PESTICIDE USAGE IN ARIZONA: 1995-1997

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Abstract

Arizona Department of Agriculture form 1080 data from 1995 to 1997 is reviewed and summarized. The data set is a unique and rich record of pesticide usage decisions. Regulatory anomalies make use of the data challenging. Results indicate a substantial general decline in the number of applications of pesticides. Active ingredient usage has not shown a similar general decrease. Contributing to the rise in active ingredient use per planted acre is an increase in application rates for many insecticides.

Introduction

Arizona cotton production remains strong. Between 1995 and 1997 Arizona averaged 4.7 percent of the annual national lint production on only 2.6 percent of national cotton acreage (1997 Arizona Agricultural Statistics). Cotton lint and cottonseed have been ranked first in Arizona crop production cash receipts in three of the last four years. The importance of cotton production to the state of Arizona makes cotton an important and useful focus of research. A relatively unique avenue for research is pesticide usage data from the Arizona Department of Agriculture (ADA) 1080 Pesticide Application Report form compiled by Arizona Agricultural Statistics Service (AASS). Only California, among all states, can claim a more complete state record of pesticide use. 1080 data provides a rare glimpse into pesticide use decisions in the state of Arizona.

The ADA 1080 reports encompass two different regulatory efforts. First, reporting pesticide usage to the ADA is required for all commercial applicators of pesticides. Second, application of pesticides that are on the Arizona Department of Environmental Quality's (DEQ) Groundwater Protection List must be reported by all applicators, private or commercial. The result is an extensive database of field-level pesticide use information. The 1080 reports do not, however, reflect full reporting of pesticide use in Arizona. The two subsets of required reporting clearly reflect a majority of pesticide use in the state but the exact extent of omitted records is, at present, unknown.

The first year of data in this report is from 1995. This was a year of severe whitefly infestation. As a result of this infestation, two new insect growth regulators (IGRs), Buprofezin (Applaud) and Pyriproxyfen (Knack) received section 18 special use permits for the 1996 season. IGR use is reported in 1996 and 1997 data. Another development that is not directly reported in the 1080 reports is transgenic Bt. cotton. These varieties, which were first used in 1996, have an indirect effect on pesticide usage. Use of these varieties not only affects pink bollworm control regimes but may affect overall use patterns as a result of lower early season application rates. (Jech and Husman 1998)

Cotton production in the U.S. is undergoing change on many different fronts. IGRs and Bt. Cotton are only two of the many new trends which also include pesticide resistant varieties (Round-up Ready, BXN) and new selective herbicides (Staple). The development of the ADA 1080 data from AASS is key to having the data to track these various trends. In this paper we provide a review of issues pertaining to ADA 1080 data, an overview of pesticide usage between 1995 and 1997 and a preview of work in progress making use of this data.

Materials and Methods

ADA 1080 Reports

Data collected and entered from the ADA 1080 reports include: Grower ID#, PCA ID#, dealer ID#, EPA registration #, total chemical use, application acreage, location by county and section, application and projected harvest dates and whether applied by ground or air. Data collected and NOT entered into the database include target pest additional field description.

Table 2 provides a full list of active ingredients (AI) used in 1997. Table 1 provides a key to some of the information in Table 2. Information regarding AI, percent AI, class and family are not reported on the 1080 forms but are derived from information from the Environmental Protection Agency. Other measures are discussed later in this paper.

While the ADA 1080 data may be second only to California in its coverage of actual pesticide usage, it is a problematically incomplete data set. This is largely because the 1080 form was designed as a regulatory tool and not as a data set for pesticide use. Reports of DEQ list and commercially applied pesticides cover an unknown majority of the pesticide applications in Arizona. Furthermore, a number of indications complicate generalizations about the exact composition of the data set. For example, early in the production cycle, preplant and time of planting herbicide treatments are routinely applied by producers. There are commonly used products that are not included on the DEQ list. With total application acres reported for herbicides at 86 percent of total planted acres this is likely an area of underreporting. Later in the season, however, after the cotton crop has closed over the rows, all applications of pesticides must be made by air. The aerial applications would be reported under the commercial applicator

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reporting requirement. This indicates that during this period of the crop cycle, the 1080 data may reflect almost 100% reporting.

There are further complicating issues. Considering herbicides again, two particular, commonly used herbicides, pendimethalin and trifluralin, do not appear on the DEQ list. The expected under reporting, however, may not be an issue with these two herbicides because they are usually tank mixed with prometryn, an herbicide that is on the DEQ list (McCloskey, Baker and Sherman 1998). This would indicate a greater likelihood of reporting. Unfortunately, recognizing that these herbicides are tank mixed makes the total herbicide applied acres an even smaller percentage of planted acres as application acres are tallied separately for each active ingredient. Further confusing this measure is the inclusion of diuron as an herbicide in many popular defoliants. Overall herbicide application acres include usage from throughout the season. Heavy counting of late season diuron usage indicates even more severe undercounting of early season weed control applications.

Finally, anecdotal evidence indicates some operations report all pesticide applications to keep record keeping simple. The end result is a data set that encompasses a large percent of the pesticide usage in Arizona with no means, at this point, of quantifying exactly what is missing. With these caveats in mind, there is still much of interest to be mined from this data. With no major changes in reporting protocol since 1995, there is no reason to believe reporting patterns have changed dramatically within the three years reported here. Thus, trends should be accurately represented. Also, There are many questions that can be answered with data that is likely to be close to complete. Study of IGR adoption and late season whitefly management is an example of a conservative use of the data set. All IGR use must be reported and most whitefly applications are late season aerial applications.

Usage Measures

Cotton acreage in Arizona has declined each year since 1995. As a result, measures of pesticide usage relative to planted acreage are a better measure for comparing usage across years. There are two basic measurements: Mean application per acre (mean app./ac.) and mean AI per acre (mean AI/ac.).

Mean applications per acre is the number of acres applied with a certain active ingredient (application acres) divided by the annual acreage figure. For overall chemical use and some of the more popular AIs, this results in a number greater than one. A mean application per acre of 1.5 could indicate that all fields were treated once and that half were treated a second time. It could also indicate that half of the field were treated three times. Most AIs were used on fewer than the statewide total of acres, so can be read roughly as a percentage of acres treated. It is still important to remember that these are mean measurements of acres treated and will mask both multiple treatments greater than the average and fields unsprayed or sprayed less than the average.

An important exception to this is the measurement of acres treated with the two IGRs. Each of the IGRs may only be used once on a field. Percent of acres treated with Knack or Applaud individually should be an accurate measurement of adoption of these products. Combining the two figures, to indicate overall IGR adoption, may overestimate adoption as a result of overlap. Though Cooperative Extension recommendations indicated the use of both products under certain threshold conditions, there is little evidence that doubling up was common practice. This was due to, among other things, lower whitefly pressures in '96 and '97, costs of the products, and underestimation of the need for very-late season control of whiteflies to avoid stickiness.

Mean AI per acre is a general measure of intensity of application. Total pounds of AI is divided by planted acres. Because of differences in application rates, amount of AI is a complicated measurement. Mean AI per acre is a simple measure that allows comparison across years.

Results and Discussion

By one important measure, overall use of pesticides in Arizona cotton declined dramatically between '95 and '97 (Tables 3-8). Total application acres dropped from 5.9 million in 1995 to 4.2 million in 1996 to 3.1 million in 1997. This greater than 47% decrease in application acres reflects, in part, the high level of infestation that characterized the 1995 growing season.

Arizona cotton acreage was 413,600 acres in 1995, declining to 357,000 acres and 347,000 acres in 1996 and 1997, respectively. This is a 16% drop in acreage between '95 and '97. Measuring application acres with respect to planted acreage is important to remove the effect of decreasing acreage. Mean applications per acre dropped from 14.3 to11.8 to 8.9 in 1997. With the effect of declining acreage removed there was still a greater than 37% drop in application acres between 1995 and 1997.

At the same time, total pounds of AI actually increased from 1995 to 1996 from 3.07 million pounds to 3.17 million pounds before falling off in 1997 to 2.96 million pounds. Mean AI per acre shows a similar pattern, from 7.4 pounds per acre in 1995 to 8.9 pounds per acre in 1996 to 8.5 pounds per acre in 1997. This finding is a result of two different factors. There has been an upward trend in application rates that will be discussed later. The other factor, however, is a good example of the need for caution with this kind of data. The application rates of AIs differ across pesticides. This unexpected increase in overall AI is, in part, a result of an increase in the use of dichloropropene (Telone). The application rate of over 45 pounds per acre for dichloropropene is more than ten times the average application rate for the other fungicides and fumigants. The threefold increase in acreage applied with dichloropropene disproportionately affects the overall totals of AI. Without using a normalizing index, these kinds of disparities in application rates can drastically affect results.

Usage by Class

Disaggregating usage by class gives a more precise indication of trends. Insecticide usage by gross application acres in 1997 was down by more than 54% from 1995 levels (Table 9). Insecticide reports were down a comparable percentage. Active ingredient usage, however, was down only 8% over the two years in gross terms. Controlling for acres planted, application acres were down only 47% between 1995 and 1997 and active ingredient usage actually increased by more than 9%. This result is explored further below.

While gross herbicide application acres and AI were both down, 16% and 27%, respectively, controlling for planted acres, application acres were unchanged from 1995 while AI usage dropped just over 13% (Table 10). Defoliant usage was almost identical to herbicide usage with mean application acres increasing a mere 2.6% while AI usage dropped more than 10% (Table 11).

Plant growth regulator usage showed the opposite trend. Gross application acres were up 32% or, controlling for planted acres, 57% (Table 12). Gross AI usage was up more than 400% in 1996 before dropping back to a 269% increase, from 1995 levels, in 1997. Taking planted acres into consideration increases these percentages to 467% and 320% respectively.

As reported above, fungicide and fumigant usage is a confusing factor in the overall totals (Table 13). Application acres, both gross and mean measures are down, 32% and 19%, respectively. AI, however, is up in both cases, 173% in gross measure, and 205% with respect to acres planted. This increase in AI, combined with the magnitude of dosage is, in part, responsible for the counterintuitive increase in overall AI usage across the three year span.

Usage by AI

To really understand trends in AI usage it is necessary to deal with each AI individually. Insecticides, the largest class of pesticides, give mixed results in the aggregate statistics. Mean application acres are down significantly while mean AI per acre is up. A look at the fifteen AIs which fill out the top ten AIs for all three years shows the change in mean application rates (Table 14-15). This statistic is different than the previously reported mean AI per acre. Mean application rate is AI usage averaged over application acres for that AI. This is a strict measurement of intensity of use.

Disaggregation of insecticide AI leads to a number of interesting conclusions. There are massive increases in the usage of acetate, a mating disruption pheromone used against pink bollworms. Also called gossyplure, this pheromone is not considered toxic (Farm Chemical Handbook, '98). Furthermore, the data on this particular substance has been problematic. Uncommon units of measurement are used (grams) with reports varying in degrees of magnitude. These unreliable statistics have a nontrivial effect on overall insecticide AI usage.

The unreliability of the acetate measures should not, however, overshadow the general trend that is evident in mean application rates. Except for three synthetic pyrethroids that have narrow application windows (lambdacyhalothrin, fenpropathrin and bifenthrin), the most used insecticides all exhibit increases in mean application rates. The mean application rate of chlorpyrifos, the most frequently applied insecticide in all three years, increased by more than 19% between 1995 and 1997. The mean application rates of Acephate and endosulfan, both in the top five for all three years, increased 40% and 14%, respectively. The mean application rate of oxamyl, the top carbamate and climbing in the ranks due to a rare increasing mean applications per acre, increased by 86% between 1995 and 1997.

These disaggregate statistics provide a much more clear picture of usage trends for a specific AI than any of the aggregate measures. The next levels of disaggregation, which will not be pursued here, would allow unique measures for different formulations of the same AI and/or AIs used in different tank mixtures. Of course another option would be to compare a statistic like mean application rate across counties as well as through the production cycle to add a spatial and temporal dimension.

IGR Adoption and Pesticide Usage

Examination of IGR adoption and insecticide use provides an interesting use of a spatial comparison. IGRs were not allowed for general use until 1996. Prior to the introduction of IGRs, the recommended whitefly application regime included organophospates combined with synthetic pyrethroids (Naranjo, Hagler and Ellsworth). These combinations, however, were also the focus of concern over developing whitefly resistance (Dennehy, et al 1998).

Tables 16-18 show the rates of IGR adoption and subsequent organophosphate and synthetic pyrethroid usage by county. Shading groups the counties into east, central and west growing regions, in that order. Figures 1-3 show the same data aggregated by growing region. These statistics give further credence to anecdotal evidence that links IGR adoption with a decrease in other whitefly-targeted insecticide applications. The primary improvement offered by these statistics, other than hard numbers, is the inclusion of planted acres. At this level of analysis, there appears to be a correlation between the adoption of IGRs and subsequent reduced organophosphate and synthetic pyrethroid usage. This correlation is based on data aggregated at the county level.

To establish a stronger correlation between IGR adoption and subsequent insecticide usage, the adoption of IGRs and subsequent pesticide usage at the field or section level must be conditioned on all other possible explanatory variables. Planted acres is an obvious example of an explanatory variable that should be included, as is location. Other variables might include various operator and operation characteristics, pest pressure indices, application timing, cotton and pesticide prices and choice of cultivar. A two-stage econometric estimation that determines IGR adoption as a function of all explanatory variables and then determines pesticide usage as a function of the same explanatory variables including IGR adoption should avoid problems with selection bias. This research project is in process.

A related use of the ADA 1080 data involves using GIS mapping software to provide visual representations of the spatial characteristics. Using layering to represent different A.I., different timing through a season or different usage across years will be a powerful tool both for identifying patterns and for educational purposes.

In summary, ADA form 1080 data is a rich and unique data set. While imperfect, the data set offers field-level pesticide usage data on a scale that is large enough to provide new insight into pesticide usage issues while remaining small enough to be manageable in commonly available database software. Research projects designed to take advantage of the strengths of this database can largely sidestep its limitations.

Within the scope of its coverage, 1080 data has provided concrete evidence of a dramatic decline in pesticide applications in Arizona. The data also indicates that AI usage has not declined as dramatically, in part as a result of increasing intensity of application in most of the major use insecticides. Finally, there is evidence of a correlation between the adoption of IGRs and a decline in usage of AIs used against whiteflies.

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Tables and Figures

Table 1. 1997 Pesticide usage, All AIs, Ranked by Application acres

Active Ingredient	Cls.	FAM.	Re-ports	App. Acres, x1000	A.I. Total, x1000	% of Tot. Ac.	Mean App. /Ac	Mean A.I. /Ac
1 Chlorpyrifos	I	OP	3,809	407.8	264.4	13.2%	1.175	0.762
2 **Acephate**	I	OP	3,461	359.3	279.3	11.6%	1.035	0.805
3 **Endosulfan**	I	SP	2,175	234.2	157.8	7.6%	0.675	0.455
4 **Thidiazuron**	D	SU	1,808	166.7	11.4	5.4%	0.480	0.033
5 Lambda-cyhalothrin	I	SP	1,497	155.1	4.9	5.0%	0.447	0.014
6 Acetate	I	P	1,403	146.8	476.3	4.7%	0.423	1.372
7 **Oxamyl**	I	CB	1,059	127.9	88.2	4.1%	0.369	0.254
8 **Diuron**	H	SU	1,384	124.1	7.1	4.0%	0.358	0.020
9 **Sodium chlorate**	D	O	1,399	119.2	482.3	3.8%	0.343	1.390
10 **Methyl parathion**	I	OP	974	104.1	81.7	3.4%	0.300	0.235
11 **Mepiquat chloride**	G	O	1,291	102.6	3.0	3.3%	0.296	0.009
12 **Pyri-proxyphen**	I	IGR	953	101.8	5.4	3.3%	0.293	0.016
13 **Methomyl**	I	CB	712	92.7	37.6	3.0%	0.267	0.108
14 Tribufos	D	OP	826	77.7	81.3	2.5%	0.224	0.234
15 **Buprofezin**	I	IGR	748	68.1	23.6	2.2%	0.196	0.068
16 **Dimethoate**	I	OP	544	62.5	30.1	2.0%	0.180	0.087
17 **Paraquat**	D	O	595	51.2	23.1	1.7%	0.148	0.067
18 **Prometryn**	H	ST	512	48.7	45.7	1.6%	0.140	0.132
19 Pendi-methalin	H	Dna	497	46.9	39.0	1.5%	0.135	0.112
20 Zeta-cypermethrin	I	SP	445	43.5	1.7	1.4%	0.125	0.005
21 Fenpropathrin	I	SP	519	39.5	7.4	1.3%	0.114	0.021
22 Cypermethrin	I	SP	360	36.0	0.7	1.2%	0.104	0.002
23 **Profenofos**	I	OP	295	34.5	28.5	1.1%	0.099	0.082
24 Trifluralin	H	Dna	353	33.3	20.5	1.1%	0.096	0.059
25 **Endothall**	D	O	419	32.4	2.3	1.0%	0.093	0.007
26 **Ethephon**	G	O	325	26.9	21.6	0.9%	0.077	0.062
27 Methidathion	I	OP	252	21.8	10.6	0.7%	0.063	0.031
28 **Cacodylic acid**	D	OA	261	19.7	12.5	0.6%	0.057	0.036
29 **Aldicarb**	I	CB	169	17.7	20.1	0.6%	0.051	0.058
30 Bifenthrin	I	SP	198	16.6	1.1	0.5%	0.048	0.003
31 **Cyanazine**	H	O	174	14.9	16.3	0.5%	0.043	0.047
32 Amitraz	I	O	149	13.2	2.3	0.4%	0.038	0.007
33 Sulfur	F	O	138	12.3	41.4	0.4%	0.035	0.119
34 Dichloro-propene	F	O	83	11.4	562.9	0.4%	0.033	1.622
35 Phorate	I	OP	59	11.3	12.8	0.4%	0.033	0.037
36 Cyfluthrin	I	SP	159	11.2	0.5	0.4%	0.032	0.001
37 Imidacloprid	I	CN	127	10.8	0.5	0.3%	0.031	0.001
38 Gibberellic acid	G	O	77	7.4	0.0	0.2%	0.021	0.000
39 IBA	G	O	77	7.4	0.0	0.2%	0.021	0.000
40 Pyrithiobac-sodium	H	O	115	7.1	0.3	0.2%	0.020	0.001
41 **Methamido-phos**	I	OP	58	7.0	3.9	0.2%	0.020	0.011
42 **Glyphosate**	H	O	79	4.9	3.4	0.2%	0.014	0.010
43 **Fluazifop-P-butyl**	H	O	71	4.5	1.3	0.1%	0.013	0.004
44 Mancozeb	F	O	54	4.0	4.5	0.1%	0.011	0.013
45 Permethrin	I	SP	37	3.6	0.1	0.1%	0.010	0.000
46 **Azinphos-methyl**	I	OP	32	3.5	1.8	0.1%	0.010	0.005
47 Cytokinins	G	O	32	3.2	0.0	0.1%	0.009	0.000
48 **Thiodicarb**	I	CB	27	3.1	1.0	0.1%	0.009	0.003
49 Esfenvalerate	I	O	40	3.0	0.1	0.1%	0.009	0.000
50 MSMA	H	OA	48	2.8	3.8	0.1%	0.008	0.011
51 PCNB	F	O	18	2.5	1.7	0.1%	0.007	0.005
52 Bromoxynil	H	O	28	2.2	0.9	0.1%	0.006	0.002
53 Tralomethrin	I	SP	12	2.0	0.0	0.1%	0.006	0.000
54 **Malathion**	I	OP	23	2.0	2.5	0.1%	0.006	0.007
55 Disulfoton	I	OP	27	2.0	1.9	0.1%	0.006	0.005
56 **Fluometuron**	H	SU	26	1.9	1.3	0.1%	0.006	0.004
57 **Norflurazon**	H	O	19	1.8	0.6	0.1%	0.005	0.002
58 Oxyfluorfen	H	O	26	1.8	0.8	0.1%	0.005	0.002
59 **Sethoxydim**	H	O	35	1.6	0.4	0.1%	0.005	0.001
60 **Oxydemeton-methyl**	I	OP	23	1.6	0.6	0.1%	0.005	0.002
61 Clethodim	H	O	22	1.5	0.3	0.0%	0.004	0.001
62 Paclobutrazol	G	O	16	1.4	0.0	0.0%	0.004	0.000
63 Dicofol	I	O	17	1.1	1.0	0.0%	0.003	0.003
64 Garlic	I	O	14	1.0	0.0	0.0%	0.003	0.000
65 **EPTC**	H	O	7	1.0	1.2	0.0%	0.003	0.003
66 Bt (Bacillus thur.)	I	O	7	0.8	0.0	0.0%	0.002	0.000
67 Copper hydroxide	F	O	9	0.6	1.9	0.0%	0.002	0.005
68 **Diazinon**	I	OP	7	0.5	0.3	0.0%	0.001	0.001
69 Pyrethrins	I	O	2	0.5	0.0	0.0%	0.001	0.000

Table 1. Continued

Active Ingredient	Cls.	FAM.	Re-ports	App. Acres, x1000	A.I. Total, x1000	% of Tot. Ac.	Mean App. /Ac	Mean A.I. /Ac
70 Rotenone	I	O	2	0.5	0.0	0.0%	0.001	0.000
71 Diclofop-methyl	H	O	4	0.4	0.3	0.0%	0.001	0.001
72 **Fenamiphos**	N	O	2	0.3	0.1	0.0%	0.001	0.000
73 Formetanate hydro.	I	O	2	0.3	0.1	0.0%	0.001	0.000
74 **Metam-Sodium**	F	O	5	0.2	13.3	0.0%	0.001	0.038
75 **Carbaryl**	I	CB	2	0.2	0.1	0.0%	0.000	0.000
76 Azadirachtin	I	O	6	0.1	0.0	0.0%	0.000	0.000
77 Benefin	H	Dna	2	0.1	0.0	0.0%	0.000	0.000
78 Triphenyltin hydrox.	F	O	1	0.1	0.1	0.0%	0.000	0.000
79 Allium sativum	I	O	3	0.1	0.0	0.0%	0.000	0.000
80 Diethatyl-ethyl	H	O	1	0.1	0.0	0.0%	0.000	0.000
81 **Ethyl parathion**	I	OP	1	0.1	0.1	0.0%	0.000	0.000
82 Propargite	I	O	3	0.1	0.1	0.0%	0.000	0.000
83 **Vinclozolin**	F	O	2	0.1	0.0	0.0%	0.000	0.000
84 Iprodione	F	O	2	0.1	0.1	0.0%	0.000	0.000
85 Thiophanate-methyl	F	CB	1	0.0	0.0	0.0%	0.000	0.000
86 **Diquat**	H	O	1	0.0	0.0	0.0%	0.000	0.000
87 Fenvalerate	I	SP	1	0.0	0.0	0.0%	0.000	0.000

DEQ Groundwater Protection List pesticides in bold

Table 2. Key for Pesticide Class and Family

	Class
I	Insecticide
H	Herbicide
D	Defoliant
F	Fungicide or Fumigant
G	Plant Growth Regulator
	Family
OP	Organophosphate
SP	Syntheic Pyrethroid
CB	Carbamate
P	Pheremone
IGR	Insect Growth Regulator
SU	Substituted Urea
Dna	Dintroaniline
CN	Chloro-nicotinyl
OA	organic-arsenical
ST	substituted Triazine

Table 3. 1997 Usage Totals by Class

	Reports	Application Acres	A.I. Total	Mean App./Ac	Mean A.I./Ac
1997 Total	31,258	3,096,648.7	2,955,679.9	8.92	8.52
Insecticides	20,413	2,149,634.4	1,549,069.3	6.19	4.46
Herbicides	3,404	299,754.4	143,059.9	0.86	0.41
Defoliants	5,308	466,882.1	612,942.8	1.35	1.77
Growth Reg.	1,818	148,798.2	24,558.0	0.43	0.07
Fung./Fum.	313	31,244.5	625,912.7	0.09	1.80

Table 4. 1997 Usage by Class, as Percent of 1997 Total Usage

	Reports	App. Acres	A.I. Total
Insecticides	65.30%	69.42%	52.41%
Herbicides	10.89%	9.68%	4.84%
Defoliants	16.98%	15.08%	20.74%
Growth Reg.	5.82%	4.81%	0.83%
Fung./Fum.	1.00%	1.01%	21.18%

Table 5. 1996 Usage Totals by Class

	Reports	Application Acres	A.I. Total	Mean App./Ac	Mean A.I./Ac
1996 Total	41,921	4,223,451.0	3,167,193.7	11.83	8.87
Insecticides	30,742	3,248,737.5	1,631,751.5	9.10	4.57
Herbicides	3,630	323,823.4	161,741.6	0.91	0.45
Defoliants	5,654	482,889.9	671,066.1	1.35	1.88
Growth Reg.	1,497	124,991.3	36,899.6	0.35	0.10
Fung./Fum.	395	42,853.6	665,700.8	0.12	1.86

Table 6. 1996 Usage by Class, as Percent of 1996 Total Usage

	Reports	App. Acres	A.I. Total
Insecticides	73.33%	76.92%	51.52%
Herbicides	8.66%	7.67%	5.11%
Defoliants	13.49%	11.43%	21.19%
Growth Reg.	3.57%	2.96%	1.17%
Fung./Fum.	0.94%	1.01%	21.02%

Table 7. 1995 Usage Totals by Class

	Reports	Application Acres	A.I. Total	Mean App./Ac	Mean A.I./Ac
1995 Total	56,614	5,895,401.9	3,065,183.1	14.25	7.41
Insecticides	44,566	4,836,461.8	1,683,824.1	11.71	4.08
Herbicides	4,134	356,425.7	196,156.6	0.86	0.47
Defoliants	5,986	541,516.2	812,128.9	1.31	1.97
Growth Reg.	1,389	112,544.0	9,144.5	0.27	0.02
Fung./Fum.	514	46,084.8	362,623.5	0.11	0.88

Table 8. 1995 Usage by Class, as Percent of 1995 Total Usage

	Reports	App. Acres	A.I. Total
Insecticides	78.72%	82.04%	54.93%
Herbicides	7.30%	6.05%	6.40%
Defoliants	10.57%	9.19%	26.50%
Growth Reg.	2.45%	1.91%	0.30%
Fung./Fum.	0.91%	0.78%	11.83%

Table 9. Insecticide Use, 1995-1997

	Reports	Application Acres	A.I. Total	Mean App./Ac	Mean A.I./Ac
1995	44,566	4,836,461.8	1,683,824.1	11.71	4.08
1996	30,742	3,248,737.5	1,631,751.5	9.10	4.57
% of 1995	69.0%	67.2%	96.9%	77.7%	112.1%
1997	20,413	2,149,634.4	1,549,069.3	6.19	4.46
% of 1995	45.8%	44.4%	92.0%	52.9%	109.5%

Table 10. Herbicide Usage, 1995-1997

	Reports	Application Acres	A.I. Total	Mean App./Ac	Mean A.I./Ac
1995	4,134	356,425.7	196,156.6	0.86	0.47
1996	3,630	323,823.4	161,741.6	0.91	0.45
% of 1995	87.8%	90.9%	82.5%	105.1%	95.4%
1997	3,404	299,754.4	143,059.9	0.86	0.41
% of 1995	82.3%	84.1%	72.9%	100.1%	86.8%

Table 11. Defoliant Usage, 1995-1997

	Reports	Application Acres	A.I. Total	Mean App./Ac	Mean A.I./Ac
1995	5,986	541,516.2	812,128.9	1.31	1.97
1996	5,654	482,889.9	671,066.1	1.35	1.88
% of 1995	94.5%	89.2%	82.6%	103.2%	95.6%
1997	5,308	466,882.1	612,942.8	1.35	1.77
% of 1995	88.7%	86.2%	75.5%	102.6%	89.8%

Table 12. Growth Regulator Usage, 1995-1997

	Reports	Application Acres	A.I. Total	Mean App./Ac	Mean A.I./Ac
1995	1,389	112,544.0	9,144.5	0.27	0.02
1996	1,497	124,991.3	36,899.6	0.35	0.10
% of 1995	107.8%	111.1%	403.5%	128.5%	466.8%
1997	1,818	148,798.2	24,558.0	0.43	0.07
% of 1995	130.9%	132.2%	268.6%	157.4%	319.6%

Table 13. Fungicide and Fumigant Usage, 1995-1997

	Reports	Treated Acres	A.I. Total	Mean App./Ac	Mean A.I./Ac
1995	514	46,084.8	362,623.5	0.11	0.88
1996	395	42,853.6	665,700.8	0.12	1.86
% of 1995	76.8%	93.0%	183.6%	107.6%	212.4%
1997	313	31,244.5	625,912.7	0.09	1.80
% of 1995	60.9%	67.8%	172.6%	80.7%	205.4%

Table 14. Combined Top Ten Insecticides, With Overall Rank, 1995-1997

Active		1997		1996		1995	
Ingredient	Family	Rank	T/Ac	Rank	T/Ac	Rank	T/Ac
Chlorpyrifos	OP	1	1.175	1	1.443	1	2.232
Acephate	OP	2	1.035	3	1.149	2	1.988
Endosulfan	SP	3	0.675	4	0.779	5	0.795
Lambda-cyhalothrin	SP	5	0.447	6	0.576	4	0.805
Acetate	P	6	0.423	2	1.153	10	0.417
Oxamyl	CB	7	0.369	13	0.324	14	0.331
Methyl parathion	OP	10	0.300	7	0.492	18	0.201
Pyriproxyphen	IGR	12	0.293	9	0.416		
Methomyl	CB	13	0.267	25	0.116	11	0.411
Buprofezin	IGR	15	0.196	21	0.157	71	0.001
Fenpropathrin	SP	21	0.114	24	0.119	3	1.401
Profenofos	OP	23	0.099	17	0.168	8	0.491
Methidathion	OP	27	0.063	11	0.362	23	0.109
Bifenthrin	SP	30	0.048	31	0.080	7	0.508
Permethrin	SP	45	0.010	5	0.583	6	0.697

Table 15. Combined Top Ten Insecticides, Mean Application Rates and Percentage Change

	1995 AI/ AI App. Ac.	1996 AI/ AI App. Ac.	1996AI/ 1995AI	1997 AI/ AI App. Ac.	1997AI/ 1995AI
Chlorpyrifos	0.544	0.609	112.0%	0.648	119.2%
Acephate	0.555	0.683	123.1%	0.777	140.1%
Endosulfan	0.592	0.681	115.2%	0.674	113.9%
Lambda-cyhalothrin	0.032	0.033	104.3%	0.032	98.8%
Acetate	0.005	0.909	16823%	3.243	60048%
Oxamyl	0.370	0.565	152.6%	0.690	186.2%
Methyl parathion	0.621	0.840	135.2%	0.785	126.4%
Pyriproxyphen		0.060		0.053	
Methomyl	0.345	0.246	71.4%	0.405	117.7%
Buprofezin		0.349		0.347	
Fenpropathrin	0.175	0.175	99.6%	0.186	106.4%
Profenofos	0.614	0.686	111.8%	0.826	134.6%
Methidathion	0.366	0.426	116.3%	0.485	132.4%
Bifenthrin	0.064	0.060	93.9%	0.068	106.5%
Permethrin	0.009	0.011	119.1%	0.038	401.0%

Table 16. 1997 IGR, Synthetic Pyrethroid and Organophospate Use

	IGRs		Synthetic Pyrethroids		Organophosphates	
	Mean App./Ac.	Mean AI/Ac.	Mean App./Ac.	Mean AI/Ac.	Mean App./Ac.	Mean AI/Ac.
Cochise	0.000	0.000	0.234	0.007	0.029	0.014
Graham	0.000	0.000	1.447	0.039	0.281	0.226
Maricopa	0.645	0.109	1.565	0.617	2.788	1.874
Pima	0.066	0.013	0.562	0.140	3.381	2.544
Pinal	0.536	0.108	1.705	0.547	4.291	3.167
La Paz	0.583	0.056	1.528	0.330	2.318	1.443
Mohave	0.446	0.024	0.164	0.049	0.211	0.101
Yuma	0.244	0.027	2.059	0.700	1.523	0.982

Table 17. 1996 IGR, Synthetic Pyrethroid and Organophospate Use

	IGRs		Synthetic Pyrethroids		Organophosphates	
	Mean App./Ac.	Mean AI/Ac.	Mean App./Ac.	Mean AI/Ac.	Mean App./Ac.	Mean AI/Ac.
Cochise	0.000	0.000	0.371	0.009	0.011	0.008
Graham	0.000	0.000	0.949	0.039	0.158	0.065
Maricopa	0.776	0.131	2.113	0.659	4.042	2.690
Pima	0.059	0.011	0.911	0.245	2.513	1.573
Pinal	0.508	0.072	2.536	0.616	4.859	3.355
La Paz	0.895	0.065	6.566	0.760	4.183	2.129
Mohave	0.142	0.015	0.653	0.143	1.034	0.688
Yuma	0.702	0.051	2.800	0.955	2.851	1.572

Table 18. 1995 Synthetic Pyrethroid and Organophospate Use (No IGRs)

1995	Synthetic Pyrethroids		Organophosphates	
	Mean App./Ac.	Mean AI/Ac.	Mean App./Ac.	Mean AI/Ac.
Cochise	0.050	0.004	0.111	0.051
Graham	0.744	0.037	0.505	0.337
Maricopa	6.722	1.341	6.614	3.528
Pima	1.280	0.250	3.198	2.240
Pinal	5.472	0.764	6.090	3.489
La Paz	8.785	1.098	4.089	2.107
Mohave	0.804	0.089	0.682	0.320
Yuma	5.269	1.383	4.198	2.33

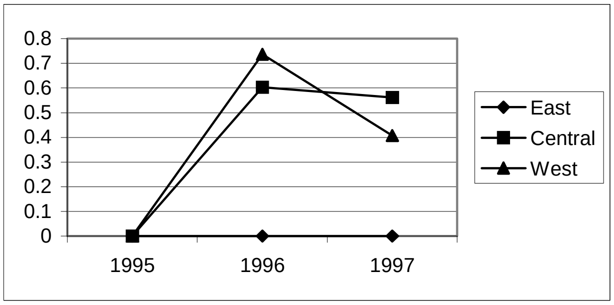

Figure 1. IGR Adoption, by Arizona Growing Region, 1995-1997

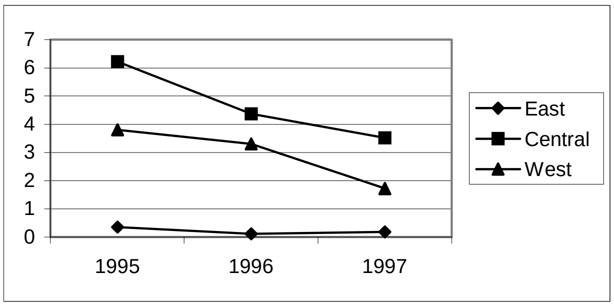

Figure 2.Organophosphate Usage, by Arizona Growing Region, 1995-1997

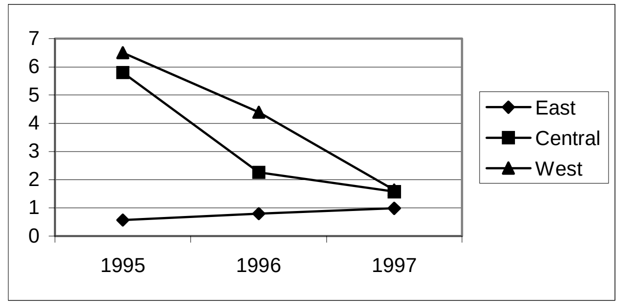

Figure 3. Synthetic Pyrethroid Usage, by Arizona Growing Region, 1995-1997