Pesticide Use in Arizona Cotton: Long-term Trends and 1999 Data

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Abstract

Arizona pesticide use, as reported on the Department of Agriculture's form 1080, can be summarized to provide a rich picture of pest management in Arizona cotton. Limitations in the pesticide use reporting system complicate the process but do not undermine results. Overall pesticide use decreased over the period 1991 to 1998 despite a peak during the whitefly infestation of 1995. Decreases in insecticide use are responsible for most of the reduction in pesticide use. Recently released 1999 data indicates that reductions continued. Comparison of the composition of pesticide applications between 1995 and 1998 reflect the changes in pest control efforts. A new "target pest" category on the 1080 provides an even richer picture of pest management practices in Arizona cotton.

Introduction

Arizona Department of Agriculture (ADA) form 1080 pesticide use reporting provides a unique opportunity to track pesticide use in the production of Arizona cotton. This information can be used to better understand actual pest management practices in Arizona cotton. This paper highlights a number of the strengths of this data. We explore trends in pesticide usage from 1991 to 1998. A summary of 1999 pesticide usage, including acres treated and the average rate of application, is provided before the start of following season. We provide a summary of the top tankmixes used in 1995 and 1998 and discuss how they reflect the recent history in Arizona cotton pest management. Finally, data from the new "target pest" category is summarized.

Methods

A common way of summarizing pesticide use is by summing the pounds of active ingredient (AI) for all pesticides used. While focusing on the AI properly isolates the part of the pesticide product that has pesticidal properties, summarizing pesticide use in terms of the pounds of AI used can be misleading. AIs are extremely diverse in almost every property of interest. Recommended label rates vary from .01 pounds per acre for some pyrethroid products (ie. Karate) to over 100 pounds per acre for some nematicides (Telone II). Combining usage statistics from applications of these two products into an overall measure would effectively lose the information on the pyrethroid while overstating the importance of the heavier nematicide. Furthermore, a pound of two different AIs could differ significantly in relative efficacy, toxicity, mobility to groundwater or any other measure of interest.

For general summaries, it is best to quantify usage by active ingredient (AI). This allows for some aggregation of the numerous pesticide products used in agriculture. Liquid or dry formulations of differing strength, but the same AI, can all be grouped together. Using a pesticide product database with conversion factors it is quite simple to summarize pesticides with common AIs in terms of pounds of that AI. Within a single crop and AI, little variation is lost by grouping products in this manner.

Rather than focusing on the pounds of AI applied, it is better to use the number of treated acres to summarize pesticide use. National Agricultural Statistics (NAS) has traditionally reported the percentage of fields treated and the average number of treatments per field. This kind of information has become particularly important in the last four years with the passing of the Food Quality Protection Act (FQPA). In the FQPA regulatory process, in the absence of actual usage data, regulators consider 100% of acres treated with applications made at maximum label applications.

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Determining the percentage of fields treated and the average number of treatments on those fields turns out to be a relatively difficult process in a pesticide use reporting system. All pesticide use reporting systems require information on the number of acres treated. However, location is only specified by county, township, or as in the case of Arizona, the section. Implementing a system that tracks *which* acres are being treated so as to determine multiple treatments is problematic. Ideally, each field would have an ID number that would allow for identification of the field through the season. California has attempted to include this in its reporting system. In Arizona, no attempt has been made to track fields. With multiple crops and changing field size and location, year to year, field tracking increases the complexity of use reporting substantially. This seemingly small detail is actually a major limitation in the Arizona reporting system and a potential weak link in any system. Without field identification, it is impossible to know which acres have been treated how many times. For this reason, reports of treated acres can only be added up into an overall total of treated acres, including possible multiple treatments, which we call "application-acres".

Application-acres is a total of acres applied with the AI or AIs of interest. This still does not provide a measure of the percent of acres treated or the number of treatments. Dividing by the number of acres planted to the crop of interest creates an intensity measure that combines percent treated and number of applications. The intensity measure indicates the number of applications that would have been made if every acre had been treated equally. This is simply the ratio of application-acres to planted acres.

While this statistic gives a rough idea of usage, it masks any variation within the area considered. For instance, at the state level in 1998, Arizona had an application intensity for insecticides of approximately five applications, implying all fields were treated, on average, five times. At the county level, however, intensities range from .22 to 6.22. Clearly usage patterns vary across the state. The smaller the area within which application acres can be normalized by planted acres the closer we get to a field-level measure. The best we can do in Arizona is a section-level intensity measure. These are being used in statistical research. For the purpose of a general summary, county level intensity measures are more convenient.

Intensity measures are particularly important for looking at trends across time. Any gross measure of Arizona pesticide use in cotton over the last five years would show usage falling precipitously. This statistic would reflect the steep decline in acres planted to cotton in the state as much as any change in pesticide use. The intensity measure, which normalizes treated acres treated with planted acres, provides a reasonable way of comparing across years.

Despite the lack of field tracking, the Arizona use data provides a means of knowing actual application rates for pesticide products in the field. Pesticide labels only provide a range of recommended rates for a certain product. The same product might have a quite wide range of recommended rates for different target pests. As mentioned before, in the absence of better data, the default assumption for regulatory purposes has been full label rates. Calculation of accurate pesticide use rates only requires the number of acres treated by a particular tank of pesticides. The lack of field tracking does not undermine the calculation of actual field level usage rates.

Usage rates are further complicated by the possibility of mixed applications of two or more AIs. While, in general, the practice of tankmixing products may be more common with herbicides, it is also a common practice with insecticides in Arizona. In 1995, a year of severe whitefly infestation, 488 combinations of up to five different AIs were recorded. These multiple AI tankmixes complicate the applied acres and intensity measures and the application rate. Importantly, because of the way the pesticide usage database has been set up, each AI in a tankmix counts as a separate application when tallying application-acres.

Starting in 1999, an entry was included on the ADA 1080 form to indicate the target pest or pests for which an application was being made. Up to four separate pests can be indicated for a single application. Information on target pests will facilitate research in the future. In this first year of operation, it is primarily useful as a general overview of the pests being treated in Arizona cotton.

Data

Pesticide use reporting in Arizona does not cover all agricultural pesticide use. Much like California's system prior to instituting full reporting, Arizona requires the reporting of only certain kinds of applications. In addition to the omission of field-tracking, this is clearly a weakness of the database. Recognizing these weaknesses, it is still possible to make good use of the data that is available.

Arizona mandates reporting of pesticide applications by commercial applicators, the applications of pesticides registered under section 18 registrations and certain applications of pesticides included on the Arizona Department of Environmental Quality (DEQ) Groundwater Protection List (GWPL). Anecdotal evidence indicates that there is also voluntary reporting of unregulated pesticide applications

Commercial applicators have a strong incentive to comply with reporting regulations. They can lose their state license if they do not follow proper procedures. In Arizona, commercial applicators play a major role in pesticide application because of the importance of aerial applications of pesticides, all of which are done by commercial operations.

Section 18 registrations have been important for tracking new chemistries as they enter into cotton production. The insect growth regulators (IGRs, Knack and Applaud) are the most recent examples of section 18 registrations that should have full reporting in the database. (Knack received section 3 registration in 1999 so no longer falls under section 18 reporting requirements.) Once again, the incentive for producers to report is relatively high because continued registration of the product is dependent on full reporting. On the other hand, the potential penalty for an individual producer is small relative to the commercial applicator and unfamiliarity with the reporting system may lower compliance.

Finally, the reporting of GWPL applications, which should be complete for those AIs on the list, is actually difficult to quantify. The lack of a visible regulatory presence for the GWPL and relative lack of producer incentives make this aspect of the Arizona use reporting system potentially unreliable. Because the GWPL applies only to soil-applied applications, this uncertainty affects reports of herbicides and nematicides more than insecticides and defoliants.

Results

The limitations of the Arizona's reporting system determine where the data can be most useful. At a minimum, reported applications provide a lower bound for actual applications in the state. They also provide hard evidence of the range of practices being used by producers across the state. Furthermore, the reporting system has been in place without serious structural changes since 1993 when the GWPL was included. Thus trends over time should reflect actual trends within the group reporting applications.

Arizona cotton acreage decreased dramatically between 1991 and 1998. Acres planted to cotton dropped from 466,000 to 265,900. Over the same period application-acres dropped even more dramatically. Figure 1 shows application intensity -- application-acres normalized by the acres planted in cotton -- for both the state and the individual counties. At the state level, controlling for the steady decrease in acres planted to cotton, the average number of pesticide applications declined. 1995 represents the high point in application intensity for the state at 14.9 applications per acre. The 1998 application intensity of 7.8 is just 52% of the 1995 level and is 3.7 applications below the average intensity over the period.

1995 was the year before IGRs became available and a year when whitefly infestation was high. Where infestations occurred, a high number of insecticide applications were made to avoid potential yield loss and reduced lint quality. Furthermore, many of the applications were multiple AI tankmixes, primarily pyrethroids synergized with an organophosphate, because of the increased efficacy against the whitefly. High application intensities in this period reflect both the increase in treatments and the heavy use of multiple AI tankmixes.

Figures 2 shows the application intensity broken down by type of pesticide. It is easy to see that insecticides dominate the database. Over the period insecticide application intensities are five times the intensity of the nearest category, defoliants. Also, changing insecticide intensities are clearly responsible for the rise and fall in the overall usage intensities.

It is important to remember the reporting requirements when considering these numbers. Over 90% of reported applications in all years are aerial applications. Insecticides, defoliants and plant growth regulators are all commonly applied by air on later season cotton where the plant canopy has closed over the row. All aerial applications should be reported. Thus, these kinds of pesticides should be well represented in the database. Defoliant application intensity appears to be steady which is consistent with no major changes in defoliation techniques. Plant growth regulator usage (Pix), at 65% of the acreage in 1998, is 50% higher than any previous year. On the other hand, herbicides are clearly severely undercounted in the pesticide use reports. Producers frequently apply their own herbicides at or before planting and at layby. Thus, for herbicides, the only non-voluntary incentive to report would come from the GWPL.

Figure 3 shows insecticide intensity by Arizona counties. As expected, Maricopa and Pinal counties are near the top in terms of application intensity. During 1995, these counties experienced widespread whitefly infestation. Interesting in this graph is the disparity between La Paz, Yuma and Mohave counties. All in western Arizona along the Colorado river, these three counties appear to have very different usage patterns through the 1990s. Application intensities in Mohave county for all kinds of pesticides are consistently lower than other counties. This might indicate a generally lower reporting rate rather than a lower level of usage.

Figure 4 tracks the usage of the top five AIs used in Arizona between 1991 and 1998. This figure still reflects the general reduction in insecticide use and also the whitefly infestation in the middle part of the decade. Acephate and chorpyrifos have activity against whiteflies, particularly in mixes, and pink bollworm (PBW). The reduction in their usage can be attributed to both the use of IGRs on whiteflies and the planting of Bt. cotton to control PBW. Gossyplure, a pheromone used to disrupt PBW breeding appears to have been increasing in popularity until Bt. cotton provided direct PBW control.

Tables 1, 2, 3, 4 and 5 provide 1998 and 1999 use statistics by pesticide type. 1999 numbers generally indicate that pest pressure was low. Only two of the top twelve insecticides increased percentage of acres treated. In fact the only increase of note in any of the different types of pesticides is an increase in the use glyphosate, the AI in RoundUp. While still representing a small percentage of acres, reported usage has increased by more than 100%, probably as a result of Roundup-Ready cotton and the possibility of over the top aerial application. Continued use of Bt. cotton explains the continued low usage of gossyplure.

Table 6 shows the twenty single and multiple AI tankmixes used more than 100 times in 1995. The Acephate-Fenpropathrin mixture was a whitefly control that showed good efficacy in extension trials. In fact, with the exception of the single AI applications, the gossyplure applications (clearly targeted on PBW) and the acephate-chlorpyrifos combination, all of the remaining 15 combinations fit University of Arizona insect resistance management requirements for whitefly recommended treatments (Ellsworth et al., 1994 and 1996).

Table 7 shows the twelve single and multiple AI tankmixes used more than 100 times in 1998. The overall lower number of reports reflects both the decrease in acres in cotton and the decrease in insecticide use. Pyriproxyfen, an IGR used specifically for whitefly control, is third on the list as a single AI and twelfth on the list when mixed with acephate. Only three potential whitefly-targetted mixes appear, well down the list. Gossyplure, used for PBW mating disruption, shows up only once on the 1998 list. With reports of tankmixes including gossyplure down from 991 on the 1995 list to 131 applications, the success of Bt. cotton for PBW control is clear. Replacing the whitefly and PBW mixes are primarily single AI applications. With respect to acephate and oxamyl, in particular, this is consistent with the increased focus on *lygus* control in the absence of serious whitefly and PBW pressure (Ellsworth et al., 1998).

Table 8 summarizes the top pests in the new "target pest" category of the ADA 1080 form. The most reported target pest is *lygus* at 1944 reports. The number of *lygus*-targeted applications is more than double the number of reports for any other single pest. Whiteflies, at 897 reports, are still a common focus of control efforts, but the IGRs, now the primary whitefly controls, can only be applied once each per season.

PBW is reported 961 times, indicating that chemical control of PBW other than plant-expressed Bt. is still widely used. In general, Bt. cotton rarely needs additional foliar treatment for PBW. Bt. cotton, however, comes with a significant additional cost. Clearly many growers still consider traditional foliar approaches economically advantageous.

The target pest category includes weeds, diseases and nematodes as well as insects. In its first year, only the insect reports appear to provide useful additional information. Identification of insects by name appears to be highly developed. The "bugs, unknown" category is well under .5% of the insect reports. This reflects the carefully targeted insecticides used on cotton today and the increased knowledge that is at the foundation of integrated pest management. On the other hand, the "weeds, unknown" category dwarfs the largest name-specific weed category by more than a factor of five. Herbicides are commonly applied preplant or preemergence, before weeds appear. Furthermore, herbicide generally have activity against whole families of weeds, grasses, broadleaves, etc and specification of the exact targeted is less important.

Discussion

With the historically limited available information on pesticide usage, the focus of research has always been on relatively simple characterizations of use patterns. With a use reporting system like the Arizona 1080 form, the possibilities expand substantially. Highly specific usage information allows for reliable estimates of the extent and nature of pesticide use. Collected over time this information provides evidence of trends in use. This kind of information can put Arizona cotton production in the proper light with respect to adoption of IPM practices. Taking advantage of information on mixed AIs and target pests, an increasingly clear picture of Arizona cotton production techniques can be developed. This picture can assist extension in better serving cotton producers in Arizona.

Funding Sources

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Table 1. ADA 1080 Insecticide Usage, 1998 and 1999, Greater Than 1% Acres Treated

	1999				1998		
Active Ingredient	App. Acres	Mean Rate	% of Plt Acres		App. Acres	Mean Rate	% of Plt Acres
Acephate	231,741	0.80	84.4%		253,544	0.79	95.4%
Endosulfan	163,927	1.15	59.7%		174,273	1.02	65.5%
Chlorpyrifos	144,848	0.69	52.8%		240,522	0.70	90.5%
Lambdacyhalothrin	96,218	0.03	35.1%		100,016	0.03	37.6%
Gossyplure	58,288	0.01	21.2%		59,312	0.02	22.3%
Oxamyl	39,675	0.79	14.5%		62,914	0.79	23.7%
Pyriproxyfen	28,676	0.05	10.4%		114,180	0.05	42.9%
Methomyl	26,076	0.36	9.5%		16,940	0.43	6.4%
Fenpropathrin	25,552	0.19	9.3%		29,527	0.20	11.1%
Cypermethrin	24,391	0.07	8.9%		18,860	0.05	7.1%
Dimethoate	24,124	0.35	8.8%		52,130	0.46	19.6%
Buprofezin	17,921	0.35	6.5%		33,864	0.35	12.7%
Methyl parathion	17,873	0.68	6.5%		21,763	0.88	8.2%
Cyfluthrin	14,221	0.04	5.2%		13,611	0.04	5.1%
Bifenthrin	12,494	0.05	4.6%		7,142	0.06	2.7%
Zeta-cypermethrin	10,406	0.04	3.8%		21,478	0.04	8.1%
Esfenvalerate	8,173	0.04	3.0%		4,422	0.04	1.7%
Profenofos	5,173	0.86	1.9%		17,261	0.93	6.5%
Malathion	4,125	1.14	1.5%		5,097	1.32	1.9%
Aldicarb	3,839	1.26	1.4%		22,267	1.05	8.4%

Table 2. ADA 1080 Herbicide Usage, 1998 and 1999.

	1999				1998		
Active Ingredient	App. Acres	Mean Rate	% of Plt Acres		App. Acres	Mean Rate	% of Plt Acres
Pendimethalin	51,172	0.89	18.6%		41,341	0.92	15.5%
Prometryn	33,141	0.87	12.1%		39,114	0.93	14.7%
Glyphosate	22,148	0.71	8.1%		10,371	0.61	3.9%
Trifluralin	21,104	0.62	7.7%		31,753	0.63	11.9%
Cyanazine	11,918	0.89	4.3%		16,364	1.00	6.2%
Diuron	10,256	0.78	3.7%		9,391	0.70	3.5%
Pyrithiobac-sodium	6,212	0.04	2.3%		5,928	0.07	2.2%
Bromoxynil	2,053	0.44	0.7%		3,904	0.32	1.5%
Fluazifop-P-butyl	2,022	0.29	0.7%		2,572	0.30	1.0%
Clethodim	1,884	0.51	0.7%		536	0.20	0.2%
MSMA	1,753	1.46	0.6%		2,872	1.35	1.1%
Sethoxydim	1,132	0.33	0.4%		807	0.34	0.3%

Table 3. ADA 1080 Fumigant and Fungicide Usage, 1998 and 1999.

	1999				1998		
Active Ingredient	App. Acres	Mean Rate	% of Plt Acres		App. Acres	Mean Rate	% of Plt Acres
Dichloropropene	10,579	41.20	3.9%		11,148	48.13	4.2%
Sulfur	9,091	3.56	3.3%		21,816	3.99	8.2%
Mancozeb	3,599	0.85	1.3%		4,055	1.14	1.5%
PCNB	1,426	1.49	0.5%		5,571	0.69	2.1%

Table 4. ADA 1080 Plant Growth Regulator Usage, 1998 and 1999.

	1999				1998		
	App. Acres	Mean Rate	% of Plt Acres	p	App. Acres	Mean Rate	% of Plt Acres
Mepiquat chloride	142938.8	0.147579	52.1%		134,778	0.04	50.7%
Ethephon	24,881	0.79	9.1%		27,748	0.86	10.4%
IBA	2,791	0.00	1.0%		3,215	0.00	1.2%
Maleic hydrazide	2,118	0.15	0.8%		356	0.32	0.1%
Gibberellic acid	2,092	0.00	0.8%		1,486	0.00	0.6%
Cytokinins	1,524	0.00	0.6%		5,499	0.00	2.1%

Table 5. ADA 1080 Defoliant Usage, 1998 and 1999.

	1999				1998		
	App. Acres	Mean Rate	% of Plt Acres	p	App. Acres	Mean Rate	% of Plt Acres
Thidiazuron	134,586	0.07	49.0%		123,974	0.08	46.6%
Diuron Defoliant	107,629	0.04	39.2%		95,857	0.04	36.1%
Sodium chlorate	89,158	4.12	32.5%		103,418	4.20	38.9%
Paraquat	40,175	0.27	14.6%		46,449	0.25	17.5%
Tribufos	39,802	1.08	14.5%		47,187	1.05	17.7%
Cacodylic acid	25,539	0.65	9.3%		18,610	0.64	7.0%
Endothall	18,589	0.08	6.8%		26,018	0.07	9.8%

Table 6. ADA 1080, 1995 Most Common Tankmixes

Active Ingredient(s)	Product Name(s)	# of Reports
Acephate-Fenpropathrin	Orthene-Danitol	1286
Chlorpyrifos	Lorsban	817
Gossyplure-Permethrin	Gossyplure-Ambush	771
Acephate-Lambdacyhalothrin	Orthene-Karate	505
Chlorpyrifos-Fenpropathrin	Lorsban-Danitol	413
Acephate-Bifenthrin	Orthene-Capture	285
Bifenthrin-Endosulfan	Capture-Thiodan	228
Chlorpyrifos-Gossyplure	Lorsban-Gossyplure	220
Acephate	Orthene	215
Acephate-Zeta-cypermethrin	Orthene-Mustang	214
Acephate-Chlorpyrifos	Orthene-Lorsban	206
Fenpropathrin-Profenofos	Danitol-Curacron	184
Chlorpyrifos-Lambdacyhalothrin	Lorsban-Karate	182
Methyl parathion	Penncap-M	173
Acephate-Chlorpyrifos-Lambdacyhalothrin	Orthene-Lorsban-Karate	159
Chlorpyrifos-Imidacloprid	Orthene-Lorsban-Danitol	131
Acephate-Chlorpyrifos-Fenpropathrin	Orthene-Lorsban-Danitol	126
Endosulfan-Zeta-cypermethrin	Thiodan-Mustang	112
Bifenthrin-Chlorpyrifos	Capture-Lorsban	107
Chlorpyrifos-Oxamyl	Lorsban-Vydate	101

Table 7. ADA 1080, 1998 Most Common Tankmixes

Active Ingredient	Product Name(s)	# of Reports
Acephate	Orthene	383
Chlorpyrifos	Lorsban	382
Pyriproxyfen	Knack	303
Endosulfan	Thiodan	265
Acephate-Chlorpyrifos	Orthene-Lorsban	228
Oxamyl	Oxamyl	175
Acephate-Fenpropathrin	Orthene-Danitol	155
Lambdacyhalothrin	Karate	146
Chlorpyrifos-Gossyplure	Lorsban	131
Acephate-Lambdacyhalothrin	Orthene-Karate	118
Chlorpyrifos-Endosulfan	Lorsban-Thiodan	118
Acephate-Pyriproxyfen	Orthene-Knack	100

Table 8. 1999 Top Target Pest Reports

Pest Name	# of Reports
lygus	1944
PBW	961
whitefly	897
bollworm/budworm	537
armyworm	362
aphids	112
cotton leafperforator	110
thrips	86
mites	65