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PESTICIDE UPDATE IN ARIZONA COTTON FOR 2002

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Abstract

Arizona's pesticide use information system is a valuable tool for pest management research and extension. Recent advances in the pesticide use reporting system are presented. Active ingredients are quantified according to application frequencies, applied acreage, and product quantity per unit volume. Data are summarized to show patterns of use for categories of insecticides, herbicides, fungicides, defoliants, and plant growth regulators. Reported applications of agricultural chemicals are quantified to depict aspects of pest management practice.

Introduction

Reporting requirements mandated under Arizona State law enable systematic monitoring and quantification of agricultural chemical use in Arizona. Enhancements to the pesticide use reporting system permit estimates of agricultural chemical usage with improved precision and accuracy. Supplemented by additional queries and data resources, the system integrates chemical and regulatory information with active ingredient codes and other identifiers, increasing query reliability and performance. Addition of complimentary databases enhances sensitivity and specificity in analysis of chemical usage, potentially strengthening the statistical power of the data set for research.

Methods

In collaboration with Arizona Agricultural Statistics Service (USDA-NASS), several components were integrated with the pesticide use database at The University of Arizona Pesticide Information and Training Office. Ongoing efforts to improve and enhance the database have culminated in a comprehensive information system, representing agricultural chemicals on all crops grown in Arizona. 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.). Collected data include active ingredient (AI), EPA Registration Number, quantity, crop, acres treated, harvest date, re-entry intervals, wind velocity, aerial and ground applications, equipment codes, and license/permit ID numbers for regulated sellers, applicators, and growers.

The system was redesigned and programmed to compute quantities of active ingredients, adjust quantities according to the reported field size, convert all active ingredient measurements to their solid formulation equivalents, and compute weight in pounds. Upgrades were performed to adjust units of measurement, accommodating metric and other scaling systems. Conversion factors were programmed to adjust for mass and volume, allowing standardized measurement units to be generated for liquids and solids. The program was upgraded with the capability to compute the *Active Ingredient Field Percent,* representing the amount of active ingredient, in pounds, applied to a given field.

The variables of total applied acreage (*TAC*) represent the geographic field area measured in acres, receiving a given portion of an application. Recent addition of a data field for EPA's *Active Ingredient ID* code, enables improved sorting and filtering of chemicals, increasing the sensitivity and specificity of queries. Computer database fields were assessed to establish criteria for data categories. Descriptions of terms representing the database fields were solicited from agency representatives at USDA-NASS and Arizona Department of Agriculture - Environmental Services Division. These were compared and combined with the credentialing information posted at Arizona Department of Agriculture's website, http://agriculture.state.az.us/ESD/esdlicensees.htm. These definitions were combined with the legal descriptions of terms set forth in Arizona Revised Statutes.

Baseline standards were identified for routine queries, and procedures established for quality control/quality assurance. Target levels of performance were prioritized according to requirements for information output and summary reports. Benchmarks were set for testing the program's reliability and accuracy in performing basic computerized tasks, as well as performing higher-level statistical functions. General procedures for QA/QC testing were observed with a baseline standard set at 90%. The program was tested for correctness in data standardization, measurement unit conversion, variable selection and adjustment, and summary value calculation.

Data were obtained from Arizona Department of Agriculture, and verified by statisticians at USDA-NASS (Arizona Agricultural Statistics Service, 2000). Validated year-end data files were transferred electronically to The University of Arizona Pesticide Information and Training Office for analysis. Pesticide usage statistics on Arizona cotton were compiled, tabulated, and summarized.

Results and Discussion

Insecticide Applications

Insecticide applications comprised 37.7% of all pesticides applications last year. The number and type of compounds was varied, with 34 active ingredients applied to cotton in several formulations. Total weight of applied active ingredients was estimated at 495,406 pounds. Analysis of data from the last three years indicates a 50% decrease in the number of pesticide applications since 1998. Despite a 7% increase in planted acreage since 1998, the total number of pesticide applications declined in 2001. The downward trend in pesticide use appears to be stabilizing, suggesting changes in pest population dynamics and decision options for treatment.

Table 1 presents pesticide application data compiled from 2001. The most frequently used insecticides were Acephate [(Orthene®) N=1143; TAC=203,478], endosulfan [(Thiodan®) N=649; TAC=114,574], pyriproxyfen [(Knack®) N=552; TAC=52,304]], and chlorpyrifos [(Lorsban®) N=554; TAC=95,399]. Aerial applications of insecticides continued to predominate, representing more than 90% of applications in number of reports and acres applied. Statistical analysis of data from 2001 showed a 13.6% increase in TAC from the previous year, unadjusted for active ingredients. Calculation of unadjusted data masks the vast differences in total applied acreage between various active ingredients. Although unadjusted data indicate a 13.6% increase, stratification of chemicals and separate estimates of usage show dramatic differences and variability between compounds.

Some active ingredients such as methomyl, cypermethrin, and methyl parathion, decreased as much as 50-75% in applied acreage. Some compounds used previously had no reported applications in 2001. There was no reported use of amitraz, disulfoton, or thiodicarb. In contrast, reports of several active ingredients increased considerably since the previous 12-month period. Among those showing increased total applied acreage last year were acephate, endosulfan, oxamyl, dimethoate, fenpropathrin, bifenthrin, propargite, and imidacloprid.

There has been a downward trend in insecticide use since 1998, however this decline varies widely across active ingredients. Usage data compiled from 1998-2001 indicates marked decreases in use of several insecticides during 1998 and 1999, using TAC as outcome measures. Despite a crude rate decrease of 24.5%, application acres increased for several active ingredients during that same period. Between 1998 and 1999, the crude total applied acreage (TAC) across all insecticides decreased 24.5%. Despite this substantial drop in the crude rate, the adjusted rate, measured as total applied acreage (TAC,) increased for the following insecticides: cypermethrin, methomyl, bifenthrin, esfenvalerate, phorate, malathion, thiodicarb, diazinon, tralomethrin, and Bacillus thuringiensis (Bt).

Several approaches may be used to estimate different aspects of chemical use (Agnew and Baker, 2000; Agnew and Baker, 2001). Quantitative summaries organized by active ingredient (AI) permit calculation of application rates, provided formulation data are obtainable. Estimates of application rates and frequencies must incorporate label and other chemical information to accurately quantify usage. Database categories in isolation do not sufficiently describe the multidimensional nature of pesticide use. The data fields represent variables and measurements of a single aspect of use that is chemical and crop-specific. Both TAC and AI Field % are important measures, but they are insufficient indicators of usage when viewed out of context.

Estimating usage according to pounds of applied chemicals produces incongruous results. When calculating unadjusted or pooled data, weight in pounds is not predictive of applied acreage across categories of active ingredients. The relationship is highly variable between classes of chemicals and active ingredients. For some chemicals, total applied acreage is large relative to their weight, while other chemicals that weigh more may be applied to smaller areas.

Pounds of applied materials are not necessarily proportional to applied acreage, nor is weight a reliable indicator of the number or frequency of applications. Relationships are even weaker between number of applications and quantity of active ingredients applied/field. For example, acephate represents 38.9% of the total pounds of applied insecticides, but only 26.7% of the number of applications. In contrast, a single application of Bt on 120 acres represents 6,000 pounds of active ingredient; a sizeable proportion of "insecticide", when measured by weight.

Pounds, acreage, and number of applications may be useful approximations for certain active ingredients. Other parameters should be considered for those active ingredients that are exceptions to the norm. Toxicology is paramount, as are the chemical and physical properties influencing exposure. Deducing health or environmental impact requires modeling with inclusion of additional variables. Assessing exposure on the basis of this information alone is potentially misleading, leading to inappropriate approximations of risk. Usage estimates should be interpreted in light of the measurement criteria and what they represent, as well as the measures of central tendency appropriate to the dataset.

In certain instances, active ingredients generally regarded by practitioners as biological control agents have been designated by regulatory entities as "insecticides". Interpretation of data is challenged by ambiguity, as the common definition of "insecticide" has been replaced by the regulatory definition. Active ingredients potentially misclassified as insecticides include piperonyl butoxide, Bacillus thuringiensis, insect growth regulators, and gossyplure. Mating disruptors were applied to 1003 cotton fields, with 624 pounds of active ingredients covering 97,619 application acres. Formulations of the pheromone, gossyplure (Checkmate® PBW-F; NoMate® PBW MEC) contain stereoisomers (mirror images) of the molecule. Gossyplure and its enantiomer, Hexadecadien (Z,Z), exist in equal proportions of formulated compounds. Gossyplure was applied to 48,276 acres in 494 applications. Equal amounts of the stereoisomer, Hexadecadien (Z,Z) were also applied. Other agents applied were garlic barrier (AG Insect Repellent) and gibberellic acid (Cytoplex® HMS). Specific attention to these agents is needed to understand their patterns of use, as well as their impact on usage statistics for the entire category of insecticides.

Pyriproxyfen (Knack®) use has increased dramatically, since its availability. Analysis of data from 1996-2001 showed a continued increase in use of IGRs, as reported last year (Shanley and Baker, 2001; Agnew et.al., 2000). Applications increased 45.1% over a twelve-month period, from 303 to 552 applications. Adjusting for planted acreage, this represents a one-year increase from 17.6% to 37.2% application acres/planted acres. Reduced susceptibility in Arizona whiteflies last year highlights concerns about overuse of IGRs, and pyriproxyfen in particular (Li et.al, 2000; Dennehy and Williams, 1997). Currently, pyriproxyfen is the third most widely used insecticide on cotton, after acephate and endosulfan. Similarly, buprofezin (Applaud®) use increased dramatically to 5,000 pounds active ingredient applied to 14,512 acres of cotton, corresponding to a five-fold increase from the previous twelve months. Along with the benefits, are concerns regarding overuse of newly registered IGR's, potentially resulting in reduced susceptibility and cross-resistance (Dennehy and Williams, 1997).

Non-Insecticide Applications

Herbicides. Herbicide usage remains high, comprising 8.9% of target pest reports on cotton, and 17.4% of reports on all crops. There were 17 separate active ingredients applied to nearly 200,000 acres of planted cotton (Table 2). Herbicide usage has increased dramatically, as has the number of reports submitted without accurate identification of a target pest. Lack of information about target species is alarming: 64% of ADA-1080 forms submitted for herbicide applications list the target pest as "Weeds, unknown". Resistant varieties of Roundup Ready cotton have been implicated in escalating rates of herbicide use; however, the increasing usage far exceeds the fraction of glyphosate-planted acreage in Arizona, represented by only 14% of planted acres in 1999.

Glyphosate (Roundup®) remains the most frequently used herbicide, accounting for 22% (N=553) of field herbicide applications and 41,613.7 acres (21%) of herbicide-applied acreage. Both the largest quantity of active ingredient, and the greatest proportion of treated acreage was attributed to Pendimethalin (Prowl®) 40,248 pounds; TAC=44,520 acres]. Pendimethalin was applied to 18% (N=451) of all herbicide-treated fields. Paraquat (Starfire®) use was sizeable, applied to 14% (N=357) of fields totaling 30,334 acres. Other reported active ingredients included Prometryn (Cotton-Pro® Caparol®4L), Trifluralin (Treflan®), and Carfentrazone-ethyl (AIM®).

Fungicides, Nematicides, and Fumigants. Summarized data for fungicides, nematicides, and soil fumigants are presented in Table 3. Highest rates of use were reported on mancozeb [(Penncozeb® 80WP) N=66; TAC=8,338; 9,821 lbs.]. Applied acreage of mancozeb has doubled in the past four years, from 4,055 in 1998 to 8,338 in 2001. Trilogy 90EC® was applied to 314 acres [N=5; 35.0 lbs.], while sulfur [(Golden-Dew®) was applied to 218 acres (N=3; 343.19 lbs.]. The fumigant, 1,3-dichlorpropene (Telone) has declined notably, from 11,148 application acres in 1998 to 4,816 application acres in 2001, totaling 240,612 pounds of active ingredient applied.

Plant Growth Regulators and Defoliants. Table 4 shows application frequencies for plant growth regulators (PGRs) and defoliants. Total applied acreage and quantities of active ingredients are also presented. Usage of PGRs was notable. Among those widely used were mepiquat chloride (PixPlus®), CottonQuik® (ethephon, aka ETK-2201), Poly-Foliant5®, Stimulate Yield Enhancer, and Cytokin Bioregulator Concentrate. Ethephon (Super Boll®) increased almost three-fold. Application acreage of defoliants has increased in recent years, and was highest for thidiazuron (Ginstar®EC), Sodium Chlorate, tribufos (Folex®6EC), glyphosate (Roundup Ultra®). More than 7,074,826 pounds of mepiquat chloride were applied to 167,430 acres of cotton, up from 136,000 application acres in 1998. Six of the defoliants reported for cotton application are also on the Arizona Department of Environmental Quality Groundwater Protection List. They are: cacodylic acid, diuron, endothall, paraquat, sodium chlorate, and thidiazuron. Endothall (Accelerate®) use has declined dramatically. Application acres are half of those reported in 1998, corresponding to a three-fold decrease in the number of applications reported.

Target Pests. Last year in Arizona, 33,377 target pest reports were generated for all crops. Of these, 47.26% represented cotton pests. Target pests on cotton were separated into Insect/Non-insect groupings, and categorized by pest species. Stratification of cotton pest reports showed 60.2% of pesticide applications were targeted toward insects, while 39.8% of applications on cotton targeted non-insect pests. Stratification of the non-insect reports showed proportions in the following categories: Weeds- 5,816 (17.45%); Diseases- 2,221 (6.65%); Plant Growth Regulators (PGR's)- 2,730 (8.18%); and Nematodes- 66 (<1%). On all crops, insects comprised 67.54% of target pests, while non-insects comprised 32.46%.

The data field for *Pest Name* allows for listings of up to three target pests per pesticide application, offering insight into field practices that influence pest management decisions. Table 5 presents active ingredient applications for Lygus control.

Acephate and endosulfan comprised 45% of the total number of pesticide applications for Lygus. Acephate was the most widely used active ingredient, representing 31.2% of applications. Endosulfan was second highest, comprising 15% of applications. Pesticide applications for whitefly are summarized in Table 6. There were 2,795 applications targeted at whitefly control, representing over 500,000 total applied acres. Acephate, pyriproxyfen, and endosulfan comprised 57% of total applied acreage for whitefly control. In terms of pounds active ingredients, acephate represented 40.5% of total pounds ai, followed by endosulfan at 38%. Reported applications for pink bollworm control are presented in Table 7. Chlorpyrifos was the most widely applied insecticide for pink bollworm control, comprising 52,404 of the total 154,473 application acres. This was followed by acephate, which was applied to 32,638 acres of cotton. Endosulfan applications comprised roughly half of the acreage represented by acephate, with 19,515 applied acres.

Relationships between reported pests and active ingredients are not automatically assumed from the results presented. Patterns of use may be suggested by the target pest data, however generalizations should be avoided. Optimizing the database requires linking the target pest reports to chemical label data corresponding to the application. Currently, reporting of pests is neither contingent upon sampling nor threshold values, nor does it necessarily reflect population levels in the field. In the absence of sampling data or other direct measures, crossover measurements of exposure and outcome may produce misclassification. Compounds comprising tank mixes may be unrelated to target pest species and may have little or no toxicological activity against pests reported. Despite these limitations, the target pest data field provides a framework to assess plant-pest-chemical interactions, and in combination with chemical data, offers valuable insight for pest management practice. The potential vigor of these data requires accurate identification of species. Training and outreach efforts in field identification will strengthen the capabilities and scope of this database.

Summary

Numerous advances to the State's pesticide information system provide opportunities for pest management investigations. Intensive work on the computerized system focused on increasing precision and accuracy. The program was tested for accuracy in standardizing data, adjusting units of measurement, converting variables, and calculating usage statistics. Preliminary results indicate 90% > accuracy in computation and adjustment of outcome measures of total applied acreage. Preliminary data indicate a decline in reported applied acreage in Arizona cotton between 1995-2001. Of 22,425 Pesticide Applications reported in Arizona, 6,199 (27.6%) were on cotton and 16,226 (63.4%) were on other crops. Active Ingredient Field Applications on cotton comprised 53.6% (N=33,020) of the total number of AI-Field Applications on all crops statewide (N=61,537). Acephate was the most widely used insecticide, followed by endosulfan, pyriproxyfen, and chlorpyrifos.

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Table 1. Insecticide applications on Arizona cotton, 2001.

Active Ingredient	Number of Field Applications	Number of Field Apps - Rel Freq (%)	Total Applied Acreage (TAC)	TAC - Rel Freq (%)	Pounds AI	Pounds AI - Rel Freq (%)
Acephate	2,142	25.31%	203,477.91	26.930%	171,635.50	34.645%
Pyriproxyfen	1,296	15.32%	106,665.37	14.117%	5,701.46	1.151%
Endosulfan	1,273	15.04%	114,574.01	15.163%	130,011.69	26.243%
Chlorpyrifos	1,163	13.74%	95,399.14	12.626%	64,888.85	13.098%
Fenpropathrin	583	6.89%	52,304.10	6.922%	9,373.95	1.892%
Cyfluthrin	491	5.80%	31,830.48	4.213%	1,370.05	0.277%
Lambda–cyhalothrin	288	3.40%	27,133.10	3.591%	839.24	0.169%
Oxamyl	282	3.33%	30,747.30	4.069%	24,509.35	4.947%
Dimethoate	216	2.55%	24,819.70	3.285%	8,461.76	1.708%
Bifenthrin	204	2.41%	16,133.80	2.135%	1,029.25	0.208%
Buprofezin	130	1.54%	14,512.93	1.921%	5,000.71	1.009%
Imidacloprid	66	0.78%	3,088.20	0.409%	32.88	0.007%
Zeta–cypermethrin	65	0.77%	8,589.40	1.137%	360.70	0.073%
Cypermethrin	47	0.56%	4,413.40	0.584%	311.93	0.063%
Phorate	40	0.47%	2,563.10	0.339%	3,739.17	0.755%
Piperonyl butoxide	32	0.38%	7,592.90	1.005%	443.85	0.090%
Dicofol	23	0.27%	1,867.50	0.247%	1,638.78	0.331%
Esfenvalerate	23	0.27%	999.40	0.132%	39.44	0.008%
Methomyl	18	0.21%	1,075.50	0.142%	465.60	0.094%
Methyl parathion	16	0.19%	1,621.20	0.215%	930.00	0.188%
Malathion	14	0.17%	2,328.60	0.308%	2,329.00	0.470%
Aldicarb	12	0.14%	1,342.10	0.178%	1,033.01	0.209%
Methamidophos	11	0.13%	691.80	0.092%	273.71	0.055%
Profenofos	5	0.06%	618.70	0.082%	512.48	0.103%
Deltamethrin	5	0.06%	401.00	0.053%	11.10	0.002%
Propargite	4	0.05%	261.40	0.035%	425.71	0.086%
Hydramethylnon	4	0.05%	210.30	0.028%	11.28	0.002%
Azinphos–methyl	3	0.04%	25.00	0.003%	12.50	0.003%
Tralomethrin	2	0.02%	90.00	0.012%	1.60	0.000%
Bt (Bacillus thur.)	1	0.01%	120.00	0.016%	59,999.98	12.111%
Abamectin	1	0.01%	42.70	0.006%	0.75	0.000%
Oxydemeton–methyl	1	0.01%	35.40	0.005%	10.00	0.002%
Spinosad	1	0.01%	17.00	0.002%	0.50	0.000%
TOTAL	8,462	100.00%	755,592.44	100.00%	495,405.77	100.00%

Table 2. Herbicide Use in Arizona cotton, 2001.

Active Ingredient	Number of Applications	Total Applied Acreage (TAC)	Pounds AI
Glyphosate	297	41,613.70	30,559.02
Pendimethalin	274	44,520.60	40,248.35
Prometryn	220	26,770.80	23,249.84
Paraquat	196	30,334.00	10,465.48
Carfentrazone-ethyl	179	18,745.98	288.23
Trifluralin	150	20,226.30	9,598.75
Pyrithiobac-sodium	32	4,991.80	179.80
Fluazifop-P-butyl	25	1,136.20	392.28
Diuron	21	3,247.60	2,196.80
Cyanazine	19	2,152.10	1,747.28
Oxyfluorfen	16	1,565.00	571.32
MSMA	14	1,590.40	1,594.80
Bromoxynil	13	1,158.10	662.28
Clethodim	11	557.40	108.00
Bentazon	7	265.00	189.76
Atrazine	2	500.00	250.00
Sulfosate	2	150.40	160.00
TOTAL	1,478	199,525.38	122,461.98

Table 3. Fungicide, Nematicides, and Fumigant Usage in Arizona Cotton, 2001.

Active Ingredient	Number AI Field Applications	Total Applied Acres (TAC)	Pounds AI Applied
Mancozeb	66	8338.20	9821.85
Neem Oil, Hydrophob	5	314.10	35.00
Sulfur	3	218.40	343.19
TOTAL	74	8,870.70	10,200.04

Table 4. Plant Growth Regulators (PGRs) and defoliants applied to Arizona cotton, 2001.

Active Ingredient	Number of Applications	Total Applied Acres (TAC)	Pounds AI
Thidiazuron	956	159,168.4	9993.51
Mepiquat chloride	619	90,242.95	2941.11
Sodium chlorate	340	54,885.49	254764.1
Gossyplure	319	48276.4	155.671
Tribufos	289	45,798.36	38664.6
Ethephon	273	51411.1	31072.61
Endothall	101	13,101.05	1043.16
Cytokinins	47	4295.3	0.15
Dichloropropene	30	4,816.53	24,0610.09
Cacodylic acid	26	3,011.5	2324.41
Garlic oil	2	720	313.07
TOTAL	3,002	475,727.08	581,882.45

Table 5. Reported active ingredient applications for Lygus control in Arizona cotton, 2001.

Active Ingredient	Number of Applications	Number of Applications Rel Freq (%)	Total Applied Acreage (TAC)	(TAC) Rel Freq (%)	Pounds AI	Pounds AI Rel Freq (%)
Acephate	837	31.30%	159,657.59	32.22%	138,670.23	47.67%
Endosulfan	397	14.85%	75,536.50	15.25%	87,934.53	30.23%
Pyriproxyfen	206	7.70%	39,297.97	7.93%	2,073.37	0.71%
Oxamyl	159	5.95%	26,799.50	5.41%	21,912.86	7.53%
Mepiquat chloride	155	5.80%	22,960.30	4.63%	675.87	0.23%
Fenpropathrin	146	5.46%	28,476.30	5.75%	4,964.11	1.71%
Lambda-cyhalothrin	137	5.12%	19,123.20	3.86%	588.07	0.20%
Gossyplure	132	4.94%	21,669.70	4.37%	71.60	0.02%
Chlorpyrifos	127	4.75%	28,245.77	5.70%	18,207.20	6.26%
Cyfluthrin	85	3.18%	14,872.88	3.00%	650.66	0.22%
Dimethoate	62	2.32%	20,381.70	4.11%	6,599.53	2.27%
Trifluralin	37	1.38%	5,244.80	1.06%	542.00	0.19%
Bifenthrin	36	1.35%	4,169.10	0.84%	302.02	0.10%
Zeta-cypermethrin	31	1.16%	5,488.90	1.11%	245.60	0.08%
Buprofezin	31	1.16%	5,479.89	1.11%	1,846.76	0.63%
Mancozeb	18	0.67%	1,266.80	0.26%	1,716.90	0.59%
Piperonyl butoxide	13	0.49%	7,592.90	1.53%	443.84	0.15%
Cypermethrin	12	0.45%	1,799.20	0.36%	108.38	0.04%
Cytokinins	10	0.37%	1,008.90	0.20%	0.06	0.00%
Imidacloprid	9	0.34%	1,147.70	0.23%	8.88	0.00%
Esfenvalerate	9	0.34%	440.30	0.09%	17.93	0.01%
Malathion	5	0.19%	1,448.60	0.29%	1,409.00	0.48%
Methomyl	3	0.11%	239.00	0.04%	141.00	0.05%
Garlic oil	2	0.07%	720.00	0.15%	313.07	0.11%
Dicofol	2	0.07%	487.90	0.10%	260.00	0.09%
Profenofos	2	0.07%	365.60	0.07%	292.48	0.10%
Aldicarb	2	0.07%	260.00	0.05%	378.00	0.13%
Thidiazuron	1	0.04%	465.20	0.09%	20.29	0.01%
Glyphosate	1	0.04%	149.00	0.03%	112.50	0.04%
Endothall	1	0.04%	143.00	0.03%	14.30	0.00%
Fluazifop-P-butyl	1	0.04%	108.00	0.03%	40.00	0.01%
Methyl parathion	1	0.04%	98.00	0.03%	50.00	0.02%
Methamidophos	1	0.04%	96.60	0.02%	70.00	0.02%
Deltamethrin	1	0.04%	72.00	0.01%	2.10	0.00%
Sulfur	1	0.04%	71.40	0.02%	193.19	0.07%
Tralomethrin	1	0.04%	60.00	0.01%	0.90	0.00%
TOTALS	2,674	100.00%	495,444.20	100.00%	290,877.21	100.00%

Table 6. Reported applications of active ingredients for whitefly control in Arizona cotton, 2001.

Active Ingredient	Number of Applications	Number of Applications Rel Freq (%)	Total Applied Acreage (TAC)	TAC Rel Freq (%)	Pounds AI	Pounds AI Rel freq (%)
Acephate	600	21.47%	107,365.28	21.30%	88,892.29	40.51%
Pyriproxyfen	544	19.46%	106,347.87	21.10%	5,679.29	2.59%
Endosulfan	432	15.46%	75,672.01	15.01%	84,945.64	38.71%
Fenpropathrin	323	11.56%	52,458.30	10.41%	9,408.89	4.29%
Mepiquat chloride	183	6.55%	33,124.50	6.57%	903.66	0.41%
Lambda-cyhalothrin	122	4.36%	17,198.10	3.41%	528.66	0.24%
Gossyplure	99	3.54%	14,993.90	2.97%	44.03	0.02%
Buprofezin	93	3.33%	14,512.93	2.88%	5,000.73	2.28%
Cyfluthrin	80	2.86%	13,704.18	2.72%	582.52	0.27%
Bifenthrin	76	2.72%	9,395.20	1.86%	662.66	0.30%
Chlorpyrifos	74	2.65%	16,077.45	3.19%	10,185.32	4.64%
Zeta-cypermethrin	29	1.04%	6,983.10	1.39%	295.53	0.13%
Oxamyl	25	0.89%	8,013.70	1.59%	5,121.81	2.33%
Dimethoate	23	0.82%	10,420.30	2.07%	2,981.72	1.36%
Mancozeb	17	0.61%	913.30	0.18%	1,230.90	0.56%
Imidacloprid	14	0.50%	2,390.40	0.47%	29.80	0.01%
Piperonyl butoxide	12	0.43%	7,583.90	1.50%	443.28	0.20%
Cytokinins	7	0.25%	647.90	0.13%	0.04	0.00%
Esfenvalerate	7	0.25%	372.60	0.07%	14.30	0.01%
Cypermethrin	6	0.21%	1,241.90	0.25%	88.75	0.04%
Methomyl	4	0.14%	521.50	0.10%	159.00	0.07%
Malathion	3	0.11%	682.00	0.14%	680.00	0.31%
Methyl parathion	3	0.11%	596.90	0.12%	265.00	0.12%
Tribufos	3	0.11%	228.50	0.05%	66.00	0.03%
Neem Oil, Hydrophob.	3	0.11%	187.50	0.04%	17.50	0.01%
Garlic oil	2	0.07%	720.00	0.14%	313.07	0.14%
Trifluralin	2	0.07%	559.00	0.11%	58.00	0.03%
Dicofol	2	0.07%	487.90	0.10%	260.00	0.12%
Clethodim	2	0.07%	145.00	0.03%	28.00	0.01%
Propargite	1	0.04%	261.40	0.05%	425.75	0.19%
Methamidophos	1	0.04%	96.60	0.02%	70.00	0.03%
Profenofos	1	0.04%	72.10	0.01%	60.00	0.03%
Tralomethrin	1	0.04%	60.00	0.01%	0.90	0.00%
Deltamethrin	1	0.04%	55.00	0.01%	1.50	0.00%
TOTALS	2,795	100.00%	504,090.22	100.00%	219,444.54	100.00%

Table 7. Reported applications of active ingredients for pink bollworm control in Arizona cotton, 2001.

Active Ingredient	Number of Field Applications	Total Applied Acreage (TAC)	Relative Freq (%) TAC	Pounds AI	Relative Freq (%) Pounds AI
Chlorpyrifos	627	52,404.00	33.92%	37,312.90	37.80%
Acephate	346	32,638.15	21.13%	27,447.12	27.81%
Endosulfan	168	19,515.50	12.63%	23,450.55	23.76%
Lambda-cyhalothrin	126	9,417.20	6.10%	295.87	0.30%
Pyriproxyfen	92	8,071.80	5.23%	435.83	0.44%
Oxamyl	59	6,969.10	4.51%	5,655.75	5.73%
Fenpropathrin	55	6,244.10	4.04%	1,061.42	1.08%
Cyfluthrin	51	5,413.30	3.50%	286.14	0.29%
Cypermethrin	32	3,060.50	1.98%	207.30	0.21%
Bifenthrin	28	2,032.70	1.32%	181.86	0.18%
Zeta-cypermethrin	25	4,245.10	2.75%	190.64	0.19%
Methyl parathion	16	1,621.20	1.05%	930.00	0.94%
Esfenvalerate	14	690.40	0.45%	27.23	0.03%
Malathion	6	880.00	0.57%	920.00	0.93%
Dimethoate	6	224.10	0.15%	91.77	0.09%
Methomyl	5	502.00	0.32%	105.00	0.11%
Deltamethrin	3	274.00	0.18%	7.50	0.01%
Buprofezin	3	91.00	0.06%	30.10	0.03%
Imidacloprid	2	72.00	0.05%	0.34	0.00%
Methamidophos	1	71.00	0.05%	44.00	0.04%
Profenofos	1	36.00	0.02%	20.00	0.02%
TOTALS	1,666	154,473.15	100.00%	98,701.31	100.00%