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Managing Basil Downy Mildew in the Greenhouse

Downy mildew continues to be the most important disease of basil throughout most of the USA, affecting plants grown outdoors at farms and in gardens as well as in greenhouses every year. Widespread regular occurrence of this devastating disease has clearly documented that management is needed to ensure a marketable crop. Below are some tips for management, an integrated approach using multiple strategies listed below is recommended.

Management practices:

1. Start with pathogen-free seed. Eurofins STA Laboratories in Colorado now tests basil seed for *Peronospora* spp (<http://www.eurofinsus.com/stalabs/products-services-seed-health.html>). There may be other companies that offer testing. It is sufficient to test only at the genus level with this pathogen since it is the only species of *Peronospora* that would be associated with basil seed.

Seed companies are starting to steam treat basil seed. Basil seed is not amenable to hot-water treatment because while in water the seed produces a gelatinous exudate, which makes the seed challenging to handle. One company known to offer steam treatment is High Mowing Organic Seeds.

2. Select resistant varieties. Good suppression of downy mildew can be obtained with new resistant varieties that started to be marketed in 2018. They are the fruition of several years of conventional breeding by breeders working separately on this goal. It can take many crosses to obtain a plant with resistance plus all the desired horticultural traits that are in a susceptible variety, which include for sweet basil large, smooth, dark green, downward cupped leaves with good classic sweet basil flavor.

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Yellowing on upper leaf surfaces.



Pathogen growth and spores on lower leaf surfaces.

Devotion, Obsession, Passion, and Thunderstruck are the first resistant varieties released from the Rutgers University basil breeding program. They are marketed by VDF Specialty Seeds. Organically-produced seed is available. Prospera is being marketed as organic seed by Johnny's Selected Seeds. Amazel is a Proven Winners variety, its seed is sterile and thus sold as cuttings. Limited suppression is typical with Eleonora, the first commercially available resistant variety. Emma and Everleaf (aka Basil Pesto Party and M4828Z) also have moderate resistance. Results and photographs from variety evaluations conducted at Cornell are available on-line at <http://blogs.cornell.edu/livegpath/research/basil-downy-mildew/>.

3. Avoid favorable environmental conditions for disease development. The basil downy mildew pathogen needs humidity of at least 85% in the plant canopy to be able to infect. This disease can be controlled effectively by keeping humidity low. Practices to achieve this include base watering, wide plant spacing, circulating fans, lights, and increasing temperature. Base heating is an especially effective method to reduce humidity. Set up sensors in the plant canopy to monitor humidity to ensure that the practices being implemented are sufficient. Fanning is a practice developed and being used in Israel for basil grown in protected culture. It entails directing greenhouse fans toward plants so that leaves move. This prevents water depositing on leaves when humidity is high.

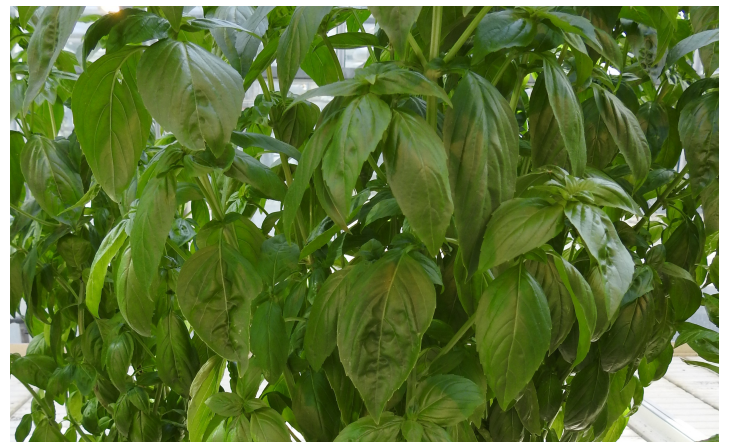
4. Turn lights on during night. Illuminating either leaf surface of plants growing under protected conditions during nighttime was shown to effectively suppress downy mildew in basil by inhibiting spore production through a study conducted in Israel. Light was supplied in high tunnel-like structures with 20W Day Light fluorescent bulbs each equipped with a white metal reflector (30 cm diameter), with one bulb per meter row. Spores formed on leaf tissue shaded by other leaves, thus this procedure is most effective when plants are small. Initial experiments were done with illumination throughout night. Recent research has revealed light exposure is most important during the first 6 hours of night, and the pathogen needs at least 7 hours of darkness. Red light was shown to be the most inhibitory under laboratory conditions.

5. Apply fungicides. A preventive program with conventional fungicides is considered necessary to achieve effective control when inoculum is present based on results from replicated fungicide evaluations. Ranman (cyazofamid; FRAC code 21) and Revus (mandipropamid; FRAC 40) have targeted activity for downy mildew and other oomycete pathogens. Their use is permitted in greenhouses. There are several phosphorous acid (phosphanate) fungicides labeled for this disease, including ProPhyt, Fosphite, Fungi-Phite, Rampart, pHorsepHite, and K-Phite. These are suggested at low label rate tank-mixed with Ranman and Revus, which are recommended used in alternation for resistance management.

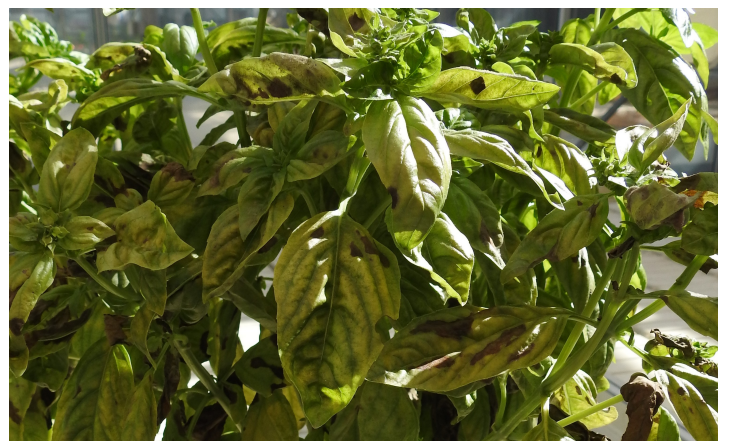
Heritage (azoxystrobin; FRAC 11), Micora (mandipropamid; FRAC 40), Segovis (oxathiapiprolin; FRAC U15), and Subdue MAXX (mefenoxam; FRAC 4) are additional fungicides that can be used in greenhouse-grown plants for retail sale to consumers. Subdue MAXX and Segovis use are on supplemental labels available in the CDMS database, <http://www.cdms.net/LabelsSDS/home/>; supplemental labels can also be found on manufacturers' websites (and, for those of you in NY, the NYS Pesticide database <http://www.dec.ny.gov/nyspad>). Subdue can be applied once to plug-production trays after seeding and before seedling emergence and once after plugs are transplanted to larger pots; it must be tank-mixed with another fungicide labeled for this use. Heritage can similarly be applied only once at each production stage but both applications are to foliage and it must be applied in alternation with another fungicide. Micora and Segovis can only be applied to foliage of plants for retail sale as transplants; they are not permitted used on plants to be marketed as fresh herbs in grocery stores. Both can be applied at most twice to a crop. According to label directions, Micora can only be used in an enclosed



Obsession exhibiting very good resistance contrasting with Martina (at bottom).



Prospera exhibiting very good resistance contrasting with Martina (below).



Martina, a susceptible variety, severely affected by downy mildew.



Basil is susceptible to downy mildew from emergence.

greenhouse with permanent floor. Segovis can also be used in outdoor nurseries. It is important to use a fungicide resistance management program including alternation among as many chemistries based on FRAC code as possible. Resistance to mefenoxam developed quickly in Israel demonstrating the capacity of this pathogen to develop resistance.

Basil downy mildew has proven difficult to manage with fungicides approved for organic production. This is partly due to the fact there is no tolerance for any amount of disease on leafy herb crops for fresh consumption or for retail sale. Additionally, it is difficult to deliver spray material to the underside of leaves where the pathogen typically infects and produces spores. Most organic fungicides are contact materials. Thus far, none of the products tested in field evaluations have provided commercially-acceptable level of control. Results from research conducted on Long Island are posted at:

<http://blogs.cornell.edu/livepath/research/basil-downy-mildew/>.

There is no tolerance for downy mildew on basil for retail sale. Very few gardeners are going to apply fungicides to basil, and the products they can use have limited activity. Downy mildew can develop very quickly. I have seen at garden centers basil plants that were very healthy appearing with some downy mildew sporulation and no leaf yellowing, but just three days later leaves on the plants not sold were yellowing and covered with spores on the underside.

6. Monitor plants for symptoms. Yellow leaf tissue in bands delimited by large veins is distinctive for basil downy mildew. It is important to examine the underside of leaves for the pathogen's spores because there are other causes of leaf yellowing and spores can be present without yellowing. Additional photographs are posted at:

<http://blogs.cornell.edu/livepath/gallery/basil/downy-mildew/>.

7. Heat treat affected plants. If symptoms are found early, it might be possible to save some plants by subjecting plants to heat and then taking steps to improve the management program. High temperature is detrimental to the pathogen. Maximum temperatures for infection, colonization, and spore production are 80 – 88 F. Research conducted in growth chambers demonstrated that temperatures up to 113 F kill spores and mycelium of the pathogen in affected plants, with length of effective exposure decreasing with higher temperature range, least being 6 - 9 hours at 104 – 113 F. Subsequently solar heating has been used to cure plants in Israel by closing greenhouse vents or using a transparent IR polyethylene sheet covering during sunny days. It is recommended done at first sign of downy mildew and over 3 consecutive days with 3-4 hours exposure. It necessitates routine and close monitoring to ensure temperature reaches effective range while not

rising high enough to kill plants. If temperature does not go above 95 F, treating for a fourth day is recommended. Given the potential for high temperature to damage plants, it is prudent to test the treatment on a small scale before implementing.

8. Promptly destroy unmarketable affected plants. Affected plants should be carefully bagged (after turning off fans) and thrown out to minimize opportunity for spores to spread to other plantings.

More information about this disease plus images and links to monitoring pages are at <http://vegetablemdonline.ppath.cornell.edu/NewsArticles/BasilDowny.html>.

Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.



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