



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

**Boscalid Reduced Risk Pesticide
Application for Extension of Exclusive Use
of Data Under FIFRA 3c(1)(f)(ii) -
Continued - part 2 of 2**

August 2, 2007

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 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® fungicide and Endura® fungicide 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*, *Stemphylium*, and *Botrytis*.

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*.

Cabrio EG (pyraclostrobin), Amistar and Quadris (azoxystrobin), and Reason (fenamidone) are strobilurin (QoI) fungicides with a single site mode of action. They must be used in alternation or tank mixed with non-strobilurin fungicides with different modes of action for resistance management.

Although the strobilurin fungicides possess the same mode of action, they differ in their biological activity. Cabrio EG, Amistar, and Quadris are active on a many of the onion diseases including *Alternaria*, downy mildew, rust and to a lesser extent, *Botrytis* leaf blight. Amistar and Quadris are also labeled for the control of *Cladosporium* and *Sclerotium*. Cabrio EG also includes the control of powdery mildew and *Stemphylium*. Reason is used primarily for downy mildew control however it also has some activity on *Alternaria*.

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 (mefanoxam + 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 (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, 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.

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® fungicide 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.
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*, *Stemphyllium*, and *Botrytis* diseases. 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*.
3. Boscalid 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. These factors contributed to Pristine usage on 33% of the bulb vegetable acres in 2006.

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® fungicide and Endura® fungicide 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® fungicide (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*.

Endura® fungicide (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*.

Cabrio EG (pyraclostrobin), Amistar and Quadris (azoxystrobin), and Reason (fenamidone) are strobilurin (QoI) fungicides with a single site mode of action. They must be used in alternation or tank mixed with non-strobilurin fungicides with different modes of action for resistance management.

Although the strobilurin fungicides possess the same mode of action, they differ in biological activity. Cabrio EG, Amistar, and Quadris are active on a many of the onion diseases including *Alternaria*, downy mildew, rust and to some extent, *Botrytis* leaf blight. Amistar and Quadris are also labeled for the control of *Cladosporium* and *Sclerotium*. Cabrio EG also includes the control of powdery mildew and *Stemphylium*. Reason is used primarily for downy mildew control however it also has activity on *Alternaria*.

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 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 (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. 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® fungicide 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, *Stemphyllium* leaf blight, *Botrytis* leaf blight, *Botrytis* neck rot and suppression of downy mildew.
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*, *Stemphyllium*, and *Botrytis* diseases. 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*.
3. Boscalid 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. 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® fungicide advantages over current control options:

The key fungicides used on peaches are Abound, Bravo, Cabrio EG, Captan, Elite, Flint, Indar, Nova, Orbit, Pristine, Scala, 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, 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, Abound, and Flint are strobilurin fungicides with a single site mode of action. They must be used in alternation or tank mixed with non-strobilurin fungicides with different modes of action for effective resistance management. These fungicides differ somewhat in their spectrum of diseases controlled. Cabrio EG is labeled for all of the key diseases of peach except brown rot and also has activity on anthracnose and Alternaria. Abound is similarly labeled except that it excludes anthracnose control but includes brown rot and rust control. Flint 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® fungicide 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 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® fungicide 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 contains 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 under a 2EE 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.

A comparison of disease control activity of the key pistachio fungicides is provided in Table 1.

Table 1. Relative activity of fungicides against pistachio diseases.

Fungicide	A. alternata	B. dothidea	B. cinerea
Pristine ® fungicide	++++	++++	++++
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.

Cabrio EG, Abound, and Flint are strobilurin fungicides with a single site mode of action. They must be used in alternation or tank mixed with non-strobilurin fungicides with different modes of action for effective resistance management. Cabrio EG, Abound and Flint are also labeled for *Alternaria* and *Botryosphaeria*, the key diseases of pistachio. Although these provide good control of these diseases, they are much less effective compared to Pristine.

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)

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® fungicide 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. In addition, the boscalid component provides a unique mode of action against the targeted diseases.

3. Pristine® fungicide 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® fungicide 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, Abound, and Flint are strobilurin fungicides with a single site mode of action. They must be used in alternation or tank mixed with non-strobilurin fungicides with different modes of action for effective resistance management. Cabrio EG and Abound can be used for blossom blight and powdery mildew. Flint is only labeled for powdery mildew.

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® fungicide 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 applanata*) 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® fungicide 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). 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 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.

Cabrio EG and Abound are strobilurin fungicides with a single site mode of action. They must be used in alternation or tank mixed with non-strobilurin fungicides with different modes of action for effective resistance management. These strobilurine fungicides are labeled for the control of anthracnose, spur blight and various minor diseases but lack sufficient control of Botrytis gray mold (suppression only).

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® fungicide 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.

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® fungicide 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). 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 control and superior disease control on these diseases.

Cabrio EG and Abound are strobilurin fungicides with a single site mode of action. They must be used in alternation or tank mixed with non-strobilurin fungicides with different modes of action for effective resistance management. These strobilurine fungicides are labeled for the control of anthracnose, powdery mildew and leaf spot and various minor diseases but lack sufficient control of Botrytis gray mold (suppression only).

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® fungicide 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® fungicide 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.

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 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 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® fungicide and Endura® fungicide 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 shown in **bold** (above) 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 disease 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.

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.

Cabrio EG, Amistar, Quadris and Flint are strobilurin (QoI) fungicides with a single site mode of action. They must be used in alternation or tank mixed with non-strobilurin fungicides with different modes of action for effective resistance management. Although the strobilurin fungicides are similar in chemistry and possess the same mode of action, they differ in their spectrum of activity.

Cabrio EG (pyraclostrobin) is a broad-spectrum strobilurin fungicide with activity against all of the key above ground squash diseases. It 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.

Amistar and Quadris (azoxystrobin) are active against many of the key cucurbit 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 fairly 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.

Although the Ridomil combination products (Ridomil Gold MZ and Ridomil Gold Bravo) have 2 active ingredients, the mefenoxam component is only active against downy mildew and Pythium. Resistance to mefenoxam 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 + 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 summer squash.

A comparison of biological 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	Anthraco	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® fungicide. It provides excellent control of all major foliar diseases of summer squash. The boscalid component provides efficacy against gummy stem blight resistant to solo QoI-fungicides such as azoxystrobin and Cabrio EG. Pristine and Endura are major components within commercial disease control programs for gummy stem blight control as alternation partners with Bravo.

2. Boscalid plays a critical role in managing pest resistance. The combination of boscalid and pyraclostrobin within Pristine provides vital resistance management against powdery mildew, Alternaria, Microdochium, Cercospora, and target leaf spot. It is used strategically to protect the powdery mildew efficacy of the triazole fungicides; Rally and Nova (myclobutanil) and Procure (triflumizole). It is also an important tool for broad-spectrum resistance management when used as a tank mixing or alternation partner with strobilurin fungicides. Boscalid alone is the only efficacious alternative to clorothalonil for the gummy stem blight control where this pathogen has developed resistance to the QoI fungicides. Endura and Pristine provide excellent control of these resistant strains. Although the older fungicides such as Bravo and Dithane have multisite modes of action, they are generally much less effective on most target pathogens and need to be used in programs with more efficacious products like Pristine.

3. Boscalid plays a significant role in managing summer squash diseases within Integrated Pest Management programs. Pristine is the most active summer squash 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 squash diseases. Boscalid is essential for the control of gummy stem blight that are resistant to strobilurin fungicides. These factors contributed to Pristine usage on 28% of the cucurbit acres in 2005.

APPENDIX

Product Information

Product Name	Active Ingredient(s)	Company
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	Syngenta 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	Syngenta Crop Protection, Inc.