UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OFCHEMICAL SAFETY
AND POLLUTION PREVENTION

MEMORANDUM

SUBJECT: Review of Bayer CropScience Benefits Document Supporting the Continued Registration of Flubendiamide (Belt SC) (DP# 427644) and BCS White Paper (DP# 427994)

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Summary

Flubendiamide is an insecticide which was conditionally registered in 2008. As part of their continued registration Bayer CropScience submitted a Flubendiamide Benefits Analysis document (EPA MRID No. 49533001). The registrant used a combination of a private pesticide market survey of growers, Arthropod Management Tests, trade journal articles, university

extension IPM websites, and expert opinions to support claims of the benefits of flubendiamide. In general, BEAD uses the same sources to conduct pesticide benefits assessments, and agrees with the registrant's findings. BEAD agrees with Bayer CropScience findings that flubendiamide plays a role in integrated pest management and insecticide resistance management based upon the following characteristics: specificity to Lepidopteran larvae; non-systemic but translaminar properties; and no to low impacts on beneficial arthropods. Bayer CropScience has determined that the main alternatives to flubendiamide will be synthetic pyrethroids. BEAD found that in crops such as alfalfa and soybeans, synthetic pyrethroids are the most used insecticides and growers will likely use them if flubendiamide were not available for use. But for other crops, such as almonds and peppers, growers are using other pesticides like methoxyfenozide and chlorantraniliprole, and these are the most likely replacements for flubendiamide. BEAD is unable to determine if multiple applications of the alternatives are required to control the primary target pests, as comparative product performance analyses were not conducted for this review.

Review of Bayer CropScience Benefits Analysis

Bayer CropScience (BCS) submitted a document (EPA MRID No. 49533001) to support their claim that flubendiamide is valuable both in integrated pest management (IPM) and insecticide resistance management (IRM) strategies. Flubendiamide has been registered on over 200 crops. BCS provided information on the general benefits of flubendiamide then examined 15 crops in more detail. The crops were selected either because the pounds of flubendiamide applied to the crop was relatively high, or the crop had a high percentage of acres treated with flubendiamide (Table 1). These crops also represent different EPA crop groups and therefore represent the other crops in those groups. BCS selected: soybean, almonds, pistachio, peanuts, tobacco, alfalfa, cotton, tomato, pepper, grape, watermelon, broccoli, lettuce, snap bean, and strawberry.

Table 1. Average Pounds of Flubendiamide Applied Annually in Crops Selected by BCS, and the Average Percent of Crops Treated with Flubendiamide.

Crop	Average Pounds A.I. Applied Annually (2011-2013)	Average Acres Treated (2011-2013)	Average Percent of Crop Treated (2011-2013)
Alfalfa	3,000	33,400	0.2
Almond	14,000	130,000	14
Broccoli	<100	1,700	1
Cotton	2,900	46,700	0.4
Grapes, Table	<500	3,500	4
Lettuce	1,100	34,300	13
Peanut	5,000	65,600	6
Pepper	<500	12,000	15
Pistachio	1,500	12,000	5
Snap Beans	<500	3,200	1
Soybean	59,000	960,000	1
Strawberry	<100	1,200	2
Tobacco	7,000	88,000	26
Tomato	1,300	30,000	9
Watermelon	1,000	18,000	14

BEAD Proprietary Data, 2011-2013.

Flubendiamide is in the Insecticide Resistance Action Committee's (IRAC) Mode of Action (MOA) Group 28, the diamides or ryanodine receptor modulators. In addition to flubendiamide, this group contains chlorantraniliprole and cyantraniliprole. Diamides have both nerve and muscle effects on insects and there is no known cross resistance to alternative modes of action (IRAC, 2015).

Company data provided by BCS demonstrate that flubendiamide is a unique diamide in that it is more selective to Lepidopteran larvae than chlorantraniliprole and cyantraniliprole. The labels for chlorantraniliprole and cyantraniliprole include larger pest lists than the flubendiamide label. These other pests include grasshoppers, leafhoppers, thrips, beetles, and flies, in addition to Lepidoptera.

BCS asserts that providing a pesticide in a different mode of action group is important to insecticide resistance management. This agrees with IRAC (2015) recommendations of rotating insecticides with different modes of action to manage resistance. This rotation decreases the selection pressure on pest species to reduce the likelihood of developing resistance. However, since flubendiamide is not the only diamide, it does not have a unique mode of action, so chlorantraniliprole and cyantraniliprole may be used equally for resistance management.

Non-systemic

Flubendiamide, unlike the other diamides, is not systemic in the plant. Data provided by the registrant does not find any movement of the pesticide in the xylem or phloem of the plants. However, it will move from the top of a leaf to the underside, in a process known as translamination. Because of this translaminar property, flubendiamide does not have the residual activity of systemic insecticides, but it is more residual than pyrethroids. Information from extension entomologists and in several of the Arthropod Management Test results demonstrated that flubendiamide was effective for two to three weeks. This was longer than the pyrethroids, but shorter than the systemic chlorantraniliprole. Entomologists favor translamination over systemic insecticides (such as chlorantraniliprole and cyantraniliprole) as it reduces selection pressure on the pest insects and fits well in both IRM and IPM strategies. BEAD agrees that the translaminar characteristic is unique to flubendiamide and makes it very suitable for IRM and IPM strategies in many crops (BCS, 2015).

Specificity to Lepidopterans

BCS provided results of numerous experiments published in the Arthropod Management Tests from 2007 to 2013. The results indicated that flubendiamide was very effective at controlling various Lepidopteran larvae in their selected crops. Some of the tests were conducted on other insects, such as earwigs, which showed that chlorantraniliprole and pyrethroids reduced those populations, but flubendiamide had no effect on non-Lepidopteran arthropods.

BCS (2015) also submitted articles from trade publications, such as Southeast Farm Press and Delta Farm Press. The articles highlighted information from University researchers and extension agents, many of whom wrote letters to support that flubendiamide is very specific to the Lepidopteran pests in their crops, and is also less likely to impact non-target insects and cause secondary pest outbreaks.

BEAD concurs that these data from the Arthropod Management Test as well as the information from University entomologists support the registrant's conclusion that flubendiamide is specific and effective against Lepidopteran larval pests in the selected crops.

Protecting Beneficials

In addition to Arthropod Management Test results, BCS (2015) submitted company data on the effects of flubendiamide on several beneficial arthropods. Results indicated little to no mortality on many beneficial insects such as ladybird beetles, soldier beetles, predatory mirid bugs, predatory mites, and various parasitoid wasps. One study indicated that first instar ladybird beetles were moderately harmed, but not all studies had the same result (BCS, 2015). Several of the experts mentioned that an early field application of flubendiamide allowed for the build-up of predators and parasitoids which prevents the Lepidopteran pests from building up too high populations later in the season. This IPM strategy eliminates the potential of a second insecticide application (BCS, 2015). The use of beneficials and parasitoids to manage pest populations is an important component of IPM. BEAD agrees with BCS that flubendiamide is relatively protective of beneficial arthropods, and does play a role in IPM.

Alternative Insecticides in Selected Crops

BCS (2015) identified the most likely alternatives to flubendiamide on 15 use sites it analyzed in more detail (Table 1). Soybeans were selected b/c they represent the largest (highest) user of flubendiamide in terms of total pounds applied annually. Other crops, like almonds, were selected because much of the crop is treated with flubendiamide. Other crops were selected because they are representative of similar crops of agronomic conditions. BEAD agreed that crops BCS selected are representative of the 200 crops for which flubendiamide is registered. BEAD analyzed the available usage data for soybean, almond, peppers, tobacco, peanuts, and alfalfa to verify the alternative analyses that BCS conducted and reached similar conclusions. BEAD did not conduct a comparative product performance analysis and is unable to quantify whether multiple applications of alternatives would be necessary to control target pests in the respective crops.

Soybeans

Lepidopteran pests are important pests of soybeans. Nearly 63 percent of soybean acres nationwide are treated annually for these pests, and as much as 75 percent of soybeans in the Southeast are treated (BCS 2015). Information provided by extension entomologists (BCS 2015) indicate that in much of the southeastern states, corn earworm and soybean looper are the primary Lepidopteran pests. The available usage data suggests that tobacco budworm and armyworm complex are also important Lepidopteran pests in soybeans in terms of acres treated (Proprietary Data, 2011-2013). Flubendiamide is used to control Lepidopteran pests on about 1 percent of U.S. soybeans; however, this use accounts for nearly 50 percent of the total amount of flubendiamide used in agriculture (Table 1). Since very little soybean acreage is treated with flubendiamide, BEAD concludes that it does not provide much benefit to soybean growers, but recognizes that this use is important to the registrant since it consists of the most pounds applied.

BCS (2015) identified that nationwide, lambda-cyhalothrin and bifenthrin (synthetic pyrethroids) are the primary insecticides in soybean acres targeting Lepidopteran pests, and that more flubendiamide is used in the Southeast soybean production area than in other areas of the country (Table 2 summarizes alternatives mode of actions). Caterpillars are more of a problem in the Southeast than in the rest of the U.S. BEAD's analysis of the available pesticide usage data determined that synthetic pyrethroids were the lead insecticides targeting Lepidopteran larvae. BEAD's analysis also shows that the majority of flubendiamide is applied to Southeast soybeans. Other insecticides used include diflubenzuron, methoxyfenozide, and chlorantraniliprole, but these are applied to fewer acres than flubendiamide. (Proprietary Data, 2011-2013).

BEAD thinks that the synthetic pyrethroids are the probable alternatives to flubendiamide in soybeans because they are currently used more, they are broader-spectrum (so will target more pest species), and are less expensive than the other chemistries. However, synthetic pyrethroids are known to cause secondary pest problems (e.g., mites) because they are broad-spectrum insecticides, and are known to kill many beneficial arthropods, thus requiring multiple insecticide applications to maintain control. In their letters of support, several extension entomologists mentioned that growers who used flubendiamide did not have to apply additional insecticides to control caterpillars later in the growing season because the predators kept the populations in check (BCS, 2015). Therefore, if flubendiamide were not available for use, soybean growers currently using flubendiamide would need to make multiple insecticide applications if they used synthetic pyrethroids to control Lepidopteran pests in soybeans.

Table 2. IRAC Mode of Actions for Insecticides Targeting Lepidoptera Identified in this Document.

Group Number	Mode of Action	Chemical Type	Example Chemical(s)
1B	Acetylcholinesterase Inhibitor	Organophosphates	Acephate
3A	Sodium Channel Modulators	Pyrethroids	Bifenthrin, Cyhalothrin, Cypermethrin
5	Nicotinic Acetylcholine Receptor Allosteric Modulators	Spinosyns	Spinetoram Spinosad
11A	Microbial Disruptors of Insect Midgut	*Bacillus thuringiensis*	*Bacillus thuringiensis*
15	Inhibitors of Chitin Biosynthesis, Type 0	Benzoylureas	Diflubenzuron
18	Ecdysone Receptor Agonists	Diacyl-hydrazines	Methoxyfenozide
22A	Voltage-dependent Sodium Channel Blockers	Indoxacarb	Indoxacarb
28	Ryanodine Receptor Modulators	Diamides	Chlorantraniliprole Cyantraniliprole Flubendiamide

Almonds

Almonds constitute the second largest user of flubendiamide in terms of pounds applied, and on average, nearly 14 percent of the crop was treated with flubendiamide annually between 2011-2013 (Table 1), indicating high benefits to flubendiamide in almonds. The main Lepidopteran pests targeted by insecticide applications are navel orangeworm and peach twig borer, about 40 percent of insecticide applications target these pests (BCS, 2015). BCS (2015) determined that methoxyfenozide, bifenthrin, and chlorantraniliprole are the top three insecticides used to control Lepidopteran pests in almonds, followed by flubendiamide (Table 2). BEAD's usage analysis had similar results, but determined that more almonds were treated with bifenthrin, then methoxyfenozide, followed by chlorantraniliprole (Proprietary Data, 2011-2013). Bifenthrin, a synthetic pyrethroid, could be the main alternative to flubendiamide in almonds. However, methoxyfenozide, an insect growth regulator, or chlorantraniliprole, another diamide, are more likely to be chosen by growers, as data suggest almond growers are selecting more IPM friendly insecticides (BCS, 2015). IRM would still be possible if rotation occurred between these chemistries. BCS (2015) provided data showing that flubendiamide is less expensive than methoxyfenozide and chlorantraniliprole, so growers choosing them may incur higher costs.

Peppers

The main Lepidopteran pests on peppers are armyworms. On average, about 47 percent of insecticide applications are used to control these pests in peppers (BCS, 2015). While less than 500 pounds of flubendiamide were applied to peppers on average between 2011 and 2013, nearly 15 percent of pepper acres were treated with flubendiamide (Table 1). Therefore, pepper growers are finding flubendiamide to be beneficial. BCS (2015) identified the main alternatives to be spinetoram, chlorantraniliprole, methoxyfenozide, zeta-cypermethrin, and cyfluthrin (Table 2). BEAD's usage analysis identifies these same chemicals to be the primary insecticides for these pests (Proprietary Data, 2011-2013). BEAD thinks that pepper growers currently using flubendiamide are likely to select chlorantraniliprole, another diamide, to replace flubendiamide, because the data indicate pepper growers are choosing more IPM friendly insecticides, even though they are more expensive than synthetic pyrethroids (BCS, 2015; Proprietary Data, 2011-2013).

Tobacco

About 6,000 pounds of flubendiamide were applied annually to tobacco on average between 2011 and 2013, and about 26 percent of tobacco acres were treated (Table 1), indicating that flubendiamide has high benefits to tobacco growers. The primary Lepidopteran pests are tobacco budworm and tobacco hornworm. BCS identified flubendiamide as the second most used insecticide, after chlorantraniliprole, then followed by spinosyn and lambda-cyhalothrin. BEAD's usage analysis found that the top insecticides targeting these pests are acephate, *Bacillus thuringiensis*, chlorantraniliprole, flubendiamide, and spinosyn (Table 2) (Proprietary Data, 2011-2013). Growers currently using flubendiamide are choosing an IPM and IRM compatible insecticide; therefore, if flubendiamide were not available for use, BEAD thinks growers would likely choose chlorantraniliprole or spinosyn over an organophosphate or synthetic pyrethroid, which are not compatible with IPM and IRM strategies.

Peanuts

On average, over the years 2011-2013, about 5,000 pounds of flubendiamide were applied to about 6 percent of peanut acres grown (Table 1). BCS' and BEAD's usage analysis determined that the most used Lepidopteran insecticides on peanuts are diflubenzuron, bifenthrin, and lambda-cyhalothrin. BCS found that methoxyfenozide was the fourth most used insecticide for control of Lepidopteran pests (Table 2), whereas BEAD found that esfenvalerate, another synthetic pyrethroid was the fourth most used insecticide. BCS thinks that synthetic pyrethroids would likely replace flubendiamide to control Lepidopteran pests in peanuts. Since data indicate that many acres are treated with synthetic pyrethroids, BEAD agrees that peanut growers are likely to choose them to replace flubendiamide. Not only will growers likely have to make multiple insecticide applications to replace flubendiamide since synthetic pyrethroids are broad spectrum insecticides and their use can cause secondary pest problems (e.g. mites), but synthetic pyrethroids use the same mode of action, thereby limiting IRM strategies.

Alfalfa

Nearly 60 percent of insecticides applied to alfalfa target Lepidopteran pests. On average, over the years 2011-2013, about 4,000 pounds of flubendiamide were applied to less than one percent of alfalfa acres grown (Table 1). BCS (2015) found that the insecticides with the highest usage on alfalfa are lambda-cyhalothrin, cyfluthrin, z-cypermethrin, and indoxacarb (Table 2). BEAD's usage analysis had similar results but with a slightly different ranking. The most likely alternatives to flubendiamide are the synthetic pyrethroids. Synthetic pyrethroids are broad-spectrum insecticides and tend to result in population explosions of secondary pests, since all the beneficial arthropods are killed. If current flubendiamide users switched to synthetic pyrethroids, the absence of predators and parasitoids will allow pest populations to increase, resulting in more applications of insecticides, but this would be on a very small percent of alfalfa acres.

Conclusions

While there are some differences in BCS' and BEAD's analysis of the potential alternatives to flubendiamide, they are minor. The reliance on synthetic pyrethroids reduces the ability to manage IRM by using insecticides with different modes of action. IPM strategies try to employ specific insecticides that target the pests while allowing beneficial arthropods to survive. Synthetic pyrethroids are broad spectrum insecticides and do not fit well with most IPM practices. BEAD agrees with BCS that synthetic pyrethroids are the likely alternatives to flubendiamide in alfalfa, peanuts, and soybeans; but these crops have very few acres treated with flubendiamide, and consequently little benefit to those growers. However, based on its analysis of the available usage data, BEAD thinks that growers of almonds, peppers, and tobacco that have chosen to use IPM friendly flubendiamide, are likely to continue to select IPM friendly alternatives, such as insect growth regulators (e.g., diflubenzuron, methoxyfenozide), other diamides (e.g., chlorantraniliprole, cyantraniliprole), and spinosyns (e.g., spinetoram). In addition, these crops have higher acres treated with flubendiamide indicating higher benefits.

References

BCS. 2015. Bayer CropScience Benefits Document Supporting the Continued Registration of Flubendiamide (Belt SC). EPA MRID No. 49533001.

BEAD Proprietary Data, 2011-2013.

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