4. Disease Control

4.1 Fungicide Mode of Action: Reducing the Risk of Fungicide Resistance

Pathogens may develop resistance to fungicides because of genetic mutations in the organism, through natural selection, or by the intensive use of high-risk fungicides. High-risk fungicides kill only susceptible individuals within a given population, while resistant individuals continue to reproduce and cause more disease. Use the practices outlined below to help reduce the chances for fungicide resistance development.

a. Long and proper crop rotations with non-host crops will help break disease cycles and decrease the need or overuse of specific fungicides. This is especially important for controlling soil-borne pathogens.

b. Do not overspray. Attempts to kill every pest in the field by multiple applications or by using higher than labeled rates often eliminate the susceptible, but not the resistant pathogen population. Do not use lower than labeled rates which allow low to moderately resistant populations to survive.

c. Fungicides are organized according to Fungicide Resistance Action Codes (FRAC codes), based on chemical structure (see Table E-8) and Mode of Action (MoA). Fungicides within a given FRAC code control fungi in a similar manner and share the same risk for fungicide resistance development. Table E-9 lists commonly used fungicides and their FRAC codes. Always rotate fungicides with different FRAC codes.

d. Some fungicides are referred to as high- or at-risk fungicides because of their very specific MoA's and high risk for resistance development, for example, the QoI's (FRAC code 11) or DMI's (FRAC code 3). Fungicides in high- or at-risk groups (**in bold in Table E-9**) should be rotated and/or tank-mixed with broad spectrum, protectant fungicides to delay or reduce the development of resistant strains of fungi. High- or at-risk fungicides have seasonal application restrictions which should be followed precisely.

e. Do not use high- or at-risk fungicides as a rescue treatment for disease control. High-risk fungicides should be used according to the label in a full season disease control program or not at all. Applying high- or at-risk fungicides only after a disease is present in a field increases the chances for the development of resistant populations of plant pathogenic fungi. If you feel control with a high-risk fungicide is no longer effective, stop using it and switch to other Modes of Action (*i.e.*, fungicides in other FRAC groups).

Table E-8. FRAC Codes and Corresponding Chemical Groups for Commonly-Used Fungicides

FRAC Code	Chemical Group		FRAC Code	Chemical Group
P1	Salicylic Acid Pathway		**14**	aromatic hydrocarbons
M01	inorganic copper		**17**	hydroxylanilide
M02	inorganic sulfur		**21**	quinone outside inhibitor (QiI)
M03	dithiocarbamate		**22**	benzamides (toluamides)
M04	phthalimide		**27**	cyanoacetamideoximes
M05	chloronitrile		**28**	carbamates
1	benzimidazole		**29**	dinitroanilines
2	dicarboximide		**30**	organotin compounds
3	triazole		**33**	phosphonates
4	phenylamide		**40**	carboxylic acid amides
7	carboxamide		**43**	benzamides (acylpicolides)
9	pyridinamine		**45**	triazolo-pyrimidylamine
11	quinone inside inhibitor (QoI)		**49**	piperidinyl-thiazole-isoxazolines
12	phenylpyrroles		**50**	benzophenone
13	quinolines			

4.2. Fungicides Registered for Vegetables

See Table E-9 "Commonly Used Fungicides Registered for Vegetables" on the following pages.

NOTE:

- **Table E-9 is not necessarily all inclusive; crop sections in chapter F Commodity Recommendations may include additional recommendations.**
- **Crop sections in chapter F should be consulted to ensure efficacy on specific pests.**

Guidelines for preventing fungicide resistance development can be found in paragraph E 4.1. "Fungicide Mode of Action: Reducing the Risk of Fungicide Resistance" (see above).

Table E-9. Commonly Used Fungicides Registered for Vegetables (<u>see NOTE on the preceding page</u>). X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days. XGH=labeled for greenhouse use (see also Table E-11. Selected Fungicides and Bactericides Labeled for Greenhouse Use).

Fungicides	**Actigard** (acibenzolar-S-methyl)	**Aliette** (fosetyl A1)	**Aproach** (picoxystrobin)	**Aprovia Top** (difenoconazole+benzovindiflupyr)	**azoxystrobin**	**Cabrio** (pyraclostrobin)	**Cannonball** (fludioxonil)	**Chlorothalonil**[a]	**Curzate** (cymoxanil)	**Elatus** (azoxystrobin+benzovindiflupyr)	**Endura** (boscalid)	**Fixed copper**[a]	**Fontelis** (penthiopyrad)
FRAC Code(s) / **Crop**	**21**	**33**	**11**	**3+ 7**	**11**	**11**	**12**	**M05**	**27**	**11+ 7**	**7**	**M1**	**7**
Asparagus		X110			X100			X190					
Beans, snap			X14	X14	X		X7	X7			X7	X	X
Beans, lima			X14	X14	X		X7	X14			X7	X	X
Beets					X	X						X	X
Broccoli	X7	X3			X	X		X7			X	X	X
Carrots					X	X		X			X	X	X
Celery		X3			X	X	X	X7			X	X	X3
Chinese cabbage	X7	X3			X	X		X7			X	X	X
Cole crops	X7	X3			X	X		X7			X14	X	X
Cucumbers	X	X		X	X1	X		X	X3		X	X	X1
Eggplants				X	X	X		X3			X	X	X
Garlic	X7				X	X7	X7	X7			X7	X	X3
Greens, mustard	X7	X3			X	X					X14	X	X
Greens, turnip	X7				X							X	X
Horseradish					X	X		X14			X		X
Leeks					X	X7	X7	X14			X7	X	X3
Lettuce	X7	X3			X	X	X		X3		X14	X	X3
Muskmelons	X	X		X	X1	X	X14	X	X3		X	X	X1
Okra				X	X			X3				X	X
Onions, dry	X7	X7			X	X7	X7	X14			X7	X	X3
Onions, green		X7			X	X7	X7	X14			X7	X	X3
Parsley		X			X	X	X				X14	X	X3
Parsnips					X	X		X10					
Peas				X14	X						X21	X	X
Peppers	X14			X	X	X		X3			X	X	X
Potatoes					X14			X7	X14	X14	X10	X	
Pumpkin/winter squash	X	X		X	X1	X		X	X3		X	X	X1
Radish					X	X							X
Spinach	X7	X3			X	X	X		X1			X	X3
Squash, summer	X	X		X	X1	X		X	X3		X	X	X1
Strawberries	X	X			X	X						X	X
Sweet corn			X7		X7			X14		X7		X	
Sweet potatoes				X14	X						X10		
Tomatoes	X14	X14		X	X	X		X	X3		X	X	X
Watermelon	X	X		X	X1	X	X14	X	X3		X	X	X1

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

Table E-9. - continued on next page.

Table E-9. Commonly Used Fungicides Registered for Vegetables - *continued*

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days. XGH=labeled for greenhouse use (see also Table E-11 "Selected Fungicides and Bactericides Labeled for Greenhouse Use)."

Fungicides	**Forum** (dimethomorph)	**Gavel** (zoxamide+mancozeb)	**Gem** (trifloxystrobin)	**Headline** (pyraclostrobin)	**Headline AMP** (pyraclostrobin+metconazole)	**Inspire Super** (difenoconazole+cyprodonil)	**iprodione**	**Luna Experience** (fluopyram+tebuconazole)	**Luna Privilege** (fluopyram)	**Luna Sensation** (fluopyram+trifloxystrobin)	**mancozeb**	**Merivon** (fluxapyroxad+pyraclostrobin)	**metalaxyl**
FRAC Code(s) / **Crop**	**40**	**22 +** M03	**11**	**11**	**11 + 3**	**3+ 9**	**2**	**7 + 3**	**7**	**7 + 11**	M03	**7 + 11**	**4**
Asparagus											X180		X
Beans, snap				X7			X[e]						X
Beans, lima	X7			X7			X[e]		X14				X
Beets			X7									X7	X
Broccoli	X7					X7	X						X
Carrots			X7				X					X7	X
Celery	X7		X7									X1	X
Chinese cabbage	X7					X7							X
Cole crops	X7					X7							X
Cucumbers	X5	X5				X7					X5	X	X
Eggplants	X5		X3			X							X
Garlic	X5	X7				X7	X				X7	X7	X
Greens, mustard	X7					X7							
Greens, turnip	X7					X7							
Horseradish			X7									X7	X
Leeks	X5					X7						X7	X
Lettuce	X7						X14					X1	X
Muskmelons	X5	X5				X7					X5	X	X
Okra													
Onions, dry	X5	X7				X7	X7				X7	X7	X
Onions, green	X5	X7				X14						X7	X
Parsley	X7											X1	X
Parsnips			X7									X7	X
Peas				X7									X
Peppers	X5		X3			X							X
Potatoes	X5	X14[d]	X7	X3			X14		X7		X14[d]		X
Pumpkin/winter squash	X5	X5				X7						X	X
Radish												X7	X
Spinach	X7											X1	X
Squash, summer	X5	X5				X7					X5	X	X
Strawberries							X[e]		X1			X	
Sweet corn				X7	X7						X7		
Sweet potatoes				X3									X
Tomatoes	X5	X5	X3			X					X5		X
Watermelon	X5	X5				X7		X7	X	X	X5	X	X

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

Table E-9. - continued on next page.

Table E-9. Commonly Used Fungicides Registered for Vegetables - *continued*

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days. XGH=labeled for greenhouse use (see also Table E-11 Selected Fungicides and Bactericides Labeled for Greenhouse Use).

Fungicides	**Moncut** (flutolanil)	**Omega** (fluazinam)	**phosphonates**[a]	**Presidio** (fluopicolide)	**Previcur Flex** (propamocarb)	**Priaxor** (fluxapyroxad+pyraclostrobin)	**Pristine** (pyraclostrobin+boscalid)	**Procure** (triflumizole)	**Proline** (prothioconazole)	**propiconazole**	**Quadris Opti** (azoxystrobin+chlorothalonil)	**Quadris Top** (difenoconazole+azoxystrobin)	**Quash** (metconazole)
FRAC Code(s) / **Crop**	**7**	**29**	**33**	**43**	**28**	**7 + 11**	**11 + 7**	**3**	**3**	**3**	**11 +** M05	**3 + 11**	**3**
Asparagus													
Beans, snap		X14	X			X7				X7			
Beans, lima		X30	X			X7				X7	X14		
Beets				X7						X14			
Broccoli	X	X50	X	X2		X3		X1				X1	
Carrots		X7		X7			X			X14	X	X7	
Celery			X	X2			X			X14	X7		
Chinese cabbage		X20	X	X2		X3		X1				X1	
Cole crops	X	X20	X	X2		X3		X1				X1	
Cucumbers			X	X2	X2		X	X	X7		X1	X1	
Eggplants		X30	X	X2		X						X	
Garlic		X7	X				X7			X14	X7	X7	
Greens, mustard	X	X20	X	X2		X3		X1				X1	
Greens, turnip	X	X20	X			X3		X1				X1	
Horseradish				X7									
Leeks			X				X7			X14	X14	X7	
Lettuce		X30	X	X2	X2			X					
Muskmelons		X30	X	X2	X2		X	X	X7		X1	X1	
Okra		X30											
Onions, dry		X7	X				X7			X14	X7	X7	
Onions, green			X				X7			X14	X14	X7	
Parsley			X	X2				X		X14			
Parsnips				X7									
Peas			X			X7			X7				
Peppers		X30	X	X2	X5	X						X	
Potatoes	X	X14	X		X14	X7					X14	X14	X1
Pumpkin/winter squash			X	X2	X2		X	X	X7		X1	X1	
Radish				X7									
Spinach			X	X2									
Squash, summer			X	X2	X2		X	X	X7		X1	X1	
Strawberries							X	X1		X		X	
Sweet corn						X7				X14			
Sweet potatoes				X7								X14	X1
Tomatoes			X	X2	X5	X					X	X	
Watermelon		X30	X	X2	X2		X	X	X7		X1	X1	

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

Table E-9. - continued on next page.

Table E-9. Commonly Used Fungicides Registered for Vegetables - *continued*

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days. XGH=labeled for greenhouse use (see also Table E-11 Selected Fungicides and Bactericides Labeled for Greenhouse Use).

Fungicides	**Quilt** (propiconazole+azoxystrobin)	**Quilt Xcel** (propiconazole+azoxystrobin)	**Quintec** (quinoxyfen)	**Rally** (myclobutanil)	**Ranman** (cyazofamid)	**Reason** (fenamidone)	**Revus** (mandipropamid)	**Revus Top** (mandipropamid+difenoconazole)	**Ridomil Gold**, **Ultra Flourish** (mefenoxam)	**Ridomil Gold Bravo** (mefenoxam+chlorothalonil)	**Ridomil Gold Copper** (mefenoxam+copper)	**Ridomil Gold MZ** (mefenoxam+mancozeb)
FRAC Code(s) / **Crop**	**3 + 11**	**3 + 11**	**13**	**3**	**21**	**11**	**40**	**3 + 40**	**4**	**4+** M05	**4+** M01	**4+** M03
Asparagus				X180					X			
Beans, snap	X7	X7		X	X	X3	X1		X[b]		X7	
Beans, lima	X7	X7			X	X3			X[b]		X3	
Beets						X14			X			
Broccoli					X	X2	X1		X[b]	X7		
Carrots	X14	X14			X14	X14			X[b]	X7	X7	
Celery	X14	X14				X2	X1		X			
Chinese cabbage					X	X2	X1		X[b]	X7		
Cole crops					X	X2	X1		X	X7		
Cucumbers				X	X	X14	X		X	X	X5	X5
Eggplants			X3	X	X	X14	X		X			
Garlic	X14	X14				X7	X7		X[a]	X7	X10	X7
Greens, mustard					X	X2	X1		X[b]			
Greens, turnip					X	X2	X1		X[b]			
Horseradish						X14			X[a]			
Leeks	X	X				X7	X7		X	X14	X10	X7
Lettuce			X1	X3	X	X2	X1		X[a]			
Muskmelons			X3	X	X	X14	X		X	X	X5	X5
Okra				X	X	X14	X					
Onions, dry	X14	X14				X7	X7		X	X7	X10	X7
Onions, green	X	X				X7	X7		X	X14	X7	
Parsley					X	X2	X1		X			
Parsnips						X14			X			
Peas									X[b]			
Peppers			X3	X	X	X14	X		X		X7	
Potatoes					X7	X14		X14	X	X14	X14	X14
Pumpkin/winter squash			X3	X	X	X14	X		X	X	X5	
Radish						X14			X		X7	
Spinach					X	X2	X1		X		X3	
Squash, summer				X	X	X14	X		X	X	X5	X5
Strawberries		X	X1	X					X			
Sweet corn	X14	X14										
Sweet potatoes					X7	X14			X			
Tomatoes			X3	X	X	X14		X1	X	X5	X14	X5
Watermelon			X3	X	X	X14	X		X	X	X5	X5

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

Table E-9. - continued on next page.

Table E-9. Commonly Used Fungicides Registered for Vegetables - *continued*

X=fungicide is registered for the crop. The number next to X=PHI (days to harvest); if no number is present PHI=0 days. XGH=labeled for greenhouse use (see also Table E-11 Selected Fungicides and Bactericides Labeled for Greenhouse Use).

	Scala (pyrimethanil)	**Stratego** (propiconazole+trifloxystrobin)	**Sulfur** [c,e]	**Switch** (cyprodinil+fludioxonil)	**Tanos** (famoxadone+cymoxanil)	**tebuconazole**	**Terraclor** (PCNB)	**thiophanate-methyl**	**Torino** (cyflufenamid)	**Uniform** (mefenoxam+azoxystrobin)	**Vivando** (metrafenone)	**Zampro** (ametoctradin+dimethomorph)	**Zing!** (zoxamide+chlorothalonil)
FRAC CODE(S)	**9**	**3 + 11**	M02	**9 + 12**	**11 + 27**	**3**	**14**	**1**	**U06**	**4 + 11**	**50**	**45+ 40**	**22+** M05
Asparagus			X			X180							
Beans, snap			X	X7		X14	X14	X14		X			
Beans, lima			X	X7		X14	X14	X14		X			
Beets			X	X7		X7				X			
Broccoli			X	X7		X7	X					X	
Carrots			X	X7									
Celery			X	X				X7		X		X	
Chinese cabbage				X7		X7	X			X		X	
Cole crops			X	X7		X7	X			X		X	
Cucumbers			X	X1	X3	X7		X1	X	X	X	X	X
Eggplants			X	X		X7					X	X4	
Garlic	X7		X	X7	X3	X7	X	Xa		X		X	X7
Greens, mustard			X	X7		X7				X		X	
Greens, turnip			X	X7		X7							
Horseradish			X	X7									
Leeks	X7			X7	X3	X7				X		X	
Lettuce			X	X	X1					X		X	
Muskmelons			X	X1	X3	X7		X1	X	X	X	X	X
Okra			X	X		X3					X		
Onions, dry	X7		X	X7	X3	X7		Xa		X		X	X7
Onions, green	X7		X	X7	X3	X7		Xa		X		X	
Parsley				X7	X1					X		X	
Parsnips			X	X7									
Peas			X							X			
Peppers			X	X	X3	X7	X				X	X4	
Potatoes	X7		X	X7	X			X21				X4	X7
Pumpkin/winter squash			X	X1	X3	X7		X1	X	X	X	X	X
Radish			X	X7						X			
Spinach			X	X	X1					X		X	
Squash, summer			X	X1	X3	X7		X1	X	X	X	X	X
Strawberries	X1		X	X				X1	X				
Sweet corn		X14				X7							
Sweet potatoes	X7		X	X7			X			X			
Tomatoes	X1		X	X	X3	X7	X				X	X4	X5
Watermelon				X1	X3	X7		X1	X	X	X	X	X

Superscripts: a=seed treatment or soil use only, b=Ultra Flourish is not labeled on these crops, c=Sulfur rates above 4 lb/A applied during high temperatures may cause crop injury, d=Only in DE, PA, MD, and VA, e=See label for PHI.

4.3 Disease Control in Seeds, Plant Growing Mix and Plant Beds

Seed Treatment

Seed treatment is essential to control seed-borne diseases in many transplanted crops. Failure to treat seed properly could lead to diseases in the plant bed that will reduce plant stands, or that are carried into the field at transplanting. Crop failure could result. Seed treatment is especially important for asparagus, broccoli, Brussels sprouts, cabbage, cauliflower, collards, eggplant, kale, kohlrabi, peppers, radish and tomato.

Heat treatment of seeds is a non-chemical alternative to conventional chlorine treatments with the additional benefit of killing pathogens that may be found within the seed coat (*e.g.*, bacterial canker organism of tomatoes). Seed heat-treatment follows a strict time and temperature protocol, and is best done with thermostatically controlled water baths. Two baths are required: one for pre-heating and a second for the effective pathogen killing temperature. The initial pre-heat treatment is 10 minutes at 100ºF (38ºC). The effective temperature treatment and time in the second bath differ between crops; protocols for several important crops are listed in Table E-10.

Immediately after removal from the second bath, seeds should be rinsed with cool water to stop the heating process and dried on screen or paper. Seeds may be re-dusted with fungicide if desired. Pelleted seed is not recommended for heat treatment. Heat treat only seed that will be used during the current season. See crop sections for specific seed treatment recommendations.

Table E-10. Effective Seed Treatment Temperature Protocols (2nd Bath) for Pathogen Eradication

Crop	Water Temperature		Minutes
	°F	°C	
Brussels sprouts, eggplant, spinach, cabbage, tomato	122	50	25
Broccoli, cauliflower, carrot, collard, kale, kohlrabi, rutabaga, turnip	122	50	20
Mustard, cress, radish	122	50	15
Pepper	125	51	30
Lettuce, celery, celeriac	118	48	30

Disease Control in Plant Growing Mix

For the best control of all soil-borne diseases, use the plant-growing mix described in Table R-4 or R-5. If this is not possible, use soil steaming or fumigation as described below.

Disease Control in Plant Beds

Preplant: Soil steaming is the only practice that ensures complete sterilization of soil. A temperature of 180°F (82°C) must be maintained throughout the entire mass of soil for a period of 30 minutes. **Soil fumigation** is also used to control disease. The following materials are suitable for small lots of soil:

- chloropicrin and metam-sodium (Vapam HL), see label for rates and instructions.

For larger areas, such as plantbeds or seedbeds, the following materials are suitable (see label for rates and instructions):

- chloropicrin
- metam-sodium (Busan, Nemasol, Vapam HL)
- Potassium N-methyldithiocarbamate (K-Pam HL)

Consul the Fumigation section in this chapter (section E 1.5) for additional recommendations.

Note: The use of soil fumigants has become severely limited because of new restrictions. Check with your local county agricultural agent.

Pre-and postseeding treatments in transplant and greenhouse production: See crop sections for seed treatment options and Table E-11. below for a list of selected fungicides for use in greenhouse production.

Nematode Control

See section E 1.6. Nematode Control

4.4 Disease Control for Greenhouse Production

Table E-11. Selected Fungicides and Bactericides Labeled for Greenhouse Use
NOTE: Some states define pesticide applications in high tunnels as greenhouse applications, others define them as field applications. Check with your extension educator or state department of agriculture for correct application. If any information in this table is inconsistent with the label, follow the label.

Fungicide	Target Diseases	Labeled Crops	Comments
Azadirachtin + Neem oil (DeBug Tres, Debug Turbo, Agro Logisitic Systems, Inc.) REI =4 h.	Nematodes. *Sclerotinia sclerotiorum* and *S. rolfsii* diseases	Cucurbits, fruiting vegetables and others (see label)	**OMRI listed[1].**
Azoxystrobin (Heritage, Syngenta Crop Protection, LLC) REI=4 h.	Rhizoctonia, leaf spots and others	Brassica, cucurbit, fruiting vegetables and others	Vegetable and herb plants grown for transplanting
Azoxystrobin + benzovindiflupyr (Mural, Syngenta Crop Protection LLC) REI=12 h.	Powdery mildew, leaf mold, leaf spots and others.	Tomatoes, cucurbits	Vegetable plants for re-sale to consumers. Do not make more than two applications per crop.
Bacillus amyloliquefaciens (Stargus, Marrone Bio Innovations) REI=4 h.	Bacteria blight, bacterial spot, Late blight, grey mold, downy mildew, and other diseases	Cucurbits, tomatoes, peppers, leafy vegetables and other greenhouse-grown vegetables	**OMRI listed[1]**. Can be used as a soil drench for soilborne diseases or as a foliar spray. Apply prior to disease infection.
Bacillus pumilus (Sonata; Bayer CropScience LP) REI=4 h.	Early blight, late blight, downy mildew, powdery mildew	Many vegetables including Brassicas, cucurbits, bulb, fruiting, and leafy vegetables and root and tuber crops	**Can be used for organic production[1].** Preventative biological fungicide.
Bacillus subtillus (Cease, BioWorks). REI= 4 h.	Suppression of soilborne and foliar diseases including damping off, root rot and early blight	Many vegetables including fruiting and leafy vegetables, cucurbits, cole crops and herbs	May be used in hydroponic and soilless production systems. Most effective used preventatively.
Basic Copper Sulfate (Cuprofix Ultra 40 Disperss; United Phosphorus, Inc.) REI=48 h.	Many diseases including angular leaf spot, downy mildew. *Alternaria* blight, *Anthracnose*, bacterial blight, etc.	Vegetables including cucumbers, eggplant, peppers, tomatoes, etc.	**Can be used for organic production[1].** Crops grown in the greenhouse may be more sensitive to copper injury so the user should determine plant sensitivity.
Burkholderia spp. (Majestene Bionematicide, Marrone Bio Innovations) REI=4 h.	Root-knot, lesion, sting, stunt, ring and other nematodes	Brassica, bulb, cucurbit, fruiting and leafy vegetables	**OMRI listed[1]**. Take soil samples prior to planting to assess nematode populations.
Coniothyrium minitans (Contans, Sipcam Agro) REI=4 h.	*Sclerotinia sclerotiorum*, *Sclerotinia minor*	Many vegetables including leafy vegetables, brassicas, legumes, fruiting vegetables and bulb vegetables. Cannot be used on tomato.	**OMRI listed[1].** Contains a beneficial fungus. Do not allow to stand overnight following mixture. Acts as a preventative.
Copper Hydroxide (Kocide 2000, DuPont) REI=24/48 h.	Leaf spots, anthracnose and bacterial spots and others	See labels for specific crops	See labels for specific usage instructions. Phytotoxicity may occur.
Cuprous Oxide (Nordox, Monterey AgResources) REI=24 h.	Bacterial spot and speck, *Alternaria* leaf spot, anthracnose, early and late blight, etc.	Eggplant, pepper and tomato	See label for specific usage instructions.
Cyazofamid (Ranman, FMC Corporation) REI=12 h.	*Pythium* damping off Basil downy mildew	Tomato greenhouse transplant production and basil	Drench transplant tray with fungicide at planting or up until one week before transplant. See label for additional details.

Table E-11. Selected Fungicides and Bactericides Labeled for Greenhouse Use - continued on next page

Table E-11. Selected Fungicides and Bactericides Labeled for Greenhouse Use - continued

Fungicide	Target Diseases	Labeled Crops	Comments
Dazomet (soil fumigant) (Basamid G, Amvac) For entry restrictions, see label	Pre-plant control of soilborne diseases	Soil treatment only	**Restricted Use Pesticide** – see label for precautionary statements, restrictions, and directions for use.
Dicloran (Botran, Gowan Company) REI=12 h.	Pink rot, gray mold, *Sclerotinia* and *Sclerotium* rots, leaf blight and neck rot	Many vegetables including celery, lettuce, onions, garlic and shallots	May cause leaf bronzing on lettuce. Use adequate volume of water.
Fenhexamid (Decree, Arysta LifeScience) REI=4 h.	*Botrytis*	Tomatoes, cucumber, pepper, lettuce, and eggplant	Protectant fungicide with some plant back restrictions. See label for details.
Fludioxonil (Emblem, Nufarm) REI=12 h.	Alternaria leaf blight, Cercospora leaf spot, gummy stem blight, powdery mildew, early blight, gray mold, Septoria leaf spot, and Sclerotinia rot	Brassica (Cole) crops, cucurbits, tomatoes and other fruiting vegetables, leafy greens	Good coverage is essential for disease control. Use good resistance management practices (see label for information).
Horticultural Oil (Ultra-Pure Oil, BASF) REI=4 h.	Powdery mildew	Cucurbits, melons, squash, tomatoes, oriental vegetables and others	Application should be made when disease is first noticed. See label for information on plant safety. Use lower label rates in the greenhouse.
Hydrogen Dioxide (Oxidate, BioSafe Systems LLC) REI=1 h.	*Anthracnose*, downy mildew, powdery mildew, *Pythium* root rot and other diseases	Many vegetables including cole crops, cucurbit, leafy vegetables, peppers and tomatoes	Strong oxidizing agent. Contact, oxidizing sanitizer. (Active ingredient: hydrogen peroxide).
Kaolin (Surround WP, Nova Source Tessenderlo Group) REI=4 h.	Powdery Mildew	Cucurbit and other vegetables	**OMRI listed[1]**. Product forms a white clay film on leaves and fruit. Reduces sunburn and heat stress.
Mancozeb (Dithane M-45, DF, Dow AgroSciences LLC) REI=24 h.	Leaf spot diseases, seed treatment for damping off, seed rots and seedling blights	Tomatoes and others	Broad-spectrum protectant fungicide.
Mandipropamid (Micora, Syngenta) REI=4 h.	Downy mildews, blue mold, and late blight, and suppression of *Phytophthora* blight	Some vegetables and basil grown for transplant and retail sale to customres	Registered for closed greenhouses with permanent flooring on transplants for re-sale to consumers.
Pentachloro-nitrobenzene PCNB (Terraclor 400, Amvac) REI=12 h.	Root and stem rot, damping off (*Rhizoctonia solani*, *Pellicularia filamentosa*)	Vegetable bedding plants. Limited to container-grown broccoli, Brussels sprouts, cabbage, cauliflower, peppers and tomatoes.	Apply as a soil drench in nursery and greenhouse to seedlings grown in containers prior to transplanting. See label for additional information.
Penthiopyrad (Fontelis, DuPont) REI=12 h.	Many diseases, including gummy stem blight, *Sclerotinia* stem rot, leaf spots, powdery mildew and *Anthracnose*	Tomatoes, eggplant, peppers and edible peel cucurbits	See label for specific usage instructions.
Phosphorous acids – mono and di-potassium salts (Fungi-Phite, Verdesian Life Sciences U.S., LLC; Rampart, Loveland Products) REI= 4 h.	Root rots, damping off downy mildew, suppression of bacterial diseases (see label)	Cucurbit, fruiting vegetable and leafy vegetable crops	See label for pre-plant seedling tray application instructions.
Potassium Bicarbonate (Milstop, BioWorks, Inc.) REI=1 h.	Powdery mildew and others	Many vegetables including cabbage, cucumber, eggplant, broccoli, cauliflower, lettuce, peppers, tomatoes and squash	**OMRI listed[1]**.Works by contact. Potassium bicarbonate disrupts the potassium ion balance in the fungus cell, causing the cell walls to collapse.
Potassium Salts of Fatty Acids (M-Pede, Gowan) REI=12 h.	Powdery Mildew	Cucurbits, fruiting, leafy, root and tuber vegetables and others	**OMRI listed[1]**.Contact fungicide. See label for details.

Table E-11. Selected Fungicides and Bactericides Labeled for Greenhouse Use - continued on next page

Table E-11. Selected Fungicides and Bactericides Labeled for Greenhouse Use - continued

Fungicide	Target Diseases	Labeled Crops	Comments
Propamocarb Hydrochloride (Previcur Flex, Bayer Crop Science) REI=12 h.	*Pythium* root rot and damping off	Tomatoes, leaf lettuce, cucurbits and peppers	See label for specific usage instructions.
Pyraclastrobin plus Boscalid (Pageant Intrinsic, BASF Corp) REI=12 h.	*Botrytis* grey mold	Transplant and greenhouse-grown tomatoes, cucurbits and leafy greens	Pageant Intrinsic is also labeled for greenhouse use on transplants grown for the home consumer market
Pyrimethanil (Scala, Bayer Crop Science) REI=12 h.	Early blight and gray mold, Botrytis	Tomatoes and greenhouse grown cucumber	Use in well-ventilated houses only and ventilate two hours after application.
Reynoutria sachalinensis (Regalia, Marrone Bio Innovations) REI=4 h.	Many diseases including powdery mildew	Cucurbits, bulb vegetables, Fruiting vegetables and others	**OMRI listed[1].**
Streptomyces lydicus (Actinovate, Novozymes BioAg, Inc.) REI=1 h.	Damping off and root rot, pathogens *Pythium*, *Rhizoctonia*, *Phytophthora*, *Verticillium*; and foliar diseases including downy and powdery mildew and *Alternaria* and *Botrytis*.	Greenhouse vegetables and herb crops	**OMRI listed[1]**. May be applied to soil or foliage through mist systems or sprayer.
Streptomycin Sulfate (Agri-mycin 17, Nufarm Americas, Inc.) REI=12 h.	Bacterial spot, bacterial speck	Tomatoes and peppers grown for transplant	Repeated applications can result in resistant bacteria. Do not apply through any irrigation system.
Sulfur (Microthiol Disperss, United Phosphorus, Inc.) REI=24 h.	Powdery mildew	Crucifers, cucurbits, peppers and tomatoes	**OMRI listed[1]**. Crops grown in greenhouses may be more sensitive to sulfur injury, so the lowest label rate should be tried initially. Do not use within two weeks of an oil spray treatment.
Thiophanate-methyl (3336 WP, Cleary Chemicals LLC) REI=12 h	Anthracnose, gray mold, sclerotinia, gummy stem blight, powdery mildew and others	Dry and succulent beans, and cucurbits for transplant.	Caution: Some populations of the pathogens that cause gummy stem blight, grey mold and powdery mildew, are resistant to thiophanate methyl.
Trichoderma harzianum (PlantShield, Rootshield, Bioworks, Inc.) REI=4 h.	*Pythium*, *Rhizoctonia*, and *Fusarium*. When applied as a foliar spray, suppresses *Botrytis* and powdery mildew.	Greenhouse vegetables	Contains a beneficial fungus. Avoid applications of fungicides at least one week before or after application. Acts as a preventative. Will not cure diseased plants.
***Trichoderma virens* GL-21** (formerly known as Gliocladium virens) (SoilGard 12G, Certis USA LLC) REI=0 h.	Damping off and root rot, pathogens *Pythium* and *Rhizoctonia*	Food crop plants in greenhouse	Has preventative activity only, will not cure already diseased plants. Allow treated soil to incubate for one day prior to planting for best results. Do not use other soil fungicides at time of incorporation.

[1]The National Organic Program (NOP) maintains a list of products that are approved for use in organic production. In addition the Organic Materials Review Institute (**OMRI**) maintains a brand name list of products that approved for use. Some fungicides that are approved for use in organic production have been reviewed by the Environmental Protection Agency (EPA) for NOP compliance and will have a three-leaf logo and the words "for organic production" on the label.