Growing Healthy Crops and Healthy Profits

December 6-8, 2005
Grand Rapids, Michigan

Great Lakes EXPO
FRUIT, VEGETABLE & FARM MARKET

Carrot

Wednesday morning 9:00 am

Moderator: Jim Breinling, Mason Co. MSU Extension

9:00 a.m. Black Rot of Carrot

Mary Hausbeck, Plant Pathology Dept., MSU

9:20 a.m. Seedborne Diseases of Carrot

Lindsey du Toit, Washington State

9:50 a.m. Aster Leafhopper Infectivity Testing Program in 2005

Beth Bishop, Entomology Dept., MSU

10:10 a.m. Update on Carrot Diseases and Their Management in New York

George S. Abawi, Plant Pathology (Geneva), Cornell Univ.

10:40 a.m. Minimizing Deer Damage in Carrot Production

Steve Middlemas, Product Manager, Kalsec, Kalamazoo, MI

Black Rot of Carrots

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Black Rot

Black rot of carrot is caused by the fungus *Alternaria radicina*, which can be present in the seeds. This pathogen can survive in crop debris or in soil for up to 8 years as spores (Fig. 1A). These spores can be spread via water and wind. *A. radicina* infects carrots at any stage of growth during periods of warm temperatures (>68ºF) and extended leaf wetness. Seedling infection results in preemergence and postemergence damping-off. Older senescing petioles on mature plants are particularly susceptible to infection and provide an avenue for infection of the carrot crown, which appears as a black ring of decay where the petioles attach to the root (black crown). Decay of petioles and crowns can interfere with mechanical harvest. Carrots infected later in the growing season may not develop visible lesions until after harvest. In storage, disease development is favored by high relative humidity (>92%) and warm storage temperatures. Symptoms on stored carrots appear as dry, black, sunken lesions (Fig. 1B) which can decay the entire root and spread to adjacent carrots.

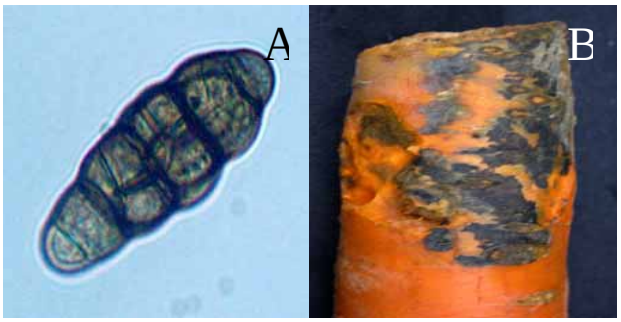

Fig. 1. Spores of *A. radicina* (A), black rot (B).

In the field, black rot symptoms on the carrot crown often become apparent only after the canopy closes, making detection difficult and reducing the effectiveness of fungicide applications. However, fungicides such as chlorothalonil, iprodione and strobilurins can be applied to reduce the damaging effect of *A. radicina*. Carrots should be washed and culled prior to storage, with wounding and breakage kept to a minimum. Maintaining proper temperature and humidity (32ºF and 95% relative humidity) in storage will prevent carrot deterioration and reduce the opportunity for disease spread. *A. radicina* was first isolated on stored carrots and on field carrots in two counties in Michigan.

Phytophthora Root Rot or Rubbery Brown Rot

Phytophthora root rot of carrot is caused by a *Phytophthora* sp., which can infect carrots in the field near harvest, with infection continuing in storage. Infected portions of the root become dark brown to black, water-soaked and rubbery in consistency. Lesions may

Fig. 2. *Phytophthora* sp.: Sporangium (A), oospore (C) and infected carrot (B).

occur in one or more bands anywhere on the carrot root (Fig. 2). White mycelia may be present on lesions, which facilitates the spread of the fungus to adjacent roots.

As lesions expand and age, a watery soft rot may develop allowing other organisms to invade the root. *Phytophthora* sp. is associated with relatively wet soil conditions from excessive rain/irrigation and temperatures between 70-75ºF. In Michigan, the pathogen was found in carrot samples from fields located in three Michigan counties in September 2005. Still in the identification process, the *Phytophthora* sp. isolated is a soilborne, self-fertile organism that requires only one mating type to produce oospores which are long term survival structures (Fig 2). *Phytophthora* sp. also produces zoospores (swimming spores) which are easily spread through water.

Managing soil waters, maintaining adequate soil drainage and avoiding prolonged periods of water saturation are means of control for this pathogen. Also, maintaining adequate storage conditions, temperature at 32º F and relative humidity <95%, and sanitation is crucial to the control of *Phytophthora* sp. after harvest.

Root Dieback (Pythium Brown Rot and Forking)

Root dieback is caused by *Pythium* spp. and occurs wherever carrots are grown. Root dieback of carrots produces excessively branched or stubbed roots. The fungus kills young tap roots after seed germination, reducing root length and/or stimulating forking. Forking and stubbing occur, but these symptoms can also be caused by soil compaction, nematodes and excessive water. The severity of the disease may be dependent on the density of *Pythium* spores in fields, in addition to other factors such as wet soil conditions and large amounts of fresh residues. *Pythium* spp. produce sporangia and overwintering spores (oospores). Spores and mycelia are responsible for the spread of the fungus in the field, which is facilitated by wet soil conditions. Disease control can be achieved by avoiding excessive watering, by providing good field drainage and by planting carrots in deep, friable and well drained soils. Postemergent fungicides containing the active ingredient mefenoxam can be applied to control damping-off. Rotations with small grains may reduce soil populations of some *Pythium* spp.

Black Root Rot

Black root rot of carrot is caused by *Chalara elegans (Thielaviopsis basicola)*, a soilborne plant pathogenic fungus commonly found in cultivated and uncultivated soils. The fungus infects a variety of crops including carrots and beans. Generally considered a postharvest pathogen, *C. elegans* can infect seedlings and mature carrots in fields under high humidity and temperatures (>75ºF). Infected carrots develop patches of superficial black lesions on the surface and in cracks and wounds (Fig. 3). Large amounts of dark thick-walled melanized spores (chlamydospores), as well as single-celled, rectangular-shaped spores (endoconidia) can be isolated from these lesions (Fig. 3). Chlamydospores are the pathogen survival structures and may remain in soils for years. Acidic soils containing high levels of organic matter favor high levels of *C. elegans*. Contamination of healthy roots by *C. elegans* occurs during mechanized harvest and grading. The pathogen develops rapidly on wounded carrots that have been washed, graded, packed and stored at temperatures >77ºF and high relative humidity. Careful harvest handling, dipping carrots in chlorinated, hydrocooled water and storage temperatures between 32 and 50ºF minimize pathogen growth. Good disease control is achieved when harvested carrots are dipped in solutions of potassium sorbate and propionic acid. *C. elegans* was first isolated on carrots from Michigan fields in 2005.

Fig.3. Chlamydospores of *C. elegans* (A) and infected carrot (B).

Crown Rot

Crown rot of carrots is caused by *Rhizoctonia solani*, a soilborne fungus with a wide host range. The fungus infects carrot roots near maturity, but it can cause damping-off of carrot seedlings. Found in

many carrot production areas, crown rot is more severe on muck-grown carrots and in areas with warm temperatures and wet conditions, especially when these environmental conditions occur near harvest. Field symptoms include premature senescence and death of foliage. On carrot roots, symptoms include dark brown sunken lesions or cankers near the crown or in other parts of the root. In general, crown rot is a dry rot, but occasional invasion by soil bacteria and other fungi may induce soft rot. *R. solani* overwinters in soils as mycelia on plant debris and as dark brown sclerotia that remain in soil for long periods. Infection of the crown from overwintering mycelia and germinating sclerotia may occur any time during the growing season under high moisture and temperatures >64º F. *R. solani* can spread from plant to plant in closely spaced carrots when the canopy is fully formed. Infection may continue in storage. Cultural practices that reduce crown injury and enhance soil drainage and air circulation within the canopy are recommended. Plant debris from previous crops should be removed before planting carrots, and carrots should not follow perennial crops such as alfalfa. Rotation of fields with small grains may reduce inoculum levels. The pathogen was isolated in carrot samples from three Michigan counties in September 2005.

Fusarium Dry Rot

Fusarium dry rot of carrot roots is caused by *Fusarium* spp., soilborne fungi that occur wherever carrots are grown. Fusarium dry rot is commonly a carrot root disease, but the fungi can also be associated with seeds. Disease is severe on carrots held in fields after maturity and it can develop in storage. *Fusarium* spp. spores survive in soil, plant debris and crop residues and the spread of the pathogen occurs through mycelia and airborne spores. Moisture, warm temperatures and wounds caused by equipment, insects and other fungi facilitate the growth and spread of *Fusarium* spp. Symptoms of the disease include brown, leathery lesions, side cankers and crown decay. In storage, rapid growth of the fungi is favored by free moisture and temperatures between 45 and 70ºF, and contamination of adjacent roots can occur quickly. Fusarium dry rot can be reduced by avoiding wounding of carrots, providing adequate storage conditions (32º F and RH< 95%) and drying the carrots before storage.

Sour Rot

Sour rot of carrot is caused by the fungus, *Geotrichum candidum*, a common soil inhabitant that infects carrots through wounds. Infection begins in the field and continues during storage. Sour rot symptoms include soft, watery, colorless decay on carrot roots (Fig. 4). Often the surface of the decayed area is covered with dull, white spores of the pathogen and a vinegar-like odor may develop. In storage, sour rot development is enhanced when storage facilities are warmer than recommended (>32°F) and improperly ventilated. In the field, control of *G. candidum* is achieved with good field drainage and by minimizing wounding of carrots. In storage, good sanitation (use of new or disinfected storage containers), precooling and storing carrots at 32º F is essential. *G. candidum* was isolated on samples from stored carrots in March 2005 and in a carrot field in September 2005 in Mason County.

Fig. 4. *G. candicum* on stored carrots, external (A) and internal (B) symptoms.

The diseases described are all caused by soilborne fungi with well developed means of survival in soils (chlamydospores, oospores, conidia). These structures allow the pathogens to remain in soils for many years, and fumigation of soils plays a major role in reducing pathogens inocula in soils.