SOLATENOL® (Benzovindiflupyr)
Application for an Extension of the Exclusive Use Period as Permitted by FIFRA Section 3(c)(1)(F)(ii)

DATA REQUIREMENT(S): Not Applicable

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COMPLETION DATE: January 18, 2022

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LABORATORY PROJECT ID: Not Applicable

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No claim of confidentiality, on any basis whatsoever, is made for any information contained in this document. I acknowledge that information not designated as within the scope of FIFRA sec. 10(d)(1)(a), (b), or (c) and which pertains to a registered or previously registered pesticide is not entitled to confidential treatment and may be released to the public, subject to the provisions regarding disclosure to multinational entities under FIFRA 10(g).

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Adora Clark, PhD Date

Syngenta is the owner of this information and data. Syngenta has submitted this material to the United States Environmental Protection Agency specifically under the provisions contained in FIFRA as amended and, hereby, consents to use and disclosure of this material by EPA according to FIFRA. In submitting this material to EPA according to method and format requirements contained in PR Notice 2011-3, we do not waive any protection or right involving this material that would have been claimed by the company if this material had not been submitted to the EPA, nor do we waive any protection or right provided under FIFRA Section 3 (concerning data exclusivity and data compensation) or FIFRA section 10(g) (prohibiting disclosure to foreign and multinational pesticide companies or their agents).

GOOD LABORATORY PRACTICE COMPLIANCE STATEMENT

Since this volume contains a compilation of information and is not a study per se, a Good Laboratory Practice (GLP) statement, as defined by 40 CFR Part 160, is not appropriate.

There is no GLP study director for this volume.

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1.0 INTRODUCTION

The active ingredient (a.i.) benzovindiflupyr is a member of the succinate dehydrogenase inhibiting (SDHI) fungicides based on its ability to inhibit this mitochondrial respiration enzyme complex (Complex II) in fungi. Solatenol® is the trade name for benzovindiflupyr and will be used interchangeably throughout this document. Benzovindiflupyr is registered as a fungicide for canola (rapeseed crop group 20A), cereals (wheat, triticale, barley, rye, and oat), corn (field, sweet), cotton (crop group 20C), cucurbits (Crop Group 9), dried shelled peas and beans (subgroup 6C), fruiting vegetables (Crop Group 8-10), small fruit vine climbing Subgroup 13-07F, grasses grown for seed (cool season grasses), onions (bulb and green; crop group 3-07), peanuts, pome (crop group 11-10), soybean, sugarcane, tuberous and corm vegetables (Subgroup 1C), sugar beet, and non-food uses on Turf and Ornamentals. The initial registration was granted August 28, 2015 and the last minor uses (lowbush blueberry and ginseng) were granted December 17, 2020. There is also a pending use on root vegetables crop group 1B at EPA for review (carrots and radish). During the initial registration, Syngenta submitted a benefits document (MRID No. 49557601) which included some comparisons to alternative products for many of these crops and can be referred to for other details. This application seeks to request extension of the exclusive use period by three years (From August 28, 2025 to August 28, 2028).

According to FIFRA section 3(c) (1) (F) (ii), the exclusive use period may be extended if new minor uses are registered within the first 7 years of the commencement of the exclusive use period, which is the case with benzovindiflupyr. In addition, the new uses must meet at least one of the four criteria outlined in FIFRA section 3(c) (1) (F) (ii). For each 3 minor uses registered within this timeframe that meet the necessary standards, the exclusive use period may be extended for 1 year. In this document, justification is provided for extending the exclusive use period of benzovindiflupyr by three years (registered for use on at least 9 minor crops, each <300,000 acres).

When determining the number of minor uses within a crop group, FIFRA 3(c)(1)(F)(ii) states that, "the registration of a pesticide for a minor use on a crop grouping established by the Administrator shall be considered for purposes of this clause 1 minor use for each representative crop for which data are provided in the crop grouping." That is, one minor use may be credited for each representative crop for which residue trial data were submitted on a one-for-one basis.

When considering this, Syngenta believes that the following Benzovindiflupyr uses qualify as minor uses to include (based on acres harvested in the USDA 2017 Ag Census report or USDA NASS statistics 2018):

1. **Blueberry: 89,200 acres (NASS statistics 2018)**

National Statistics for Blueberries		
Data Items	2018	2017
BLUEBERRIES, TAME- ACRES HARVESTED	89,200	83,900

2. **Sweet Potatoes (Crop Group 1C- one rep crop): 172,983 acres**

Geographic area	2017			
	Total harvested		**Harvested for fresh market**	
SWEET POTATOES	Farms	Acres	Farms	Acres
United States Total				
United States_____	4,798	172,983	4,429	132,220

3. **Triticale (Cereal, small grains): 81,475 acres**

Geographic area	2017		
	Harvested		
TRITICALE (BUSHELS	Farms	Acres	Quantity
United States Total			
United States_____	952	81,475	4,585,764

4. **Garlic (Crop Group 3-07A- one rep crop): 34,903 acres**

Crop	2017			
	Total harvested		**Harvested for fresh market**	
	Farms	Acres	Farms	Acres
Garlic	7,852	34,903	7,495	20,014

5. **Onion, green (Crop Group 3-07B- one rep crop): 6,792 acres**

Crop	2017			
	Total harvested		**Harvested for fresh market**	
	Farms	Acres	Farms	Acres
Onions, green	6,278	6,792	6,002	6,081

6. **Ginseng: 1050 acres**

Crop	2017			
	Total harvested		**Harvested for fresh market**	
	Farms	Acres	Farms	Acres
Ginseng	189	1,050	85	(D)

7. **Dry Lima Bean (Crop Subgroup 6C- two rep crops): 21,557 acres**

Geographic area	2017		
	Harvested		
	Farms	Acres	Quantity
DRY LIMA BEANS (CWT)			
United States Total			
United States	137	21,557	479,525

8. **Dry Southern Peas (Crop Subgroup 6C- two rep crops): 32,312 acres**

Geographic area	2017		
	Harvested		
	Farms	Acres	Quantity
DRY SOUTHERN PEAS (COWPEAS) (BUSHELS)			
United States Total			
United States	352	32,312	616,676

9. **Bell peppers (Fruiting Vegetables 8-10- four rep. crops): 48,801 acres**

Geographic area	2017			
	Total harvested		**Harvested for fresh market**	
	Farms	Acres	Farms	Acres
PEPPERS, BELL (EXCLUDING PIMENTOS)				
United States Total				
United States	15,107	48,801	14,417	43,686

10. **Non-bell Peppers (Fruiting Vegetables 8-10- four rep. crops): 24,165 acres**

Geographic area	2017			
	Total harvested		Harvested for fresh market	
	Farms	Acres	Farms	Acres
PEPPERS, OTHER THAN BELL (INCLUDING CHILE)				
United States Total				
United States	10,855	24,165	10,094	13,155

11. **Eggplant (Fruiting Vegetables 8-10- four rep. crops): 5,365 acres**

Geographic area	2017			
	Total harvested		Harvested for fresh market	
	Farms	Acres	Farms	Acres
EGGPLANT				
United States Total				
United States	7,564	5,365	7,407	5,294

12. **Tomatillo** (Fruiting Vegetables Crop Group 8-10- 4 rep crops): acres not in AgCensus

13. **Cucumbers (Cucurbit Crop Group 9- three rep. crops): 119,655 acres**

Geographic area	2017			
	Total harvested		Harvested for fresh market	
	Farms	Acres	Farms	Acres
CUCUMBERS AND PICKLES				
United States Total				
United States	16,813	119,655	15,819	40,519

14. **Watermelon (Cucurbit Crop Group 9- three rep. crops): 129,790 acres**

Geographic area	2017			
	Total harvested		Harvested for fresh market	
	Farms	Acres	Farms	Acres
WATERMELONS				
United States Total				
United States	13,520	129,790	13,196	127,133

15. **Squash (Cucurbit Crop Group 9-three rep. crops): 70,190 acres**

Geographic area	2017			
	Total harvested		Harvested for fresh market	
	Farms	Acres	Farms	Acres
SQUASH, ALL				
United States Total				
United States	22,704	70,190	21,866	58,598

16. **Pears (Pome Crop Group 11-10- two rep. crops): 56,719 acres**

Geographic area	Total	
	Farms	Acres
PEARS, ALL		
United States Total		
United States 2017	11,749	56,719

17. **Quince** (Pome Crop Group 11-10- two rep. crops): acres not in AgCensus 2017
There is a 2007 publication from USDA called "Quest for Quince," where USDA reports that fewer than 200 acres of quince are commercially grown in the United States.
Website Link Reference:
https://agresearchmag.ars.usda.gov/AR/archive/2007/Jan/quince0107.pdf

18. **kiwifruit (Grape and small fruit vine 13-07F- one rep. crop): 4,354 acres**

Geographic area	Total	
KIWIFRUIT	Farms	Acres
United States Total		
United States 2017	426	4,354

(Amur river grape also falls in this crop group, but no Ag Census data is available)

19. **Sesame (Rapeseed Crop group 20A- one rep. crop): 55,178 acres**

Geographic area	2017				
	Harvested			Irrigated	
	Farms	Acres	Quantity	Farms	Acres
SESAME (POUNDS)					
United States Total					
United States	216	55,178	31,615,176	33	5,014

20. **Fescue Grass (Grasses Grown for Seed-Cool Season): 170,284 acres**

Crop	2017		
	Farms	Acres	Quantity
Fescue seed (pounds)	814	170,284	203,472,014

Therefore, Syngenta believes that 20 minor uses qualify for consideration of exclusive use, even though only 9 are required for the three-year extension. These minor uses can be found across several Syngenta commercial labels [EPA Reg. Nos.:100-1613 (Trivapro®); 100-1476 (Aprovia® Top); 100-1480 (Elatus®); and 100-1471 (Aprovia®)].

2.0 CRITERIA MET PER FIFRA SECTION 3(C) (1) (F) (II)

According to regulation, only one of the four following criteria must be met to qualify a minor use registration toward extension of the exclusive use data period:

1. There are insufficient efficacious alternative registered pesticides available for the use.
2. The alternatives to the minor use pesticide pose greater risks to the environment or human health.
3. The minor use pesticide plays or will play a significant part in managing pest resistance.
4. The minor use pesticide plays or will play a significant part in an integrated pest management program.

The criteria met for all 20 benzovindiflupyr minor uses are briefly outlined in this section, since a more detailed Benefits document (MRID No. 49557601) was previously submitted during initial registration. Appendix 1 contains a table to summarize the criteria met for all 20 of the minor crop uses.

BLUEBERRY (IR-4 SUBMISSION)

Meets Criteria 4- important for integrated pest management (IPM)

IR-4 conducted residue trials that they submitted to EPA for a new tool to control diseases of lowbush blueberry (crop subgroup 13-07B). Specifically, IR-4 notes the importance to IPM, as shown here from their chemical website, for PR#12636:

BENZOVINDIFLUPYR	BLUEBERRY (LOWBUSH) (13-07B)

IPM Compatibility:	Per Requestor: Good IPM Fit; Material is in a different FRAC Group than the other major fungicides, Chlorothalonil (M05) and Prothioconazole (3), currently used for Leaf Spot control.
Reasons for need:	Blueberry Leaf Rust, Thekopsora, Minima - Suppression; Leaf Rust can cause significant early leaf loss which can result in few flower buds for next year and may affect overall health of the plant; There is Canadian data to support a use in crop year and this will be an advantage to the blueberry industry to have harmonized use and MRLS across Lowbush blueberry regions.

After EPA reviewed IR-4's data, they approved the minor use on lowbush blueberry (crop subgroup 13-07B), December 17, 2020.

GARLIC AND GREEN ONIONS (CROP GROUPS 3-07A AND 3-07B)

Meets Criteria 1, 3 and 4

Criteria 1- more efficacious than alternatives & 3- plays a role in resistance management
IR-4 conducted residue trials that they submitted to EPA for a new tool to control garlic rust. A section from the IR-4 chemical website is copied below to highlight their needs:

Priority Setting Tool

Pr num: 11129 Chemical/Commodity: BENZOVINDIFLUPYR / GARLIC

Region	Name	Comments
WSR	Historical	WR "A/B" based on need pending additional input and efficacy data
		Project submitted as Solatenol (RS 8/16/12)
		RE (CA)… The use we have keen interest in is garlic rust control as tebuconazole is much less effective than when first I got a Sec 18. My only other choice on rust is azoxystrobin and I need that for preventative control and we are limited to 2 apps only.

Specifically, as seen in the above table, because tebuconazole is much less effective than when a Section 18 was first sought, the only other choice on rust is azoxystrobin (criteria 1) and they need that for preventative control and are limited to 2 applications only. Also, it was important to IR-4 because the strobilurins are becoming more resistant (criteria 3). IR-4 received EPA approval for the bulb vegetable group (3-07A and 3-07B), which included garlic and green onions on December 21, 2017 (joint with Canada PMC).

4- plays a significant role in Integrated Pest Management (IPM)
The Canadian IR-4 counterpart, i.e. PMC, conducted efficacy trials (Study # AAFC13-066 and AAFC13-070) with benzovindiflupyr (end use product Aprovia) and found that Garlic rust (*Puccinia allii*) severity was reduced by up to 97% by four applications of benzovindiflupyr in three trials on garlic at 75 g ai/ha. Similarly, four applications of benzovindiflupyr at 75 g ai/ha in reported trials on onion reduced purple blotch, *Alternaria porri* disease severity up to 96%. PMC concluded "Aprovia® fungicide would be an excellent additional tool in an IPM strategy for the management of foliar diseases of Crop Group 3-07." The report also states that benzovindiflupyr is efficacious and represents a new fungicide mode of action for garlic rust control. The broad-spectrum activity and ability of benzovindiflupyr end use products to be used as a tank mix partner will help target and limit the number of fungicide treatments required. The PMC efficacy report on onions (crop group 3-07) is enclosed with this submission as reference.

GINSENG (IR-4 SUBMISSION)

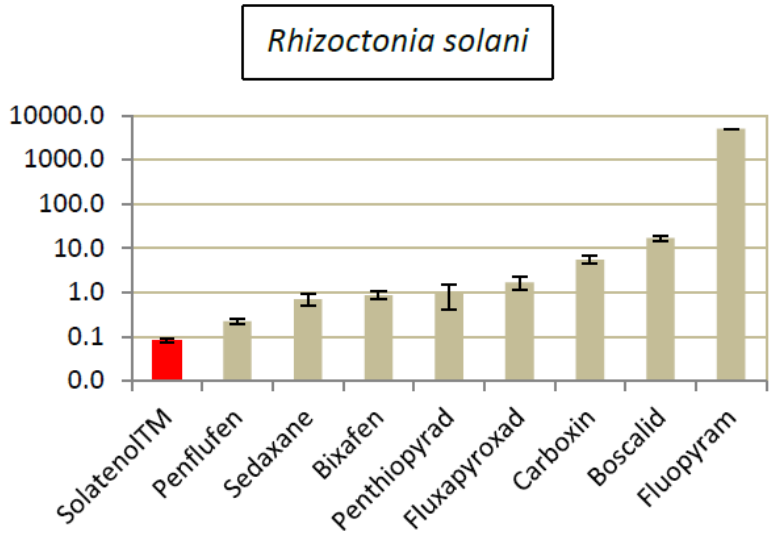
Meets Criteria 4- plays a significant role in Integrated Pest Management (IPM)

IR-4 conducted residue trials that they submitted to EPA for a new tool to control ginseng diseases. Specifically, IR-4 notes the importance to IPM, as shown here from their chemical website, for PR#11760:
"Per Requestor: Very good IPM fit; New AI (Benzovindiflupyr or Solateno[l®]) Will be helpful in managing *Alternaria* which requires an intensive fungicide program."
After EPA reviewed IR-4's data, they approved the minor use on ginseng December 17, 2020.

SWEET POTATO (TUBEROUS AND CORM CROP GROUP 1C)

Meets criteria 1 and 3

Criteria 1: insufficient efficacious alternative registered pesticides
Rhizoctonia, a soil-borne disease, can severely affect the quality and yield of sweet potatoes. Currently, there are limited products with efficacy against fungal disease. Azoxystrobin is one of the major alternatives that has good efficacy, but due to increasing resistance cannot always be used. Benzovindiflupyr (Solatenol®) is more effective against *Rhizoctonia solani* when compared against other SDHI fungicides (see following graph):



Enzymatic benchmarking demonstrates the lowest concentration (nM) to inhibit the SDH enzyme by 50% (benefits document, EPA MRID No. 49557601). Therefore, at a lower rate, benzovindiflupyr is more effective than other active ingredients of the same mode of action for Rhizoctonia control.

Criteria 3: plays a role in resistance management
Strobilurins are the key mode of action used as an alternate product, as others are not efficacious against soil-borne diseases. When mixed with azoxystrobin, benzovindiflupyr plays a role in strobilurin resistance management. Quadris (azoxystrobin) has been used successfully as an in-furrow treatment on potatoes for control of *Rhizoctonia* – a disease that can infect the seed potato and result in poor plant stands and/or infection of daughter tubers. Benzovindiflupyr has been

mixed with azoxystrobin to provide resistance management, resulting in a product (Elatus®) that controls *Rhizoctonia* effectively at a lower rate than alternative products.

In the EPA BEAD document during registration (EPA-HQ-OPP-2013-0141-0065), EPA stated "On potatoes soil-borne *Rhizoctonia solani* (causing stem canker and black scurf disease) can be a major problem and managed by using azoxystrobin at the time of planting seeds (Syngenta. 2015). The fungal pest has become less sensitive to azoxystrobin at many locations. Benzovindiflupyr, when used alone or in combination with azoxystrobin, provides an excellent control of this pest on potatoes (Syngenta, 2015)."

During the initial comment period for benzovindiflupyr, John Keeling with the National Potato council (EPA-HQ-OPP-2013-0141-0025), Michael R. Wenkel with the Potato Growers of Michigan, Inc. (EPA-HQ-OPP-2013-0141-0027) and Chuck Gunnerson with the Northern Plains Potato Growers Association (EPA-HQ-OPP-2013-0141-0031), all commented on the importance of having this tool for resistance management to control soil-borne diseases including *Rhizoctonia*, silver scurf, and black dot.

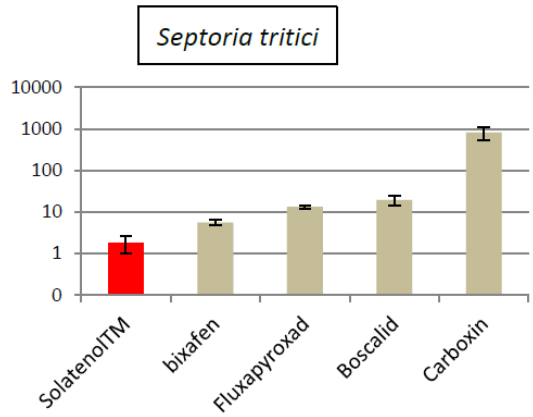
It's also worth mentioning that IR-4 is currently conducting trials with benzovindiflupyr on other root vegetables (garden beet) to help with resistance management and as a good fit for integrated pest management (IR-4 PR number: 12351). There is also a pending tolerance petition at EPA to add a new use for root vegetable crop group 1B (carrot and radish).

TRITICALE**:** *Meets criteria 1 and 3*

Criteria 1: insufficient efficacious alternative registered pesticides

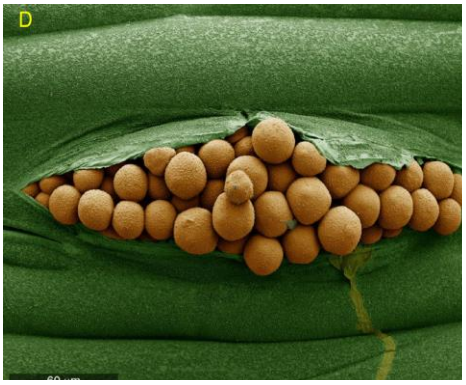
Benzovindiflupyr (Solatenol®) and its end use products (Trivapro® in cereals) is an excellent active ingredient that provides both broad spectrum disease control as well as plant health benefit

on cereal grains that greatly enhance grower's ability to protect their crops from disease and boost their yield and quality of their crop. Although there are many fungicides available today to help growers protect their field crops from fungal diseases, benzovindiflupyr is the most efficacious active ingredient available for control of rust diseases. Benzovindiflupyr is also more effective than other SDHI fungicides against *Septoria tritici* in cereals.



Enzymatic benchmarking demonstrates the lowest concentration (nM) to inhibit the SDH enzyme by 50% (From benefits document, EPA MRID No. 49557601).

The spectrum of activity of this active ingredient is broad and covers most of the key fungal diseases of cereals, but in particular, it is extremely efficacious against rust pathogens. Rusts are devastating diseases because the pathogens that cause them rip open the cuticle (outer waxy layer) of infected leaves to liberate masses of spores.



As a result of this more efficacious active ingredient on rust (and glume blotch), Trivapro (EPA Reg. No 100-1613) has become the leading standard fungicide for cereals (including triticale). In fact, Trivapro® was selected as the AgriMarketing product of the year in 2018. Benzovindiflupyr helps to provide plant health benefits that delay senescence in cereals over and above any other alternative products. Adding benzovindiflupyr (Solatenol®) to the mix of azoxystrobin and propiconazole in Trivapro® provides even greater green leaf retention than

does Quilt Xcel (Appendix 2: Figure 3). Given increasing resistance to strobilurins and triazoles, benzovindiflupyr also meets criteria 3, playing an important role in resistance management. See Appendix 2 for a more detailed benefit description of benzovindiflupyr use on cereal grains (and other row crops).

In the EPA BEAD document during registration (EPA-HQ-OPP-2013-0141-0065), EPA stated "On wheat and barley, leaf rust and glume blotch diseases are of high economic importance (Syngenta, 2015). They are controlled by triazole (propiconazole, tebuconazole) and strobilurin fungicides (azoxystrobin, pyraclostrobin). These fungal pests have developed resistance against strobilurins and tolerance against triazole fungicides is increasing (Syngenta, 2015). A benzovindiflupyr treatment may result in better control of these diseases and resistance management against currently used fungicides."

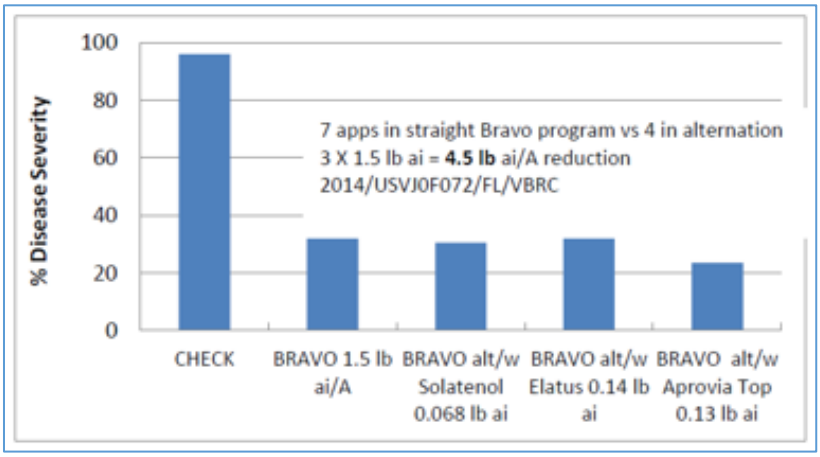
Also to support the benefits of benzovindiflupyr on cereals, Dr. Jason Bond- a Professor of Plant Pathology- commented (EPA-HQ-OPP-2013-0141-0038) during the initial registration that his research group has conducted many fungicide trials, several with benzovindiflupyr (Solatenol®). Dr. Bond stated that benzovindiflupyr offers an excellent job controlling many foliar pathogens on wheat (which applies to triticale). He stated that when it is added to other chemistries, the spectrum of disease control is outstanding, and helps manage these difficult pathogens by bringing a new chemistry class into many disease management programs. Additional benefits that he noted is that benzovindiflupyr helps protect and prolong the effectiveness of the strobilurin and triazole fungicides, and provides complementary control options that can be paired with host resistance for many diseases.

WATERMELON, CUCUMBER, SQUASH

Meets Criteria 3 and 4

Criteria 3: plays a role in resistance management and 4: in Integrated Pest Management
Cucurbit crops (cucumbers, squash, cantaloupe, watermelons, etc.) are inundated with numerous foliar and soil diseases affecting the foliage and the fruit. Resistance to several classes of fungicides has occurred. Benzovindiflupyr helps manage powdery mildew and gummy stem blight. It is premixed with difenoconazole (a triazole chemistry; Aprovia Top), for resistance management as well as to broaden the disease spectrum. Currently, Chlorothalonil and EBDCs (e.g. Mancozeb) are used frequently to bring multi-site mode of action to the program. These fungicides are useful tools and will not be totally replaced, but due to the increased efficacy from benzovindiflupyr products, the use rate and resulting total pounds applied per year across all acres will be reduced, as depicted in the following figure.

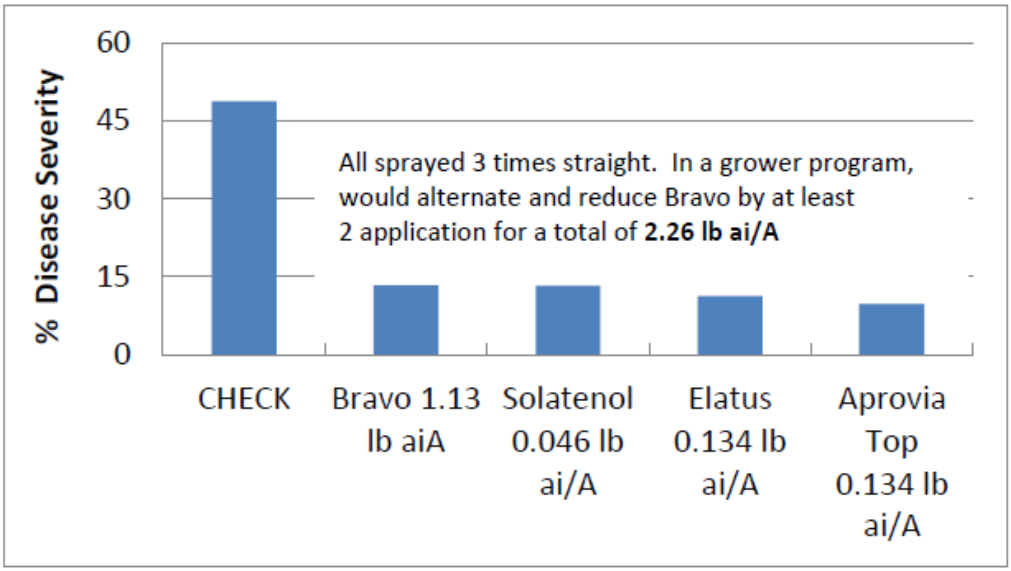
Gummy Stem Blight Control (Watermelons) Using Less Chlorothalonil (Bravo) when adding a Low Rate of Benzovindiflupyr (Solatenol™; Solo and Mixtures)



Powdery Mildew Control with Benzovindiflupyr (Solatenol®)

Aprovia Top = Benzovindiflupyr plus difenoconazole

Control of Powdery Mildew (Zucchini) Using Chlorothalonil (Bravo) + Solatenol® (Solo and Mixtures)



Bravo = Chlorothalonil
Solatenol = Benzovindiflupyr
Elatus = Benzovindiflupyr plus azoxystrobin
Aprovia Top = Benzovindiflupyr plus difenoconazole

Powdery mildews on cucurbit crops can be better managed using benzovindiflupyr in a rotation program comprised of multiple fungicides (such as mancozeb, chlorothalonil, strobilurins and triazoles).

In the EPA BEAD document during registration (EPA-HQ-OPP-2013-0141-0065), EPA stated "On cucurbits (watermelon, melon, cucumber and others) gummy stem blight is a major disease and currently managed by using chlorothalonil, strobilurins and triazole fungicides. Addition of Benzovindiflupyr in the disease control program would help in reducing chlorothalonil use, resistance management against strobilurins and triazole fungicides in addition to better disease management (Syngenta, 2015). Benzovindiflupyr has been demonstrated to be effective against powdery disease on cucurbits (Syngenta, 2015)."

The EPA BEAD document also stated:
"Benefits might also be recognized for benzovindiflupyr treatments on registered crops with minor pesticide uses on minor crops (e.g., cucurbits, fruiting vegetables) where there are few registered fungicides."

Stakeholders also recognize the importance of benzovindiflupyr for resistance management. For example, Robert Guenther, with United Fresh Produce Association, stated (EPA-HQ-OPP-2013-0141-0041) during the registration comment period how important benzovindiflupyr would be for use in fruiting vegetable and cucurbit production. The benefits that he outlined were, 1) a broad-spectrum fungicide in the FRAC group 7, 2) Incorporates a greater diversity of active

ingredients in rotation, which helps maintain the utility of other active ingredients, and 3) resistance control- Aprovia® Top provides two modes of action against a broad range of foliar and root pathogens, including powdery mildews.

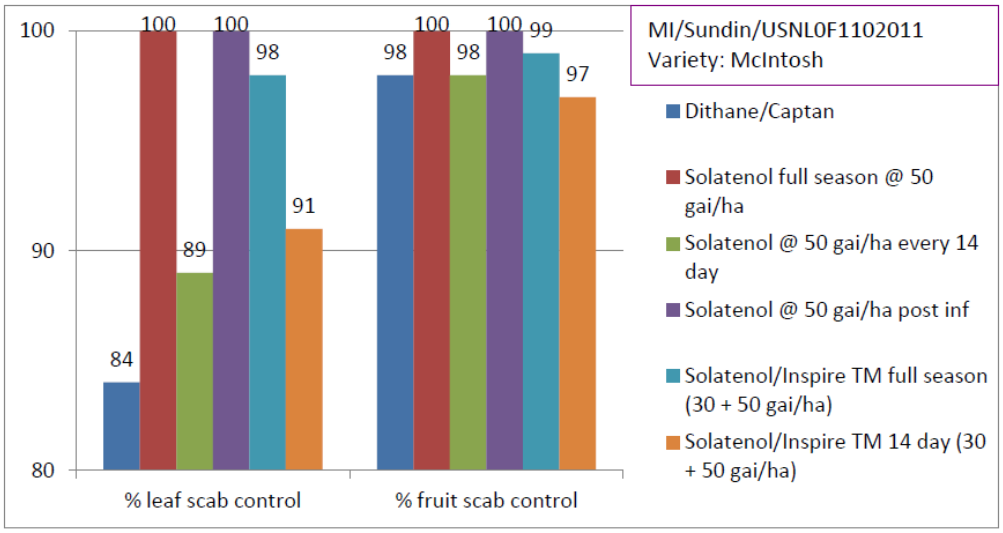
PEARS AND QUINCE (POME FRUITS)

Meets Criteria 1, 2 and 3

Criteria 1- more efficacious than alternatives

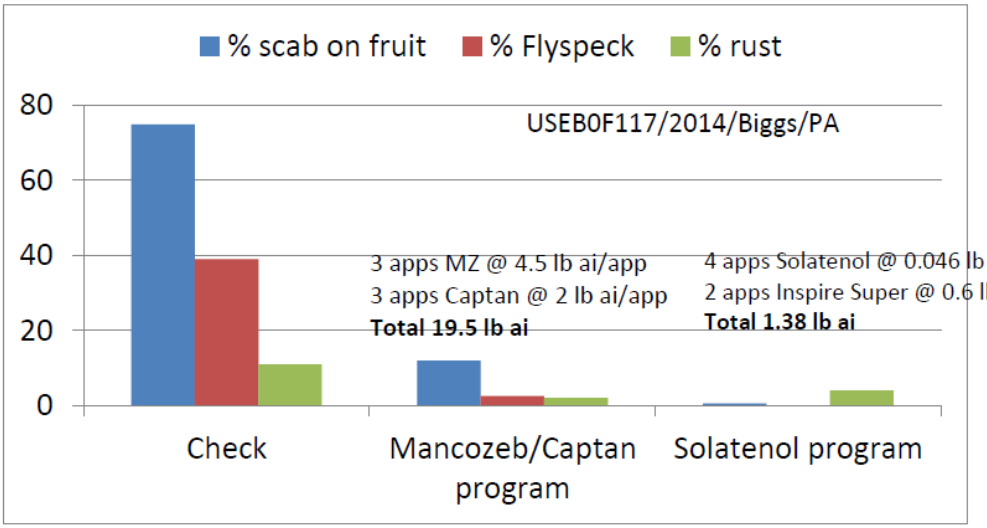
Benzovindiflupyr (Solatenol®) brings a new level of control to several key diseases, including Venturia in pome fruit. An example of using a lower rate of benzovindiflupyr for improved efficacy to control Apple Scab, compared to higher levels of alternative products to get the same control, is shown in the next two figures.

Control of Leaf and Apple Scab (*Venturia inaequalis*) with Solatenol® solo (Aprovia®) or mixed with Inspire® (difenoconazole)

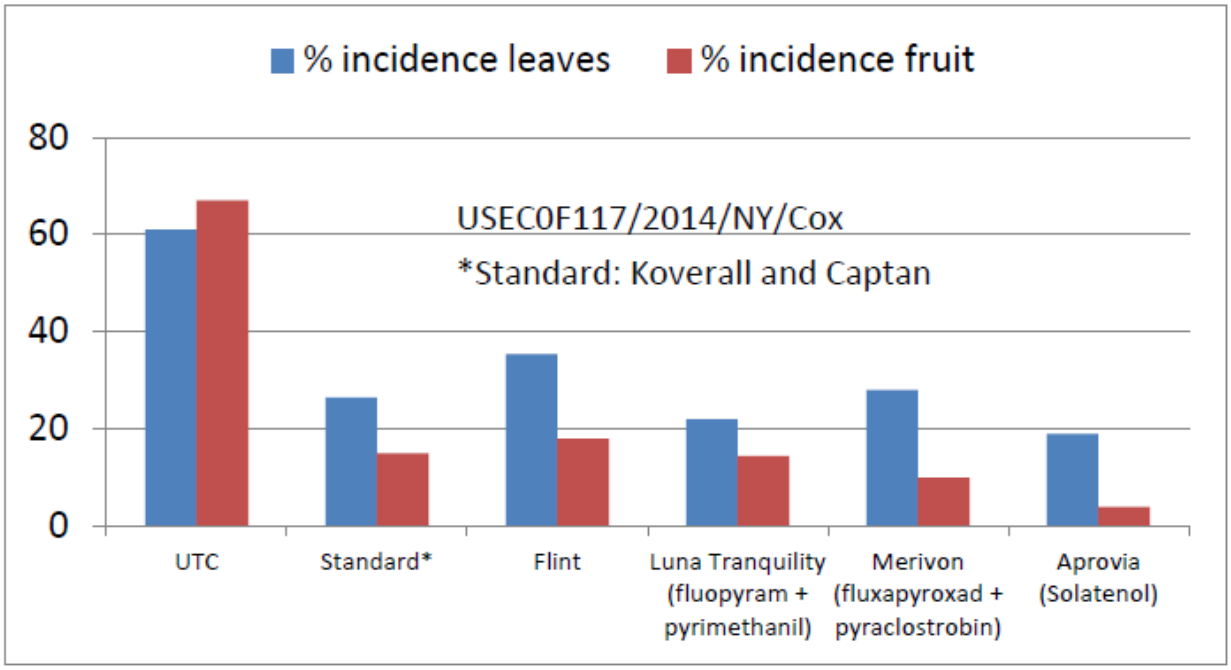


Captan label- 8 pounds/A
Dithane = Mancozeb 4.8 qt/A

Control of Apple Scab (Venturia inaequalis)



Activity of SDHIs for Apple Scab Control: Fluopyram, Fluxapyroxad, and Solatenol®



Using conservative estimates, a total of 610,000 lb ai of EBDCs and 391,000 lb ai of Captan could be replaced with the use of Solateno[l®] based products per year.

Assumption for Captan replacement:

- Will replace 2 applications in NY
- Will replace 1.5 applications in remaining acres throughout the US.

Assumption for EBDC replacement:
- Will replace 1.5 sprays in apples grown in the Eastern US

Criteria 2- alternatives pose greater risks to the environment or human health
The endpoints for benzovindiflupyr were compared to other products it would replace for human safety. Benzovindiflupyr has a better human safety profile than captan, chlorothalonil and Mancozeb, currently used to control the same diseases on pome fruit. The safety profile was equally favorable to Fluxapyroxad and Penthiopyrad. A complete safety profile comparison can be found in the initial benefits document previously submitted to EPA (MRID No. 49557601, submitted March 30, 2015).

Criteria 3- plays a role in resistance management:
As mentioned for other minor use crops above, benzovindiflupyr plays a significant role in resistance management due to strobilurin and triazole resistance.

In the EPA BEAD document during registration (EPA-HQ-OPP-2013-0141-0065), EPA stated "This practice would result in reduction of environmental load of captan and/or mancozeb. In addition to captan and mancozeb, strobilurin fungicides (such as azoxystrobin and trifloxystrobin) and triazole fungicides (such as myclobutanil) are used for controlling apple scab. Resistance against strobilurin and many triazole fungicides is common (Rosenberger and Cox, 20 I 0) and benzovindiflupyr is expected to play a significant role on apple scab disease management and resistance management to maintain the efficacy of strobilurin and triazole fungicides."

FRUITING VEGETABLES (EGGPLANT, BELL AND NON-BELL PEPPERS, TOMATILLO)
Meets Criteria 1, 3 and 4

Fruiting vegetables (tomatoes and peppers primarily) are also prone to numerous diseases – mostly foliar, but some soil-borne. Benzovindiflupyr is more efficacious on leafspot and powdery mildew than alternatives and has longer residual activity. Benzovindiflupyr, premixed with difenoconazole (Aprovia® Top), is a useful tool for further control of leafspot and powdery mildew; and it would reduce the use of chlorothalonil and the EBDCs (as similarly described for cucurbits and pome fruit). In fruiting vegetables, benzovindiflupyr products could replace approximately 128,000lb ai of EBDCs and 129,000 lb ai of chlorothalonil (cited from previously submitted Benefit Document, EPA MRID No. 49557601).
Assumptions for EBDC replacement:
- Replace 1.5 sprays in FL
- Replace ½ of avg number of sprays in remaining key use areas

Assumptions for chlorothalonil replacement:
- Replace 1 spray in FL
- Replace 0.5 sprays in remaining key states

The maximum use rates for benzovindiflupyr use on fruiting vegetables is lower than most of the alternate products (excluding Fluxapyroxad- which has an equivalent annual rate).

Crop	*Rate (lb. ai / acre), No. of Applications, (Treatment Interval)					
	Benzovindiflupyr[1]	**Chlorothalonil[2]**	**Mancozeb[3]**	**Captan[4]**	**Penthiopyrad[5]**	**Fluxapyroxad[6]**
Fruiting Vegetable	**0.067 x 4, (7d)**	**1.5 x 10, (7d)**	2.4 x 7, (7d)	--	**0.31 x 3, (7d)**	0.089 x 3, (7d)

1 Benzovindiflupyr solo (A15457) draft label
2 Bravo® label (EPA Reg. No. 50534-188-100)
3 Dithane® label (EPA Reg. No. 62719-387)
4 Captan 80 label (EPA Reg. No. 66222-58-66330)
5 Fontelis ™ label (EPA Reg. No. 352-834)
6 Merivon® label (EPA Reg. No. 7969-310)

In the EPA BEAD document during registration (EPA-HQ-OPP-2013-0141-0065), EPA stated "Benefits might also be recognized for benzovindiflupyr treatments on registered crops with minor pesticide uses on minor crops (e.g., cucurbits, fruiting vegetables) where there are few registered fungicides."

During the registration comment period, a representative with Ohio State University (EPA-HQ-OPP-2013-0141-0033) commented on its importance to fruiting vegetables. Specifically, research conducted with Solatenol™ at the Ohio State University over a two-year period, combined with either difenoconazole (Aprovia® Top) or azoxystrobin (Elatus®) showed excellent activity against early blight and anthracnose of tomato. He further stated that it is very important that vegetable farmers have access to effective products (such as benzovindiflupyr) that can be used to manage these serious diseases as part of an integrated pest management program.

SOUTHERN PEAS AND DRY LIMA BEANS (CROP GROUP 6C)
Meets Criteria 1 and 3

Benzovindiflupyr is very efficacious against Rust on legumes (*Uromyces* and *Phakopsora*), where there are few alternatives.

During the initial benzovindiflupyr registration comment period, IR-4 listed growers of pea and bean, dried shelled, subgroup 6C among those that would benefit most from the use of Solatenol® (EPA-HQ-OPP-2013-0141-0043) for resistance management. When used as a combination (dual -mode-of-action) product, there will be no cross-resistance to strobilurin or triazole fungicides.

Joe Cramer with The Michigan Bean Commission commented on the importance of benzovindiflupyr during the registration comment period (EPA-HQ-OPP-2013-0141-0048). He outlined the importance of Elatus® (benzovindiflupyr plus azoxystrobin) in control of problematic pathogens on beans, as well as its role to minimize resistance development while ensuring high quality development of dry beans.

SESAME (CROP GROUP 20A)

Meets Criteria 3 and 4

Benzovindiflupyr effectively controls Powdery Mildew (*Erysiphe/Blumeria spp.*) and leafspots (*Alternaria spp.*) on the Rapeseed Crop Group 20A commodities, which includes the minor crop, sesame. As mentioned for the other minor uses above, benzovindiflupyr is a needed tool to combat increasing resistance problems with strobilurins and triazoles.

During the initial benzovindiflupyr registration comment period, IR-4 listed growers of rapeseed subgroup 20A among those that would benefit most from the use of Solatenol® (EPA-HQ-OPP-2013-0141-0043). IR-4 cited the following reasons for its importance:
1) Sustainable pest management tools
2) Replacing or reducing reliance on older products
3) Demonstrated safety on a wide range of crops, an increase in yield potential and tank mixing compatibility with other products
4) When used as a combination (dual-mode-of-action) product, there will be no cross-resistance to strobilurin or triazole fungicides
5) Control and/or suppression will be obtained on a wide range of diseases.

FESCUE GRASS
Meets Criteria 3 and 4

IR-4 received requests (PR number 11749) to control rusts in grasses with benzovindiflupyr (as a class 7 AI), since it is a good IPM fit because it provides a third MOA (pyrazole carboxamide) that is unique to grasses grown for seed. Alternative products are needed for resistance management. The Trivapro product is a 3-way combo with propiconazole and azoxystrobin which is a benefit for managing disease resistance. Trivapro has provided long residual, thus reducing applications needed per crop season.

Given IR-4's need for a new mode of action to control grasses diseases, Syngenta made the submission to bring growers this new fungicide tool to control Ergot Stem Diseases, Powdery Mildew, Rusts and Selenophoma Stem Eyespot in cool season grasses. EPA approved the petition for use on bluegrass, bromegrass, fescue, orchardgrass, and ryegrass (June 19, 2018).

KIWIFRUIT, HARDY (CROP GROUP 13-07F INCLUDES AMUR RIVER GRAPE)
Meets Criteria 2 and 4

As indicated in the previously submitted benefits document during initial registration (MRID No. 49557601), benzovindiflupyr is efficacious in controlling powdery mildews (*Erysiphe/Blumeria spp.*) on grapes at lower rates than the alternate products.

Crop	*Rate (lb. ai / acre), No. of Applications, (Treatment Interval)					
	Benzovindiflupyr[1]	Chlorothalonil[2]	Mancozeb[3]	Captan[4]	Penthiopyrad[5]	Fluxapyroxad[6]
Grapes	0.067 x 4, (7d)	--	3.2 x 6, (7d)	2.2 x 6, (10d)	--	0.18 x 3, (7d)

1 Benzovindiflupyr solo (A15457) draft label
2 Bravo® label (EPA Reg. No. 50534-188-100)
3 Dithane® label (EPA Reg. No. 62719-387)
4 Captan 80 label (EPA Reg. No. 66222-58-66330)
5 Fontelis ™ label (EPA Reg. No. 352-834)
6 Merivon® label (EPA Reg. No. 7969-310)

Terrestrial and aquatic EECs for benzovindiflupyr evaluated in the same benefits document are generally much lower than those for the older alternative fungicides (mancozeb and captan) and are comparable with fluxapyroxad. Having an efficacious product at lower rates and replacing some of the older chemistries plays an important role in integrated pest management.

OVERALL SUMMARY

With this document, Syngenta believes that benzovindiflupyr qualifies for the 3-year exclusive use extension. Benefits on 20 registered minor uses were shown to meet one or more of the 4 criteria, for these crops grown on $\leq$ 300,000 acres, while only 9 minor uses are required.

3.0 APPENDIX 1

APPENDIX 1: Benzovindiflupyr Summary of Minor Crops Registered and Criteria Met

Minor Use Crop	Acres harvested per Year (AgCensus 2017)	Summary of Benefits Compared to Alternatives	Criteria met of FIFRA 3(c)(1)(F)(ii)	Registration Date	Comments
Blueberry (Crop Subgroup 13-07B) (On Aprovia® label 100-1471 and Aprovia Top 100-1476)	89,200 (2018 NASS Statistics)	Good IPM fit	Criteria 4	12/17/2020	IR-4 submission
Triticale (On Trivapro label; 100-1613)	81,475	Better efficacy against rust and glume blotch (criteria 1) and also more effective than other SDHI fungicides against Septoria tritici in cereals. Important to resistance management (criteria 3) due to triazole and strobilurin resistance.	Criteria 1 Criteria 3	8/28/2015	Trivapro® for cereals Selected by AgriMarketing as best new product of 2018. Also see Benefits document submitted to EPA during registration (MRID No. 49557601) and Appendix 2.
Sweet potatoes (Tuberous & corm veg. subgroup 1C) (On Aprovia® Top Fungicide label; 100-1476)	172,983	There are limited products with efficacy against soil-borne fungal disease and Azoxystrobin is one of the major alternatives. Solatenol™ is extremely efficacious against rust pathogens compared to alternatives. Solatenol™ is more effective to control Rhizoctonia in potatoes than all other SDHI products. When mixed with azoxystrobin, it also plays a role in strobilurin resistance management (Criteria 3).	Criteria 1 Criteria 3		This was detailed in the Benefits document submitted to EPA during registration (MRID No. 49557601).
Garlic (Bulb Veg. Crop Group 3-07A) (On Trivapro® label; 100-1613)	34,903	For garlic rust: tebuconazole is much less effective. The only other choice on rust is azoxystrobin, but growers need that for preventative control and are limited to 2 apps only. Also, helps manage strobilurin resistance (good IPM fit).	Criteria 1 Criteria 3 Criteria 4	12/31/2017 (IR-4)	IR-4 submission

Minor Use Crop	Acres harvested per Year (Ag Census 2017)	Summary of Benefits Compared to Alternatives	Criteria met of FIFRA 3(c)(1)(F)(ii)	Registration Date	Comments
Green Onion (Crop Group 3-07B) (On Trivapro® label; 100-1613)	6,792	Same as above for garlic to control rust.	Criteria 1 Criteria 3 Criteria 4	12/31/2017 (IR-4)	IR-4 submission
Ginseng (On Aprovia® Top label; 100-1476; also on Elatus label (100-1480)	1050	Good IPM fit	Criteria 4	12/17/2020	IR-4 submission
Dry Lima Beans (Crop Group 6C) (On Aprovia® Top Fungicide label; 100-1476)	21,557	Efficacious against rust on legumes (Uromyces and Phakopsora), where there are few alternatives. When used as a combination (dual-mode-of-action) product, there will be no cross-resistance to strobilurin or triazole fungicides.	Criteria 1 Criteria 3	8/28/2015	
Southern Pea (Crop Group 6C) (On Aprovia® Top Fungicide label; 100-1476)	15,244	Same as above for dry lima beans	Criteria 1 Criteria 3	8/28/2015	
Tomatillo (Fruiting Vegetables Crop Group 8-10) (On Aprovia® Top Fungicide label; 100-1476)	Not specified	More efficacious on leafspot and powdery mildew than alternatives; has longer residual activity. Benzovindiflupyr would reduce the use of chlorothalonil and the EBDCs. In fruiting vegetables, Benzovindiflupyr products could replace approximately 128,000lb ai of EBDCs and 129,000 lb ai of chlorothalonil.	Criteria 1 Criteria 3 Criteria 4	8/28/2015	Previous Benefit Document, Syngenta No. EPA MRID No. 49557601

Minor Use Crop	Acres harvested per Year (AgCensus 2017)	Summary of Benefits Compared to Alternatives	Criteria met of FIFRA 3(c)(1)(F)(ii)	Registration Date	Comments
Bell peppers (Fruiting Vegetables 8-10) (On Aprovia® Top Fungicide label; 100-1476)	48,801	Same as above for Tomatillo	Criteria 1 Criteria 3 Criteria 4	8/28/2015	Same as above for Tomatillo
Non-bell Peppers (Fruiting Veg. 8-10) (On Aprovia® Top Fungicide label; 100-1476)	24,165	Same as above for Tomatillo	Criteria 1 Criteria 3 Criteria 4	8/28/2015	Same as above for Tomatillo
Eggplant (Fruiting Vegetables 8-10) (On Aprovia® Top Fungicide label; 100-1476)	5,365	Same as above for Tomatillo	Criteria 1 Criteria 3 Criteria 4	8/28/2015	Same as above for Tomatillo
Cucumbers (Cucurbit Crop Group 9) (On Aprovia® Top Fungicide label; 100-1476)	119,655	Resistance to several classes of fungicides makes Solatenol™ an important tool to help manage powdery mildew and gummy stem blight in cucurbits. It is premixed with difenoconazole for resistance management as well as to broaden the disease spectrum. Chlorothalonil and EBDCs are used frequently to bring multi-site mode of action to the program. Resulting total pounds applied per year for these older fungicides across all acres will be reduced.	Criteria 3 Criteria 4	8/28/2015	Previous Benefit Document: EPA MRID No. 49557601.
Watermelon (Cucurbit group 9) (On Aprovia® Top Fungicide label; 100-1476)	129,790	Same as above for cucumbers	Criteria 3 Criteria 4	8/28/2015	Same as above for cucumbers
Squash (Cucurbit Crop Group 9) (On Aprovia® Top Fungicide label; 100-1476)	70,190	Same as above for cucumbers	Criteria 3 Criteria 4	8/28/2015	Same as above for cucumbers

Minor Use Crop	Acres harvested per Year (AgCensus 2017)	Summary of Benefits Compared to Alternatives	Criteria met of FIFRA 3(c)(1)(F)(ii)	Registration Date	Comments
Pears (Pome Crop Group 11-10) (On Aprovia® label; 100-1471)	56,719	Benzovindiflupyr brings a new level of control to Venturia in pome and is the best control for apple scab. Benzovindiflupyr has a more favorable human safety and environmental profile compared to older fungicides that it replaces: captan and mancozeb, whereas with benzovindiflupyr, the application rate is much less. Benzovindiflupyr also plays a role in triazole and strobilurin resistance management.	Criteria 1 Criteria 2 Criteria 3	8/28/2015	1) Benefit Document: EPA MRID No. 49557601. 2) EPA BEAD (EPA-HQ-OPP-2013-0141-0065) concluded for pome fruit: benzovindiflupyr "is a more effective SDHI fungicide in an integrated fungicide program."
Quince (Pome Crop Group 11-10) (On Aprovia® label; 100-1471)	Not available	Same as above for pears	Criteria 1 Criteria 2 Criteria 3	8/28/2015	Benefit Document submitted during registration, EPA MRID No. 49557601.
Kiwifruit, Hardy (Grape and small fruit vine 13-07F) (On Aprovia® label; 100-1471 and Aprovia Top 100-1476)	4,354	Terrestrial and aquatic EECs for benzovindiflupyr evaluated in the previously submitted benefits document were generally much lower than those for the older alternative fungicides (mancozeb and captan), and at much lower use rates. This plays a significant role in IPM with more alternatives.	Criteria 2 Criteria 4	8/28/2015	13-07F Group includes Amur River Grape, but no AgCensus data on acres. Benefit Document submitted during registration, EPA MRID No. 49557601.
Sesame (Rapeseed Crop group 20A) (On Elatus® label; 100-1480)	55,178	Benzovindiflupyr effectively controls Powdery Mildew (Erysiphe/Blumeria spp.) and leafspots (Alternaria spp.) on the Rapeseed Crop Group 20A. Benzovindiflupyr is a needed tool to combat increasing resistance problems with strobilurins and triazoles.	Criteria 3 Criteria 4	8/28/2015	
Fescue Grass (On Trivapro® label; 100-1613)	170,284	Per IR-4: benzovindiflupyr (as a class 7 AI) is a good IPM fit because it provides a 3rd MOA that is unique to grasses grown for seed. Trivapro is a 3-way combo with propiconazole and azoxystrobin which is a benefit for managing disease resistance since more alternatives are needed.	Criteria 3 Criteria 4	6/19/2018	Identified by IR-4 as a need and Syngenta conducted the trials and made the submission.

4.0 APPENDIX 2

Plant Health and Disease Control Benefits from Benzovindiflupyr (Solatenol®) on Row Crops (e.g. Triticale)

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Completion Date: March 28, 2019

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1.0 Plant health benefits from benzovindiflupyr

The concept of using fungicides to provide plant physiological benefits that enhance plant growth (plant health benefits) above and beyond disease control is relatively new. This is particularly true for the row crops like corn. Twenty years ago there were very few fungicides used on corn, and the ones that were used were only used on high value corn like seed corn or specialty corn. Today the percentage of corn acres treated with fungicides is much higher than it was twenty years ago. This is largely because growers have recognized the benefits to plant health, stalk quality, water use efficiency, reduction in the rate of senescence, harvest efficiency, and yield that they get from some fungicides. Not all fungicides provide plant health benefits. Strobilurin fungicides have been documented the most for providing these kinds of benefits. A high level overview of some of these benefits is provided below.

Azoxystrobin, the active ingredient in Quadris® fungicide, and one of the three active ingredients in Trivapro® fungicide, increases many of the beneficial antioxidant enzymes in plants and decreases some of the damaging reactive oxygen species (ROX). Azoxystrobin decreases super oxide (O^{-2}) production in wheat while increasing both super oxide dismutase and peroxidase (Wu and von Tiedemann, 2001), which subsequently reduces ozone injury (Wu and von Tiedemann, 2002b). Azoxystrobin also reduces super oxide levels in barley (Wu and von Tiedemann, 2004), which is highly correlated with physiological leaf spot (Wu and von Tiedemann 2002b, Wu and von Tiedemann, 2004), a malady that causes abiotic necrotic lesions and often decreases yield in parts of Europe (Jabs, et al., 2002; Wu and von Tiedemann, 2002a). Azoxystrobin has also been found to increase super oxide dismutase, peroxidase, catalase, ascorbate peroxidase, glutathione reductase, and protein content in spring barley (Wu and von hTiedemann, 2002b). Other strobilurin fungicides have been shown to increase nitrate reductase levels in plants (Glaab and Kaiser, 1999; Wu and von Tiedemann, 2002b; Ruske, et al., 2003), resulting in increased protein content (Wu and von Tiedemann, 2002b). Strobilurin fungicides also can reduce transpiration (Grossmann et al., 1999; Nason et al., 2007) and delay senescence in plants (Grossmann and Retzlaff, 1997; Gerhard et al., 1999; Beck et al., 2002). Therefore plants tend to utilize water more efficiently (Giuliani et al., 2011) and the leaves stay green longer (Below and Uribelarrea, 2009; Byamukama et al. 2013). Longer green leaf duration in corn is positively correlated with increased corn grain yields (Tollenaar and Daynard, 1978; Gregersen et al., 2013). The translation of many of these physiological benefits in terms of greener plants, stronger stalks, reduced lodging, and yield benefits have all supported grower adoption of fungicide use on corn.

There is less documentation on physiological effects from carboxamide fungicides like benzovindiflupyr (Solatenol™) than for QoI fungicides, but they do provide similar

physiological plant health benefits. The plant health benefit of delaying senescence (keeping plants green longer) can clearly be seen in images from Dr. Carl Bradley's field trial in Princeton, Kentucky (**Figure 1**).

Figure 1. Visible differences in senescence between the untreated (left) and Trivapro treated at the R1 growth stage (right).

Source: FAD001A3 – Dr. Carl Bradley University of KY, Princeton, KY.

In this field trial disease pressure was fairly low so the differences seen in figure 1 are not due to control of any particular disease. This is a response in the plant to the SDHI component (benzovindiflupyr) and the strobilurin component (azoxystrobin).

A similar result can clearly be seen in a field trial conducted by Dr. Travis Gustafson in Gibbon, Nebraska in 2017. Again there was very low disease pressure in this trial. One application of Trivapro at the R1 growth stage delayed senescence and kept plants green longer than did the untreated (**Figure 2**).

Figure 2. Visible differences in senescence between the untreated (left) and Trivapro treated at the R1 growth stage (right).

Source: Travis Gustafson, Gibbon, NE. 2017

The benefit of keeping plants green longer is translated into yield benefits for the grower. Allowing plants to maximize photosynthesis to bulk up yield has provided consistent yield benefits to corn growers regardless if disease pressure is high or low. Across 138 large plot demonstration trials in 2016-2017 Trivapro provided an average yield benefit over the untreated plots of 18.5 bu/A and 79% of the time growers made a profit.

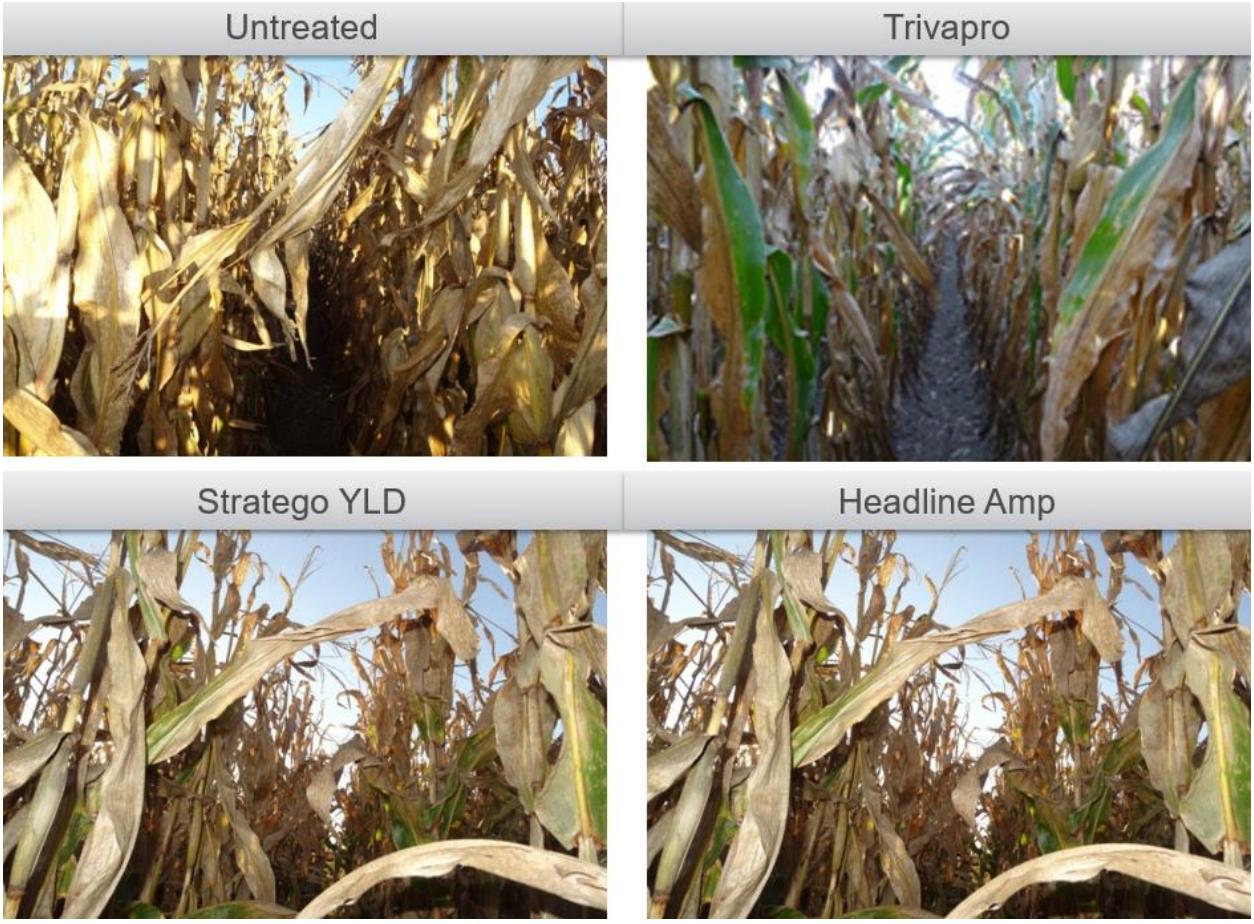
Benzovindiflupyr helps to provide plant health benefits that delay senescence. This can be seen when comparing senescence of Quilt Xcel vs Trivapro (**Figure 3**). Quilt Xcel contains the active ingredients azoxystrobin and propiconazole, and it is well documented that azoxystrobin helps to keep plants green longer. However, adding solatenol to the mix of azoxystrobin and propiconazole in Trivapro provided even greater green leaf retention than did Quilt Xcel.

Figure 3. Visible differences in senescence between the untreated (left), Quilt Xcel (middle), and Trivapro (right). Quilt Xcel and Trivapro were applied at the V4-V8 and R1 growth stages.

Source: USFS9002B3 Cristin Weber, Clinton, IL. 2015. Hybrid 53W3. Applications 6/16 (V4-V8) and 7/15 (R1). Photos taken 34 days after last application.

It is important to recognize that not all fungicides provide physiological plant health benefits and that the ones that do are not all the same. With the combination of two active ingredients in Trivapro fungicide that delay senescence, plants treated with Trivapro tend to stay green longer than when treated with other products in the market (**Figure 4**).

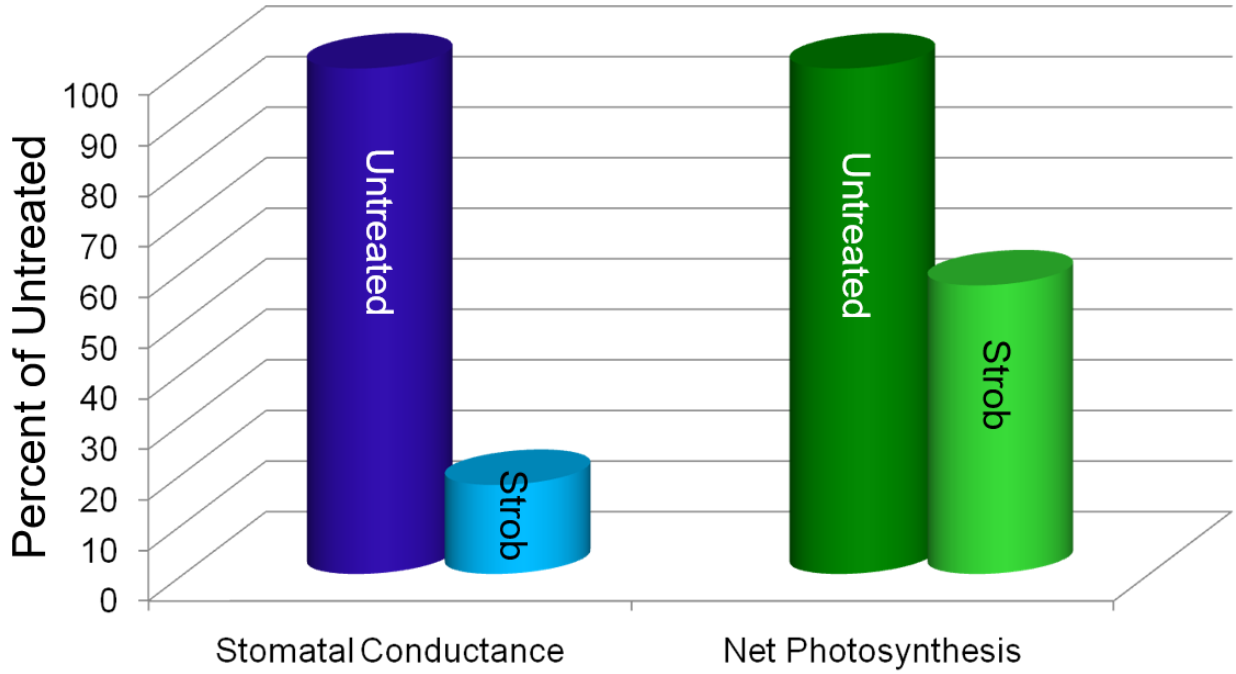
Figure 4. Visible differences in senescence between the untreated (top left), Trivapro (top right), Stratego YLD (bottom left), and Headline Amp (bottom right).



Source: Rend Lake, Illinois. 2014.

The effects of some strobilurin fungicides on plant physiological effects that influence water use in wheat have been well documented (Nason et al., 2007). Nason et. al. reported that strobilurin fungicides reduce stomatal conductance. They also demonstrated there was a reduction in transpiration (movement of water through plant stomates) as well as a reduction in net photosynthesis. Although there is a reduction in net photosynthesis, plants are very efficient in energy production so the difference between reduction in transpiration (water loss) and net photosynthesis is that plants are better able to utilize the limited water that is available to them under dry conditions (**Figure 5**).

Figure 5. Effects of strobilurin fungicides on reduction of stomatal conductance and net photosynthesis in wheat.



Calculations based on M.A. Nason, J. Farrar, and D. Bartlett. Pest Management Sci. 63: 1191-1200 (2007).

The same effects can be seen in corn under drought conditions. Azoxystrobin contributes to this effect in corn as seen in a field trail from 2012 under extremely dry conditions (**Figure 6**).

Figure 6. Quilt Xcel fungicide allowing corn to better utilize limited water (left) vs. water stressed corn (right).

In the trial above the same corn hybrid was grown. The same planting date. The only difference between the two pictures was use of fungicide or not. Clearly Quilt Xcel allowed plants to better utilize the limited water available to produce ears worth harvesting vs the untreated.

Solatenol provides the same water use benefits that azoxystrobin provide. The drought conditions were not quite as extreme in the images below but you can see that plants are less stressed when treated with Solatenol alone vs the untreated (**Figure 7**).

Figure 7. Solatenol alone allowing corn to better utilize limited water (right) vs. water stressed corn of the untreated plants (left).

Untreated leaves of the plants on the left are curling and stressed whereas the leaves of the plants treated with Solatenol look normal. You can also see more of the ground in the image of the untreated because the leaves are curled.

1.1 Disease control benefits

Although there are many fungicides available today to help growers protect their field crops from fungal diseases, benzovindiflupyr is the most potent active ingredient available for control of rust diseases. The spectrum of activity of this active ingredient is broad and covers most of the key fungal diseases of corn, soybeans, and wheat. However, it is extremely efficacious against rust pathogens. Rusts are import diseases because the pathogens that cause them rip open the cuticle (outer waxy layer) of infected leaves to liberate masses of spores (**Figure 8**). Cuticle is important because it prevents diseases from getting in the plant and it helps plants keep water in. When the cuticle is ripped open to liberate spores plants lose moisture and begin to desiccate.

Figure 8. (**A**) Southern rust on an untreated corn leaf, (**B**) Corn leaf that was treated with Trivapro fungicide at 13.7 oz/A at the R1 growth stage, and (**C**) close up images of brown rust and common rust on rye and corn, respectively illustrating ripping open plant cuticle to liberate spores of these fungal pathogens. (**D**) Scanning electron micrograph illustrating the extent of the damage to the leaf surface.

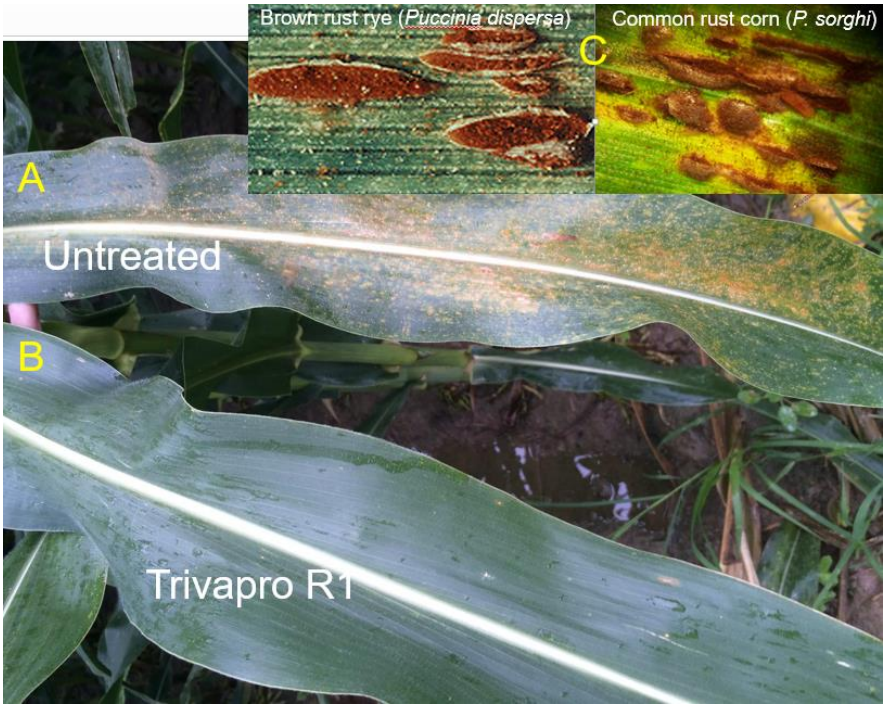
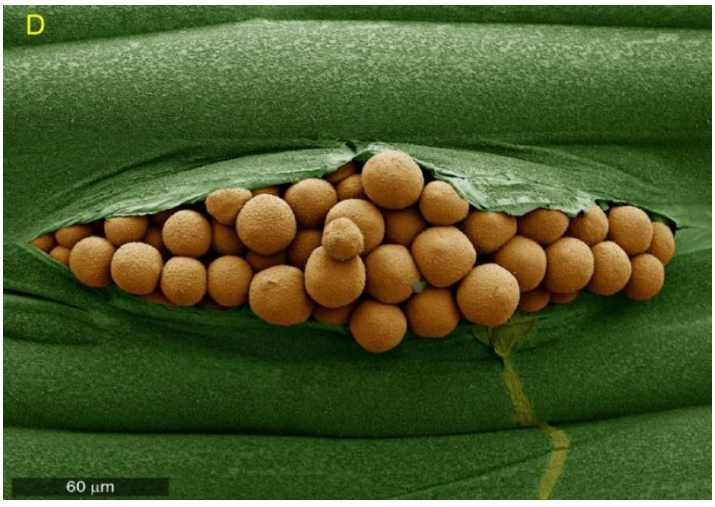


Figure 8 (Continued)



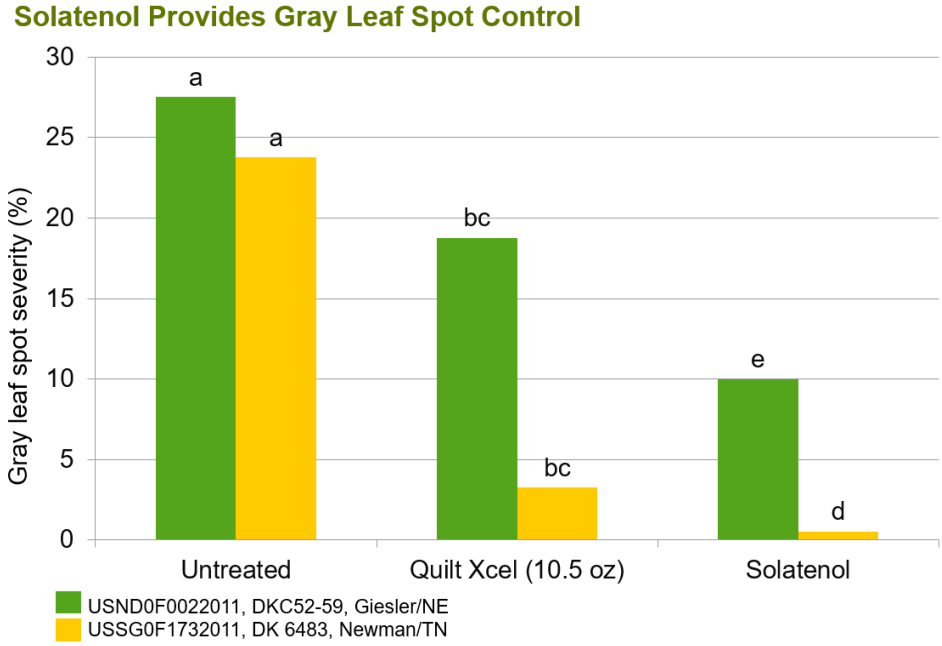
Damage to the plants cuticle leads to premature dessication. Therefore plants die down instead of dry down and all energy production from photosynthesis that would normally go into boosting yield stops. This is one of the reasons why benzovindiflupyr is so important to growers with potential rust diseases. With solatenol in the three-way mixture of Trivapro fungicide, growers are protected against the key diseases that attack corn and soybeans. The value of gaining superior rust control in addition to the other foliar diseases of corn is recognized in geographies where rust is annually present. An example of this can be seen in the field trial on Security Farms in Hopkinsville, KY in 2017 where Southern rust came in strong late in the season (**Figure 9**).

Figure 9. (**A**) Visible differences in rust infection (two rows on the left) vs the Trivapro treated plants (two rows on the right). (**B)** Close up on a Southern rust infected ear leaf (left) and a Trivapro treated ear leaf (right).

Security Farms – Hopkinsville, KY

Solatenol provides broad spectrum activity against most of the key diseases of corn, soybeans, and wheat. So, it is not just a fungicide for rust control. For example, Solatenol alone provides excellent control of gray leaf on corn (**Figure 10**).

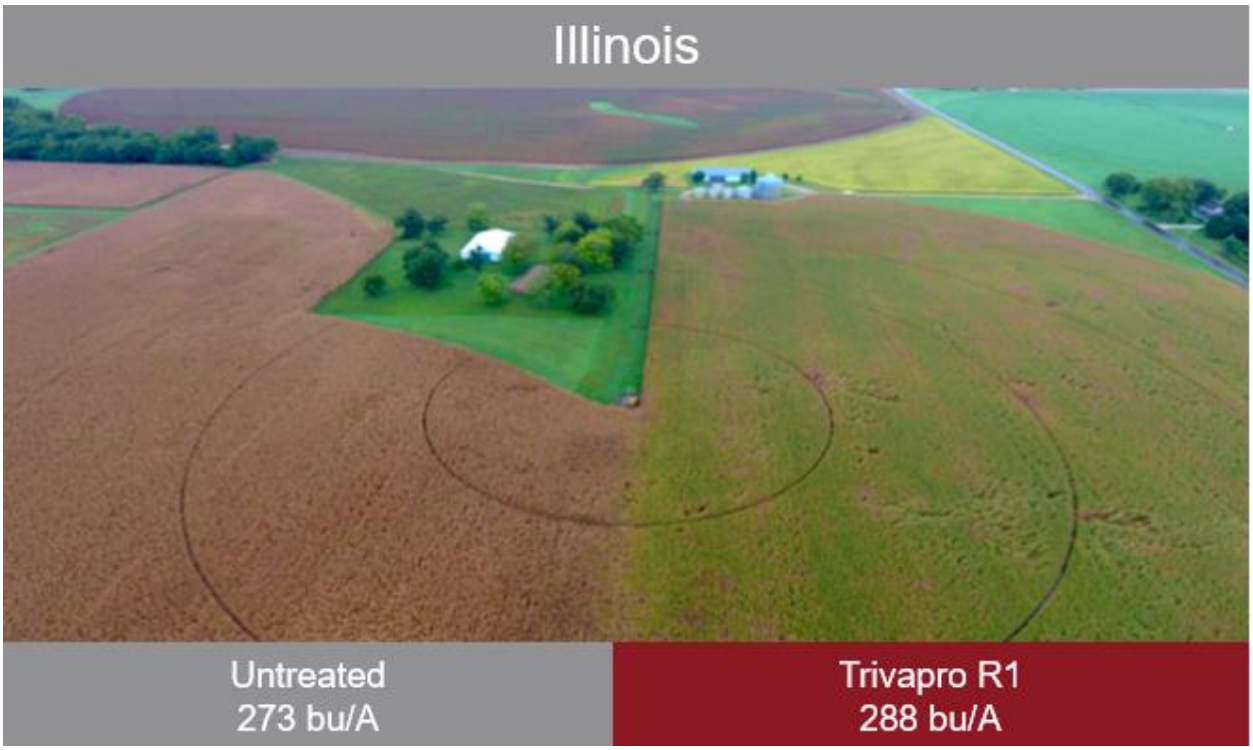
Figure 10. Efficacy of Quilt Xcel and solo benzovindiflupyr (Solatenol) against Gray leaf spot on corn.



Means with the same letter above them are not significantly different within trials according to Fisher's protected LSD at $P \leq 0.05$.

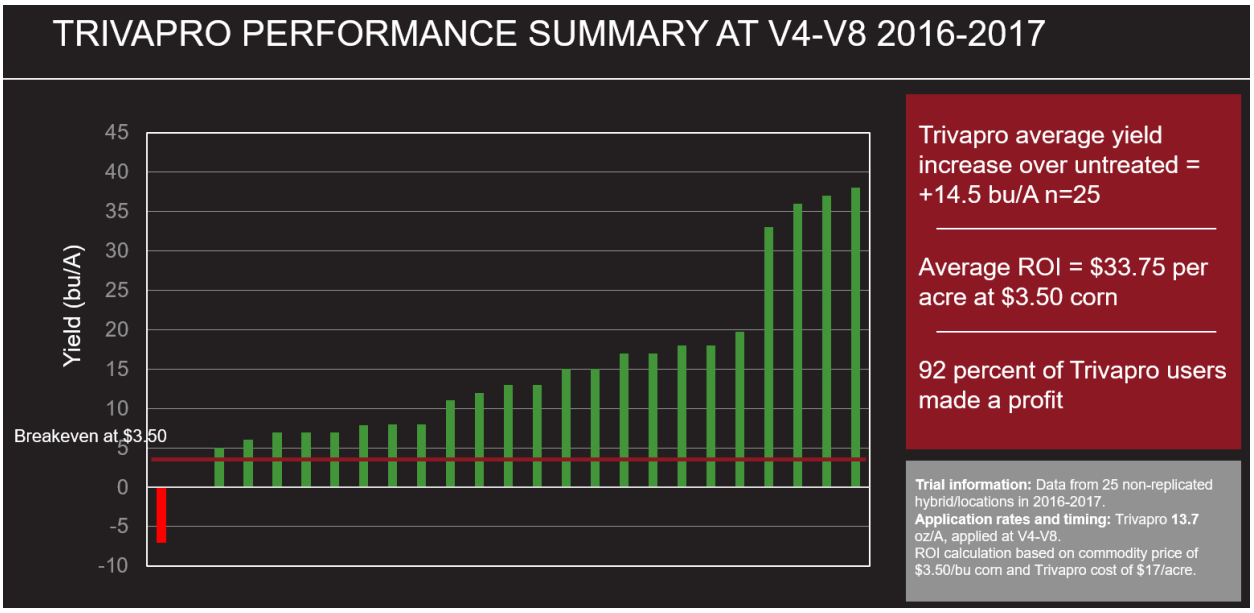
Ultimately Trivapro has provided growers with some visible clear benefits. In 2016 a co-pak of Trivapro was sold in the US. The premix formulation was not registered in time for the 2016 growing season so Syngenta launched a co-pak to provide growers with this technology and not wait. The challenges of co-paks are they are not user friendly because you have to remove caps from twice as many jugs. Many growers in 2016 did not treat their entire fields. They treated half fields or strips of their fields. The benefit from doing that is that they were able to recognize the value of using the fungicide because they could see the difference (**Figure 11**).

Figure 11. Differences in senescence and yields between untreated corn (left) and corn treated with Trivapro fungicide at the R1 growth stage (right).



Over the past few years we evaluated Trivapro applied either early (at the V4-V8 growth stages) or late (at the VT/R1 growth stages) for effects on corn yields. We conducted 25 on farm trials across 2016 and 2017. The average yield benefit from Trivapro fungicide vs untreated was 14.5 Bu/A across these 25 trials (**Figure 12**).

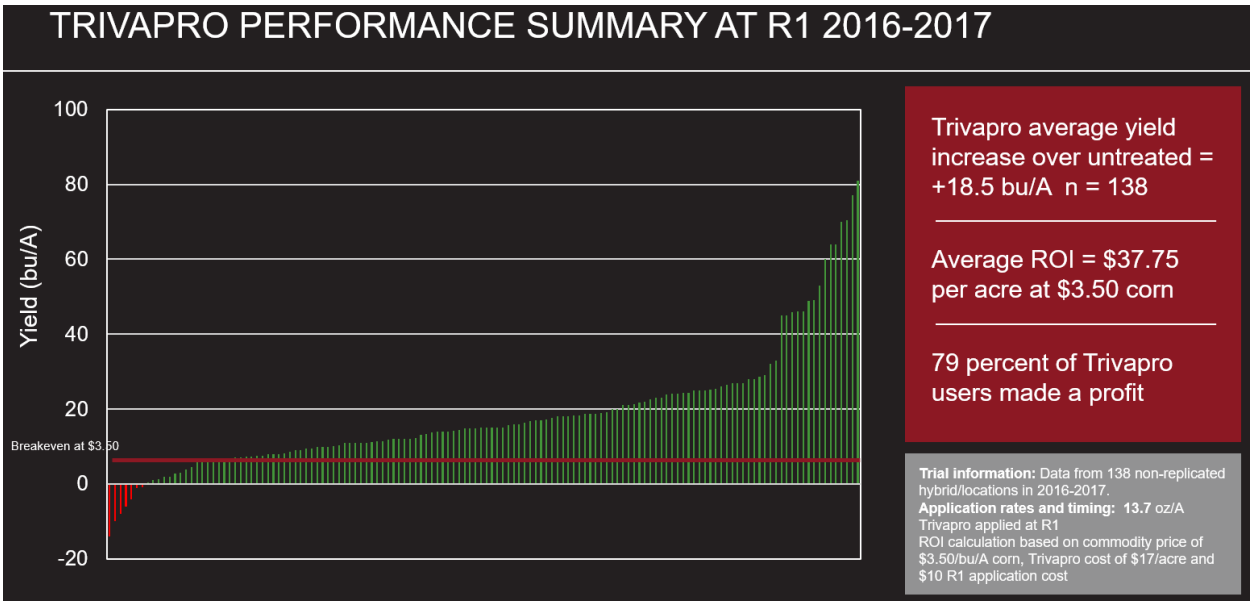
Figure 12. Piano chart illustrating yield difference between Trivapro applied at the V4-V8 growth stage vs untreated. Red bars represent yield decrease and green bars yield increase with Trivapro fungicide.



Using a trade price of $3.50/Bu corn the estimated average return on investment from Trivapro applied at the V4-V8 growth stages was $33.75. Taking out fungicide and application costs, 92% of the growers made a profit from this treatment.

Similar large plot trials were conducted across 2016-2017 where Trivapro was applied at the R1 growth stage. There were 138 trials conducted and the average yield benefit from the fungicide was 18.5 Bu/A (**Figure 13**).

Figure 13. Piano chart illustrating yield difference between Trivapro applied at the R1 growth stage vs untreated. Red bars represent yield decrease and green bars yield increase with Trivapro fungicide.



Using a trade price of $3.50/Bu corn the estimated average return on investment from Trivapro applied at the R1 growth stages was $37.75. Taking out fungicide and application costs 79% of the growers made a profit from this treatment.

1.1 Benefits beyond yield

Yield is important to all growers but if yield is the only thing we measure for success we are under estimating the full value that a fungicide like Trivapro provides. For example, Trivapro provides benefits to corn stalk integrity under both heavy and light disease pressure (**Figure 14**).

Figure 14. Trivapro can improve stalk quality in corn. Fungicide treated corn stalks (left) and untreated stalks (right).

Stalk quality is important for many reasons. Corn is a nutrient sink. If leaves are compromised by heavy disease pressure the plant will digest the starches of the stalk to feed developing ear. The end result is that weakened or damaged stalks lead to lodging. Lodging returns seed to the field that can become volunteer corn in the crop that follows. Lodging also decreases harvest efficiency directly impacting grower's output costs. For example, in a field trial in Monfort, WI. there was 25% lodging in the untreated plots vs. 3% lodging in the fungicide treated plots. Due to the reduction in lodging the combine could harvest the treated corn 1.7 miles per hour faster than the heavily lodged untreated corn. Using an economic model this increase in harvest speed translated to a $16/acre saving to the grower.

1.2 Conclusions

Benzovindiflupyr is an excellent new active ingredient that provides both broad spectrum disease control as well as plant health benefit that greatly enhance grower's ability to protect their crops from disease and boost their yield and quality of their crop regardless if disease comes in or not. As a result, Trivapro has become the leading standard fungicide for many crops. This product has only been on the market six years now and the number of growers that use it and rely on it for their production is high and growing.

1.3 Literature Cited (for Appendix 2)

Beck, C., Oerke, E. C., Dehne, H. W., 2002. Impact of strobilurins on physiology and yield formation of wheat. Mededelingen - Faculteit Landbouwkundige en Toegepaste Biologische Wetenschappen, Universiteit Gent 67: 181-187.

Below, F.E., Uribelarrea, M., 2009. Stress control for achieving high yields: the quest for 300 bushel per acre corn. In: Fidelibus, M.W. (Ed.), 36th Annual Meeting Plant Growth Regulation Society of America 2009: Asheville, North Carolina, USA, 2-6 August 2009. Plant Growth Regulation Society of America. Research Triangle Park. pp. 45-52.

Byamukama, E., Abendroth, L.J., Elmore, R.W., Robertson, A.E., 2013. Quantifying the effect of pyraclostribin on grain-fill period and kernel dry matter accumulation in maize. In: Plant Health Progress http://dx.doi.org/10.1094/PHP-2013-1024-1002-RS.

Gerhard, M., Habermeyer, J., Zinkernagel, V., 1999. The impact of strobilurins on plant vitality on winter wheat under field conditions. Pages 197-208 in: Modern Fungicides and Antifungal Compounds II, H. Lyr, ed. Intercept, Andover.

Giuliani, M.M., Nardella, E., Gatta, G., De Caro, A., 2011. Processing tomato cultivated under water deficit conditions: the effect of Azoxystrobin, Proc. IIIrd IS on Tomato Diseases. In: Crescenzi, A. (Ed.). Acta Hort, 914, pp. 287-294. ISHS.

Glaab, J., Kaiser, W. M., 1999. Increased nitrate reductase activity in leaf tissue after application of the fungicide Kresoxim-methyl. Planta 207:442-448. doi:10.1007/s004250050503.

Gregersen, P.L., Culetic, A., Boschian, L., Krupinska, K., 2013. Plant senescence and crop productivity. Plant Mol. Biol. 82, 603-622.

Grossmann K., Retzlaff, G., 1997. Bioregulatory Effects of the Fungicidal Strobilurin Kresoxim-methyl in Wheat (Triticum aestivum), Pest Sci. 50:11-20.

Grossmann K., Kwiatkowski, J., Casper, G., 1999. Regulation of Phytohormone Levels, Leaf Senescence and Transpiration by the Strobilurin Kresoxim-Methyl in wheat (Triticum aestivum). J. Plant Physiol. 154:805-808.

Jabs, T., Pfiirmann, J., Schäfer, S., Wu, Y. X., v. Tiedemann, A., 2002. Anti-oxidative and anti-senescence effects of the strobilurin pyraclostrobin in plants: A new strategy to cope with environmental stress in cereals. The BCPC Conference – Pests & Diseases.

Nason, M. A., Farrar, J., Bartlett, D., 2007. Strobilurin fungicides induce changes in photosynthetic gas exchange that do not improve water use efficiency of plants grown under conditions of water stress. Pest Management Sci. 63:1191-1200.

Ruske, R., Gooding, M., Jones, S., 2003. The effects of triazole and strobilurin fungicide programmes on nitrogen uptake, partitioning, remobilization and grain N accumulation in winter wheat cultivars. J Agric Sci 140:395-407. doi:10.1017/S0021859603003228

Tollenaar, M., Daynard, T.B., 1978. Leaf senescence in short-season maize hybrids. Can. J. Plant Sci. 58 (3),869-874.

Wu Y-X., von Tiedemann, A., 2001. Physiological Effects of Azoxystrobin and Epoxiconazole on Senescence and the Oxidative Status of Wheat. Pesticide Pestic Biochem Physiol 71:1-10.

Wu Y-X., von Tiedemann, A., 2002a. Evidence for Oxidative Stress Involved in Physiological Leaf Spot Formation in Winter and Spring Barley. Phytopathology 92:145-155.

Wu Y-X., von Tiedemann, A., 2002b. Evidence for Oxidative Stress Involved in Physiological Leaf Spot Formation in Winter and Spring Barley. Environ Pollut 116:37-47.

Wu Y-X., von Tiedemann, A., 2004. Light-Dependent Oxidative Stress Determines Physiological Leaf Spot Formation in Barley. Phytopathology 94:584-592.