

Downy Mildew of Crucifers

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Cause

Downy mildew of cruciferous crops is caused by the fungus *Peronospora parasitica*. Cabbage, Chinese cabbage (including NAPA and bok choy), broccoli, cauliflower, radish, turnips, Brussels sprouts, mustard, collard, rutabagas, kohlrabi, rape, forage kales, and kale are susceptible. The susceptibility of many cruciferous weeds in Florida is unknown; they are infected by this fungus but it remains unknown at this time if the strains infecting such weeds will also infect cruciferous crops. For practical purposes it is presumed that at least some cruciferous weed strains of this fungus infect cruciferous crops. Varieties within cruciferous crops and the crops themselves will vary in their susceptibility to downy mildew, but information on this aspect is scant. Therefore, do not make hasty decisions about changing varieties without first inquiring into the availability of current information about varieties or first experimenting with small plantings of new varieties. If varietal reaction to downy mildew is available, it would be available for major cruciferous crops such as cabbage, broccoli, cauliflower and maybe radish. On the other cruciferous crops, personal experience may have to be relied upon. This issue is further complicated by the presence of different strains (races) of this pathogen. The presence of different races is known, but practically speaking this infor-

mation is of minimal value at this time. When race surveys are conducted and crop varieties are evaluated extensively each year, such knowledge could become useful. There is some evidence that strains that infect radish are not aggressive on other cruciferous crops. Also, the weed, shepards purse, has not been successfully infected with the downy mildew fungus using spores from commercial crops even though this fungus was first described on shepards purse in 1796.

The fungus causing downy mildew on crucifers produces two spore types. One spore is called an oospore and presumably functions as a survival spore. It is formed within infected host tissue primarily during crop senescence. Then, when the next cruciferous crop is planted it might serve as a new source of inoculum by germinating, developing microscopic threads (hyphae) that later produce the second spore type called conidia. Some reports suggest the possibility that oospores can be carried on seed if infected plants are used for seed production.

It is questionable at this time whether the oospore stage of the life cycle is of any practical consequence for carry over of this fungus. First, germination of oospores has not been reported. Second, cruciferous crops or volunteers infected with downy mildew abound throughout the year in Florida. During the summer this disease spreads slowly but it can exist in previously infected plants either in a systemic or

locally infected manner. Then, when cooler temperatures occur, the fungus will produce conidia that are disseminated by wind or wind driven rains. Third, cruciferous weeds may harbor the fungus in a similar manner as cruciferous crops but at this time it is unknown if such weeds act as reservoirs for strains of this fungus that infect cruciferous crops. Some scientists believe that weeds are not a source of inoculum while others are in doubt. Whatever the source of inoculum may be, it is ample because when environmental conditions are conducive for downy mildew, this disease can abound on cruciferous crops.

Cool and wet conditions are conducive for downy mildew of crucifers. Spore production is greatest from 53° to 61°F but occurs to some extent from 39° to 85°F and maybe at slightly higher temperatures. When spores are in contact with a leaf with moisture they germinate and the germ tube apparatus penetrates the tissue. Temperatures between 42° to 61°F are ideal for these activities but they can occur between 39°F to 75°F. Symptoms can occur within 3 to 4 days after infection if temperatures near 75°F prevail during days following the infection period. As temperatures deviate from previously mentioned optima, disease development and spread is progressively slower.

Moisture is required for disease development. It is probably correct to say that the greater the rainfall or overhead irrigation or the longer the wetting periods from rainfall, dew, etc., the more severe this disease will be if temperatures are suitable.

Symptoms

All plant parts of crucifers can become infected with this fungus. In Florida, leaf symptoms are commonly observed. Black or dark specks appear on young leaves, usually on the underside of the leaf first. Such spots are often irregular in shape and may appear net-like (Figs. 1 & 2). The upper side of the leaf will also develop dark spots similar in shape and may

be accompanied by leaf yellowing (Figs. 3 & 4). On older leaves, coalescence of these spots can occur, resulting in larger areas of the leaf blade having large, sunken, paper tan-colored spots (Fig. 5). Leaf yellowing, again, may accompany these symptoms. Early infection on young plants can cause stunting.

On the underside of the leaf spots, a white-grey, downy growth can be observed with or without the aid of a hand lens, especially when leaves are wet. On mature cabbage, downy mildew can appear as dark sunken spots on the head or wrapper leaves (Fig. 6). Often infections on the cabbage head will result in a purplish tinge. Such infections predispose the plant to soft rot bacteria or Sclerotinose (see PP Fact Sheets 12 and 22), which can further rot tissue in the field or after harvest.

Cauliflower curds and broccoli heads can become infected with blackened areas on the outside of the tissue. The infection can become systemic and turn inner curd and stem tissue dark. Radish and turnip "roots" can become infected by spores that are washed down to the soil from the leaves. Symptoms might predominate on the upper part of the root but the entire root is susceptible. Black spotting or a netted appearance can be observed on the outside of the root but an internal, firm rot can occur as well in some situations. Some root distortion could occur, especially, if infection occurred early in relation to root swelling. Flowers and seed stalks of cruciferous crops, especially mustard, are also infected.

Control

Downy mildew is controlled primarily by fungicides at the present time. Nonsystemic fungicides should be applied at least weekly beginning when night time temperatures are in the range conducive for sporulation and dis-

ease development and when rains or irrigations are frequent or heavy. Systemic fungicides, as they are developed, will more than likely require considerably fewer applications but should be used as a tank mix with non-systemic, protective fungicides. Systemic fungicides have a history of losing their effectiveness because "new" strains, resistant to systemic fungicides, increase in population. The tank mix of systemic and non-systemic fungicides may lengthen the effective "lifespan" of these specific, systemic fungicides. For details on current fungicide usage contact your local county extension office. Downy mildew favorable weather may occur at seeding or transplanting time.

Therefore, be prepared to spray even at an early stage of crop development.

It is customary with many plant diseases to integrate fungicide spray programs with cultural controls and resistant varieties. With downy mildew of crucifers, however, many sources of spores may exist. The life cycle of this disease is imperfectly understood and resistant varieties may be difficult to document, making it difficult to recommend a long list of definitive non-chemical controls. Certainly, the grower should purchase or produce downy mildew-free transplants. Excess plants produced in ground transplant beds should be plowed down, preferably with a mold-board plow, as soon as successful transplanting is complete. Similarly, excess plants produced in other types of transplant operations should be destroyed as soon as possible. Do not dump such plants in cull piles where they might con-

tinue to grow and serve as sources of inoculum for downy mildew and other diseases. When growing plants in doors maximize ventilation within the structure. This practice reduces moisture retention periods on the leaves. Transplants grown indoors under partial shade will retain moisture for a longer period of time and temperatures might be cool enough for downy mildew development even though temperatures outside are too high for disease development. Crop rotation with non-cruciferous crops might be of some benefit.

Where ground transplant beds are used, rotate sites each year. Transplant production should be at least 1/4 mile from production fields if possible. Volunteer cruciferous plants should be eliminated. Cruciferous weeds should be controlled as best as possible in case they might serve as a source of spores.

This may be difficult or impractical in some cases such as in ditch banks. Weed control in the vicinity of transplant beds should be maximized. Direct seeded field plantings have been observed to have less downy mildew, presumably because the initial canopy is thin and allows for faster evaporation of leaf moisture compared to the thick canopy associated with some transplant beds.

Determine which varieties are more resistant to downy mildew by consulting seed catalogs and local data sources. When experimenting with new sources of seed, isolate them in transplant production areas and fields to reduce chances of introducing black rot (See P.P. Fact Sheet No. 13) on your farm.



Figure 1. Downy mildew in cabbage leaf.



Figure 2. Downy mildew on underside of cabbage leaf.



Figure 3. Downy mildew in cabbage leaves.



Figure 4. Downy mildew in radish leaves.



Figure 5. Downy mildew in broccoli leaf.



Figure 6. Downy mildew in cabbage head.