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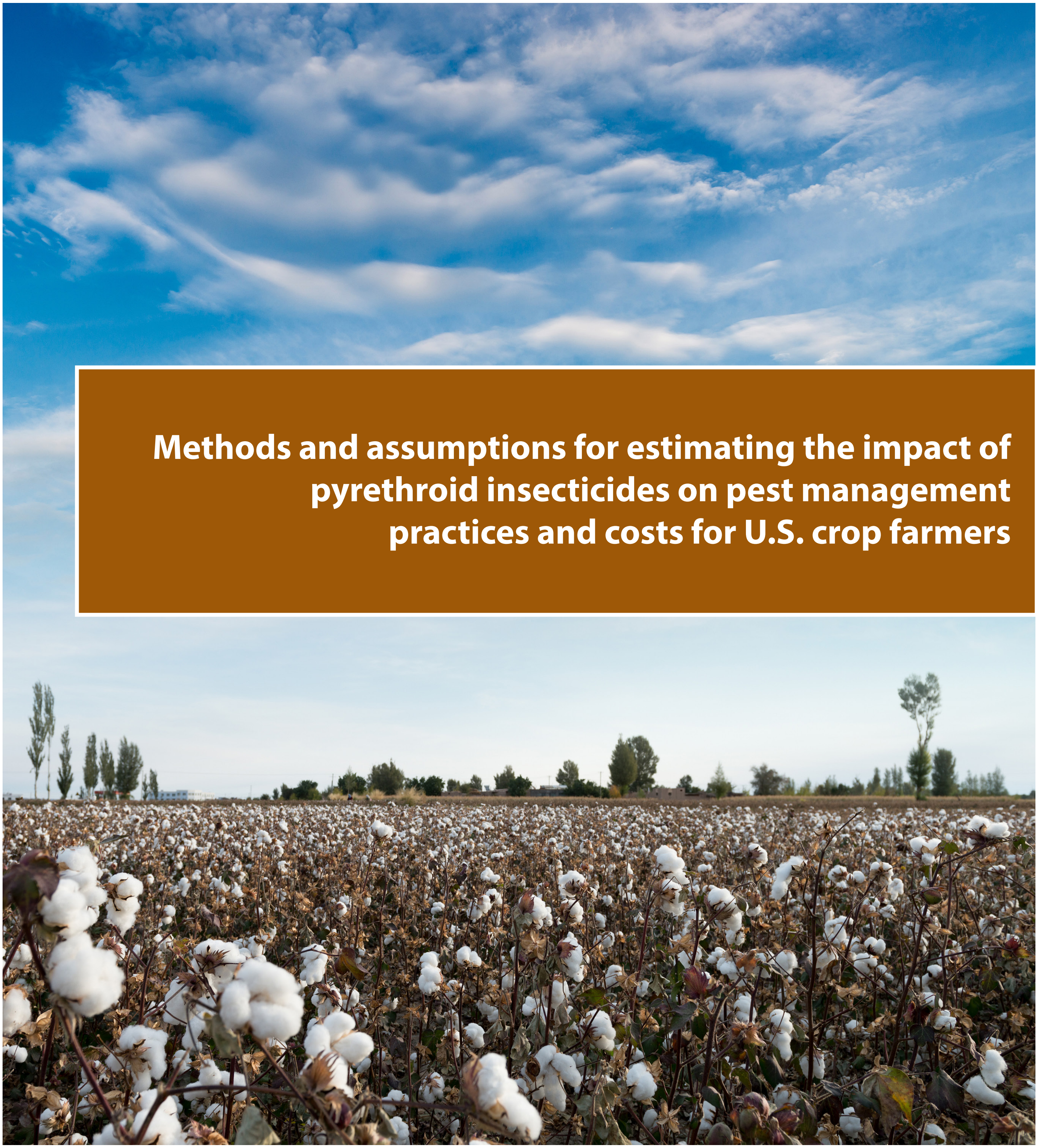
The value of pyrethroids in U.S. agricultural and urban settings:



Methods and assumptions for estimating the impact of pyrethroid insecticides on pest management practices and costs for U.S. crop farmers

2017

This report series, researched and produced by AgInfomatics, LLC, is an independent and comprehensive analysis of the economic and societal benefits of pyrethroid insecticides (bifenthrin, cyfluthrins, cyhalothrins, cypermethrins, deltamethrin, esfenvalerate, fenpropathrin, permethrin, and tefluthrin). The research was sponsored by the Pyrethroid Working Group, an informal association of firms marketing products based on the above pyrethroid active ingredients. These products are used in agricultural, structural and landscape applications.

AgInfomatics, an agricultural consulting firm established in 1995, conducted an analyses exploring the answer to the question: *What would happen if pyrethroids were no longer available or restricted beyond the current situation?* Comparing this hypothetical future to the economics associated with current applications allowed AgInfomatics to derive an estimate of the value of pyrethroids.

This estimated value was based on robust quantitative and qualitative study methods including econometrics, modeling of insecticide use, crop yield data, market impacts, surveys of growers, surveys of professional applicators and in-depth case studies. All these data sources and methods were used to triangulate on the above question.

The value of pyrethroids in North American agriculture

Reports include:

1. Executive summary
2. Methods and assumptions for estimating the impact of pyrethroid insecticides on pest management practices and costs for U.S. crop farmers
3. Summary of the use of pyrethroid insecticides by U.S. crop farmers and the impacts of non-pyrethroid scenario on insecticide use and farmer costs
4. Estimated yield benefits and efficacy of pyrethroid insecticides for major U.S. crops based on a meta-analysis of small plot data
5. Use and value of insect management practices in U.S. alfalfa corn, cotton and soybean production
6. Value of pyrethroid insecticides to urban pest management professionals
7. An economic assessment of the benefits of pyrethroid insecticides in the U.S.
8. Case studies of pyrethroid use patterns and potential impacts of regulatory changes on production of high value fruits and vegetables in primary U.S. production states
9. A case study of pyrethroid use patterns and potential impacts of regulatory changes on the control of mosquito vectors in Florida

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Methods and assumptions for estimating the impact of pyrethroid insecticides on pest management practices and costs for U.S. crop farmers

Pyrethroid benefits project

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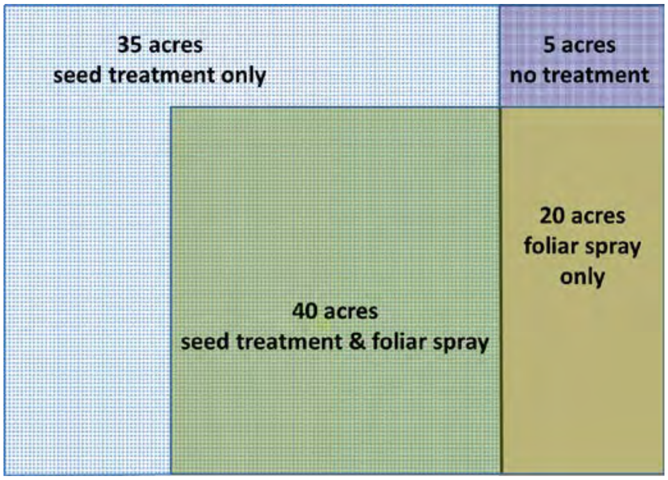
1.0 Introduction

This technical report is supporting documentation for an economic assessment of the benefits of the pyrethroid insecticides. In this report, the term pyrethroid is used for the following active ingredients (AIs): bifenthrin, cyfluthrins, cyhalothrins, cypermethrins, deltamethrin, esfenvalerate, fenpropathrin, permethrin, and tefluthrin. This technical report describes the process used to reallocate acres treated with pyrethroids to non-pyrethroid AIs as part of developing a non-pyrethroid scenario to estimate the benefits of pyrethroid insecticides. The process relies primarily on GfK Kynetec data for 2012-2014, using national-level annual averages over these three years. For this technical report, cotton is used as the specific example to illustrate and describe the methodology, with an appendix reporting results for the other commodity crops examined: alfalfa, citrus, corn, potato, rice, sorghum, soybean, spring wheat, sugar beet, sunflower, sweet corn, tomato, and winter wheat. These 14 crops were chosen for this project because they provided a mix of large-acreage commodity crops and high-value specialty crops, and included crops that were among those with the most pyrethroid treated acres or the greatest total pounds of pyrethroids applied. Cotton was chosen as the example crop for this report because it has both foliar and soil-applied uses of pyrethroid insecticides and multiple non-pyrethroid AIs available as alternatives

GfK Kynetec pesticide use data are widely recognized as among the best survey-based data on agricultural chemical use and biotech seed adoption, having been collected annually for almost 50 years. Data collection covered sixty crops in the continental U.S. in 2013 and has been averaging about twenty-thousand farmgate level interviews per year in recent surveys. Data collection uses both in-person and telephone interviews, as well as mail and web-based questionnaires, not only of the growers themselves, but also processors, packing houses, crop consultants, custom applicators, and retailers. In 2013, approximate sample sizes were 4,300 each for corn and soybean, 2,200 for winter wheat, 2,000 for alfalfa, 1,350 for cotton, 1,000 for spring wheat, 800 for sorghum, 400 for sugar beet, 375 each for potato, rice, and sunflower, plus pesticide use for about 40% of citrus acres, 35% of tomato acres and 30% of sweet corn acres.

GfK Kynetec data collection includes a wide range of variables, but the specific variables used for this analysis include planted acres, total area treated and base area treated for each crop, plus the total area treated, target pests, application method, and grower expenditures for each AI used in each crop. Respondents are farmers, plus in some cases their agents, including pest control advisors, crop consultants, custom applicators and retailers, as long as the individuals have documented records of actual field applications, not intended treatments.

Understanding the differences between planted acres, base area treated and total area treated is important for this analysis. Planted acres (or crop area grown) are the number of acres planted, base area treated is the unique number of these planted acres treated with an insecticide once or more, and total area treated is the number of acres treated with insecticides, potentially the same acre more than once. For this project, planted acres are also referred to as “cropped acres,” while the base area treated is referred to as “base acres” and the total area treated is referred to as “treated acres.”



A simple hypothetical example and a graphic aid illustrate these definitions. Suppose a farmer plants 100 acres of cotton (whole figure), with 75 of these acres using an insecticidal seed treatment. The farmer later treats 60 acres with a foliar applied insecticide: 20 of the acres that did not use a seed treatment and 40 of the acres that did. This farmer would generate 100 planted acres. Of these, the base area treated is 95 "base acres" or "base acres treated," while the total area treated is 135 "treated acres." The ratio of treated acres to base acres is the average number of applications per acre treated, which for this farmer is 135/95 = 1.42 insecticide applications per acre treated. Similarly, the ratio of treated acres to planted acres is the average number of applications per planted acre, which for this farmer is 135/100 = 1.35 insecticide applications per planted acre. To give some sense of the practical difference between base acres and treated acres, using the 2012-2014 three-year average for cotton for foliar-applied pyrethroids, there were 3.27 million base acres and 5.32 million treated acres. This analysis primarily focuses on treated acres, with base acres only used to calculate the average number of applications per acre treated for each AI. However, base acres for a few crops (citrus, sweet corn and tomato) were not used due to difficulty deriving them from the GfK Kynetec database, and so the average number of applications for these crops is calculated using acres treated.

For this analysis, insecticide treated acres are categorized into foliar-based systems and soil-based systems as defined by GfK Kynetec, which are based on target pest and the application method and timing. Foliar-based systems use insecticides to manage above ground pests, using application methods such as broadcast and aerial application. Soil-based systems use insecticides to manage below ground pests and early season pests, both above and below ground, using in-furrow applications. Note that treated acres for seed treatments are excluded for cotton since the focus is on pyrethroids and pyrethroid seed treatments are not used in cotton. Foliar-based systems are used for all the crops examined in this analysis, while soil-based are used only for corn, cotton, potato, and sugar beet.

Based on the GfK Kynetec data, Cotton Table 1 below summarizes the three-year average pyrethroid treated acres for 2012-2014 for cotton and their classification into either foliar-based or soil-based systems. The data show that foliar-applied insecticides dominated insecticide use on cotton, constituting more than 96% of total insecticide treated acres in the crop. For both foliar and soil-applied insecticides, pyrethroids constitute about 27% of the insecticide treated acres, and 27% overall as well.

Cotton Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	Soil	Total
Pyrethroids	5,321,048	208,872	5,529,920
Non-Pyrethroids	14,637,955	556,676	15,194,631
All AIs	**19,959,003**	**765,548**	**20,724,551**

For the purposes of this analysis, grower treated acres are categorized into either a foliar-based or a soil-based insect management system as defined by GfK Kynetec based on the reported application method and target pests. Both systems are consistent with IPM, since growers in general choose pest management strategies that balance efficacy and cost to identify systems that provide effective pest control while maintaining profitability and managing risk. Foliar-based systems target above ground pests that are mostly mid and later season pests. A threshold-based IPM scouting program is used and when pest population densities exceed action thresholds, insecticide applications are made. Soil-based systems target both below-ground and above-ground pests that are almost exclusively early season pests of seeds, seedlings and young plants. Because scouting of below ground pests with timely delivery of insecticides is impractical, a protective IPM program is adopted that uses soil-applied insecticides (or a seed treatment) at planting time based on historical occurrence of the pest in fields in the region, expert advice from various agricultural professionals, early season scouting and/or other informative signals.

This analysis assumes that for the non-pyrethroid scenario, growers would continue to use pest control on pyrethroid treated acres. The assumption is that, since growers find pyrethroid insecticide applications economical, they would in most cases also find a non-pyrethroid insecticide application economical for the non-pyrethroid scenario. For the non-pyrethroid scenario, pyrethroid treated acres in a foliar-based system remain in a foliar-based system for this analysis and simply switch to a non- pyrethroid AI. Similarly, pyrethroid treated acres in a soil-based system remain in a soil-based system and simply switch to a non- pyrethroid AI. Scouting costs do not change, since the grower is already scouting, and the insecticide application frequency is adjusted to reflect differences in field half-life and efficacy for the alternative AIs. As a result, grower costs change to reflect the net difference in AI costs and the net change in application costs due to changes in the average number of applications.

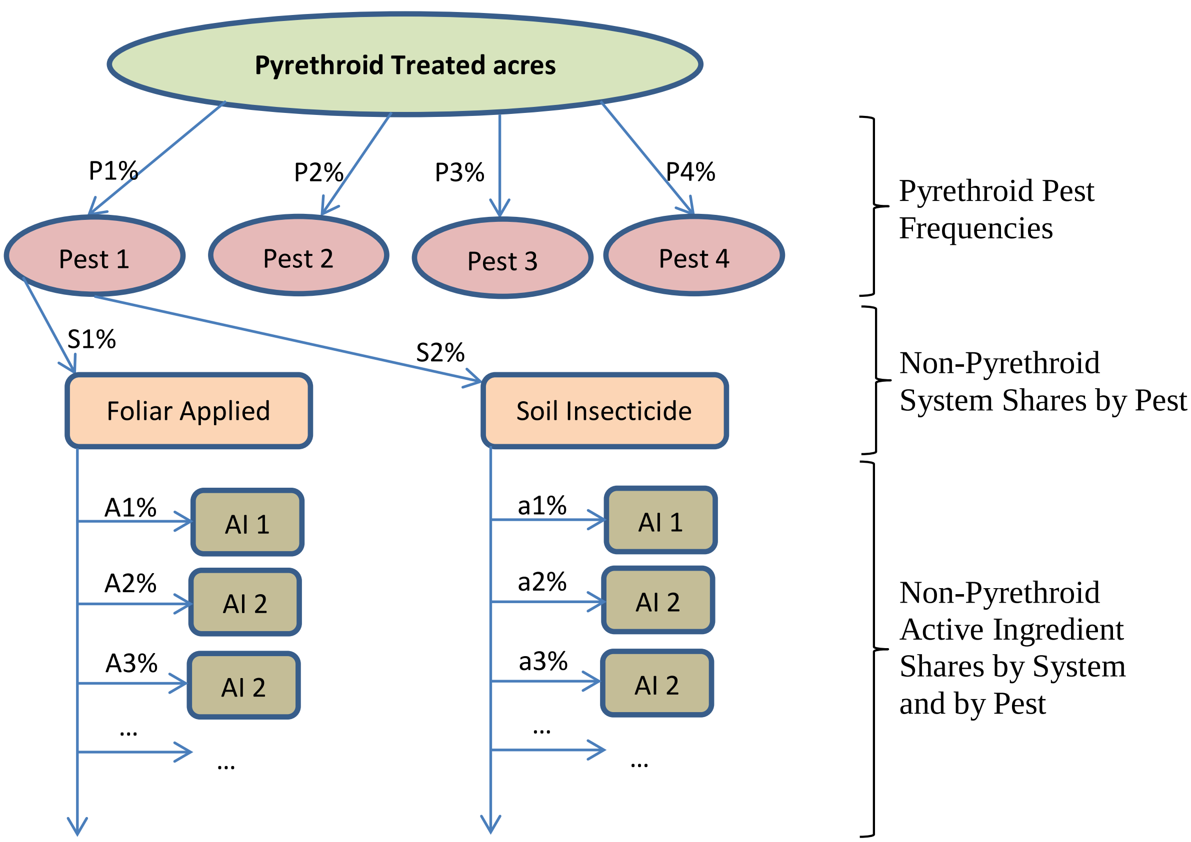
2.0 Analysis and reallocation of treated acres

This section describes the processing and analysis of the GfK Kynetec data and its use to reallocate pyrethroid treated acres to non-pyrethroid AIs. The GfK Kynetec data includes treated acres by application method and target pest for 98 different AIs, including pyrethroids. The 2012-2014 data for cotton includes 72 different target pest species (including no answer and preventive program) and 11 different application methods categorized into either a foliar-applied or soil-based system. Data for other crops include other target pest species associated with each crop and multiple application methods again categorized as either a foliar-applied or soil-based system.

Given this level of detail (target pest, application method, AI) a process was developed to allocate pyrethroid treated acres to non-pyrethroid AIs while accounting for the target pest frequencies and application systems.

For this analysis, the data were first prepared by focusing on the major pests targeted by pyrethroids and the frequency each pest was targeted. Next, for each target pest, the data were analyzed to determine acreage shares for foliar-based and soil-based systems for non-pyrethroid insecticides. Then finally, within each application system for each target pest, the treated acre shares of each non-pyrethroid AI were determined. The figure below illustrates this process.

The first step begins with pyrethroid treated acres and determines the proportion targeted at each major pest. The figure assumes four pests (P1 to P4). Next, for each of these pyrethroid target pests, the process determines the non-pyrethroid treated acre system shares, i.e., the proportion of non-pyrethroid treated acres using a soil-based and foliar-based system when targeting that pest (S1 and S2). Finally, for non-pyrethroids targeted at that pest and using that application system, the process determines the proportion of treated acres using each AI. The figure assumes three AIs for each system, though more are likely. Since the AIs used in each system likely differ, the labels are A1 to A3 and a1 to a3. The number of non-pyrethroid AIs with non-zero shares for this final step varies by crop, application method and target pest due to differences in product registrations and AI activity. These three steps create several tables and require various assumptions as described and reported in the sections below. Furthermore, after this part of the process, adjustments are made for differences in field efficacy of the different AIs and other factors, which are also described in the next sections, along with careful specification of the equations as used.



2.1 Preparing treated acres for analysis

For this analysis, treated acres were categorized as either a foliar-based or a soil-based insect management system as defined by GfK Kynetec based on the reported application method and target pests. Based on this classification, each system was analyzed separately to develop non-pyrethroid alternatives for pyrethroid treated acres. The first step was to drop AIs with zero treated acres for cotton, which left 46 AIs for foliar-based systems and 16 for soil-based systems. Because 79 unique target pests were reported for cotton, target pest groups were developed that combined multiple target pest species into a single group to reduce the number of target pests to a more manageable number. For example, the target pests brown marmorated stink bug, green stink bug, leaf footed stink bug, redbanded stink bug, rice stink bug, southern green stink bug, and stink bug were all categorized as simply stink bug. Relative to the other crops, cotton is among the crops with a high number of unique target pests reported; citrus reported 87, corn reported 82, soybeans 81, and tomatoes 80, while crops like potatoes and sweet corn reported 65, with crops like wheat, alfalfa, sorghum and sugar beets ranged between 50 and 58, and at the low end was rice reporting 25 unique pests and sunflowers 33. Next treated acres were then summed across all AIs to generate the total treated acres for all AIs, and then these treated acres were summed across all target pest species to generate total treated acres for each of these target pest groups.

Next, target pest groups were dropped to focus on the main target pests of pyrethroid insecticide use in cotton. Treated acres for which the respondent provided no answer or reported a preventive program for the target pest were dropped. Why respondents did not always provide a target pest is unknown and likely varied among respondents (e.g., could not recall, followed an expert's advice, or survey response burden). This analysis conservatively assumes no answer meant the farmer did not have a target pest, which likely over estimates this occurrence. After dropping these responses, the share of the total remaining treated acres targeted for each insect group was then calculated. Any insect group with less than 1.5% of these treated acres was dropped as a minor pest, as was any insect group not registered as a target pest for pyrethroid insecticides. Next, treated acres were then summed across all pyrethroid AIs to generate the total pyrethroid treated acres for each of the remaining insect groups. The share of the total pyrethroid treated acres for each insect group was then calculated and any insect group with less than 1% share of pyrethroid treated acres was dropped. For cotton using either a foliar-based or a soil-based system, this process left six target insect groups: fleahoppers, lepidopterans, mites, plant bugs, stink bugs, and thrips. This list is not intended to imply that other cotton pests targeted by pyrethroid are not important. These other insects can be significant pests in some years and in some regions, but on a national level, these other pests become relatively minor targets and are dropped from this analysis. Relative to the other crops, cotton is intermediate in terms of the number of the major target pest groups remaining: sugar beets had 14 and corn 12, while crops like potatoes, tomatoes, soybeans, sorghum and wheat had 6 to 9 pest groups remaining, and the remaining crops had 4 to 5 pest groups.

Cotton Table 2 reports the initial treated acres for all AIs and for pyrethroids for both systems from Cotton Table 1, and then summarizes the aggregate results of this process. For foliar-based systems, 95.7% of the total treated acres for all AIs are targeted at specific pests, but 80.3% of foliar-applied pyrethroids are. However, for soil-based systems, 76.2% of the total treated acres for all AIs are targeted at specific pests, but 99.1% of soil-applied pyrethroids are.

Cotton Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		**Soil-Based Systems**	
	All AIs	Pyrethroids	All AIs	Pyrethroids
Initial Treated Acres	19,959,003	5,321,048	765,548	208,872
No Answer	4.3%	0.9%	23.8%	0.9%
Targeted at Specific Pests	95.7%	80.3%	76.2%	99.1%

2.2 Reallocating pyrethroid treated acres

Pyrethroid treated acres in the initial data are reallocated to non-pyrethroid practices largely based on acreage shares of non-pyrethroid insecticides for each major pest targeted by pyrethroid insecticides. The reallocation process begins with the treated acres remaining after the preparation process described above.

First, the share of non-pyrethroid acres treated with each non-pyrethroid AI is calculated for each target insect group separately in order to identify the major non-pyrethroid AIs used and their relative importance for controlling each target pest group. Any AI that has a maximum acreage share across all insect groups that is less than 2% is dropped in order to identify the main non-pyrethroid alternatives in the foliar-based system and in the soil-based system. In addition, any AIs are dropped that appear in the data but are no longer registered (such as aldicarb), though they were registered during 2012-2014. Also, AIs are dropped when the reported target pest is not a registered use of the AI. This type of misreporting generally occurs rarely in the data, due to imperfect recall or in some cases when pre-mixes or tank mixes of multiple AIs targeted at multiple pests are applied.

This process left 15 non-pyrethroid AIs for foliar-based systems and 4 AIs for soil-based systems, with some overlap in AIs between the systems. The relatively small number of AI remaining for soil-based systems also occurs for some other crops due to the limited number of non-pyrethroid alternatives that farmers have for controlling some types of soil insects in some crops. For all the crops analyzed here, at least one non-pyrethroid alternative was available for every pest.

After dropping these AIs and making other adjustments as described, acreage shares for the remaining non-pyrethroid AIs are renormalized for each target insect group separately so that they again add to 100%. Cotton Table 3 reports the resulting treated acreage shares for foliar-based systems and soil-based systems. In general, the spectrum of target pests is very similar for both systems, which is not surprising, since most of the targets for pyrethroids used in soil-based systems are actually above-ground pests. The only difference in target pests is that foliar-based systems drop fleahoppers.

Cotton Table 3 shows the share of treated acres for each AI by pyrethroid target pest, so that each column for a target pest adds to 100% within each system. In terms of interpretation, for example, the results for lepidopterans imply that 37.5% of all the non-pyrethroid treated acres targeted at lepidopterans use acephate, 33.4% use novaluron, 11.0% use chlorpyrifos, with the remaining two AIs having less than a 10% acreage share. Cotton Table 3 also shows that there are more non-pyrethroid alternatives for foliar-based systems than for use in soil-based systems.

Cotton Table 3 show which non-pyrethroid AIs are used for each pyrethroid target pest, but not how frequently growers target each pest group; Cotton Table 4 reports these frequencies. More specifically, for the foliar-based and the soil-based systems, the share of pyrethroid treated acres targeted at each pest group is calculated (i.e., the share of the pyrethroid treated acres in the last row of Cotton Table 2 targeted to each insect pest group listed in the row headings of Cotton Table 3). Cotton Table 4 reports these shares, which can also be interpreted as the frequencies that each pest group is targeted by growers using pyrethroids, and as a result, each row adds to 100%. The results in Cotton Table 4 show that stink bugs are the primary target pest of pyrethroid insecticides in foliar-based systems, with a 43.8% share of all foliar pyrethroid treated acres, while lepidopterans are overwhelmingly the primary target pest in soil-based systems, with an 86.3% treated acre share.

Cotton Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based and soil-based systems

	-------------------------------- Foliar-Based Systems --------------------------------					
Active Ingredient	**Fleahoppers***	**Lepidopterans**	**Mites**	**Plant Bugs**	**Stink Bugs**	**Thrips**
Abamectin	---	0.0%	71.7%	0.4%	0.0%	0.0%
Acephate	---	37.5%	0.0%	32.8%	5.6%	75.2%
Chlorantraniliprole	---	8.6%	0.0%	0.0%	0.0%	0.0%
Chlorpyrifos	---	11.0%	4.3%	0.2%	10.4%	0.1%
Dicrotophos	---	0.0%	10.0%	23.9%	72.9%	14.7%
Dimethoate	---	0.0%	0.1%	0.0%	0.0%	2.5%
Etoxazole	---	0.0%	7.2%	0.0%	0.0%	0.0%
Fenpyroximate	---	0.0%	5.2%	0.0%	0.0%	0.0%
Flonicamid	---	0.0%	0.0%	3.8%	0.0%	0.0%
Imidacloprid	---	0.0%	0.0%	13.1%	3.9%	0.0%
Indoxacarb	---	9.5%	0.0%	0.0%	0.0%	0.0%
Novaluron	---	33.4%	0.0%	9.0%	3.8%	0.1%
Spinetoram	---	0.0%	0.0%	0.0%	0.0%	5.1%
Spiromesifen	---	0.0%	1.5%	0.0%	0.0%	0.0%
Thiamethoxam	---	0.0%	0.0%	16.7%	3.3%	2.4%
	--------------------------------- Soil-Based Systems ---------------------------------					
Active Ingredient	**Fleahoppers**	**Lepidopterans**	**Mites**	**Plant Bugs**	**Stink Bugs**	**Thrips**
Acephate	0.0%	0.0%	0.0%	0.0%	0.0%	42.6%
Imidacloprid	71.3%	0.0%	0.0%	11.9%	0.0%	37.3%
Phorate	0.0%	100.0%	100.0%	0.0%	100.0%	18.0%
Thiamethoxam	28.7%	0.0%	0.0%	88.1%	0.0%	2.1%

*Fleahoppers are not a target for foliar-based systems.

Cotton Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based and soil-based pest management systems.

Target Pest	Foliar-Based	Soil-Based
Fleahoppers	---	1.7%
Lepidopterans	26.0%	86.3%
Mites	4.0%	1.8%
Plant Bugs	24.2%	4.9%
Stink Bugs	43.8%	3.5%
Thrips	1.9%	1.9%

2.3 Pyrethroid reallocation equations

Based on these results, the pyrethroid treated acres in Cotton Table 1 can be allocated to non-pyrethroid AIs using the pyrethroid acreage shares for each target pest group in Cotton Table 4 and the non-pyrethroid acreage shares for each AI by target pest group in Cotton Table 3. To express this process mathematically, let $\textit{Non-PyrethroidTrtdAcres}_{i,j,s}$ be the pyrethroid treated acres in pest management system *s* allocated to non-pyrethroid AI *j*, targeted at pest group *i*. Here *i* indexes the pest groups listed in the column headings of Cotton Tables 3 and 4, *j* indexes the AIs listed in first column of Cotton Table 3, and *s* is *foliar* or *soil* for the foliar-based and the soil-based pest control systems respectively. Let $\textit{PyrethroidTrtdAcres}_{s}$ be the pyrethroid treated acres in Cotton Table 1 for pest control system *s*. Let $\textit{PestFreq}_{i,s}$ be the pyrethroid acreage share for target pest group *i* in Cotton Table 4 for pest control system *s*. Let $\textit{AIShare}_{i,j,s}$ be the non-pyrethroid acreage share of AI *j* targeted at pest group *i* in Cotton Table 3 for pest control system *s*.

Based on these definitions, the basic equation for allocating pyrethroid treated acres to non-pyrethroid treated acres for each AI *j* targeted at pest group *i* in pest management system *s* ($\textit{Non-PyrethroidTrtdAcres}_{i,j,s}$) is the product of pyrethroid treated acres in system *s* to be allocated ($\textit{PyrethroidTrtdAcres}_{s}$), the frequency that these pyrethroid treated acres are targeted at pest group *i* ($\textit{PestFreq}_{i,s}$), and the share of non-pyrethroid acres for AI *j* targeted at pest group *i* in system *s* ($\textit{AIShare}_{i,j,s}$):

(1) $\textit{Non-PyrethroidTrtdAcres}_{i,j,s} = \textit{PyrethroidTrtdAcres}_{s} \times \textit{PestFreq}_{i,s} \times \textit{AIShare}_{i,j,s}$.

Equation (1) requires adjustment to account for differences in the duration of control, efficacy and range of species controlled for the different AIs. For example, switching from a pyrethroid that provides 15 days of control to a non-pyrethroid that provides 20 days of control will save applications in some cases, depending on pest pressure, efficacy of control and various environmental factors. The average number of applications used for each AI captures the impact of these differences in the duration of control and performance in different environments. For the GfK Kynetec data, the average number of applications for each AI is the ratio of treated acres to base acres, which is tracked separately for soil-based and foliar-based systems for each crop, but not by target pest. Thus for AI j in system s, the average number of applications is:

$$AvgApps_{j,s} = TreatedAcres_{j,s} / BaseAcres_{j,s}.$$

The basic pyrethroid reallocation equation is a one-to-one mapping of pyrethroid treated acres to non-pyrethroid alternatives. The ratio of the average number of applications for each AI relative to the average number of applications for pyrethroids is used to proportionally increase or decrease the number of non-pyrethroid treated acres to reflect these differences in product efficacy and field half-life. For example, 100 pyrethroid treated acres would be reallocated to 110 non-pyrethroid treated acres if the non-pyrethroid AI had an average number of applications 10% greater than for the pyrethroids. The key to note is that insecticide treated acres could increase or decrease for the non-pyrethroid scenario if the 2012-2014 data show that non-pyrethroid AIs on average used more applications than were used for pyrethroids.

Cotton Table 5 reports the average number of applications for each non-pyrethroid AI in Cotton Table 3, as well as the ratios to adjust for differences in the number of applications for non-pyrethroids relative to pyrethroids. Results in Cotton Table 5 show that soil-based systems generally use one application for most AIs, likely as a seed treatment or as a soil-applied insecticide at the time of planting. Foliar-based systems use multiple applications for all AIs, ranging from 1.000 for spiromesifen to 1.713 for acephate. However, for both systems the average number of applications is greatest for pyrethroids: 1.074 for pyrethroid AIs in the soil-based systems and 1.912 for pyrethroid AIs in the foliar-based systems. As a result, the foliar to foliar and soil to soil ratios are all less than 1.0 for the non-pyrethroids AIs, from 0.523 for spiromesifen to 0.896 for acephate in foliar systems and from 0.931 to 0.954 for the AIs used in soil-based systems

Cotton Table 5. Average number of applications for each AI and ratios of these averages.

	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
Active Ingredient	**Foliar-Based**	**Soil-Based**	**Foliar:Foliar**	**Soil:Soil**
Abamectin	1.275	---	0.667	---
Acephate	1.713	1.024	0.896	0.954
Chlorantraniliprole	1.171	---	0.612	---
Chlorpyrifos	1.491	---	0.780	---
Dicrotophos	1.676	---	0.877	---
Dimethoate	1.115	---	0.583	---
Etoxazole	1.178	---	0.616	---
Fenpyroximate	1.147	---	0.600	---
Flonicamid	1.364	---	0.713	---
Imidacloprid	1.681	1.000	0.880	0.931
Indoxacarb	1.019	---	0.533	---
Novaluron	1.601	---	0.837	---
Phorate	---	1.000	---	0.931
Spinetoram	1.014	---	0.531	---
Spiromesifen	1.000	---	0.523	---
Thiamethoxam	1.436	1.000	0.751	0.931
Pyrethroids	1.912	1.074	---	---

Based on these definitions, equations (2) and (3) report the final specific equations for pyrethroid treated acres allocated to each non-pyrethroid AI to control each target pest in foliar-based and soil-based pest management systems for the non-pyrethroid scenario:

(2) $Non\text{-}PyrethroidTrtdAcres_{i,j,foliar} =$

$$PyrethrodiTrtdAcres_{foliar} \times PestFreq_{i,foliar} \times AIShare_{i,j,foliar} \times \frac{AvgApps_{j,foliar}}{AvgApps_{pyrethroids,foliar}},$$

(3) $Non\text{-}PyrethroidTrtdAcres_{i,j,soil} =$

$$PyrethroidTrtdAcres_{soil} \times PestFreq_{i,soil} \times AIShare_{i,j,soil} \times \frac{AvgApps_{j,soil}}{AvgApps_{pyrethroids,soil}}.$$

Equation (2) is the same as the basic reallocation equation (1) with *s* replaced with *foliar* to denote pyrethroid treated acres in a foliar system reallocated for the non-pyrethroid scenario and the ratio to adjust for the average number of applications at the end. $PyrethroidTrtdAcres_{foliar}$ is from Cotton Table 1 (i.e., 5,321,048), the $PestFreq_{i,foliar}$ for each target pest *i* is from Cotton Table 4 (i.e., 26.0% for lepidopterans), the $AIShare_{i,j,foliar}$ for each AI *j* for each target pest group *i* is in Cotton Table 3 (i.e., 37.5% for acephate targeted at lepidopterans), and the ratio for each AI *j* in Cotton Table 5 (i.e., 0.896 for acephate). The calculation gives 465,085 treated acres of acephate as a foliar application to control lepidopterans, reallocated from the 1,383,710 pyrethroid foliar treated acres targeted to control lepidopterans. The remaining equations follow a similar logic.

Cotton Tables 6 and 7 report the non-pyrethroid treated acres by AI and target pest reallocated from the pyrethroid treated acres calculated using equations (2) and (3) and the values from Tables 1, 3, 4 and 5 tables. Cotton Table 6 shows that for the non-pyrethroid scenario, most of the pyrethroid treated acres in foliar-based systems are reallocated to dicrotophos, acephate, and novaluron, with dicrotophos mostly to manage stink bugs and acephate and novaluron to manage lepidopterans. Cotton Table 7 shows that for soil-based systems, almost all of the pyrethroid treated acres are reallocated to phorate mostly to manage lepidopterans.

Cotton Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Lepidop-terans	Mites	Plant Bugs	Stink Bugs	Thrips	Total	AI Weights
Abamectin	0	102,435	3,834	202	0	106,472	2.4%
Acephate	465,085	0	378,954	116,991	69,464	1,030,494	23.1%
Chlorantraniliprole	72,545	0	0	0	0	72,545	1.6%
Chlorpyrifos	119,036	7,243	2,295	188,830	54	317,459	7.1%
Dicrotophos	0	18,754	270,969	1,488,673	13,299	1,791,695	40.2%
Dimethoate	0	138	0	0	1,497	1,634	0.0%
Etoxazole	0	9,561	0	0	0	9,561	0.2%
Fenpyroximate	0	6,663	0	0	0	6,663	0.1%
Flonicamid	0	0	35,208	477	0	35,686	0.8%
Imidacloprid	0	0	148,149	80,366	0	228,515	5.1%
Indoxacarb	69,947	0	0	0	0	69,947	1.6%
Novaluron	387,180	0	97,123	74,648	84	559,036	12.5%
Spinetoram	0	0	0	0	2,799	2,799	0.1%
Spiromesifen	0	1,656	0	0	0	1,656	0.04%
Thiamethoxam	0	0	162,088	58,574	1,827	222,489	5.0%
Total	**1,113,794**	**146,451**	**1,098,621**	**2,008,762**	**89,023**	**4,456,651**	**100%**

Cotton Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Active Ingredient	Fleahoppers	Lepidopterans	Mites	Plant Bugs	Stink Bugs	Thrips	Total	AI Weights
Acephate	0	0	0	0	0	1,575	1,575	0.8%
Imidacloprid	2,311	0	0	1,131	0	1,347	4,788	2.5%
Phorate	0	167,808	3,525	0	6,791	648	178,771	91.9%
Thiamethoxam	929	0	0	8,386	0	74	9,389	4.8%
Total	**3,240**	**167,808**	**3,525**	**9,516**	**6,791**	**3,643**	**194,523**	**100%**

3.0 Results: Impacts of the non-pyrethroid scenario on pest management

3.1 Changes in treated acres and treated acre shares by AI

Cotton Table 8 summarizes the results of this process for cotton. For the non-pyrethroid scenario, the 2012-2014 average pyrethroid treated acres are allocated to several non-pyrethroid AIs and Cotton Table 8 lists these 16 specific AIs and their IRAC mode of action (MOA) classification (http://www.irac-online.org/modes-of-action/). Cotton Table 8 then lists the 2012-2014 annual average treated acres for each of these AIs for their use in cotton targeted at any pest. Cotton Table 8 does not list all AIs used for cotton, only those non-pyrethroid AIs to which pyrethroid treated acres were reallocated using the process described above. Minor use AIs were dropped (if their maximum treated acre share was < 2% across all target pest groups), as were AIs no longer registered for use or otherwise misreported (see Section 2.1), and so totals in Cotton Table 8 do not match those in Cotton Table 1. Cotton Table 8 then lists the pyrethroid treated acres added to each non-pyrethroid AI for the non-pyrethroid scenario, which is the sum of the treated acres reallocated to each AI as reported in Cotton Tables 6 and 7. Next, Cotton Table 8 reports the new updated total treated acres for each non-pyrethroid AI implied by the non-pyrethroid scenario and the associated percentage increase in treated acres that this updated total represents relative to average use in 2012-2014. Finally, Cotton Table 8 reports the same data (2012-2014 average, added and new total treated acres), but aggregated by insecticide class using the IRAC MOA classifications. Cotton Figure 1 graphically reports the 2012-2014 average treated acres and the new total treated acres for the non-pyrethroid scenario by insecticide class as reported in Cotton Table 8.

In terms of net increases in treated acres for each non-pyrethroid AI, the results in Cotton Table 8 show large increases for dicrotophos, acephate and novaluron with this reallocation. By far the largest increase is estimated for dicrotophos, which adds almost 1.8 million treated acres, while acephate adds more than 1.0 million treated acres and novaluron adds 559,000; all other AIs add less than 360,000 treated acres. The insecticide class results in the lower portion of Cotton Table 8 show large estimated increases for organophosphates, which add more than 3.5 million treated acres, and more modest increases for benzoylureas and neonicotinoids, which add 559,000 and 479,000 treated acres respectively. Overall, the total acres treated with these non-pyrethroid insecticides increases from 13.8 to 18.6 million acres, or more than 35%. However, total acres treated with insecticides actually decreases about 684,000 acres, or 3.5% due to the slightly lower average number of applications for the non-pyrethroid AIs compared to pyrethroids (Cotton Table 5). Cotton Figure 1 graphically shows these same results for all insecticide classes, while Cotton Figure 2 focuses on just major insecticide classes. The importance of neonicotinoids, organophosphates and pyrethroids as insecticide classes for insect management in cotton during 2012-2014 is clear in Cotton Figures 1 and 2, as are the large increases in organophosphates that are estimated under the non-pyrethroid scenario. The other insecticide classes and their changes seem relatively minor in comparison.

Cotton Figures 1 and 2 also highlights how cotton growers rely heavily on these three insecticide modes of action (organophosphates, neonicotinoids, and pyrethroids) and shift to even heavier reliance on only two modes of action for the non-pyrethroid scenario. As Cotton Table 1 indicates, there were annually 20.0 million treated acres for all insecticide AIs applied to cotton on average for 2012-2014. For these three modes of action, Cotton Figure 3 shows the 2012-2014 average shares of these treated acres devoted to each mode of action and the estimated shares for the non-pyrethroid scenario. The data show that 48% of all cotton treated acres were treated with organophosphates, 29% with pyrethroids and 14% with neonicotinoids and the remaining 9% received one or more of all other modes of action. The non-pyrethroid scenario eliminates the 29% share for pyrethroids, reallocating most of it to organophosphates, so that the share for organophosphates increases to 69%; the share for neonicotinoids increases to 17% and the share for the remaining modes of action increases to 14%.

In terms of relative increases, the percentage changes in Cotton Table 8 show the largest increases for phorate, indoxacarb, and chlorantraniliprole, which all increase more than 100%, while chlorpyrifos and novaluron increase more than 50%. In general, these large relative increases occur because the average use for 2012-2014 is rather small, so any increase is large in percentage terms. In terms of relative increases in the different insecticide classes, classes such the oxadiaines, diamides and benzoylureas show the largest increases, but each of these classes is represented by a single AI and the percentage changes for these classes is the same as for these respective AIs: indoxacarb, chlorantraniliprole and novaluron. Organophosphate treated acres are the largest actual increase, but in percentage terms the increase is almost 38%, with neonicotinoid treated acres increasing almost 18%.

These estimated shifts in insecticide use in Cotton Table 8 and Cotton Figures 1-3 raise additional concerns that this analysis does not capture. Over-reliance on only a few modes of action contributes to the development of insect resistance to these modes of action and the shifts in treated acreage shares indicated by these results would seem to be a concern. This contribution of pyrethroids to improved insect resistance management is a benefit missing from this analysis.

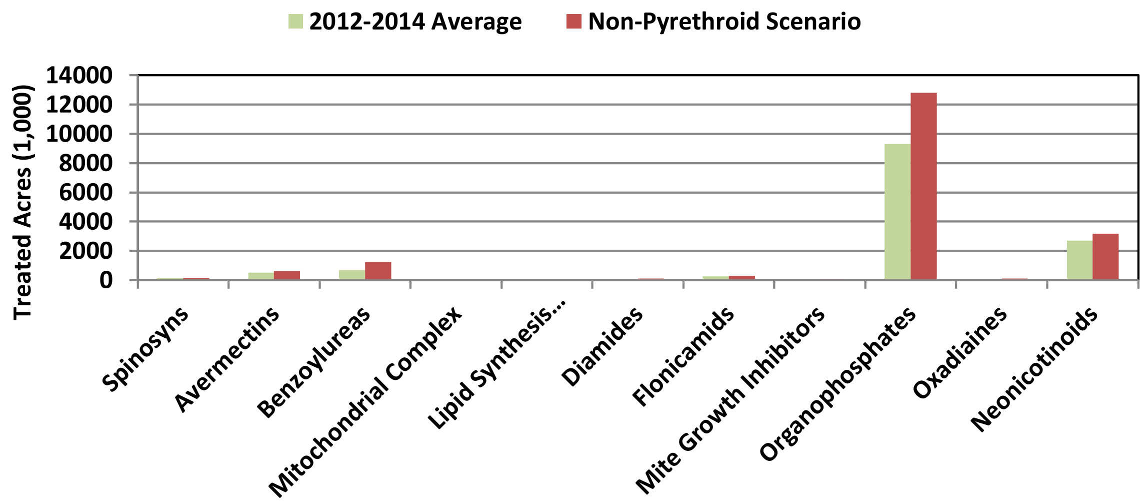
Cotton Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
6	Abamectin	529,720	106,472	636,192	20.1%
1B	Acephate	5,115,950	1,033,643	6,149,594	20.2%
28	Chlorantraniliprole	46,974	72,545	119,519	154.4%
1B	Chlorpyrifos	349,914	317,459	667,373	90.7%
1B	Dicrotophos	3,629,952	1,791,695	5,421,647	49.4%
1B	Dimethoate	130,234	1,634	131,868	1.3%
10B	Etoxazole	54,650	9,561	64,212	17.5%
21	Fenpyroximate	37,537	6,663	44,200	17.8%
29	Flonicamid	251,840	35,686	287,525	14.2%
4A	Imidacloprid	1,149,984	238,091	1,388,075	20.7%
22A	Indoxacarb	24,886	69,947	94,832	281.1%
15	Novaluron	689,099	559,036	1,248,134	81.1%
1B	Phorate	84,101	357,542	441,643	425.1%
5	Spinetoram	150,749	2,799	153,548	1.9%
23	Spiromesifen	4,716	1,656	6,372	35.1%
4A	Thiamethoxam	1,551,185	241,268	1,792,453	15.6%
	Total Non-Pyrethroids*	**13,801,491**	**4,845,697**	**18,647,188**	**35.1%**
	Total Pyrethroids	**5,529,920**	**-5,529,920**	**0**	**-100.0%**
	Total Treated with These AIs*	**19,331,411**	**-684,223**	**18,647,188**	**-3.5%**

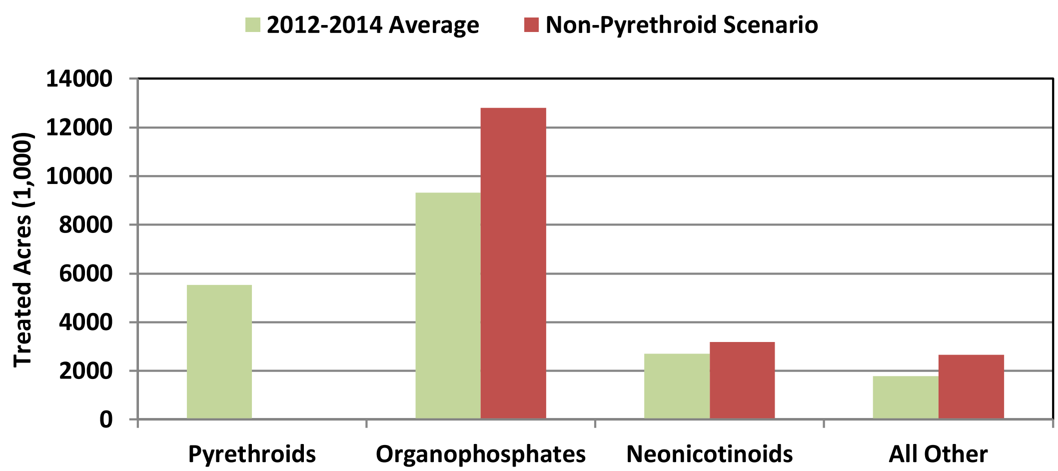
		------------- Treated Acres -------------			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
5	Spinosyns	150,749	2,799	153,548	1.9%
6	Avermectins	529,720	106,472	636,192	20.1%
15	Benzoylureas	689,099	559,036	1,248,134	81.1%
21	Mitochondrial Complex	37,537	6,663	44,200	17.8%
23	Tetronic Acid Derivatives	4,716	1,656	6,372	35.1%
28	Diamides	46,974	72,545	119,519	154.4%
29	Flonicamids	251,840	35,686	287,525	14.2%
10A/B	Mite Growth Inhibitors	54,650	9,561	64,212	17.5%
1B	Organophosphates	9,310,152	3,501,974	12,812,125	37.6%
22A	Oxadiaines	24,886	69,947	94,832	281.1%
4A	Neonicotinoids	2,701,170	479,358	3,180,528	17.7%
	Total	**13,801,491**	**4,845,697**	**18,647,188**	**35.1%**
	Total Non-Pyrethroids*	**13,801,491**	**4,845,697**	**18,647,188**	**35.1%**
	Total Pyrethroids	**5,529,920**	**-5,529,920**	**0**	**-100.0%**
	Total Treated with These AIs*	**19,331,411**	**-684,223**	**18,647,188**	**-3.5%**

*Does not match Cotton Table 1 totals because totals here do not include minor use AIs.

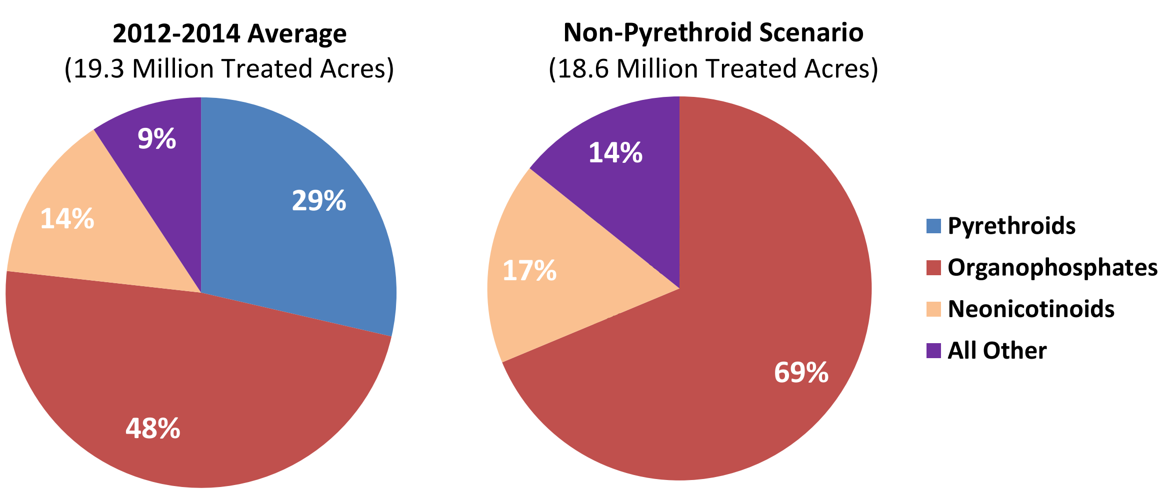
Cotton Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Cotton Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Cotton Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Cotton Table 8).



3.2 Changes in total pounds of AIs applied

Cotton Table 9 reports the average application rate in pounds per treated acre for each active ingredient by method of application (foliar, soil, seed treatment). These are calculated separately for each AI and each application method as total pounds of the AI applied divided by the total treated acres, and so average across all the different pests targeted by that AI, the different formulations, and across the years 2012-2014. Cotton Table 9 shows that most AIs are used at relatively low rates per acre, except for indoxacarb and the organophosphates (acephate, chlorpyrifos, dicrotophos, dimethoate, phorate). Multiplying these average application rates by the added treated acres for each AI for each application method for the non-pyrethroid scenario gives the increase in the total pounds of each AI applied for the non-pyrethroid scenario. Cotton Table 10 reports the total pounds of each AI and for each insecticide class using this method.

In Cotton Table 10, the observed differences between the 2012-2014 averages and the non-pyrethroid scenario generally match the trends evident in Cotton Table 8 treated acres, but with small variations since some AIs are used at different rates for different application methods. The results in Cotton Table 10 show that the non-pyrethroid scenario increases the total application of the non-pyrethroid insecticide active ingredients by more than 1.7 million pounds, increasing it from 3.86 million pounds to 5.57 million pounds, or more than 44%. Most of this increase comes from replacing almost 330,000 pounds of pyrethroids with more than 1.5 million pounds of organophosphates, which as Cotton Table 9 shows are used at higher application rates than most other insecticides. Total pounds applied of organophosphates increases 42%. The net impact on total pounds of insecticide active ingredients applied for the non-pyrethroid scenario is a net increase of almost 1.38 million pounds or almost 33%, from 4.20 million pounds for the 2012-2014 average to 5.57 pounds.

Cotton Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	**Active Ingredient**	**Foliar Insecticide**	**Soil Insecticide**
6	Abamectin	0.008	---
1B	Acephate	0.438	0.367
28	Chlorantraniliprole	0.051	---
1B	Chlorpyrifos	0.302	---
1B	Dicrotophos	0.335	---
1B	Dimethoate	0.216	---
10B	Etoxazole	0.040	---
21	Fenpyroximate	0.050	---
29	Flonicamid	0.080	---
4A	Imidacloprid	0.070	0.172
22A	Indoxacarb	0.094	---
15	Novaluron	0.045	---
1B	Phorate	---	0.904
5	Spinetoram	0.018	---
23	Spiromesifen	0.140	---
4A	Thiamethoxam	0.042	0.038

Cotton Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
6	Abamectin	4,372	893	5,265	20.4%
1B	Acephate	2,225,674	451,660	2,677,334	20.3%
28	Chlorantraniliprole	2,391	3,692	6,083	154.4%
1B	Chlorpyrifos	105,584	95,791	201,374	90.7%
1B	Dicrotophos	1,200,457	599,961	1,800,418	50.0%
1B	Dimethoate	27,522	353	27,875	1.3%
10B	Etoxazole	2,192	383	2,575	17.5%
21	Fenpyroximate	1,893	336	2,229	17.8%
29	Flonicamid	20,126	2,852	22,977	14.2%
4A	Imidacloprid	93,995	16,051	110,046	17.1%
22A	Indoxacarb	2,334	6,560	8,894	281.1%
15	Novaluron	31,012	25,158	56,170	81.1%
1B	Phorate	75,998	382,283	458,281	503.0%
5	Spinetoram	2,670	50	2,719	1.9%
23	Spiromesifen	3,407	232	3,639	6.8%
4A	Thiamethoxam	64,360	121,482	185,842	188.8%
	Total	**3,863,984**	**1,707,738**	**5,571,722**	**44.2%**

		Pounds of Active Ingredient Applied			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
5	Spinosyns	4,372	893	5,265	20.4%
6	Avermectins	2,670	50	2,719	1.9%
15	Benzoylureas	31,012	25,158	56,170	81.1%
21	Mitochondrial Complex	1,893	336	2,229	17.8%
23	Tetronic Acid Derivatives	3,407	232	3,639	6.8%
28	Diamides	2,391	3,692	6,083	154.4%
29	Flonicamids	20,126	2,852	22,977	14.2%
10A/B	Mite Growth Inhibitors	2,192	383	2,575	17.5%
1B	Organophosphates	3,635,234	1,530,049	5,165,283	42.1%
22A	Oxadiaines	2,334	6,560	8,894	281.1%
4A	Neonicotinoids	158,355	137,533	295,888	86.9%
	Total Non-Pyrethroids	**3,863,984**	**1,707,738**	**5,571,722**	**44.2%**
3A	Pyrethroids	329,892	-329,892	0	-100.0%
	Total	**4,193,876**	**1,377,846**	**5,571,722**	**32.9%**

3.3 Impact on farmer costs

This section describes the partial budget analysis used to estimate the impact of the reallocation of pyrethroid treated acres to non-pyrethroid insecticides on grower costs. The cost analysis for the non-pyrethroid scenario focuses on two costs: AI costs and application costs. AI costs depend on the per acre cost for each alternative non-pyrethroid AI relative to the pyrethroid AI cost, with GfK Kynetec data providing estimates of the per acre costs for each AI. Application costs for this analysis vary depending on whether the pyrethroid treated acre is in a foliar-based system or a soil-based system. Information from custom rate surveys and crop budgets were collected and analyzed to estimate application costs for both systems, which can vary for each crop, since crops differ in terms of their pest management practices. Specific assumptions regarding changes in application costs are explained for each crop. Scouting costs are not varied in this analysis of the non-pyrethroid scenario. The assumption is that farmers scouting their acres would continue to do so under the non-pyrethroid scenario and those that are not scouting their acres would not begin to do so. Also, scouting is on a base acre basis, not a treated acre basis, and in this non-pyrethroid scenario, base acres remain unchanged. If under the non-pyrethroid scenario a farmer switched from 2 applications of a pyrethroid to 1 application of a non-pyrethroid, scouting costs would not change, just application costs.

3.3.1 Cost data

GfK Kynetec data are used to determine the average cost of each AI per treated acre. Specifically, the GfK Kynetec data include total farmer expenditures on each AI in Cotton Tables 6 and 7. Dividing these expenditures by the treated acres of each AI gives the average grower cost per treated acre for each AI. Note that these AI costs do not include any application costs, just the cost for the AI. Also, this average cost estimate averages over the different application rates that farmers use for a specific AI, and furthermore, weights costs by the treated acres, so that the final cost estimate used for this analysis is an acreage-weighted average of per acre expenditures for each AI during 2012-2014. For the non-pyrethroid scenario, Cotton Table 6 reports all the AIs that would be used in a foliar-based system, while Cotton Table 7 reports the AIs that would be used in a soil-based system. Cotton Table 11 reports the 2012-2014 average grower cost per acre for each AI listed in Cotton Tables 6 and 7, as well as for the pyrethroid insecticides. The average costs in Cotton Table 11 range from $2.66/A for foliar-applied dimethoate to $20.50/A for foliar-applied spiromesifen. Cotton Table 11 shows that pyrethroids are on the lower end of the cost per acre range among the foliar and soil insecticides in Cotton Tables 6 and 7. For foliar-applied insecticides, the treated acre weighted average AI cost for the non-pyrethroids is $5.23/A, while for the pyrethroids it is $3.86/A. For soil-applied insecticides, the cost difference is even larger – the treated acre weighted average for non-pyrethroids is $12.18/A, but only $2.49 for pyrethroids.

Cotton Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied
Abamectin	$7.16	---
Acephate	$3.38	$3.19
Chlorantraniliprole	$13.89	---
Chlorpyrifos	$5.23	---
Dicrotophos	$4.32	---
Dimethoate	$2.66	---
Etoxazole	$15.01	---
Fenpyroximate	$11.40	---
Flonicamid	$10.88	---
Imidacloprid	$3.93	$7.54
Indoxacarb	$14.66	---
Novaluron	$8.11	---
Phorate	---	$12.71
Spinetoram	$10.87	---
Spiromesifen	$20.50	---
Thiamethoxam	$6.84	$5.85
Non-Pyrethroid Average*	**$5.23**	**$12.18**
Pyrethroid Average*	**$3.86**	**$2.49**
Application Costs	**$7.46**	**$3.11**

*Average weighted by treated acres.

Cotton Table 11 also reports per acre costs for both foliar and in-furrow application. Costs for foliar applications are based on custom rate surveys from 15 states assembled for a previous analysis (Mitchell 2014). Surveys were from different years, so reported costs were adjusted for inflation using the USDA NASS annual prices paid index for services (USDA-NASS 2014, 2015). The original estimate was an average for 2010-2012 and it was adjusted to a 2012-2014 average using USDA NASS annual prices paid index for services. Specific index values were 98 for 2010, 100 for 2011, 103 for 2012, 105 for 2013 and 107 for 2014, giving a price index for 2010-2012 of 101.3 and for 2012-2014 of 105.0, which implies an inflation rate of 3.6% between the two periods. The original estimated application costs were $7.20/A for foliar applications and $3.00/A for in-furrow soil applications (Mitchell 2014). Based on the 3.6% inflation rate, the respective application costs for the 2012-2014 period are the $7.46/A and $3.11/A, which are the values reported in Cotton Table 11.

3.3.2 Cost analysis

Based on this information, multiplying the new treated acres from Cotton Tables 6 and 7 by the average cost for each AI from Cotton Table 11 gives the total expenditures by growers for the alternative insecticides that would be used for the non-pyrethroid scenario. Cotton Table 12 reports added treated acres for each AI from Cotton Tables 6 and 7 and per acre costs for these AIs from Cotton Table 11, and then the total cost to growers for these AIs, separately for foliar-based and soil-based systems. The final rows of Cotton Table 12 report the totals after summing over all AIs, and then the total application costs based on the total added treated acres and per acre cost.

As expected, total costs for each AI in Cotton Table 12 generally follow the AIs with the most added treated acres under the non-pyrethroid scenario, with some variation due to per acre cost differences. For example, dicrotophos has the largest total cost for foliar-based systems since it has by far the most added treated acres (almost 1.8 million) and a nearly average per acre cost. However, chlorantraniliprole still has an added total cost of more than $1 million even though it only has 72,545 added treated acres because its per acre cost is among the largest. For soil-based systems, phorate dominates the total cost among the AIs – it also has the most added treated acres for soil-based systems and the highest per acre cost. Overall, Cotton Table 12 reports that the total cost estimate for the AIs added for the non-pyrethroid scenario is $23.3 million for foliar-applied AIs and $2.4 million for soil-applied AIs. Total application costs to apply these foliar AIs are an estimated $33.2 million for the foliar systems and $600,000 for soil-based systems.

Estimating the net cost impact must account for the fact that under the non-pyrethroid scenario, costs for the pyrethroid AIs would be avoided, as would the costs for applying these AIs. Cotton Table 13 combines these avoided costs for the pyrethroids no longer used and the added costs for the non-pyrethroids to calculate the estimated net cost impact. In addition, Cotton Table 13 uses the pyrethroid base acres and planted acres to estimate the cost effect on a per acre basis. Based on the pyrethroid treated acres in Cotton Table 1 and the AI costs and application costs, the total avoided costs for the pyrethroids no longer used for the non-pyrethroid scenario can be calculated. Cotton Table 13 reports these avoided costs as $20.5 million for foliar AIs and $39.7

million for foliar application, while for soil-based systems, avoided AI costs are $520,000 and $650,000 for application costs. Thus, the total avoided costs from not using pyrethroids are $61.4 million.

The next column in Cotton Table 13 gives the AI and application costs for the added non-pyrethroids from the bottom rows of Cotton Table 12. Total new costs for the added non-pyrethroid AIs and applications to replace the avoided pyrethroids is $59.5 million. The final column in Cotton Table 13 combines these results to calculate the estimated net effect. For both foliar and soil-based systems, the costs for the replacement non-pyrethroid AIs exceed the costs for the pyrethroid AIs. However, the application costs for the non-pyrethroid scenario are lower since the total treated acres decrease about 684,000 based on Cotton Table 8. As a result, the estimated net effect of the non-pyrethroid scenario on farmer costs is a decrease of almost $1.9 million. Given the 5.5 million pyrethroid treated acres, this cost effect is an average decrease of $0.34/A for each pyrethroid treated acre. When spread over all cotton planted acres, the average cost impact is a decrease of $0.17/A for the non-pyrethroid scenario. This result suggests that pyrethroid insecticides are priced to be fairly cost competitive relative to their substitutes, as the analysis shows little net cost difference between pyrethroids and non-pyrethroids once application costs are accounted for. The fact that pyrethroid insecticides are used on such a large portion of cotton acres is evidence that the source of their value is something beyond cost, since they are slightly more costly than the non-pyrethroid alternatives.

Cotton Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	--------- Foliar-Based ---------			----------- Soil-Based -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Abamectin	106,472	$7.16	$762,711	---	---	---
Acephate	1,030,494	$3.38	$3,486,090	1,575	$3.19	$5,016
Chlorantraniliprole	72,545	$13.89	$1,007,594	---	---	---
Chlorpyrifos	317,459	$5.23	$1,661,043	---	---	---
Dicrotophos	1,791,695	$4.32	$7,731,797	---	---	---
Dimethoate	1,634	$2.66	$4,344	---	---	---
Etoxazole	9,561	$15.01	$143,523	---	---	---
Fenpyroximate	6,663	$11.40	$75,980	---	---	---
Flonicamid	35,686	$10.88	$388,146	---	---	---
Imidacloprid	228,515	$3.93	$899,204	4,788	$7.54	$36,091
Indoxacarb	69,947	$14.66	$1,025,600	---	---	---
Novaluron	559,036	$8.11	$4,533,758	---	---	---
Phorate	---	---	---	178,771	$12.71	$2,272,957
Spinetoram	2,799	$10.87	$30,422	---	---	---
Spiromesifen	1,656	$20.50	$33,951	---	---	---
Thiamethoxam	222,489	$6.84	$1,522,189	9,389	$5.85	$54,939
Total AI Cost	**4,456,651**	**$5.23**	**$23,306,351**	**194,523**	**$12.18**	**$2,369,002**
Application Cost	**4,456,651**	**$7.46**	**$33,246,617**	**194,523**	**$3.11**	**$604,966**

Cotton Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

	Avoided Expenditures from 2012-2014 Average	New Expenditures for the Non-Pyrethroid Scenario	Net Change in Farmer Expenditures
Foliar AI Costs	$20,539,245	$23,306,351	$2,767,105
Foliar Application Costs	$39,695,018	$33,246,617	-$6,448,401
Soil AI Costs	$520,090	$2,369,002	$1,848,912
Soil Application Costs	$649,591	$604,966	-$44,624
Total Costs	**$61,403,945**	**$59,526,937**	**-$1,877,008**

Net Change in Grower Expenditures ($/A)	Acres	$/Acre
Pyrethroid Treated Acres	5,529,920	-$0.34
Planted Acres	11,236,000	-$0.17

3.3.3 Caveats

This cost analysis has several caveats, some of which are described here. First, the per acre costs for each AI reported in Cotton Table 11 are accurate for the 2012-2014 market structure. If pyrethroids were no longer available, farmer demand for the non-pyrethroid AIs would increase sharply and likely increase the costs in Cotton Table 11, which would then increase the net change in grower expenditures on AIs in Cotton Tables 12 and 13. Additionally, the cost analysis depends on the assumptions used for how farmers would adjust their pest management practices. This analysis assumed farmers stayed within a foliar-based system or soil-based systems when reallocating AIs from pyrethroids to non-pyrethroids. In some cases, farmers using soil-based control of some early season pests could possibly switch to foliar applications or vice versa. This cost analysis does not account for this possibility.

This cost analysis also does not capture any changes in insect resistance to the non-pyrethroid AIs that would likely occur for the non-pyrethroid scenario. Specifically, as Cotton Figure 2 shows, cotton farmers rely primarily on three insecticide modes of action: pyrethroids organophosphates and neonicotinoids. If pyrethroids were no longer available, farmers would increase their reliance in organophosphates and neonicotinoids, likely accelerating the development of resistance to those MOAs and increasing farmer costs and losses. In addition, farmers would have to increase efforts to manage or slow the development of resistance, such as rotating to other MOAs besides organophosphates and neonicotinoids, which tend to be more costly. This analysis does not capture either of these costs – the cost of increased resistance or the cost of increased resistance management.

A final cost factor not accounted for in this analysis is the potential for cotton farmers to use or develop lower cost ways to manage these pests to reduce these costs, not only insecticide based methods, but also cultural control practices. With the availability of pyrethroids, farmers and other agricultural professionals have little or no incentive to pursue use or development of such methods. However, one effect of the non-pyrethroid scenario would be to incentivize innovation and reduce the cost impacts of the non-pyrethroid scenario. Given the relatively small estimated cost effect of the non-pyrethroid scenario, this cost reduction possibility seems less likely for cotton, but the cost impacts for other crops could be larger and incentivize such efforts. This analysis does not account for such cost effects.

4.0 References

Mitchell, P.D. 2014. *Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers.* AgInfomatics Research Report, Madison, WI (96 p).

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U.S. Department of Agriculture, National Agricultural Statistics Service (USDA-NASS). 2015. Agricultural Prices (February). USDA-NASS, Washington, DC. Online: http://usda.mannlib.cornell.edu/usda/nass/AgriPric//2010s/2015/AgriPric-02-27-2015.pdf .

5.0 Appendix: Results for other crops

This appendix briefly reports the tables and figures summarizing the analysis process and results for the following 13 other crops:

- Alfalfa
- Citrus
- Corn
- Potato
- Rice
- Sorghum
- Soybean
- Spring Wheat
- Sugar Beet
- Sunflower
- Sweet Corn
- Tomato
- Winter Wheat

Since the process for each crop is essentially the same, no explanation is given for each crop. To make finding information easier, table and figure numbers are kept the same for all crops as for cotton in the main text and an effort is made to have each table and figure look the same across crops. Thus, rather than number tables consecutively across crops, tables are numbered consecutively within each crop, with the crop added to the title.

5.1 Alfalfa

Alfalfa has no soil-applied insecticides registered for use and so many sections of the tables are left empty. Alfalfa Table 1 shows that of the 5.3 million treated acres for foliar-applied insecticides, almost 3.0 million are pyrethroids, making them the largest single insecticide class in terms of treated acres. Alfalfa Table 4 shows that about half of these pyrethroid treated acres were targeted at weevils and almost one fourth at leafhoppers. The remaining treated acres were targeted at aphids, and lepidopteran and orthopteran insect pests. Alfalfa Table 3 shows that for these pests, chlorpyrifos is the most commonly used non-pyrethroid alternative. Other commonly used alternatives include dimethoate for aphids and leafhoppers, indoxacarb for lepidopteran pests and weevils, and chlorantraniliprole for lepidopteran pests, with several other AIs also used. Alfalfa Table 6 reports the projected treated acres added for each non-pyrethroid AI by target pest to replace pyrethroids for the non-pyrethroid scenario. In total, an estimated 2.5 million non-pyrethroid treated acres are added and not surprisingly, chlorpyrifos is the most added non-pyrethroid replacement, adding 1.6 million treated acres. Dimethoate and indoxacarb are next largest in terms of added treated acres, but each are projected to add only around 200,000 treated acres.

Alfalfa Table 8 aggregates the added treated acres across target pests and all AIs within each insecticide class. Overall, almost 3.0 million pyrethroid treated acres are replaced with 2.5 million non-pyrethroid treated acres for the non-pyrethroid scenario, so that non-pyrethroid treated acres increase 112%, but total insecticide treated acres decrease almost 10%. Of the 2.5 million treated acres added as replacements, 2.0 million are organophosphates, mostly chlorpyrifos, and as a result, total organophosphate treated acres increase 115%. Based on the average application rates, Alfalfa Table 10 estimates the change in pounds of insecticide AIs applied. The non-pyrethroid scenario replaces almost 79,000 pounds of pyrethroid AIs with an estimated 1.1 million pounds of non-pyrethroid AIs, mostly organophosphates. As a result, the projected pounds of insecticide AI applied to alfalfa increases 99% to essentially double from the 2012-2014 average of almost 1.1 million pounds.

Alfalfa Figure 1 graphically shows that organophosphates predominate among the non-pyrethroid AIs in terms of treated acres and only more so under the non-pyrethroid scenario. Alfalfa Figure 2 graphically illustrates how pyrethroids dominate insect use for alfalfa, but that for the non-pyrethroid scenario, this use shifts to organophosphates. Finally, Alfalfa Figure 3 expresses these same results graphically in terms of the share of insecticide treated acres for each major insect class. The 2012-2014 average share for pyrethroid AIs is 57%, with the organophosphate share at 34%. For the non-pyrethroid scenario, the organophosphate share increases to 80% and the share for other insecticide classes increases from 9% to 20%.

Alfalfa Table 12 combines the added treated acres by AI with the average per acre cost for these AIs to estimate the total AI and application costs to replace pyrethroids with non-pyrethroids. The total cost is an estimated $16.9 million, of which $9.0 million is for chlorpyrifos. Other major AI costs are $2.5 million for indoxacarb, $1.7 million for chlorantraniliprole, and $1.1 million each for dimethoate and malathion. Application costs for these non-pyrethroid AIs are an estimated $18.5 million. Alfalfa Table 13 combines these cost estimates with the estimated costs for AIs and application for the pyrethroid AIs replaced to estimate the net impact on grower costs for the non-pyrethroid scenario. Total estimated costs for pyrethroid AIs and application are $35.1 million, while the total estimated costs for non-pyrethroid replacement is $35.4 million for the AIs and their application. Total costs for AIs increase by $3.9 million, but application costs decrease by $3.6 million since the total number of insecticide treated acres decreases. As a result, the net cost impact is $276,000, which is $0.09 per pyrethroid treated acre, or $0.01 per alfalfa harvested acre.

Alfalfa Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	Soil*	Total
Pyrethroids	2,972,708	---	2,972,708
Non-Pyrethroids	2,303,656	---	2,303,656
All AIs	**5,276,364**	---	**5,276,364**

*No soil-applied insecticides registered for use on alfalfa.

Alfalfa Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		Soil-Based Systems*	
	All AIs	**Pyrethroids**	**All AIs**	**Pyrethroids**
Initial Treated Acres	5,276,364	2,972,708	---	---
No Answer	3.8%	3.7%	---	---
Targeted at Specific Pests	96.2%	96.3%	---	---

*No soil-applied insecticides registered for use on alfalfa.

Alfalfa Table 3. Non-pyrethroid shares by pyrethroid target pest group for foliar-based systems*

	----------------------- Foliar-Based Systems -----------------------				
Active Ingredient	**Aphids**	**Leafhoppers**	**Lepidopterans**	**Orthopterans**	**Weevils**
Carbaryl	0.0%	4.4%	0.5%	0.0%	0.4%
Chlorantraniliprole	0.0%	0.0%	22.9%	0.0%	0.6%
Chlorpyrifos	62.4%	74.8%	34.9%	88.6%	67.8%
Diflubenzuron	0.0%	0.0%	0.0%	4.6%	0.0%
Dimethoate	18.2%	18.5%	0.0%	0.0%	4.2%
Indoxacarb	0.0%	0.0%	21.0%	0.0%	16.2%
Malathion	15.8%	0.2%	0.0%	6.8%	6.6%
Methomyl	3.3%	0.0%	8.0%	0.0%	0.4%
Methoxyfenozide	0.0%	0.0%	12.2%	0.0%	0.0%
Methyl Parathion	0.0%	0.0%	0.5%	0.0%	3.5%
Thiamethoxam	0.3%	2.1%	0.0%	0.0%	0.2%

*No soil-applied insecticides registered for use on alfalfa.

Alfalfa Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based*
Aphids	17.2%	---
Leafhoppers	22.6%	---
Lepidopterans	8.1%	---
Orthopterans	2.9%	---
Weevils	49.1%	---

*No soil-applied insecticides registered for use on alfalfa.

Alfalfa Table 5. Average number of applications for each AI and ratios of these averages.

Active Ingredient	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
	Foliar-Based	Soil-Based*	Foliar:Foliar	Soil:Soil*
Carbaryl	1.319	---	1.144	---
Chlorantraniliprole	1.057	---	0.917	---
Chlorpyrifos	1.098	---	0.952	---
Diflubenzuron	1.000	---	0.867	---
Dimethoate	1.122	---	0.973	---
Indoxacarb	1.193	---	1.034	---
Malathion	1.270	---	1.102	---
Methomyl	1.060	---	0.920	---
Methoxyfenozide	1.134	---	0.983	---
Methyl Parathion	1.715	---	1.487	---
Thiamethoxam	1.000	---	0.867	---
Pyrethroids	1.153	---	---	---

*No soil-applied insecticides registered for use on alfalfa.

Alfalfa Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Leaf-hoppers	Lepido-pterans	Ortho-pterans	Weevils	Total	AI Weights
Carbaryl	0	25,811	2,921	0	2,626	31,359	1.3%
Chlorantraniliprole	0	0	107,449	0	2,904	110,353	4.4%
Chlorpyrifos	303,390	363,883	169,599	430,940	329,800	1,597,612	64.3%
Diflubenzuron	0	0	0	20,303	0	20,303	0.8%
Dimethoate	90,621	91,916	0	0	20,929	203,466	8.2%
Indoxacarb	0	0	111,176	0	85,494	196,671	7.9%
Malathion	89,076	1,152	210	38,525	37,077	166,041	6.7%
Methomyl	15,412	0	37,619	0	1,882	54,913	2.2%
Methoxyfenozide	0	0	61,060	0	0	61,060	2.5%
Methyl Parathion	0	0	3,461	0	26,898	30,359	1.2%
Thiamethoxam	1,355	9,290	0	0	999	11,644	0.5%
Total	**499,855**	**492,053**	**493,496**	**489,768**	**508,608**	**2,483,779**	**100%**

Alfalfa Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Table not needed since no soil-applied insecticides registered for use in alfalfa.

Alfalfa Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	Active Ingredient	2012-2014 Average	Added	New Total	Change
1A	Carbaryl	12,814	31,359	44,173	245%
28	Chlorantraniliprole	95,335	110,353	205,687	116%
1B	Chlorpyrifos	1,304,461	1,597,612	2,902,073	122%
15	Diflubenzuron	2,095	20,303	22,399	969%
1B	Dimethoate	226,144	203,466	429,610	90.0%
22A	Indoxacarb	251,055	196,671	447,726	78.3%
1B	Malathion	157,644	166,041	323,685	105%
1A	Methomyl	77,005	54,913	131,918	71.3%
18A	Methoxyfenozide	36,327	61,060	97,387	168%
1B	Methyl Parathion	49,200	30,359	79,559	61.7%
4A	Thiamethoxam	5,557	11,644	17,201	210%
	Total Non-Pyrethroids*	**2,217,638**	**2,483,779**	**4,701,417**	**112%**
	Total Pyrethroids	**2,972,708**	**-2,972,708**	**0**	**-100%**
	Total Treated with These AIs*	**5,190,346**	**-488,929**	**4,701,417**	**-9.4%**

		------------- Treated Acres -------------			
MOA	Insecticide Class	2012-2014 Average	Added	New Total	Change
15	Benzoylureas	2,095	20,303	22,399	969%
28	Diamides	95,335	110,353	205,687	116%
18B	Azadirachtin	36,327	61,060	97,387	168%
1A	Carbamates	89,819	86,272	176,091	96.1%
1B	Organophosphates	1,737,450	1,997,477	3,734,926	115%
22A	Oxadiaines	251,055	196,671	447,726	78.3%
4A	Neonicotinoids	5,557	11,644	17,201	210%
	Total Non-Pyrethroids*	**2,217,638**	**2,483,779**	**4,701,417**	**112%**
	Total Pyrethroids	**2,972,708**	**-2,972,708**	**0**	**-100%**
	Total Treated with These AIs*	**5,190,346**	**-488,929**	**4,701,417**	**-9.4%**

*Does not match Alfalfa Table 1 totals because totals here do not include minor use AIs.

Alfalfa Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	Active Ingredient	Foliar Insecticide	Soil Insecticide*
1A	Carbaryl	0.462	--
28	Chlorantraniliprole	0.033	--
1B	Chlorpyrifos	0.520	--
15	Diflubenzuron	0.031	--
1B	Dimethoate	0.377	--
22A	Indoxacarb	0.061	--
1B	Malathion	0.982	--
1A	Methomyl	0.401	--
18A	Methoxyfenozide	0.073	--
1B	Methyl Parathion	0.300	--
4A	Thiamethoxam	0.028	--

*No soil-applied insecticides registered for use on alfalfa.

Alfalfa Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	Active Ingredient	2012-2014 Average	Added	New Total	Change
1A	Carbaryl	5,918	14,484	20,402	245%
28	Chlorantraniliprole	3,104	3,593	6,698	116%
1B	Chlorpyrifos	678,959	831,541	1,510,501	122%
15	Diflubenzuron	65	633	698	969%
1B	Dimethoate	85,332	76,774	162,106	90.0%
22A	Indoxacarb	15,344	12,020	27,365	78.3%
1B	Malathion	154,748	162,990	317,738	105%
1A	Methomyl	30,865	22,010	52,874	71.3%
18A	Methoxyfenozide	2,639	4,436	7,075	168%
1B	Methyl Parathion	14,760	9,108	23,868	61.7%
4A	Thiamethoxam	153	321	475	210%
	Total	**991,888**	**1,137,911**	**2,129,799**	**115%**

		Pounds of Active Ingredient Applied			
MOA	Insecticide Class	2012-2014 Average	Added	New Total	Change
15	Benzoylureas	65	633	698	969%
28	Diamides	3,104	3,593	6,698	116%
18B	Azadirachtin	2,639	4,436	7,075	168%
1A	Carbamates	36,783	36,493	73,276	99.2%
1B	Organophosphates	933,799	1,080,413	2,014,212	116%
22A	Oxadiaines	15,344	12,020	27,365	78.3%
4A	Neonicotinoids	153	321	475	210%
	Total Non-Pyrethroids	**991,888**	**1,137,911**	**2,129,799**	**115%**
3A	**Pyrethroids**	**78,855**	**-78,855**	**0**	**-100%**
	Total	**1,070,743**	**1,059,056**	**2,129,799**	**99%**

Alfalfa Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied*
Carbaryl	$7.21	--
Chlorantraniliprole	$15.03	--
Chlorpyrifos	$5.65	--
Diflubenzuron	$4.06	--
Dimethoate	$5.42	--
Indoxacarb	$12.52	--
Malathion	$6.40	--
Methomyl	$8.66	--
Methoxyfenozide	$9.26	--
Methyl Parathion	$4.94	--
Thiamethoxam	$3.50	--
Non-Pyrethroid Average**	$6.79	--
Pyrethroid Average**	$4.35	--
		--
Application Costs	**$7.46**	**--**

*No soil-applied insecticides registered for use on alfalfa.
**Average weighted by treated acres.

Alfalfa Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	--------- Foliar-Based ---------			----------- Soil-Based* -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Carbaryl	31,359	$7.21	$226,142	--	--	--
Chlorantraniliprole	110,353	$15.03	$1,658,321	--	--	--
Chlorpyrifos	1,597,612	$5.65	$9,030,261	--	--	--
Diflubenzuron	20,303	$4.06	$82,348	--	--	--
Dimethoate	203,466	$5.42	$1,101,943	--	--	--
Indoxacarb	196,671	$12.52	$2,462,774	--	--	--
Malathion	166,041	$6.40	$1,063,445	--	--	--
Methomyl	54,913	$8.66	$475,776	--	--	--
Methoxyfenozide	61,060	$9.26	$565,112	--	--	--
Methyl Parathion	30,359	$4.94	$149,935	--	--	--
Thiamethoxam	11,644	$3.50	$40,783	--	--	--
Total AI Cost	2,483,779	$6.79	$16,856,839	--	--	--
				--	--	--
Application Cost	2,483,779	$7.46	$18,528,992	--	--	--

*No soil-applied insecticides registered for use on alfalfa.

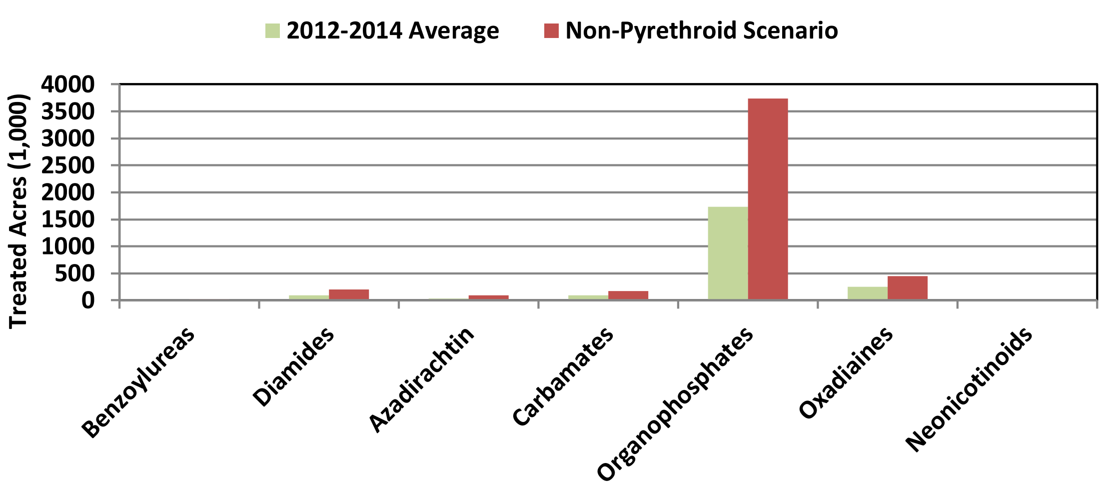
Alfalfa Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$12,933,731	$16,856,839	$3,923,108
Foliar Application Costs	$22,176,404	$18,528,992	-$3,647,412
Soil AI Costs*			
Soil Application Costs*			
Total Costs	**$35,110,135**	**$35,385,831**	**$275,696**

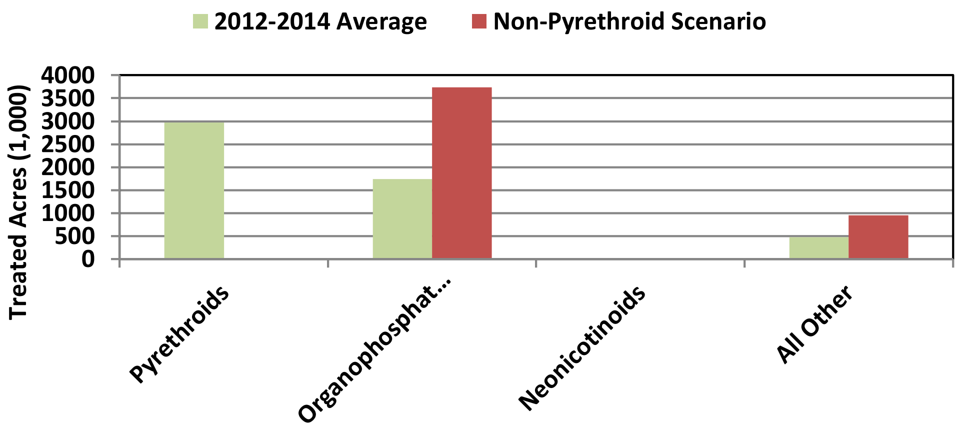
Net Change in Grower Expenditures ($/A)	**Acres**	**$/Acre**
Pyrethroid Treated Acres	2,972,708	$0.09
Harvested Acres	20,547,000	$0.01

*No soil-applied insecticides registered for use on alfalfa.

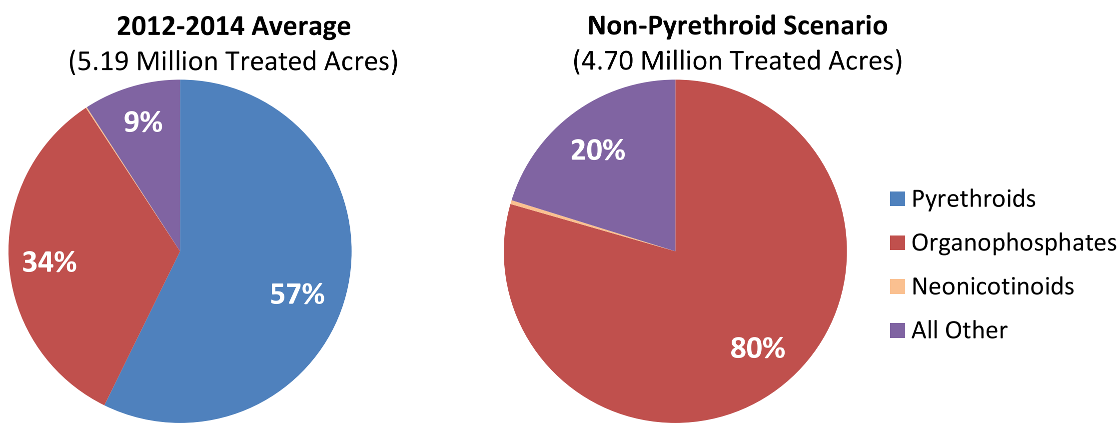
Alfalfa Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Alfalfa Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Alfalfa Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Alfalfa Table 8).



5.2 Citrus

Citrus Table 1 shows only data for foliar-applied insecticides, as soil-applied insecticides are not registered for use in the crop. As result, several tables have empty sections. In Citrus Table 1, insecticide treated acres total more than 6 million, of which 1 million are pyrethroids. Citrus Table 4 reports the target pests for these pyrethroid applications based on the 2012-2014 average, showing that psyllids were by far the most common target, capturing a 73% share. Other minor but important target pests included mites, leafminers, and orthopteran pests (grasshoppers and crickets), and thrips. Citrus Table 3 shows the wide range of non-pyrethroid AIs used to manage these pests. Across many pests, abamectin has relatively large shares, about a third of treated acres for leafminers and mites and 15%-20% for pysillids and thrips. Imidacloprid and thiamethoxam also have larger treated acre shares for managing psyllids and leafminers. Petroleum oil also has larger treated acre shares across many pests: almost a third for mit4s and more than 10% for leafminers, psyllids and thrips. Finally specific AIs have large treated shares for specific pests, most notably spinetoram has almost a 50% share for thrips, while chlorantraniliprole, cryolite and chlorpyrifos have large shares for orthopteran pests.

Based on these shares and the target pest information, the non-pyrethroid scenario re-allocates the 1 million pyrethroid treated acres to non-pyrethroid alternatives. Citrus Table 6 lists 20 non-pyrethroid AIs and the new treated acre projected for the non-pyrethroid scenario by target pests. Abamectin has the largest total projected treated acres added at more than 200,000, with petroleum oil projected to add not quite 150,000 new treated acres, with psyllids the most common target. In addition, imidacloprid adds an estimated 126,000 treated acres and thiamethoxam almost 87,000, while spintoram adds an estimated 70,000 new treated acres.

Citrus Table 8 reports the 2012-2014 average treated acres and the new treated acres added for the non-pyrethroid scenario to estimate the new totals and percentage changes, plus aggregates results by insecticide class. For the non-pyrethroid scenario, 1 million pyrethroid treated acres are replaced with 1 million non-pyrethroid AIs. As previously noted, AIs such as abamectin, petroleum oil, imidacloprid, thiamethoxam and spinetoram added the most new treated acres, so that abamectin and petroleum oil have a total treated acres projected to exceed 1 million each. However, percentage changes for these AIs commonly used in citrus are in the range of 15%-30%, so that overall, non-pyrethroid treated acres increased 23%. Examining these trends after aggregated to insecticide class shows that the largest projected increase in treated acres is for neonicotinoids with 213,000, then avermetcins with 210,000. The other large projected increases are for organophosphates and spinosyns, both of which have multiple AIs in Citrus Table 8. Based on the average application rates in Citrus Table 9, Citrus Table 10 reports these same results for the non-pyrethroid scenario, but in terms of pounds of AI applied. Because application rates vary greatly, by far the largest increase is for petroleum oil, which has a projected increase of almost 3.5 million pounds of AI, which is less than a 17% increase from the 2012-2014 average. Other large increases are for cryolite and sulfur, both AIs with relatively large application rates. On average across all AIs, the projected total increase in pounds applied is almost 16% for the non-pyrethroid scenario. When examined by insecticide class, after the “other” class that includes petroleum oil, the largest increase is for organophosphates, for which pounds applied increase an estimated 223,000 or 27%.

Citrus Figures 1 to 3 report these results graphically. Citrus Figure 1 shows the range of insecticide classes used and the relative importance of each non-pyrethroid class. Again the neonicotinoids, avermectins, organophosphates, and spinosyns are important classes, as is the “other” class dominated by petroleum oil. This diversity in the AIs used is important for managing insect resistance. Citrus Figure 2 focuses on the major insecticide classes (pyrethroids, organophosphates, neonicotinoids), but because of the diverse range of AIs used in citrus, the “other” category dominates. Citrus Figure 3 focuses on the treated acre shares of the major insecticide classes. The 20102-2014 averages show that pyrethroid constituted 19% of the total insecticide treated acres, and so eliminating this share for the non-pyrethroid scenario has more modest effects than seen for other crops with greater dependence on pyrethroids. The projected share for neonicotinoids increases from 13% to 17%, while the share for organophosphates increase from 11% to 14%,; the projected shares for all other insecticide classes shows the largest increase in share size, from 57% to 69%.

Citrus Table 12 combines the added treated acres and the average cost of each AI to estimate the total cost to replacing pyrethroids with non-pyrethroid AIs for the non-pyrethroid scenario. The overall cost for the replacement AIs is $19.4 million. The largest single AI in terms of added costs is $2.7 million for spirotetramat which appears because, even though few treated acres were added, the average cost per application for the AI is more than $51 per acre. Abamectin is next at $2.6 million in total costs, then spinetoram also with $2.6 million in added costs, largely due to its relatively large per acre cost for the AI. Other AIs with large added costs include petroleum oil, imidacloprid, thiamethoxam, and chlorpyrifos. Another AI that appears with almost $1.5 million in costs is diflubenzuron, which would add a modest number of treated acres, but has a relatively large per acre costs for the AI. Finally, the added application costs for these non-pyrethroid AIs would be an estimated $7.5 million.

Citrus Table 13 combines these cost estimates with the estimated costs for buying and applying pyrethroids to estimate the net cost impact of the non-pyrethroid scenario. The 2012-2014 average is $16.7 million in estimated cost to purchase the pyrethroid AIs and make foliar applications, and $27.0 million for the non-pyrethroid scenario, implying a net cost increase of $10.2 million. Since the total insect treated acres do not differ between the 2012-2014 baseline and the non-pyrethroid scenario, the cost impact is purely due to estimated change in the cost of replacement AIs. The average cost of pyrethroid AIs is $9.06 per treated acre, but $19.22 per treated acre for the non-pyrethroid scenario, which is an increase of 112% in the cost for AIs to manage citrus insects. Thus grower costs increase by $10.16 per treated acre for the non-pyrethroid scenario. Citrus insecticide treated acres exceed harvested acres because on average growers make more than one insecticide application per year. As result, the average cost increase for the non-pyrethroid scenario is $13.19 per harvested acre.

Citrus Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	**Soil***	**Total**
Pyrethroids	1,010,250	---	1,010,250
Non-Pyrethroids	5,024,926	---	5,024,926
All AIs	6,035,176	---	6,035,176

*No soil-applied insecticides registered for use on citrus.

Citrus Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		**Soil-Based Systems***	
	All AIs	**Pyrethroids**	**All AIs**	**Pyrethroids**
Initial Treated Acres	6,035,176	1,010,250	---	---
No Answer	0.5%	0.3%	---	---
Targeted at Specific Pests	99.5%	99.7%	---	---

*No soil-applied insecticides registered for use on citrus.

Citrus Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based systems*

	----------------------- Foliar-Based Systems -----------------------				
Active Ingredient	**Leafminers**	**Mites**	**Orthopterans**	**Psyllids**	**Thrips**
Abamectin	34.9%	32.5%	0.0%	19.6%	16.3%
Acetamiprid	0.0%	0.0%	3.9%	0.0%	0.3%
Azadirachtin	7.2%	0.0%	0.0%	4.1%	0.5%
Carbaryl	0.0%	0.4%	0.0%	1.5%	0.0%
Chlorantraniliprole	0.4%	0.0%	36.6%	0.0%	0.0%
Chlorpyrifos	1.5%	0.0%	16.6%	6.0%	1.3%
Cryolite	0.0%	0.0%	19.6%	0.0%	0.0%
Diflubenzuron	4.5%	5.4%	7.9%	3.6%	0.1%
Dimethoate	0.0%	0.3%	0.0%	7.8%	2.3%
Formetanate	0.0%	0.0%	0.0%	0.0%	2.9%
Imidacloprid	13.9%	0.0%	0.0%	15.5%	3.4%
Malathion	0.0%	0.0%	0.0%	7.0%	1.8%
Methoxyfenozide	5.1%	0.0%	0.0%	0.0%	0.0%
Petroleum Oil	10.2%	31.3%	4.3%	13.5%	11.0%
Spinetoram	8.2%	0.0%	10.9%	5.3%	47.1%
Spinosyn	0.0%	0.0%	0.2%	0.0%	9.5%
Spirodiclofen	0.0%	8.6%	0.0%	0.0%	0.0%
Spirotetramat	1.9%	7.2%	0.0%	5.7%	2.7%
Sulfur	0.0%	14.3%	0.0%	0.0%	0.0%
Thiamethoxam	12.1%	0.0%	0.0%	10.5%	0.8%

*No soil-applied insecticides registered for use on citrus.

Citrus Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	**Foliar-Based**	**Soil-Based***
Leafminers	7.4%	---
Mites	9.8%	---
Orthopterans	5.6%	---
Psyllids	73.3%	---
Thrips	3.9%	---

*No soil-applied insecticides registered for use on citrus.

Citrus Table 5. Average number of applications for each AI and ratios of these averages.

Active Ingredient	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
	Foliar-Based**	Soil-Based*	Foliar:Foliar	Soil:Soil*
Abamectin	1.000	---	1.000	---
Acetamiprid	1.000	---	1.000	---
Azadirachtin	1.000	---	1.000	---
Carbaryl	1.000	---	1.000	---
Chlorantraniliprole	1.000	---	1.000	---
Chlorpyrifos	1.000	---	1.000	---
Cryolite	1.000	---	1.000	---
Diflubenzuron	1.000	---	1.000	---
Dimethoate	1.000	---	1.000	---
Formetanate	1.000	---	1.000	---
Imidacloprid	1.000	---	1.000	---
Malathion	1.000	---	1.000	---
Methoxyfenozide	1.000	---	1.000	---
Petroleum Oil	1.000	---	1.000	---
Spinetoram	1.000	---	1.000	---
Spinosyn	1.000	---	1.000	---
Spirodiclofen	1.000	---	1.000	---
Spirotetramat	1.000	---	1.000	---
Sulfur	1.000	---	1.000	---
Thiamethoxam	1.000	---	1.000	---
Pyrethroids	1.000	---	---	---

*No soil-applied insecticides registered for use on citrus.

**Ratio of treated acres to treated acres used, not base acres to treated acres.

Citrus Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Leaf-miners	Mites	Ortho-pterans	Psyllids	Thrips	Total	AI Weights
Abamectin	26,097	32,294	0	144,767	6,383	209,541	20.7%
Acetamiprid	0	0	2,211	0	130	2,342	0.2%
Azadirachtin	5,414	0	0	30,128	184	35,726	3.5%
Carbaryl	0	446	0	10,763	0	11,209	1.1%
Chlorantraniliprole	311	0	20,734	0	0	21,045	2.1%
Chlorpyrifos	1,127	0	9,424	44,546	521	55,619	5.5%
Cryolite	0	5	11,124	0	0	11,128	1.1%
Diflubenzuron	3,344	5,357	4,447	26,689	36	39,874	3.9%
Dimethoate	0	294	0	57,934	899	59,128	5.9%
Formetanate	0	36	0	285	1,155	1,475	0.1%
Imidacloprid	10,366	0	0	114,407	1,338	126,111	12.5%
Malathion	0	0	0	51,613	698	52,311	5.2%
Methoxyfenozide	3,843	0	0	0	0	3,843	0.4%
Petroleum Oil	7,635	31,117	2,411	99,741	4,333	145,237	14.4%
Spinetoram	6,116	0	6,156	39,488	18,462	70,222	7.0%
Spinosyn	0	0	133	0	3,714	3,847	0.4%
Spirodiclofen	0	8,564	0	0	0	8,564	0.8%
Spirotetramat	1,424	7,141	0	42,311	1,059	51,935	5.1%
Sulfur	0	14,210	0	0	0	14,210	1.4%
Thiamethoxam	9,001	0	0	77,569	313	86,883	8.6%
Total	**74,678**	**99,463**	**56,640**	**740,241**	**39,227**	**1,010,250**	**100%**

Citrus Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Table not needed since no soil-applied insecticides registered for use in citrus.

Citrus Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
6	Abamectin	819,405	209,541	1,028,946	25.6%
1B	Acetamiprid	126	2,342	2,468	1858%
18B	Azadirachtin	23,231	35,726	58,957	154%
1A	Carbaryl	38,929	11,209	50,138	28.8%
28	Chlorantraniliprole	48,919	21,045	69,964	43.0%
1B	Chlorpyrifos	221,468	55,619	277,087	25.1%
8C	Cryolite	19,859	11,128	30,988	56.0%
15	Diflubenzuron	136,776	39,874	176,650	29.2%
1B	Dimethoate	199,975	59,128	259,103	29.6%
1A	Formetanate	9,937	1,475	11,412	14.8%
4A	Imidacloprid	415,451	126,111	541,562	30.4%
1B	Malathion	167,235	52,311	219,546	31.3%
18A	Methoxyfenozide	85,659	3,843	89,502	4.5%
--	Petroleum Oil	867,468	145,237	1,012,706	16.7%
5	Spinetoram	287,781	70,222	358,003	24.4%
5	Spinosyn	33,370	3,847	37,217	11.5%
23	Spirodiclofen	167,838	8,564	176,402	5.1%
5	Spirotetramat	236,428	51,935	288,363	22.0%
--	Sulfur	323,107	14,210	337,317	4.4%
4A	Thiamethoxam	304,816	86,883	391,699	28.5%
	Total	**4,407,778**	**1,010,250**	**5,418,028**	**22.9%**

		------------- Treated Acres -------------			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
5	Spinosyns	557,579	126,004	683,583	22.6%
6	Avermectins	819,405	209,541	1,028,946	25.6%
15	Benzoylureas	136,776	39,874	176,650	29.2%
23	Tetronic acid derivatives	167,838	8,564	176,402	5.1%
28	Flubendiamide	48,919	21,045	69,964	43.0%
18A	Diacylhydrazines	85,659	3,843	89,502	4.5%
18B	Azadirachtin	23,231	35,726	58,957	154%
1A	Carbamates	48,866	12,684	61,550	26.0%
1B	Organophosphates	588,803	169,399	758,203	28.8%
4A	Neonicotinoids	720,267	212,994	933,261	29.6%
8C	Cryolite	19,859	11,128	30,988	56.0%
--	Other	1,190,576	159,447	1,350,022	13.4%
	Total Non-Pyrethroids*	**4,407,778**	**1,010,250**	**5,418,028**	**22.9%**
	Total Pyrethroids	**1,010,250**	**-1,010,250**	**0**	**-100%**
	Total Treated with These AIs*	**5,418,028**	**0**	**5,418,028**	**0.0%**

*Does not match Citrus Table 1 totals because totals here do not include minor use AIs.

Citrus Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	**Active Ingredient**	**Foliar Insecticide**	**Soil Insecticide***
6	Abamectin	0.014	---
1B	Acetamiprid	0.154	---
18B	Azadirachtin	0.006	---
1A	Carbaryl	2.065	---
28	Chlorantraniliprole	0.076	---
1B	Chlorpyrifos	2.158	---
8C	Cryolite	16.217	---
15	Diflubenzuron	0.277	---
1B	Dimethoate	0.644	---
1A	Formetanate	1.074	---
4A	Imidacloprid	0.262	---
1B	Malathion	1.214	---
18A	Methoxyfenozide	0.148	---
--	Petroleum Oil	23.873	---
5	Spinetoram	0.076	---
5	Spinosyn	0.126	---
23	Spirodiclofen	0.249	---
5	Spirotetramat	0.150	---
--	Sulfur	12.389	---
4A	Thiamethoxam	0.084	---

*No soil-applied insecticides registered for use on citrus.

Citrus Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
6	Abamectin	11,451	2,928	14,380	25.6%
1B	Acetamiprid	3,586	361	3,948	10.1%
18B	Azadirachtin	852	230	1,082	26.9%
1A	Carbaryl	80,392	23,147	103,539	28.8%
28	Chlorantraniliprole	3,731	1,605	5,336	43.0%
1B	Chlorpyrifos	477,976	120,038	598,014	25.1%
8C	Cryolite	322,066	180,474	502,540	56.0%
15	Diflubenzuron	37,835	11,030	48,865	29.2%
1B	Dimethoate	128,822	38,089	166,911	29.6%
1A	Formetanate	10,669	1,584	12,252	14.8%
4A	Imidacloprid	108,870	33,048	141,918	30.4%
1B	Malathion	203,002	63,499	266,501	31.3%
18A	Methoxyfenozide	12,712	570	13,282	4.5%
--	Petroleum Oil	20,709,304	3,467,286	24,176,590	16.7%
5	Spinetoram	21,873	5,337	27,210	24.4%
5	Spinosyn	4,193	483	4,676	11.5%
23	Spirodiclofen	41,845	2,135	43,980	5.1%
5	Spirotetramat	35,467	7,791	43,258	22.0%
--	Sulfur	4,003,059	176,047	4,179,106	4.4%
4A	Thiamethoxam	25,511	7,271	32,782	28.5%
	Total	**26,243,215**	**4,142,956**	**30,386,171**	**15.8%**

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MOA	Insecticide Class	Pounds of Active Ingredient Applied 2012-2014 Average	Added	New Total	Change
5	Spinosyns	61,533	13,612	75,145	22.1%
6	Avermectins	11,451	2,928	14,380	25.6%
15	Benzoylureas	37,835	11,030	48,865	29.2%
23	Tetronic acid derivatives	41,845	2,135	43,980	5.1%
28	Flubendiamide	3,731	1,605	5,336	43.0%
18A	Diacylhydrazines	12,712	570	13,282	4.5%
18B	Azadirachtin	852	230	1,082	26.9%
1A	Carbamates	91,060	24,731	115,791	27.2%
1B	Organophosphates	813,386	221,988	1,035,375	27.3%
4A	Neonicotinoids	134,381	40,319	174,700	30.0%
8C	Cryolite	322,066	180,474	502,540	56.0%
--	Other	24,712,363	3,643,333	28,355,696	14.7%
	Total Non-Pyrethroids	**26,243,215**	**4,142,956**	**30,386,171**	**15.8%**
3A	Pyrethroids	117,267	-117,267	0	-100%
	Total	**26,360,483**	**4,025,689**	**30,386,171**	**15.3%**

Citrus Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied*
Abamectin	$12.44	---
Acetamiprid	$40.44	---
Azadirachtin	$14.06	---
Carbaryl	$21.33	---
Chlorantraniliprole	$30.38	---
Chlorpyrifos	$19.96	---
Cryolite	$47.93	---
Diflubenzuron	$36.69	---
Dimethoate	$6.78	---
Formetanate	$44.32	---
Imidacloprid	$16.19	---
Malathion	$6.62	---
Methoxyfenozide	$16.22	---
Petroleum Oil	$16.22	---
Spinetoram	$36.42	---
Spinosyn	$43.07	---
Spirodiclofen	$27.66	---
Spirotetramat	$51.32	---
Sulfur	$11.47	---
Thiamethoxam	$13.39	---
Non-Pyrethroid Average**	**$19.22**	**---**
Pyrethroid Average**	**$9.06**	**---**
Application Costs	**$7.46**	**---**

*No soil-applied insecticides registered for use on citrus.
**Average weighted by treated acres.

Citrus Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	--------- Foliar-Based ---------			----------- Soil-Based* -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Abamectin	209,541	$12.44	$2,607,163	---	---	---
Acetamiprid	2,342	$40.44	$94,699	---	---	---
Azadirachtin	35,726	$14.06	$502,205	---	---	---
Carbaryl	11,209	$21.33	$239,117	---	---	---
Chlorantraniliprole	21,045	$30.38	$639,388	---	---	---
Chlorpyrifos	55,619	$19.96	$1,110,002	---	---	---
Cryolite	11,128	$47.93	$533,370	---	---	---
Diflubenzuron	39,874	$36.69	$1,462,783	---	---	---
Dimethoate	59,128	$6.78	$401,099	---	---	---
Formetanate	1,475	$44.32	$65,374	---	---	---
Imidacloprid	126,111	$16.19	$2,041,308	---	---	---
Malathion	52,311	$6.62	$346,390	---	---	---
Methoxyfenozide	3,843	$16.22	$62,330	---	---	---
Petroleum Oil	145,237	$16.22	$2,355,501	---	---	---
Spinetoram	70,222	$36.42	$2,557,368	---	---	---
Spinosyn	3,847	$43.07	$165,698	---	---	---
Spirodiclofen	8,564	$27.66	$236,855	---	---	---
Spirotetramat	51,935	$51.32	$2,665,116	---	---	---
Sulfur	14,210	$11.47	$163,048	---	---	---
Thiamethoxam	86,883	$13.39	$1,163,297	---	---	---
Total AI Cost	**1,010,250**	**$19.22**	**$19,412,111**	---	---	---
Application Cost	**1,010,250**	**$7.46**	**$7,536,465**	---	---	---

*No soil-applied insecticides registered for use on citrus.

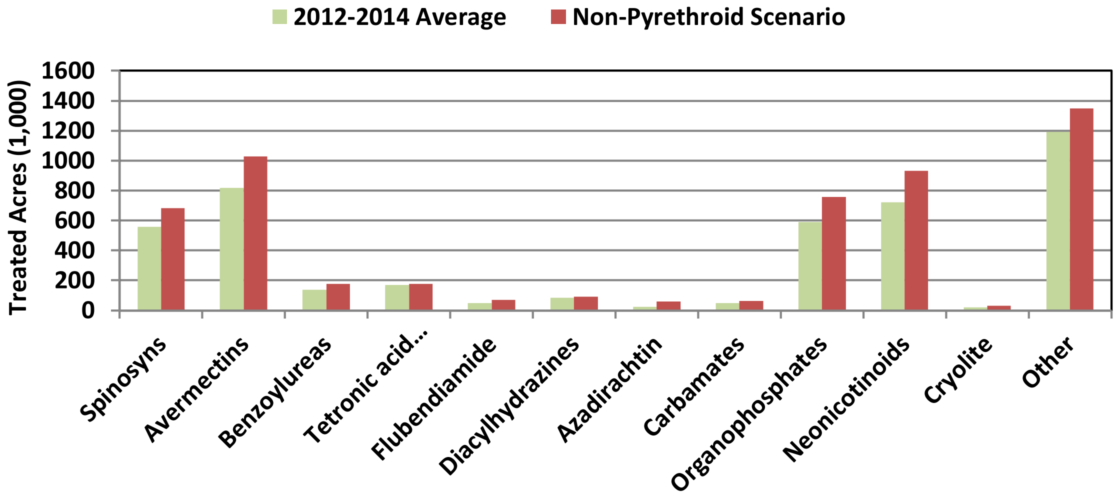
Citrus Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$9,152,618	$19,412,111	$10,259,493
Foliar Application Costs	$7,536,465	$7,536,465	$0
Soil AI Costs*			
Soil Application Costs*			
Total Costs	**$16,689,083**	**$26,948,576**	**$10,259,493**

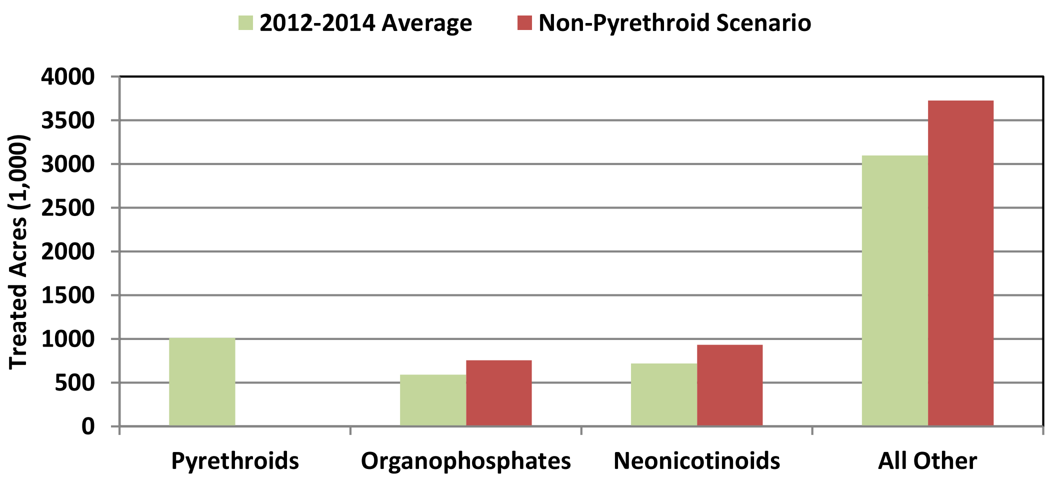
Net Change in Grower Expenditures ($/A)	**Acres**	**$/Acre**
Pyrethroid Treated Acres	1,010,250	$10.16
Harvested Acres	777,933	$13.19

*No soil-applied insecticides registered for use on citrus.

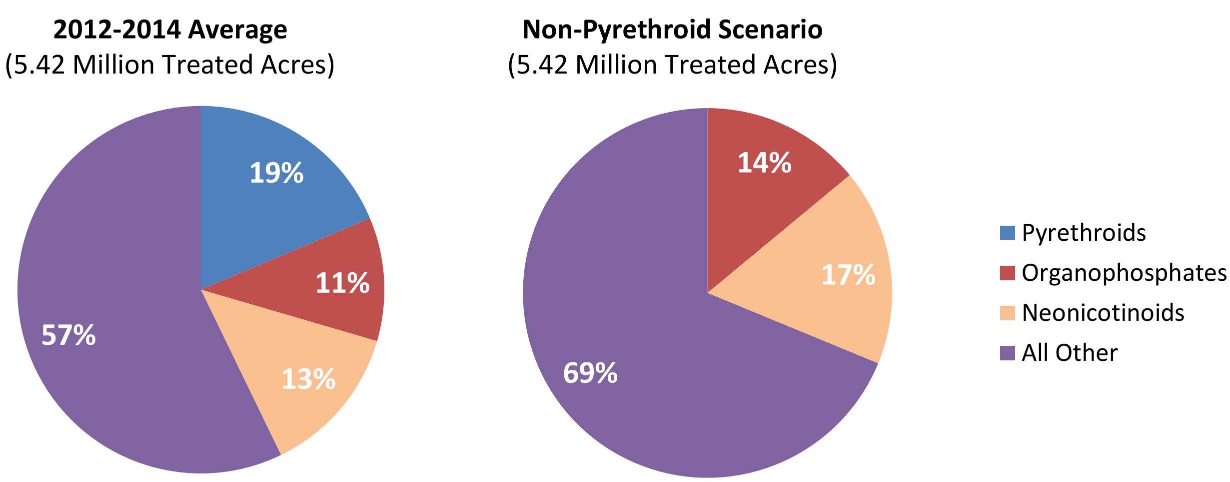
Citrus Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Citrus Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Citrus Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Citrus Table 8).



5.3 Corn

Corn Table 1 shows that insecticide use in corn is dominated by soil-applied insecticides. Of the 19.4 million insecticide treated acres (not including insecticidal seed treatments) in corn, 13.2 million are soil-applied, which is just over two-thirds of the total. Pyrethroids are a major component of insecticide treated acres in corn – of the 19.4 million insecticide treated acres in corn (both soil-applied and foliar-applied), 14.4 million treated acres, or almost three-fourths, are pyrethroids. These data indicate that pyrethroid insecticides are the most important class of insecticides used in corn, for both below-ground and above-ground pests. Corn Table 4 shows that for soil-applied pyrethroid insecticides, the primary insect targets were corn rootworm larvae and early-season lepidopteran pests, primarily cutworms; these targets accounted for 71% of the soil-applied pyrethroid treated acres. Other important target pests for soil-applied pyrethroids included wireworms, white grubs and seed corn maggots. For foliar-applied pyrethroids, target pests were dominated by lepidopteran pests, with mites, adult corn rootworm, and stink bugs also having significant shares, while aphids, flea beetles, and grasshoppers and other orthopteran pests as minor but important pests.

Corn Table 3 shows the most commonly used alternatives to pyrethroids for foliar-based and soil-based systems by target pest group. For most target pest groups, chlorpyrifos is the most common non-pyrethroid alternative AI used for foliar pests. The only exceptions are spiromesifen and propargite for mites and dimethote is used a nearly equivalent levels as chlorpyrifos to manage corn rootworm adults. In soil-based systems, tebupirimphos is the most common non-pyrethroid used for corn rootworm larvae, seed corn maggots, white grubs and wireworms, with chlorpyrifos the most common for lepidopteran pests. Corn Table 5 shows that the average number of applications is fairly similar for each AI, right around 1 for both soil and foliar applied. The results in corn tables 6 and 7 in report the projected new treated acres added for each AI by target pest group for foliar-based and soil-based systems for the non-pyrethroid scenario. Chlorpyrifos constitutes almost 56% of the new treated acres added to replace foliar-applied pyrethroids, while tebupirimphos and chlorpyrifos together constitute 81% of the new treated acres added to replace soil-applied pyrethroids for the non-pyrethroid scenario.

Corn Table 8 combines the results for foliar and soil applications to report the total treated acres for new AIs projected to replace pyrethroids for the non-pyrethroid scenario. As expected, the projected increase in chlorpyrifos is quite large, more than 5.5 million new treated acres, which is a 712% increase from the 2012-2014 average. The other large increase is for tebuprimphos with almost 4.9 million new treated acres projected, which is a 283% increase from the 2012-2014 average. Across the other AIs, the only other one with a projected increase of more than a million treated acres is terbufos. The bottom portion of Corn Table 8 reports results by insecticide class and given the results as summarized so far, it is not surprising that organophosphates are the main replacement class for pyrethroids. The non-pyrethroid scenario projects that 14.3 million pyrethroid treated acres would be replaced by almost 13.0 million treated acres of organophosphates, with six other classes constituting the remaining 1 million treated acres. These results imply that organophosphate treated acres increase by almost five times their 2012-2014 average. Based on the average application rates in Corn Table 9, Corn Table 10 projects changes in total pounds of AI applied. Results show a projected addition of almost 4.6 million more pounds of chlorpyrifos applied, a 719% increase from the 2012-2014 average. Overall, the projected increase in organophosphates is 7.2 million more pounds, with increase in other classes much smaller in terms of total pounds.

Corn Figures 1 and 2 graphically shows that organophosphates are the primary non-pyrethroid insecticide used in corn, with a large increase projected in organophosphate use for the non-pyrethroid scenario. Corn Figures 2 and 3 show the predominance of pyrethroid insecticide use in corn and the projected shift to organophosphates for the non-pyrethroid scenario. The average share of all other classes of insecticides was 9% of insecticide treated acres in 2012-2014, with a projected increase to a 14% share for the non-pyrethroid scenario.

Corn Table 12 combines results for treated acre changes and AI costs to estimate total costs for the AI and their application to replace pyrethroids for the non-pyrethroid scenario. As expected, most of the AI costs are for chlorpyrifos, with a cost increase of $11.1 million for foliar applications and $41.7 million for soil applications. However, because the per acre cost of chlorpyrifos is relatively small, several other AIs show substantial cost increases, even though treated acre increases were quite modest. The largest single cost increase by AI is for tebupirimphos, with a $78 million increase – though it added far fewer treated acres, its per acre cost was almost three times the cost of chlorpyrifos. Similarly, terbufos was the third largest cost increase at $24 million, with a per acre cost that was more than 3.5 times that of chlorpyrifos. Overall, the total cost increase for AIs to replace pyrethroids for the non-pyrethroid scenario was an estimated $30.7 million for foliar-applied insecticides and nearly $150 million for soil-applied insecticides. The estimated cost to make these applications was almost $27 million for foliar application costs and more than $32 million for soil application costs. In total, these costs would be almost $240 million.

Corn Table 13 combines all of these results to report the estimated net effect of the non-pyrethroid scenario on farmer costs. The non-pyrethroid scenario means that farmers would no longer pay the costs to buy and apply pyrethroids, which in total implies $137 million in avoided costs. This estimate includes $58 million in AI costs for soil-applied pyrethroids and $17 million for foliar applied pyrethroids, as well as $32 million in soil application costs and $28 million in foliar application costs. The new costs for the non-pyrethroid AIs and their application would be an estimated $240 million as reported in Corn Table 12. As a result, the estimated impact of the non-pyrethroid scenario would be a net cost increase of $103 million for farmers, largely from a $91 million net increase in farmer costs for soil-applied non-pyrethroid insecticides. On average, this would increase the cost per pyrethroid treated acre by $7.24, from $9.59 to $16.83, which is a 75% increase. Allocating this $103 million net cost increase across all corn planted acres gives an average increase of $1.09 per planted acre, which is much smaller since pyrethroids are used on so few corn acres relative to total planted acres.

In summary, of the 19.3 million insecticide treated acres in corn, 14.2 million are for pyrethroids, of which more than 70% are for soil-applied insecticides targeted primarily at corn rootworm larvae and early-season lepidopteran pests. The non-pyrethroid scenario projects that these 14.2 million pyrethroid treated acres would be replaced by 14.0 million treated acres of non-pyrethroid AIs, mostly organophosphates, primarily including chlorpyrifos, tebupirimphos and terbufos. This change in AIs and treated acres would result in a net cost increase of $103 million, or on average $7.24 per pyrethroid treated acre, or $1.09 per corn planted acre.

Corn Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	Soil	Total
Pyrethroids	3,817,481	10,419,753	14,237,234
Non-Pyrethroids	2,304,117	2,819,068	5,123,185
All AIs	**6,121,598**	**13,238,821**	**19,360,419**

Corn Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		Soil-Based Systems	
	All AIs	**Pyrethroids**	**All AIs**	**Pyrethroids**
Initial Treated Acres	6,121,598	3,817,481	13,238,821	10,419,753
No Answer	6.8%	7.8%	34.7%	5.4%
Targeted at Specific Pests	93.2%	252.8%	65.3%	94.6%

Corn Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based and soil-based systems

	-- Foliar-Based Systems --						
Active Ingredient	**Aphids**	**Corn Rootworm Adults**	**Flea Beetles**	**Lepidopterans**	**Mites**	**Orthopterans**	**Stink Bugs**
Carbaryl	0.0%	2.2%	0.0%	7.2%	0.0%	0.0%	0.0%
Chlorantraniliprole	0.0%	0.0%	0.0%	17.7%	0.0%	0.0%	0.0%
Chlorpyrifos	83.4%	51.5%	74.3%	52.0%	0.0%	79.3%	73.2%
Dimethoate	4.8%	45.6%	0.0%	0.0%	11.2%	20.7%	0.0%
Etoxazole	0.0%	0.0%	0.0%	0.0%	6.0%	0.0%	0.0%
Harpin Protein	0.0%	0.0%	0.0%	4.1%	0.0%	0.0%	0.0%
Hexythiazox	0.0%	0.0%	0.0%	0.0%	14.1%	0.0%	0.0%
Methomyl	0.0%	0.0%	22.2%	12.1%	0.0%	0.0%	0.0%
Methyl Parathion	0.0%	0.7%	3.5%	3.4%	0.0%	0.0%	26.8%
Propargite	0.0%	0.0%	0.0%	0.0%	38.8%	0.0%	0.0%
Spiromesifen	0.0%	0.0%	0.0%	0.0%	29.6%	0.0%	0.0%
Sulfur	11.8%	0.0%	0.0%	3.5%	0.2%	0.0%	0.0%

	------------------------------------ Soil-Based Systems --------------------------------				
Active Ingredient	**Corn Rootworm Larvae**	**Lepidopterans**	**Seed Corn Maggots**	**White Grubs**	**Wireworms**
Chlorethoxyfos	6.9%	10.3%	23.7%	2.9%	7.3%
Chlorpyrifos	13.0%	66.9%	27.8%	16.7%	21.1%
Tebupirimphos	72.8%	0.0%	41.4%	78.6%	54.5%
Terbufos	7.3%	22.8%	7.1%	1.8%	17.1%

Corn Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based and soil-based pest management systems.

Target Pest	Foliar-Based	Soil-Based
Aphids	3.7%	---
Corn Rootworm Larvae	---	40.9%
Corn Rootworm Adults	14.3%	---
Flea Beetles	5.8%	---
Lepidopterans	40.9%	29.9%
Mites	18.6%	---
Orthopterans	6.3%	---
Seed Corn Maggots	---	7.8%
Stink Bugs	10.4%	---
White Grubs	---	8.9%
Wireworms	---	12.5%

Corn Table 5. Average number of applications for each AI and ratios of these averages.

	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
Active Ingredient	Foliar-Based	Soil-Based	Foliar:Foliar	Soil:Soil
Carbaryl	1.000	---	1.000	---
Chlorantraniliprole	1.000	---	1.000	---
Chlorethoxyfos	---	1.000		0.995
Chlorpyrifos	1.086	1.000	1.086	0.995
Dimethoate	1.040	---	1.040	---
Etoxazole	1.000	---	1.000	---
Harpin Protein	1.000	---	1.000	---
Hexythiazox	1.000	---	1.000	---
Methomyl	1.000	---	1.000	---
Methyl Parathion	1.028	---	1.028	---
Propargite	1.035	---	1.035	---
Spiromesifen	1.002	---	1.002	---
Sulfur	1.000	---	1.000	---
Tebupirimphos	---	1.000	---	0.995
Terbufos	---	1.000	---	0.995
Pyrethroids	1.000	1.005	---	

Corn Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Corn Root-worm Adults	Flea Beetles	Lepidop-terans	Mites	Ortho-pterans	Stink Bugs	Total	AI Weights
Carbaryl	0	12,011	0	111,745	0	0	0	123,756	3.4%
Chlorantraniliprole	0	0	0	275,531	0	0	0	275,531	7.6%
Chlorpyrifos	127,751	306,305	179,873	880,186	0	208,149	314,998	2,017,262	55.8%
Dimethoate	7,042	259,260	0	0	82,476	51,928	0	400,707	11.1%
Etoxazole	0	0	0	0	42,783	0	0	42,783	1.2%
Harpin Protein	0	0	0	64,137	0	0	0	64,137	1.8%
Hexythiazox	0	0	0	0	100,168	0	0	100,168	2.8%
Methomyl	0	0	49,492	189,034	0	0	0	238,525	6.6%
Methyl Parathion	0	3,880	8,043	55,090	0	0	108,968	175,981	4.9%
Propargite	0	0	89,521	0	0	0	0	89,521	2.5%
Spiromesifen	0	0	66,200	0	0	0	0	66,200	1.8%
Sulfur	0	19,419	473	0	0	0	0	19,892	0.6%
Total	**134,793**	**600,876**	**393,601**	**1,575,722**	**225,427**	**260,077**	**423,966**	**3,614,464**	**100%**

Corn Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Active Ingredient	Corn Rootworm Larvae	Lepidop-terans	Seed Corn Maggots	White Grubs	Wireworms	Total	AI Weights
Chlorethoxyfos	295,146	138,698	190,165	26,412	94,761	745,182	7.2%
Chlorpyrifos	555,920	2,319,898	223,415	153,134	274,016	3,526,383	34.0%
Tebupirimphos	3,106,854	0	332,574	719,996	706,985	4,866,410	46.9%
Terbufos	310,375	624,999	57,428	16,764	221,510	1,231,076	11.9%
Total	**4,268,295**	**3,083,595**	**803,582**	**916,307**	**1,297,271**	**10,369,051**	100%

Corn Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
1A	Carbaryl	20,229	123,756	143,986	612%
28	Chlorantraniliprole	25,605	275,531	301,135	1076%
1B	Chlorethoxyfos	154,623	745,182	899,805	482%
1B	Chlorpyrifos	778,778	5,543,645	6,322,424	712%
1B	Dimethoate	274,610	400,707	675,317	146%
10B	Etoxazole	108,250	42,783	151,033	39.5%
---	Harpin Protein	6,647	64,137	70,784	965%
10A	Hexythiazox	291,541	100,168	391,709	34.4%
1A	Methomyl	27,123	238,525	265,648	879%
1B	Methyl Parathion	49,581	175,981	225,562	355%
12C	Propargite	535,576	89,521	625,097	16.7%
23	Spiromesifen	574,932	66,200	641,132	11.5%
---	Sulfur	9,644	19,892	29,536	206%
1B	Tebupirimphos	1,718,212	4,866,410	6,584,622	283%
1B	Terbufos	339,603	1,231,076	1,570,680	363%
	Total Non-Pyrethroids*	**4,914,955**	**13,983,516**	**18,898,470**	**285%**
	Total Pyrethroids	**14,237,234**	**-14,237,234**	**0**	**-100%**
	Total Treated with These AIs*	**19,152,188**	**-253,718**	**18,898,470**	**-1.3%**

		------------- Treated Acres -------------			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
1A	Carbamates	47,352	362,282	409,634	765%
1B	Organophosphates	3,315,408	12,963,002	16,278,410	391%
10A-B	Mite Growth Inhibitors	399,791	142,951	542,742	35.8%
12C	Propargite	535,576	89,521	625,097	16.7%
23	Tetronic acid derivatives	574,932	66,200	641,132	11.5%
28	Diamides	25,605	275,531	301,135	1076%
---	Other	16,291	84,029	100,320	516%
	Total Non-Pyrethroids*	**4,914,955**	**13,983,516**	**18,898,470**	**285%**
	Total Pyrethroids	**14,237,234**	**-14,237,234**	**0**	**-100%**
	Total Treated with These AIs*	**19,152,188**	**-253,718**	**18,898,470**	**-1.3%**

*Does not match Corn Table 1 totals because totals here do not include minor use AIs.

Corn Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	**Active Ingredient**	**Foliar Insecticide**	**Soil Insecticide**
1A	Carbaryl	0.990	---
28	Chlorantraniliprole	0.056	---
1B	Chlorethoxyfos	---	0.201
1B	Chlorpyrifos	0.501	1.012
1B	Dimethoate	0.416	---
10B	Etoxazole	0.089	---
---	Harpin Protein	0.000	---
10A	Hexythiazox	0.101	---
1A	Methomyl	0.350	---
1B	Methyl Parathion	0.291	---
12C	Propargite	2.117	---
23	Spiromesifen	0.119	---
---	Sulfur	4.785	---
1B	Tebupirimphos	---	0.131
1B	Terbufos	---	1.131

Corn Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
1A	Carbaryl	18,313	122,475	140,787	669%
28	Chlorantraniliprole	1,436	15,449	16,885	1076%
1B	Chlorethoxyfos	30,533	150,079	180,612	492%
1B	Chlorpyrifos	636,859	4,579,082	5,215,940	719%
1B	Dimethoate	114,215	166,661	280,875	146%
10B	Etoxazole	9,588	3,789	13,377	39.5%
	Harpin Protein	2	19	21	965%
10A	Hexythiazox	29,521	10,143	39,664	34.4%
1A	Methomyl	9,318	83,382	92,700	895%
1B	Methyl Parathion	14,418	51,175	65,593	355%
12C	Propargite	1,133,730	189,502	1,323,233	16.7%
23	Spiromesifen	68,194	7,852	76,046	11.5%
Unknown	Sulfur	46,142	95,179	141,321	206%
1B	Tebupirimphos	225,424	638,458	863,883	283%
1B	Terbufos	383,958	1,391,865	1,775,823	363%
	Total	**2,721,652**	**7,505,110**	**10,226,762**	**276%**

		Pounds of Active Ingredient Applied			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
1A	Carbamates	27,631	116,330	143,960	421%
1B	Organophosphates	1,405,407	7,231,573	8,636,980	515%
10A-B	Mite Growth Inhibitors	39,109	10,750	49,859	27.5%
12C	Propargite	1,133,730	465,148	1,598,878	41.0%
23	Tetronic acid derivatives	68,194	19,274	87,468	28.3%
28	Diamides	1,436	5,420	6,855	377%
Other	Other	46,144	95,198	141,342	206%
	Total Non-Pyrethroids	**2,721,652**	**7,943,692**	**10,665,343**	**292%**
3A	**Pyrethroids**	**611,259**	**-611,259**	**0**	**-100%**
	Total	**3,332,911**	**7,332,432**	**10,665,343**	**220%**

Corn Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied
Carbaryl	$10.82	---
Chlorantraniliprole	$20.11	---
Chlorethoxyfos	---	$8.32
Chlorpyrifos	$5.51	$11.82
Dimethoate	$6.46	---
Etoxazole	$28.72	---
Harpin Protein	$3.88	---
Hexythiazox	$26.68	---
Methomyl	$8.91	---
Methyl Parathion	$3.31	---
Propargite	$23.19	---
Spiromesifen	$16.22	---
Sulfur	$7.97	---
Tebupirimphos	---	$15.99
Terbufos	---	$19.50
Non-Pyrethroid Average*	**$8.51**	**$14.44**
Pyrethroid Average*	**$4.58**	**$5.59**
Application Costs	**$7.46**	**$3.11**

*Average weighted by treated acres.

Corn Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

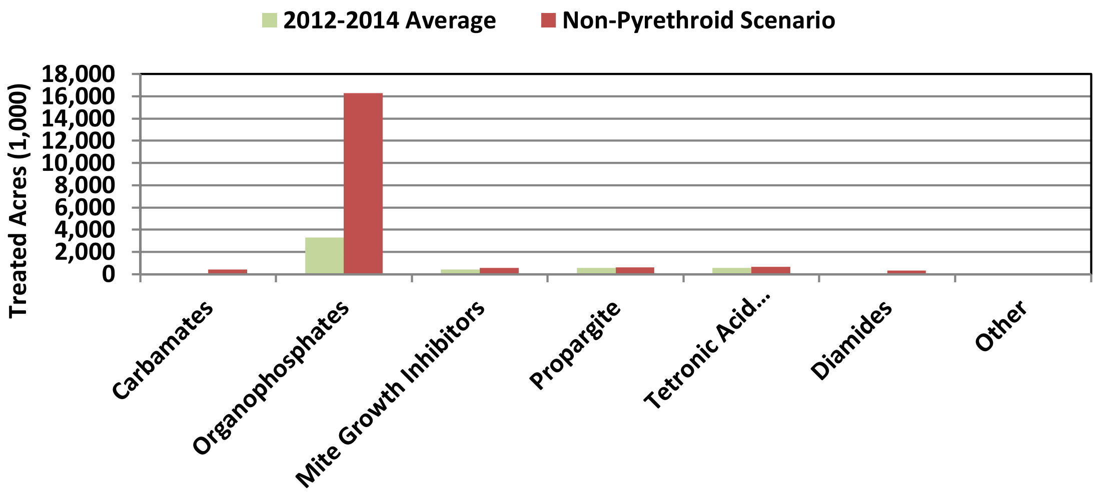
	--------- Foliar-Based ---------			----------- Soil-Based -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Carbaryl	123,756	$10.82	$1,338,689	---	---	---
Chlorantraniliprole	275,531	$20.11	$5,540,914	---	---	---
Chlorethoxyfos				745,182	$8.32	$6,201,901
Chlorpyrifos	2,017,262	$5.51	$11,110,337	3,526,383	$11.82	$41,669,036
Dimethoate	400,707	$6.46	$2,587,610	---	---	---
Etoxazole	42,783	$28.72	$1,228,657	---	---	---
Harpin Protein	64,137	$3.88	$248,941	---	---	---
Hexythiazox	100,168	$26.68	$2,672,668	---	---	---
Methomyl	238,525	$8.91	$2,126,015	---	---	---
Methyl Parathion	175,981	$3.31	$581,769	---	---	---
Propargite	89,521	$23.19	$2,075,815	---	---	---
Spiromesifen	66,200	$16.22	$1,073,750	---	---	---
Sulfur	19,892	$7.97	$158,631	---	---	---
Tebupirimphos	---	---	---	4,866,410	$15.99	$77,826,297
Terbufos	---	---	---	1,231,076	$19.50	$24,002,796
Total AI Cost	**3,614,464**	**$8.51**	**$30,743,796**	**10,369,051**	**$14.44**	**$149,700,030**
Application Cost	**3,614,464**	**$7.46**	**$26,963,903**	**10,369,051**	**$3.11**	**$32,247,750**

Corn Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

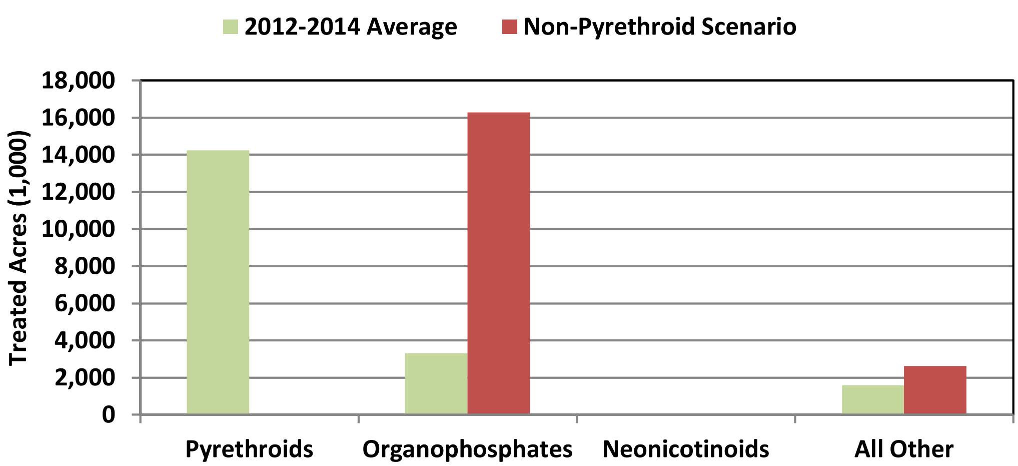
	Avoided Expenditures from 2012-2014 Average	New Expenditures for the Non-Pyrethroid Scenario	Net Change in Farmer Expenditures
Foliar AI Costs	$17,486,493	$30,743,796	$13,257,303
Foliar Application Costs	$28,478,406	$26,963,903	-$1,514,503
Soil AI Costs	$58,234,374	$149,700,030	$91,465,656
Soil Application Costs	$32,405,432	$32,247,750	-$157,682
Total Costs	$136,604,704	$239,655,479	$103,050,775

Net Change in Grower Expenditures ($/A)	Acres	$/Acre
Pyrethroid Treated Acres	14,237,234	$7.24
Planted Acres	94,418,000	$1.09

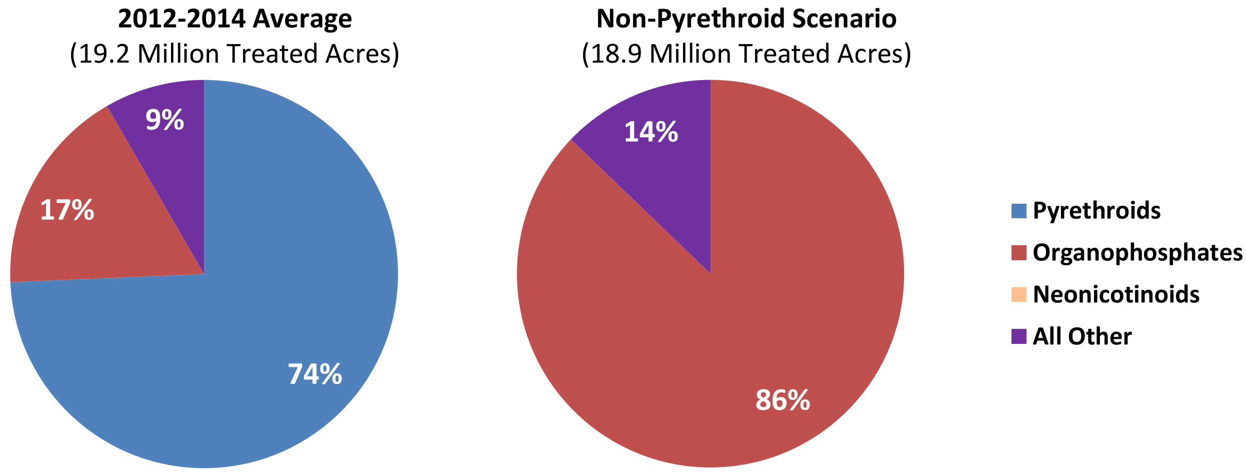
Corn Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Corn Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Corn Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Corn Table 8).



5.4 Potato

Potato Table 1 shows that most of the insecticide and pyrethroid treated acres for potato are foliar-applied rather than soil-applied. Of the 3.1 million total insecticide treated acres in potato, 2.5 million are foliar-applied or about 80%. This trend is even more pronounced for pyrethroids – of the total 718,000 pyrethroid treated acres in potato, 691,000 are foliar-applied, or about 96%. In addition, Potato Table 1 shows that pyrethroids are a relatively more important insecticide class in foliar systems than soil systems – pyrethroids constitute 28% of the foliar-applied insecticide treated acres, but 4% of soil-applied treated acres. Based on Potato Table4, the primary targets of foliar-applied pyrethroids are psyllids and aphids, with Colorado potato beetles and lepidopteran pests also important. In addition, minor but important target pests for foliar pyrethroid applications include leafhoppers, flea beetles, wireworms and plant bugs. The primary targets for soil-applied pyrethroids are wireworms, with other significant pests including Colorado potato beetles, aphids, orthopteran pests, and white grubs, with lepidopteran pests, mites and flea beetles minor but important targets.

Potato Table 3 reports the insecticide treated acre shares by target pest and AI. Some AIs are important for many pests, such as imidacloprid, while others such as dimethoate are only important for one target pest (leafhoppers). Overall, Potato Table 3 shows a relatively wide range of AIs are used for the wide range of pests managed in potato. However, examining the second part of Potato Table 3 shows fewer soil-applied AIs used and with more concentration on a few AIs for each pest, such as for white grubs or lepidopteran pests. However, imidacloprid and thiamethoxam are again important for managing many insect pests.

Potato Table 6 combines the AI shares and target pest information to project the added treated acres for each AI as foliar-applied replacements for pyrethroids for the non-pyrethroid scenario. Most of the AIs show small additions since only 690,000 non-pyrethroid treated acres are added; only imidacloprid, spirotetramat and abamectin project more than 100,000 new treated acres, with pymetrozine the next largest in terms of added treated acres with 68,000. Potato Table 7 reports the non-pyrethroid soil-applied insecticides projected to be replacements for pyrethroids for the no-pyrethroid scenario. Since only 22,000 treated acres are added, the AI shares indicate the main AIs added. Fipronil has the largest share of the new treated acres, then imidacloprid clothianidin and thiamethoxam; all other AIs have less than a 10% share.

Potato Table 8 aggregates these results across target pests and compares them to the 2012-2014 average to report percentage changes in treated acres for the non-pyrethroid scenario by AI and insecticide class, as well as combining soil- and foliar-applied. In total, 718,000 treated acres of pyrethroids are replaced by 712,000 treated acres of non-pyrethroids. The largest increases are for imidacloprid, spirotetramat and abamectin, each with more than 100,000 new treated acres added, then pymetrozine is next with 68,000 new treated acres added; all other AIs are projected to add less than 40,000 new treated acres. The total increase in non-pyrethroid treated acres projected for the non-pyrethroid scenario is 33%, with specific percentage changes across all AIs ranging from a low of 6% to 102% as the highest. The second part of Potato Table 8 aggregates these results to the insecticide class level. Of the 712,000 new treated acres projected, 204,000 are for neonicotinoids, then 130,000 for spinosyns, and 106,000 for avermectins. However, overall there are 15 insecticide classes projected to be used, a wide diversify effective for managing insecticide resistance.

Potato Table 10 uses the average application rates in Potato Table 9 to estimate the changes in total pounds of AIs applied for the non-pyrethroid scenario. Overall, almost 29,000 pounds of pyrethroids are replaced with almost 74,000 pounds of non-pyrethroids, so that the total pounds of insecticide AIs applied has a projected increase of 14.5%. The largest increase if for organophosphates, which add almost 20,000 pounds, mostly due to the relatively high average application rates used for this class. The next largest is almost 15,000 pounds for neonicotinoids, in that case more due to the relatively large increase in treated acres.

Potato Figure 1 illustrates graphically the wide range of non-pyrethroid insecticide classes used by potato growers – 15 different classes, with neonicotinoids having a noticeably larger number of treated acres among them. Potato Figure 2 focuses on the major insecticide classes used by potato growers and shows that pyrethroids are an important class used by potato growers, but that in terms of treated acres, the “all other” category is the largest and has the largest increase for the non-pyrethroid scenario. Potato Figure 3 shows the shares of treated acres by major insecticide class, with pyrethroids capturing a 25% treated acre share for the 2012-2014 average. For the non-pyrethroid scenario, organophosphates show a small increase, neonicotinoids show a modest increase, from a 27% share to a 34% share, with the largest increase for the “all other” category, from a 44% share to a 61% share.

Potato Table 12 combines the projected increase in treated acres and per acre average costs for each AI and applications to estimate the cost of replacing pyrethroids with non-pyrethroid alternatives. The estimated total cost for foliar-applied AIs is $11.6 million, with the largest cost component for a single AI of $3.7 million for spirotetramat, which occurs because not only does the AI add a large number of treated acres, but also has a relatively large per acre cost. The next largest AI cost components are $1.6 million for pymetrozine, $1.1 million for abamectin, and $692,000 for chlorantraniliprole. For soil-applied AIs the added cost is much smaller since so few treated acres are added for the non-pyrethroid scenario – the cost of these AIs is $392,000 in total, with $142,000 for fipronil. Application costs for the foliar-applied AIs are $5.1 million, but only $69,000 for the soil-applied AIs.

Potato Table 13 combines these cost estimates with the estimated costs avoided by no longer using pyrethroid insecticides to estimate the net impact of the non-pyrethroid scenario on grower costs for managing insect pests. The total cost for foliar and soil-applied pyrethroid AIs and their application is $8.1 million, while the total cost for the foliar and soil-applied non-pyrethroid AIs and their application to replace these pyrethroids is an estimated $17.2 million, for a net increase of $9.1 million. Almost all of the $9.1 million cost increase is due to the higher average cost of the foliar non-pyrethroid AIs to replace the pyrethroids –foliar pyrethroids cost less than $2.6 million in total for potato growers, while the foliar non-pyrethroid replacements cost $11.6 million. These results highlight one of the main benefits of pyrethroids for potato growers – a low cost AI to rotate with more expensive AIs to help manage insect resistance. This $9.1 million increase represents an average cost increase of $12.67 per pyrethroid treated acre, increasing the cost of insect management from $11.27 to $23.93 per pyrethroid treated acre, or 112%. When spread over all potato acres, this cost increase is on average $8.32 per planted acre.

Potato Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	**Soil**	**Total**
Pyrethroids	691,357	26,765	718,122
Non-Pyrethroids	1,769,257	595,646	2,364,903
All AIs	**2,460,614**	**622,411**	**3,083,025**

Potato Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		**Soil-Based Systems**	
	All AIs	**Pyrethroids**	**All AIs**	**Pyrethroids**
Initial Treated Acres	2,460,614	691,357	622,411	26,765
No Answer	4.6%	5.0%	6.6%	29.0%
Targeted at Specific Pests	95.4%	95.0%	93.4%	71.0%

Potato Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based and soil-based systems

	---------- Foliar-Based Systems ----------						
Active Ingredient	**Aphids**	**Colorado Potato Beetles**	**Flea Beetles**	**Leafhoppers**	**Lepidop-terans**	**Plant Bugs**	**Psyllids**
Abamectin	0.0%	6.1%	0.0%	0.0%	0.0%	0.0%	41.6%
Acetamiprid	0.7%	1.8%	6.5%	5.1%	0.0%	0.0%	0.0%
Azadirachtin	1.2%	1.7%	0.0%	0.0%	0.0%	0.0%	1.0%
Bacillus thurin.	0.0%	0.0%	0.0%	0.0%	12.1%	0.0%	0.0%
Carbaryl	0.0%	1.6%	13.8%	5.3%	0.1%	0.0%	0.0%
Chlorantraniliprole	0.0%	9.9%	0.0%	0.0%	41.5%	0.0%	0.0%
Clothianidin	1.7%	10.1%	17.4%	4.8%	0.0%	0.0%	0.0%
Cyromazine	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%
Dimethoate	4.7%	0.0%	0.0%	33.3%	0.0%	0.0%	0.0%
Dinotefuran	2.6%	5.8%	22.2%	8.6%	0.0%	0.0%	0.3%
Flonicamid	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Imidacloprid	22.5%	24.5%	17.5%	35.5%	0.0%	0.0%	8.3%
Indoxacarb	0.0%	0.0%	0.0%	0.0%	16.5%	0.0%	0.0%
Methomyl	0.0%	0.0%	0.0%	0.0%	5.6%	0.0%	0.2%
Novaluron	0.0%	10.9%	0.0%	0.0%	20.7%	0.0%	4.4%
Phosmet	0.8%	3.4%	0.0%	2.5%	0.0%	0.0%	0.0%
Pymetrozine	21.2%	0.0%	0.0%	0.0%	0.0%	0.0%	11.9%
Spinosyn	0.0%	13.4%	1.2%	0.0%	3.0%	0.0%	0.0%
Spiromesifen	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.7%
Spirotetramat	22.6%	0.0%	0.0%	0.0%	0.0%	0.0%	24.4%
Thiamethoxam	7.6%	9.7%	21.4%	4.9%	0.5%	100.0%	2.3%

	---------- Soil-Based Systems ----------					
Active Ingredient	**Aphids**	**Colorado Potato Beetles**	**Flea Beetles**	**Lepidop-terans**	**White Grubs**	**Wireworms**
Chlorantraniliprole	0.0%	0.0%	0.0%	71.5%	0.0%	0.0%
Clothianidin	1.6%	9.8%	20.6%	0.0%	100.0%	2.8%
Ethoprophos	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%
Fipronil	0.0%	0.0%	0.0%	0.0%	0.0%	70.9%
Imidacloprid	61.7%	56.1%	25.4%	0.0%	0.0%	14.1%
Phorate	1.9%	0.2%	3.2%	0.0%	0.0%	8.1%
Thiamethoxam	34.9%	33.9%	50.9%	28.5%	0.0%	1.6%

Potato Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based
Aphids	28.1%	10.8%
Colorado Potato Beetles	16.9%	14.7%
Flea Beetles	2.2%	1.5%
Leafhoppers	7.7%	---
Lepidopterans	12.3%	4.8%
Mites	---	3.3%
Orthopterans	---	10.8%
Plant Bugs	0.8%	---
Psyllids	30.8%	---
White Grubs	---	10.0%
Wireworms	1.3%	43.9%

Potato Table 5. Average number of applications for each AI and ratios of these averages.

Active Ingredient	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
	Foliar-Based	Soil-Based	Foliar:Foliar	Soil:Soil
Abamectin	1.611	---	1.106	---
Acetamiprid	1.242	---	0.853	---
Azadirachtin	2.147	---	1.474	---
Bacillus thuringeniensis	1.716	---	1.178	---
Carbaryl	1.185	---	0.813	---
Chlorantraniliprole	1.112	1.000	0.763	0.961
Clothianidin	1.319	1.000	0.906	0.961
Cyromazine	1.556	---	1.069	---
Dimethoate	1.782	---	1.224	---
Dinotefuran	1.655	---	1.136	---
Ethoprophos	---	1.000	---	0.961
Fipronil	---	1.000	---	0.961
Flonicamid	1.100	---	0.755	---
Imidacloprid	1.476	1.011	1.013	0.971
Indoxacarb	1.789	---	1.228	---
Methomyl	1.210	---	0.830	---
Novaluron	1.331	---	0.913	---
Phorate	---	1.000	---	0.961
Phosmet	1.346	---	0.924	---
Pymetrozine	1.481	---	1.017	---
Spinosyn	1.521	---	1.044	---
Spiromesifen	1.424	---	0.978	---
Spirotetramat	1.692	---	1.162	---
Thiamethoxam	1.084	1.000	0.744	0.961
Pyrethroids	1.457	1.041	---	---

Potato Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Colorado Potato Beetles	Flea Beetles	Leaf-hoppers	Lepidop-terans	Plant Bugs	Psyllids	Total	AI Weights
Abamectin	0	7,913	0	0	0	0	98,075	105,988	15.4%
Acetamiprid	1,148	1,823	840	2,305	0	0	0	6,116	0.9%
Azadirachtin	3,421	2,920	0	0	0	0	3,000	9,341	1.4%
Bacillus thurin.	0	0	0	0	12,080	0	0	12,080	1.8%
Carbaryl	0	1,517	1,693	2,305	73	0	0	5,588	0.8%
Chlorantraniliprole	0	8,825	0	0	26,872	0	0	35,696	5.2%
Clothianidin	2,991	10,685	2,368	2,299	0	0	0	18,344	2.7%
Cyromazine	0	1,102	0	0	0	0	0	1,102	0.2%
Dimethoate	11,239	0	0	21,692	0	0	0	32,931	4.8%
Dinotefuran	5,760	7,745	3,791	5,193	0	0	783	23,272	3.4%
Flonicamid	21,010	0	0	0	0	0	0	21,010	3.0%
Imidacloprid	44,165	29,022	2,670	19,106	0	0	17,921	112,885	16.4%
Indoxacarb	0	0	0	0	17,156	0	0	17,156	2.5%
Methomyl	27	0	0	0	3,964	0	379	4,371	0.6%
Novaluron	0	11,659	0	0	16,065	0	8,540	36,263	5.3%
Phosmet	1,358	3,694	0	1,243	0	0	0	6,294	0.9%
Pymetrozine	41,861	0	0	0	0	0	25,742	67,603	9.8%
Spinosyn	0	16,343	183	0	2,619	0	0	19,145	2.8%
Spiromesifen	0	0	0	0	0	0	11,946	11,946	1.7%
Spirotetramat	51,030	0	0	0	0	0	60,347	111,377	16.1%
Thiamethoxam	10,979	8,446	2,402	1,943	291	3,975	3,597	31,633	4.6%
Total	**194,991**	**111,693**	**13,948**	**56,087**	**79,120**	**3,975**	**230,328**	**690,142**	**100%**

Potato Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Active Ingredient	Aphids	Colorado Potato Beetles	Flea Beetles	Lepidopterans	White Grubs	Wireworms	Total	AI Weights
Chlorantraniliprole	0	0	0	883	0	0	883	4.0%
Clothianidin	43	372	79	0	2,579	320	3,393	15.3%
Ethoprophos	0	0	0	0	0	287	287	1.3%
Fipronil	0	0	0	0	0	8,008	8,008	36.2%
Imidacloprid	1,738	2,150	99	0	0	1,609	5,595	25.3%
Phorate	52	8	12	0	0	919	991	4.5%
Thiamethoxam	972	1,285	196	352	0	177	2,980	13.5%
Total	**2,804**	**3,814**	**386**	**1,235**	**2,579**	**11,319**	**22,137**	**100%**

Potato Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
6	Abamectin	286,449	105,988	392,437	37.0%
4A	Acetamiprid	9,194	6,116	15,310	66.5%
18B	Azadirachtin	16,533	9,341	25,874	56.5%
11A	Bacillus thuringeniensis	17,680	12,080	29,760	68.3%
1A	Carbaryl	18,122	5,588	23,710	30.8%
28	Chlorantraniliprole	99,878	36,579	136,457	36.6%
4A	Clothianidin	74,090	21,737	95,827	29.3%
17	Cyromazine	2,964	1,102	4,066	37.2%
1B	Dimethoate	72,452	32,931	105,383	45.5%
4A	Dinotefuran	22,763	23,272	46,034	102.2%
1B	Ethoprophos	2,837	287	3,124	10.1%
2B	Fipronil	78,714	8,008	86,722	10.2%
29	Flonicamid	88,323	21,010	109,333	23.8%
4A	Imidacloprid	499,311	118,480	617,791	23.7%
22A	Indoxacarb	24,198	17,156	41,355	70.9%
1A	Methomyl	13,253	4,371	17,624	33.0%
15	Novaluron	141,746	36,263	178,009	25.6%
1B	Phorate	17,841	991	18,832	5.6%
1B	Phosmet	11,493	6,294	17,787	54.8%
9B	Pymetrozine	120,578	67,603	188,180	56.1%
5	Spinosyn	77,107	19,145	96,252	24.8%
23	Spiromesifen	85,504	11,946	97,450	14.0%
5	Spirotetramat	219,141	111,377	330,518	50.8%
4A	Thiamethoxam	184,794	34,614	219,408	18.7%
	Total Non-Pyrethroids*	**2,184,964**	**712,280**	**2,897,244**	**32.6%**
	Total Pyrethroids	718,122	-718,122	0	-100.0%
	Total Treated with These AIs*	**2,903,086**	**-5,842**	**2,897,244**	**-0.2%**

*Does not match Potato Table 1 totals because totals here do not include minor use AIs.

Table continued on next page

Potato Table 8 (continued). Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
5	Spinosyns	296,248	130,522	426,770	44.1%
6	Avermectins	286,449	105,988	392,437	37.0%
15	Benzoylureas	141,746	36,263	178,009	25.6%
17	Cyromazine	2,964	1,102	4,066	37.2%
23	Tetronic Acid Derivatives	85,504	11,946	97,450	14.0%
28	Diamides	99,878	36,579	136,457	36.6%
11A	Microbial Disruptors	17,680	12,080	29,760	68.3%
18B	Azadirachtin	16,533	9,341	25,874	56.5%
1A	Carbamates	31,375	9,959	41,334	31.7%
1B	Organophosphates	104,623	40,503	145,126	38.7%
22A	Oxadiaines	24,198	17,156	41,355	70.9%
2B	Phenylpyrazoles	78,714	8,008	86,722	10.2%
4A	Neonicotinoids	790,152	204,218	994,371	25.8%
9B	Pyridines	120,578	67,603	188,180	56.1%
29	Flonicamid	88,323	21,010	109,333	23.8%
	Total Non-Pyrethroids*	**2,184,964**	**712,280**	**2,897,244**	**32.6%**
	Total Pyrethroids	718,122	-718,122	0	-100.0%
	Total Treated with These AIs*	**2,903,086**	**-5,842**	**2,897,244**	**-0.2%**

*Does not match Potato Table 1 totals because totals here do not include minor use AIs.

Potato Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	**Active Ingredient**	**Foliar Insecticide**	**Soil Insecticide**
6	Abamectin	0.014	---
4A	Acetamiprid	0.068	---
18B	Azadirachtin	0.011	---
11A	Bacillus thuringeniensis	0.090	---
1A	Carbaryl	0.943	---
28	Chlorantraniliprole	0.048	0.026
4A	Clothianidin	0.054	0.125
17	Cyromazine	0.245	---
1B	Dimethoate	0.337	---
4A	Dinotefuran	0.103	---
1B	Ethoprophos	---	2.788
2B	Fipronil	---	0.098
29	Flonicamid	0.079	---
4A	Imidacloprid	0.055	0.247
22A	Indoxacarb	0.072	---
1A	Methomyl	0.475	---
15	Novaluron	0.069	---
1B	Phorate	---	2.456
1B	Phosmet	0.851	---
9B	Pymetrozine	0.136	---
5	Spinosyn	0.067	---
23	Spiromesifen	0.208	---
5	Spirotetramat	0.075	---
4A	Thiamethoxam	0.080	0.091

Potato Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	Active Ingredient	2012-2014 Average	Added	New Total	Change
6	Abamectin	4,035	1,499	5,534	37.2%
4A	Acetamiprid	628	418	1,045	66.5%
18B	Azadirachtin	178	100	278	56.5%
11A	Bacillus thuringeniensis	1,600	1,093	2,693	68.3%
1A	Carbaryl	17,087	5,269	22,355	30.8%
28	Chlorantraniliprole	4,658	1,740	6,398	37.4%
4A	Clothianidin	6,755	1,422	8,177	21.0%
17	Cyromazine	725	269	994	37.2%
1B	Dimethoate	24,426	11,102	35,528	45.5%
4A	Dinotefuran	2,209	2,394	4,602	108.4%
1B	Ethoprophos	7,910	800	8,710	10.1%
2B	Fipronil	7,699	783	8,483	10.2%
29	Flonicamid	6,974	1,659	8,633	23.8%
4A	Imidacloprid	77,200	7,558	84,757	9.8%
22A	Indoxacarb	1,739	1,233	2,972	70.9%
1A	Methomyl	6,289	2,074	8,363	33.0%
15	Novaluron	6,094	2,494	8,588	40.9%
1B	Phorate	37,895	2,434	40,329	6.4%
1B	Phosmet	9,786	5,359	15,145	54.8%
9B	Pymetrozine	16,443	9,219	25,662	56.1%
5	Spinosyn	5,156	1,280	6,437	24.8%
23	Spiromesifen	17,790	2,485	20,275	14.0%
5	Spirotetramat	16,238	8,399	24,636	51.7%
4A	Thiamethoxam	4,493	2,798	7,291	62.3%
	Total	**284,005**	**73,882**	**357,887**	**26.0%**

		Pounds of Active Ingredient Applied			
MOA	Insecticide Class	2012-2014 Average	Added	New Total	Change
5	Spinosyns	21,394	9,679	31,073	45.2%
6	Avermectins	4,035	1,499	5,534	37.2%
15	Benzoylureas	6,094	2,494	8,588	40.9%
17	Cyromazine	725	269	994	37.2%
23	Tetronic Acid Derivatives	17,790	2,485	20,275	14.0%
28	Diamides	4,658	1,740	6,398	37.4%
11A	Microbial Disruptors	1,600	1,093	2,693	68.3%
18B	Azadirachtin	178	100	278	56.5%
1A	Carbamates	23,376	7,343	30,718	31.4%
1B	Organophosphates	80,016	19,696	99,712	24.6%
22A	Oxadiaines	1,739	1,233	2,972	70.9%
2B	Phenylpyrazoles	7,699	783	8,483	10.2%
4A	Neonicotinoids	91,284	14,589	105,873	16.0%
9B	Pyridines	16,443	9,219	25,662	56.1%
29	Flonicamid	6,974	1,659	8,633	23.8%
	Total Non-Pyrethroids	**284,005**	**73,882**	**357,887**	**26.0%**
3A	**Pyrethroids**	**28,577**	**-28,577**	**0**	**-100%**
	Total	**312,582**	**45,305**	**357,887**	**14.5%**

Potato Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied
Abamectin	$10.83	---
Acetamiprid	$18.60	---
Azadirachtin	$17.87	---
Bacillus thurin.	$7.50	---
Carbaryl	$10.15	---
Chlorantraniliprole	$19.39	$14.49
Clothianidin	$14.95	$14.95
Cyromazine	$56.51	---
Dimethoate	$4.33	---
Dinotefuran	$16.44	---
Ethoprophos	---	$46.06
Fipronil	---	$17.73
Flonicamid	$20.39	---
Imidacloprid	$4.69	$16.78
Indoxacarb	$23.18	---
Methomyl	$8.75	---
Novaluron	$15.23	---
Phorate	---	$29.76
Phosmet	$12.41	---
Pymetrozine	$23.56	---
Spinosyn	$17.81	---
Spiromesifen	$30.39	---
Spirotetramat	$33.27	---
Thiamethoxam	$13.33	$16.63
Non-Pyrethroid Average*	**$16.78**	**$17.69**
Pyrethroid Average*	**$3.71**	**$10.66**
Application Costs	**$7.46**	**$3.11**

*Average weighted by treated acres.

Potato Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

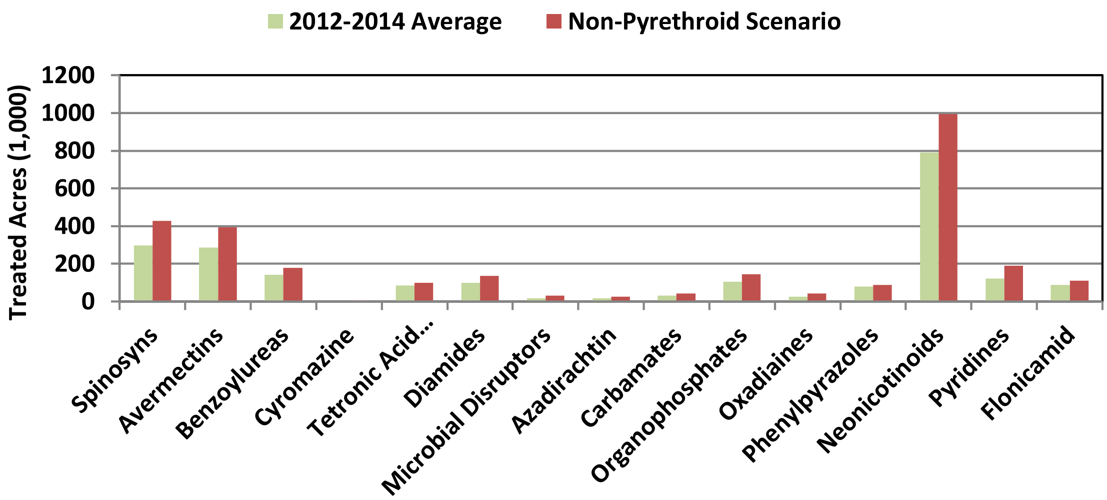
	--------- Foliar-Based ---------			----------- Soil-Based -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Abamectin	105,988	$10.83	$1,147,389	---	---	---
Acetamiprid	6,116	$18.60	$113,787	---	---	---
Azadirachtin	9,341	$17.87	$166,962	---	---	---
Bacillus thurin.	12,080	$7.50	$90,655	---	---	---
Carbaryl	5,588	$10.15	$56,740	---	---	---
Chlorantraniliprole	35,696	$19.39	$692,323	883	$14.49	$12,795
Clothianidin	18,344	$14.95	$274,158	3,393	$14.95	$50,710
Cyromazine	1,102	$56.51	$62,260	---	---	---
Dimethoate	32,931	$4.33	$142,703	---	---	---
Dinotefuran	23,272	$16.44	$382,638	---	---	---
Ethoprophos	---	---	---	287	$46.06	$13,226
Fipronil	---	---	---	8,008	$17.73	$141,998
Flonicamid	21,010	$20.39	$428,491	---	---	---
Imidacloprid	112,885	$4.69	$529,709	5,595	$16.78	$93,881
Indoxacarb	17,156	$23.18	$397,623	---	---	---
Methomyl	4,371	$8.75	$38,236	---	---	---
Novaluron	36,263	$15.23	$552,360	---	---	---
Phorate	---	---	---	991	$29.76	$29,495
Phosmet	6,294	$12.41	$78,100	---	---	---
Pymetrozine	67,603	$23.56	$1,592,692	---	---	---
Spinosyn	19,145	$17.81	$340,939	---	---	---
Spiromesifen	11,946	$30.39	$363,083	---	---	---
Spirotetramat	111,377	$33.27	$3,706,057	---	---	---
Thiamethoxam	31,633	$13.33	$421,559	2,980	$16.63	$49,579
Total AI Cost	**690,142**	**$16.78**	**$11,578,464**	**22,137**	**$17.69**	**$391,683**
Application Cost	**690,142**	**$7.46**	**$5,148,463**	**22,137**	**$3.11**	**$68,847**

Potato Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

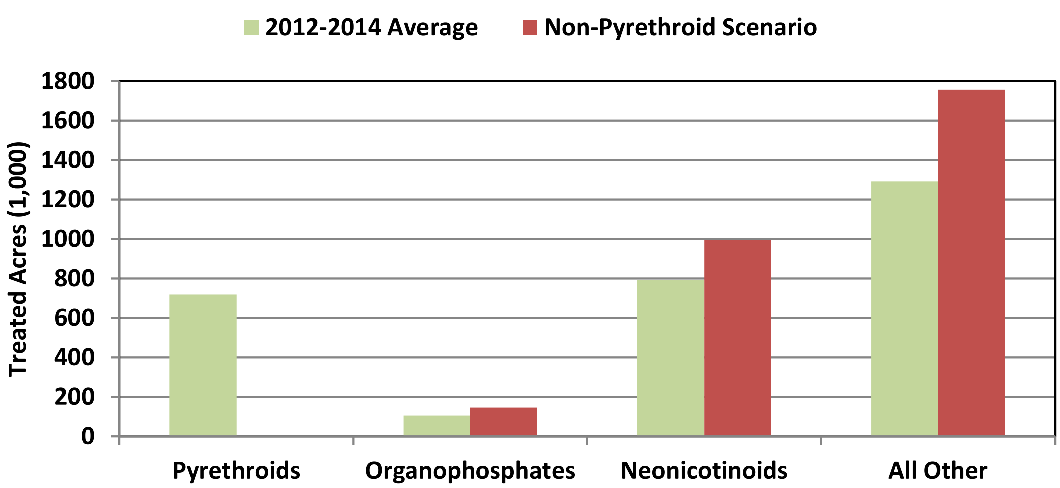
	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$2,564,879	$11,578,464	$9,013,585
Foliar Application Costs	$5,157,521	$5,148,463	-$9,058
Soil AI Costs	$285,192	$391,683	$106,491
Soil Application Costs	$83,239	$68,847	-$14,392
Total Costs	**$8,090,831**	**$17,187,458**	**$9,096,627**

Net Change in Grower Expenditures ($/A)	**Acres**	**$/Acre**
Pyrethroid Treated Acres	718,122	$12.67
Planted Acres	1,093,333	$8.32

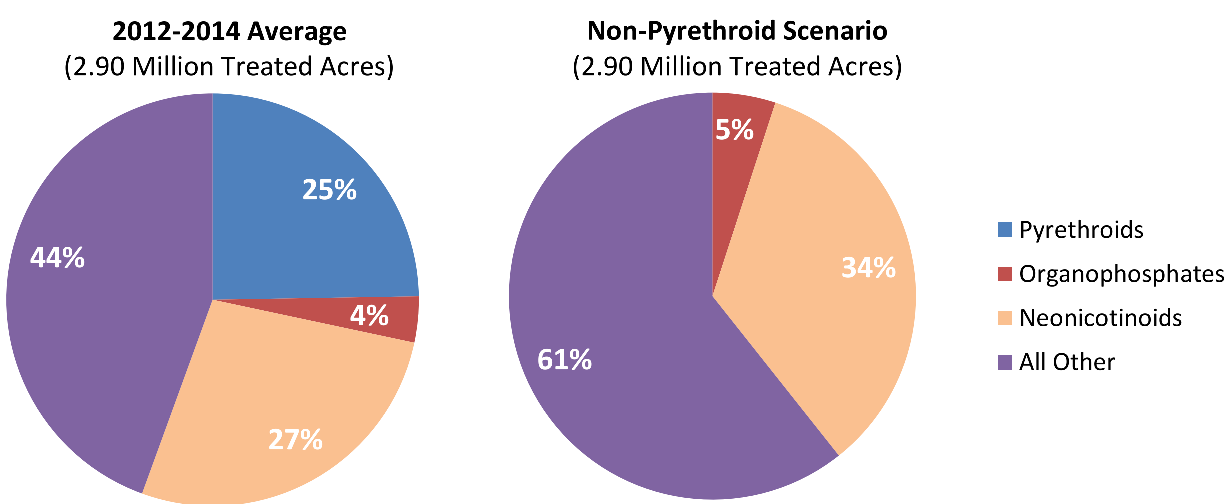
Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Potato Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Potato Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Potato Table 8).



5.5 Rice

Rice is a crop with only foliar insecticide applications, which simplifies several tables and this discussion. As Rice Table 1 indicates, almost all of the insecticide treated acres for rice are pyrethroids – 1.2 million total treated acres, with less than 100,000 acres of non-pyrethroid AIs. Rice Table 4 indicates that stink bugs are by far the primary target pest of these applications, with weevils, lepidopteran pests, and grasshoppers and the orthopteran insects also significant, but more minor targets. Rice Table 3 shows only five non-pyrethroid AIs were used significantly on rice, with malathion by far the most commonly non-pyrethroid AI used on stink bugs, the most common target pest. Diflubenzuron is the only other AI used for weevil management, with acephate, Bacillus thuringiensis (Bt), and diflubenzuron also important for management of lepidopteran pests.

Based on these data, the replacement of pyrethroids with non-pyrethroid alternatives for the non-pyrethroid scenario projects a substantial shift to malathion and diflubenzuron, with these two AIs constituting more than 89% of the new treated acres. As Rice Table 8 shows, the 1.1 million pyrethroid treated acres are replaced with nearly the same number of non-pyrethroid treated acres: more than 700,000 new malathion treated acres and 245,000 for diflubenzuron. These results only amplify when examined by insecticide class – the organophosphates (malathion, acephate, and methyl parathion) constitute 766,000 new treated acres to replace pyrethroids, a 6,900% increase. In terms of projected changes in pounds of AIs applied, the non-pyrethroid scenario replaces 28,000 pounds of pyrethroids with more than 800,000 pounds of non-pyrethroids, largely due to higher application rates of organophosphates, especially malathion (Rice Table 9 and 10).

Rice Figure 1 graphically shows the predominance of organophosphates as the major non-pyrethroid alternative used by rice farmers, while Rice Figures 2 and 3 show the resulting major shift to organophosphates for the non-pyrethroid scenario. Based on the 2012-02104 average, pyrethroids constitute 97% of insecticide treated acres, and for the non-pyrethroid scenario, organophosphates are projected to become 72% of total insecticide treated acres.

Rice Table 12 combines projected shifts in treated acres and average AI costs to estimate the cost of the replacement AIs and applications for the non-pyrethroid scenario. The replacement AIs have a projected cost of $9 million, with 4.8 million for malathion and $3.3 million for diflubenzuron. Application costs for these replacement AIs are an estimated $7.7 million. Given the relatively low per acre cost for pyrethroids and similar number of treated acres for the 2012-2014 average and the non-pyrethroid scenario, Rice Table 13 shows that total costs increase by $4.1 million for the non-pyrethroid scenario, all due to higher costs for replacement AIs. Based on the 1.1 million treated acres for pyrethroid insecticides, this cost increase represents an increase in AI and application costs of $3.70 per treated acre, from $11.49 to $15.19, or 32% increase. Spreading this cost across all rice planted acres implies an average cost increase for rice producers of $1.51 per planted acre.

Rice Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	Soil*	Total
Pyrethroids	1,105,696	---	1,105,696
Non-Pyrethroids	93,564	---	93,564
All AIs	1,199,260	---	1,199,260

*No soil-applied insecticides registered for use on rice.

Rice Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		Soil-Based Systems*	
	All AIs	Pyrethroids	All AIs	Pyrethroids
Initial Treated Acres	1,199,260	1,105,696	---	---
No Answer	1.7%	1.8%	---	---
Targeted at Specific Pests	98.3%	98.2%	---	---

*No soil-applied insecticides registered for use on rice.

Rice Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based systems*

	----------------------- Foliar-Based Systems -----------------------			
Active Ingredient	Lepidopterans	Orthopterans	Stink Bugs	Weevils
Acephate	21.3%	0.0%	2.4%	0.0%
Bacillus thuringiensis	42.8%	0.0%	0.0%	0.0%
Diflubenzuron	35.9%	0.0%	0.0%	100%
Malathion	0.0%	96.6%	95.1%	0.0%
Methyl Parathion	0.0%	3.4%	2.6%	0.0%

*No soil-applied insecticides registered for use on rice.

Rice Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based*
Lepidopterans	11.6%	---
Orthopterans	7.5%	---
Stink Bugs	62.9%	---
Weevils	18.0%	---

*No soil-applied insecticides registered for use on rice.

Rice Table 5. Average number of applications for each AI and ratios of these averages.

	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
Active Ingredient	Foliar-Based	Soil-Based*	Foliar:Foliar	Soil:Soil*
Acephate	1.000	---	0.937	---
Bacillus thuringiensis	1.000	---	0.937	---
Diflubenzuron	1.000	---	0.937	---
Malathion	1.000	---	0.937	---
Methyl Parathion	1.000	---	0.937	---
Pyrethroids	1.067	---		---

*No soil-applied insecticides registered for use on rice.

Rice Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Lepidopterans	Orthopterans	Stink Bugs	Weevils	Total	AI Weights
Acephate	25,526	0	15,529	0	41,055	4.0%
Bacillus thurin.	51,286	0	0	0	51,286	5.0%
Diflubenzuron	42,927	0	0	186,513	229,440	22.1%
Malathion	0	75,356	619,490	0	694,846	67.1%
Methyl Parathion	0	2,686	16,700	0	19,387	1.9%
Total	119,738	78,042	651,720	186,513	1,036,013	100%

Rice Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Table not needed since no soil-applied insecticides registered for use in rice.

Rice Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
1B	Acephate	1,610	41,055	42,665	2,549%
11A	Bacillus thuringiensis	2,925	51,286	54,210	1,754%
15	Diflubenzuron	16,070	229,440	245,510	1,428%
1B	Malathion	6,170	694,846	701,016	11,262%
1B	Methyl Parathion	3,099	19,387	22,485	626%
	Total Non-Pyrethroids*	**29,873**	**1,036,013**	**1,065,887**	**3,468%**
	Total Pyrethroids	**1,105,696**	**-1,105,696**	**0**	**-100%**
	Total Treated with These AIs*	**1,135,569**	**-69,683**	**1,065,887**	**-6.1%**

		------------- Treated Acres -------------			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
15	Benzoylureas	16,070	229,440	245,510	1,428%
1B	Organophosphates	10,879	755,288	766,167	6,943%
11A	Microbial Disruptors	2,925	51,286	54,210	1,754%
	Total Non-Pyrethroids*	**29,873**	**1,036,013**	**1,065,887**	**3,468%**
	Total Pyrethroids	**1,105,696**	**-1,105,696**	**0**	**-100%**
	Total Treated with These AIs*	**1,135,569**	**-69,683**	**1,065,887**	**-6.1%**

*Does not match Rice Table 1 totals because totals here do not include minor use AIs.

Rice Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	**Active Ingredient**	**Foliar Insecticide**	**Soil Insecticide***
1B	Acephate	0.278	---
11A	Bacillus thuringiensis	0.355	---
15	Diflubenzuron	0.152	---
1B	Malathion	1.050	---
1B	Methyl Parathion	0.500	---

*No soil-applied insecticides registered for use on rice.

Rice Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
1B	Acephate	447	11,405	11,852	2,549%
11A	Bacillus thuringiensis	1,038	18,196	19,234	1,754%
15	Diflubenzuron	2,447	34,938	37,385	1,428%
1B	Malathion	6,477	729,419	735,896	11,262%
1B	Methyl Parathion	1,549	9,693	11,243	626%
	Total	**11,958**	**803,651**	**815,610**	**6,720%**

		Pounds of Active Ingredient Applied			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
15	Benzoylureas	2,447	34,938	37,385	1428%
1B	Organophosphates	8,474	750,517	758,991	8857%
11A	Microbial Disruptors	1,038	18,196	19,234	1754%
	Total Non-Pyrethroids	**11,958**	**803,651**	**815,610**	**6,720%**
3A	**Pyrethroids**	**28,152**	**-28,152**	**0**	**-100%**
	Total	**40,111**	**775,499**	**815,610**	**1,933%**

Rice Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied*
Acephate	$2.04	---
Bacillus thuringiensis	$14.07	---
Diflubenzuron	$14.45	---
Malathion	$6.97	---
Methyl Parathion	$5.24	---
Non-Pyrethroid Average**	**$8.75**	**---**
Pyrethroid Average**	**$4.03**	**---**
Application Costs	**$7.46**	**---**

*No soil-applied insecticides registered for use on rice.
**Average weighted by treated acres.

Rice Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	--------- Foliar-Based ---------			-------------- Soil-Based* -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Acephate	41,055	$2.04	$83,937	---	---	---
Bacillus thuringiensis	51,286	$14.07	$721,808	---	---	---
Diflubenzuron	229,440	$14.45	$3,316,529	---	---	---
Malathion	694,846	$6.97	$4,843,689	---	---	---
Methyl Parathion	19,387	$5.24	$101,515	---	---	---
Total AI Cost	**1,036,013**	**$8.75**	**$9,067,478**	**---**	**---**	**---**
Application Cost	**1,036,013**	**$7.46**	**$7,728,659**	**---**	**---**	**---**

*No soil-applied insecticides registered for use on rice.

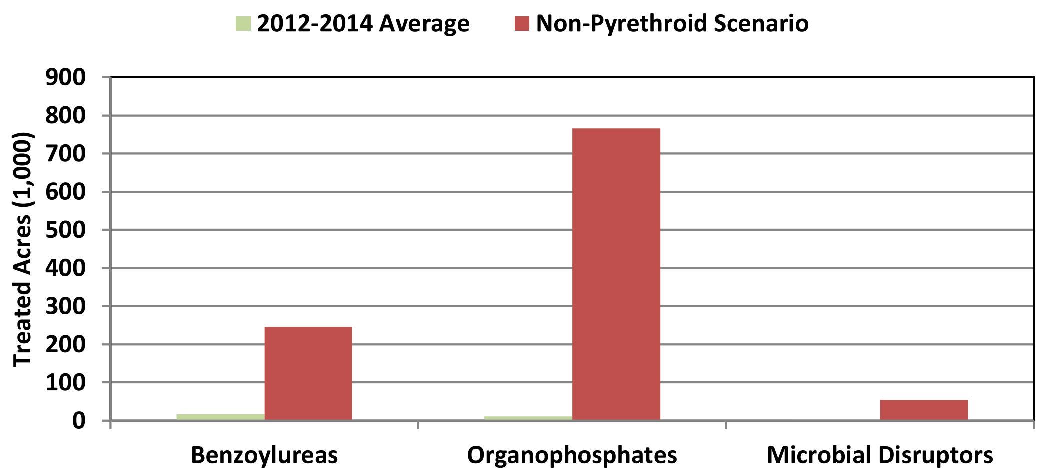
Rice Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$4,452,560	$9,067,478	$4,614,918
Foliar Application Costs	$8,248,492	$7,728,659	-$519,833
Soil AI Costs*			
Soil Application Costs*			
Total Costs	**$12,701,052**	**$16,796,137**	**$4,095,086**

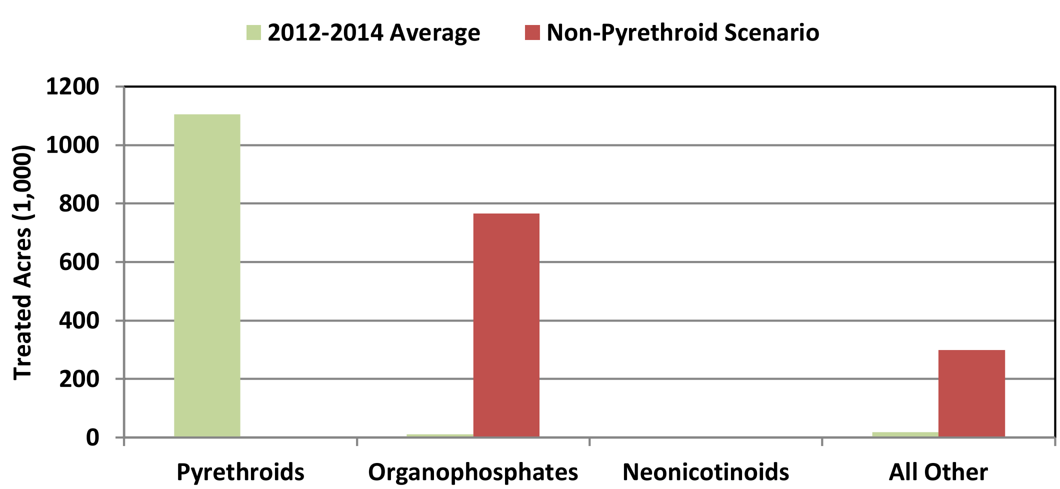
Net Change in Grower Expenditures ($/A)	**Acres**	**$/Acre**
Pyrethroid Treated Acres	1,105,696	$3.70
Planted Acres	2,709,667	$1.51

*No soil-applied insecticides registered for use on rice.

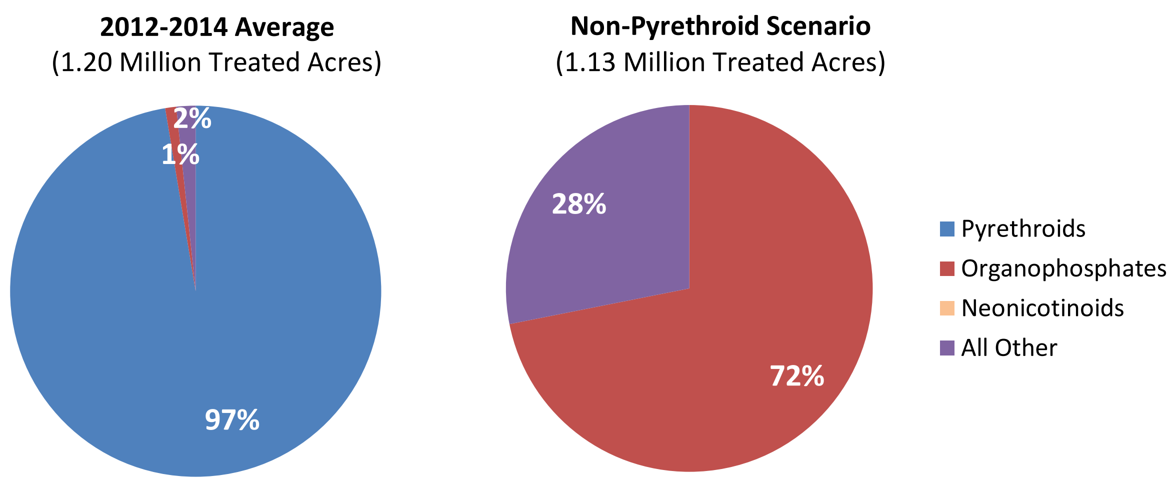
Rice Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Rice Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Rice Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Rice Table 8).



5.6 Sorghum

The 2012-2014 insecticide treated acre data summarized Sorghum Table 1 shows that no soil-applied insecticides are registered for use on sorghum, and so only data for foliar-applied insecticides are reported. As a result, several sections in subsequent tables are empty. Sorghum Table 1 also shows that pyrethroid insecticides are the largest single class of insecticides used in terms of treated acres – of the 1.1 million insecticide treated acres, pyrethroids constituted 689,000. Sorghum Table 4 reports that the primary targets of these pyrethroid insecticides were lepidopteran insect pests and midges and then multiple stink bug species, with a range of minor pests, including grasshoppers, mites, aphids and greenbugs. Sorghum Table 3 shows that only six non-pyrethroid AIs were used to manage these insects, with chlorpyrifos by far the most common. Based on the average number of applications and these non-pyrethroid shares, Sorghum Table 6 reports the projected non-pyrethroid treated acres by insect target and AI. Chlorpyrifos by far dominates the new treated acres, at more than 459,000 of the total added; dimethoate is next with almost 79,000 treated acres added.

Sorghum Table 8 summarizes the projected treated acre changes by AI and insecticide class. Chlorpyrifos treated acres increase the most in terms of added acres, from 90,500 to 550,000, or a 505% increase. Diamethoate also adds almost 79,000 acres, but had a larger initial total for the 2012-2014 average, and so only increase 116%. Given these results for the AIs, as expected, total organophosphate treated acres have the largest projected increase among the insecticide classes – adding 538,000 of the total 619,000 non-pyrethroid treated acres replacing pyrethroids for the non-pyrethroid scenario. The diamides are the next largest class in terms of added treated acres, with not quite 35,000 acres added. Based on the average application rates for each AI in Sorghum Table 9, Sorghum Table 10 summarizes projected changes in total pounds of insecticide AIs to replace pyrethroids for the non-pyrethroid scenario. The 17,000 pounds of pyrethroids are replaced with 267,000 pounds of non-pyrethroid AIs for the non-pyrethroid scenario. Not surprisingly, 240,000 of these 267,000 pounds are organophosphates.

Sorghum Figures 1 and 2 graphically show these same trends and results –pyrethroids dominate the insecticide classes used by sorghum farmers and under the non-pyrethroid scenario, the shift is to organophosphates. Sorghum Figure 3 shows that the share of insecticide treated acres using pyrethroids was 78% for the 2012-2014 average, while the share for organophosphates was only 18%. For the non-pyrethroid scenario, the organophosphate share is projected to increase to 86%, with all other classes still only constituting 11%.

Sorghum Table 12 uses the AI-specific costs and added treated acres for each AI to estimate the cost to replace pyrethroid AIs with non-pyrethroid AIs for the non-pyrethroid scenario. The cost of these added non-pyrethroid AIs is an estimated $3.3 million, of which $1.9 million is for chlorpyrifos. The second largest AI in terms of cost is chlorantraniliprole, which added only a modest number of treated acres, but appear next because its per cost exceeds $20/A, well above all other AIs. Application costs for these replacement project acres actually exceed AI costs, projected to be $4.6 million. Sorghum Table 13 combines these AI and application costs for the non-pyrethroid treated acres added to replace the pyrethroid treated acres to estimate the net cost impact of the non-pyrethroid scenario. AI costs for the replacement AIs increase, from $2.6 million for the pyrethroid AIs to $3.3 million for the non-pyrethroid alternatives. However, application costs decrease since total insecticide treated acres decrease for the non-pyrethroid scenario. As a result, the total cost impact of the non-pyrethroid scenario is a cost increase of $138,000. Given the 689,000 pyrethroid treated acres, this change implies an average cost increase $0.20 per pyrethroid treated acre, increasing from $11.29 to $11.49 or 2%. Spreading this $138,000 projected cost increase over all sorghum planted acres gives an average increase of $0.02 per planted acre since many sorghum acres do not receive any insecticide treatment.

In summary, pyrethroids constituted most of the insecticide treated acres for sorghum, more than three-fourths of the 1.1 million insecticide treated acres for the crop, with about two-thirds of these pyrethroid applications targeted at lepidopteran pests and midges. The non-pyrethroid scenario projects that these 689,000 pyrethroid treated acres would be replaced by 619,000 treated acres of non-pyrethroid AIs, mostly the organophosphate insecticides chlorpyrifos and dimethoate. This change in AIs and treated acres would result in an estimated net cost increase of $138,000, or on average $0.20 per pyrethroid treated acre and $0.02 per sorghum planted acre.

Sorghum Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	**Soil***	**Total**
Pyrethroids	688,697	---	688,697
Non-Pyrethroids	409,673	---	409,673
All AIs	1,098,370	---	1,098,370

*No soil-applied insecticides registered for use on sorghum.

Sorghum Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		Soil-Based Systems*	
	All AIs	**Pyrethroids**	**All AIs**	**Pyrethroids**
Initial Treated Acres	1,098,370	688,697	---	---
No Answer	3.7%	2.9%	---	---
Targeted at Specific Pests	96.3%	97.1%	---	---

*No soil-applied insecticides registered for use on sorghum.

Sorghum Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based systems*

	-- Foliar-Based Systems --						
Active Ingredient	**Aphids**	**Midges**	**Greenbugs**	**Lepidop-terans**	**Mites**	**Orthop-terans**	**Stink Bugs**
Chlorantraniliprole	0.0%	0.0%	0.0%	14.2%	0.0%	0.0%	0.0%
Chlorpyrifos	43.3%	93.7%	41.1%	79.4%	0.0%	100.0%	40.8%
Dimethoate	45.4%	6.3%	0.0%	0.0%	0.0%	0.0%	52.1%
Imidacloprid	11.3%	0.0%	58.9%	0.0%	0.0%	0.0%	7.1%
Methomyl	0.0%	0.0%	0.0%	6.3%	0.0%	0.0%	0.0%
Propargite	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%

*No soil-applied insecticides registered for use on sorghum.

Sorghum Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based*
Aphids	2.3%	---
Midges	34.4%	---
Greenbugs	1.2%	---
Lepidopterans	38.6%	---
Mites	2.2%	---
Orthopterans	2.8%	---
Stink Bugs	18.4%	---

*No soil-applied insecticides registered for use on sorghum.

Sorghum Table 5. Average number of applications for each AI and ratios of these averages.

	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
Active Ingredient	**Foliar-Based**	**Soil-Based***	**Foliar:Foliar**	**Soil:Soil***
Chlorantraniliprole	1.025	---	0.915	---
Chlorpyrifos	1.000	---	0.892	---
Dimethoate	1.000	---	0.892	---
Imidacloprid	1.249	---	1.114	---
Methomyl	1.000	---	0.892	---
Propargite	1.000	---	0.892	---
Pyrethroids	1.121			

*No soil-applied insecticides registered for use on sorghum.

Sorghum Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Midges	Green-bugs	Lepido-pterans	Mites	Ortho-pterans	Stink Bugs	Total	AI Weights
Chlorantraniliprole	0	0	0	34,654	0	0	0	34,654	5.6%
Chlorpyrifos	6,200	198,221	3,064	188,579	0	16,965	46,178	459,208	74.2%
Dimethoate	6,495	13,316	0	0	0	0	59,071	78,882	12.7%
Imidacloprid	2,024	0	5,482	0	0	0	10,035	17,541	2.8%
Methomyl	0	0	0	15,019	0	0	0	15,019	2.4%
Propargite	0	0	0	0	13,430	0	0	13,430	2.2%
Total	**14,719**	**211,538**	**8,546**	**238,253**	**13,430**	**16,965**	**115,285**	**618,736**	**100%**

Sorghum Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Table not needed since no soil-applied insecticides registered for use in sorghum.

Sorghum Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
28	Chlorantraniliprole	6,495	34,654	41,149	534%
1B	Chlorpyrifos	90,853	459,208	550,062	505%
1B	Dimethoate	67,923	78,882	146,805	116%
4A	Imidacloprid	15,007	17,541	32,549	117%
1A	Methomyl	10,178	15,019	25,197	148%
12C	Propargite	1,326	13,430	14,756	1013%
	Total Non-Pyrethroids*	**191,782**	**618,736**	**810,517**	**323%**
	Total Pyrethroids	688,697	-688,697	0	-100%
	Total Treated with These AIs*	**880,479**	**-69,962**	**810,517**	**-7.9%**
		------------- Treated Acres -------------			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
28	Diamides	6,495	34,654	41,149	534%
1A	Carbamates	15,007	17,541	32,549	117%
1B	Organophosphates	158,776	538,090	696,867	339%
4A	Neonicotinoids	10,178	15,019	25,197	148%
12C	Propargite	1,326	13,430	14,756	1013%
	Total Non-Pyrethroids*	**191,782**	**618,736**	**810,517**	**323%**
	Total Pyrethroids	**688,697**	**-688,697**	**0**	**-100%**
	Total Treated with These AIs*	**880,479**	**-69,962**	**810,517**	**-7.9%**

*Does not match Sorghum Table 1 totals because totals here do not include minor use AIs.

Sorghum Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	**Active Ingredient**	**Foliar Insecticide**	**Soil Insecticide***
28	Chlorantraniliprole	0.060	---
1B	Chlorpyrifos	0.465	---
1B	Dimethoate	0.338	---
4A	Imidacloprid	0.036	---
1A	Methomyl	0.291	---
12C	Propargite	1.500	---

*No soil-applied insecticides registered for use on sorghum.

Sorghum Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
28	Chlorantraniliprole	389	2,074	2,463	534%
1B	Chlorpyrifos	42,257	213,583	255,840	505%
1B	Dimethoate	22,947	26,650	49,597	116%
4A	Imidacloprid	540	632	1,172	117%
1A	Methomyl	2,962	4,371	7,333	148%
12C	Propargite	1,988	20,144	22,132	1013%
	Total	**71,084**	**267,454**	**338,537**	**376%**

		Pounds of Active Ingredient Applied			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
28	Diamides	389	2,074	2,463	534%
1A	Carbamates	2,962	4,371	7,333	148%
1B	Organophosphates	65,204	240,233	305,438	368%
4A	Neonicotinoids	540	632	1,172	117%
12C	Propargite	1,988	20,144	22,132	1013%
	Total Non-Pyrethroids	**71,084**	**267,454**	**338,537**	**376%**
3A	**Pyrethroids**	**17,307**	**-17,307**	**0**	**-100%**
	Total	**88,390**	**250,147**	**338,537**	**283%**

Sorghum Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	**Foliar-Applied**	**Soil-Applied***
Chlorantraniliprole	$20.57	---
Chlorpyrifos	$4.22	---
Dimethoate	$4.17	---
Imidacloprid	$3.36	---
Methomyl	$7.29	---
Propargite	$11.00	---
Non-Pyrethroid Average**	**$5.33**	**---**
Pyrethroid Average**	**$3.83**	**---**
Application Costs	**$7.46**	**---**

*No soil-applied insecticides registered for use on sorghum.
**Average weighted by treated acres.

Sorghum Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	--------- Foliar-Based ---------			----------- Soil-Based* -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Chlorantraniliprole	34,654	$20.57	$712,809	---	---	---
Chlorpyrifos	459,208	$4.22	$1,939,548	---	---	---
Dimethoate	78,882	$4.17	$328,969	---	---	---
Imidacloprid	17,541	$3.36	$59,025	---	---	---
Methomyl	15,019	$7.29	$109,446	---	---	---
Propargite	13,430	$11.00	$147,718	---	---	---
Total AI Cost	**618,736**	**$5.33**	**$3,297,514**	**---**	**---**	**---**
Application Cost	**618,736**	**$7.46**	**$4,615,768**	**---**	**---**	**---**

*No soil-applied insecticides registered for use on sorghum.

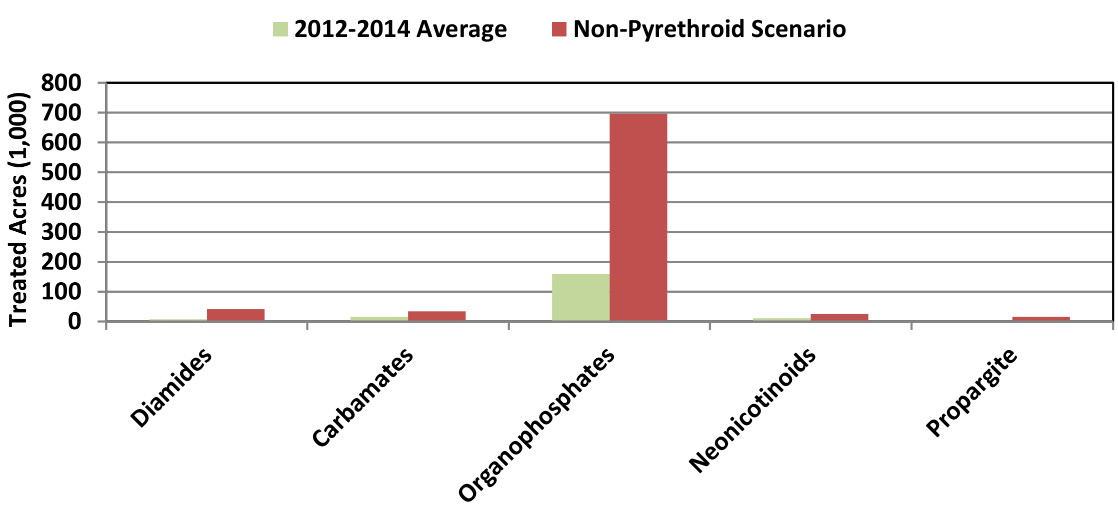
Sorghum Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$2,637,202	$3,297,514	$660,312
Foliar Application Costs	$5,137,682	$4,615,768	-$521,914
Soil AI Costs*	---	---	---
Soil Application Costs*	---	---	---
Total Costs	**$7,774,884**	**$7,913,282**	**$138,398**

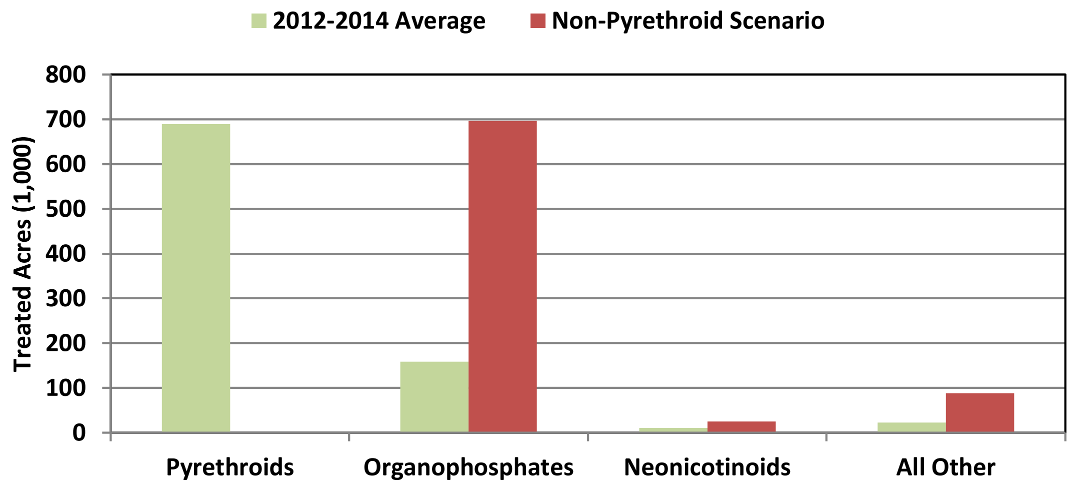
Net Change in Grower Expenditures ($/A)	**Acres**	**$/Acre**
Pyrethroid Treated Acres	688,697	$0.20
Planted Acres	7,157,667	$0.02

*No soil-applied insecticides registered for use on sorghum.

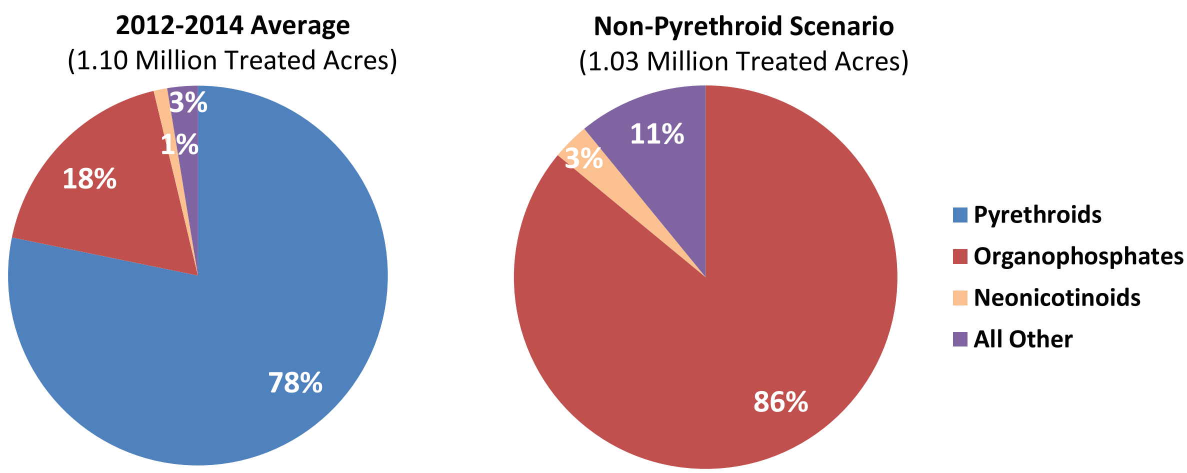
Sorghum Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Sorghum Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Sorghum Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Sorghum Table 8).



5.7 Soybean

No soil-applied insecticides were registered for soybean during 2012-2014, though insecticidal seed treatments were available. As a result, treated acres data are only available for foliar-applied insecticides and no treated acres data are reported for soil-based systems and so sections in several tables are empty and Soybean Table 7 is not needed.

Soybean Table 1 shows that pyrethroid insecticides constituted about two-thirds of insecticide treated acres in soybean for 2010-2014 – 14.9 million acres of the 22.9 million total insecticide treated acres. Soybean Table 4 indicates that the primary insect targets were stink bugs, aphids, beetles and various lepidopteran insects, with mites, grasshoppers and other orthopterans, and treehoppers as minor but significant targets. Soybean Table 3 shows that the primary non-pyrethroid AIs used to manage these pests were chlorpyrifos, acephate and imidacloprid. Some other non-pyrethroid AIs showed substantial use for some key pests. For example, chlorantraniliprole was the most commonly used non-pyrethroid alternative for lepidopteran pests in soybean, while thiamethoxam showed significant use for managing aphids and orthopteran pests. However, in aggregate, Soybean Table 6 shows that chlorpyrifos, acephate and imidacloprid are projected to have the greatest shares of replacements for pyrethroids in the non-pyrethroid scenario.

Soybean Table 8 aggregates the new treated acres for each AI for the non-pyrethroid scenario as replacements for the 14.9 million pyrethroid treated acres. In terms of added treated acres, chlorpyrifos has the largest increases, adding more than 6.3 million treated acres, then almost 2.7 million treated acres for acephate and 2.6 million of imidacloprid and 1 million of thiamethoxam. All non-pyrethroid AIs show large projected percentage increases in treated acres, from 127% for carbaryl to 322% for acephate. In terms of insecticide classes, organophosphates show the largest projected increase of 9.1 million acres, then neonicotinoids, adding 3.6 million, both of which slightly more than double. The oxadines and diamides show the largest percentage increases due to the projected increased use of indoxacarb and chlorantraniliprole. Based on the average application rates in Soybean Table 9, Soybean Table 10 shows that the 469,000 pounds of pyrethroids are replaced by 4.5 million pounds of non-pyrethroid AIs for the non-pyrethroid scenario. As expected, organophosphates constitute the largest part of these added pounds, more than 91% of the 4.5 million pounds added.

Soybean Figure 1 shows the wide range of non-pyrethroid AIs used to control insects in soybean, while Soybean Figure 2 shows the predominance of pyrethroids and the projected shift to predominantly organophosphates and to some extent neonicotinoids for the non-pyrethroid scenario. In terms of projected shares of insecticide treated acres, the projected shifts reported graphically in Soybean Figure 3 imply that the 20% share for organophosphates increases to 62% for the non-pyrethroid scenario, while the share for neonicotinoids increases from 8% to 24%.

Soybean Table 12 uses the added treated acres by AI and AI average costs to estimate the cost of these new AIs to replace pyrethroids for the non-pyrethroid scenario, as well as application costs. The overall cost is $70 million for these non-pyrethroid AIs, with $23.5 million for chlorpyrifos and $14.7 million for acephate. Surprisingly, chlorantraniliprole was third largest at $11.5 million, but this occurs because it has the greatest per acre cost of all the AIs in Soybean Table 12. Application costs for these replacement AIs was estimated to be $110 million. Soybean Table 13 combines all of these results to estimate the average net cost increase for the non-pyrethroid scenario. No longer using the pyrethroid insecticides means avoiding $53 million AI costs and $111 million in application costs, but the non-pyrethroid replacement AIs cost $70 million and application costs are very similar at $110 million. As a result, the projected net cost increase for the non-pyrethroid scenario is $16.4 million. Based on the 14.9 million pyrethroid treated acres for 2012-2014, this cost increases represents a 10% increase, from

$11.02 to 12.12, or $1.10 per treated acre. Spreading this $16.4 million projected cost increase over all soybean planted acres gives an average increase of $0.21 per planted acre.

In summary, pyrethroids constituted 14.9 million of the 22.9 million insecticide treated acres in soybean, all foliar applied. Most of these pyrethroids were targeted at stink bugs, aphids, and various beetle and lepidopteran pests. The non-pyrethroid scenario projects that these 14.9 million pyrethroid treated acres would be replaced by 14.8 million treated acres of non-pyrethroid AIs, mostly the organophosphate insecticides chlorpyrifos and acephate and the neonicotinoid insecticides imidacloprid and thiamethoxam. This change in AIs and treated acres would result in an estimated net cost increase of $16.4 million, or on average $1.10 per pyrethroid treated acre and $0.21 per soybean planted acre.

Soybean Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	**Soil***	**Total**
Pyrethroids	14,869,265	---	14,869,265
Non-Pyrethroids	7,996,516	---	7,996,516
All AIs	22,865,780	---	22,865,780

*No soil-applied insecticides registered for use on soybeans.

Soybean Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		**Soil-Based Systems***	
	All AIs	**Pyrethroids**	**All AIs**	**Pyrethroids**
Initial Treated Acres	22,865,780	14,869,265	---	---
No Answer	27.1%	6.3%	---	---
Targeted at Specific Pests	72.9%	93.7%	---	---

*No soil-applied insecticides registered for use on soybeans.

Soybean Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based systems*

	---------- Foliar-Based Systems ----------						
Active Ingredient	**Aphids**	**Beetles**	**Lepidop-terans**	**Mites**	**Orthop-terans**	**Stink Bugs**	**Treehoppers**
Acephate	0.5%	16.1%	19.1%	0.0%	2.1%	40.3%	19.5%
Bacillus thuringiensis	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%
Carbaryl	0.0%	0.2%	0.0%	0.0%	0.8%	8.2%	0.0%
Chlorantraniliprole	0.0%	0.0%	37.9%	0.0%	0.0%	0.0%	0.0%
Chlorpyrifos	81.8%	44.0%	11.5%	94.7%	83.5%	10.2%	0.0%
Diflubenzuron	0.0%	0.0%	9.0%	0.0%	0.0%	0.0%	0.0%
Dimethoate	0.6%	1.6%	0.0%	5.3%	0.2%	0.0%	0.0%
Imidacloprid	7.1%	30.4%	0.0%	0.0%	0.0%	31.5%	72.1%
Indoxacarb	0.0%	0.0%	8.1%	0.0%	0.0%	0.0%	0.0%
Methoxyfenozide	0.0%	0.0%	8.3%	0.0%	0.0%	0.0%	0.0%
Thiamethoxam	10.1%	7.6%	0.0%	0.0%	13.4%	9.8%	8.4%

*No soil-applied insecticides registered for use on soybeans.

Soybean Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based*
Aphids	20.5%	---
Beetles	18.2%	---
Lepidopterans	17.4%	---
Mites	8.6%	---
Orthopterans	7.6%	---
Stink Bugs	23.8%	---
Treehoppers	3.8%	---

*No soil-applied insecticides registered for use on soybeans.

Soybean Table 5. Average number of applications for each AI and ratios of these averages.

	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
Active Ingredient	Foliar-Based	Soil-Based*	Foliar:Foliar	Soil:Soil*
Acephate	1.119	---	1.059	---
Bacillus thuringiensis	1.000	---	0.946	---
Carbaryl	1.033	---	0.977	---
Chlorantraniliprole	1.000	---	0.946	---
Chlorpyrifos	1.032	---	0.977	---
Diflubenzuron	1.036	---	0.980	---
Dimethoate	1.010	---	0.956	---
Imidacloprid	1.063	---	1.006	---
Indoxacarb	1.076	---	1.019	---
Methoxyfenozide	1.022	---	0.967	---
Thiamethoxam	1.005	---	0.951	---
Pyrethroids	1.057	---		---

*No soil-applied insecticides registered for use on soybeans.

Soybean Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Beetles	Lepido-pterans	Mites	Ortho-pterans	Stink Bugs	Tree-hoppers	Total	AI Weight
Acephate	15,371	461,770	523,431	0	25,128	1,510,066	117,924	2,653,690	18.0%
Bacillus thurin.	0	0	148,300	0	0	0	0	148,300	1.0%
Carbaryl	0	5,540	0	0	8,725	283,359	0	297,624	2.0%
Chlorantraniliprole	0	0	929,911	0	0	0	0	929,911	6.3%
Chlorpyrifos	2,437,358	1,163,588	292,002	1,177,663	923,059	353,679	0	6,347,349	43.0%
Diflubenzuron	0	0	230,013	0	0	0	0	230,013	1.6%
Dimethoate	16,272	42,101	0	64,271	2,381	0	0	125,026	0.8%
Imidacloprid	217,799	829,195	0	0	0	1,122,206	415,130	2,584,330	17.5%
Indoxacarb	0	0	213,634	0	0	0	0	213,634	1.4%
Methoxyfenozide	0	0	209,380	0	0	0	0	209,380	1.4%
Thiamethoxam	292,560	196,487	0	0	144,365	328,194	45,591	1,007,196	6.8%
Total	**2,979,359**	**2,698,680**	**2,546,670**	**1,241,934**	**1,103,658**	**3,597,504**	**578,645**	**14,746,451**	**100%**

Soybean Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Table not needed since no soil-applied insecticides registered for use in soybeans.

Soybean Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	Active Ingredient	2012-2014 Average	Added	New Total	Change
1B	Acephate	824,886	2,653,690	3,478,576	322%
11A	Bacillus thuringiensis	60,773	148,300	209,073	244%
1A	Carbaryl	233,991	297,624	531,615	127%
28	Chlorantraniliprole	326,175	929,911	1,256,086	285%
1B	Chlorpyrifos	3,394,435	6,347,349	9,741,783	187%
15	Diflubenzuron	140,732	230,013	370,745	163%
1B	Dimethoate	91,074	125,026	216,099	137%
4A	Imidacloprid	1,200,721	2,584,330	3,785,051	215%
22A	Indoxacarb	74,515	213,634	288,149	287%
18A	Methoxyfenozide	105,353	209,380	314,732	199%
4A	Thiamethoxam	480,910	1,007,196	1,488,106	209%
	Total Non-Pyrethroids*	**6,933,564**	**14,746,451**	**21,680,015**	**213%**
	Total Pyrethroids	**14,869,265**	**-14,869,265**	**0**	**-100%**
	Total Treated with These AIs*	**21,802,829**	**-122,814**	**21,680,015**	**-0.6%**

		------------- Treated Acres -------------			
MOA	Insecticide Class	2012-2014 Average	Added	New Total	Change
1A	Carbamates	233,991	297,624	531,615	127%
1B	Organophosphates	4,310,394	9,126,064	13,436,458	212%
4A	Neonicotinoids	1,681,631	3,591,526	5,273,156	214%
11A	Microbial Disruptors	60,773	148,300	209,073	244%
15	Benzoylureas	140,732	230,013	370,745	163%
18A	Diacylhydrazines	105,353	209,380	314,732	199%
22A	Oxadiaines	74,515	213,634	288,149	287%
28	Diamides	326,175	929,911	1,256,086	285%
	Total Non-Pyrethroids*	**6,933,564**	**14,746,451**	**21,680,015**	**213%**
	Total Pyrethroids	**14,869,265**	**-14,869,265**	**0**	**-100%**
	Total Treated with These AIs*	**21,802,829**	**-122,814**	**21,680,015**	**-0.6%**

*Does not match Soybean Table 1 totals because totals here do not include minor use AIs.

Soybean Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	Active Ingredient	Foliar Insecticide	Soil Insecticide*
1B	Acephate	0.674	---
11A	Bacillus thuringiensis	0.061	---
1A	Carbaryl	0.521	---
28	Chlorantraniliprole	0.051	---
1B	Chlorpyrifos	0.362	---
15	Diflubenzuron	0.036	---
1B	Dimethoate	0.431	---
4A	Imidacloprid	0.040	---
22A	Indoxacarb	0.072	---
18A	Methoxyfenozide	0.073	---
4A	Thiamethoxam	0.035	---

*No soil-applied insecticides registered for use on soybeans.

Soybean Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
1B	Acephate	556,090	1,789,123	2,345,213	322%
11A	Bacillus thuringiensis	3,689	9,001	12,690	244%
1A	Carbaryl	121,864	155,004	276,868	127%
28	Chlorantraniliprole	16,578	47,263	63,841	285%
1B	Chlorpyrifos	1,158,933	2,300,292	3,459,224	198%
15	Diflubenzuron	5,085	8,310	13,395	163%
1B	Dimethoate	39,276	53,918	93,195	137%
4A	Imidacloprid	47,972	104,446	152,418	218%
22A	Indoxacarb	5,351	15,342	20,694	287%
18A	Methoxyfenozide	7,669	15,242	22,911	199%
4A	Thiamethoxam	15,793	35,444	51,238	224%
	Total	**1,978,300**	**4,533,386**	**6,511,686**	**229%**

		Pounds of Active Ingredient Applied			
MOA	Insecticide Class	**2012-2014 Average**	**Added**	**New Total**	**Change**
1A	Carbamates	121,864	155,004	276,868	127%
1B	Organophosphates	1,754,299	4,143,333	5,897,632	236%
4A	Neonicotinoids	63,765	139,891	203,656	219%
11A	Microbial Disruptors	3,689	9,001	12,690	244%
15	Benzoylureas	5,085	8,310	13,395	163%
18A	Diacylhydrazines	7,669	15,242	22,911	199%
22A	Oxadiaines	5,351	15,342	20,694	287%
28	Diamides	16,578	47,263	63,841	285%
	Total Non-Pyrethroids	**1,978,300**	**4,533,386**	**6,511,686**	**229%**
3A	**Pyrethroids**	**469,064**	**-469,064**	**0**	**-100%**
	Total	**2,447,364**	**4,533,386**	**6,511,686**	**166%**

Soybean Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	**Foliar-Applied**	**Soil-Applied***
Acephate	$5.54	---
Bacillus thuringiensis	$4.12	---
Carbaryl	$4.55	---
Chlorantraniliprole	$12.39	---
Chlorpyrifos	$3.70	---
Diflubenzuron	$4.37	---
Dimethoate	$5.50	---
Imidacloprid	$3.08	---
Indoxacarb	$12.02	---
Methoxyfenozide	$8.93	---
Thiamethoxam	$4.50	---
Non-Pyrethroid Average**	**$4.77**	---
Pyrethroid Average**	**$3.56**	---
Application Costs	**$7.46**	---

*No soil-applied insecticides registered for use on soybeans.
**Average weighted by treated acres.

Soybean Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	--------- Foliar-Based ---------			----------- Soil-Based* -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Acephate	2,653,690	$5.54	$14,710,126	---	---	---
Bacillus thuringiensis	148,300	$4.12	$610,925	---	---	---
Carbaryl	297,624	$4.55	$1,354,914	---	---	---
Chlorantraniliprole	929,911	$12.39	$11,520,410	---	---	---
Chlorpyrifos	6,347,349	$3.70	$23,466,028	---	---	---
Diflubenzuron	230,013	$4.37	$1,004,301	---	---	---
Dimethoate	125,026	$5.50	$687,185	---	---	---
Imidacloprid	2,584,330	$3.08	$7,960,666	---	---	---
Indoxacarb	213,634	$12.02	$2,568,284	---	---	---
Methoxyfenozide	209,380	$8.93	$1,869,431	---	---	---
Thiamethoxam	1,007,196	$4.50	$4,528,629	---	---	---
Total AI Cost	**14,746,451**	**$4.77**	**$70,280,898**	**---**	**---**	**---**
Application Cost	**14,746,451**	**$7.46**	**$110,008,524**	**---**	**---**	**---**

*No soil-applied insecticides registered for use on soybeans.

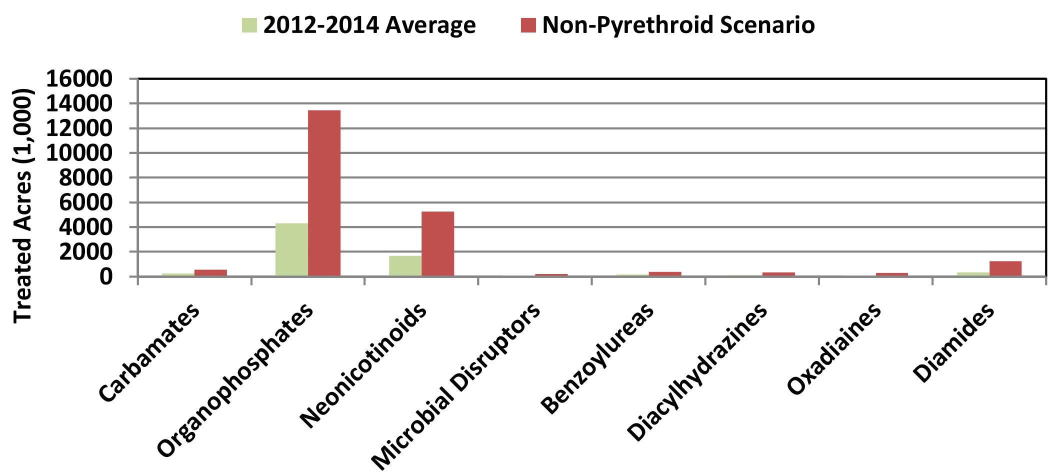
Soybean Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$52,971,319	$70,280,898	$17,309,579
Foliar Application Costs	$110,924,714	$110,008,524	-$916,190
Soil AI Costs*			
Soil Application Costs*			
Total Costs	$163,896,033	$180,289,422	$16,393,389

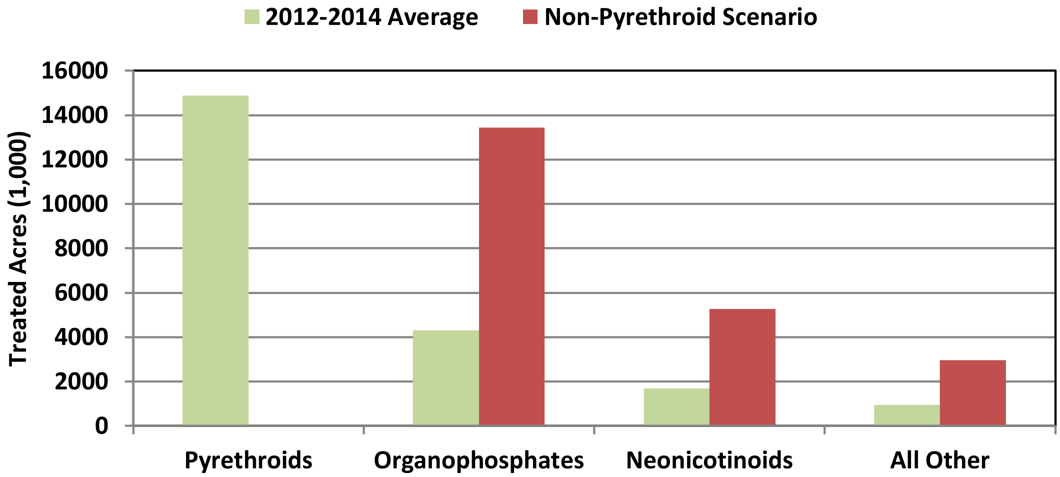
Net Change in Grower Expenditures ($/A)	**Acres**	**$/Acre**
Pyrethroid Treated Acres	14,869,265	$1.10
Planted Acres	79,246,333	$0.21

*No soil-applied insecticides registered for use on soybeans.

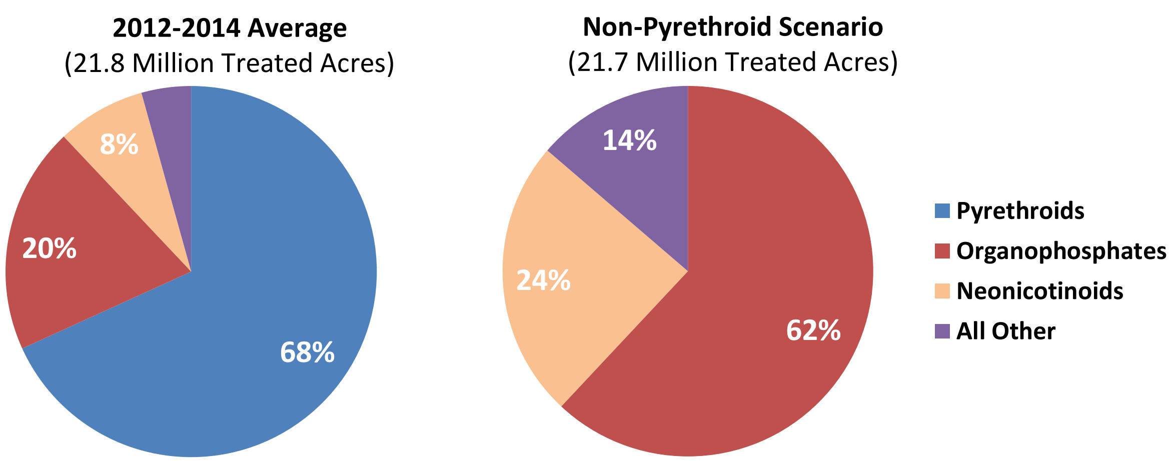
Soybean Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Soybean Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Soybean Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Soybean Table 8).



5.8 Spring wheat

Like many crops examined in this report, wheat does not have any soil-applied insecticides registered for use (not including insecticidal seed treatments), and so several tables have empty sections. Spring Wheat Table 1 shows that of the 2.4 million insecticide treated acres in spring wheat, 1.5 million are for pyrethroid insecticides, making it the most used insecticide class in spring wheat. Based on Spring Wheat Table 4, these pyrethroids are targeted at a variety of insect pests, but aphids capture more than half of the total pyrethroid treated acres. The next most targeted insect group is grasshoppers and other orthopteran insects, with almost a 16% share of pyrethroid treated acres. Other minor but significant target pests include midges, lepidopteran insects, hessian flies, sawflies, beetles and mites. Based on Spring Wheat Table 3, only three non-pyrethroid AIs are used significantly in spring wheat: chlorpyrifos, dimethoate and methyl parathion, which are all organophosphates. Chlorpyrifos is by far the most commonly used of these three, though for lepidopteran pests methyl parathion has a 21% share and dimethoate has 42% share for control of mites.

Based on these results, Spring Wheat Table 6 reports that chlorpyrifos captures more than 90% of the non-pyrethroid treated acres projected to replace pyrethroids for the non-pyrethroid scenario. Because the average number of applications reported in Spring Wheat Table 5 is larger for pyrethroids than these non-pyrethroid AIs, the total treated acres that replace these pyrethroids decreases. Spring Wheat Table 8 shows that the 1.52 million pyrethroid treated acres are replace by 1.36 million non-pyrethroid treated acres, so that insecticide treated acres decrease by almost 161,000 acres for the non-pyrethroid scenario. Of the 1.36 million non-pyrethroid treated acres added, 1.23 million are chlorpyrifos, with dimethoate and methyl parathion each adding less than 100,000 new treated acres for the non-pyrethroid scenario. Overall, these projected changes imply a 150% increase in organophosphate treated acres. Based on the results in Spring Wheat Table 10, the pounds of insecticide AI applied also increases 150% for the non-pyrethroid scenario, with 27,650 pounds of pyrethroids replaced with almost 500,000 pounds of organophosphates.

Given the replacement of pyrethroids with organophosphates, the figures are simplified. Spring Wheat Figure 1 is not presented, since the information is essentially the same as in Spring Wheat Figure 2, which shows the projected shift from pyrethroids to organophosphates for the non-pyrethroid scenario. As Spring Wheat Figure 3 shows, the organophosphate share of insecticide treated acres increases from 37% for the 2012-2014 average to 100% for the non-pyrethroid scenario.

The final tables report the cost impacts of the non-pyrethroid scenario. As Spring Wheat Table 9 shows, the costs of pyrethroids and organophosphates are very similar, with organophosphates slightly lower. Also, since the number of insecticide treated acres is projected to decrease under the non-pyrethroid scenario due to difference in the average number of applications (Spring Wheat Table 5). As a result, the overall cost impact under the non-pyrethroid scenario is negative. Spring Wheat Table 13 shows that the cost of the non-pyrethroid AIs is $4.7 million in aggregate, while pyrethroids cost almost $4.9 million in total. Similarly, while application costs are $10.1 million for the non-pyrethroid replacements, but $11.3 million for the pyrethroids since there are more pyrethroid treated acres. As a result, the projected total cost decrease for the non-pyrethroid scenario is $1.3 million. Based on the 2012-2014 average pyrethroid treated acres, this cost decrease represents a $0.87 per treated acre decrease, which is an 8% decrease in the cost of AI and application. On a planted acre basis, the estimated cost decrease is $0.11 per planted acre, since many spring wheat acres remain untreated with insecticides.

Spring Wheat Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	**Soil***	**Total**
Pyrethroids	1,517,493	---	1,517,493
Non-Pyrethroids	911,321	---	911,321
All AIs	2,428,814	---	2,428,814

*No soil-applied insecticides registered for use on spring wheat.

Spring Wheat Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		**Soil-Based Systems***	
	All AIs	**Pyrethroids**	**All AIs**	**Pyrethroids**
Initial Treated Acres	2,428,814	1,517,493	---	---
No Answer	18.6%	7.4%	---	---
Targeted at Specific Pests	81.4%	92.6%	---	---

*No soil-applied insecticides registered for use on spring wheat.

Spring Wheat Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based systems*

Target Pest	Chlorpyrifos	Dimethoate	Methyl Parathion
Aphids	86.6%	9.5%	3.9%
Beetles	100%	0%	0%
Hessian Flies	100%	0%	0%
Lepidopterans	79.0%	0%	21.0%
Midges	99.1%	0%	0.9%
Mites	59.1%	40.9%	0%
Orthopterans	100%	0%	0%
Sawflies	100%	0%	0%

*No soil-applied insecticides registered for use on spring wheat.

Spring Wheat Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based*
Aphids	51.1%	---
Beetles	3.0%	---
Hessian Flies	5.0%	---
Lepidopterans	6.5%	---
Midges	12.1%	---
Mites	2.0%	---
Orthopterans	15.7%	---
Sawflies	4.6%	---

*No soil-applied insecticides registered for use on spring wheat.

Spring Wheat Table 5. Average number of applications for each AI and ratios of these averages.

	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
Active Ingredient	Foliar-Based	Soil-Based*	Foliar:Foliar	Soil:Soil*
Chlorpyrifos	1.005	---	0.894	---
Dimethoate	1.000	---	0.890	---
Methyl Parathion	1.000	---	0.890	---
Pyrethroids	1.123	---	---	---

*No soil-applied insecticides registered for use on spring wheat.

Spring Wheat Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Beetles	Hessian Flies	Lepido-pterans	Midges	Mites	Orthopterans	Sawflies	Total	AI Weights
Chlorpyrifos	600,628	40,421	68,271	69,831	162,704	15,935	212,660	62,533	1,232,984	90.9%
Dimethoate	65,918	0	0	0	0	10,983	0	0	76,902	5.7%
Methyl Parathion	26,968	0	0	18,505	1,397	0	0	0	46,871	3.5%
Total	**693,515**	**40,421**	**68,271**	**88,337**	**164,101**	**26,918**	**212,660**	**62,533**	**1,356,756**	**100%**

Spring Wheat Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Table not needed since no soil-applied insecticides registered for use in spring wheat.

Spring Wheat Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

MOA	Active Ingredient	2012-2014 Average (Treated Acres)	Added (Treated Acres)	New Total (Treated Acres)	Change (Treated Acres)
1B	Chlorpyrifos	815,501	1,232,984	2,048,485	151%
1B	Dimethoate	57,578	76,902	134,480	134%
1B	Methyl Parathion	30,955	46,871	77,826	151%
	Total Non-Pyrethroids*	**904,034**	**1,356,756**	**2,260,790**	**150%**
	Total Pyrethroids	**1,517,493**	**-1,517,493**	**0**	**-100%**
	Total Treated with These AIs*	**2,421,527**	**-160,737**	**2,260,790**	**-6.6%**

MOA	Insecticide Class	2012-2014 Average (Treated Acres)	Added (Treated Acres)	New Total (Treated Acres)	Change (Treated Acres)
1B	Organophosphates	904,034	1,356,756	2,260,790	150%
	Total Non-Pyrethroids*	**904,034**	**1,356,756**	**2,260,790**	**150%**
	Total Pyrethroids	**1,517,493**	**-1,517,493**	**0**	**-100%**
	Total Treated with These AIs*	**2,421,527**	**-160,737**	**2,260,790**	**-6.6%**

*Does not match Spring Wheat Table 1 totals because totals here do not include minor use AIs.

Spring Wheat Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

MOA	Active Ingredient	Foliar Insecticide (Average Application Rate, Pounds per Treated Acre)	Soil Insecticide* (Average Application Rate, Pounds per Treated Acre)
1B	Chlorpyrifos	0.375	---
1B	Dimethoate	0.320	---
1B	Methyl Parathion	0.250	---

*No soil-applied insecticides registered for use on spring wheat.

Spring Wheat Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

MOA	Active Ingredient	2012-2014 Average (Pounds of Active Ingredient Applied)	Added (Pounds of Active Ingredient Applied)	New Total (Pounds of Active Ingredient Applied)	Change (Pounds of Active Ingredient Applied)
1B	Chlorpyrifos	306,111	462,819	768,930	151%
1B	Dimethoate	18,409	24,588	42,997	134%
1B	Methyl Parathion	7,739	11,718	19,457	151%
	Total	**332,259**	**499,125**	**831,384**	**150%**

MOA	Insecticide Class	2012-2014 Average (Pounds of Active Ingredient Applied)	Added (Pounds of Active Ingredient Applied)	New Total (Pounds of Active Ingredient Applied)	Change (Pounds of Active Ingredient Applied)
1B	Organophosphates	332,259	499,125	831,384	150%
	Total Non-Pyrethroids	**332,259**	**499,125**	**831,384**	**150%**
3A	**Pyrethroids**	**27,650**	**-27,650**	**0**	**-100%**
	Total	**359,909**	**471,475**	**831,384**	**131%**

Spring Wheat Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied*
Chlorpyrifos	$3.45	---
Dimethoate	$3.88	---
Methyl Parathion	$3.64	---
Non-Pyrethroid Average**	$3.49	---
Pyrethroid Average**	$3.20	---
Application Costs	**$7.46**	**---**

*No soil-applied insecticides registered for use on spring wheat.
**Average weighted by treated acres.

Spring Wheat Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	--------- Foliar-Based ---------			----------- Soil-Based* -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Chlorpyrifos	1,232,984	$3.45	$4,259,761	---	---	---
Dimethoate	76,902	$3.88	$298,586	---	---	---
Methyl Parathion	46,871	$3.64	$170,833	---	---	---
Total AI Cost	**1,356,756**	**$3.49**	**$4,729,179**	**---**	**---**	**---**
Application Cost	**1,356,756**	**$7.46**	**$10,121,400**	**---**	**---**	**---**

*No soil-applied insecticides registered for use on spring wheat.

Spring Wheat Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

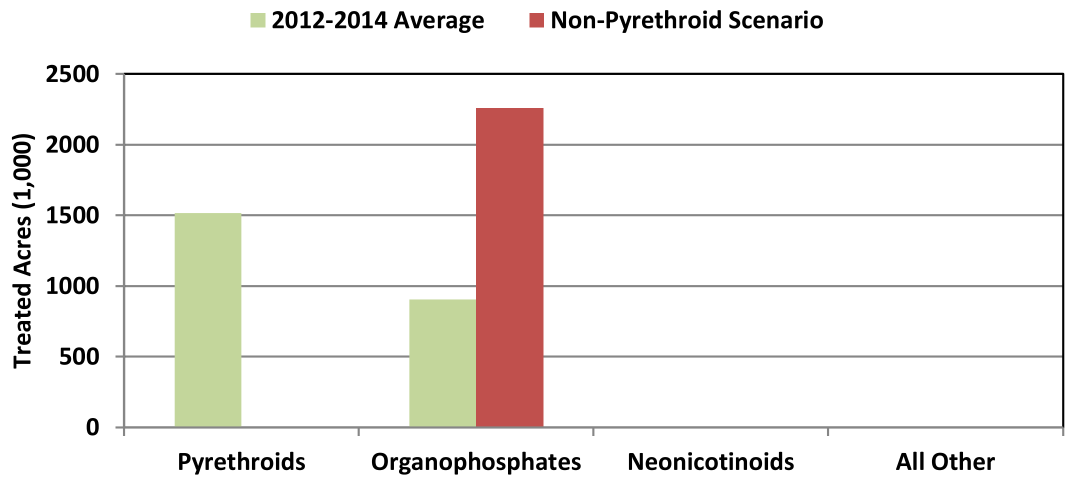
	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$4,850,175	$4,729,179	-$120,996
Foliar Application Costs	$11,320,495	$10,121,400	-$1,199,096
Soil AI Costs*			
Soil Application Costs*			
Total Costs	**$16,170,670**	**$14,850,579**	**-$1,320,091**
Net Change in Grower Expenditures ($/A)		**Acres**	**$/Acre**
Pyrethroid Treated Acres		1,517,493	-$0.87
Planted Acres		12,337,000	-$0.11

*No soil-applied insecticides registered for use on spring wheat.

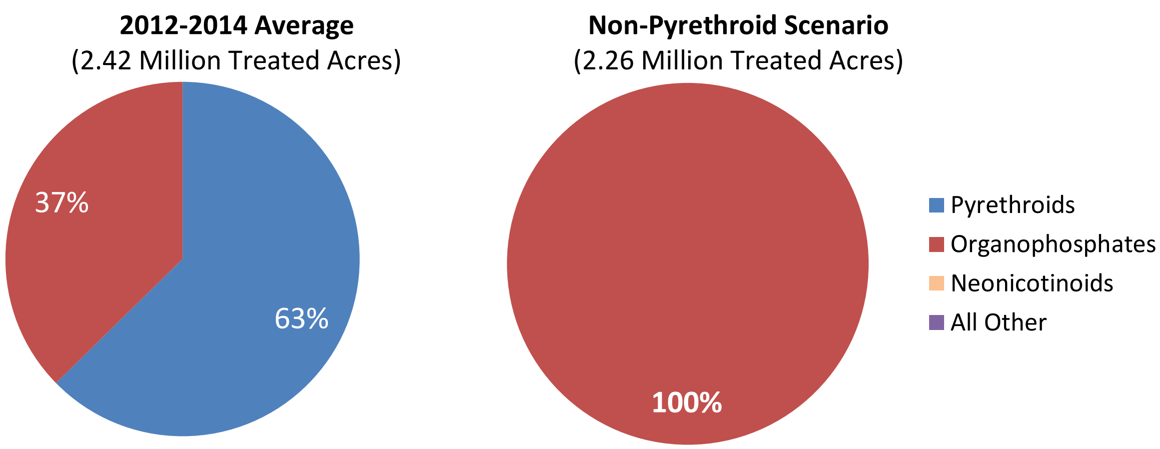
Spring Wheat Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.

Spring Wheat Figure 1 not presented as it is essentially the same as Spring Wheat Figure 2.

Spring Wheat Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Spring Wheat Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Spring Wheat Table 8).



5.9 Sugar beet

Sugar Beet Table 1 shows the use of both foliar-applied and soil-applied insecticides on the crop. Pyrethroids are the largest single foliar-applied insecticide class used in sugar beet, with 268,000 treated acres of the 532,000 total insecticide treated acres. For sugar beet, soil-applied insecticides are relatively important as well, with 321,000 total treated acres, but unlike foliar-applied insecticides, pyrethroids are a smaller component, constituting not quite 95,000 of the total. Sugar Beet Table 4 reports the shares of treated acres targeted at the different insect pests. For foliar systems, the main insect targets were lepidopteran pests with a 46% share of foliar-applied pyrethroid treated acres, with adult flies of the root maggot and leafminers also significant targets. In addition, several pests were minor but important targets, including aphids, flea beetles, leafhoppers, mites, orthopteran pests, root aphids, springtails and wireworms. For soil-applied pyrethroids, the main targets were wireworms and lepidopteran pests, each with about one third of the treated acres. Other minor but important pests included white grubs, springtails, larvae of the root maggot, mites, flea beetles, and whiteflies.

Sugar Beet Table 3 reports the share non-pyrethroid treated acres for each AI by target pest. For foliar-applied insecticides, chlorpyrifos is the only AI used to control all target pests expect lepidopterans and mites. For these two target pests, chlorpyrifos has the largest treated acre share, but other AIs are also used. For mites, chlorpyrifos has an 85% share, leaving one small shares for other AIs naled and hexythiazox, but for lepidopterans, the chlorpyrifos share is only 37%, while methoxyfenozide has a 34% share, while spinetoram, chlorantraniliprole and methomyl also have small shares. For soil-applied insecticides, chlorpyrifos is important for flea beetles and lepidopterans, but terbufos is more widely used, with a 100% share for mites and white grubs and large shares for lepidoperetans, root maggots, springtails, and wireworms. Imidacloprid has a 100% share for whiteflies and a 20% share for flea beetles.

Sugar Beet Tables 6 and 7 combine the target pest information and the AI shares by target pest to project the new added treated acres for each AI by target pest for the non-pyrethroid scenario. As expected, given its 100% shares for foliar use, chlorpyrifos has the largest projected increase for foliar-applied insecticides, adding 200,000 new treated acres of the 292,000 added in total, or 68% of the total added. Other large increases are almost 50,000 treated acres for methoxyfenozide and 24,000 for spinetoram. For soil-applied insecticides, of the almost 95,000 treated acre added, more than 74,000 are projected for terbufos, since it is the main non-pyrethroid alternative used for many of the target pests; chlorpyrifos is second in added acres with 16,000.

Sugar Beet Table 8 aggregates these added treated acres across target pests and foliar and soil applications to report the new treated acres for each AI and insecticide class, as well as the percentage increase from the 2012-2014 average. The non-pyrethroid scenario projects that 363,000 pyrethroid treated acres are replaced with 387,000 non-pyrethroid acres, implying an 80% increase in non-pyrethroid acres and almost a 3% increase in overall insecticide treated acres for sugar beets. For specific AIs the largest increases are for chlorpyrifos, which adds 216,000 treated acres, and terbufos with 74,000 added treated acres and methoxyfenozide with almost 50,000. When aggregated by insecticide class, organophosphates would add an estimated 291,000 treated acres for a 67% increase from the 2012-2014 average level. Based on the average application rates in Sugar Beet Table 9, Sugar Beet Table 10 reports the changes in pounds of AI applied for the non-pyrethroid scenario. Overall, the scenario projects that 6,700 pounds of pyrethroid AIs would be replaced by 256,000 pounds of non-pyrethroid AIs, mostly the organophosphates chlorpyrifos and terbufos. As a result, the total pounds of insecticide AI applied increases 57%, with organophosphates increasing by 62%.

Sugar Beet Figures 1 to 3 graphically summarize these results. Sugar Beet Figure 1 shows the dominance of organophosphates among the non-pyrethroids in terms of the number of treated acres. Many of the other insecticide classes also increase, but by far the largest increase is for organophosphates. In Sugar Beet Figure 2, this result is demonstrated as well, but the relative importance of pyrethroids is also evident based on the 2012-

2014 average. Sugar Beet Figure 3 shows the shares for the major insecticide classes. Pyrethroids had a 43% share of insecticide treated acres based on the 2012-2014 average, second only to organophosphates with a 51% share. For the non-pyrethroid scenario, the organophosphate share was projected to grow to 83%. Combining the neonicotinoid and other categories, the treated acre share for other inside classes was 6%, which is projected to increase to 17% for the non-pyrethroid scenario.

Sugar Beet Table 12 reports the estimated cost for adding these new non-pyrethroid treated acres to replace pyrethroids, focusing on costs for the replacement AIs and application costs. For foliar-applied AIs, the cost would be an estimated $4.1 million for the replacement AIs, plus $2.2 million for applications. For the foliar AI costs, chlorpyrifos has the largest component at $1.5 million due to the large number of added treated acres, but second is spinetoram with $1.3 million because of it relatively high average cost per treated acre. For soil-applied insecticides, the cost for the non-pyrethroid AIs to replace the pyrethroids is an estimated $1.6 million, with $1.3 million for terbufos and almost $200,000 for chlorpyrifos. Because of the low application cost per acre and the small number of treated acres, the application costs are an estimated $294,000 for the soil-applied AIs. Finally, Sugar Beet Table 13 combines these results with the avoided costs with no longer needing to buy and apply pyrethroids to estimate the cost impact of the non-pyrethroid scenario. Small increase in application costs are projected for both soil and foliar systems due to the small increase in treated acres in each system, however the main cost increase is due to the more costly non-pyrethroid AIs to replace pyrethroids. The estimated cost for pyrethroid AIs and their application is almost $3.9 million, while the total costs for replacement, non-pyrethroid, AIs and their application is $8.1 million, for an increase of $4.2 million. Based on the 363,000 pyrethroid treated acres, this projected cost increase averages $11.69 per pyrethroid treated acre. Given the almost 1.2 million planted acres, the average cost impact for replacing pyrethroid AIs with non-pyrethroid alternatives is $3.55 per planted acre.

Sugar Beet Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	**Soil**	**Total**
Pyrethroids	268,446	94,539	362,985
Non-Pyrethroids	263,789	226,804	490,593
All AIs	532,234	321,343	853,578

Sugar Beet Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		**Soil-Based Systems**	
	All AIs	**Pyrethroids**	**All AIs**	**Pyrethroids**
Initial Treated Acres	532,234	268,446	321,343	94,539
No Answer	3.1%	3.1%	7.6%	7.5%
Targeted at Specific Pests	96.9%	96.9%	92.4%	92.5%

Sugar Beet Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based and soil-based systems

	---------- Foliar-Based Systems ----------										
Active Ingredient	**Aphids**	**Flea Beetles**	**Root Maggot Adult Flies**	**Leaf-hoppers**	**Leaf-miners**	**Lepido-pterans**	**Mites**	**Ortho-pterans**	**Root Aphids**	**Spring-tails**	**Wire-worms**
Chloran-traniliprole	0.0%	0.0%	0.0%	0.0%	0.0%	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%
Chlorpyrifos	100%	100%	100%	100%	100%	37.0%	84.7%	100%	100%	100%	100%
Hexythiazox	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.4%	0.0%	0.0%	0.0%	0.0%
Methomyl	0.0%	0.0%	0.0%	0.0%	0.0%	7.9%	0.0%	0.0%	0.0%	0.0%	0.0%
Methoxy-fenozide	0.0%	0.0%	0.0%	0.0%	0.0%	34.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Naled	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.9%	0.0%	0.0%	0.0%	0.0%
Spinetoram	0.0%	0.0%	0.0%	0.0%	0.0%	12.4%	0.0%	0.0%	0.0%	0.0%	0.0%

	----------Soil-Based Systems----------							
Active Ingredient	**Flea Beetles**	**Lepido-pterans**	**Mites**	**Root Maggots**	**Spring -tails**	**White Grubs**	White-flies	Wire-worms
Chlorpyrifos	80.2%	36.2%	0.0%	6.5%	2.0%	0.0%	0.0%	4.1%
Imidacloprid	19.8%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
Phorate	0.0%	0.0%	0.0%	5.6%	0.0%	0.0%	0.0%	0.0%
Spinetoram	0.0%	6.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Terbufos	0.0%	56.9%	100.0%	87.9%	98.0%	100.0%	0.0%	95.9%

Sugar Beet Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based
Aphid	3.7%	---
Flea Beetle	3.3%	2.5%
Root Maggot Adult Fly	15.9%	---
Leafhopper	3.2%	---
Leafminer	12.5%	---
Lepidopteran	46.4%	34.6%
Mite	1.6%	3.0%
Orthopteran	3.1%	---
Root Aphid	1.9%	---
Root Maggot Larvae	---	7.8%
Springtail	4.9%	7.8%
White Grub	---	8.1%
Whitefly	---	1.1%
Wireworm	3.5%	35.1%

Sugar Beet Table 5. Average number of applications for each AI and ratios of these averages.

Active Ingredient	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
	Foliar-Based	Soil-Based	Foliar:Foliar	Soil:Soil
Chlorantraniliprole	1.106	---	0.942	---
Chlorpyrifos	1.239	1.030	1.055	1.027
Hexythiazox	1.000	---	0.851	---
Imidacloprid	---	1.000	---	0.996
Methomyl	1.000	---	0.851	---
Methoxyfenozide	1.367	---	1.164	---
Naled	1.000	---	0.851	---
Phorate	---	1.000	---	0.996
Spinetoram	1.835	1.000	1.562	0.996
Terbufos	---	1.000	---	0.996
Pyrethroids	1.174	1.004	---	---

Sugar Beet Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Flea Beetles	Root Mag-got Adult Flies	Leaf-hopper	Leaf-miners	Lepido-pterans	Mites	Orth-opter ans	Root Aphids	Spring -tails	Wire-worm	Total	AI Weight
Chloran-traniliprole	0	0	0	0	0	10,143	0	0	0	0	0	10,143	3.5%
Chlorpyrifo s	10,335	9,255	44,885	9,016	35,469	48,662	3,887	8,801	5,383	13,939	9,939	199,572	68.3%
Hexythiazo x	0	0	0	0	0	0	162	0	0	0	0	162	0.1%
Methomyl	0	0	0	0	0	8,342	0	0	0	0	0	8,342	2.9%
Methoxy-fenozide	0	0	0	0	0	49,486	0	0	0	0	0	49,486	16.9%
Naled	0	0	0	0	0	0	404	0	0	0	0	404	0.1%
Spinetoram	0	0	0	0	0	24,148	0	0	0	0	0	24,148	8.3%
Total	**10,335**	**9,255**	**44,885**	**9,016**	**35,469**	**140,781**	**4,454**	**8,801**	**5,383**	**13,939**	**9,939**	**292,257**	**100%**

Sugar Beet Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Active Ingredient	Flea Beetles	Lepido-pterans	Mites	Root Maggots	Spring-ails	White Grubs	White-flies	Wire-worms	Total	AI Weights
Chlorpyrifos	1,970	12,169	0	494	155	0	0	1,400	16,188	17.1%
Imidacloprid	471	0	0	0	0	0	1,016	0	1,487	1.6%
Phorate	0	0	0	414	0	0	0	0	414	0.4%
Spinetoram	0	2,235	0	0	0	0	0	0	2,235	2.4%
Terbufos	0	18,544	2,830	6,484	7,217	7,607	0	31,670	74,354	78.5%
Total	**2,442**	**32,948**	**2,830**	**7,392**	**7,372**	**7,607**	**1,016**	**33,071**	**94,678**	**100%**

Sugar Beet Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

MOA	Active Ingredient	Treated Acres: 2012-2014 Average	Added	New Total	Change
28	Chlorantraniliprole	6,379	10,143	16,521	159%
1B	Chlorpyrifos	249,671	215,760	465,431	86.4%
10A	Hexythiazox	414	162	576	39.2%
4A	Imidacloprid	13,570	1,487	15,057	11.0%
1A	Methomyl	10,862	8,342	19,204	76.8%
18A	Methoxyfenozide	16,217	49,486	65,703	305%
1B	Naled	1,031	404	1,435	39.2%
1B	Phorate	7,699	414	8,114	5.4%
5	Spinetoram	5,808	26,383	32,191	454%
1B	Terbufos	174,301	74,354	248,654	42.7%
	Total Non-Pyrethroids*	**485,952**	**386,935**	**872,887**	**79.6%**
	Total Pyrethroids	**362,985**	**-362,985**	**0**	**-100%**
	Total Treated with These AIs*	**848,936**	**23,950**	**872,887**	**2.8%**

MOA	Insecticide Class	Treated Acres: 2012-2014 Average	Added	New Total	Change
5	Spinosyns	5,808	26,383	32,191	454%
28	Diamides	6,379	10,143	16,521	159%
10A/B	Mite Growth Inhibitors	414	162	576	39.2%
18A	Diacylhydrazines	16,217	49,486	65,703	305%
1A	Carbamates	10,862	8,342	19,204	76.8%
1B	Organophosphates	432,702	290,932	723,634	67.2%
4A	Neonicotinoids	13,570	1,487	15,057	11.0%
	Total Non-Pyrethroids*	**485,952**	**386,935**	**872,887**	**79.6%**
	Total Pyrethroids	**362,985**	**-362,985**	**0**	**-100%**
	Total Treated with These AIs*	**848,936**	**23,950**	**872,887**	**2.8%**

*Does not match Sugar Beet Table 1 totals because totals here do not include minor use AIs.

Sugar Beet Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

MOA	Active Ingredient	Average Application Rate (Pounds per Treated Acre): Foliar Insecticide	Soil Insecticide
28	Chlorantraniliprole	0.053	---
1B	Chlorpyrifos	0.683	1.023
10A	Hexythiazox	0.050	---
4A	Imidacloprid	---	0.107
1A	Methomyl	0.587	---
18A	Methoxyfenozide	0.103	---
1B	Naled	0.938	---
1B	Phorate	---	1.290
5	Spinetoram	0.047	0.036
1B	Terbufos	---	1.212

Sugar Beet Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	Active Ingredient	2012-2014 Average	Added	New Total	Change
28	Chlorantraniliprole	5,486	542	6,029	9.9%
1B	Chlorpyrifos	181,940	152,848	334,788	84.0%
10A	Hexythiazox	414	8	422	2.0%
4A	Imidacloprid	1,458	160	1,618	11.0%
1A	Methomyl	10,862	4,893	15,755	45.0%
18A	Methoxyfenozide	16,217	5,084	21,301	31.3%
1B	Naled	1,031	379	1,410	36.8%
1B	Phorate	6,632	534	7,166	8.1%
5	Spinetoram	239	1,211	1,450	506%
1B	Terbufos	202,999	90,123	293,122	44.4%
	Total	**427,279**	**255,781**	**683,060**	**59.9%**

		Pounds of Active Ingredient Applied			
MOA	Insecticide Class	2012-2014 Average	Added	New Total	Change
5	Spinosyns	239	1,211	1,450	506%
28	Diamides	5,486	542	6,029	9.9%
10A/B	Mite Growth Inhibitors	414	8	422	2.0%
18A	Diacylhydrazines	16,217	5,084	21,301	31.3%
1A	Carbamates	10,862	4,893	15,755	45.0%
1B	Organophosphates	392,602	243,884	636,486	62.1%
4A	Neonicotinoids	1,458	160	1,618	11.0%
	Total Non-Pyrethroids	**427,279**	**255,781**	**683,060**	**59.9%**
3A	**Pyrethroids**	**6,676**	**-6,676**	**0**	**-100%**
	Total	**433,955**	**249,105**	**683,060**	**57.4%**

Sugar Beet Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied
Chlorantraniliprole	$34.05	---
Chlorpyrifos	$7.67	$12.24
Hexythiazox	$12.79	---
Imidacloprid	---	$12.91
Methomyl	$15.29	---
Methoxyfenozide	$15.35	---
Naled	$11.50	---
Phorate	---	$16.46
Spinetoram	$53.44	$23.58
Terbufos	---	$17.34
Non-Pyrethroid Average*	$13.90	$16.55
Pyrethroid Average*	$4.24	$4.48
Application Costs	**$7.46**	**$3.11**

*Average weighted by treated acres.

Sugar Beet Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

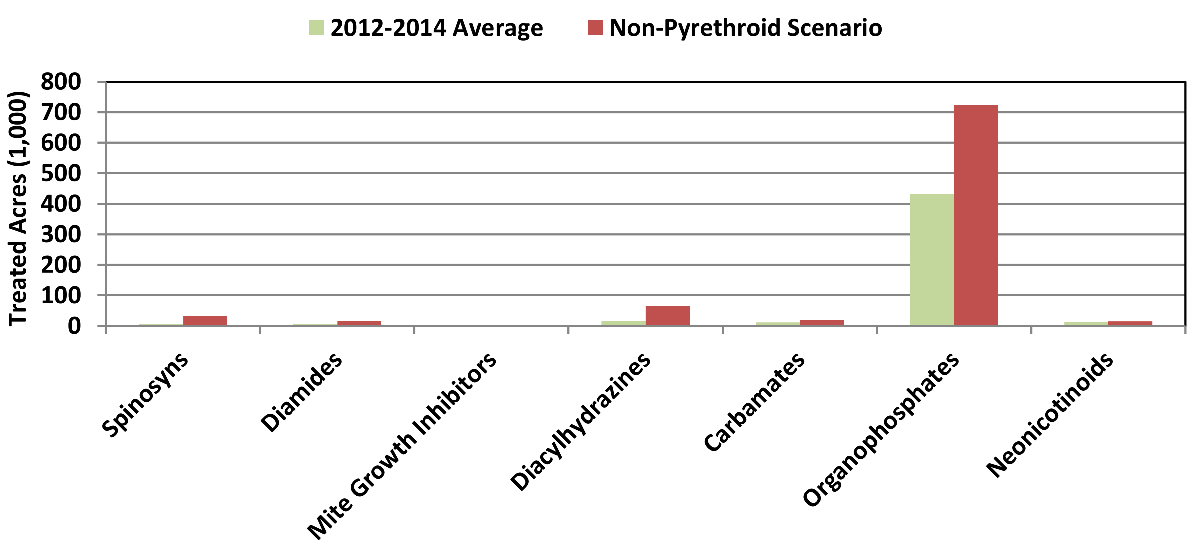
	--------- Foliar-Based ---------			----------- Soil-Based -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Chlorantraniliprole	10,143	$34.05	$345,379	---	---	---
Chlorpyrifos	199,572	$7.67	$1,531,590	16,188	$12.24	$198,134
Hexythiazox	162	$12.79	$2,076			
Imidacloprid				1,487	$12.91	$19,199
Methomyl	8,342	$15.29	$127,587	---	---	---
Methoxyfenozide	49,486	$15.35	$759,485	---	---	---
Naled	404	$11.50	$4,647	---	---	---
Phorate	---	---	---	414	$16.46	$6,819
Spinetoram	24,148	$53.44	$1,290,461	2,235	$23.58	$52,703
Terbufos	---	---	$0	74,354	$17.34	$1,289,406
Total AI Cost	**292,257**	**$13.90**	**$4,061,225**	**94,678**	**$16.54**	**$1,566,262**
Application Cost	**292,257**	**$7.46**	**$2,180,239**	**94,678**	**3.11**	**$294,447**

Sugar Beet Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

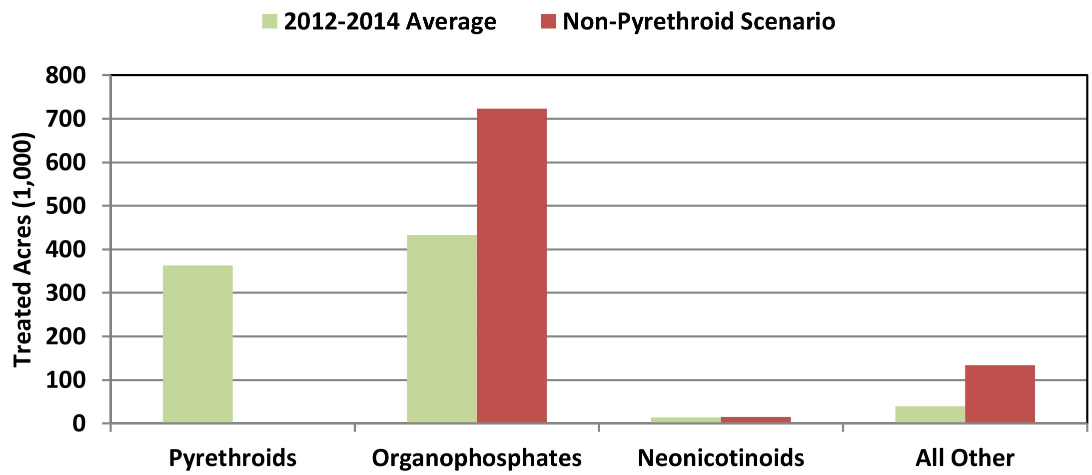
	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$1,137,157	$4,061,225	$2,924,068
Foliar Application Costs	$2,002,605	$2,180,239	$177,635
Soil AI Costs	$423,368	$1,566,262	$1,142,894
Soil Application Costs	$294,016	$294,447	$431
Total Costs	**$3,857,146**	**$8,102,174**	**$4,245,028**

Net Change in Grower Expenditures ($/A)	**Acres**	**$/Acre**
Pyrethroid Treated Acres	362,985	$11.69
Planted Acres	1,196,667	$3.55

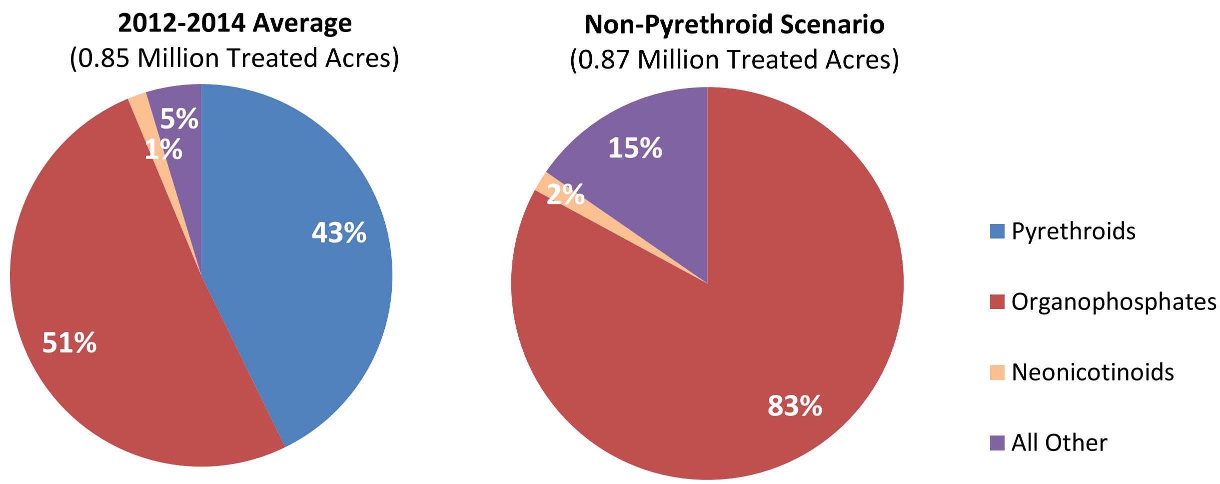
Sugar Beet Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Sugar Beet Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Sugar Beet Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Sugar Beet Table 8).



5.10 Sunflower

Sunflower Table 1 indicates that only foliar insecticides were used on sunflower, with pyrethroids constituting most of these – of the almost 1.7 million total insecticide treated acres, 1.4 were pyrethroids (not including insecticidal seed treatments). Sunflower Table 4 shows that about half of these pyrethroid applications were targeted at weevils and a third at lepidopteran insects, with grasshoppers and other orthopteran insects and beetles being the remaining insect targets. Based on Sunflower Table 3, five non-pyrethroid AIs were used for insect management in sunflower, with chlorpyrifos the most commonly used non-pyrethroid across all major insect pests. As a result, Sunflower Table 6 shows that chlorpyrifos is projected to constitute about 85% of the treated acres replacing pyrethroids for the non-pyrethroid scenario.

Based on the average number of applications (Sunflower Table 5) and the AI shares (Sunflower Table 6), Sunflower Table 8 reports the projected new treated acres and percentage increases for the non-pyrethroid scenario. The largest changes in absolute terms are for chlorpyrifos, which increases from almost 200,000 treated acres to almost 1.5 million, a 646% increase. Projected treated acres added for the other AIs are much smaller in absolute terms, though all show large projected increases in terms of percentage changes from the 2012-2014 average. Not surprisingly, when aggregated by insecticide class, the largest change is for organophosphates, mostly driven by the large projected increases in chlorpyrifos treated acres, with dimethoate adding a small number of treated acres. Organophosphates are estimated to add more than 1.3 million new treated acres for the non-pyrethroid scenario to the 200,000 treated acres they average for 20120-2014, or a 652% increase. Based on the average application rates in Sunflower Table 9 and the projected new treated acres, the total pounds of insect AIs applied would increase by 625% for the non-pyrethroid scenario. As Sunflower Table 10 shows, 31,000 pounds of pyrethroids would be replaced by 494,000 pounds of non-pyrethroids.

Sunflower Figures 1 to 3 illustrate these results graphically. Sunflower Figures 1 and show the projected shift from relying primarily on pyrethroids to relying primarily on organophosphates for the non-pyrethroid scenario. Sunflower Figure 3 shows how the 2012-2014 average insecticide treated acres are 86% pyrethroids, while for the non-pyrethroid scenario, the projected organophosphate share is 88%. Though not shown explicitly, diamides would constitute almost all of the non-organophosphate share for the non-pyrethroid scenario.

Sunflower Table 12 uses the projected new treated acres and average per acre costs for each AI to estimate the costs for non-pyrethroid AIs to replace pyrethroids for the non-pyrethroid scenario. The projected total cost for non-pyrethroid AIs is more than $9.7 million, with almost $6.4 for chlorpyrifos. The next largest cost contributor is chlorantraniliprole at $2.6 million, mostly due to its average cost of more than $20 per acre, which is almost $10 per acre more than the next most costly AI. Application costs for these non-pyrethroid acres are an estimated $11.2 million. Sunflower Table 13 combines all this information to estimate the net cost impact of the non-pyrethroid scenario. Estimated total costs for the 2012-2014 average use and application of pyrethroid insecticides is $15.7 million, while the AI and application costs for the non-pyrethroids to replace them is $20.9 million, so that in net, costs increase by an estimated $5.2 million. Based on the 1.4 million pyrethroid treated acres, this is an average cost increase of $3.64 per acre treated, while on a planted acre basis, this cost increase is $3.09 per planted acre.

Sunflower Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	Soil*	Total
Pyrethroids	1,428,502	---	1,428,502
Non-Pyrethroids	246,231	---	246,231
All AIs	1,674,733	---	1,674,733

*No soil-applied insecticides registered for use on sunflowers.

Sunflower Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		Soil-Based Systems*	
	All AIs	**Pyrethroids**	**All AIs**	**Pyrethroids**
Initial Treated Acres	1,674,733	1,428,502	---	---
No Answer	4.2%	4.2%	---	---
Targeted at Specific Pests	95.8%	95.8%	---	---

*No soil-applied insecticides registered for use on sunflowers.

Sunflower Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based systems*

	----------------------- Foliar-Based Systems -----------------------			
Active Ingredient	**Beetles**	**Lepidopterans**	**Orthopterans**	**Weevils**
Bacillus thuringiensis	0.0%	0.0%	0.0%	3.1%
Carbaryl	9.0%	0.0%	0.0%	1.8%
Chlorantraniliprole	0.0%	26.0%	0.0%	0.0%
Chlorpyrifos	91.0%	67.8%	100.0%	92.7%
Dimethoate	0.0%	6.2%	0.0%	2.5%

*No soil-applied insecticides registered for use on sunflowers.

Sunflower Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based*
Beetles	7.7%	---
Lepidopterans	33.2%	---
Orthopterans	10.0%	---
Weevils	49.2%	---

*No soil-applied insecticides registered for use on sunflowers.

Sunflower Table 5. Average number of applications for each AI and ratios of these averages.

	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
Active Ingredient	**Foliar-Based**	**Soil-Based***	**Foliar:Foliar**	**Soil:Soil***
Bacillus thuringiensis	1.000	---	0.866	---
Carbaryl	1.000	---	0.866	---
Chlorantraniliprole	1.207	---	1.046	---
Chlorpyrifos	1.201	---	1.041	---
Dimethoate	1.578	---	1.368	---
Pyrethroids	1.154	---	---	---

*No soil-applied insecticides registered for use on sunflowers.

Sunflower Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Beetles	Lepidopterans	Orthopterans	Weevils	Total	AI Weights
Bacillus thurin.	0	0	0	18,691	18,691	1.2%
Carbaryl	8,558	0	0	10,732	19,289	1.3%
Chlorantraniliprole	0	128,980	0	0	128,980	8.6%
Chlorpyrifos	103,607	334,397	148,788	677,438	1,264,229	84.5%
Dimethoate	0	40,267	0	23,834	64,101	4.3%
Total	**112,164**	**503,644**	**148,788**	**730,694**	**1,495,290**	**100%**

Sunflower Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Table not needed since no soil-applied insecticides registered for use in sunflowers.

Sunflower Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
11A	Bacillus thuringiensis	3,278	18,691	21,969	570%
1A	Carbaryl	6,024	19,289	25,313	320%
28	Chlorantraniliprole	27,827	128,980	156,807	464%
1B	Chlorpyrifos	195,739	1,264,229	1,459,968	646%
1B	Dimethoate	7,904	64,101	72,005	811%
	Total Non-Pyrethroids*	**240,772**	**1,495,290**	**1,736,062**	**621%**
	Total Pyrethroids	**1,428,502**	**-1,428,502**	**0**	**-100%**
	Total Treated with These AIs*	**1,669,274**	**66,788**	**1,736,062**	**4.0%**
		------------- Treated Acres -------------			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
28	Diamides	27,827	128,980	156,807	464%
11A	Microbial Disruptors	3,278	18,691	21,969	570%
1A	Carbamates	6,024	19,289	25,313	320%
1B	Organophosphates	203,643	1,328,330	1,531,973	652%
	Total Non-Pyrethroids*	**240,772**	**1,495,290**	**1,736,062**	**621%**
	Total Pyrethroids	**1,428,502**	**-1,428,502**	**0**	**-100%**
	Total Treated with These AIs*	**1,669,274**	**66,788**	**1,736,062**	**4.0%**

*Does not match Sunflower Table 1 totals because totals here do not include minor use AIs.

Sunflower Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	**Active Ingredient**	**Foliar Insecticide**	**Soil Insecticide***
11A	Bacillus thuringiensis	0.037	---
1A	Carbaryl	1.000	---
28	Chlorantraniliprole	0.050	---
1B	Chlorpyrifos	0.350	---
1B	Dimethoate	0.395	---

*No soil-applied insecticides registered for use on sunflowers.

Sunflower Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

MOA	Active Ingredient	Pounds of Active Ingredient Applied 2012-2014 Average	Added	New Total	Change
11A	Bacillus thuringiensis	120	682	802	570%
1A	Carbaryl	6,024	19,289	25,313	320%
28	Chlorantraniliprole	1,394	6,460	7,853	464%
1B	Chlorpyrifos	68,300	442,120	510,419	647%
1B	Dimethoate	3,122	25,316	28,438	811%
	Total	**78,958**	**493,868**	**572,826**	**625%**

MOA	Insecticide Class	Pounds of Active Ingredient Applied 2012-2014 Average	Added	New Total	Change
28	Diamides	1,394	6,460	7,854	464%
11A	Microbial Disruptors	120	582	702	486%
1A	Carbamates	6,024	19,289	25,313	320%
1B	Organophosphates	71,421	467,436	538,857	654%
	Total Non-Pyrethroids	**78,958**	**493,868**	**572,826**	**625%**
3A	**Pyrethroids**	**30,693**	**-30,693**	**0**	**-100%**
	Total	**109,651**	**463,075**	**572,726**	**422%**

Sunflower Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied*
Bacillus thuringiensis	$4.16	---
Carbaryl	$10.18	---
Chlorantraniliprole	$20.11	---
Chlorpyrifos	$5.02	---
Dimethoate	$7.67	---
Non-Pyrethroid Average**	$6.49	---
Pyrethroid Average**	$3.51	---
Application Costs	**$7.46**	**---**

*No soil-applied insecticides registered for use on sunflowers.
**Average weighted by treated acres.

Sunflower Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

Active Ingredient	--------- Foliar-Based --------- Added Acres	Cost ($/A)	Total Cost ($)	----------- Soil-Based* ----------- Added Acres	Cost ($/A)	Total Cost ($)
Bacillus thuringiensis	18,691	$4.16	$77,687	---	---	---
Carbaryl	19,289	$10.18	$196,441	---	---	---
Chlorantraniliprole	128,980	$20.11	$2,593,395	---	---	---
Chlorpyrifos	1,264,229	$5.02	$6,352,721	---	---	---
Dimethoate	64,101	$7.67	$491,592	---	---	---
Total AI Cost	1,495,290	$6.49	$9,711,835	---	---	---
Application Cost	**1,495,290**	**$7.46**	**$11,154,863**	**---**	**---**	**---**

*No soil-applied insecticides registered for use on sunflowers.

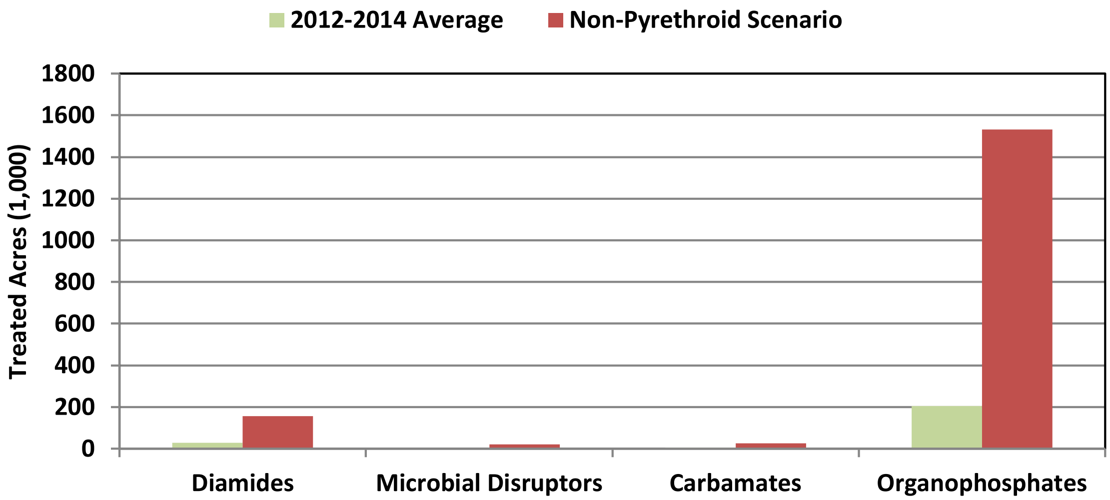
Sunflower Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

	Avoided Expenditures from 2012-2014 Average	New Expenditures for the Non-Pyrethroid Scenario	Net Change in Farmer Expenditures
Foliar AI Costs	$5,008,165	$9,711,835	$4,703,669
Foliar Application Costs	$10,656,627	$11,154,863	$498,235
Soil AI Costs*	---	---	---
Soil Application Costs*	---	---	---
Total Costs	**$15,664,793**	**$20,866,697**	**$5,201,905**

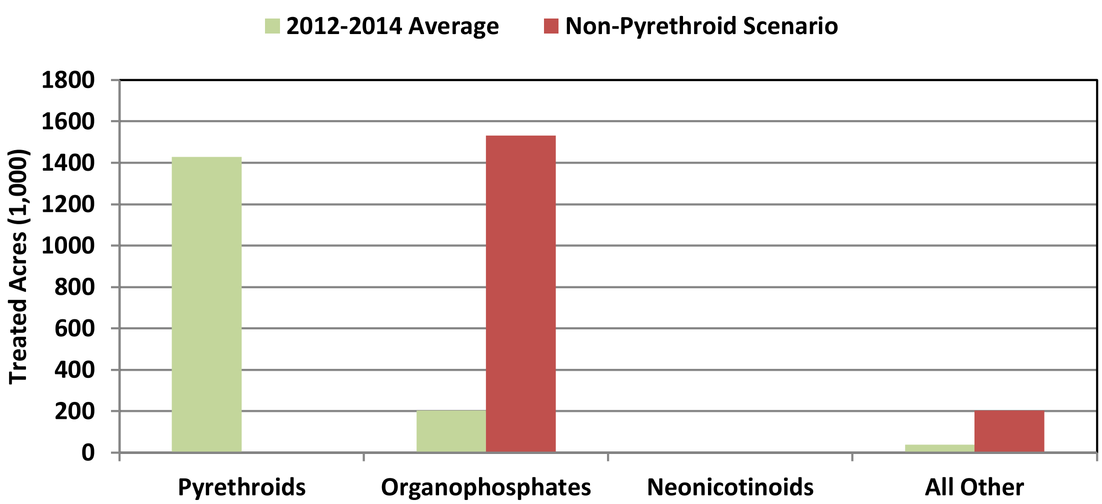
Net Change in Grower Expenditures ($/A)	Acres	$/Acre
Pyrethroid Treated Acres	1,428,502	$3.64
Planted Acres	1,685,667	$3.09

*No soil-applied insecticides registered for use on sunflowers.

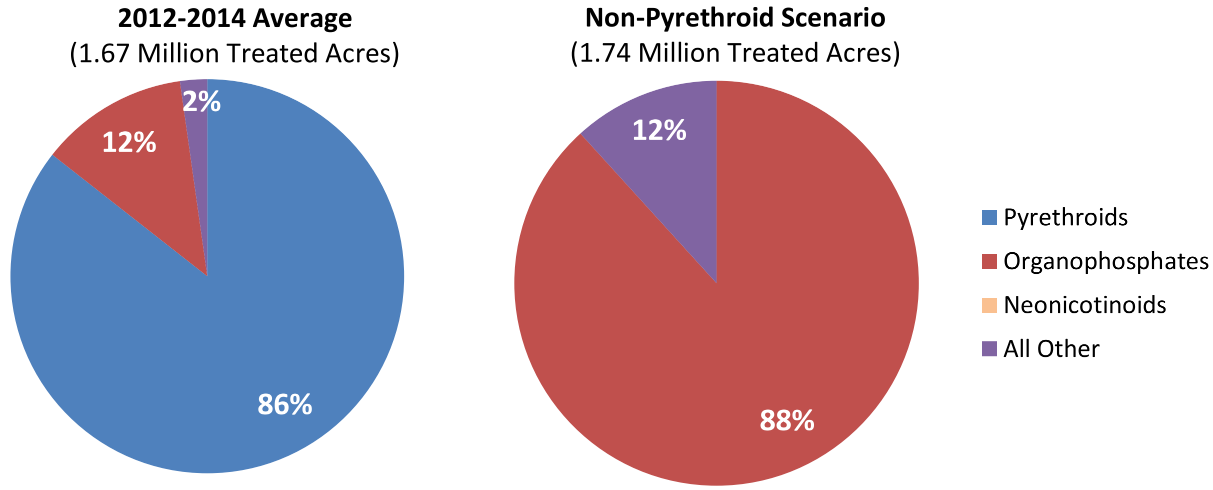
Sunflower Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Sunflower Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Sunflower Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Sunflower Table 8).



5.11 Sweet corn

Sweet Corn Table 1 indicates that only foliar insecticides were used to manage insect pests in sweet corn. The 2012-2014 average was 1.9 million pyrethroid treated acres in sweet corn, with 1.0 million of other non-pyrethroid AIs, so that in total, the insecticide treated acres round up to 3.0 million acres. Based on Sweet Corn Table 4, lepidopteran insect pests are the target of more than 80% of these treated acres, with corn rootworm adults, aphids and Japanese beetles each minor insect targets with treated acre shares ranging from 6% to 8%. Sweet Corn Table 3 shows five non-pyrethroids with significant use for 2012-2014, with methomyl the most commonly used for lepidopteran pests and aphids by a large margin, while chlorpyrifos is the primary AI used for corn rootworm adults and carbaryl for Japanese beetles. Chlorantraniliprole and spinetoram have significant but small market shares for lepidopteran pests.

Sweet Corn Table 6 reports the treated acres added for these five AIs for the non-pyrethroid scenario. Aggregating across the four main insect target pests, methomyl is projected to capture almost two-thirds of the added non-pyrethroid treated acres, while chlorantraniliprole and spinetoram each have around a 10% share of the new added treated acres. Sweet Corn Table 8 aggregates all treated acres by AI and insecticide class added for the non-pyrethroid scenario. Overall, more than 1.9 million pyrethroid treated acres are replaced with non-pyrethroid alternative for the non-pyrethroid scenario. Almost 1.3 million new treated acres are projected for methomyl, with all other AIs adding less than 215,000 treated acres. Given the increased use of methomyl and carbaryl, when aggregated by insecticide class, carbamates increase by almost t1.4 million acres, or more than 1,900%. For the other insecticide classes, projected treated acre increases were more modest – ranging from 215,000 for organophosphates to 140,000 for diamides. Based on average application rates, Sweet Corn Table 10 reports the projected changes in pounds of AI used. The non-pyrethroid scenario replaces 88,000 pounds of pyrethroids with

791,000 pounds of non-pyrethroid AIs, consisting mostly of methomyl, chlorpyrifos and carbaryl, generating a 269% increase in pounds of AI applied.

Sweet Corn Figures 1 to 3 reports these results graphically. Sweet Corn Figures 1 and 2 show the importance of pyrethroids for sweet corn insect management and the projected large shift to carbamates for the non-pyrethroid scenario, with spinosyns maintaining a significant portion of insecticide treated acres. Sweet corn Figure 3 shows the importance of pyrethroids in sweet corn insect management and the projected shift to insecticide classes other than organophosphates and neonicotinoids, namely carbamates, spinosyns, and diamides that in Sweet Corn Figure 3 are combined into the other category.

Sweet Corn Table 12 combines the predicted increases in treated acres and average per acre costs for the AIs to estimate the costs for the non-pyrethroid AIs and their application. The total projected cost for the non-pyrethroid replacement AIs is $25.2 million, with methomyl generating $13.2 million in added costs. Spinetoram and chlorantraniliprole generate $4.4 million and $3.8 million, respectively, mostly due to the high per acre costs relative to the other AIs – chlorantraniliprole had an average cost of $27 per acre and more than $22 per are for spinetoram, while the other AIs were in the $10-$11 per are range. Finally, projected application costs for the non-pyrethroid scenario were $14.5 million. Sweet Corn Table 213 combine and the cost results to estimate the net cost impact of the non-pyrethroid scenario. The average cost of the 2012-2014 average use was an estimated $9.0 million for AI costs and $14.5 million for application costs. For the non-pyrethroid scenario, insecticide treated acres remained the same, so application costs are also $14.5 million, but AI costs increased to $25.1 million of the replacement non-pyrethroid AIs. As a result, the net cost increase for the non-pyrethroid scenario was an estimated $16.2 million for sweet corn growers. This cost increase represents a 69% increase in the cost of insecticide AIs and application for those spring wheat farmers treating for insects, increasing from $12.08 per treated acre to $20.40 per treated acre. Given the 1.9 million pyrethroid treated acres for sweet corn, the average cost increase is $8.32 per treated acre, but since multiple application are made per planted acre, the average cost is $28.05 per sweet corn planted acre.

Sweet Corn Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	Soil*	Total
Pyrethroids	1,942,574	---	1,942,574
Non-Pyrethroids	1,011,183	---	1,011,183
All AIs	2,953,757	---	2,953,757

*No soil-applied insecticides registered for use on sweet corn.

Sweet Corn Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		Soil-Based Systems*	
	All AIs	Pyrethroids	All AIs	Pyrethroids
Initial Treated Acres	1,011,183	1,942,574	---	---
No Answer	0.3%	0.4%	---	---
Targeted at Specific Pests	99.7%	99.6%	---	---

*No soil-applied insecticides registered for use on sweet corn.

Sweet Corn Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based systems*

Active Ingredient	Foliar-Based Systems: Aphids	Adult Corn Rootworm	Japanese Beetles	Lepidopterans
Carbaryl	0.0%	0.4%	100.0%	0.7%
Chlorantraniliprole	0.0%	0.0%	0.0%	9.0%
Chlorpyrifos	8.7%	98.6%	0.0%	3.2%
Methomyl	91.3%	1.0%	0.0%	74.5%
Spinetoram	0.0%	0.0%	0.0%	12.6%

*No soil-applied insecticides registered for use on sweet corn.

Sweet Corn Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based*
Aphids	6.0%	---
Adult Corn Rootworm	8.1%	---
Japanese Beetles	5.7%	---
Lepidopterans	80.2%	---

*No soil-applied insecticides registered for use on sweet corn.

Sweet Corn Table 5. Average number of applications for each AI and ratios of these averages.

	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
Active Ingredient	Foliar-Based**	Soil-Based*	Foliar:Foliar	Soil:Soil*
Carbaryl	1.000	---	1.000	---
Chlorantraniliprole	1.000	---	1.000	---
Chlorpyrifos	1.000	---	1.000	---
Methomyl	1.000	---	1.000	---
Spinetoram	1.000	---	1.000	---
Pyrethroids	1.000	---	---	---

*No soil-applied insecticides registered for use on sweet corn.
**Ratio of treated acres to treated acres used, not base acres to treated acres.

Sweet Corn Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Adult Corn Rootworm	Japanese Beetles	Lepido-pterans	Total	AI Weights
Carbaryl	0	597	110,497	10,366	121,459	6.3%
Chlorantraniliprole	0	0	0	140,204	140,204	7.2%
Chlorpyrifos	10,135	154,658	0	50,116	214,909	11.1%
Methomyl	106,354	1,577	0	1,161,697	1,269,629	65.4%
Spinetoram	0	0	0	196,373	196,373	10.1%
Total	**116,489**	**156,832**	**110,497**	**1,558,756**	**1,942,574**	**100%**

Sweet Corn Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Table not needed since no soil-applied insecticides registered for use in sweet corn.

Sweet Corn Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

MOA	Active Ingredient	------------- Treated Acres ------------- 2012-2014 Average	Added	New Total	Change
1A	Carbaryl	3,934	121,459	125,393	3,087%
28	Chlorantraniliprole	61,969	140,204	202,172	226%
1B	Chlorpyrifos	9,357	214,909	224,266	2,297%
1A	Methomyl	68,625	1,269,629	1,338,254	1,850%
5	Spinetoram	589,052	196,373	785,425	33.3%
	Total Non-Pyrethroids*	**732,937**	**1,942,574**	**2,675,510**	**265%**
	Total Pyrethroids	**1,942,574**	**-1,942,574**	**0**	**-100%**
	Total Treated with These AIs*	**2,675,510**	**0**	**2,675,510**	**0.0%**

MOA	Insecticide Class	------------- Treated Acres ------------- 2012-2014 Average	Added	New Total	Change
5	Spinosyns	589,052	196,373	785,425	33.3%
28	Diamides	61,969	140,204	202,172	226%
1A	Carbamates	72,559	1,391,088	1,463,647	1,917%
1B	Organophosphates	9,357	214,909	224,266	2,297%
	Total Non-Pyrethroids*	**732,937**	**1,942,574**	**2,675,510**	**265%**
	Total Pyrethroids	**1,942,574**	**-1,942,574**	**0**	**-100%**
	Total Treated with These AIs*	**2,675,510**	**0**	**2,675,510**	**0.0%**

*Does not match Sweet Corn Table 1 totals because totals here do not include minor use AIs.

Sweet Corn Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

MOA	Active Ingredient	Average Application Rate (Pounds per Treated Acre) Foliar Insecticide	Soil Insecticide*
1A	Carbaryl	0.823	---
28	Chlorantraniliprole	0.061	---
1B	Chlorpyrifos	0.976	---
1A	Methomyl	0.367	---
5	Spinetoram	0.035	---

*No soil-applied insecticides registered for use on sweet corn.

Sweet Corn Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

MOA	Active Ingredient	Pounds of Active Ingredient Applied 2012-2014 Average	Added	New Total	Change
1A	Carbaryl	3,238	99,961	103,198	3,087%
28	Chlorantraniliprole	3,761	8,508	12,269	226%
1B	Chlorpyrifos	66,993	209,798	276,791	313%
1A	Methomyl	216,310	466,229	682,539	216%
5	Spinetoram	3,567	6,944	10,511	195%
	Total	**293,868**	**791,441**	**1,085,309**	**269%**

MOA	Insecticide Class	Pounds of Active Ingredient Applied 2012-2014 Average	Added	New Total	Change
5	Spinosyns	3,567	6,944	10,511	195%
28	Diamides	3,761	8,508	12,269	226%
1A	Carbamates	219,548	566,190	785,737	258%
1B	Organophosphates	66,993	209,798	276,791	313%
	Total Non-Pyrethroids	**293,868**	**791,441**	**1,085,309**	**269%**
3A	Pyrethroids	87,718	-87,718	0	-100%
	Total	**381,586**	**703,723**	**1,085,309**	**184%**

Sweet Corn Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied*
Carbaryl	$10.52	---
Chlorantraniliprole	$27.02	---
Chlorpyrifos	$11.48	---
Methomyl	$10.42	---
Spinetoram	$22.31	---
Non-Pyrethroid Average**	$12.94	---
Pyrethroid Average**	$4.62	---
Application Costs	$7.46	---

*No soil-applied insecticides registered for use on sweet corn.
**Average weighted by treated acres.

Sweet Corn Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	---------------Foliar-Based --------------			------------- Soil-Based* -------------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Carbaryl	121,459	$10.52	$1,277,547	---	---	---
Chlorantraniliprole	140,204	$27.02	$3,787,691	---	---	---
Chlorpyrifos	214,909	$11.48	$2,467,487	---	---	---
Methomyl	1,269,629	$10.42	$13,228,131	---	---	---
Spinetoram	196,373	$22.31	$4,380,512	---	---	---
Total AI Cost	1,942,574	$12.94	$25,141,368	---	---	---
Application Cost	**1,942,574**	**$7.46**	**$14,491,600**	---	---	---

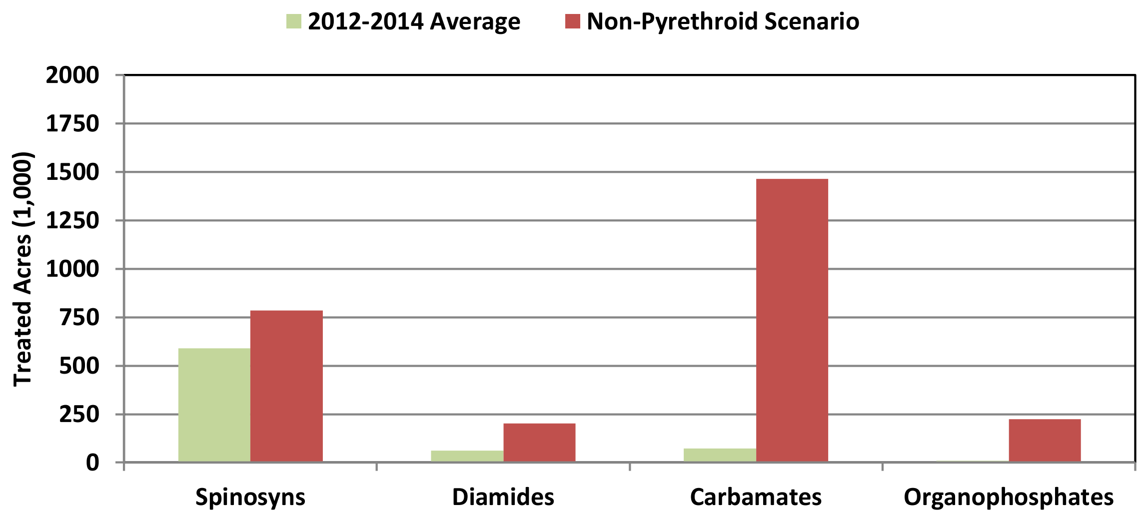
*No soil-applied insecticides registered for use on sweet corn.

Sweet Corn Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

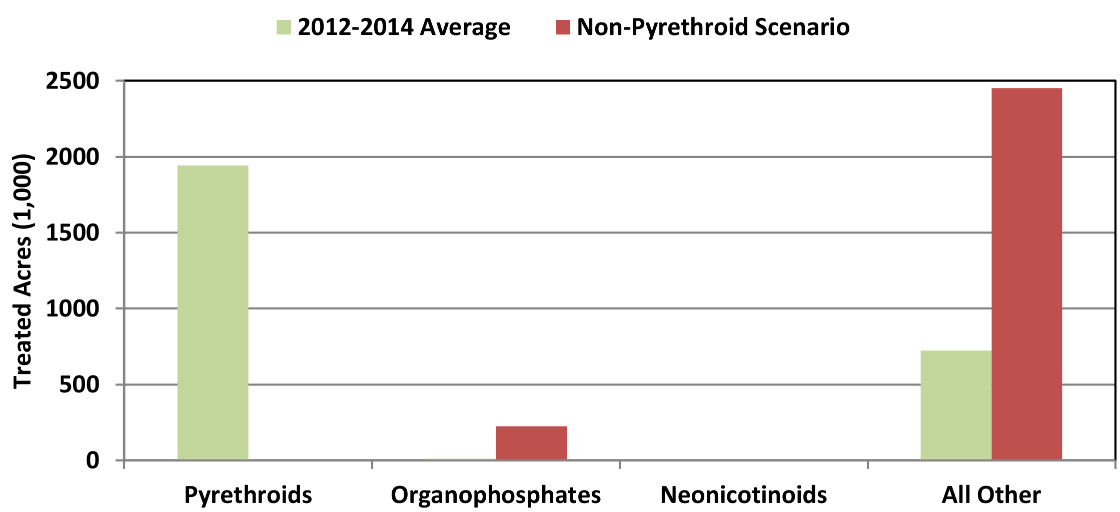
	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$8,970,434	$25,141,368	$16,170,934
Foliar Application Costs	$14,491,600	$14,491,600	$0
Soil AI Costs*	---	---	---
Soil Application Costs*	---	---	---
Total Costs	**$23,462,034**	**$39,632,968**	**$16,170,934**
Net Change in Grower Expenditures ($/A)		**Acres**	**$/Acre**
Pyrethroid Treated Acres		1,942,574	$8.32
Planted Acres		576,457	$28.05

*No soil-applied insecticides registered for use on sweet corn.

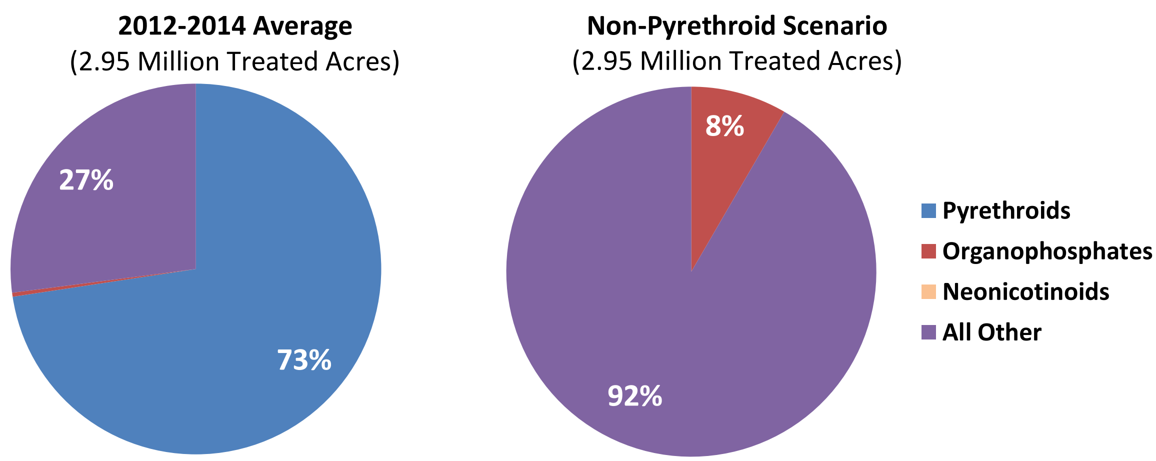
Sweet Corn Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Sweet Corn Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Sweet Corn Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Sweet Corn Table 8).



5.12 Tomato

Tomato Table 1 shows that of the 2.1 million insecticide treated acres for the crop, all foliar-applied, 483,000 are pyrethroids, or almost one fourth. Tomato Table 4 shows the wide range of insect pests targeted by these pyrethroid applications. The most commonly targeted were lepidopteran pests, but several others had a larger than 10% share of pyrethroid treated acres: aphids, stink bugs, thrips and whiteflies. In addition, beetles, leafminers and mites were minor but significant pests. Tomato Table 3 indicates the wide range of non-pyrethroid AIs used by tomato growers – the table lists 25 AIs. Each target pest usually has at least two AIs that had a large share of pyrethroid treated acres targeted at hat pest. For example, imidacloprid and dimethoate were the two most commonly used non-pyrethroid alternatives to manage aphids. However, these AIs tended to vary across the insect targets – carbaryl had by far the largest share for beetle management, chlorantraniliprole and cyromazine for leafminers, chlorantraniliprole and methoxyfenozide for lepidopteran pests, and so on. Tomato Table 3 shows the diversity of insect pests and AIs used for tomato insect management.

Tomato Table 6 uses the shares and target pest information to project the added treated acres for each non-pyrethroid replacements for the non-pyrethroid scenario. Given the large number of AIs, few have large projected increases in treated acres. Imidacloprid is the only AI projected to add more than 100,000 treated acres, capturing almost 24% of the total added non-pyrethroid treated acres. Chlorantraniliprole is projected to add almost 68,000 treated acres, while methoxyfenozide adds almost 57,000 treated acres and spinetoram adds 42,000. All other AIs add less than 30,000 treated acres and have less than a 10% of added treated acres for the non-pyrethroid scenario.

Tomato Table 8 aggregates these results across all target pests and for each insecticide class. As discussed, the largest increases in terms of added treated acres were for imidacloprid, chlorantraniliprole, methoxyfenozide, and spinetoram. In terms of percentage changes, none of the AIs showed extremely large increases as has been projected for some AIs in other crops. Increases range between 3% for diazinon to 55% for azadirachtin, with the total projected increase in non-pyrethroid treated acres equal to 34%. When aggregated by insecticide class, the neonicotinoids show the largest increase, adding 171,000 treated acres for the non-pyrethroid scenario, which is almost a 50% increase. The next largest increase is 68,000 projected for diamides from increased use of chlorantraniliprole, then 57,000 new treated acres of diacylhydrazines from increased use of methoxyfenozide and 56,000 for spinosyns from increased use of sprintoram and other related AIs. Tomato Table 10 uses the average application rates and the projected added treated acres for the non-pyrethroid scenario to estimate the net changes in pounds of AI applied. The 1.4 million pounds of pyrethroids are replaced with an estimated 161,000 pounds of non-pyrethroid AIs for the non-pyrethroid scenario, resulting in a 40% decrease in total pounds of insecticide AIs applied. This result is primarily due to the low application rates used for many AIs relative to pyrethroids.

Tomato Figure 1 graphically shows the 2012-2014 average non-pyrethroid treated acres for each insecticide class and the projected increases for the non-pyrethroid scenario. The number of classes used is large compared to most other crops examined in this report, with most increases modest as reported in Tomato Table 8. Tomato Figure 2 focuses on the major insecticide classes. Because of the wide range of insecticide classes used in tomatoes, the other class is the largest and shows the largest increase. Finally, Tomato Figure 3 shows the projected shift in the treated acre shares for major insecticide classes for the non-pyrethroid scenario. Pyrethroids constituted 26% of the treated acre share based on the 2012-2014 average. For the non-pyrethroid scenario, neonicotinoids increase from an 18% treated acre share to a 27% share, while organophosphates only increase from a 7% share to an 8%. By far the largest share is 49% for the other category, which increases to 65% for the non-pyrethroid scenario.

Tomato Table 12 combines the added treated acres with the average costs for AIs and application to estimate the cost of the replacement AIs for the non-pyrethroid scenario. The estimated total cost for the replacement AIs is $8.8 million, but because there are so many different AIs used, only three exceed $1 million in projected costs: $1.76 million for chlorantraniliprole, $1.32 million for imidacloprid, and $1.27 million for spinetoram, with methoxyfenozide and azadirachtin also showing high costs. These cost increases are relatively large not only because the added treated acres are large, but also because the per acre costs for these AIs are large when compared to AI costs for most other crops. Tomato Table 13 combines these costs results with the pyrethroid costs avoided to estimate the net cost impact of the non-pyrethroid scenario. Because projected insecticide treated acres remain unchanged for the non-pyrethroid scenario, the net cost impact depends on the increase in AI costs. Because pyrethroids are relatively low cost compared to the alternatives, the overall cost for insecticides increases by an estimated $6.1 million for the non-pyrethroid scenario. This represents a cost increase of $12.64 per pyrethroid treated acre replaced by a non-pyrethroid. This cost increase represents almost a doubling the costs for AIs and application for pyrethroid treated acres – an increase from $12.97 per pyrethroid treated acre to $25.61, or a 97% increase. Because there are fewer planted acres than pyrethroid treated acres, since each planted acre on average receives more than one treatment, the average cost impact is $15.55 per tomato planted acre for the non-pyrethroid scenario.

Tomato Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	Soil*	Total
Pyrethroids	483,248	---	483,248
Non-Pyrethroids	1,580,341	---	1,580,341
All AIs	2,063,589	---	2,063,589

*No soil-applied insecticides registered for use on tomato.

Tomato Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		Soil-Based Systems*	
	All AIs	Pyrethroids	All AIs	Pyrethroids
Initial Treated Acres	2,063,589	483,248	---	---
No Answer	0.1%	0.0%	---	---
Targeted at Specific Pests	99.9%	100.0%	---	---

*No soil-applied insecticides registered for use on tomato.

Tomato Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based systems*

	----- Foliar-Based Systems -----							
Active Ingredient	**Aphids**	**Beetles**	**Leaf-miners**	**Lepidop-terans**	**Mites**	**Stink Bugs**	**Thrips**	**White-flies**
Abamectin	0.1%	4.2%	16.3%	0.1%	55.8%	0.0%	2.7%	0.0%
Acetamiprid	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	6.1%
Azadirachtin	8.5%	0.0%	3.0%	0.5%	0.0%	0.0%	7.5%	7.5%
Bacillus thurin.	0.4%	0.9%	0.1%	11.9%	0.0%	0.0%	0.0%	0.0%
Bifenazate	0.0%	0.0%	0.0%	0.0%	3.0%	0.0%	0.0%	0.0%
Carbaryl	0.0%	86.3%	0.0%	1.8%	0.0%	0.0%	0.0%	0.0%
Chenopodium ambro.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	4.1%
Chlorantraniliprole	0.0%	0.0%	35.1%	30.4%	0.0%	0.0%	0.0%	7.8%
Clothianidin	0.8%	0.0%	0.0%	0.0%	0.0%	38.4%	0.0%	0.0%
Cyromazine	0.0%	0.0%	28.3%	0.0%	0.0%	0.0%	0.0%	0.0%
Diazinon	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%
Dimethoate	29.6%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%
Dinotefuran	0.3%	0.0%	2.3%	0.1%	0.0%	0.0%	0.2%	7.4%
Emamectin	0.0%	0.0%	1.9%	8.1%	0.0%	0.0%	0.0%	0.0%
Imidacloprid	43.8%	0.9%	0.0%	0.0%	0.0%	57.4%	24.3%	45.2%
Indoxacarb	0.0%	0.0%	4.7%	4.4%	0.0%	0.0%	0.0%	0.0%
Kaolin Clay	0.0%	3.7%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%
Methomyl	2.7%	0.0%	0.0%	3.8%	0.0%	2.1%	0.0%	0.0%
Methoxyfenozide	0.0%	0.0%	0.0%	28.2%	0.0%	0.0%	0.0%	0.0%
Spinetoram	0.0%	0.0%	6.9%	9.2%	0.0%	0.0%	43.5%	1.1%
Spinosyn	0.0%	4.0%	0.6%	1.3%	0.0%	0.0%	1.3%	0.0%
Spiromesifen	0.0%	0.0%	0.0%	0.0%	5.1%	0.0%	0.0%	4.1%
Spirotetramat	2.4%	0.0%	0.0%	0.0%	0.3%	0.0%	1.8%	14.4%
Sulfur	0.0%	0.0%	0.0%	0.0%	35.7%	0.0%	0.0%	0.0%
Thiamethoxam	7.1%	0.0%	0.0%	0.0%	0.0%	2.1%	11.2%	2.4%

*No soil-applied insecticides registered for use on tomato.

Tomato Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	**Foliar-Based**	**Soil-Based***
Aphids	17.5%	---
Beetles	1.5%	---
Leafminers	1.6%	---
Lepidopterans	41.5%	---
Mites	1.5%	---
Stink Bugs	14.7%	---
Thrips	10.8%	---
Whiteflies	10.8%	---

*No soil-applied insecticides registered for use on tomato.

Tomato Table 5. Average number of applications for each AI and ratios of these averages.

Active Ingredient	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
	Foliar-Based**	Soil-Based*	Foliar:Foliar	Soil:Soil*
Abamectin	1.000	---	1.000	---
Acetamiprid	1.000	---	1.000	---
Azadirachtin	1.000	---	1.000	---
Bacillus thurin.	1.000	---	1.000	---
Bifenazate	1.000	---	1.000	---
Carbaryl	1.000	---	1.000	---
Chenopodium ambro.	1.000	---	1.000	---
Chlorantraniliprole	1.000	---	1.000	---
Clothianidin	1.000	---	1.000	---
Cyromazine	1.000	---	1.000	---
Diazinon	1.000	---	1.000	---
Dimethoate	1.000	---	1.000	---
Dinotefuran	1.000	---	1.000	---
Emamectin	1.000	---	1.000	---
Imidacloprid	1.000	---	1.000	---
Indoxacarb	1.000	---	1.000	---
Kaolin Clay	1.000	---	1.000	---
Methomyl	1.000	---	1.000	---
Methoxyfenozide	1.000	---	1.000	---
Spinetoram	1.000	---	1.000	---
Spinosyn	1.000	---	1.000	---
Spiromesifen	1.000	---	1.000	---
Spirotetramat	1.000	---	1.000	---
Sulfur	1.000	---	1.000	---
Thiamethoxam	1.000	---	1.000	---
Pyrethroids	1.000	---		---

*No soil-applied insecticides registered for use on tomato.
**Ratio of treated acres to treated acres used, not base acres to treated acres.

Tomato Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Beetles	Leaf-miners	Lepido-pterans	Mites	Stink Bugs	Thrips	White-flies	Total	AI Weights
Abamectin	71	318	1,274	133	4,176	0	1,401	0	7,374	1.5%
Acetamiprid	3,596	0	0	0	0	0	2,691	3,185	9,472	2.0%
Azadirachtin	7,179	0	232	1,082	0	0	3,942	3,906	16,341	3.4%
Bacillus thurin.	323	66	11	23,876	0	0	0	0	24,275	5.0%
Bifenazate	0	0	0	0	223	0	0	0	223	0.0%
Carbaryl	0	6,451	0	3,604	0	0	0	0	10,055	2.1%
Chenopodium ambro.	0	0	0	0	0	0	962	2,128	3,089	0.6%
Chlorantraniliprole	0	0	2,739	61,048	0	0	0	4,052	67,839	14.0%
Clothianidin	669	0	0	0	0	27,275	13	0	27,958	5.8%
Cyromazine	0	0	2,210	0	0	0	0	0	2,210	0.5%
Diazinon	18	0	0	456	0	0	0	0	474	0.1%
Dimethoate	24,981	0	49	0	0	0	0	0	25,029	5.2%
Dinotefuran	267	0	183	148	0	0	107	3,836	4,541	0.9%
Emamectin	0	0	146	16,253	0	0	0	0	16,399	3.4%
Imidacloprid	36,955	67	0	0	0	40,718	12,749	23,595	114,083	23.6%
Indoxacarb	0	0	364	8,788	0	0	0	0	9,151	1.9%
Kaolin Clay	0	277	0	0	0	0	297	0	574	0.1%
Methomyl	2,274	0	0	7,591	0	1,507	0	0	11,372	2.4%
Methoxyfenozide	0	0	0	56,670	0	0	0	0	56,670	11.7%
Spinetoram	0	0	542	18,377	0	0	22,762	558	42,238	8.7%
Spinosyn	0	301	49	2,619	0	0	656	0	3,625	0.8%
Spiromesifen	0	0	0	0	385	0	0	2,117	2,501	0.5%
Spirotetramat	1,999	0	0	0	26	0	926	7,519	10,469	2.2%
Sulfur	0	0	0	0	2,672	0	0	0	2,672	0.6%
Thiamethoxam	6,008	0	0	0	0	1,483	5,862	1,259	14,612	3.0%
Total	**84,340**	**7,479**	**7,799**	**200,645**	**7,481**	**70,983**	**52,369**	**52,154**	483,248	100%

Tomato Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.

Table not needed since no soil-applied insecticides registered for use in tomato.

Tomato Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
6	Abamectin	92,591	7,374	99,965	8.0%
4A	Acetamiprid	27,857	9,472	37,329	34.0%
18B	Azadirachtin	29,993	16,341	46,334	54.5%
11A	Bacillus thurin.	63,421	24,275	87,696	38.3%
25	Bifenazate	4,463	223	4,686	5.0%
1A	Carbaryl	59,145	10,055	69,200	17.0%
--	Chenopodium ambro.	5,888	3,089	8,978	52.5%
28	Chlorantraniliprole	148,095	67,839	215,933	45.8%
4A	Clothianidin	9,837	27,958	37,794	284%
17	Cyromazine	27,872	2,210	30,082	7.9%
1B	Diazinon	12,465	474	12,939	3.8%
1B	Dimethoate	115,735	25,029	140,764	21.6%
4A	Dinotefuran	14,034	4,541	18,575	32.4%
6	Emamectin	55,389	16,399	71,788	29.6%
4A	Imidacloprid	238,681	114,083	352,763	47.8%
22A	Indoxacarb	31,806	9,151	40,957	28.8%
--	Kaolin Clay	4,145	574	4,719	13.8%
1A	Methomyl	30,208	11,372	41,580	37.6%
18A	Methoxyfenozide	131,640	56,670	188,310	43.0%
5	Spinetoram	150,500	42,238	192,738	28.1%
5	Spinosyn	10,095	3,625	13,720	35.9%
23	Spiromesifen	9,476	2,501	11,977	26.4%
5	Spirotetramat	26,416	10,469	36,885	39.6%
--	Sulfur	57,387	2,672	60,059	4.7%
4A	Thiamethoxam	59,548	14,612	74,160	24.5%
	Total Non-Pyrethroids*	**1,416,684**	**483,248**	**1,899,932**	**34.1%**
	Total Pyrethroids	**483,248**	**-483,248**	**0**	**-100%**
	Total Treated with These AIs*	**1,899,932**	**0**	**1,899,932**	**0.0%**

		------------- Treated Acres -------------			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
5	Spinosyns	187,010	56,333	243,343	30.1%
6	Avermectins	147,980	23,773	171,753	16.1%
17	Cyromazine	27,872	2,210	30,082	7.9%
23	Tetronic acid derivatives	9,476	2,501	11,977	26.4%
25	Bifenazate	4,463	223	4,686	5.0%
28	Diamides	148,095	67,839	215,933	45.8%
18A	Diacylhydrazines	131,640	56,670	188,310	43.0%
18B	Azadirachtin	29,993	16,341	46,334	54.5%
11A	Microbial Disruptors	63,421	24,275	87,696	38.3%
1A	Carbamates	89,353	21,427	110,780	24.0%
1B	Organophosphates	128,200	25,503	153,704	19.9%
22A	Oxadiaines	31,806	9,151	40,957	28.8%
4A	Neonicotinoids	349,955	170,666	520,621	48.8%
--	Other	67,421	6,335	73,755	9.4%
	Total Non-Pyrethroids*	**1,416,684**	**483,248**	**1,899,932**	**34.1%**
	Total Pyrethroids	**483,248**	**-483,248**	**0**	**-100%**
	Total Treated with These AIs*	**1,899,932**	**0**	**1,899,932**	**0.0%**

*Does not match Tomato Table 1 totals because totals here do not include minor use AIs.

Tomato Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	**Active Ingredient**	**Foliar Insecticide**	**Soil Insecticide***
6	Abamectin	0.011	---
4A	Acetamiprid	0.065	---
18B	Azadirachtin	0.026	---
11A	Bacillus thurin.	0.200	---
25	Bifenazate	0.500	---
1A	Carbaryl	0.526	---
--	Chenopodium ambro.	0.919	---
28	Chlorantraniliprole	0.058	---
4A	Clothianidin	0.066	---
17	Cyromazine	0.122	---
1B	Diazinon	1.867	---
1B	Dimethoate	0.397	---
4A	Dinotefuran	0.197	---
6	Emamectin	0.011	---
4A	Imidacloprid	0.211	---
22A	Indoxacarb	0.061	---
--	Kaolin Clay	23.749	---
1A	Methomyl	1.269	---
18A	Methoxyfenozide	0.165	---
5	Spinetoram	0.043	---
5	Spinosyn	0.076	---
23	Spiromesifen	0.107	---
5	Spirotetramat	0.077	---
--	Sulfur	23.186	---
4A	Thiamethoxam	0.134	---

*No soil-applied insecticides registered for use on tomato.

Tomato Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
6	Abamectin	995	79	1,074	8.0%
4A	Acetamiprid	1,800	612	2,412	34.0%
18B	Azadirachtin	775	422	1,197	54.5%
11A	Bacillus thurin.	12,686	4,856	17,542	38.3%
25	Bifenazate	2,232	111	2,343	5.0%
1A	Carbaryl	31,103	5,288	36,391	17.0%
--	Chenopodium ambro.	5,410	2,838	8,248	52.5%
28	Chlorantraniliprole	8,557	3,920	12,477	45.8%
4A	Clothianidin	649	1,845	2,494	284%
17	Cyromazine	3,403	270	3,672	7.9%
1B	Diazinon	23,270	885	24,155	3.8%
1B	Dimethoate	45,935	9,934	55,870	21.6%
4A	Dinotefuran	2,771	897	3,668	32.4%
6	Emamectin	620	184	804	29.6%
4A	Imidacloprid	50,357	24,069	74,427	47.8%
22A	Indoxacarb	1,942	559	2,501	28.8%
--	Kaolin Clay	98,442	13,625	112,067	13.8%
1A	Methomyl	5,429	14,432	19,861	266%
18A	Methoxyfenozide	21,668	9,328	30,995	43.0%
5	Spinetoram	6,524	1,831	8,355	28.1%
5	Spinosyn	770	277	1,047	35.9%
23	Spiromesifen	1,017	268	1,285	26.4%
5	Spirotetramat	2,024	802	2,827	39.6%
--	Sulfur	1,330,602	61,948	1,392,550	4.7%
4A	Thiamethoxam	7,999	1,963	9,962	24.5%
	Total	**1,666,980**	**161,243**	**1,828,223**	**9.7%**

		Pounds of Active Ingredient Applied			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
5	Spinosyns	187,010	56,333	243,343	30.1%
6	Avermectins	147,980	23,773	171,753	16.1%
17	Cyromazine	27,872	2,210	30,082	7.9%
23	Tetronic acid derivatives	9,476	2,501	11,977	26.4%
25	Bifenazate	4,463	223	4,686	5.0%
28	Diamides	148,095	67,839	215,933	45.8%
18A	Diacylhydrazines	131,640	56,670	188,310	43.0%
18B	Azadirachtin	29,993	16,341	46,334	54.5%
11A	Microbial Disruptors	63,421	24,275	87,696	38.3%
1A	Carbamates	89,353	21,427	110,780	24.0%
1B	Organophosphates	128,200	25,503	153,704	19.9%
22A	Oxadiaines	31,806	9,151	40,957	28.8%
4A	Neonicotinoids	349,955	170,666	520,621	48.8%
--	Other	67,421	6,335	73,755	9.4%
	Total Non-Pyrethroids	**1,666,980**	**161,243**	**1,828,223**	**9.7%**
3A	Pyrethroids	1,400,794	-1,400,794	0	-100%
	Total	**3,067,774**	**-1,239,552**	**1,828,223**	**-40%**

Tomato Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied*
Abamectin	$9.54	---
Acetamiprid	$17.62	---
Azadirachtin	$47.37	---
Bacillus thurin.	$11.18	---
Bifenazate	$50.21	---
Carbaryl	$7.26	---
Chenopodium ambro.	$18.90	---
Chlorantraniliprole	$25.98	---
Clothianidin	$12.30	---
Cyromazine	$27.44	---
Diazinon	$26.27	---
Dimethoate	$4.13	---
Dinotefuran	$26.46	---
Emamectin	$21.84	---
Imidacloprid	$11.56	---
Indoxacarb	$21.54	---
Kaolin Clay	$25.29	---
Methomyl	$7.59	---
Methoxyfenozide	$16.58	---
Spinetoram	$30.11	---
Spinosyn	$31.68	---
Spiromesifen	$17.68	---
Spirotetramat	$31.56	---
Sulfur	$8.32	---
Thiamethoxam	$16.88	---
Non-Pyrethroid Average**	$18.15	---
Pyrethroid Average**	$5.51	---
Application Costs	$7.46	---

*No soil-applied insecticides registered for use on tomato.
**Average weighted by treated acres.

Tomato Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	--------- Foliar-Based ---------			----------- Soil-Based* -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Abamectin	7,374	$9.54	$70,348	---	---	---
Acetamiprid	9,472	$17.62	$166,922	---	---	---
Azadirachtin	16,341	$47.37	$774,105	---	---	---
Bacillus thurin.	24,275	$11.18	$271,441	---	---	---
Bifenazate	223	$50.21	$11,178	---	---	---
Carbaryl	10,055	$7.26	$72,954	---	---	---
Chenopodium ambro.	3,089	$18.90	$58,377	---	---	---
Chlorantraniliprole	67,839	$25.98	$1,762,433	---	---	---
Clothianidin	27,958	$12.30	$343,896	---	---	---
Cyromazine	2,210	$27.44	$60,651	---	---	---
Diazinon	474	$26.27	$12,456	---	---	---
Dimethoate	25,029	$4.13	$103,275	---	---	---
Dinotefuran	4,541	$26.46	$120,164	---	---	---
Emamectin	16,399	$21.84	$358,231	---	---	---
Imidacloprid	114,083	$11.56	$1,318,989	---	---	---
Indoxacarb	9,151	$21.54	$197,094	---	---	---
Kaolin Clay	574	$25.29	$14,512	---	---	---
Methomyl	11,372	$7.59	$86,283	---	---	---
Methoxyfenozide	56,670	$16.58	$939,545	---	---	---
Spinetoram	42,238	$30.11	$1,271,686	---	---	---
Spinosyn	3,625	$31.68	$114,836	---	---	---
Spiromesifen	2,501	$17.68	$44,226	---	---	---
Spirotetramat	10,469	$31.56	$330,436	---	---	---
Sulfur	2,672	$8.32	$22,231	---	---	---
Thiamethoxam	14,612	$16.88	$246,631	---	---	---
Total AI Cost	**483,248**	**$18.15**	**$8,772,899**	---	---	---
Application Cost	**483,248**	**$7.46**	**$3,605,028**	---	---	---

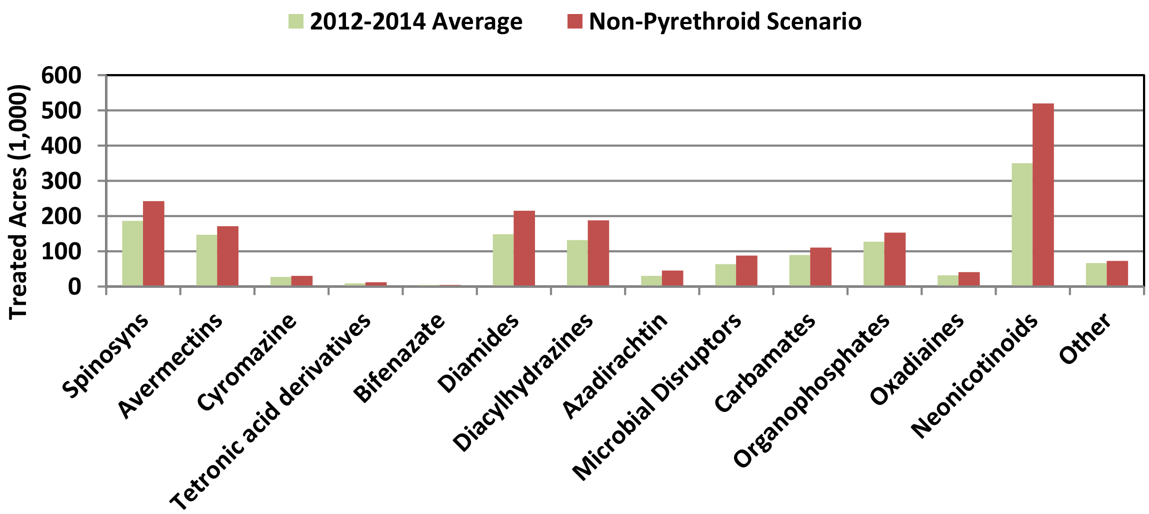
*No soil-applied insecticides registered for use on tomato.

Tomato Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

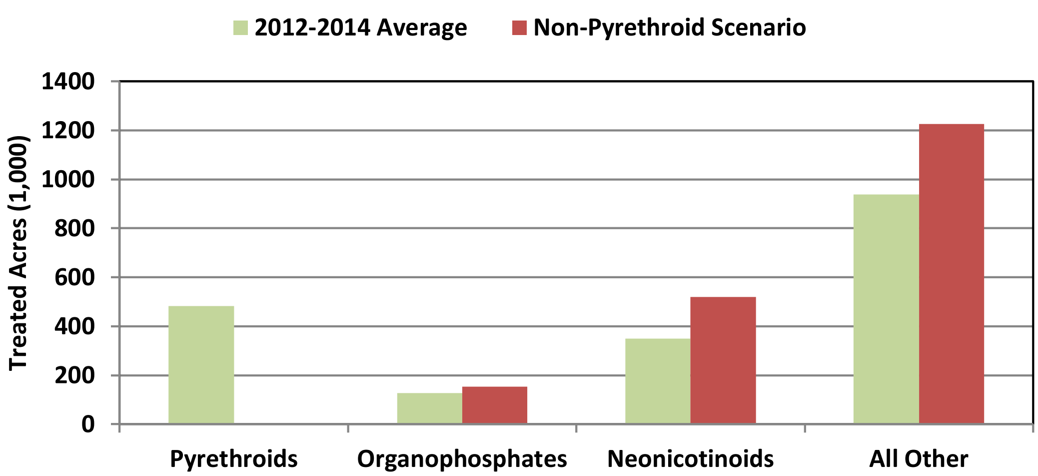
	Avoided Expenditures from 2012-2014 Average	**New Expenditures for the Non-Pyrethroid Scenario**	**Net Change in Farmer Expenditures**
Foliar AI Costs	$2,664,370	$8,772,899	$6,108,529
Foliar Application Costs	$3,605,028	$3,605,028	$0
Soil AI Costs*			
Soil Application Costs*			
Total Costs	$6,269,398	$12,377,927	$6,108,529
Net Change in Grower Expenditures ($/A)		Acres	$/Acre
Pyrethroid Treated Acres		483,248	$12.64
Planted Acres		**392,900**	**$15.55**

*No soil-applied insecticides registered for use on tomato.

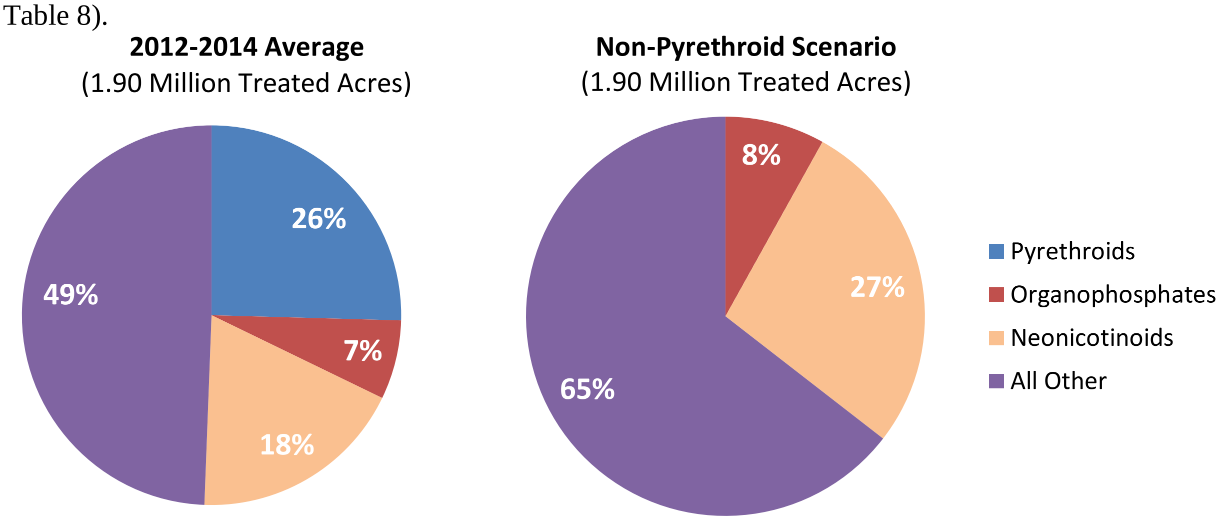
Tomato Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Tomato Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Tomato Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Tomato Table 8).



5.13 Winter wheat

Winter wheat has no soil-applied insecticides registered for use, and so many of the tables for this crop have empty sections. Winter Wheat Table 1 shows that the 2012-2014 average was almost 3.9 million treated acres for insecticides in winter wheat, all foliar-applied, of which 2.7 million were pyrethroids, the single largest insecticide class in terms of treated acres. Winter Wheat Table 4 shows that the most commonly targets of these pyrethroid applications were aphids, lepidopteran pests, and beetle species. Minor but significant pest included mites, hessian flies and orthopteran pests. Winter Wheat Table 3 indicates that farmers used five non-pyrethroid AIs as alternatives, with chlorpyrifos by far the most popular AI among these non-pyrethroid AIs for each target pest. Dimethoate was a common option for mites and aphids, while malathion was used for aphids and orthopteran pests, while chlorantraniliprole was used as an option for lepidopteran pests.

Winter Wheat Table 6 reports the new non-pyrethroid AIs added as replacements for pyrethroids for the non-pyrethroid scenario. Not surprisingly, chlorpyrifos is projected to have more than 85% share of the added non-pyrethroid treated acres, with all other AIs replacements having less than 10% share. Winter Wheat Table 8 reports the total added treated acres for each non-pyrethroid AI after aggregating across all target pests and also by insecticide class. The 2.7 million pyrethroid treated acres are replaced by 2.5 million non-pyrethroid treated acres for the non-pyrethroid scenario, with 2.1 million of these new added acres projected to shift to chlorpyrifos. Malathion and dimethoate add more than 100,000 treated acres, while chlorantraniliprole and imidacloprid also add treated acres. Winter Wheat Table 10 uses average application rates to project the change in pounds of insectcide AI applied for the non-pyrethroid scenario. Overall, 60,000 pounds of pyrethroids are replaced with an estimated 1.1 million pounds of non-pyrethroids, again mostly chlorpyrifos and other organophosphates.

Winter Wheat Figures 1 to 3 summarize these results graphically. Winter Wheat Figure 1 shows the large increase in organophosphate treated acres for the non-pyrethroid scenario, while Winter Wheat Figure 2 illustrates the predominate use of pyrethroids based on the 2012-2014 average and the projected shift to organophosphates. Indeed, Winter Wheat Figure 3 shows that based on the 2012-2014 average, pyrethroids constituted a 71% share of insecticide treated acres and organophosphates 28%, but for the non-pyrethroid scenario, the organophosphate share increases to 97%.

Winter Wheat Table 12 uses the projected increase in non-pyrethroid treated acres and estimated application costs to estimate the net cost impact of the non-pyrethroid scenario. Overall, the cost of the added AIs to replace pyrethroids is estimated to be $12.1 million, with application costs reaching $18.5 million. Winter Wheat Table 13 then combines these estimates with the avoided costs due to no longer using pyrethroids to estimate the net cost impact. Costs for foliar AI to replace pyrethroids increase in net by almost $2.5 million since the non-pyrethroid alternatives have greater per acre costs, but estimated application costs decrease by $1.9 million since fewer applications are needed, based on the average number of applications used for each AI. Asa result, the projected net cost increase is almost $579,000 in total. On average, this small change represents a $0.21 increase per pyrethroid treated acre, or a 2% net increase in costs for AIs and application, increasing average farmer costs per treated acre from $10.97 to $11.18 for those using pyrethroid insecticides. As there are many non-treated winter wheat acres, once spread over all planted acres, the cost increase is $0.01 per planted acre.

Winter Wheat Table 1. Treated acres for all AIs and pyrethroids (three-year average, 2012-2014)

	Foliar	Soil*	Total
Pyrethroids	2,735,074	---	2,735,074
Non-Pyrethroids	1,124,151	---	1,124,151
All AIs	3,859,225	---	3,859,225

*No soil-applied insecticides registered for use on winter wheat.

Winter Wheat Table 2. Initial treated acres for foliar-based and soil-based systems and remaining treated acres after focusing on major pests targeted by pyrethroids

	Foliar-Based Systems		Soil-Based Systems*	
	All AIs	Pyrethroids	All AIs	Pyrethroids
Initial Treated Acres	3,859,225	2,735,074	---	---
No Answer	18.1%	18.1%	---	---
Targeted at Specific Pests	81.9%	81.9%	---	---

*No soil-applied insecticides registered for use on winter wheat.

Winter Wheat Table 3. Non-pyrethroid treated acre shares by pyrethroid target pest group for foliar-based systems*

	-------------------------------------- Foliar-Based Systems -----------------------------------					
Active Ingredient	Aphids	Beetles	Hessian Flies	Lepidopterans	Mites	Orthopterans
Chlorantraniliprole	0.0%	0.0%	0.0%	13.5%	0.0%	0.0%
Chlorpyrifos	77.7%	100.0%	100.0%	86.5%	78.5%	92.3%
Dimethoate	7.1%	0.0%	0.0%	0.0%	21.5%	0.0%
Imidacloprid	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Malathion	14.2%	0.0%	0.0%	0.0%	0.0%	7.7%

*No soil-applied insecticides registered for use on winter wheat.

Winter Wheat Table 4. Share of pyrethroid treated acres targeted at each insect pest group for foliar-based pest management systems.

Target Pest	Foliar-Based	Soil-Based*
Aphids	44.2%	---
Beetles	20.2%	---
Hessian Flies	2.0%	---
Lepidopterans	24.1%	---
Mites	7.8%	---
Orthopterans	1.7%	---

*No soil-applied insecticides registered for use on winter wheat.

Winter Wheat Table 5. Average number of applications for each AI and ratios of these averages.

	Average Number of Applications		Ratio of Average Non-Pyrethroid Applications to Pyrethroid Applications	
Active Ingredient	Foliar-Based	Soil-Based*	Foliar:Foliar	Soil:Soil*
Chlorantraniliprole	1.000	---	0.892	---
Chlorpyrifos	1.020	---	0.910	---
Dimethoate	1.000	---	0.892	---
Imidacloprid	1.000	---	0.892	---
Malathion	1.000	---	0.892	---
Pyrethroids	1.121	---		---

*No soil-applied insecticides registered for use on winter wheat.

Winter Wheat Table 6. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in foliar-based pest management systems.

Active Ingredient	Aphids	Beetles	Hessian Flies	Lepidop-terans	Mites	Orthop-terans	Total	AI Weights
Chlorantraniliprole	0	0	0	79,257	0	0	79,257	3.2%
Chlorpyrifos	853,801	502,286	50,376	519,354	151,788	39,356	2,116,961	85.3%
Dimethoate	76,672	0	0	0	40,786	0	117,458	4.7%
Imidacloprid	10,682	0	0	0	0	0	10,682	0.4%
Malathion	153,229	0	0	0	0	3,212	156,441	6.3%
Total	**1,094,385**	**502,286**	**50,376**	**598,611**	**192,574**	**42,568**	**2,480,800**	**100%**

Winter Wheat Table 7. Non-pyrethroid treated acres by AI and target pest group reallocated from pyrethroid treated acres in soil-based pest management systems.
Table not needed since no soil-applied insecticides registered for use in winter wheat.

Winter Wheat Table 8. Impact of non-pyrethroid scenario on non-pyrethroid treated acres by individual active ingredients and by insecticide class.

		------------- Treated Acres -------------			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
28	Chlorantraniliprole	2,935	79,257	82,192	2,701%
1B	Chlorpyrifos	757,960	2,116,961	2,874,921	279%
1B	Dimethoate	215,071	117,458	332,529	54.6%
4A	Imidacloprid	16,028	10,682	26,710	66.6%
1B	Malathion	119,708	156,441	276,149	131%
	Total Non-Pyrethroids*	**1,111,702**	**2,480,800**	**3,592,502**	**223%**
	Total Pyrethroids	**2,735,074**	**-2,735,074**	**0**	**-100%**
	Total Treated with These AIs*	**3,846,776**	**-254,274**	**3,592,502**	**-6.6%**
		------------- Treated Acres -------------			
MOA	**Insecticide Class**	**2012-2014 Average**	**Added**	**New Total**	**Change**
28	Diamides	2,935	79,257	82,192	2,701%
1B	Organophosphates	1,092,740	2,390,860	3,483,600	219%
4A	Neonicotinoids	16,028	10,682	26,710	66.6%
	Total Non-Pyrethroids*	**1,111,702**	**2,480,800**	**3,592,502**	**223%**
	Total Pyrethroids	**2,735,074**	**-2,735,074**	**0**	**-100%**
	Total Treated with These AIs*	**3,846,776**	**-254,274**	**3,592,502**	**-6.6%**

*Does not match Winter Wheat Table 1 totals because totals here do not include minor use AIs.

Winter Wheat Table 9. Average application rate (pounds per treated acre) for each non-pyrethroid active ingredient when foliar-applied and soil-applied.

		Average Application Rate (Pounds per Treated Acre)	
MOA	**Active Ingredient**	**Foliar Insecticide**	**Soil Insecticide***
28	Chlorantraniliprole	0.007	---
1B	Chlorpyrifos	0.407	---
1B	Dimethoate	0.371	---
4A	Imidacloprid	0.063	---
1B	Malathion	1.231	---

*No soil-applied insecticides registered for use on winter wheat.

Winter Wheat Table 10. Impact of non-pyrethroid scenario on pounds of active ingredient applied by insecticide class.

		Pounds of Active Ingredient Applied			
MOA	**Active Ingredient**	**2012-2014 Average**	**Added**	**New Total**	**Change**
28	Chlorantraniliprole	20	531	551	2,701%
1B	Chlorpyrifos	308,620	861,966	1,170,585	279%
1B	Dimethoate	79,808	43,586	123,394	54.6%
4A	Imidacloprid	1,003	669	1,672	66.6%
1B	Malathion	147,342	192,555	339,897	131%
	Total	**536,793**	**1,099,306**	**1,636,099**	**205%**

		Pounds of Active Ingredient Applied			
MOA	Insecticide Class	**2012-2014 Average**	**Added**	**New Total**	**Change**
28	Diamides	20	531	551	2,701%
1B	Organophosphates	535,770	1,098,107	1,633,877	205%
4A	Neonicotinoids	1,003	669	1,672	66.6%
	Total Non-Pyrethroids	**536,793**	**1,099,306**	**1,636,099**	**205%**
3A	Pyrethroids	60,392	-60,392	0	-100%
	Total	**597,185**	**1,038,914**	**1,636,099**	**174%**

Winter Wheat Table 11. Average cost for each AI ($/Treated Acre) for 2012-2014 for foliar and soil use (not including application costs), plus application costs.

Active Ingredient	Foliar-Applied	Soil-Applied*
Chlorantraniliprole	$2.40	---
Chlorpyrifos	$4.77	---
Dimethoate	$4.02	---
Imidacloprid	$4.38	---
Malathion	$8.10	---
Non-Pyrethroid Average**	$4.86	---
Pyrethroid Average**	$3.51	---
Application Costs	**$7.46**	---

*No soil-applied insecticides registered for use on winter wheat.

**Average weighted by treated acres.

Winter Wheat Table 12. Estimated additional grower costs for alternative AIs for foliar-based and soil-based systems for the non-pyrethroid scenario.

	--------- Foliar-Based ---------			----------- Soil-Based* -----------		
Active Ingredient	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**	**Added Acres**	**Cost ($/A)**	**Total Cost ($)**
Chlorantraniliprole	79,257	$2.40	$189,915	---	---	---
Chlorpyrifos	2,116,961	$4.77	$10,090,506	---	---	---
Dimethoate	117,458	$4.02	$472,141	---	---	---
Imidacloprid	10,682	$4.38	$46,746	---	---	---
Malathion	156,441	$8.10	$1,266,775	---	---	---
Total AI Cost	2,480,800	$4.86	$12,066,083	---	---	---
				---	---	---
Application Cost	**2,480,800**	**$7.46**	**$18,506,765**	---	---	---

*No soil-applied insecticides registered for use on winter wheat.

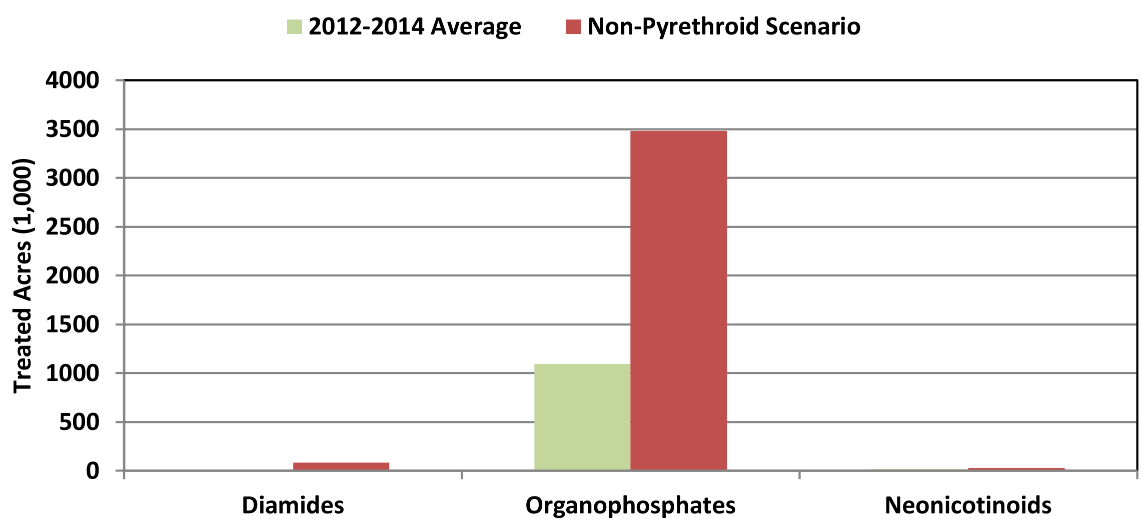
Winter Wheat Table 13. Estimated net change in grower expenditures when switching from the 2012-2014 average to the non-pyrethroid scenario.

	Avoided Expenditures from 2012-2014 Average	New Expenditures for the Non-Pyrethroid Scenario	Net Change in Farmer Expenditures
Foliar AI Costs	$9,590,644	$12,066,083	$2,475,440
Foliar Application Costs	$20,403,652	$18,506,765	-$1,896,887
Soil AI Costs*			
Soil Application Costs*			
Total Costs	**$29,994,296**	**$30,572,848**	**$578,553**

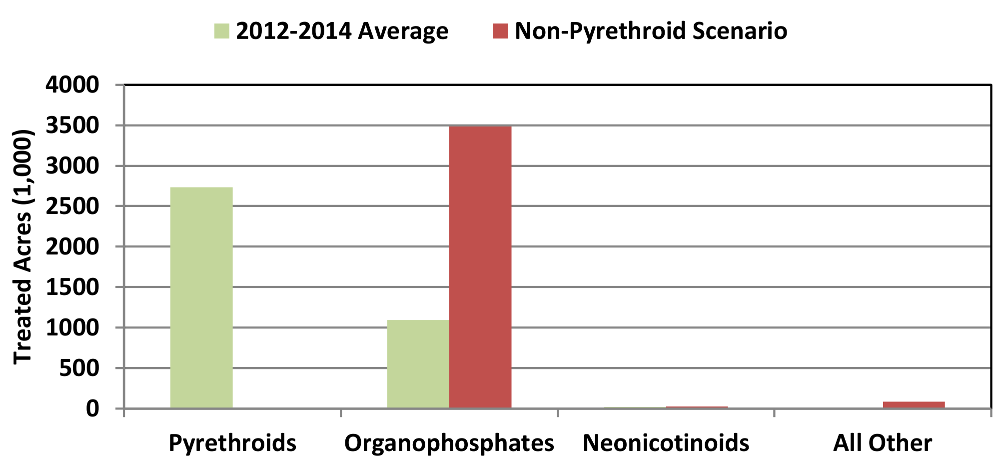
Net Change in Grower Expenditures ($/A)	**Acres**	**$/Acre**
Pyrethroid Treated Acres	2,735,074	$0.21
Planted Acres	42,175,333	$0.01

*No soil-applied insecticides registered for use on winter wheat.

Winter Wheat Figure 1. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by insecticide class.



Winter Wheat Figure 2. 2012-2014 average treated acres and new total treated acres for the non-pyrethroid scenario by major insecticide class.



Winter Wheat Figure 3. 2012-2014 average shares of total insecticide treated acres allocated to major insecticide modes of action and estimated shares for the non-pyrethroid scenario (based on treated acres data in Winter Wheat Table 8).