

Guidelines for Developing an Effective Fungicide Spray Program for Wine Grapes in Maryland, 2008

The information in this publication is intended to help wine grape growers in Maryland develop effective fungicide spray programs to control five major fungal diseases affecting vines and fruit: powdery mildew, downy mildew, black rot, Botrytis bunch rot, and Phomopsis cane and leaf spot. The spray schedules below suggest several options for each spray but do not include all fungicides registered in Maryland for control of these diseases. Two supplemental tables are provided to further assist growers in choosing fungicides. Table 1 rates the effectiveness of all fungicides listed in the schedules against these five diseases, based on research in New York, Pennsylvania, and Virginia. Information on effectiveness is intended as general guidance only. Results in a given vineyard will depend on weather, disease pressure, canopy management, age of vines, fungicide formulation and rate, and spray intervals and coverage. Table 2 lists resistance-prone fungicides by chemical class (mode of action) to help growers rotate fungicides with different modes of action within a spray program to minimize the chances of resistance development.

Treat the information in this publication as a general recommendation. Your final program will depend on the characteristics of your vineyard site, the varieties of grapes grown, the complex of diseases you typically see in the vineyard, weather conditions, and economic considerations.

The fungicides listed in the schedule vary considerably in price, so check the cost per acre per application as you plan your program. Finally, *always* read the fungicide label for allowable usage rates, cautions and restrictions on use, and recommendations on resistance management strategies.

Special Note on Powdery and Downy Mildew Resistance to Fungicides

Grape growers who are planning their 2008 disease management programs should be aware that we have now found strains of both powdery and downy mildew in Maryland vineyards that are resistant to strobilurin fungicides (Abound, Sovran, Flint, and one component of Pristine). In addition, strobilurin-resistant strains of powdery mildew also appear to be losing sensitivity to sterol-inhibiting (SI) fungicides, particularly Rally (formerly named Nova) and Elite. Strobilurin resistance may appear suddenly and result in a control failure and crop loss. Once resistant fungi become dominant, all strobilurins are useless against that pathogen. SI resistance occurs more slowly, and growers may be able to compensate for a few seasons by increasing the application rate (up to the label rate), spraying at shorter intervals, or switching to a different SI. The more frequently any SI material is used, however, the higher the level of resistance that is likely to develop.

Powdery Mildew. If you have ever applied strobilurins for powdery mildew control in your vineyard, or if other vineyards nearby have used them, be aware that resistance may appear suddenly. Consider replacing Abound, Flint, or Sovran in your rotation with sulfur, JMS Stylet Oil, Quintec, Endura, or a potassium salt product such as Armicarb 100, Kaligreen, or Nutrol. Pristine is a combination of a strobilurin and Endura and should therefore be safe to use alone for powdery mildew control in rotation with other materials. Limit applications of any strobilurin, including Pristine, to two per year at critical times like the bloom period, and rotate to another class of fungicide after each application.

If you have been using the SIs Nova/Rally or Elite for some years for powdery mildew

control, you may want to switch to Rubigan and/or mix your SI with sulfur (on sulfur-tolerant grape varieties) to deal with any resistant strains of powdery mildew and slow further resistance development. Again, limit applications of SIs to two per year and rotate to another class of fungicide after each SI application.

Downy Mildew. If you use a strobilurin, including Pristine, to control other diseases and need downy mildew control, add another fungicide to the tank mix. Good choices include captan, mancozeb, or a phosphorous acid (phosphite). Pristine alone will *not* control strobilurin-resistant downy mildew because its other component, Endura, is not active against the downy mildew pathogen.



GUIDELINES FOR BEARING VINEYARDS

Growth stage or timing	Material and rate/acre	Comments
½- to 1-inch shoot	<p>Mancozeb @ 4 lb/ac PLUS one of the following for PM: Wettable sulfur @ 5–10 lb/ac or Liquid sulfur @ 3–4 qt/ac or JMS Stylet Oil @ 1% concentration or a sterol-inhibiting (SI) fungicide [Elite 45 WP @ 4 oz/ac or Rally 40WSP* @ 4 oz/ac or Rubigan @ 3 fl oz/ac] or Quintec @ 4 fl oz/ac or Endura @ 4.5 oz/ac</p>	<p>Apply mancozeb to protect against early Phomopsis (Ph) and black rot (BR) infection. Choose one of the materials listed to protect against powdery mildew (PM) infections on the rachis that will give rise to later infections on clusters. Sulfur and stylet oil are inexpensive but require thorough coverage to be effective. To avoid vine injury:</p> <ul style="list-style-type: none"> • Do not use sulfur on Concord, red-fruited French-American hybrids, or any sulfur-sensitive variety. Use stylet oil, an SI, Quintec, or Endura. • Do not combine sulfur with oil or spray them within 14 days of one another. • Do not apply sulfur when the temperature exceeds 85°F. <p><i>*Note: Nova 40 W has been renamed Rally 40 WSP and is now sold in 4-oz packets.</i></p>
3- to 5-inch shoot or 7–10 days after the last spray	Same as ½- to 1-inch shoot spray	<p>Use a 7-day interval if:</p> <ul style="list-style-type: none"> • you are applying sulfur • there has been a lot of rain since the last spray, or • it is unusually warm, and shoots are growing rapidly. <p>If rain is predicted between 7 and 10 days after your last spray, make another application before the rain. Most of these fungicides act only as protectants. They must be on the shoot before fungal spores arrive to be effective, and they do not move through the shoot to new growth. New growth must be protected by sprays at regular intervals.</p>

Growth stage or timing	Material and rate/acre	Comments
6- to 10-inch shoot or 7–10 days after the last spray	Same as ½- to 1-inch shoot spray	If you are using an SI fungicide, Quintec, or Endura, rotate to one with a different mode of action after each spray to avoid resistance development. See Table 2 for classes of fungicides. Read the label for seasonal limits on applications and amounts of fungicide. In general, make no more than 2 sprays of any resistance-prone fungicide per season.
12- to 17-inch shoot or 7–10 days after the last spray (if necessary)	Same as ½- to 1-inch shoot spray	<p>If you have been spraying at 10-day intervals and your vines are approaching bloom, go to the pre-bloom spray guidelines.</p> <p>If you have been spraying every 7 days, you may need to make one more spray using these materials.</p> <p>If you have been using stylet oil, switch to another fungicide after this spray. Later in the season, oil can slow growth and retard fruit ripening.</p> <p>Remember to increase spray volume as the canopy fills out to ensure thorough coverage!</p>
Pre-bloom to early bloom or 10 days after the last spray	<p>For BR, Ph, DM, and PM: A. Mancozeb @ 4 lb/ac or captan @ 3 lb/ac</p> <p>PLUS one of the following: Wettable sulfur @ 5 lb/ac or Liquid sulfur @ 3 qt/ac or a sterol-inhibiting (SI) fungicide [Elite 45 WP @ 4 oz/ac or Rally 40WSP @ 4 oz/ac or Rubigan @ 3 fl oz/ac] or Quintec @ 4 fl oz/ac or Endura @ 4.5 oz/ac OR B. Pristine @ 10.5 oz/ac (see Comments on DM control)</p>	<p>The period from just before bloom to 3 or 4 weeks after bloom is critical for protecting fruit from BR, Ph, downy mildew (DM), and PM infection. Early Botrytis control may also be advisable in wet years, especially on varieties with tight fruit clusters such as Pinots.</p> <p>For BR, Ph, DM, and PM:</p> <ul style="list-style-type: none"> • Mancozeb plus sulfur is an inexpensive, effective option recommended for sulfur-tolerant grape varieties. • Captan is less toxic to predator mites than mancozeb but also less effective against BR. If you are using captan and an SI, Rally or Elite will be more effective against BR but may be less effective on PM than Rubigan. Do not combine captan and oil or spray them within 14 days of each other to avoid vine injury. <p>If DM is a problem, do not use Pristine alone. Add 3–4 lb mancozeb, 3 lb captan, or a phosphorous acid (see label for rate) to the tank mix for DM control. Do not use Pristine on Concord or Noiret grapes.</p>

Growth stage or timing	Material and rate/acre	Comments
Pre-bloom to early bloom or 10 days after the last spray (<i>continued</i>)	<p>For early Botrytis control: Use Endura at 8 oz/ac as part of Option A above or use Pristine @ 18.5–23 oz/ac as Option B (see Comments on DM control)</p> <p style="text-align: center;">OR</p> <p>Add one of the following to Option A: Elevate @ 0.5–1 lb/ac or Scala @ 18 fl oz/ac or Vanguard @ 10 oz/ac</p>	<p>For Botrytis:</p> <ul style="list-style-type: none"> • Endura at the higher rate will control Botrytis as well as PM. Tank-mix with mancozeb or captan for protection against BR, Ph, and DM. • Pristine at the higher rate will control Botrytis as well as PM, BR, and Ph—but may not control DM. • Elevate, Scala, and Vanguard are effective only against Botrytis. Add one of them to your Option A tank mix unless you are using Endura at the 8 oz rate. <p>At bloom, scout for primary PM infections on rachises. If you see actively sporulating colonies, apply an eradicant such as a potassium salt (Nutrol, Armicarb 100, or Kaligreen). These materials provide moderate to good control of developing powdery mildew colonies if coverage is thorough but no protection against future infections. Nutrol is cheaper than Armicarb or Kaligreen but comparable in effectiveness, according to research in New York. Consult the labels for usage rates and other recommendations.</p>
Post-bloom or 10–14 days after the last spray	<p>For BR, Ph, DM, and PM: Same options as pre-bloom/bloom</p> <p>For Botrytis control: Use Endura at 8 oz/ac as part of Option A above or use Pristine @ 18.5–23 oz/ac as Option B (but see Comments on DM control under pre-bloom/bloom sprays)</p> <p style="text-align: center;">OR</p> <p>Add one of the following to Option A: Elevate @ 0.5–1 lb/ac or Scala @ 18 fl oz/ac or Vanguard @ 10 oz/ac</p>	<p>The first post-bloom spray is also critical for protecting fruit from BR, Ph, DM, and PM infection. Begin Botrytis control if you did not do so at pre-bloom. See comments on Botrytis materials under the pre-bloom spray.</p> <p>Be aware of the seasonal limit on the amount of mancozeb you can apply (about 6 sprays at the 4 lb/ac rate, but read the label for your formulation) as well as the 66-day preharvest interval. Captan plus an SI is a good alternate (see pre-bloom comments on captan).</p> <p>If the weather is warm and wet during bloom, use a shorter spray interval (10 days), especially on PM-susceptible varieties. If PM colonies appear on leaves or fruit clusters, apply a potassium salt (Nutrol, Armicarb 100, or Kaligreen) to eradicate infections. Use a high enough spray volume to ensure thorough coverage of foliage and clusters.</p> <p>Never spray an SI, Quintec, Endura, or a strobilurin fungicide (Pristine, Abound, Flint, Sovran) on actively sporulating PM colonies as this will accelerate resistance development.</p>

Growth stage or timing	Material and rate/acre	Comments
1st cover spray (2nd post-bloom spray) or 10–14 days after the last spray	<p>A. A phosphorous acid product (Phostrol, ProPhyt, or Agri-Fos) at the labeled rate or captan @ 3–4 lb/ac</p> <p>PLUS one of the following:</p> <p>Wettable sulfur @ 5 lb/ac or Liquid sulfur @ 3 qt/ac or a sterol-inhibiting (SI) fungicide [Elite 45 WP @ 4 oz/ac or Rally 40WSP @ 4 oz/ac or Rubigan @ 3 fl oz/ac] or Quintec @ 4 fl oz/ac or Endura @ 4.5 oz/ac</p> <p>OR</p> <p>B. Pristine @ 10.5 oz/ac (but see Comments on DM control under pre-bloom/bloom sprays)</p>	<p>The risks of BR and Ph are decreasing, and DM and PM will be the main threats for the rest of the season. The second postbloom spray should be made near the end of the critical period for controlling fruit infection by BR, PM, and DM (immediate prebloom through 3 to 4 weeks after bloom). By this time, the fruit of most varieties should be resistant to infection.</p> <p>It is very important to maintain excellent fungicide coverage (protection) until fruit become resistant. Failure to provide adequate fungicide protection can result in the development of “diffuse infections” of PM on fruit. It is difficult to see these infections with the naked eye, and they can lead to fruit rots later in the season. Remember that the rachis and leaves remain susceptible to PM and DM throughout the growing season.</p> <p>If the weather has been unusually wet and/or BR or Ph have been problems in your vineyard, use captan in this application, as it offers some protection against Ph and BR (at low disease pressure) as well as good control of DM and late-season fruit rots. Otherwise, phosphorous acid products are inexpensive and effective for DM control. Choose a product that is registered as a fungicide, such as those listed here, not a nutritional supplement or “plant conditioner.” Consult the label for the correct rate.</p> <p>Remember to rotate among resistance-prone fungicides (SIs, Quintec, Endura, Pristine) from different classes after each spray and observe seasonal limits on applications (see Table 2).</p>
2nd cover spray or 10–14 days after the last spray	<p>A phosphorous acid product (Phostrol, ProPhyt, or Agri-Fos) at the labeled rate or captan @ 3–4 lb/ac</p> <p>PLUS one of the following:</p> <p>Wettable sulfur @ 5 lb/ac or Liquid sulfur @ 3 qt/ac or Quintec @ 4 fl oz/ac or Endura @ 4.5 oz/ac or a potassium salt (Nutrol, Armicarb 100, or Kaligreen) at the labeled rate</p>	<p>Continue DM and PM control. See general comments under 1st cover spray.</p> <p>The need for DM control will vary with weather conditions. Captan offers protection against late-season fruit rots as well as DM and may be the best choice for this spray in warmer parts of the state.</p> <p>Vinifera varieties and some hybrids that are susceptible to PM may need PM control throughout the season to protect fruit, and sulfur remains an effective, inexpensive option, especially if you have used up your seasonal allocation of SIs, Quintec, and Endura. Use shorter spray intervals for sulfur and do not apply it when temperatures are above 85°F.</p> <p>Because of resistance concerns, the strobilurins Abound, Flint, and Sovran are no longer recommended for later-season PM or DM control. For grape varieties that cannot tolerate sulfur, use a potassium salt, especially if you have active PM infections on your vines. You may also use one “rescue” spray of stilet oil for severe PM, as research in New York indicates that a single spray on developing grapes will not delay ripening.</p>

Growth stage or timing	Material and rate/acre	Comments
Additional cover sprays at 10–14 day intervals	Same as 2nd cover spray PLUS one of the following for Botrytis at bunch closing, veraison, and preharvest (as needed): Elevate @ 0.5–1 lb/ac or Scala @ 18 fl oz/ac or Vangard @ 10 oz/ac	At bunch closing, veraison, and preharvest , include a fungicide for Botrytis control, especially on bunch rot-prone varieties. For the rest of the season, scout for DM and PM in your vineyard and adjust your spray program according to the weather, the varieties you are growing, diseases observed, and anticipated harvest date. Do not apply sulfur or captan within 30 days of the expected harvest date, as it may affect wine quality. As you approach harvest, be aware of the preharvest interval (PHI) specified on the label for any fungicide you plan to use.

GUIDELINES FOR NON-BEARING VINEYARDS

Growth stage or timing	Material and rate/acre	Comments
New shoots (3 or 4 sprays) Begin at ½- to 1-inch shoot Spray every 10 days until pre-bloom	Mancozeb @ 4 lb/ac PLUS one of the following for PM: Wettable sulfur @ 5–10 lb/ac or Liquid sulfur @ 3–4 qt/ac or JMS Stylet Oil @ 1% concentration	In non-bearing vineyards (1st and 2nd year), you may use a simplified program to control black rot (BR), Phomopsis (Ph), downy mildew (DM), and powdery mildew (PM). For sulfur-tolerant varieties, mancozeb plus sulfur should be the backbone of your program. Observe the seasonal limit on mancozeb applications on the label for your formulation. Sulfur and stylet oil are inexpensive but require thorough coverage to be effective. To avoid vine injury: <ul style="list-style-type: none"> • Do not use sulfur on Concords, red-fruited French-American hybrids, or any sulfur-sensitive variety. • Do not combine sulfur with oil or spray them within 14 days of one another. • Do not apply sulfur when the temperature exceeds 85°F. If rain is predicted between 7 and 10 days after your last spray, make another application before the rain. Most of these fungicides act only as protectants. They must be on the shoot before fungal spores arrive to be effective, and they do not move through the shoot to new growth. New growth must be protected by sprays at regular intervals. Increase spray volume as the canopy fills out to ensure thorough coverage!

Growth stage or timing	Material and rate/acre	Comments
<p>Pre-bloom to post-bloom (3 sprays)</p> <p>Begin at immediate pre-bloom or early bloom (10 days after the last new shoot spray)</p> <p>Spray twice more at 10-day intervals</p>	<p>Mancozeb @ 4 lb/ac or captan @ 3 lb/ac</p> <p>PLUS one of the following for PM:</p> <p>Wettable sulfur @ 5 lb/ac or Liquid sulfur @ 3 qt/ac or a sterol-inhibiting (SI) fungicide [Elite 45 WP @ 4 oz/ac or Rally 40WSP* @ 4 oz/ac or Rubigan @ 3 fl oz/ac] or Quintec @ 4 fl oz/ac or Endura @ 4.5 oz/ac</p>	<p>This is a critical period for controlling DM as well as BR, Ph, and PM. Use mancozeb plus sulfur if possible. One spray of an SI, Quintec, or Endura instead of sulfur might be preferable when planning canopy management tasks, as some people are sensitive to sulfur residues.</p> <p>Captan is less toxic to predator mites than mancozeb but also less effective against BR. If you are using captan and an SI, Rally or Elite will be more effective against BR but may be less effective on PM than Rubigan.</p> <p>Do not combine captan and oil or spray them within 14 days of each other to avoid vine injury.</p> <p><i>*Note: Nova 40 W has been renamed Rally 40 WSP and is now sold in 4-oz packets.</i></p> <p>If you are using an SI fungicide, Quintec, or Endura, rotate to one with a different mode of action after each spray to avoid resistance development. See Table 2 for classes of fungicides. Read labels for restrictions on the number of applications and amount to be applied in one season. In general, make no more than 2 sprays of any resistance-prone fungicide per season.</p> <p>If PM colonies appear on leaves, apply an eradicator such as one of the potassium salts (Nutrol, Armicarb 100, or Kaligreen) or stylet oil. Stylet oil is an excellent eradicator of existing infections and provides several days of protection against new infections. Potassium salts provide moderate to good control of developing PM colonies but no protection against future infections. Nutrol is cheaper than Armicarb or Kaligreen but comparable in effectiveness, according to research in New York. Consult labels for usage rates and other recommendations. Use a high enough spray volume to ensure thorough coverage. Never spray an SI, Quintec, Endura, or a strobilurin fungicide on actively sporulating PM colonies as this will accelerate the development of resistance.</p>

Table 1. Relative Effectiveness of Selected Fungicides on Grape Diseases.

(Key: E=excellent; G=good; F=fair; P=poor, N=none or not labeled)

Fungicide		Effectiveness against				
Brand	Common (chemical) name	Black rot	Botrytis	Downy mildew	Phomopsis	Powdery mildew
			bunch rot		cane & leaf spot	
Abound	azoxystrobin	E	P	G-E	G	G-E ¹
Armcarb, Kaligreen	potassium bicarbonate	N	N	N	N	F-G
Captan, Captec	captan	F-G	P	G-E	G-E	N
Dithane, Penncozeb	mancozeb	G	N	G-E	G-E	F
Elevate	fenhexamid	N	E	N	N	P-F
Elite	tebuconazole	E	N	N	N	E ²
Endura	boscalid	N	F, E ³	N	N	E
Flint	trifloxystrobin	E	F, E ³	F-G	F-G	E ¹
JMS Stylet Oil	spray oil	N	N	N	N	G
Nutrol	potassium phosphate	N	N	N	N	F
Phostrol, ProPhyt, Agri-Fos	phosphorous acid	N	N	G-E	N	N
Pristine	boscalid + pyraclostrobin	E	F, E ³	E	F	E ¹
Quintec	quinoxifen	N	N	N	N	E
Rally (Nova)	myclobutanil	E	N	N	N	E ²
Rubigan	fenarimol	F	N	N	N	E ²
Scala	pyrimethanil	N	G-E	N	N	N
Sovran	kresoxim-methyl	E	F	F-G	F	E ¹
Sulfur (various)	sulfur	N	N	N	N	G ⁴
Vanguard	cyprodinil	N	G-E	N	N	N

Ratings based on the 2007 New York and Pennsylvania Pest Management Guidelines for Grapes and the 2008 Virginia Pest Management Guide for Commercial Vineyards.

¹ Powdery mildew and downy mildew strains that are resistant to strobilurin fungicides (Abound, Flint, Sovran, and one component of Pristine) have now been found in Maryland vineyards as well as elsewhere in the mid-Atlantic. Resistance may appear suddenly and result in a control failure. See the special note on fungicide resistance on pages 1 and 2 of this fact sheet for suggested replacements and tank mixes to prevent crop losses.

² Powdery mildew strains that are resistant to strobilurins may also be less sensitive to sterol-inhibiting fungicides (Elite, Rally, and Rubigan). Use them with caution, as they may be less effective than in the past. Research in Virginia suggests that Rubigan may be more effective than Rally or Elite where PM isolates are losing sensitivity to SIs. SIs may also be tank-mixed with 2-5 lb wettable sulfur as insurance against control failures on varieties that tolerate sulfur.

³ Excellent control at the high rate labeled for Botrytis; fair control at the lower rate labeled for powdery mildew.

⁴ Sulfur is highly effective when applied at high rates and short spray intervals (7 days), but efficacy declines with lower rates, longer spray intervals, or in rainy weather.

Table 2. Resistance-prone Fungicides and Risk of Resistance by Chemical Class.

Fungicide class	Risk	Common (chemical) name(s)	Trade name(s)
Benzimidazole (Group 1)	High	thiophanate-methyl	Topsin-M
Phenylamide (Group 4)	High	mefenoxam mefenoxam (+ copper) mefenoxam (+ mancozeb)	Ridomil Gold Ridomil Gold/Copper Ridomil Gold MZ
Strobilurin (QoI) (Group 11)	High	azoxystrobin kresoxim-methyl pyraclostrobin (+ boscalid) trifloxystrobin	Abound Sovran Pristine Flint
Dicarboximide (Group 2)	Medium to High	iprodione	Rovral
Sterol inhibitors (Group 3)	Medium	fenarimol myclobutanil tebuconazole triflumizole	Rubigan Rally (Nova) Elite Procure
Carboximide (anilide) (Group 7)	Medium	boscalid boscalid (+ pyraclostrobin)	Endura Pristine
Anilinopyrimidine (Group 9)	Medium	cyprodinil pyrimethanil	Vanguard Scala
Quinolines (Group 13)	Medium	quinoxifen	Quintec
Hydroxyanilid (Group 17)	Medium	fenhexamid fenhexamid + captan	Elevate CaptEstate

Resistance ratings apply to all members of a class of fungicides. All fungicide classes with a medium or high risk of resistance development must be used in accordance with resistance management guidelines listed on the label. Tactics for avoiding or slowing resistance development include:

- Rotating among fungicides from different classes. Make only one application of a resistance-prone fungicide (or of fungicides from the same class) before switching to a fungicide from a different class.
- Tank-mixing fungicides from different classes that are effective against the same disease or diseases. Some pre-mixes such as Pristine and CaptEstate take advantage of this tactic.
- Using the correct rate of fungicide and spray interval for the target disease, level of inoculum, and weather conditions.

- Spraying correctly; that is, using a properly calibrated sprayer with the right nozzles to deliver a spray volume sufficient to thoroughly cover all susceptible parts of the vine.

Consult the labels of all fungicides for maximum amounts or applications per year. As a rule of thumb, make no more than 2 applications per season of fungicides at high or medium risk of resistance. Fungicides at low risk of resistance development include sulfur, copper, Bordeaux mixture, phosphorous acid products, mancozeb, captan, ferbam, ziram, stilet oil, potassium salts, and Oxidate (hydrogen peroxide). These fungicides may be used more often, but some have limits on the amount that may be applied per season. Always consult the label for restrictions on usage and preharvest interval (PHI), even for low-risk fungicides.

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