



**US Environmental Protection Agency  
Office of Pesticide Programs**

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

**August 2, 2007**

## **8. GREEN ONION**

According to a USDA census conducted in 1992, approximately 12,400 acres of green onions were grown in the US. Most green onions are grown in California, however significant acres of green onion are also grown in Texas, Arizona, and New York.

### **Important Diseases:**

The most important green 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.

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 elongated leaf lesions. 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 advantages over current control options:**

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

**Pristine** (boscalid + pyraclostobin) provides the most effective control of *Alternaria* purple blotch, *Stemphylium* leaf blight and stalk rot and *Botrytis* leaf blight. It also suppresses downy mildew. The two modes of action provide effective resistance management of *Alternaria*, *Stemphylium*, 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 *Stemphylium*. It also suppresses *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) **Reason** is used primarily for downy mildew control however it also has some activity on *Alternaria*.

**Endura** (boscalid) is labeled for the control of *Alternaria* purple blotch and *Botrytis* leaf blight. 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. Pyrimethanil 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** (mefenoxam + clorothalonil) is labeled for downy mildew, Botrytis, and Alternaria. Since mefenoxam 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** (mefenoxam + mancozeb) and **Ridomil Gold CU** (mefenoxam + 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. Its 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.

### 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 green 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, Stemphylium 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 Stemphylium. 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** 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.

## **9. PEACH**

According to a survey conducted in 2006 by the National Agricultural Statistics Service, USDA, there were approximately 140,000 acres of peaches grown in the US in 2005. This includes both bearing and nonbearing peach acres. Most of the acres (97%) were treated with an average of 4 to 5 fungicide applications per year. The primary production areas include California, Georgia and South Carolina. Nectarines were grown on 36,000 acres, almost exclusively in California.

### **Important Diseases:**

The most important peach diseases are brown rot, blossom blight, powdery mildew, scab and shot hole. Other diseases of localized importance are *Alternaria* leaf spot and anthracnose.

Blossom blight / Brown rot (*Monilinia fructicola*, *M. laxa*) 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. 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, powdery mildew fungi are prone to development of fungicide resistance. Resistance to certain DMI-fungicides is suspected in cherry powdery mildew in the Pacific Northwest.



Scab (*Cladosporium carpophilum*) mainly occurs on peach and nectarine. It is of minor or no importance on apricot, cherries, plums and prunes. On peaches and nectarines, the fungus is most prevalent in areas where high humidity is common, such as the southeastern United States. The fungus overwinters on infected twigs and produces wind- and water-dispersed conidia during bloom. The fungus infects foliage, fruit and twigs, covering the plant tissue with dark-colored lesions. Applications of certain fungicides for control brown rot, blossom blight and shot hole during bloom will also protect developing fruit from scab. More sprays may be necessary in areas where environmental conditions favor scab development.

Shothole (*Wilsonomyces carpophilus*) is an important disease on certain stonefruits, particularly apricots, peaches and nectarines. The disease is less severe on sweet cherries in California, but occasionally causes damage on sweet cherries elsewhere. Plums and prunes are rarely affected. The fungus overwinters on infected buds and twigs and conidia, dispersed by wind and water, infect leaves and fruits during the season. During dry weather the lesions abscise from the leaves, creating a shothole-like appearance. Developing fruit may become infected, resulting in corky rough lesions as the fruits mature. Severe infection may cause defoliation of the trees. Other than cultural control measures, fungicide treatments are an important part of a shot hole disease management program. Dormant applications are recommended to reduce the incidence of twig infections. On apricots, additional fungicide sprays during the season are timed at petal fall early fruit set to protect the fruit.

#### **Pristine and Cabrio EG advantages over current control options:**

The key fungicides used on peaches are **Abound**, **Bravo**, **Cabrio EG**, **Captan**, **Elite**, **Flint**, **Indar**, **Nova**, **Orbit**, **Pristine**, **Scala** and **Vanguard**. Of these, only **Pristine**, contains 2 active ingredients with 2 different modes of action providing resistance management of blossom blight, brown rot, Alternaria, leaf spot, shot hole and powdery mildew.

**Pristine** (boscalid + pyraclostobin) is the most effective broad-spectrum fungicide available for use on peaches. It controls all seven of the key peach diseases (Alternaria leaf spot, anthracnose, brown rot, blossom blight, powdery mildew, scab, and shot hole). Both components are active against all of these diseases except anthracnose, providing effective resistance management of these diseases. Boscalid's unique mode of action provides another resistance management tool for these diseases when used in alternations with other fungicides. **Pristine** has a PHI of zero days, allowing the growers flexibility of applying the product shortly before harvest.

**Cabrio EG** is labeled for most of the key diseases of peach including Alternaria, anthracnose, blossom blight, powdery mildew, scab and shothole. **Cabrio EG** is used in tank mixtures to increase activity, broaden the spectrum of disease control, and for resistance management especially for the triazole fungicide products.

**Abound** (axoystrobin) is similarly labeled except that it excludes anthracnose control but includes brown rot and rust control. **Flint** (trifloxystrobin) is only labeled for powdery mildew and scab.

**Bravo** (clorothalonil), an older fungicide product is labeled only for peach leaf curl, shot hole, and scab. There are no known instances of fungal resistance to Bravo making it a potential alternation fungicide for resistance management within commercial programs for these diseases. However, its narrow spectrum of control limits its usefulness.

**Captan** is also an older fungicide. It is labeled only for brown rot, scab, and shothole. It has no activity on powdery mildew. It is used because it is very inexpensive; however it is less effective than **Pristine**. Since, there are no known instances of fungal resistance to **Captan**, it can be used as a mixing or alternation partner with other fungicides for resistance management.

Many of the peach fungicides belong to the triazole (DMI) class of chemistry. These include **Elite** (tebuconazole), **Indar** (fenbuconazole), **Nova** (myclobutanil), and **Orbit** (propiconazole). All of these have the same mode of action but differ slightly in the spectrum of diseases controlled. All are labeled for brown rot and blossom blight. The labels for **Elite** and **Nova** include rust control. **Indar** includes scab control whereas **Nova** and **Orbit** include powdery mildew on their labels. This class of chemistry is prone to resistance development and should be used in conjunction with other fungicides with different modes of action.

**Scala** (pyrimethanil) and **Vanguard** (cyprodinil) belong to the anilinopyrimidine fungicide class and have a single site mode of action. They are both labeled for the control of blossom blight and brown rot. The *Monilinia* species responsible for these diseases are high risk for resistance development. These products must be used in conjunction with other fungicides active on *Monilinia* for resistance management. The label for **Scala** also lists the control of shot hole and Botrytis however its use is limited by its 30 day preharvest interval.

Sulfur fungicides are widely used on peaches 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** provides excellent control of all seven of the key peach diseases including *Alternaria* leaf spot, anthracnose, brown rot, blossom blight, powdery mildew, scab, and shot hole. Other fungicides lack control of one or more of the key diseases on peaches.
2. **Pristine** contains two active ingredients (2 modes of action) that are effective against *Alternaria* leaf spot, brown rot, blossom blight, powdery mildew, scab, and shot hole. providing effective resistance management of these diseases. No other peach fungicide contains two active ingredients with two modes of action. **Pristine** and **Cabrio EG** 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 peach 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.



## 10. PISTACHIO

According to the California Pistachio Commission, there were approximately 104,000 acres of pistachios grown in the US in 2005. Most of the acres (96%) are in California with the remainder in Arizona, New Mexico, Nevada, and Texas.

### **Important Diseases:**

The most important pistachio diseases are *Alternaria* late blight and *Botryosphaeria* panicle and shoot blight.

*Alternaria* late blight is caused by *Alternaria alternata*. It causes dark lesions on foliage and hulls of the nuts. A blighting of the foliage results from numerous infections. It causes severe lesions of the foliage and fruit leading to defoliation and deterioration of the hulls. Nuts are subsequently stained resulting in poor quality. The infection can progress into the shell causing moldy nuts. The disease is worsened by irrigation especially sprinkler irrigation, that is common in pistachio production. Late blight is best controlled using an integrated approach including fungicide applications and minimal irrigation during early August.

Panicle and shoot blight is caused by *Botryosphaeria dothidea*. In recent years, warm wet spring weather has triggered major epidemics resulting in heavy losses throughout California. This disease infects the buds resulting in death of the buds or severe blighting of the new shoot. Fruit are often infected early in the season but may remain dormant until mid summer when lesions become obvious. Flower infections can spread into the rachis resulting in total loss of the nut cluster. Newly infected shoots develop large cankers that begin to sporulate during late summer. Spores are redeposited during rainfall to leaf and bud scars as well as buds. Buds become infected upon emergence in late winter. Control is dependent upon the removal of diseased tissues by pruning and by the use of effective fungicides applied at bloom and repeated in spring and summer.

Michailides, T. J. 2002. Panicle and shoot blight. Pages 68-69 in: Compendium of Nut Crop Diseases in Temperate Zones. B. L. Teviotdale, T. J. Michailides, and J. W. Pscheidt, eds. American Phytopathological Society, St. Paul, MN.

### **Pristine and Cabrio EG advantages over current control options:**

The key fungicides available for use on pistachio are **Abound**, **Bravo**, **Cabrio EG**, **Flint**, **Pristine**, **Scala** and **Switch**. Of these, only **Pristine** and **Switch** contain 2 active ingredients with 2 different modes of action providing resistance management.

**Pristine** (boscalid + pyraclostobin) is the most effective fungicide available for use on pistachios. It controls all of the most important pistachio diseases. In addition to *Alternaria* late blight and panicle and shoot blight, **Pristine** also delivers excellent control of *Botrytis* blossom and shoot blight. **Pristine** is registered for this use in California as a FIFRA Section 2(ee) recommendation and plans are underway to add this disease to the master label. Both active ingredient components within **Pristine** are active against all of these diseases, providing effective resistance management. Boscalid's unique mode of action provides another resistance management tool for these diseases when used in alternations with other fungicides.



**Cabrio EG** (pyraclostrobin) provides very good control of *Alternaria* late blight, *Botryosphaeria* panicle and shoot blight, and suppression of *Botrytis* blossom blight. Other strobilurin fungicides, **Abound** (azoxystrobin) and **Flint** (trifloxystrobin), provide similar control of *Alternaria* and *Botryosphaeria* but not *Botrytis*. Although these fungicides provide very good control of these diseases, they are much less effective compared to **Pristine**.

A comparison of disease control activity of the key pistachio fungicides is provided in Table 2.

**Table 2: Relative activity of fungicides against pistachio diseases**

Fungicide	A. alternata	B. dothidea	B. cinerea
Pristine	++++	++++	++++
Abound	+++	+++	-
Bravo	++	++	-
Cabrio EG	+++	+++	+
Flint	+++	+++	-
Scala	++	++	++
Switch	+++	++	+++

This table demonstrates the superior activity of **Pristine** against the key pistachio diseases compared to all other fungicides that are currently available for use.

**Switch** (cyprodinil + fludioxanil) and **Scala** (pyrimethanil) are labeled for the control of *Alternaria* and *Botrytis* blights. Pyrimethanil and cyprodinil are similar in structure and share the same mode of action. 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, however it is relatively weak on *Botryosphaeria*.

Adaskaveg, J. E., B. A. Holtz, T. J. Michailides, and W. D. Gubler. 2006. Fungicide Efficacy and Timing for Deciduous Tree Fruit and Nut Crops and Grapevines ([www.ipm.ucdavis.edu](http://www.ipm.ucdavis.edu))

### 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. There are insufficient efficacious alternative registered fungicides available for use that delivers the high level of control of all key pistachio diseases including *Alternaria* late blight, *Botryosphaeria* panicle and shoot blight, and *Botrytis* blossom and shoot blight.
2. **Pristine** contains two active ingredients (2 modes of action) that are effective against all key pistachio diseases resulting in effective resistance management of these diseases. **Pristine** is an excellent alternation partner to other fungicide modes of action that are at risk for resistance development.
3. **Pristine** plays a major part in Integrated Pest Management programs for pistachio production because of its broad-spectrum activity and resistance management. These characteristics contributed to the use of **Pristine** on 50% of the pistachio acres in 2006.

## 11. PLUM

Production acreage estimates for plums vary but range between 100,000 and 150,000 acres. Most of the acres are in California with most of the remaining production in Idaho, Michigan, Oregon, and Washington.

### Important Diseases:

The most important plum diseases are brown rot, blossom blight, and powdery mildew.

Blossom blight / Brown rot (*Monilinia fructicola*, *M. laxa*) 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 may be needed during fruit development and maturation.

Powdery mildew (*Podosphaera clandestina*) generally affects the fruit of the plum trees. The foliage is somewhat resistant to infection. 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. 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, powdery mildew fungi are prone to development of fungicide resistance. Resistance to certain DMI-fungicides is suspected in cherry powdery mildew in the Pacific Northwest.



### **Pristine and Cabrio EG advantages over current control options:**

The key fungicides used on plums are **Abound**, **Cabrio EG**, **Captan**, **Flint**, **Nova**, **Orbit**, **Pristine**, **Rovral**, **Scala**, **Scholar**, sulfur, and **Vanguard**. 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 effective broad-spectrum fungicide available for use on plums. It controls all three of the key plum diseases (brown rot, blossom blight, and powdery mildew). Both components are active against all of these diseases providing effective resistance management. Boscalid's unique mode of action provides another resistance management tool for these diseases when **Pristine** is used in alternations with other fungicides. **Pristine** has a PHI of zero days, allowing the growers flexibility of applying the product shortly before harvest. **Pristine** surpasses all other fungicides in spectrum of disease control and superior disease control on these diseases.

**Cabrio EG** (pyraclostrobin) controls Anthracnose, blossom blight, and powdery mildew on plums. The key feature of **Cabrio EG** is its control of anthracnose while spraying for the other key diseases on plums. Anthracnose is considered a minor disease on plums, however, it can be mistaken for early brown rot infections on the fruit. **Abound** (azoxystrobin) is similarly labeled except that it excludes anthracnose control but includes brown rot and rust control. **Flint** (trifloxystrobin) is only labeled for powdery mildew and scab. **Cabrio EG** is used in tank mixtures to increase activity, broaden the spectrum of disease control, and for resistance management especially for the triazole fungicide products.

**Captan** is also an older fungicide that has some utility on plum for brown rot control. It has no activity on powdery mildew and is not labeled for blossom blight. It is used because it is very inexpensive, however it is less effective than **Pristine**. Since, there are no known instances of fungal resistance to **Captan**, it can be used as a mixing or alternation partner for other fungicides for resistance management.

**Nova** (myclobutanil) and **Orbit** (propiconazole) fungicides belong to the triazole (DMI) class of chemistry. Both are labeled for brown rot, blossom blight and powdery mildew. However, these pathogens are high risk for resistance development and this class of chemistry is prone to resistance development. These fungicides need to be used in conjunction with other fungicides with different modes of action for resistance management.

**Rovral** (iprodione) is a dicarboximide fungicide labelled for the control of blossom blight. It can only be used twice during the bloom period and may not be used after petal fall. It needs to be used in conjunction with other fungicides for resistance management.

**Scala** (pyrimethanil) and **Vanguard** (cyprodinil) belong to the anilinopyrimidine fungicide class and have a single site mode of action. They are both labeled for the control of blossom blight and brown rot. The *Monilinia* species responsible for these diseases are high risk for resistance development. These products must be used in conjunction with other fungicides active on *Monilinia* for resistance management. **Scala** is limited by its 30 day preharvest interval.

Sulfur is widely used on plums 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** provides excellent control of all three of the key plum diseases including brown rot, blossom blight, and powdery mildew. No other plum fungicide contains two active ingredients with two modes of action.
2. Both components are active against all of these key plum diseases providing effective resistance management. Boscalid's unique mode of action provides another resistance management tool for these diseases when **Pristine** used in alternations with other fungicides that have different modes of action.
3. **Pristine** plays a key role in integrated pest management programs for plum disease control. Broad-spectrum disease control and resistance management are key characteristics that contributed to the use of **Pristine** on 36% of the stonefruit acres in 2006.

## 12. RASPBERRY

Raspberry is the predominant bramble crop. The average annual acreage of all types of brambles is estimated to be around 27,000 acres. Most of the acres are in Oregon and Washington with 12,200 and 8,600 acres, respectively. Other minor but significant production occurs in Michigan, Missouri, New York, and Ohio for an additional 3,700 acres.

### Important Diseases:

The most important raspberry diseases are anthracnose, cane blight, spur blight, and Botrytis gray mold. Fungicides are necessary to control all of these except cane blight.

Anthracnose (*Elsinoe veneta*) occurs on the canes of black raspberry and susceptible cultivars of red raspberry. Symptoms first appear on young canes in late spring as reddish-purple lesions. Expanding lesions can girdle the stem causing it to die. Surviving but infected canes produce malformed fruit. Lesions can also occur on leaves, flowers and fruit.

Cane blight (*Coniothyrium fuckelii*) primarily infects damaged canes especially through pruning cuts leading to their eventual death. Fungicides are not effective in controlling cane blight. The primary means of control is cultural methods including pruning during dry weather.

Spur blight (*Didymella appianata*) is a very serious disease of red raspberry. Infections begin along the edges of the leaves. These lesions advance toward the center of the leaves and eventually move through the petiole and into the stem resulting in defoliation. Buds on infected canes fail to develop or produce a reduced number of flowers.



Botrytis gray mold (*Botrytis cinerea*) is a very common and serious disease of raspberry. Botrytis can infect blossoms, fruit, stems and senescing leaves. In early spring, infections begin on blossoms and spread to developing fruit. As these fruit mature, the infections rapidly progress resulting in rotten fruit often covered by a proliferation of gray spores. Botrytis gray mold favors cool and wet conditions.

**Pristine and Cabrio EG advantages over current control options:**

The key fungicides used on raspberries are **Abound**, **Cabrio EG**, **Captan**, **Nova**, **Pristine**, **Rovral**, and **Switch**. Of these, only **Pristine** and **Switch** contain 2 active ingredients with 2 different modes of action.

**Pristine** (boscalid + pyraclostobin) is the most effective broad-spectrum fungicide available for use on raspberry. It controls three of the key raspberry diseases (anthracnose, spur blight, and Botrytis gray mold) and minor diseases including Alternaria leaf spot and fruit rot, Anthracnose, Mycosphaerella leaf spot and blotch, powdery mildew, Phomopsis, rust, and monilinia blight. The two modes of action provide critical fungal resistance management for all of these diseases except anthracnose. **Pristine** has a PHI of zero days, allowing the growers flexibility of applying the product shortly before harvest. **Pristine** surpasses all other fungicides in spectrum of disease control and superior disease control on these diseases.

**Cabrio EG** (pyraclostrobin) is a broad-spectrum strobilurin fungicide for use on raspberries. It controls Alternaria, spur blight, Mycosphaerella, Septoria, anthracnose, powdery mildew, and Phomopsis. It also provides significant suppression of Botrytis gray mold, Monilinia blight and rust. It also has a zero day PHI. Due to the spectrum of diseases controlled, it is a very important tank mixing and alternation partner for resistance management and integrated pest management programs.

**Abound** (azoxystrobin) is labeled for Botryosphaeria canker, anthracnose, powdery mildew, Septoria, spur blight and Cercospora. Although there are some similarities with **Cabrio EG**, its spectrum of diseases controlled on the label are somewhat different. Abound is not labeled for Alternaria, Mycosphaerella leaf spot and blotch, Phomopsis, Botrytis gray mold, or Monilinia blight.

**Captan** is also an older fungicide that has some utility on plum for brown rot control. It is labeled for anthracnose, spur blight, and Botrytis gray mold. It is very cost efficient, however it is less effective than **Pristine**. Since, there are no known instances of fungal resistance to **Captan**, it can be used as a mixing or alternation partner for other fungicides for resistance management.

**Nova/Rally** (myclobutanil) belong to the triazole (DMI) class of chemistry. They are labeled only for some minor diseases of raspberry including rusts, powdery mildew and leaf spot. These fungicides need to be used in conjunction with other fungicides with different modes of action for resistance management.

**Rovral** (iprodione) is a dicarboximide fungicide labelled only for the control of Botrytis gray mold. Its usefulness is limited due to the development of resistance. It needs to be used in conjunction with other fungicides for resistance management.

**Switch** (cyprodinil + fludioxanil) is labeled for the control of *Alternaria*, anthracnose and *Botrytis* gray mold. **Switch** provides two modes of action useful for resistance management of *Alternaria* and *Botrytis* 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. The major weakness of **Switch** is that it does not control spur blight.

### 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. There are insufficient fungicide alternatives available for raspberry production that can match the disease control afforded by **Pristine**. **Pristine** provides excellent control of three of the key raspberry diseases including anthracnose, spur blight, and *Botrytis* gray mold. No other raspberry fungicide that controls these three diseases contains two active ingredients with two modes of action. **Pristine** also provides effective control of *Alternaria*, *Septoria*, *Phomopsis*, powdery mildew, rust, and *Monilinia* blight diseases. **Pristine** surpasses all other fungicides in spectrum of disease control and superior disease control on these diseases.
2. **Pristine** plays a key role in managing pest resistance. Both boscalid and pyraclostrobin components are active against spur blight and *Botrytis* gray mold diseases providing effective resistance management. Boscalid's unique mode of action provides another resistance management tool for these diseases when **Pristine** used in alternations with other fungicides that have different modes of action.
3. **Pristine** plays a significant part in Integrated Pest Management in raspberry production. It is the most effective fungicide available for use in raspberries. Due to its broad-spectrum, high level of effectiveness, and dual modes of action (resistance management), **Pristine** was used on 39% of the berry acres in 2006.
4. **Cabrio EG** (pyraclostrobin) is the most broad-spectrum strobilurin fungicide for use on raspberries. It controls *Alternaria*, spur blight, *Mycosphaerella*, *Septoria*, anthracnose, powdery mildew, and *Phomopsis* and also suppresses *Botrytis* gray mold, *Monilinia* blight and rust. Due to the spectrum of diseases controlled, it is a very important tank mixing and alternation partner for resistance management and integrated pest management programs.



### **13. STRAWBERRY**

Approximately 55,000 acres of strawberries are grown in the US each year. California accounts for nearly half of the total acreage. Florida is the second largest producer with approximately 6,000 acres. Most of the remaining acres are in North Carolina, Oregon, New York, Michigan, Washington, Pennsylvania, Ohio and Wisconsin.

#### **Important Diseases:**

The most important strawberry diseases in California and Oregon are Botrytis gray mold, anthracnose, powdery mildew and common leaf spot. Botrytis is by far the most important disease. In Florida, the most important diseases are Botrytis, anthracnose, and common leaf spot. Powdery mildew is only of importance in Florida during the winter months.

Botrytis gray mold (*Botrytis cinerea*) is the most common and devastating disease of strawberry. Botrytis can infect blossoms, fruit, stems and senescing leaves. In early spring, infections begin on blossoms and spread to developing fruit. As these fruit mature, the infections rapidly progress resulting in rotten fruit often covered by a proliferation of gray spores. Botrytis gray mold favors cool and wet conditions.

Anthracnose (*Colletotrichum* spp.) occurs on the fruit, runners, crowns and leaves of strawberry. Severe outbreaks can destroy up to 85% of the crop. Anthracnose fruit rot is very difficult to control especially in warm wet weather conditions.

Powdery mildew (*Sphaerotheca fragariae*) occurs wherever strawberries are grown. Symptoms are most obvious on the foliage. However, fruit infections lead to misshapen fruit. Varieties vary widely in their resistance to powdery mildew. It is generally considered a minor disease except in certain areas of California and in Florida during the winter months.

Leaf spot and blotch (*Mycosphaerella fragariae*) was once considered the most important strawberry disease but recent variety introductions are more tolerant. It still remains a very common and potentially devastating disease of strawberry. Symptoms are commonly observed as leaf spots but lesions often develop on fruits, calyxes, petioles, and stolons.

#### **Pristine and Cabrio EG advantages over current control options:**

The key fungicides used on strawberry are **Abound, Cabrio EG, Captan, Nova, Pristine, Procure, Rally, Rovral, Scala**, sulfur, and **Switch**. Of these, only **Pristine** and **Switch** contain 2 active ingredients with 2 different modes of action.

Most effective fungicides currently registered in strawberries can only be used for a limited number of applications per season, whereas the period in which fungicides are needed can last from 6 to 10 months. Growers subsequently extend spray intervals to cover the entire period with the risk of encountering inadequate disease control. Other effective fungicides with high intrinsic activity and different modes of action are needed to provide effective disease management in strawberries.

**Pristine** (boscalid + pyraclostobin) is the most effective broad-spectrum fungicide available for use on strawberry. It controls all four of the key strawberry diseases (Botrytis gray mold, anthracnose, powdery mildew and Mycosphaerella leaf spot/blotch) and many minor diseases including Alternaria, Septoria, Phomopsis, and rust diseases. Both components are active against Botrytis gray mold, powdery mildew and common leaf spot diseases providing effective resistance management. Boscalid's unique mode of action provides another resistance management tool for these diseases when **Pristine** is used in alternations with other fungicides. **Pristine** has a PHI of zero days, allowing the growers flexibility of applying the product shortly before harvest. **Pristine** surpasses all other fungicides in spectrum of disease controlled.

**Cabrio EG** (pyraclostrobin) is a very broad-spectrum strobilurin fungicide for use on strawberries. It controls Alternaria, Mycosphaerella, Septoria, anthracnose, powdery mildew, and Phomopsis. It also provides significant suppression of Botrytis gray mold and rust. It also has a zero day PHI. Due to the spectrum of diseases controlled, it is a very important tank mixing and alternation partner for resistance management and integrated pest management programs.

**Abound** (azoxystrobin) is labeled for anthracnose, powdery mildew, Septoria, and Cercospora. Although there are some similarities with **Cabrio EG**, its spectrum of diseases controlled on the label are somewhat different. Abound is not labeled for Mycosphaerella leaf spot and blotch, Phomopsis or Botrytis gray mold.

**Captan** is also an older fungicide that has some utility on strawberry for Botrytis gray mold and leafspot control. It is very cost efficient, however it is less effective than **Pristine**. Since, there are no known instances of fungal resistance to **Captan**, it can be used as a mixing or alternation partner for other fungicides for resistance management.

**Nova/Rally** (myclobutanil) and **Procure** (triflumizole) belong to the triazole (DMI) class of chemistry. **Rally** and **Nova** are labeled for powdery mildew, leafspot, and a minor disease, Phomopsis leaf blight. **Procure** is only labeled for the control of powdery mildew. These fungicides need to be used in conjunction with other fungicides with different modes of action for resistance management and to broaden the spectrum of activity.

**Rovral** (iprodione) is a dicarboximide fungicide labelled only for the control of Botrytis gray mold, leaf spot and a few minor fruit rots. It is not effective on anthracnose or powdery mildew. Its usefulness is limited due to the development of resistance. It needs to be used in conjunction with other fungicides for resistance management. Its use is extremely limited to only the preflowering period.

**Scala** (pyrimethanil) belongs to the anilinopyrimidine fungicide class and has a single site mode of action. It is labeled for the control of Botrytis gray mold. Botrytis is high risk for resistance development. Therefore, this product must be used in conjunction with other fungicides active on Botrytis for resistance management. Scala is limited by its 1 day preharvest interval.

**Switch** (cyprodinil + fludioxanil) is labeled only for the control of Botrytis gray mold. **Switch** provides two modes of action useful for resistance management of Botrytis. When **Switch** is alternated with **Pristine**, the 4 modes of action should be the most effective means of preventing resistance development within the high risk Botrytis pathogen populations. It is not effective on the other key diseases of strawberry.

Sulfur is widely used on strawberries 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. There are insufficient fungicide alternatives that can match the disease control performance of **Pristine**. It controls all four of the key strawberry diseases (Botrytis gray mold, anthracnose, powdery mildew and common leaf spot. No other strawberry fungicide that controls all of these key diseases contains two active ingredients with two modes of action.
2. **Pristine** plays a key role in managing pest resistance. Both boscalid and pyraclostrobin components are active against Botrytis gray mold, powdery mildew and common leaf spot diseases providing effective resistance management. Boscalid's unique mode of action provides another resistance management tool for all of the key diseases when **Pristine** used in alternations with other fungicides that have different modes of action.
3. **Pristine** plays a significant part in Integrated Pest Management in strawberry production. It is the most effective fungicide available for use in strawberries. Due to its broad-spectrum, high level of effectiveness, and dual modes of action (resistance management), **Pristine** was used on 66% of the berry acres in 2005.
4. **Cabrio EG** is a very broad-spectrum strobilurin fungicide for use on strawberries. It controls Alternaria, Mycosphaerella, Septoria, anthracnose, powdery mildew, and Phomopsis and suppresses Botrytis gray mold and rust. Due to the spectrum of diseases controlled, it is a very important tank mixing and alternation partner for resistance management and integrated pest management programs.

## 14. SUMMER SQUASH

Summer squash are grown on approximately 29, 000 acres in the United States. The primary growing regions are Florida, California, Georgia, New Jersey, and Texas.

### Important diseases:

The most important foliar diseases of summer squash are gummy stem blight, downy mildew, and powdery mildew.

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 Qol 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 Qol fungicides has been reported, although resistance to Qol fungicides has not been confirmed in the United States to date.

Gummy stem blight (*Didymella bryoniae*) affects fruit, stems and leaves of summer squash. 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.

#### **Pristine advantages over current control options:**

The main fungicides currently available for foliar use in summer squash are **Amistar**, **Bravo**, **Cabrio EG**, **Dithane**, **Endura**, **Flint**, **Gavel\***, **Nova**, **Pristine\***, **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 + pyraclostrobin) is the most active broad-spectrum cucurbit fungicide. It controls numerous diseases including all of the key summer squash diseases occurring aboveground:

Downy Mildew (*Pseudoperonospora cubensis*)  
Powdery Mildew (*Sphaerotheca fuliginea*, *Erysiphe chichoracearum*)  
Anthracnose (*Colletotrichum orbiculare*)  
Alternaria Blight (*Alternaria cucumerina*, *A. alternata*)  
Gummy Stem Blight (*Didymella bryoniae*)  
Microdochium Blight (*Microdochium tabacinum*)  
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 summer squash 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 possess 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 in most 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 triazoles. 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 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 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 + chlorothalonil) is a fairly broad-spectrum fungicide listing diseases that can be controlled by either active ingredient. See discussion above for azoxystrobin and chlorothalonil regarding resistance, crop safety, and tank mix compatibility. It has only moderate activity against powdery mildew, a key disease affecting summer squash.

A comparison of biological activity for **Pristine** and key competitive fungicides is presented in Table 3. **Pristine** offers the most effective and broad-spectrum control of the most important cucurbit diseases.

**Table 3: 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 summer squash 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 summer squash 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 squash. Many other 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 summer squash diseases within Integrated Pest Management programs. **Pristine** is the most active squash 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 diseases. These factors contributed to **Pristine** usage on 28% of the cucurbit acres.

**APPENDIX**

**Products Mentioned in this Document**

<b>Product Name</b>	<b>Active Ingredient(s)</b>	<b>Company</b>
Abound® Fungicide	Azoxystrobin	Syngenta Crop Protection, Inc.
Accrue® Fungicide	Spiroxamine	Bayer Crop Science LP
Aliette® Fungicide	Fosetyl aluminum	Bayer Crop Science LP
Amistar® Fungicide	Azoxystrobin	Syngenta Crop Protection, Inc.
Bayleton® Fungicide	Triadimefon	Bayer Crop Science LP
Bravo® Fungicide	Chlorothalonil	Syngental Crop Science LP
Cabrio® EG Fungicide	Pyraclostrobin	BASF Corporation
Captan Fungicide brands	Captan	Arysta Life Science North America
Curzate® 60 DF Fungicide	Cymoxanil	DuPont Crop Protection
Dithane® Fungicide brands	Mancozeb	Dow AgroSciences LLC
Elite® WP Fungicide	Tebuconazole	Bayer Crop Science LP
Flint® Fungicide	Trifloxystrobin	Bayer Crop Science LP
Gavel® 75 DF Fungicide	Mancozeb + Zoxamide	Dow AgroSciences LLC
Indar® Fungicide brands	Fenbuconazole	Dow AgroSciences LLC
Kocide® Fungicide brands	Copper Hydroxide	DuPont Crop Protection
Maneb Fungicide brands	Maneb	Cerexagri-NISSO LLC
Nova® 40 W Fungicide	Myclobutanil	Dow AgroSciences LLC
Orbit™ Fungicide	Propiconazole	Syngenta Crop Science LP
Previcur® Flex Fungicide	Propamocarb Hydrochloride	Bayer Crop Science LP
Pristine® Fungicide	Boscalid + Pyraclostrobin	BASF Corporation
Procure® Fungicide brands	Triflumizole	Chemtura Corporation
Quadris® Fungicide	Azoxystrobin	Syngenta Crop Protection, Inc.
Quadris Opti® Fungicide	Azoxystrobin + Chlorothalonil	Syngenta Crop Protection, Inc.
Quintec® Fungicide	Quinoxifen	Dow AgroSciences LLC
Rally® 40 WP Fungicide	Myclobutanil	Dow AgroSciences LLC
Reason® 500 SC Fungicide	Fenamidone	Bayer Crop Science LP
Ridomil Gold® Bravo® Fungicide	Mefenoxam + Chlorothalonil	Syngenta Crop Protection, Inc.
Ridomil Gold® CU	Mefenoxam + Copper Hydroxide	Syngenta Crop Protection, Inc.
Ridomil Gold® MZ Fungicide	Mefenoxam + Mancozeb	Syngenta Crop Protection, Inc.
Rovral® 4 Flowable Fungicide	Iprodione	Bayer Crop Science LP
Scala™ SC Fungicide	Pyrimethanil	Bayer Crop Science LP
Scholar® Fungicide	Fludioxonil	Syngenta Crop Protection, Inc.
Switch® Fungicide	Cyprodinil + fludioxonil	Syngenta Crop Protection, Inc.
Tanos® Fungicide	Famoxadone + Cymoxanil	DuPont Crop Protection
Topsin® M Fungicide	Thiophanate methyl	Cerexagri-NISSO LLC
Vanguard® Fungicide	Cyprodinil	Syngental Crop Protection, Inc.