

Management of Gummy Stem Blight (Black Rot) on Cucurbits in Florida¹

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Host range

Gummy stem blight (GSB) is a major disease of many cucurbits, including watermelon, cantaloupe, cucumber, pumpkin, squash, muskmelon, and other melons. The fungus *Didymella bryoniae* is the causal organism for this disease. Infection on watermelon and cantaloupe is commonly seen in Florida, and the disease can cause significant production losses when conditions are ideal for the spread of this fungal pathogen (**Figure 1**). The disease is also known as black rot due to its characteristic appearance on infected fruits.



Figure 1. Watermelon field severely infected with *D. bryoniae* (click to enlarge). (Credit: Hank Dankers)

Symptoms

Cucurbit plants can become infected with *D. bryoniae* at any growth stage of the plant, from seedling to mature vine with fruit. Infection signs and symptoms can be seen on all parts of the plant except for the roots. Yellowing of the leaf margins (chlorosis) is an early symptom on the plant, and light- to dark-brown spots (necrosis) can appear on the seed leaves (cotyledons) (**Figure 2**). These symptoms are often visible before and after transplanting in the field. Prior to the occurrence of chlorosis or necrosis, the same tissue may appear water soaked (**Figure 3**). Wilting, followed by death of the transplants, can occur.

Lesions can also form on the stem that enlarge and girdle the main stem (**Figure 4**). Cracking is often visible on the stem, accompanied by gummy ooze (**Figure 5**). Cankers develop on the stem that can be red, brown, or black in color, and a red to amber gummy substance can exude from this region (**Figure 6**). Anthracnose (caused by *Colletotrichum orbiculare*) and inadequate soil liming can also cause the exudation of a gummy substance from cucurbit stems; hence, "gummy" should not be relied upon

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Figure 2. Necrosis on cantaloupe transplants due to gummy stem blight (click to enlarge). (Credit: Hank Dankers)



Figure 3. Water-soaked regions on the stem of cantaloupe transplants due to gummy stem blight (click to enlarge). (Credit: Hank Dankers)

as a definitive diagnosis of GSB. Black fruiting bodies of the fungus (pycnidia, perithecia, or pseudothecia) are often visible on the infected leaves, stems, and fruits and serve in confirmatory diagnosis (**Figures 4 and 7**). Pycnidia swell and release tendrils of spores if the tissue is wetted in water (**Figures 8 and 9**). This is easily observed with the use of a hand lens or microscope. Large, brown lesions from severe infections can form on areas of the leaves that retain moisture for long periods of time, such as around veins or leaf margins. (**Figure 10**). Vine wilting symptoms are usually not observed until later in the infection cycle, typically a period of three to four weeks after infection (**Figure 1**).

Fruit rot in watermelon is only a problem if the vines are severely infected with gummy stem blight. Lesions on fruits of cucumber, muskmelon, and watermelon are first oval to circular and greasy green in color. The lesions subsequently merge and become brownish-black in color—hence the disease is also known as black rot (**Figure 11**). These lesions appear



Figure 4. Canker on watermelon stem due to gummy stem blight (click to enlarge). (Credit: Hank Dankers)



Figure 5. Gummy ooze from a stem crack on a *D. bryoniae*-infected watermelon (click to enlarge). (Credit: Mathews L. Paret and Stephen M. Olson)



Figure 6. Gummy red exudation from a *D. bryoniae*-infected cantaloupe stem (click to enlarge). (Credit: Hank Dankers)

depressed in the center. Internally, the rind becomes dark brown to black and cracked. Butternut squash fruit can be infected with the vines being healthy. A lesion, dark yellow to brown in color and crusty in appearance, occurs on large areas of the butternut squash (**Figure 11**).



Figure 7. Black fruiting body (pycnidia) of *D. bryoniae* on an infected watermelon leaf (click to enlarge). (Credit: Mathews L. Paret and Stephen M. Olson)



Figure 8. Conidia exuding from pycnidia in the shape of a "spore horn." (Credit: Hank Dankers)

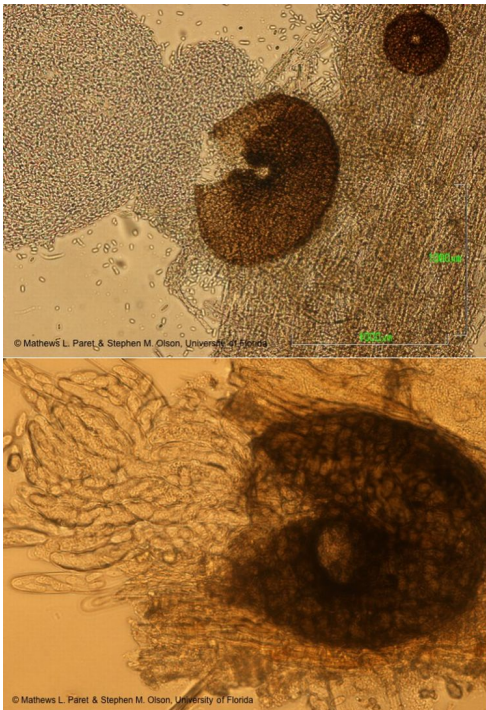


Figure 9. Conidia released from pycnidia and ascospores inside asci, the flask-shaped structure released from perithecia, on an infected plant tissue (click to enlarge). (Credit: Mathews L. Paret and Stephen M. Olson)



Figure 10. Brown, irregularly shaped lesions containing a concentric ring pattern can be seen on cantaloupe and watermelon leaf margins and interveinal areas with high moisture retention (click to enlarge). (Credit: Hank Dankers)

Causal agent and disease spread

Didymella bryoniae (anamorph is *Phoma cucurbitacearum*) is an ascomycete fungus that can survive on seeds, weeds (citron, balsam pear, and other volunteer cucurbits), and plant debris from previously infected cucurbits. The fungus produces two spore stages, a sexually produced spore (perithecia giving rise to ascospores; **Figure 12**) and an asexually produced spore (pycnidia giving rise to conidia; **Figure 13**). Perithecia and pycnidia can be found embedded in the same lesion. Ascospores serve as the primary inoculum and are readily spread from field to field by wind. Conidia are released in a gummy substance and are therefore more adapted for short-distance movement through splashing water, which leads to secondary spread of the disease. Dark pseudothecia may also form, especially on stems (**Figure 14**), but are rarely seen.

Moisture and temperature play an important role in germination, sporulation, colonization of conidia into the plant tissue, and symptom development. The optimum conditions for the infection process are temperatures ranging from 61°F–75°F and a

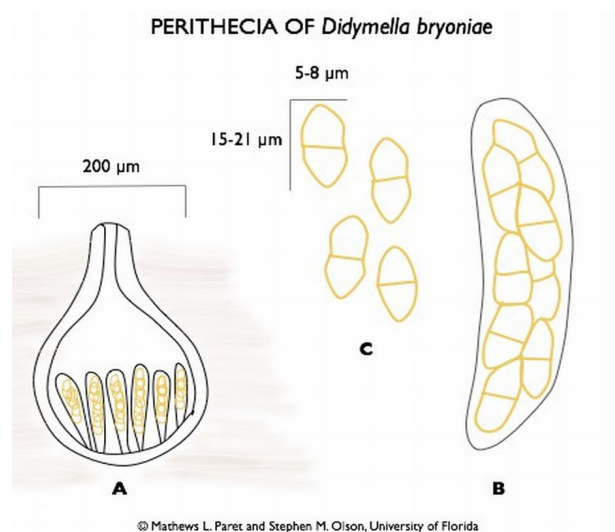


Figure 11. Black rot symptoms on watermelon, honeydew melon, and butternut squash. (Credit: Tom Kucharek and Norm Schenck)

moisture level of 85% RH caused by consistent leaf wetness for 1–10 hours. Nighttime temperature and moisture conditions prevalent in Florida are ideal for GSB infection during much of the crop-growing season. After spore germination on a susceptible host tissue, symptoms can appear in 7–12 days.

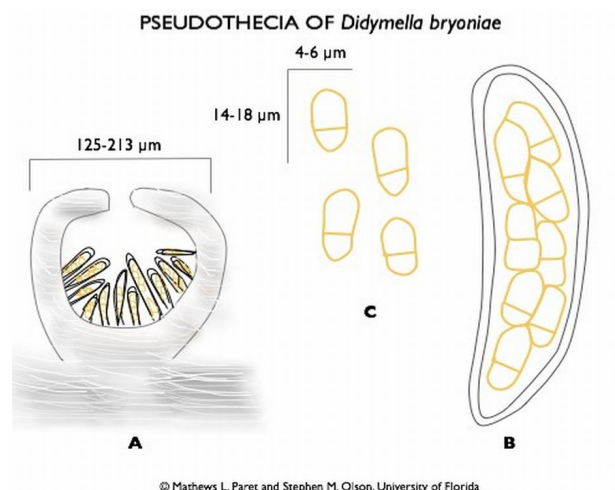
Wounding of host tissue by mechanical injury, feeding by aphids and striped cucumber beetles, and infections from other diseases, including powdery mildew (caused by *Sphaerotheca fuliginea*), may provide entry sites for the GSB pathogen. Harvest points on fruits can also be a point of entry for the pathogen, leading to postharvest decay.

Important steps for management of gummy stem blight (GSB) / black rot of cucurbits



Didymella bryoniae (Auersw.) Rehm (syn. *Mycosphaerella melonis* [Pass.] Chiu & J.C. Walker). **A.** Perithecia up to 200 µm diameter, black **B.** Asci with ascospores **C.** Ascospores are 15-21 x 5-8 µm, hyaline, monoseptate. This cartoon is not drawn to scale. The scale markers indicate the actual dimensions.

Figure 12. Peridicia, the black fruiting body of *Didymella bryoniae*, the gummy stem blight pathogen. (Credit: Mathews L. Paret and Stephen M. Olson)

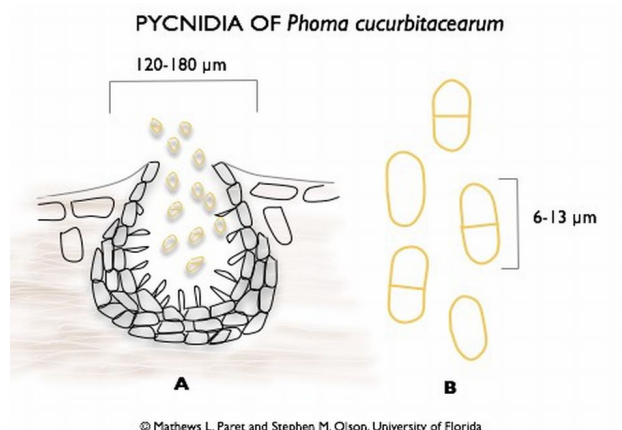


Didymella bryoniae (Auersw.) Rehm (syn. *Mycosphaerella melonis* [Pass.] Chiu & J.C. Walker). **A.** Pseudothecia 125-213 µm in diameter, dark, found on stems **B.** Asci bitunicate, with eight ascospores per ascus **C.** Ascospores are 14-16 x 4-6 µm, hyaline, monoseptate with constriction at the septum, and rounded on the ends. The upper cell is usually wider than the lower cell. This cartoon is not drawn to scale. The scale markers indicate the actual dimensions.

Figure 13. Psuedothecia, the black fruiting body of *Didymella bryoniae*, the gummy stem blight pathogen. Pseudothecia is not often seen and only noted on infected stems. (Credit: Mathews L. Paret and Stephen M. Olson)

A sequence of management plans must be initiated to control GSB:

1. Seed: One source of GSB inoculum is the seed. Purchase seeds from reputable companies with a good history of GSB-free seed production. Seeds from healthy fruits are free of GSB. Remember:



Phoma cucurbitacearum (Fr.: Fr.) Sacc. (syn. *Aschochyta cucumis* Fautrey & Roum.).
A. Pycnidia are dark, 120-180 µm in diameter, forms on the surface of leaves, stems, and fruits. **B.** The conidia are hyaline, cylindrical with rounded ends, non- or monoseptate, and 6-13 µm long. This cartoon is not drawn to scale. The scale markers indicate the actual dimensions.

Figure 14. Pycnidia, the black fruiting body of *Phoma cucurbitacearum*, the gummy stem blight pathogen. (Credit: Mathews L. Paret and Stephen M. Olson)

Seeds can be infested without expressing symptoms. Seed treatment is necessary if not previously treated, and disinfectants as solutions are more effective than dry-dust treatments. GSB-resistant varieties are not available in any cucurbits.

2. Transplants: GSB is common at the seedling stage and displays one or more of the characteristic symptoms (necrotic areas on the margin of the leaves, water-soaked regions on the stem, gummy ooze from the stem). Growers should regularly inspect transplant seedlings in the greenhouses. Whenever possible, avoid using healthy-looking seedlings from trays with infected plants.

3. Organic debris: Another source of primary inoculum is organic debris from previous cucurbit crops. As soon as a cucurbit crop is harvested (especially crops with GSB inoculum), the decaying debris from that crop should be disked and deep plowed into the soil if it is to be followed by a long-term crop rotation practice.

4. Volunteer plants: Wild citrons, balsam pear, or volunteer cucurbits are other sources of inoculum and should be eradicated before planting cucurbits.

5. Crop rotation: Fields should not be cultivated with cucurbits routinely, and rotation with a non-cucurbit crop is important. A two- to three-year

rotation with non-hosts is an effective way to reduce incidence of GSB.

6. Scouting: Routine scouting of the fields helps in timely application of fungicides that can prevent major crop losses.

7. Biological control and biopesticides: A strain of the bacterium *Bacillus subtilis* is available in the market as a biocontrol agent against GSB. However, the effectiveness of biocontrol agents is heavily dependent upon environmental conditions at the time of application and therefore has minimal success. In addition, extract of *Reynoutria sachalinensis* (giant knotweed), a host plant defense inducer, is available for use in organic production for management of GSB. A list of currently labeled biological products for use on cucurbits in Florida is provided in **Table 1**.

8. Fungicide application: Apply fungicides in a preventative manner. Chlorothalonil (Bravo[®], Echo[®], Equus[®]), mancozeb (Dithane[®], Manzate[®], Penncozeb[®]), and maneb (Maneb, Manex[®]) are effective contact fungicides, and difenoconazole (Inspire Super[™]), tebuconazole (Tebuzol[™], Folicur[®]), and thiophanate-methyl (Topsin M[®]) are effective systemic fungicides for management of GSB. If weather conditions are conducive for the occurrence and rapid spread of GSB, fungicide application should start during the early stages of plant growth. A list of currently labeled chemicals for use on cucurbits in Florida is provided in **Table 2**. To prevent development of fungicide resistance, various chemistries should be alternated during the spray program.

9. Storage: GSB infection can also occur on the fruit. Avoid wounding fruits during harvest, and store fruits at 45°F–50°F to prevent postharvest black rot.

Chemical control

Fungicides are available for chemical control and are labeled for use in some vegetable crops in Florida. Currently labeled fungicides for use in Florida are given in **Table 2**.

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Table 1. Registered biological control agents and a host plant defense inducer for management of GSB on cucurbits in 2011

Biological	Fungicide group*	Application Maximum rate/acre	Min. days to harvest	Remarks
<i>Bacillus subtilis</i> strain QST 713 (Serenade® ASO)	44	6 lb	0	Do not use product alone. Apply with registered fungicide. OMRI listed.
<i>Bacillus subtilis</i> strain QST 713 (Serenade® Max)	44	3 lb	0	Do not use product alone. Apply with registered fungicide. OMRI listed.
<i>Bacillus subtilis</i> strain QST 713 (Rhapsody®)	44	6 qt/100 gal	0	Do not use product alone. Apply with registered fungicide. OMRI listed.
Extract of <i>Reynoutria sachalinensis</i> (Regalia™)	P	1% v/v dilution	0	For use in organic production.

* Sorting based on the mode of action of the different chemistries and is known as the FRAC code (fungicide group).

Disclaimer: Follow label instructions before application of fungicides on crops. The list above is based on available labels in 2011. Local county Extension agents should be consulted prior to application.

Table 2. Registered fungicides for management of GSB on cucurbits in 2011

Chemical	Fungicide group*	Maximum rate/acre		Min. days to harvest	Remarks
		Application	Season		
Mancozeb (Dithane® DF Rainshield, Dithane® F45 Rainshield, Dithane® M45, Manzate® Flowable 4F, Manzate® Pro-Stick, Penncozeb® 4FL, Penncozeb® 75DF, Penncozeb® 80WP)	M3	See individual labels		5	Labeled for all cucurbits.
Maneb (Maneb 75DF, Maneb 80WP, and Manex®)	M3	See individual labels		5	Labeled for all cucurbits.
Mancozeb + copper hydroxide (ManKocide® 61.1DF)	M1 + M3	2.5 lb	128 lb	5	Labeled for cucumber, melons, and summer squash.

Table 2. Registered fungicides for management of GSB on cucurbits in 2011

Chemical	Fungicide group*	Maximum rate/acre		Min. days to harvest	Remarks
Chlorothalonil (Bravo® Ultrex, Bravo® Weather Stik, Bravo® ZN, Chloronil® 720, Chlorothalonil 720SC, Echo® 720, Echo® 90DF, Echo® ZN, Equus® DF, Equus® 720 SST, Initiate® 720)	M5	See individual labels		0	Follow label instructions on watermelon after fruit set. Labeled for all cucurbits.
Chlorothalonil + mefenoxam (Ridomil Gold® Bravo® SC)	M5 + 4	3.35 pt	See label	7	
Thiophanate-methyl (Topsin M® 70WP, Topsin® 4.5FL, Topsin M® WSB, Thiophanate Methyl 85WDG, T-Methyl E-Ag 70WSB)	1	See individual labels		1	Follow resistant management guidelines on label. Labeled for all cucurbits.
Tebuconazole (Folicur® 3.6F, Monsoon 3.6F, Orius® 3.6F, Tebustar® 3.6L, Toledo Tebuzol 3.6F)	3	8 fl oz	24 fl oz	7	Gummy stem blight suppression only for watermelon, squash, pumpkin, and melon.
Mefenoxam + chlorothalonil (Ridomil Gold® Bravo® 76.4W)	4 + M5	3 lb	12 lb	7	Limit to four appl/crop. Labeled for all cucurbits.
Boscalid + pyraclostrobin (Pristine® 38WG)	7 + 11	18.5 oz	74 oz	0	Same as Amistar
Cyprodinal + difenoconazole (Inspire Super™)	9 + 3	20 fl oz	80 fl oz	7	
Cyprodinal + fludioxonil (Switch™ 62.5WG)	9 + 12	14 oz	See label and remarks	1	Do not apply more than 56 oz per acre per plot of land per year. Do not make more than two consecutive applications before switching to fungicide with a different mode of action. Labeled for all cucurbits.
Azoxystrobin (Amistar 80DF, Quadris® 2.08F)	11	5 oz	1.88 lb	1	Limit to four applications. Do not make more than two consecutive applications. Labeled for all cucurbits.
Azoxystrobin (Heritage®)	11	8 oz	3 lb	1	Do not make more than two consecutive applications. Do not make more than six appl/crop. Labeled for all cucurbits.

Table 2. Registered fungicides for management of GSB on cucurbits in 2011

Chemical	Fungicide group*	Maximum rate/acre		Min. days to harvest	Remarks
Pyraclostrobin (Cabrio® 20EG)	11	16 fl oz	64 fl oz	0	Limit to four applications. Do not make more than two consecutive applications. Labeled for all cucurbits.
Kresoxim-methyl (Sovran®)	11	4.8	19.2	0	Follow resistance management guidelines on label.
Polyoxin D zinc salt (PH-D™)	19	6.2 oz	31 oz	0	Use in alternation with fungicides that have different modes of action. Labeled for all cucurbits.
Hydrogen dioxide (OxiDate)	NC	Various dilution rates	See label	0	See label for specific use on cucurbits.

* Sorting based on the mode of action of the different chemistries and is known as the FRAC code (fungicide group).

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