data from the IGR registrants. This data appears to indicate that there are some IGR application acres somewhere which are not being reported . To avoid basing the estimation on the assumption of full reporting of IGR acres by growers, the discrepancy between Ellsworth's IGR acreage estimates and the 1080 PUR database estimates is assumed to be under-reported grower application acres. With these inflated grower applications of IGRs included, the same simple process as above is repeated.

With all possible IGR application acres accounted for, the multiplier increases to 18 from 5.5. However, even this upper bound estimate only increases overall applications of the top 16 non-IGR AIs by 19.0%. The year 2000 increase is only 8%.

This kind of under-reporting is not insignificant. It will always undermine the usefulness of the database. However, the magnitude of the shortfall is not great and is within the margin of error of survey sample techniques otherwise employed to determine pesticide usage. In fact, a quick comparison of 1998 NASS estimates of Arizona insecticide usage (NASS, 1999) compared to ADA totals makes the limitations of sample based estimation all too clear (Table 14). Most importantly, the use of sales data to quantify usage of the IGRs in Arizona means the conservative estimates of the shortfall in reporting are not fundamentally based on an assumption of full reporting by non-custom, grower applicators.

Summary

The ADA PUR database provides timely data on pesticide use and pest patterns in Arizona cotton production. The combination of AI and target pest data makes this data substantially more informative than most PUR databases. A simple, conservative estimate of the insecticide acreage reporting shortfall puts the upper bound at twenty percent. Quantifying the shortfall further enhances the usefulness of the database.

Data from the 2000 growing season indicates that overall insecticide use continued to decrease on both a gross and per acre basis. Despite declines, acephate, endosulfan and chlorpyrifos remained the three most used AIs. Lygus remained the most treated pest followed by whitefly and pink bollworm.

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Table 1. Application Intensity and Percent Aerially Applied, 1995-2000, Based on Acres Treated.

	Insecticides		**Defoliants**		**Plant Growth Regulators**		**Herbicides**	
	App. Intensity	**% Aerial**	**App. Intensity**	**% Aerial**	**App. Intensity**	**% Aerial**	**App. Intensity**	**% Aerial**
1995	6.28	96%	0.97	94%	0.26	89%	0.46	46%
1996	5.20	95%	0.94	94%	0.33	92%	0.41	35%
1997	3.53	94%	0.94	91%	0.41	89%	0.36	29%
1998	3.10	92%	0.99	88%	0.64	91%	0.45	24%
1999	2.15	96%	0.91	88%	0.62	89%	0.45	26%
2000	1.79	95%	1.05	87%	0.62	87%	0.51	27%

Multiple AI mixes counted as single application.
Application Intensity = Application acres/Planted acres.

Table 2. Percent of reports by Type of Pesticide

	Insecticides	**Defoliants**	**Plant Growth Regulators**	**Herbicides**	**Fumigants/ Fungicides**
1995	72%	17%	6%	9%	1%
1996	70%	18%	7%	8%	1%
1997	64%	21%	10%	9%	1%
1998	58%	21%	16%	11%	1%
1999	47%	26%	18%	13%	1%
2000	54%	25%	17%	15%	1%

Percents add up to greater than 100% because of combination applications across type categories.

Table 3. Arizona Insecticide Usage, 1999-2000.

Active Ingredient (Product)	99 Reps	1999 Acres x 1000	1999 Rate	1999 %PA	2000 Reps	2000 Acres x 1000	2000 Rate	2000 %PA
Acephate (Orthene)	1,378	231.7	0.80	83%	1,183	192.3	0.79	67%
Endosulfan (Thiodan)	915	163.9	1.14	59%	723	115.3	1.07	40%
Chlorpyrifos (Lorsban)	835	144.8	0.66	52%	736	122.9	0.68	43%
Lambda-cyhalothrin (Karate)	502	96.2	0.03	34%	305	54.8	0.03	19%
Gossyplure (Decoy PBW)	359	58.3	0.01	21%	293	52.6	0.02	18%
Pyriproxyfen (Knack)	192	28.7	0.05	10%	303	50.3	0.05	18%
Fenpropathrin (Danitol)	190	25.6	0.19	9%	314	41.9	0.19	15%
Oxamyl (Vydate)	219	39.7	0.78	14%	205	25.6	0.76	9%
Cyfluthrin (Baythroid)	109	14.2	0.04	5%	206	32.6	0.04	11%
Methomyl (Lannate)	138	26.1	0.36	9%	102	14.6	0.40	5%
Cypermethrin (Ammo)	119	24.4	0.07	9%	113	16.2	0.08	6%
Buprofezin (Applaud)	107	17.9	0.35	6%	89	14.2	0.34	5%
Dimethoate (Dimethoate)	142	24.1	0.33	9%	68	7.7	0.27	3%
Methyl parathion (Penncap-M)	109	17.9	0.72	6%	43	8.9	0.58	3%
Bifenthrin (Capture)	78	12.5	0.05	4%	94	11.6	0.06	4%
Zeta-cypermethrin (Mustang)	65	10.4	0.04	4%	79	11.0	0.05	4%
Sulfur (Thiolux)	59	9.1	3.59	3%	39	7.4	3.06	3%
Amitraz (Ovasyn)	15	2.3	0.19	1%	65	13.9	0.16	5%
Esfenvalerate (Asana)	51	8.2	0.04	3%	44	4.7	0.04	2%
Malathion (Malathion)	13	4.1	1.18	1%	29	4.6	1.30	2%
Thiodicarb (Larvin)	13	2.2	0.68	1%	20	6.0	0.49	2%
Profenofos (Curacron)	28	5.2	0.86	2%	7	1.7	0.89	1%
Aldicarb (Temik)	15	3.8	1.25	1%	20	2.2	0.93	1%
Phorate (Thimet)	19	2.8	1.53	1%	14	2.6	1.39	1%
Dicofol (Dicofol)	15	1.9	0.63	1%	20	3.5	0.90	1%

2000 summaries based on preliminary data and 1999 planted acres. Reps=reports. % PA =application acres / statewide planted acres

Table 4. Arizona Target Pest Reports and Application Acres, 1999-2000.

	1999		2000	
Target Pest	Reports	Application Acres	Reports	Application Acres
lygus	1944	344,883	1326	213,632
whitefly	899	142,885	1230	198,655
PBW	961	153,837	880	145,748
bollworm_ budworm	524	97,505	499	90,474
armyworm	386	78,750	309	58,363
aphids	127	20,137	154	25,749
thrips	92	20,289	97	11,747
nematode	23	6,198	48	10,287
mite	69	11,631	65	9,995
caterpillar_ saltmarsh			29	4,881
worm_ unknown	4	958	55	3,167
stinkbug	21	4,517		
leafhopper	28	4,057		
weevil	15	3,193		

2000 summaries based on preliminary data.

Table 5. Arizona Insecticide and Pest Combinations, 1999.

Active Ingredient	Target Insect(s)	Acres
Endosulfan	lygus	48,178
Acephate	lygus	40,809
Acephate/Endosulfan	lygus	28,036
Oxamyl	lygus	17,033
Chlorpyrifos/Gossyplure	Pink bollworm	16,790
Chlorpyrifos/ Lambdacyhalothrin	Armyworm/bollworm_budworm	14,793
Chlorpyrifos	Pink bollworm	14,485
Chlorpyrifos	armyworm	11,287
Cypermethrin	Pink bollworm	11,264
Acephate/Chlorpyrifos	lygus	10,902
Endosulfan	Lygus/whitefly	8,910
Lambdacyhalothrin	bollworm_budworm	8,206
Gossyplure	Pink bollworm	8,087
Acephate/Fenpropathrin	whitefly	7,745
Buprofezin	whitefly	6,544
Acephate/Pyriproxyfen	Lygus/whitefly	6,035
Pyriproxyfen	whitefly	5,971
Lambdacyhalothrin	Pink bollworm	5,861
Acephate/Chlorpyrifos	Lygus/armyworm	5,289
Acephate/ Lambdacyhalothrin	Lygus/bollworm_budworm	5,078

Table 6. Arizona Insecticide and Pest combinations, 2000.

Active Ingredient	Target Insect(s)	Acres
Acephate	lygus	28,895
Chlorpyrifos	Pink bollworm	27,248
Pyriproxyfen	whitefly	26,378
Chlorpyrifos/Gossyplure	Pink bollworm	12,065
Chlorpyrifos	armyworm	11,812
Acephate/Fenpropathrin	Lygus/whitefly	10,696
Endosulfan	Lygus/whitefly	10,589
Gossyplure	Pink bollworm	10,425
Acephate/Fenpropathrin	whitefly	9,960
Acephate/Endosulfan	Lygus/whitefly	9,852
Oxamyl	lygus	7,104
Chlorpyrifos/Cyfluthrin	Armyworm/bollworm_budworm	6,206
Endosulfan	lygus	6,062
Acephate	Lygus/stinkbug	5,747
Acephate/Endosulfan	Aphids/lygus	5,720
Thiodicarb	armyworm	4,951
Acephate/	bollworm_budworm/	4,944
Acephate/Endosulfan	whitefly	4,685
Endosulfan	whitefly	4,503
Methylparathion	bollworm_PBW	4,413

2000 summaries based on preliminary data.

Table 7. Arizona Top Ten Lygus Active Ingredients, 1999-2000.

	1999				2000			
Active Ingredient (Product)	Reps	Acres x 1000	Mean Rate	% PA	Reps	Acres x 1000	Mean Rate	% PA
Acephate (Orthene)	1,051	182.1	0.84	65%	782	130.0	0.83	46%
Endosulfan (Thiodan)	796	149.1	1.18	53%	422	71.5	1.09	25%
Chlorpyrifos (Lorsban)	334	57.5	0.69	21%	136	23.2	0.70	8%
Lambda-cyhalothrin (Karate)	259	45.4	0.03	16%	136	22.1	0.03	8%
Oxamyl (Vydate)	178	33.4	0.80	12%	169	22.3	0.78	8%
Methomyl (Lannate)	88	17.9	0.42	6%	39	7.4	0.47	3%
Fenpropathrin (Danitol)	61	8.6	0.20	3%	110	16.3	0.19	6%
Pyriproxyfen (Knack)	80	14.8	0.05	5%	68	9.2	0.05	3%
Dimethoate (Dimethoate)	109	17.5	0.33	6%	29	3.4	0.33	1%
Cyfluthrin (Baythroid)	38	7.1	0.04	3%	70	13.1	0.04	5%

2000 summaries based on preliminary data and 1999 planted acres. Reps=reports. % PA =application acres / statewide planted acres

Table 8. Arizona Top Ten Whitefly Active Ingredients, 1999-2000.

	1999				2000			
Active Ingredient (Product	Reps	Acres x 1000	Mean Rate	% PA	Reps	Acres x 1000	Mean Rate	% PA
Acephate (Orthene)	430	69.5	0.75	25%	569	89.3	0.78	31%
Endosulfan (Thiodan)	267	45.0	1.07	16%	398	69.7	1.06	24%
Pyriproxyfen (Knack)	188	28.0	0.05	10%	301	50.1	0.05	18%
Fenpropathrin (Danitol)	171	23.1	0.19	8%	286	39.6	0.19	14%
Lambda-cyhalothrin (Karate)	109	21.3	0.03	8%	116	21.8	0.03	8%
Chlorpyrifos (Lorsban)	114	18.2	0.68	7%	116	20.5	0.72	7%
Buprofezin (Applaud)	101	17.5	0.34	6%	87	14.1	0.34	5%
Gossyplure (Decoy PBW)	67	7.8	0.01	3%	79	12.9	0.01	5%
Oxamyl (Vydate)	45	7.7	0.74	3%	36	5.5	0.77	2%
Bifenthrin (Capture)	43	7.8	0.06	3%	43	4.2	0.07	1%

2000 summaries based on preliminary data and 1999 planted acres. Reps=reports. % PA =application acres / statewide planted acres

Table 9. Arizona Top Ten Pink Bollworm Active Ingredients, 1999-2000.

	1999				2000			
Active Ingredient (Product)	Reps	Acres x 1000	Mean Rate	% PA	Reps	Acres x 1000	Mean Rate	% PA
Chlorpyrifos (Lorsban)	374	60.0	0.61	21%	352	59.8	0.64	21%
Gossyplure (Decoy PBW)	327	54.1	0.01	19%	268	48.0	0.02	17%
Acephate (Orthene)	238	36.3	0.72	13%	228	36.8	0.73	13%
Lambda-cyhalothrin (Karate)	128	22.0	0.03	8%	95	16.9	0.03	6%
Endosulfan (Thiodan)	93	12.5	0.90	4%	119	18.3	1.03	6%
Cypermethrin (Ammo)	94	19.7	0.07	7%	50	6.6	0.09	2%
Methyl parathion (Penncap-M)	80	13.8	0.71	5%	33	6.4	0.65	2%
Fenpropathrin (Danitol)	69	8.2	0.19	3%	77	10.1	0.18	4%
Cyfluthrin (Baythroid)	39	4.7	0.05	2%	57	9.0	0.04	3%
Zeta-cypermethrin (Mustang)	38	5.3	0.04	2%	28	4.6	0.04	2%

2000 summaries based on preliminary data and 1999 planted acres. Reps=reports. % PA =application acres / statewide planted acres

Table 10. Arizona Insecticide Application Acres, 1995-2000, By Active Ingredient, 1000s of Acres.

Active Ingredient (Product)	1995	1996	1997	1998	1999	2000
Acephate (Acephate)	853.6	402.8	356.9	256.0	231.7	192.3
Chlorpyrifos (Lorsban)	969.0	567.6	412.9	240.2	144.8	122.3
Endosulfan (Thiodan)	338.7	273.4	233.1	176.4	163.9	115.3
Lambdacyhalothrin (Karate)	340.6	201.8	154.4	100.7	96.2	54.8
Gossyplure (Decoy PBW)	426.8	409.5	146.8	58.9	58.3	52.2
Pyriproxyfen (Knack)	0.0	143.8	101.8	115.6	28.7	50.3
Fenpropathrin (Danitol)	578.1	42.2	39.5	29.8	25.6	41.9
Cyfluthrin (Baythroid)	13.4	11.6	10.8	13.6	14.2	31.8
Oxamyl (Vydate)	145.1	111.6	127.4	63.4	39.7	25.6
Cypermethrin (Ammo)	7.8	34.9	36.2	19.1	24.4	16.2
Methomyl (Lannate)	172.2	36.6	92.4	16.9	26.1	14.6
Amitraz (Ovasyn)	77.9	104.2	13.1	6.5	2.3	13.9
Bifenthrin (Capture)	210.0	28.4	16.6	7.2	12.5	11.6
Zeta-cypermethrin (Mustang)	174.0	47.6	43.5	21.9	10.4	11.0
Dimethoate (Dimethoate)	41.8	37.6	61.6	53.3	24.1	7.7
Sulfur (Thiolux)	35.0	25.9	12.1	21.9	9.1	7.4
Methyl parathion (Penncap-M)	124.9	209.9	103.2	21.6	17.9	6.9
Thiodicarb (Larvin)	8.4	4.1	3.1	0.6	2.2	6.0
Buprofezin (Applaud)	0.0	55.8	68.0	34.3	17.9	5.7
Esfenvalerate (Asana)	44.6	12.9	3.0	4.4	8.2	4.7
Dicofol (Dicofol)	0.4	1.0	1.1	5.7	1.9	3.5
Malathion (Malathion)	30.2	5.2	1.5	5.0	4.1	3.3
Deltamethrin (Decis)	0.0	8.7	11.1	7.1	1.7	2.6
Phorate (Thimet)	2.2	10.6	11.4	6.3	2.8	2.6
Aldicarb (Temik)	6.5	17.9	17.7	22.3	3.8	2.2
Azinphos-methyl (Azinphos-M)	14.7	4.6	3.5	3.2	0.9	2.1
Profenofos (Curacron)	213.9	58.0	34.1	17.3	5.2	1.7
Permethrin (Ambush)	292.6	208.0	3.6	0.2	0.3	1.2
Allium sativum (Garlic)	0.0	1.9	0.1	2.1	0.4	1.0
Piperonyl butoxide (Evergreen)	0.0	0.9	0.0	1.7	0.0	0.9
Methamidophos (Monitor)	22.2	4.3	7.0	9.2	1.7	0.7
Imidacloprid (Admire)	72.7	56.7	10.8	2.1	0.0	0.7
Oxydemeton-methyl (Metasystox-R)	2.4	5.8	1.6	4.2	0.4	0.3
Propargite (Comite)	0.5	0.8	0.1	4.5	0.2	0.2
Diazinon (Diazinon)	0.1	0.2	0.5	0.1	0.0	0.2
Disulfoton (Di-Syston)	1.4	1.5	2.0	0.6	0.0	0.1
Methidathion (Supracide)	56.4	119.4	21.6	2.2	0.2	0.1
Carbaryl (Sevin)	0.9	0.2	0.2	0.4	0.1	0.0
Tralomethrin (Scout)	34.9	29.1	2.1	0.0	0.6	0.0

2000 summaries based on preliminary data.

Table 11. Arizona Insecticide Application Intensities, 1995-2000, By Active Ingredient.

Active Ingredient (Product)	1995	1996	1997	1998	1999	2000
Acephate (Acephate)	206%	113%	103%	96%	83%	69%
Chlorpyrifos (Lorsban)	234%	159%	119%	90%	52%	44%
Endosulfan (Thiodan)	82%	77%	67%	66%	59%	41%
Lambdacyhalothrin (Karate)	82%	57%	44%	38%	34%	20%
Gossyplure (Decoy PBW)	103%	115%	42%	22%	21%	19%
Pyriproxyfen (Knack)	0%	40%	29%	43%	10%	18%
Fenpropathrin (Danitol)	140%	12%	11%	11%	9%	15%
Cyfluthrin (Baythroid)	3%	3%	3%	5%	5%	11%
Oxamyl (Vydate)	35%	31%	37%	24%	14%	9%
Cypermethrin (Ammo)	2%	10%	10%	7%	9%	6%
Methomyl (Lannate)	42%	10%	27%	6%	9%	5%
Amitraz (Ovasyn)	19%	29%	4%	2%	1%	5%
Bifenthrin (Capture)	51%	8%	5%	3%	4%	4%
Zeta-cypermethrin (Mustang)	42%	13%	13%	8%	4%	4%
Dimethoate (Dimethoate)	10%	11%	18%	20%	9%	3%
Sulfur (Thiolux)	8%	7%	3%	8%	3%	3%
Methyl parathion (Penncap-M)	30%	59%	30%	8%	6%	2%
Thiodicarb (Larvin)	2%	1%	1%	0%	1%	2%
Buprofezin (Applaud)	0%	16%	20%	13%	6%	2%
Esfenvalerate (Asana)	11%	4%	1%	2%	3%	2%
Dicofol (Dicofol)	0%	0%	0%	2%	1%	1%
Malathion (Malathion)	7%	1%	0%	2%	1%	1%
Deltamethrin (Decis)	0%	2%	3%	3%	1%	1%
Phorate (Thimet)	1%	3%	3%	2%	1%	1%
Aldicarb (Temik)	2%	5%	5%	8%	1%	1%
Azinphos-methyl (Azinphos-M)	4%	1%	1%	1%	0%	1%
Profenofos (Curacron)	52%	16%	10%	7%	2%	1%
Permethrin (Ambush)	71%	58%	1%	0%	0%	0%
Allium sativum (Garlic)	0%	1%	0%	1%	0%	0%
Piperonyl butoxide (Evergreen)	0%	0%	0%	1%	0%	0%
Methamidophos (Monitor)	5%	1%	2%	3%	1%	0%
Imidacloprid (Admire)	18%	16%	3%	1%	0%	0%
Oxydemeton-methyl (Metasystox-R)	1%	2%	0%	2%	0%	0%
Propargite (Comite)	0%	0%	0%	2%	0%	0%
Diazinon (Diazinon)	0%	0%	0%	0%	0%	0%
Disulfoton (Di-Syston)	0%	0%	1%	0%	0%	0%
Methidathion (Supracide)	14%	33%	6%	1%	0%	0%
Carbaryl (Sevin)	0%	0%	0%	0%	0%	0%
Tralomethrin (Scout)	0%	8%	1%	0%	0%	0%

2000 summaries based on preliminary data and 1999 planted acres.

Table 12. Arizona Herbicide usage, 1999-2000.

Active Ingredient (product)	1999 Application Acres	1999 Mean Rate	1999 % Plt. Acres	2000 (Preliminary) Application Acres	2000 (Preliminary) Mean Rate	2000 (Preliminary) % Plt. Acres
Prometryn (Caparol)	33,141	0.98	12%	44,115	0.92	15%
Glyphosate (Roundup)	22,148	0.64	8%	40,478	0.73	14%
Pendimethalin (Prowl)	51,172	0.94	18%	39,496	0.89	14%
Trifluralin (Treflan)	21,104	0.66	8%	21,489	0.57	8%
Cyanazine (Bladex)	11,918	1.08	4%	13,319	0.98	5%
Diuron (Karmex)	10,256	0.73	4%	10,485	0.76	4%
Pyrithiobac-sodium (Staple)	6,212	0.08	2%	5,482	0.03	2%
MSMA (MSMA)	1,753	1.44	1%	3,596	1.21	1%
Bromoxynil (Buctril)	2,053	0.32	1%	1,798	0.51	1%
Oxyfluorfen (Goal)	909	0.46	0%	1,159	0.44	0%
Fluometuron (Cotoran)	210	0.61	0%	1,025	1.11	0%
Sethoxydim (Poast)	1,132	0.35	0%	820	0.36	0%
Clethodim (Select)	1,884	0.20	1%	799	0.20	0%
Fluazifop-P-Butyl (Fusilade)	2,022	0.30	1%	775	0.34	0%

2000 summaries based on preliminary data and 1999 planted acres.

Table 13. Arizona Defoliant, Fungicide, Nematicide and Plant Growth Regulator Usage, 1999-2000.

Active Ingredient (product)	Application Acres	Mean Rate	% Plt. Acres	Application Acres	Mean Rate	% Plt. Acres
Defoliants						
Thidiazuron (Ginstar)	134,452	0.08	48%	217,931	0.06	78%
Diuron Def. (Ginstar)	107,495	0.04	39%	194,280	0.03	70%
Sodium chlorate (Pick Quik)	89,158	4.21	32%	93,539	3.72	34%
Paraquat (Starfire)	40,175	0.24	14%	61,265	0.25	22%
Tribufos (Folex)	39,802	1.09	14%	50,408	0.73	18%
Endothall (Hydrothol)	18,589	0.08	7%	23,054	0.07	8%
Cacodylic acid (Cotton-Aide)	25,539	0.69	9%	16,134	0.56	6%
Fungicide/Nematicide						
Mancozeb (Ridomil)	3,599	1.15	1%	16,409	1.36	6%
Dichloropropene (Telone II)	10,579	48.26	4%	9,739	49.31	3%
Plant Growth Regulators						
Mepiquat chloride (Pix)	142,939	0.04	51%	105,486	0.16	37%
Ethephon (Super Boll)	24,881	0.92	9%	73,333	0.57	26%
Maleic hydrazide (Retard)	2,118	0.42	1%	4,089	0.35	1%
Cytokinins (Promalin)	1,524	0.00	1%	1,661	0.00	1%
IBA (PGR IV)	2,791	0.00	1%	1,345	0.00	0%

2000 summaries based on preliminary data and 1999 planted acres.

Table 14. 1998 NAS and ADA Arizona Cotton Application Acres

Active Ingredients (Products)	NAS acres	ADA acres	ADA/NAS Ratio
Acephate (Orthene)	176,000	240,673	137%
Aldicarb (Temik)	39,000	20,931	54%
Buprofezin (Applaud)	30,000	32,204	107%
Chlorpyrifos (Lorsban)	126,000	225,802	179%
Cyfluthrin (Baythroid)	12,750	12,812	100%
Dimethoate (Dimethoate)	35,000	50,060	143%
Endosulfan (Thiodan)	164,000	165,822	101%
Fenpropathrin (Danitol)	17,500	27,991	160%
Lambdacyhalothrin (Karate)	42,250	94,678	224%
Methyl parathion (Penncap-M)	18,000	20,334	113%
Oxamyl (Vydate)	63,250	59,589	94%
Phorate (Thimet)	12,500	5,959	48%
Profenofos (Curacron)	24,500	16,225	66%
Propargite (Comite)	5,000	4,248	85%
Pyriproxyfen (Knack)	127,500	108,619	85%
Zeta-cypermethrin (Mustang)	22,750	20,541	90%

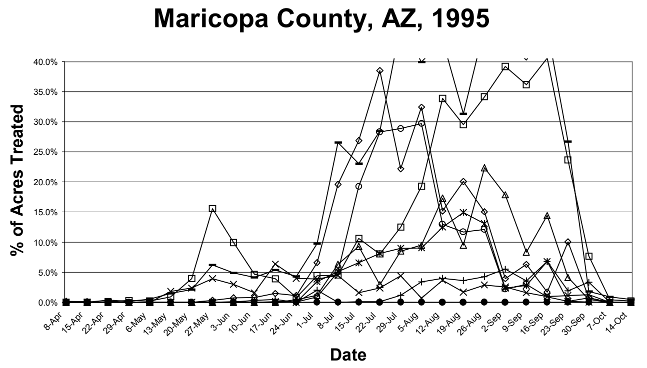

Figure 1. Insecticide Usage in Maricopa County AZ, 1995, by Week and Percentage of Planted Acres.

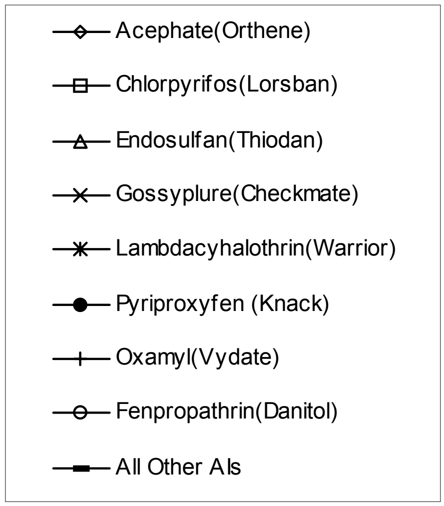

Figure 2. Usage Chart Legend.

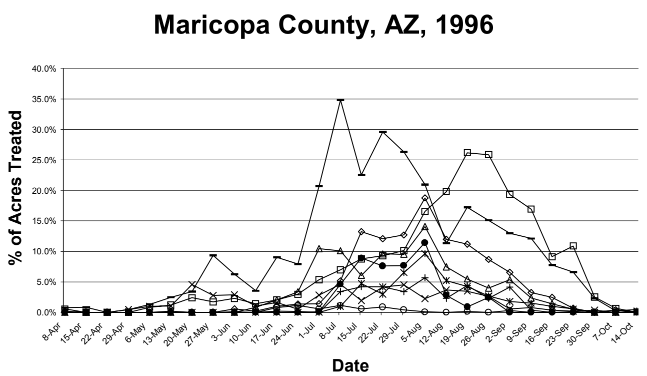

Figure 3. Insecticide Usage in Maricopa County AZ, 1996, by Week and Percentage of Planted Acres.

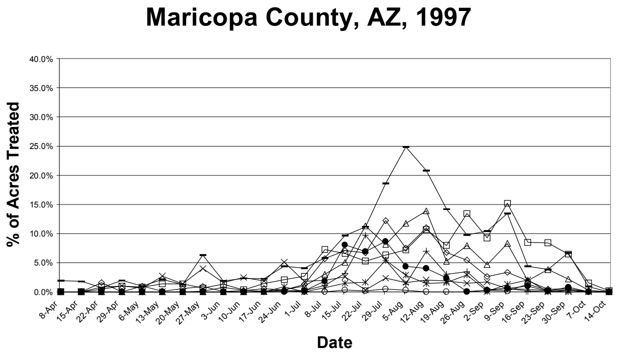

Figure 4. Insecticide Usage in Maricopa County AZ, 1997, by Week and Percentage of Planted Acres.

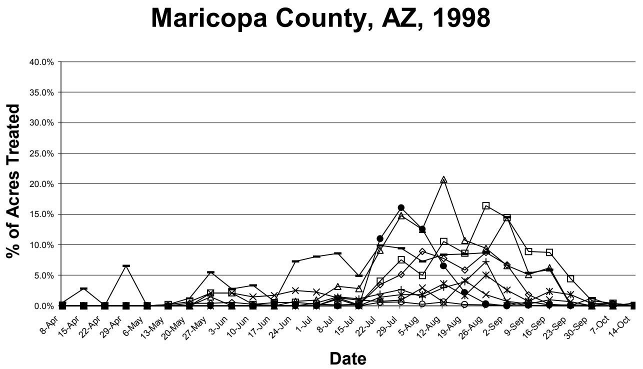

Figure 5. Insecticide Usage in Maricopa County AZ, 1998, by Week and Percentage of Planted Acres.

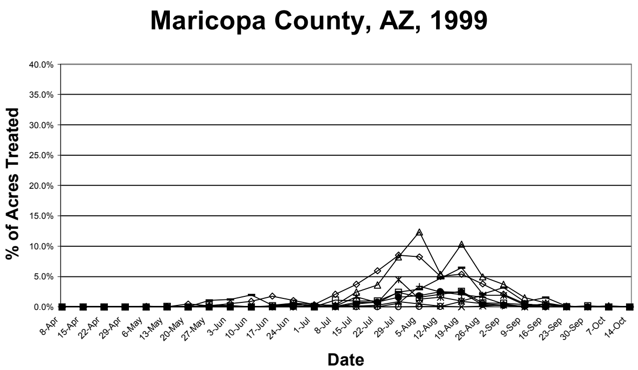

Figure 6. Insecticide Usage in Maricopa County AZ, 1999, by Week and Percentage of Planted Acres.