US Environmental Protection Agency
Office of Pesticide Programs

Pyraclostrobin Application for Extension of the Exclusive Use Data Under FIFRA 3c(1)(f)(ii) - Part 1 of 2

August 2, 2007

BASF

The Chemical Company

Agricultural Products Division

August 2, 2007

U.S. Environmental Protection Agency
Document Processing Desk - **APPL**
Office of Pesticide Programs (7505C)
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460-0001

ATTENTION: Cynthia Giles-Parker – Branch Chief, Fungicide Branch

Dear Ms. Giles-Parker:

SUBJECT: Pyraclostrobin (EPA Reg. No. 7969-185)

REFERENCE: Application for Extension of Exclusive Use of Data under FIFRA Section 3c(1)(F)(ii).

This letter conveys an application by BASF Corporation for a 3-year Extension of Exclusive Use of Data for the active ingredient, pyraclostrobin (EPA Reg. No. 7969-185), under the provisions in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Section 3c(1)(F)(ii), [As Amended Through P.L. 108–199, January 23, 2004]. The approval of this application by EPA will extend the exclusive use period of 10 years for the pyraclostrobin data from the current effective date of September 2012 to a new effective date of September 2015. The application for the Extension of Exclusive Use is based primarily on the registrations of pyraclostrobin (EPA Reg. No. 7969-185), Pristine® Fungicide (EPA Reg. No. 7969-199), Cabrio® Fungicide (EPA Reg. No. 7969-187), and Headline® Fungicide (EPA Reg. No. 7969-186). However, it is also intended to cover all the data supporting other currently registered products containing pyraclostrobin: BAS 500 ST® Seed Treatment Fungicide (EPA Reg. No. 7969-240) and Insignia® Fungicide (EPA Reg. No. 7969-184).

FIFRA Section 3c(1)(F)(ii) states:

"The period of exclusive data use provided under clause (i) shall be extended 1 additional year for each 3 minor uses registered after August 3, 1996, and within 7 years of the commencement of the exclusive use period, up to a total of 3 additional years for all minor uses registered by the Administrator if the Administrator, in consultation with the Secretary of Agriculture, determines that, based on information provided by an applicant for registration or a registrant, that----

(I) there are insufficient efficacious alternative registered pesticides available for the use;

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(II) the alternatives to the minor use pesticide pose greater risks to the environment or human health;
(III) the minor use pesticide plays or will play a significant part in managing pest resistance; OR
(IV) the minor use pesticide plays or will play a significant part in an integrated pest management program.

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".

This application for the 3-year Extension of Exclusive Use of Data for Pyraclostrobin is based primarily on **(III)** above that pyraclostrobin "**will play a significant part in managing pest resistance**" and to some extent on **(I)** above that "**there are insufficient efficacious alternative registered pesticides available for the use**" for some of the minor crops. Pyraclostrobin satisfies these criteria as follows:

- Pyraclostrobin is a very active and broad-spectrum fungicide that acts both preventatively and curatively against target fungi. The spectrum of activity is extremely useful to prevent the buildup of resistant pathogens, especially secondary pathogens where the other registered strobilurin fungicides lack activity. The curative properties make this product a very useful tool in Integrated Pest Management programs where pathogens or the environment are monitored for infection periods and fungicides are applied after infection has taken place. The long intervals of protection further allow for the reduction of overall fungicide use.
- Pyraclostrobin is used in combination with boscalid in **Pristine® Fungicide** (EPA Reg. No. 7969-199), providing an important tool for use in IPM and resistance management programs. Since many of the key disease targets are controlled by both active ingredients, effective resistance management can be achieved with each component protecting the other from resistance. Further protection against resistance development is achieved by rotation with fungicides of different chemistries and limiting the number of applications per season, as required and explained on the current EPA-approved labels for **Cabrio**, **Headline**, and **Pristine**.

The justification for the 3-year extension is based on tolerances obtained for the following minor crops: **blueberry, cantaloupe, carrot, cherry, cucumber, hops, dry bulb onion, green onion, peach, pistachio, plum, raspberry, strawberry, and summer squash**. All of the residue data supporting these tolerances was generated by BASF. In addition to these crops, tolerances for pyraclostrobin have also obtained for other minor crops including cabbage, broccoli, mustard greens, bell pepper, non-bell pepper, leaf lettuce, head lettuce, pecan, and pear for a total of 23 minor crops on which residue studies have been conducted either by BASF or IR-4. This is more than enough crops to justify the full 3-year extension of the exclusive use period from September 2012 to September 2015.

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The enclosed document, **Pyraclostrobin, Application for Extension of Exclusive Use Period**, is provided in support of BASF's application to extend the exclusive use period the three additional years, explaining in more detail the features and characteristics of pyraclostrobin that are described above.

If you have any questions or need further information concerning this submission, please contact me directly by phone at (919) 547-2983, or by e-mail and charlotte.sanson@basf.com.

Best regards,

Charlotte A. Sanson
Product Registration Manager
BASF Corporation, Agricultural Products

cc: Tony Kish, EPA PM 22
Dan Kunkel – IR-4, Associate Director, Regulatory Affairs

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TRANSMITTAL DOCUMENT

Submitter: BASF Corporation
Agricultural Products Division
26 Davis Drive
Raleigh, NC 27709

Regulatory action in support of which this package is submitted:

Application for extension of the exclusive use period (data protection).
Active ingredient: pyraclostrobin (7969-185), Headline® Fungicide (7969-186), Cabrio® Fungicide (7969-187), and Pristine® Fungicide (7969-199).

List of submitted studies: The study submitted with this application is shown on the following page.

Submitted by: _____

Charlotte A. Sanson
Product Registration Manager
BASF Corporation, Agricultural Products Division
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TRANSMITTAL DOCUMENT FOR PYRACLOSTROBIN

OPPTS No.	EPA GLN	Study Reference	MRID No.
None	None	Bardinelli, Ted, and Sanson, Charlotte. **Pyraclostrobin, Application for Extension of Exclusive Use Period**. BASF Registration Document No. 2007/7007823, August 2, 2007. 50 pages.	

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Report Title

Pyraclostrobin
Application for Extension of Exclusive Use Period

EPA Guideline Number

None

Author
Ted Bardinelli
Charlotte Sanson

Completion Date

August 2, 2007

BASF Registration Document No.

2007/7007823.

This report consists of 48 pages

STATEMENT OF NO DATA CONFIDENTIALITY CLAIMS

No claim of confidentiality is made for any information contained in this study on the basis of its falling within the scope of FIFRA §10(d)(1)(A), (B) or (C). This claim specifically supercedes any claim or implication of confidentiality contained in this document.

Company: BASF Corporation, Agricultural Products
P.O. Box 13528
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Company Agent: Charlotte A. Sanson Title: Product Registration Manager

Signature: Charlotte A Sanson Date: 8-2-2007

GOOD LABORATORY PRACTICES STATEMENT

This study does not meet the requirements of 40 CFR Part 160.

This study is not required to meet the standards of good laboratory practices since it does not meet the definition of study contained in part 160.3 as there is no test material or experimentation.

STUDY DIRECTOR: As this study does not meet the definition of a study as defined in Part 160.3, there is no study director of record.

Sponsor and Submitter: Charlotte A Sanson 8-2-2007

Charlotte A. Sanson
Product Registration Manager
BASF Corporation, Agricultural Products

Date

BASF Corporation

Application for Extension of Exclusive Use Period (Data Protection) for Pyraclostrobin Pristine® Fungicide, Cabrio® EG Fungicide

Minor crops included in this justification are blueberry, cantaloupe, carrot, cherry, cucumber, hops, dry bulb onion, green onion, peach, pistachio, plum, raspberry, strawberry, and summer squash.

Overview/General statement

Pyraclostrobin (methyl N-(2-{[1-(4-chlorophenyl)-1H-pyrazol-3-yl]oxymethyl}phenyl)N-methoxy carbamate)) is a foliar fungicide that belongs to the class of strobilurin (QoI) chemistry. Depending on the pathogen, pyraclostrobin inhibits spore germination, established mycelium, and sporulation. Although the active ingredient is not highly mobile within the plant and there is little root uptake, systemic biological activity has been observed for certain diseases on which pyraclostrobin has high intrinsic activity. Pyraclostrobin exhibits strong translaminar mobility and weak acropetal transport. The active ingredient inhibits electron transport in the mitochondrial respiratory chain at the position of the cytochrome-bc1 complex within the fungal cell. The protective effect is due to the inhibition of energy production that stops spore germination. Pyraclostrobin also acts curatively to prevent the increase and spread of fungal infections by inhibiting mycelial growth and sporulation on the leaf surface.

Pyraclostrobin is a very active and broad-spectrum fungicide that acts both preventatively and curatively against target fungi. The spectrum of activity is extremely useful to prevent the buildup of resistant pathogens, especially the secondary pathogens where the other strobilurin fungicides lack activity. The curative properties make this product a very useful tool in Integrated Pest Management programs where pathogens or the environment are monitored for infention periods and fungicides are applied after infection has taken place. The long intervals of protection further allow for the reduction of overall fungicide use.

The tradenames for products containing **pyraclostrobin in the US are Cabrio EG® Fungicide, Headline® Fungicide, and Pristine® Fungicide**. **Cabrio EG** (20% WG) and **Headline** (2.09 lb ai/gallon EC) contain pyraclostrobin as the sole fungicidal active ingredient. **Cabrio EG** is labeled for many of the minor crops and vegetables whereas **Headline** is labeled primarily for row crops and potatoes. **Pristine** (38% WG) contains boscalid and pyraclostrobin fungicidal active ingredients in a 2:1 ratio, respectively. **Pristine** provides broad-spectrum efficacy against diseases that is unmatched by other fungicides available in the blueberry, cantaloupe, carrot, cherry, cucumber, hops, dry bulb onion, green onion, peach, pistachio, plum, raspberry, strawberry, and summer squash markets. In addition to its broad-spectrum activity, Pristine also reduces the risk of development of fungicide resistance in key at-risk pathogens, such as powdery mildews, *Alternaria* spp., *Botrytis* spp. *Cercospora* spp., and *Monilinia* spp. Furthermore, the combination of boscalid and pyraclostrobin provides a true synergistic control of a variety of fungal diseases, well beyond the additive activity of either component alone. This is especially obvious on diseases such as anthracnose, Botrytis, powdery mildews and cucurbit gummy stem blight.

EPA initially granted registration of pyraclostrobin on September 30, 2002, in more than 100 plant diseases on a mulitude of crops. Crop uses included barley, berries, bulb vegetables, cucurbits, fruiting vegetables, grapes, peanut, pistachio, root vegetables, rye, strawberry, stonefruit, sugarbeet, tree nuts, triticale, and wheat. EPA has since established additional tolerances in beans, brassicas, citrus, corn, hops, leafy vegetables, mint, peas, pome fruits, root and tuber vegetables, small grain, soybean and sunflower.

Minor Crops Registrations

The current application for extension of data protection includes justifications based on tolerances obtained for **blueberry, cantaloupe, carrot, cherry, cucumber, hops, dry bulb onion, green onion, peach, pistachio, plum, raspberry, strawberry, and summer squash minor crops**. Each of these crops will be discussed individually in subsequent sections. In addition to these crops, tolerances for pyraclostrobin were also obtained for other minor crops including cabbage, broccoli, mustard greens, bell pepper, non-bell pepper, leaf lettuce, head lettuce, pecan, and pear for a total of 23 minor crops on which residue studies have been conducted.

Status of resistance to pyraclostrobin and other QoI fungicides

A few years after introduction of QoI (strobilurin) fungicides in the cereal markets in Europe, QoI-resistant strains of cereal powdery mildew were detected in 1996. Since then, several other pathogens on various crops have developed resistance to QoI fungicides in Europe, Asia and North America, notably the powdery mildews on cereals, grapes and cucurbits, downy mildews on grapes and cucurbits, several species of *Alternaria* and *Septoria tritici* in European wheat. QoI-fungicides are currently classified by FRAC as high-risk fungicides with regards to development of resistance. Especially foliar pathogens with short generation cycles that produce large numbers of spores, such as the ones mentioned above, are prone to development of resistance.
QoI-resistance mechanisms identified to date are caused by two mutations (coded G143A and F129L) in the mitochondrial cytochrome B-gene that directly confer changes in the binding site of QoI's in complex III of the mitochondrial electron transport chain. These mutations can lead to various levels of decreased sensitivity to the QoI fungicides (F129L), or complete loss of activity (G143A).

Fungicide resistance management

The recommended program of applications for pyraclostrobin is consistent with FRAC (Fungicide Resistance Action Committee) guidelines for use of QoI fungicides. Strategies for resistance management are to limit the number of sequential applications of QoI fungicides to no more than one or two, and to limit the aggregate number of seasonal applications on registered crops to approximately 33% to 50% of the grower's total number of fungicide applications, depending on product, crop and disease.

In spite of resistance having occurred in a number of target pathogens of QoI fungicides, their spectrum of activity is one of the broadest of all fungicide classes, and they remain to be valuable tools for management of a multitude of diseases on a broad range of crops.

Cabrio EG is the most active and broad-spectrum strobilurin fungicide. It is most valuable to resistance management and integrated pest management (IPM) programs using tank mixtures and alternations with other fungicides that posess different modes of action.

Pristine, the premix of boscalid and pyraclostrobin, provides an important tool for use in IPM and resistance management programs. Since many of the key disease targets are controlled by both active ingredients, effective resistance management can be achieved with each component protecting the other from resistance. Additionally, boscalid possesses a unique mode of action against the target pathogens providing **Pristine** with another layer of resistance protection. Further protection against resistance development can be achieved by rotations with fungicides of different chemistries and limiting the number of applications per season.

DISCUSSION OF PRISTINE IMPORTANCE BY MINOR CROP TO SATISFY CRITERIA FOR EXTENSION OF DATA PROTECTION

The following arguments are focused primarily on **Pristine** (premix of boscalid + pyraclostrobin). **Pristine** offers a critical resistance management tool for most of the key diseases in many of the minor crops presented in this document. In some cases, however, **Cabrio EG** also is an excellent tool for resistance management by tank mixing or alternating with fungicides having a different mode of action, especially those with single site activity. Both products play integral roles in Integrated Pest Management programs especially where multiple products and fungicide applications are needed for disease control throughout the season. Since their introduction, **Pristine** and **Cabrio EG** have replaced a significant amount of older fungicides such as **Bravo** (chlorothalonil) and **Captan** (captan). Each crop will be discussed individually, however in a few cases similar arguments apply for closely related but distinct minor crops.

Crop

1.) **Blueberry**

2.) **Cantaloupe**

3.) **Carrot**

4.) **Cherry**

5.) **Cucumber**

6.) **Hops**

7.) **Dry bulb onion**

8.) **Green onion**

9.) **Peach**

10.) **Pistachio**

11.) **Plum**

12.) **Raspberry**

13.) **Strawberry**

14.) **Summer squash**

See **APPENDIX** for a list of products mentioned in this document and associated active ingredient name and company.

1. BLUEBERRY

Blueberries are harvested from approximately 120,000 acres in the United States. This includes both those planted and those growing in the wild. The primary growing regions are Maine with 60,000 acres and Michigan with 19,000 acres. The remainder of the production acres are scattered throughout the Northeast, Mid Atlantic, South, and Northwest United States.

Important diseases:

The most important blueberry diseases are Botrytis blossom blight and fruit rot (*Botrytis cinerea*), mummyberry (*Monilinia vacinii corymbosi*), Phomopsis twig blight and fruit rot (*Phomopsis vacinii*), anthracnose (*Colletotrichum gloeosporioides*), and Alternaria leaf spot and fruit rot (*Alternaria tenuissima*). Other diseases including spur blights (*Phoma* spp., *Didymella* spp.), *Mycosphaerella* leafspot and blotch (Mycosphaerella spp.), Septoria leaf spot (*Septoria* spp.) and rust (*Pucciniastrum vacinii*) are prevalent along the east coast and can cause sporadic outbreaks. Powdery mildew can be found on most blueberries however it only causes severe damage in isolated instances.

Botrytis blight is caused by the fungus, *Botrytis cinerea*. It causes significant crop losses under cool wet conditions. It infects the blossom clusters causing a blight killing the blossoms and new shoots. Blossom fungicide applications are required to prevent early infections. Early berry infections may remain latent until maturity when they can cause considerable losses during shipping and storage.

Mummyberry, caused by the fungus *Monilinia vacinii-corymbosi,* is the most well known blueberry disease. The first symptom is a shoot blight that appears soon after bud break resulting from early infections of emerging leaves. As flower blossoms emerge they are also infected from conidiospores. These infections remain inconspicuous until the fruit begin to ripen and can cause significant losses during shipping and storage. Infected berries shrivel or mummify. Fungicides must be applied prebloom and during bloom to contol this disease.

Phomopsis twig blight and fruit rot is caused by the fungus *Phomopsis vaccinii.* This disease primarily affects the stems causing cankers, followed by wilting and death during the summer months. This disease is more severe on frost damaged bushes. Infections occur all season long during rainy periods. The use of season long, fungicide applications are necessary to control Phomopsis twig blight.

Anthracnose, caused by *Colletotrichum gloeosporioides*, can cause berry losses up to 20%. The first symptoms are shoot blighting and a blackening of blossom clusters if conditions are warm and humid in the spring. As the fruit begin to ripen, the blossom end of the fruit will rot and spread to other ripening berries. The ripening berries are most susceptible and can cause major losses during shipping and storage. Fungicides must be applied to protect the emerging shoots and clusters and developing berries.

Alternaria leaf spot and fruit rot are caused by *Alternaria tenuissima.* The most important symptom is a fruit rot within a few weeks of harvest leading to major crop losses. This disease can also cause losses during shipping and storage. Infected fruit bear large numbers of dark green spores. Fungicides must be applied to protect maturing fruit.

Pristine and Cabrio EG advantages over current control options:

The key fungicides currently used in blueberries are **Abound**, **Bravo**, **Cabrio EG**, **Captan**, **Indar**, **Pristine**, and **Switch**. Of these, only **Pristine** and **Switch** contain 2 active ingredients with 2 different modes of action. Products with multiple modes of action provide an effective means of resistance management for those fungal pathogens where each active ingredient has sufficient biological activity.

Pristine has a very broad spectrum of activity, greater than any other blueberry fungicide. It is the best fungicide product for the control of Botrytis. **Pristine** plays a key role in protecting the berry fruit from infections leading to reduced losses to fungal rots during shipping and storage. It is registered for the control of Alternaria leafspot and fruit rot, anthracnose, Botrytis blights and rots, leafspot and blotch caused by *Mycosphaerella* and *Septoria*, Monilinia blight and mummyberry, Phomopsis leafspot, twig blight, and fruit rot, powdery mildews, rusts, and spur blights (*Didymella* and *Phoma* spp.). **Pristine** provides effective resistance management of Alternaria leafspot and fruit rot, Botrytis blights and rots, leafspot and blotch caused by *Mycosphaerella* and *Septoria*, Monilinia blight and mummyberry, powdery mildews, rusts, and spur blights (*Didymella* and *Phoma* spp.).

In contrast, **Switch** is labeled only for the control of mummyberry, anthracnose, Alternaria fruit rot, Phomopsis, and Botrytis fruit rot. It lacks control of Mycosphaerella, Septoria, Didymella, Phoma, powdery mildew, and rust.

Cabrio EG is a strobilurin fungicide with the broadest activity spectrum within this class of chemistry. It controls Alternaria leafspot and fruit rot, anthracnose, Botrytis blights and rots, leafspot and blotch caused by *Mycosphaerella* and *Septoria*, Monilinia blight and mummyberry, Phomopsis leafspot, twig blight, and fruit rot, powdery mildews, rusts, and spur blights (*Didymella* and *Phoma* spp.). **Cabrio EG** also suppresses Botrytis gray mold and Monilinia blight. Although it has a single site mode of action, it is commonly used for broad-spectrum disease control and resistance management within integrated pest management programs employing tank mixtures and fungicide alternations.

Abound is also a strobilurin fungicide, sharing the same mode of action as **Cabrio EG**. **Abound** however, is only labeled for anthracnose, Botryosphaeria, powdery mildew, mummyberry, and Phomopsis stem canker.

Indar (fenbuconazole) is a triazole fungicide (DMI) that was recently approved for use in blueberry. It is labeled for the control of *Alternaria*, anthracnose, *Mycosphaerella, Septoria*, mummyberry, *Phomopsis*, powdery mildew, and rusts. It lacks control of *Botrytis, Didymella,* and *Phoma*.

Bravo and **Captan** are older fungicide products. **Captan** is labeled only for Botrytis fruit rot and mummy berry. **Bravo** has very weak activity and is only labeled for suppression of anthracnose and mummyberry. **Pristine** and **Cabrio EG** have replaced much of the **Bravo** and **Captan** uses in blueberries.

Resistance Management

Management of pathogen resistance development to commercial fungicides requires the use of multiple modes of action and effective rates of application within the spray program. The two modes of action, disease control performance, and broad-spectrum of activity of **Pristine** make it the best choice as an alternation partner for other chemistries to reduce the potential for resistance development.

Summary

1. There is insufficient efficacious fungicide alternatives to **Pristine** (boscalid + pyraclostrobin) registered for blueberry disease control. The only other available fungicide that has a similar spectrum of activity is **Cabrio EG** (pyraclostrobin). **Cabrio EG**, however, provides only one mode of action and is not quite as effective as **Pristine** for two of the key diseases, Botrytis gray mold and Monilinia blight. **Pristine** controls 11 blueberry pathogens. The other alternative fungicides only control 2-5 diseases and even with tank mixtures of these, they cannot match the spectrum of control afforded by **Pristine**.

2. Pyraclostrobin plays a key role in managing resistance development to the boscalid component within the **Pristine** fungicide. The pyraclostrobin component of Pristine provides excellent control of 8 blueberry diseases that are in common with the activity spectrum of boscalid. This dual mode of action provides greater resistance management than other fungicides with only a single site mode of action and those with a limited spectrum of diseases controlled.

3. **Pristine** plays a significant part in Integrated Pest Management programs for blueberries. It is the most broad-spectrum fungicide for use on blueberries reducing the overall fungicide usage. **Pristine** is the best fungicide for the control of Botrytis. It provides excellent control of the various fruit infecting fungi resulting in reduced losses during shipping and storage. As a result, 49% of all berry production acres were treated with **Pristine** in 2005.

2. CANTALOUPE

Cantaloupes are grown on approximately 130,000 acres in the United States. The primary growing regions are the California, Arizona, Texas, and Georgia.

Important diseases:

The most important foliar diseases of cantaloupes are powdery mildew, Alternaria blight, downy mildew, gummy stem blight and anthracnose. All of these diseases, except powdery mildew, require wet weather conditions for infection.

Powdery mildew (*Sphaerotheca fuliginea, Erysiphe cichoracearum*) is prevalent in all regions of the US including the arid growing regions of California and Arizona. Loss of foliage causes exposure of the fruit to sunscald reducing their quality and quantity. Resistance of *S. fuliginea* to benzimidazoles, DMI-fungicides, and QoI fungicides has been reported in the United States.

Alternaria blight (*Alternaria cucumerina*) can infect most cucurbit crops, however, it is most devastating on cantaloupes and watermelons. It is prevalent in areas with high temperatures and rainfall. Infected leaves are rapidly killed resulting in crop failure. Fruit may fail to mature completely. Late season epidemics cause exposure of the fruit to sunscald reducing their quality and quantity.

Downy mildew (*Pseudoperonospora cubensis*) prevails in the temperate-tropical regions of the US where adequate free moisture is available, especially dew. It is one of the most important cucurbit diseases. Downy mildew primarily affects the foliage leading to severe blighting and subsequent yield loss. Resistance of *Pseudoperonospora cubensis* to mefenoxam and QoI fungicides has been reported, although resistance to QoI fungicides has not been confirmed in the United States to date.

Gummy stem blight (*Didymella bryoniae*) affects fruit, stems and leaves of cantaloupes. It occurs primarily in the Southern and Eastern regions of the US. It affects foliage, stems and fruit leading to loss in fruit number and quality. Complete yield loss may occur. Resistance to QoI fungicides (azoxystrobin) was first detected in 2001 in several counties in Maryland, Delaware and Georgia. In laboratory tests with *Didymella bryoniae*, this mutation has conferred resistance to all QoI fungicides, including azoxystrobin, trifloxystrobin, kresoxim-methyl and pyraclostrobin.

Anthracnose (*Colletotrichum* spp.) is also very common on the fruits and foliage of cantaloupes. This disease also thrives in warm and moist environments that often occur in the East and Southeast US.

Pristine and Cabrio EG advantages over current control options:

The main fungicides currently available for foliar use in cantaloupes are **Amistar**, **Bravo**, **Cabrio EG**, **Dithane**, **Endura**, **Flint**, **Gavel***, **Maneb**, **Nova**, **Pristine***, **Procure**, **Quadris**, **Quadris Opti***, **Rally**, **Ridomil Gold MZ***, **Ridomil Gold Bravo***, **Tanos*, Topsin M**, and sulfur. Those fungicides marked with an asterisk (*) are premixes containing 2 active ingredients, however, there are key differences in spectrum of activity and resistance management.

Pristine (boscalid + pyraclostobin) is the most active broad-spectrum cantaloupe fungicide. It controls all of the key cantaloupe diseases occurring aboveground:

Downy Mildew (*Pseudoperonospora cubensis*)
Powdery Mildew (*Sphaerotheca fuligena, Erysiphe chichoracearum*)
Anthracnose (*Colletotrichum orbiculare*)
Alternaria Blight (*Alternaria cucumerina*)
Gummy Stem Blight (*Didymella bryoniae*)
Microdochium Blight (*Microdochium tabicinum*)
Cercospora Leaf Spot (*Cercospora citrulina*)
Target Leaf Spot (*Corynespora cassiicola*)

The combination of boscalid and pyraclostrobin provides vital resistance management against powdery mildew, Alternaria, Microdochium, Cercospora, and target leaf spot. Although the gummy stem blight pathogen has developed resistance to the QoI fungicides in some areas, **Pristine** continues to provide excellent control of these resistant strains. The high level of control demonstrates synergy between the boscalid and pyraclostrobin components.

Cabrio EG (pyraclostrobin) is the broadest spectrum strobilurin fungicide with activity against all key above ground cantaloupe diseases. **Cabrio EG** is labeled for the control of downy mildew, powdery mildew, anthracnose, Alternaria blight, gummy stem blight (no longer effective on gummy stem blight in many areas due to resistance), Microdochium blight, Cercospora leaf spot, and target spot. This spectrum of activity is a key component for resistance management and integrated pest management programs using tank mixtures and fungicide alternations.

Amistar and **Quadris** (azoxystrobin) are also strobilurin fungicides with activity against many of the key melon diseases. They are labeled for the control of anthracnose, belly rot, downy mildew, gummy stem blight (no longer effective on gummy stem blight in many areas due to resistance), Alternaria, Cercospora leaf spot, Microthecium and powdery mildew. Their activity on powdery mildew, downy mildew and anthracnose is relatively weak.

Flint (trifloxystrobin) is a strobilurin fungicide with a narrow spectrum of activity. It is only labeled for powdery mildew control and suppression of downy mildew.

Endura (boscalid) is presently labeled for the control of Alternaria blight, gummy stem blight and suppression of powdery mildew however it also has significant activity against Microdochium, Cercospora, and target leaf spot. This activity provides an important tool for resistance management of these diseases when used as a tank mixing or alternation partner with complementary fungicides including strobilurins and triazoles.

Although the **Ridomil** combination products (**Ridomil Gold MZ** and **Ridomil Gold Bravo**) have 2 active ingredients, the mefanoxam component is only active against downy mildew and Pythium. Resistance to mefanoxam is fairly widespread in downy mildew and has limited its use to premixes with **Bravo** and mancozeb, that are chiefly responsible for the disease control.

Bravo (chlorothalonil) is a commonly used fungicide because it is relatively inexpensive and fairly broad-spectrum. There are no known instances of resistance to chlorothalonil from any of the cucurbit pathogens making it a useful alternation fungicide for resistance management within a commercial program. Its importance has recently increased in cucurbit production following the detection of resistance in D. bryoniae (gummy stem blight) to QoI fungicides, one of the few other fungicide classes with efficacy against this pathogen. Chlorothalonil's weaknesses are many including lack of powdery mildew control, high application rates, short reapplication intervals, visible residues, crop injury potential, and tank mix incompatibilities.

Dithane (mancozeb), Maneb (maneb) and other EBDC fungicides have a fairly broad-spectrum of activity and a low potential for resistance. It has no activity on powdery mildew or Alternaria blight and is only moderately effective on downy mildew, anthracnose and gummy stem blight. Other weaknesses are the need for high rates and visible residues.

Rally/Nova (myclobutanil) and **Procure** (triflumizole) are triazole (DMI) fungicides that have a narrow spectrum of activity with activity only against powdery mildew. Resistance of powdery mildew to another member of the DMI-family, triadimefon (**Bayleton**), was reported in previous years and has contributed to withdrawal of this product from the cucurbit market. Due to cross-resistance between the different DMI-fungicides, there are also concerns about reduced sensitivity in powdery mildew populations to myclobutanil and triflumizole and subsequent reduction in efficacy.

Tanos (femoxadone + cymoxanil) is primarily targeted against downy mildew. The 2 active ingredients confer some resistance management against this disease. It is also labeled for the control of Alternaria and anthracnose.

Gavel (mancozeb + zoxamide) includes Alternaria leaf spot, Cercospora leaf spot, downy mildew and fruit and stem rot on the label however the main target is downy mildew. The mancozeb in the premix provides some control of the other diseases but is primarily used for downy mildew resistance management.

Quadris Opti (azoxystrobin + clorothalonil) is a fairly broad-spectrum fungicide listing diseases that can be controlled by either active ingredient. See discussion above for azoxystrobin and clorothalonil regarding resistance, crop safety, and tank mix compatibility. It has only moderate activity against powdery mildew, a key disease affecting most cantaloupes.

Sulfur fungicides are widely used on cantaloupes primarily to assist in the control of powdery mildew.

A comparison of biologiocal activity for **Pristine** and key competitive fungicides is presented in Table 1. **Pristine** offers the most effective and broad-spectrum control of the most important cucurbit diseases.

Table 1. Comparison of Use Patterns and Biological Activity for Endura, Pristine and Competitive Cucurbit Fungicides

Product	Rate (lb ai/A)	PHI (days)	Spray Interval (days)	Biological Activity				
				Downy Mildew	Powdery Mildew	Anthra cnose	Alternaria	Gummy Stem Blight
Pristine	0.25-0.45	0	7-14	+++	++++	+++	+++	+++ (if QoI-resistant: +++)
Cabrio EG	0.1-0.2	0	7-14	+++	+++	+++	+++	+++ (if QoI-resistant: -)
Endura	0.2-0.3	0	7-14	+	++	+	+++	+++ (if QoI-resistant: +++)
Quadris	0.18-0.25	1	5-7 (DM, PM) 7-14 (others)	++	++	++	+++	++ (if QoI-resistant: -)
Bravo	1.1-2.5	0	5-7	++	+	++	++	++
Mancozeb	1.5-2.25	5	7-10	++	-	++	-	+
Tanos	0.25	3	5-7	+++	-	+	+	-
Gavel	1.13-1.5	5	7-10	++	-	++	++	+
Rally, Nova,	0.06-0.12	0	7-10	-	++++	+	-	-

Resistance Management

Management of pathogen resistance development to commercial fungicides requires the use of multiple modes of action and effective rates of application within the spray program. The use of weaker products (e.g. azoxystrobin) allow for greater survival and potentially greater probability for these survivors to develop resistance. The disease control performance and broad-spectrum of activity of **Pristine** and **Cabrio EG** make them the best choices as alternation partners for other chemistries to reduce the potential for resistance development.

Summary

1. Although there are numerous fungicide products available for use in cantaloupe production, there are insufficient alternatives that can match the spectrum and level of activity afforded by **Pristine** and **Cabrio EG**. **Pristine** provides excellent control of all major foliar diseases of cantaloupe including gummy stem blight. It is a major component within commercial disease control programs for gummy stem control as an alternation partner with **Bravo**. Only **Cabrio EG** has a similar spectrum of activity but lacks control of gummy stem blight that are resistant to solo QoI-fungicides. Cabrio is the most active and broad-spectrum strobilurin fungicide registered on cantaloupe. Many other cantaloupe fungicides lack control of one or more of the key diseases.

2. Pyraclostrobin plays a key role in managing pest resistance. The combination of boscalid and pyraclostrobin within **Pristine** provides vital resistance management against powdery mildew, Alternaria, Microdochium, Cercospora, target leaf spot, and non-QOI resistant gummy stem blight pathogens. Each component protects the other from resistance development. **Pristine** is used strategically to protect the powdery mildew efficacy of the triazole fungicides, **Rally** and **Nova** (myclobutanil) and **Procure** (triflumizole). **Cabrio EG** is also an important tool for broad-spectrum resistance management when used as a tank mixing or alternation partner with non-strobilurin fungicides. Although the older fungicides such as **Bravo** and **Dithane** have multisite modes of action, they are generally much less effective, lack control of some key diseases and need to be used in programs with more efficacious products like **Pristine** and **Cabrio EG**.

3. Pyraclostrobin plays a significant role in managing cantaloupe diseases within Integrated Pest Management programs. **Pristine** is the most active cantaloupe fungicide overall and has the broadest-spectrum of diseases controlled. It is also the only product containing two modes of action and controls all of the key cantaloupe diseases. These factors contributed to **Pristine** usage on 28% of the cucurbit acres.

3. CARROT

Nearly 100,000 acres of carrots are grown in the US, of which 90 % are treated with an average of 6 to 7 fungicide applications per season. Most carrots are grown in California, Florida, Texas and Michigan.

Important Diseases:

Alternaria leaf spot (*Alternaria dauci*) is the most important carrot disease. Alternaria is most prevalent on older leaves. The fungus needs free moisture on the leaf to successfully infect. The fungus causes dark brown to black leaf spots that may coalesce under severe disease pressure. Yield and quality are affected when severe infection of the foliage occurs.

Cercospora leaf spot (*Cercospora carotae*) is also an important carrot disease. Cercospora is most prevalent on the younger leaves. The fungus also needs free moisture on the leaf to successfully infect. The fungus mainly affects the leaves, causing brown to gray leaf spots that coalesce under severe disease pressure. Yields are affected when severe infection of the foliage occurs. Alternaria and Cercospora leaf spots often occur as a disease complex.

Powdery mildew (*Erysiphe polygoni*) is an important disease especially in the western United States. The fungus attacks all green parts of the plant. Fungicides are the most important means of controlling this disease. Due to its short asexual reproduction cycle, the fungus is prone to development of fungicide resistance.

Southern root rot (*Sclerotium rolfsii*) is a soilborne disease that affects the underground organs of over 200 plant species. Initial symptoms include retarded growth and wilting. Infected roots are covered with mycelium on which vast numbers of spherical sclerotia are produced. Sclerotia remain in the soil and are dispersed by equipement and irrigation water. Control measures are aimed at reducing inoculum levels by crop rotation and modification of irrigation and fertilization practices. Few fungicides are currently registered for control of this fungus.

Pristine and Cabrio advantages over current control options:

The key fungicides currently used for foliar disease control in carrot production are **Amistar**, **Bravo**, **Cabrio EG**, **Endura**, **Flint**, **Pristine**, **Quadris**, **Quadris Opti**, **Ridomil Gold Bravo**, sulfur, and **Switch**. Of these, only **Pristine**, **Quadris Opti**, and **Switch** contain 2 active ingredients with 2 different modes of action. Products with multiple modes of action can provide an effective means of resistance management provided that each active ingredient has sufficient biological activity on target pathogens. **Pristine is presently the only fungicide that alone can provide effective resistance management of all three key foliar diseases (Cercospora, Alternaria, and powdery mildew) on carrots.**

Pristine (boscalid + pyraclostobin) is a very effective broad-spectrum fungicide available for use on carrot. It controls Cercospora, Alternaria, powdery mildew and provides considerable suppression of Southern root rot. It is the only fungicide product containing two active ingredients that have activity against all three key carrot diseases providing vital resistance management against Cercospora, Alternaria, and powdery mildew. **Pristine** has a PHI of zero days, allowing the growers flexibility of applying the product shortly before harvest.

Cabrio EG (pyraclostobin) also controls all three key carrot diseases (Alternaria leaf spot, Cersospora leaf spot, and powdery mildew). It also has a PHI of zero days. The other strobilurin products, **Amistar**, **Quadris**, and **Flint** lack one or more of these attributes. **Cabrio EG** is the most valuable solo strobilurin product for resistance management and integrated management programs where tank mixtures and fungicide alternations are employed.

Amistar and **Quadris** (azoxystrobin) are labeled for the control of Cercospora, Alternaria and Southern root rot (*Sclerotium rolfsii*). They also can be soil applied for the control of Rhizoctonia root rot. They are not labeled for the control of powdery mildew.

Flint may be used for the control of Alternaria, Cercospora, powdery mildew, and rust. Its strength is the control of powdery mildews. It cannot be used within 7 days of harvest.

Endura (boscalid) is labeled for the control of Alternaria leaf spot although it is also active against powdery mildew, and Cercospora leaf spot. **Endura** possesses a unique single site mode of action useful in conjunction with other fungicides with different modes of action for resistance management.

Switch (cyprodinil + fludioxanil) is labeled only for the control of Alternaria. It may not be applied within 7 days of harvest.

Ridomil Gold Bravo (mefanoxam + clorothalonil) lists Cercospora and Alternaria control on the label. The clorothalonil component is solely responsible for this activity. The mefanoxam component only provides some activity against Pythium cavity spot. The pre-harvest interval for the mefenoxam-premix is 7 days.

Quadris Opti (azoxystrobin + clorothalonil) controls Cercospora and Alternaria. Although it provides resistance management for these two diseases, it is not labeled for powdery mildew control.

Bravo (clorothalonil) is an older fungicide product labeled only for Cersospora and Alternaria. It is commonly used because it is relatively inexpensive. It does not control powdery mildew. There are no known instances of fungal resistance to **Bravo** making it a useful alternation fungicide for resistance management within commercial programs.

Sulfur fungicides are widely used on carrots primarily to assist in the control of powdery mildew.

Resistance Management

Management of pathogen resistance development to commercial fungicides requires the use of multiple modes of action and effective rates of application within the spray program. The two modes of action, disease control performance, and broad-spectrum of activity of **Pristine** make it the best choice as an alternation partner for other chemistries to reduce the potential for resistance development.

Summary

1. There are insufficient fungicide alternatives to **Pristine** that can provide excellent control and resistance management of all three key foliar carrot diseases including Alternaria leaf spot, Cercospora leaf spot, and powdery mildew. The only other alternatives for powdery mildew control are strobilurin fungicides, **Cabrio EG** and Flint, with the same single site mode of action and are less effective than **Pristine**.

2. **Pristine** plays a vital role in the management of resistance for all three key carrot diseases because both fungicide components have activity on these diseases and boscalid possesses a unique mode of action. No other carrot fungicide contains two active ingredients with two modes of action that are active on all three of these key carrot diseases. This is expecially important in resistance management for powdery mildew where the only alternatives for powdery mildew control are strobilurin fungicides. Without a suitable alternation partner, the only resistance management tool available to growers is **Pristine**.

3. **Pristine** plays a significant part in managing carrot diseases within Integrated Pest Management programs. Reasons for this are spectrum of activity, dual modes of action, and excellent disease control. These factors contributed to **Pristine** usage on an estimated 17% of the root and tuber vegetable acres in 2005.

4. **Cabrio EG** is the most valuable solo strobilurin carrot fungicide product for resistance management and integrated management programs where tank mixtures and fungicide alternations are employed. Last year, **Cabrio EG** rose to the second most used fungicide on carrots, surpassed only by sulfur.

4. CHERRY

There are approximately 130,000 acres of cherries grown in the US. This includes both bearing and nonbearing cherry acres. Sweet cherries are grown on 61,000 acres, with most production occurring in Washington, California, Oregon and Michigan. Tart cherries were grown on 69,000 acres, with 28,000 acres in Michigan alone. Most of the cherries are treated with fungicides with an average of 4-7 applications depending on variety and location.

Important Diseases:

The most important cherry diseases are brown rot, blossom blight, cherry leaf spot and powdery mildew.

Blossom blight / Brown rot (*Monilinia laxa, M. fructicola*) are major diseases of all stonefruits in all areas where they are grown. Blossom blight, caused by *M. laxa* and *M. fructicola* reduces yields by infection of and destruction of the flowers during spring and subsequent reduction in fruit set. The fungus can also cause twig dieback after moving in from the infected flowers. Both fungi are dispersed as conidia by wind and rain. The fungi overwinter on infected twigs, flowers and fruit. *M. laxa* and *M. fructicola* also cause brown rot on all stone fruit species (apricot, cherry, peach, nectarine, prune and plum). The main economic damage on stonefruits is infection of the fruit, in addition to blossom and twig blight. Fruit becomes more susceptible to brown rot as it ripens. Other than cultural control measures, fungicide treatments are an important part of a brown rot disease management program. Fungicide sprays are aimed at protecting the flowers from bud break until petal fall, and at protecting the fruit up to the day of harvest. At least 2 fungicide applications are applied during bloom and another 2 applications are needed during fruit development and maturation.

Powdery mildew (*Podosphaera clandestina*) affects foliage and fruits of all stonefruit. The fungus develops a white powdery growth on affected tissues and spreads by airborne conidia. Fruit infection causes most damage, as it distorts the fruit. Most fruit become resistant to infection after pit-hardening with the exception of cherries, the fruits of which remain susceptible until harvest. Depending on the powdery mildew species and host involved, the fungus either survives the winter in infected buds or as cleistothecia. Fungicides are the most important means of control for powdery mildew. They are generally applied beginning at petal fall and reapplied every 7-10 days through harvest. Due to their short asexual reproduction cycle, powder mildew fungi are prone to development of fungicide resistance. Resistance to certain DMI-fungicides is suspected in cherry powdery mildew in the Pacific Northwest.

Cherry leaf spot (*Blumeriella jaapii*) is a disease that affects the foliage of cherries. It is most prevalent in areas with higher precipitation and higher air humidity. The fungus overwinters on leaves on the orchard floor and produces conidia from bloom to several weeks after petal fall, that are dispersed by water and wind. Foliage remains susceptible throughout the season and severe disease severity may cause defoliation of the trees. Fungicides are applied to control this disease whenever environmental conditions are favorable for infection beginning at petal fall and reapplied every 7-10 days through harvest. In addition, additional applications are made to the trees beginning 2-3 weeks after harvest.

Pristine and Cabrio EG advantages over current control options:

The key fungicides used on cherries are **Abound**, **Bravo**, **Cabrio EG**, **Captan**, **Elite**, **Flint**, **Indar**, **Nova**, **Orbit**, **Pristine**, **Procure**, **Rally**, **Rovral**, sulfur, and **Vangard**. Of these, only **Pristine**, contains 2 active ingredients with 2 different modes of action providing resistance management of blossom blight, brown rot, and powdery mildew.

Pristine (boscalid + pyraclostobin) is the most important fungicide used in cherry production. It is a very effective broad-spectrum fungicide available for use on cherry. It controls all four of the key cherry diseases (brown rot, blossom blight, powdery mildew and cherry leaf spot). Both components are active against brown rot, blossom blight and powdery mildew providing effective resistance management of these diseases. Boscalid is very active against cherry leaf spot. Its unique mode of action provides another resistance management tool for cherry leaf spot when used in alternations with other fungicides active against this disease. **Pristine** has a PHI of zero days, allowing the growers flexibility of applying the product shortly before harvest.

Cabrio EG (pyraclostobin) controls blossom blight and powdery mildew. Due to its activity spectrum, it fits well within fungicide alternation programs. It is generally used during bloom for blossom blight and again after harvest for powdery mildew control. **Cabrio EG** is an excellent complement to the triazole fungicides for resistance management.

Abound (azoxystrobin) is similarly labeled for the control of blossom blight, brown rot and powdery mildew. Although **Flint** (trifloxystrobin) is also a strobilurin fungicide, its activity spectrum is somewhat different. It is only labeled for the control of powdery mildew and cherry leaf spot. **Flint** cannot be used within 7 days of harvest. In general the strobilurins are not as effective as **Pristine** on all four key diseases of cherry.

Bravo (clorothalonil), an older fungicide product is labeled only for cherry leaf spot. There are no known instances of fungal resistance to Bravo making it a useful alternation fungicide for resistance management within commercial programs for cherry leaf spot only.

Captan is also an older fungicide. It is labeled for blossom blight, brown rot, cherry leaf spot and Botrytis fruit rot. It has no activity on powdery mildew. It is commonly used because it is very inexpensive and fairly broad-spectrum, however it is generally less effective than **Pristine**. Since, there are no known instances of fungal resistance to **Captan**, it is useful as a mixing or alternation partner for other fungicides for resistance management.

Most of the cherry fungicides belong to the triazole (DMI) class of chemistry. These include **Elite** (tebuconazole), **Indar** (fenbuconazole), **Rally** and **Nova** (myclobutanil), **Orbit** (propiconazole), and **Procure** (triflumizole). All of these have the same mode of action and are similar in their spectrum of activity. All except **Indar** are labeled for all four key cherry diseases. **Indar** is not labeled for the control of powdery mildew. This class of chemistry is prone to resistance development and should be used in conjunction with other fungicides with different modes of action.

Rovral (iprodione) is labeled for the control of blossom blight and brown rot but can only be applied up to petal fall and only 2 applications are allowed. Resistance to iprodione has been reported further reducing the utility of this fungicide.

Vangard (cyprodinil) use is only allowed on tart cherries. It is only labeled for the control of blossom blight and brown rot. It has a two day preharvest interval. Cyprodinil has a single site mode of action and should be used in conjunction with other fungicides for resistance management.

Sulfur fungicides are widely used on cherries to assist in the control of powdery mildew.

Resistance Management

Management of pathogen resistance development to commercial fungicides requires the use of multiple modes of action and effective rates of application within the spray program. The use of weaker products allow for greater survival and potentially greater probability for these survivors to develop resistance. The two modes of action, disease control performance, and broad-spectrum of activity of **Pristine** make it the best choice as an alternation partner for other chemistries to reduce the potential for resistance development.

Summary

1. **Pristine** is an important fungicide used in cherry production. There are insufficient efficacious alternative fungicides that control all four key diseases of cherry and provide two modes of action for resistance management. **Pristine** controls all four of the key cherry diseases (brown rot, blossom blight, powdery mildew and cherry leaf spot). Most other fungicides lack control of one or more of the key diseases of cherry except some of the triazoles. These triazoles are prone to resistance development and should be used in conjunction with other fungicides with different modes of action.

2. **Pristine** contains two active ingredients (2 modes of action) that are effective against blossom blight and powdery mildew providing effective resistance management of these diseases. **Pristine** and Cabrio are excellent alternation partners to other fungicide modes of action within resistance management programs. This is especially important for the triazole fungicides.

3. **Pristine** plays a significant part in Integrated Pest Management programs for cherry production because of its broad-spectrum activity and resistance management. These characteristics contributed to the use of **Pristine** on 36% of the stonefruit acres in 2006.

5. CUCUMBER

Cucumbers are grown on approximately 200,000 acres in the United States. The largest acreages are in North Carolina, Michigan, South Carolina, Texas, and Wisconsin.

Important diseases:

The most important foliar diseases of cucumbers are powdery mildew, downy mildew, gummy stem blight, target leaf spot, and anthracnose. All of these diseases, except powdery mildew, require wet weather conditions for infection.

Powdery mildew (*Sphaerotheca fuliginea, Erysiphe cichoracearum*) is prevalent in all regions of the US including the arid growing regions of California and Arizona. Resistance of *S. fuliginea* to benzimidazoles, DMI-fungicides, and QoI fungicides has been reported in the United States.

Downy mildew (*Pseudoperonospora cubensis*) prevails in the temperate-tropical regions of the US where adequate free moisture is available, especially dew. It is one of the most important cucurbit diseases. Resistance of *Pseudoperonospora cubensis* to mefenoxam and QoI fungicides has been reported, although resistance to QoI fungicides has not been confirmed in the United States to date.

Gummy stem blight (*Didymella bryoniae*) affects fruit, stems and leaves of cucumbers. It occurs primarily in the Southern and Eastern regions of the US. Resistance to QoI fungicides (azoxystrobin) was first detected in 2001 in several counties in Maryland, Delaware and Georgia. In laboratory tests with *Didymella bryoniae*, this mutation has conferred resistance to all QoI fungicides, including azoxystrobin, trifloxystrobin, kresoxim-methyl and pyraclostrobin.

Anthracnose (*Colletotrichum* spp.) and Alternaria blight (*Alternaria cucumerina*) diseases are very common on the fruits and foliage of cucumbers. These diseases also thrive in warm and moist environments that often occur in the East and Southeast US.

Target spot (*Corynespora cassiicola*) is also called Corynespora blight. It is common on cucumbers and can be devastating in the South and mid-Atlantic states under conditions of high humidity and warm temperatures. Young expanding fruit are not susceptible. There are some resistant cucumber varieties however susceptible varieties require repeated fungicide applications to control this disease.

Pristine and Cabrio EG advantages over current control options:

The most important fungicides currently available for foliar use in cucumbers are **Amistar**, **Bravo**, **Cabrio EG**, **Dithane**, **Endura**, **Flint**, **Gavel***, **Nova**, **Pristine***, **Previcur Flex**, **Procure**, **Quadris**, **Quadris Opti***, Rally, **Ridomil Gold MZ***, **Ridomil Gold Bravo***, and **Tanos***. Those fungicides marked with an asterisk(*) are premixes containing 2 active ingredients, however, there are key differences in spectrum of activity and resistance management.

Pristine (boscalid + pyraclostobin) is the most active broad-spectrum cucumber fungicide. It controls all of the key and many minor foliar diseases:

Downy Mildew (*Pseudoperonospora cubensis*)
Powdery Mildew (*Sphaerotheca fuligena, Erysiphe chichoracearum*)
Anthracnose (*Colletotrichum orbiculare*)
Alternaria Blight (*Alternaria cucumerina*)
Gummy Stem Blight (*Didymella bryoniae*)
Microdochium Blight (*Microdochium tabicinum*)
Cercospora Leaf Spot (*Cercospora citrulina*)
Target Leaf Spot (*Corynespora cassiicola*)

The combination of boscalid and pyraclostrobin provides vital resistance management against powdery mildew, Alternaria, Microdochium, Cercospora, and target leaf spot. Although the gummy stem blight pathogen has developed resistance to the QoI fungicides in some areas, **Pristine** continues to provide excellent control of these resistant strains. The high level of control demonstrates synergy between the boscalid and pyraclostrobin components.

Cabrio EG (pyraclostrobin) is a very broad-spectrum strobilurin fungicide with activity against all of the key cucumber diseases. **Cabrio EG** is labeled for the control of downy mildew, powdery mildew, anthracnose, Alternaria blight, gummy stem blight (no longer effective on gummy stem blight in many areas due to resistance), Microdochium blight, Cercospora leaf spot, and target spot. Although other strobilurin fungicides are similar in chemistry and posess the same mode of action, they differ in their biological activity.

Amistar and **Quadris** (azoxystrobin) are labeled for the control of anthracnose, belly rot, downy mildew, gummy stem blight (no longer effective on gummy stem blight in many areas due to resistance), Alternaria, Cercospora leaf spot, Microthecium and powdery mildew. Although **Amistar** and **Quadris** have a similar list of labeled diseases, the level of control is much less than **Cabrio EG**.

Flint (trifloxystrobin) is a strobilurin fungicide with a narrow spectrum of activity. It is only labeled for powdery mildew control and suppression of downy mildew.

Endura (boscalid) is presently labeled for the control of Alternaria blight, gummy stem blight and suppression of powdery mildew however it also has significant activity against Microdochium, Cercospora, and target leaf spot. This activity provides an important tool for resistance management of these diseases when used as a tank mixing or alternation partner with complementary fungicides including strobilurins and traizoles. Recent data has shown that when **Endura** is combined with penetrating adjuvants, it provides excellent control of powdery mildew.

Although the **Ridomil** combination products (**Ridomil Gold MZ** and **Ridomil Gold Bravo**) have 2 active ingredients, the mefanoxam component is only active against downy mildew and Pythium. Resistance to mefanoxam is fairly widespread in downy mildew and has limited its use to premixes with **Bravo** and mancozeb, that are chiefly responsible for the disease control.

Bravo (chlorothalonil) is the most commonly used fungicide onn cucumber because it is relatively inexpensive and fairly broad-spectrum. There are no known instances of resistance to chlorothalonil from any of the cucurbit pathogens making it a useful alternation fungicide for resistance management within a commercial program. Its importance has recently increased in cucurbit production following the detection of resistance in D. bryoniae (gummy stem blight) to QoI fungicides, one of the few other fungicide classes with efficacy against this pathogen. Chlorothalonil's weaknesses are many including lack of powdery mildew control, high application rates, short reapplication intervals, visible residues, crop injury potential, and tank mix incompatibilities.

Dithane (mancozeb) is an old EBDC fungicide with a fairly broad-spectrum of activity and a low potential for resistance. It has no activity on powdery mildew or Alternaria blight and is only moderately effective on downy mildew, anthracnose and gummy stem blight. Other weaknesses are the need for high rates and visible residues.

Rally/Nova (myclobutanil) and **Procure** (triflumizole) are triazole (DMI) fungicides that have a narrow disease spectrum with activity only against powdery mildew. Resistance of powdery mildew to another member of the DMI-family, triadimefon (**Bayleton**), was reported in previous years and has contributed to withdrawal of this product from the cucurbit market. Due to cross-resistance between the different DMI-fungicides, there are also concerns about reduced sensitivity in powdery mildew populations to myclobutanil and triflumizole and subsequent reduction in efficacy.

Tanos (femoxadone + cymoxanil) is primarily targeted against downy mildew. The 2 active ingredients confer some resistance management against this disease. It is also labeled for the control of Alternaria and anthracnose.

Previcur Flex (propamocarb) has activity only against downy mildew and Pythium seedling disease and root rot. It has a single site of action and therefore may be prone to resistance development. It is used within tank mixtures and alternation programs for resistance management.

Gavel (mancozeb + zoxamide) includes Alternaria leaf spot, Cercospora leaf spot, downy mildew and fruit and stem rot on the label however the main target is downy mildew. The mancozeb in the premix provides some control of the other diseases but is primarily used for downy mildew resistance management.

Quadris Opti (azoxystrobin + clorothalonil) is a fairly broad-spectrum fungicide listing diseases that can be controlled by either active ingredient. See discussion above for azoxystrobin and clorothalonil regarding resistance, crop safety, and tank mix compatibility. It has only moderate activity against powdery mildew, a key disease affecting most cantaloupes.

A comparison of biologiocal activity for **Pristine** and key competitive fungicides is presented in Table 1. **Pristine** offers the most effective and broad-spectrum control of the most important cucurbit diseases.

Table 1: Comparison of Use Patterns and Biological Activity for Endura, Pristine and Competitive Cucurbit Fungicides

Product	Rate (lb ai/A)	PHI (days)	Spray Interval (days)	Biological Activity				
				Downy Mildew	Powdery Mildew	Anthracnose	Alternaria	Gummy Stem Blight
Pristine	0.25-0.45	0	7-14	+++	++++	+++	+++	+++ (if QoI-resistant: +++)
Cabrio EG	0.1-0.2	0	7-14	+++	+++	+++	+++	+++ (if QoI-resistant: -)
Endura	0.2-0.3	0	7-14	+	++	+	+++	+++ (if QoI-resistant: +++)
Quadris	0.18-0.25	1	5-7 (DM, PM) 7-14 (others)	++	++	++	+++	++ (if QoI-resistant: -)
Bravo	1.1-2.5	0	5-7	++	+	++	++	++
Mancozeb	1.5-2.25	5	7-10	++	-	++	-	+
Tanos	0.25	3	5-7	+++	-	+	+	-
Gavel	1.13-1.5	5	7-10	++	-	++	++	+
Rally, Nova,	0.06-0.12	0	7-10	-	++++	+	-	-

Resistance Management

Management of pathogen resistance development to commercial fungicides requires the use of multiple modes of action and effective rates of application within the spray program. The use of weaker products (e.g. azoxystrobin) allow for greater survival and potentially greater probability for these survivors to develop resistance. The disease control performance and broad-spectrum of activity of **Pristine** make it the best choice as an alternation partner for other chemistries to reduce the potential for resistance development and to manage existing resistance in gummy stem blight and powdery mildew populations.

Summary

1. Although there are numerous fungicide products available for use in cucumber production, there are insufficient alternatives that can match the spectrum and level of activity afforded by **Pristine** and **Cabrio EG**. **Pristine** provides excellent control of all major foliar diseases of cucumber including gummy stem blight. It is a major component within commercial disease control programs for gummy stem control as an alternation partner with **Bravo**. Only **Cabrio EG** has a similar spectrum of activity but lacks control of gummy stem blight that are resistant to solo QoI-fungicides. **Cabrio EG** is the most active and broad-spectrum strobilurin fungicide registered on cucumber. Many other cucumber fungicides lack control of one or more of the key diseases.

2. Pyraclostrobin plays a key role in managing pest resistance. The combination of boscalid and pyraclostrobin within **Pristine** provides vital resistance management against powdery mildew, Alternaria, Microdochium, Cercospora, target leaf spot, and non-QOI resistant gummy stem blight pathogens. Each component protects the other from resistance development. **Pristine** is used strategically to protect the powdery mildew efficacy of the triazole fungicides, **Rally** and **Nova** (myclobutanil) and **Procure** (triflumizole). **Cabrio EG** is also an important tool for broad-spectrum resistance management when used as a tank mixing or alternation partner with non-strobilurin fungicides. Although the older fungicides such as **Bravo** and **Dithane** have multisite modes of action, they are generally much less effective, lack control of some key diseases and need to be used in programs with more efficacious products like **Pristine** and **Cabrio EG**.

3. Pyraclostrobin plays a significant role in managing cantaloupe diseases within Integrated Pest Management programs. **Pristine** is the most active cucumber fungicide overall and has the broadest-spectrum of diseases controlled. It is also the only product containing two modes of action and controls all of the key cantaloupe diseases. These factors contributed to **Pristine** usage on 28% of the cucurbit acres in 2005.

6. HOPS

Approximately 30,000 acres of hops are grown in the United States. The main production areas are in the states of Washington, California, Oregon, and Idaho.

Important diseases:

Hops are perennial vine crops that are grown on trellises. The estimated lifespan of the crop is 20 years under this system of production. Until recently, the only significant disease on hops has been downy mildew. The causal organism for downy mildew is *Pseudoperonospora humuli*. Within the last five years, powdery mildew, caused by *Erysiphe chicoracearum* has become increasingly important, requiring the use of new powdery mildew fungicides.

Pristine advantages over current control options:

The key fungicides currently used in hops are **Accrue**, **Aliette**, **Curzate**, **Flint**, **Fosphite**, **Kocide**, **Quintec**, and **Pristine**. Of these, only **Pristine** contains 2 active ingredients with 2 different modes of action.

Pristine (boscalid + pyraclostrobin) is unique in that it is the only fungicide available for use on hops that provides excellent control of both powdery mildew and downy mildew. Since both active ingredients have activity on powdery mildew, it provides effective resistance management on this disease. For downy mildew resistance management, **Pristine**'s use is recommended for no more than two sequential applications before alternating to a non-strobilurin fungicide that is active on downy mildew.

Accrue (spiroxamine), **Flint** (trifloxystrobin) and **Quintec** (quinoxyfen) are used only for powdery mildew control, however **Flint** can also provide some suppression against downy mildew. **Aliette** (fosetyl aluminum), **Curzate** (cymoxanil), **Fosphite** (potassium salts of phosphorous acid) and **Kocide** (copper hydroxide) are labeled only for downy mildew control. **Curzate** must be mixed with another protectant fungicide active against downy mildew for resistance management. All of these products except **Aliette**, **Fosphite**, and **Kocide**, are prone to resistance development due to their single site modes of action.

Resistance Management

Management of pathogen resistance development to commercial fungicides requires the use of multiple modes of action and effective rates of application within the spray program. The two modes of action, disease control performance, and broad-spectrum of activity of **Pristine** make it the best choice as an alternation partner for other chemistries to reduce the potential for resistance development.

Summary

1. There are insufficient efficacious alternative fungicides available for use on hops that effectively control both powdery mildew and downy mildew diseases. Only **Pristine** can control both key diseases and contains two modes of action providing effective resistance management for powdery mildew.

2. **Pristine** plays a significant part in managing resistance in powdery mildew and downy mildew populations. It is an excellent alternation partner with other fungicides that contain single site modes of action such as **Accrue** and **Quintec**.

3. **Pristine** plays a vital part in Integrated Pest Management for disease control in hops. The most biologically sound disease control program for both mildew diseases is a fungicide program that alternates **Pristine** with **Accrue** or **Quintec** tank mixed with **Curzate** and **Aliette**.

7. DRY BULB ONION

According to the USDA, approximately 173,000 acres of onions were grown in the US in 2005. This figure is predominately dry bulb onion with 132,000 acres according to a 1992 census. Approximately 96% of the acreage is treated with an average of 5 fungicide applications per season. Most dry bulb onions are grown in California, Texas, Colorado, Oregon, New York, Idaho, Georgia, New Mexico, Washington, and Michigan.

Important Diseases:

The most important onion diseases are Alternaria purple blotch and Botrytis leaf blight. Downy mildew can be devastating in certain locations where the environment favors the infection and spread of the disease (see below under downy mildew).

Alternaria purple blotch (*Alternaria porri*) is one of the most important onion diseases. The fungus infects leaves directly, but infection is favored by wounds and abrasions on the leaves. Older leaves are more susceptible to infection. The fungus produces brown to purple lesions on the foliage and seed stalks. As lesions expand, they may coalesce and girdle the leaf or seed stalk, which results in dying of the tissue above the girdled area. Loss of foliage and resulting yield loss can be extensive under conditions favorable for *A. porri*, such as moderate temperatures (25 C) and high humidity. The fungus occasionally attacks the bulbs themselves. Host resistance is not available in commercial varieties and frequent fungicide applications are the most important control measure.

Botrytis leaf blight (*Botrytis squamosa)* also infects leaves, causing lesions with a white necrotic center surrounded by a light green halo. Lesions may remain restricted in size, but will expand under favorable environmental conditions, such as moderate temperatures and high humidity, causing extensive leaf blight and subsequent yield loss. The fungus occasionally also attacks the bulbs themselves. Frequent fungicide applications are the most important control measure. Botrytis neck rot (*B. allii*) is another disease affecting bulbs during storage. Infections occur during the growing season and especially during harvest. Plants generally remain asymptomatic until storage.

Downy mildew (*Peronospora destructor*) is less frequently a major disease in onion. It can be devastating under cool moist conditions in certain locations. Downy mildew primarily infects the leaves, initially causing causing elongated leaf lesions that are either lighter in color than the surrounding tissue or light tan to brown. Sporulation, grayish violet in color, may be visible in the lesions under moist conditions. Lesions may remain restricted in size and further spread of the disease may be halted when temperatures exceed 24 C and the relative humidity falls below 80%. However, the fungus spreads rapidly under favorable environmental conditions, such as lower temperatures, high relative humidity and rainfall, and is capable of destroying the entire foliage in a field. Yield will be negatively affected by extensive disease on the foliage, but the fungus may also infect the bulbs directly. Other than cultural practices aimed at reducing the moisture content in soil and on the foliage, fungicide sprays are an important control measure. Under conditions favorable for the disease, frequent sprays are necessary to protect the newly emerging foliage.

Stemphylium leaf blight and stalk rot (*Stemphylium vesicarium*). The fungus infects leaves directly, but infection is favored by wounds or abrasions, and on tissue infected by other foliar pathogens such as downy mildew or Alternaria. The fungus produces brown to tan lesions on the foliage and seed stalks that turn brown to black as sporulation is initiated. As lesions expand, they may coalesce and girdle the leaf or seed stalk, which results in dying of the tissue above the girdled area. Loss of foliage can be extensive under conditions favorable for *Stemphylium*, such as warm temperatures (25 C) and high humidity. Fungicide applications are an important control measure for this disease.

Pristine and Cabrio EG advantages over current control options:

There are numerous fungicides currently available for use for foliar disease control in onion production. These are **Amistar**, **Bravo**, **Cabrio EG**, **Dithane**, **Endura**, **Kocide**, **Pristine**, **Quadris**, **Reason**, **Ridomil Gold Bravo**, **Ridomil Gold MZ**, **Ridomil Gold CU**, **Rovral** (dry bulb only), **Scala**, and **Switch**.

Pristine (boscalid + pyraclostobin) provides excellent control of Alternaria purple blotch, Stemphylium leaf blight and stalk rot, Botrytis leaf blight and Botrytis neck rot. It is the most effective product for the control of Botrytis neck rot than any other product leading to reduced losses after harvest during shipping and storage. It also suppresses downy mildew. The two modes of action provide effective resistance management of Alternaria, Stemphyllium, and Botrytis, unique only to **Pristine**.

Cabrio EG (pyraclostrobin) provides excellent control of many of the onion diseases including Alternaria, downy mildew, rust, powdery mildew and Stemphyllium. It also supresses Botrytis leaf blight.

Both **Pristine** and **Cabrio EG** are vital components of onion disease management programs because these products are the only fungicides labeled for Stemphylium control.

Amistar and **Quadris** (azoxystrobin) are active on Alternaria, downy mildew, rust, Cladosporium, Sclerotium and to a lesser extent, Botrytis leaf blight.

Reason (fenamidone) is used primarily for downy mildew control however it also has some activity on Alternaria.

Endura (boscalid) is labeled for the control of Alternaria and Botrytis diseases. It has a unique single site mode of action in onions. **Endura** is most useful in commercial fungicide programs as an alternation partner or as a tank mix. Boscalid's unique mode of action makes it valuable for resistance management for the 2 most important onion diseases, Alternaria and Botrytis.

Switch (cyprodinil + fludioxanil) and Scala (pyrimethanil) are labeled for the control of Alternaria purple blotch and Botrytis diseases. Pymethanil and cyprodinil are similar in structure and share the same mode of action. Although **Switch** is less effective than **Pristine** on Alternaria and Botrytis diseases, **Switch** provides two modes of action useful for resistance management of these two diseases. When **Switch** is alternated with **Pristine**, the 4 modes of action should be the most effective means of preventing resistance development within the Alternaria and Botrytis pathogen populations.

Bravo (clorothalonil) is an older fungicide product labeled for Botrytis, Alternaria, and downy mildew suppression. It is commonly used because it is relatively inexpensive. There are no known instances of fungal resistance to **Bravo** making it a useful alternation fungicide for resistance management within commercial programs.

Ridomil Gold Bravo (mefanoxam + clorothalonil) is labeled for downy mildew, Botrytis, and Alternaria. Since mefanoxam is only active on downy mildew, the clorothalonil component is responsible for control of the other diseases and provides some resistance management against the downy mildew pathogen. **Ridomil Gold MZ** (mefanoxam + mancozeb) and **Ridomil Gold CU** (mefanoxam + copper) are only labeled for downy mildew control. The mancozeb and copper components of these premixes are used to reduce the potential for downy mildew resistance development. The mefenoxam premixes therefore do not provide effective resistance management against other diseases. In case mefenoxam-resistant *P. destructor* is present, only the protective tank-mix partner contributes to control of downy mildew. Management of mefenoxam-resistance in *P. destructor* by these premixes remains questionable. The two active ingredients – one systemic and one not systemic - are effectively separated by the plant and protective control essentially relies on the protective ingredient. If protection from downy mildew by the premix partner is not adequate, the risk of control failure due to mefenoxam-resistance remains high.

Kocide (copper hydroxide) is recommended for use against Alternaria purple blotch and downy mildew. However, it's activity is only preventative and deposits are easily washed off by rain. Good coverage is essential for satisfactory disease control. An adjuvant is recommended to increase coverage on onion foliage. It is mainly useful within programs designed for downy mildew control.

Dithane (mancozeb) is effective against Alternaria purple blotch, downy mildew, Botrytis leaf blight and Botrytis neck rot however its intrinsic activity is much less than **Pristine**. Good coverage and preventative applications are essential to insure proper disease control. EBDC-fungicides require spray intervals from 3 to 7 days. High application rates vary from 1.5 to 2.25 pounds active ingredient per acre.

Rovral (iprodione) is a contact fungicide with a relatively high application rate (0.75 lb a.i./acre) recommended for control of Alternaria purple blotch, Botrytis leaf blight and Botrytis neck rot. **Rovral** must be applied preventatively and deposits are easily washed off by rain. Good coverage is essential for satisfactory disease control. Resistance can develop in certain *Botrytis* species to iprodione over the season, and occasionally it has led to control failures in certain crops such as strawberry and grapes.

Resistance Management

Management of pathogen resistance development to commercial fungicides requires the use of multiple modes of action and effective rates of application within the spray program. The use of weaker products allow for greater survival and potentially greater probability for these survivors to develop resistance. The two modes of action, disease control performance, and broad-spectrum of activity of **Pristine** make it the best choice as an alternation partner for other chemistries to reduce the potential for resistance development.

Summary

1. Although there are numerous fungicide products available for use in dry bulb onion production, there are insufficient alternatives that can match the spectrum and level of activity afforded by **Pristine**. It provides excellent control of all major foliar diseases of onion including Alternaria purple blotch, Stemphyllium leaf blight, Botrytis leaf blight, Botrytis neck rot and suppression of downy mildew. **Cabrio EG** also provides excellent control of many of the onion diseases including Alternaria, downy mildew, rust, powdery mildew and Stemphyllium. Both **Pristine** and **Cabrio EG** are vital components of onion disease management programs because these products are the only fungicides labeled for Stemphylium control.

2. **Pristine** is the only onion fungicide that contains two active ingredients with two modes of action that are active on the key onion diseases, providing effective resistance management against Alternaria, Stemphylium, and Botrytis diseases. **Cabrio EG** is also useful in commercial fungicide programs as an alternation partner or as a tank mix for resistance management.

3. Pyraclostrobin plays a significant role in managing onion diseases within Integrated Pest Management programs. **Pristine** is the most active onion fungicide on the key diseases overall and has the broadest-spectrum of diseases controlled. It is also the only product containing two modes of action that controls all of the key onion diseases. **Pristine** and **Cabrio EG** provide critical tools for managing Stemphylium that is unique compared to other available products. These factors contributed to **Pristine** usage on 33% of the bulb vegetable acres in 2006.