IDENTIFICATION OF FOLIAR PATHOGENS AND BEST MANAGEMENT PRACTICES FOR CERCOSPORA LEAF SPOT

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The New York table beet industry is expanding and has unique challenges to minimize crop loss in both conventional and organic production. Diseases may reduce plant population density and increase heterogeneity in a stand, reduce the duration of time foliage is healthy, and decrease the yield of marketable roots. A complex of foliar diseases affects New York table beet production and maintaining green, healthy leaves for the duration of the season is critically important to ensure adequate carbohydrate production for optimal root growth, and to enable harvest using top-pulling machinery.

Disease Identification

The three most common diseases affecting foliage of table beet in New York are:

1. Bacterial leaf spot (BLS) caused by *Pseudomonas syringae* pv. *aptata*;
2. Cercospora leaf spot (CLS) caused by the fungus, *Cercospora beticola*; and
3. Phoma leaf spot (PLS) caused by the fungus, *Phoma betae.*

Bacterial leaf spot (BLS) is most common when conditions are cool and wet, early in the season and therefore most commonly found early on young plants that are also more susceptible to the disease. Symptoms of BLS are black spots and can be easily confused with other diseases but can be differentiated by the absence of fungal structures within the lesions and presence of deformation and distortion of the leaves around the lesions (Fig. 1).

Fig. 1. *Bacterial leaf spot lesions caused by Pseudomonas syringae pv. aptata on table beet are most commonly found in cool, wet conditions and on young plants. Leaves usually have a necrotic lesion and are distorted and malformed around the lesion.*

Cercospora leaf spot (CLS) is the most important disease affecting table beet production and epidemics occur annually and usually in mid to late summer. CLS symptoms first appear as small, individual gray to black-colored lesions on the leaves, which rapidly grow together resulting in defoliation (Fig. 2). In a red table beet cultivar, the lesions are surrounded by a reddish-purple color. In yellow or white table beet cultivars, these lesions may by surrounded by a tan-brown ring. Older leaves often show symptoms first and younger leaves become infected as the disease progresses.

Fig. 2. *Cercospora leaf spot lesions on table beet are initially small and have a gray to black center (left). The lesions rapidly expand and cause defoliation and death of leaves (right).*

CLS lesions can be distinguished from other diseases by their color and the presence of structures produced by *C. beticola* called pseudostromata in the lesion. Pseudostromata are small (pin-head size), black, and numerous across the lesions (not in a circular pattern). On the pseudostromata, the spores of the fungus may be visible (Fig. 3). These may be observed with a hand lens in the field.

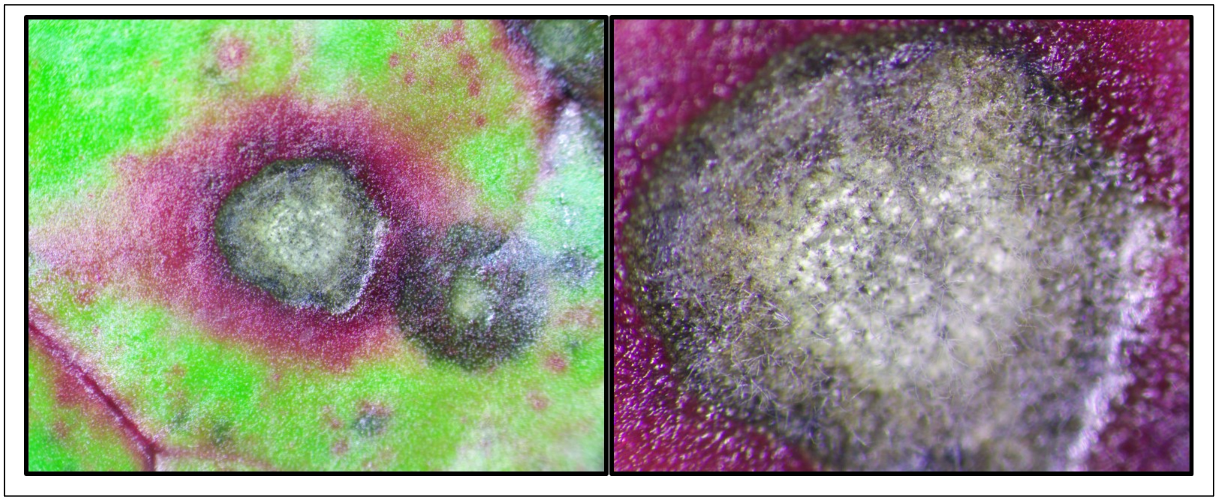

Fig. 3. *Cercospora leaf spot lesions on table beet with black pseudostromata within the lesion. The gray, needle-like structures on the lesion on the right image are the asexual spores produced from the pseudostromata. Observation of these structures within a lesion by a hand lens is the best method to distinguish CLS symptoms from those caused by other bacterial or fungal pathogens.*

Cercospora beticola life cycle. *Cercospora beticola* typically survives between seasons as pseudostromata on infested plant debris for up to 24 months. In addition to table beet, crops that are also susceptible to CLS include spinach and Swiss chard; and hence should be avoided in the cropping rotation. Weeds that may form 'green bridges' for *C. beticola* include lambsquarters, dock weed, safflower, and wild mustard. The fungus is also opportunistic and may colonize necrotic (dead) tissue on other hosts without causing infection. Spores (conidia) are produced on the pseudostromata which are disseminated by wind, rain, irrigation, water splash, and potentially insects to infect the leaves and petioles.

The spread of CLS is caused by multiple infection cycles within a cropping season under conducive environmental conditions. The disease typically begins in small, random areas within the field, which rapidly enlarge over several weeks. If left uncontrolled, at the end of the season, the spatial distribution of CLS may be uniform across the field.

Phoma leaf spot (PLS) symptoms are characteristic tan to brown, large, circular lesions containing dark rings of fungal structures called pycnidia (Fig. 4). The disease is most often observed in organic production as conventional seed treatments are highly effective at controlling seedborne inoculum. PLS symptoms on leaves may also increase the risk of root rot and decay also caused by this pathogen.

Fig. 4. *Phoma leaf spot lesions on table beet are large, tan in color and usually have rings of black fungal structures (pycnidia) within the lesion.*

Management of Cercospora leaf spot

Effective planning of crop rotations to maintain a 3-year gap between table beet and susceptible crops is a critical part of mitigating disease risk and reducing the impact of CLS epidemics**.** However, situations that do not allow rotation away from beets at a 3-year interval, and result in significant potential for crop loss in most years from CLS, means that fungicide applications are critical to reduce the rate of disease spread (Table 1).

Cercospora beticola is at high risk of developing resistance to single-site mode of action fungicides. Resistance to FRAC group 11 fungicides (e.g. Quadris) is prevalent within the *C. beticola* population and use is hence discouraged for CLS control in table beet in New York (Table 1). This has been a major factor in the development of a decision support system for fungicide application for CLS management in table beet in New York. In our research, multi-site copper-based products provided relatively poor control of CLS.

Decision support. The effect of temperature and relative humidity on the growth of *C. beticola* and spread of CLS have been well-studied in sugar beet, and these have been used to develop a CLS decision support system. This system has been operating for many years in North Dakota for CLS management in sugar beet. In our table beet studies in New York, using this decision support system reduced the number of sprays applied throughout the season for CLS management without significantly reducing root yield or increasing disease severity. The CLS decision support system will soon be available through the Network for Environment and Weather Applications (NEWA; New York State Integrated Pest Management Program, Cornell University, Geneva, NY and the Northeast Regional Climate Center, Ithaca, NY).

Table 1. Conventional site-specific mode of action fungicides currently registered for Cercospora leaf spot control in table beet in New York[a].

Product	Active ingredient (s)	FRAC groups[b]	Re-Entry Interval (hours)	Pre-Harvest Interval (days)
Quadris	Azoxystrobin	11	4	0
Reason	Fenamidone	11	12	14
Cabrio	Pyraclostrobin	11	12	0
Flint Extra	Trifloxystrobin	11	12	7
Luna Tranquility	Fluopyram + pyrimethanil	7 + 9	12	7
Luna Sensation	Fluopyram + trifloxystrobin	7 + 11	12	7
Merivon	Fluxapyroxad + pyraclostrobin	7 + 11	12	7
Tilt	Propiconazole	3	12	14
Not registered but under development				
Miravis Prime	Pydiflumetofen + difenoconazole	7 + 3	Unknown	Unknown

[a] The latest information should be checked by regular consultation with the label and the Cornell Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production.

[b] FRAC = Fungicide Resistance Action Committee.

Fungicide resistance best management practices. Resistance to single-site mode of action fungicides is a major issue within the *C. beticola* population in New York due to high diversity and rate of reproduction. Fungicide resistance may occur due to mutations within single genes causing a rapid shift in resistance. This phenomenon is typical of resistance development to the strobilurin fungicides (FRAC group 11, e.g. Quadris). If multiple genes are involved in conferring sensitivity, resistance progression usually occurs slowly within the pathogen population. This phenomenon is typical of resistance development to the demethylation inhibitors (FRAC group 3; e.g. Tilt).

Adhering to best management practices for fungicide resistance is essential to preserve the efficacy of the single-site modes of action currently registered. These include:

- Using the maximum labelled rate;
- Ensure adequate spray coverage;
- Alternate fungicides with different modes of action (represented by FRAC groups) where possible;
- Be aware of the different FRAC groups in a pre-mixed fungicide formulation and plan sequences accordingly; and
- Consider using the CLS decision support system to schedule fungicides at periods of risk to ensure efficacy.

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