Bacterial Soft Rots of Vegetables and Agronomic Crops

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Cause and General Symptoms

Plant diseases called soft rots occur commonly on vegetable and agronomic crops in Florida. Such diseases may occur in the field or on the commodity after harvest. Most soft rot diseases are caused by bacteria. Bacteria are microscopic one-celled plants that multiply by cell division. A typical cell of a bacterium is about 1/12,000 of an inch long. Bacteria which cause soft rot in Florida include *Erwinia carotovora* pv *carotovora*, *E. carotovora* pv *atroseptica*, *E. chrysanthemi*, *Pseudomonas marginalis* and *Clostridium* sp. More than one of these bacteria may be involved in a given disease situation. Soft rotting bacteria produce enzymes which destroy the "cementing" material between cells resulting in a watery, slimy rot. Initially, soft rot lesions appear water soaked, sunken and darker in color than surrounding healthy tissue. Later a whitish, cloudy liquid may ooze from breaks in the plant tissue. Such lesions often have a rotted odor. Any plant tissue with such symptoms should be suspected of having soft rot. Fruits, tubers, fleshy roots, fleshy stems, and leaves are susceptible to soft rot. Woody tissues such as old pepper and soybean stems are not susceptible. Succulent tissues within woody stems, such as the pith in tobacco stems, are susceptible.

Environmental conditions that are conducive for soft rot development include high humidity, abundant rainfall or irrigation, poor drying conditions and warm temperatures. Specifically, temperatures of 73 to 95°F are best for soft rot development. Black leg of potato is an exception as it develops best in water-logged soils at temperatures below 75°F. Soft rot diseases in the field often occur in lower, wetter portions of the field where drying is delayed in the morning because of trees and hedge rows.

Infection of plant tissue occurs when free water is present. Natural openings in the plant such as hydathodes, lenticels and abcission tissues are points of entry for soft rot bacteria. However, wounds or conditions associated with harvesting fruits, tubers or leaves, suckering or topping tobacco, rough handling of produce, cold water immersion of tomato fruit, sunscald, staking and tieing plants, tissue bruising, inadequate suberization of potato seed pieces and insect damage are some of the more common means by which soft rot bacteria enter tissue.

Specific Diseases

Soft rot of stems occurs commonly in plants such as tobacco, collards, broccoli, and tomatoes. Such diseases are called hollow stalk. First, the fleshy inner part of the stem becomes

slimy and discolored. Eventually the stem becomes hollow (Fig. 1 and 2). The rot may extend into the leaves (Fig. 3) or fruit remaining on the plant. When the leaves or fruit are infected in such a manner, they become sources of inoculum during post-harvest operations. Barn rot of tobacco is a disease that is brought from the field into the drying barn. Sweet and field corn sometimes become infected in the stem causing a wet, slimy stalk rot. (Fig. 4 & 5).

Tomato and pepper fruit are commonly infected with soft rot bacteria but other vegetable fruits are also susceptible. Fruits are infected prior to harvest if wounded by insects or other means or the rot may progress from infected stems and branches into the fruit. Post-harvest infection of fruit may occur through wounds made during harvesting, transit or storage periods or when warmer fruit are washed in cooler contaminated water. Symptoms at first include small, sunken, water-soaked lesions that progress rapidly and liquefy the tissue (Figs. 6 & 7). Rot may begin anywhere on the fruit if wounding, insect damage or cracks occur. On peppers soft rot often begins at the broken stem (peduncle) attached to the fruit after harvest. Rot will progress from this point into the fruit if the stem end is wet. Often such rot ceases if the stem end becomes dry.

Potatoes can be infected by either the black leg organism (*E. carotovora* var. *atroseptica*) or the soft rot organism (*E. carotovora* var. *carotovora*) . Black leg is characterized by a wet seed piece breakdown, lower stem blackening, yellowed foliage and death of the emerged plant. Where black leg persists on older plants, young tubers may be infected. Soft rot occurs on developing or mature tubers as a wet, foul smelling water-soaked lesion that may engulf the entire tuber (Fig.8). In some situations soft rot infections are "walled-off" which appear as dried, discolored, and chalky white tissue. Infections of lenticils in tubers are often limited in this manner.

Salad crops such as lettuce, endive and escarole may be infected at leaf margins or the stem end. Leaf edges appear greasy with no definite margin between rotted and healthy tissues, (Fig.9). Such decay often occurs when cold weather is followed by warm, humid weather. Leaf ribs may turn brown, red or pink.

Occasionally soft rot may be caused by fungi rather than bacteria. *Rhizopus stolonifer* causes soft rots on sweet potatoes, tomatoes, peppers, eggplants and other vegetables. Infected tissue becomes wet and often the fungus sporulates producing black "whiskers" (sporangia). On squash fruit, a fungus wet rot occurs which is caused by *Choenephora cucurbitarum* (See Plant Pathology Fact Sheet No. 11). On tomato fruit a yeast-like growth may be seen on soft rotted tissue. The fungus causing this "sour-rot" is *Geotrichum candidum.* Sour rot lesions have a pickled odor rather that the putrid odor associated with soft rot bacteria and sour rot lesions have a pH below 5.0 whereas bacterial soft rot lesions have a pH of 5.6 or above.

Control

Soft rot diseases can be reduced by utilizing a combination of control measures.

Cultural practices: 1) Plant on well drained land or provide for adequate drainage. 2) Avoid excessive plant populations so that plants will dry faster. 3) For potatoes, purchase disease-free seed that do not have enlarged lenticels. 4) Cutting knives for potato seed pieces should be clean. If diseased seed pieces are cut inadvertantly, clean knives with rubbing alcohol before continuing with the cutting operation. 5) Plant suberized seed pieces that are treated with a recommended seed piece fungicide. Suberization occurs faster when seed pieces are stored at high humidity and warm temperatures. Seed pieces of potato must never be allowed to become wet. Storage areas should be shaded and well ventilated. 6) Plants should

be dry when harvesting, pruning, suckering, tieing or topping. 7) Prune promptly as removal of larger suckers results in larger wounds that are more apt to become infected. 8) When topping tobacco use a sharp knife and cut stem at an angle to minimize water accumulation on exposed stem. Clean the knife frequently with rubbing alcohol and clean the knife immediately if an infected plant is cut. Do not hand break stems. Better yet, do not touch infected plants. 9) Grow resistant varieties when possible. For example,with tomatoes, Florida MH-1, Floramerica, Flora-dade, and Homestead 24 produced more resistant fruit than Walter or Floridel. Flora-Dade, Sunny and Hayslip were more resistant than Walter or MH-1 to infiltration of water (accompanied by soft rot bacteria) through the stem scar. 10) When fertilizing tomatoes avoid excessive rates of nitrogen and use N:K ratio of 1:1.5 or 1:2. Soft rot might be more severe where fertilizer is banded rather that where it was applied in a broadcast manner. 11) Control insects.

Harvest practices: 1) Avoid rough handling of fruit. For example, tomato fruit should be rolled out of baskets as opposed to dumping or throwing. Potatoes should not be allowed to drop further than necessary. 2) Harvest crews should be taught to recognize diseased plants or fruit and then be told not to handle them. If they do, they should wash their hands with rubbing alcohol. 3) Where possible harvest produce when plants are dry. 4) Also, potatoes that are harvested dry are not as susceptible to soft rot as those harvested when the soil is wet. 5) Harvested produce should never be allowed to sit in the sun. Move harvested produce to shade as soon as possible. 6) Baskets, pallet boxes, trailers, etc. should be clean. 7) Healthy produce is less likely to have soft rot during post-harvest periods.

Post-harvest practices: 1) Free chlorine from gas, bleach or other sources should be in water (dump flume, gondola, wash water etc.) that *first* contacts tomato, pepper or radish. Maintain free chlorine levels at 75 ppm by periodically testing. Peppers should not be immersed in water. Rather, wash peppers with a warm water spray containing chlorine or use a dry belt line. Tomatoes should be water flumed as fast as possible and the water depth should be less than 12 inches. The deeper and longer fruit are in the water the greater the probability that water will infiltrate and soft rot bacteria will enter the fruit. Remove trash or use clean water (with chlorine) periodically as organic matter "ties-up" chlorine. 2) Surfactants added to produce wash water for cleansing action can promote water infiltration and soft rot bacteria entrance into produce. 3) Never wash pepper or tomato fruit in water cooler than the produce. Washing warm produce in cooler water may cause water and bacteria to move into the produce. 4) Where precooling is used on produce, it should be done as soon as possible with produce stored and shipped at recommended temperatures. For further information see USDA Agricultural Handbook No. 66. 5) Avoid freezing or excessively low temperatures during storage and shipment. 6) Do not wax wet produce. 7) Provide ventilation for stored produce but avoid excessive air velocity. Ventilation minimizes moisture condensation and reduces temperatures. 8) Where barn rot of tobacco occurs, use degreening temperatures of 100-105°F and advance tobacco into drying phase as soon as possible. It is best to avoid placing suspect leaves in the barn. 9) Potato tubers should not remain wet more than 16 hours after washing.

Figure 1. Soft rot inside collard stem.

Figure 2. Soft rot inside tobacco stem.

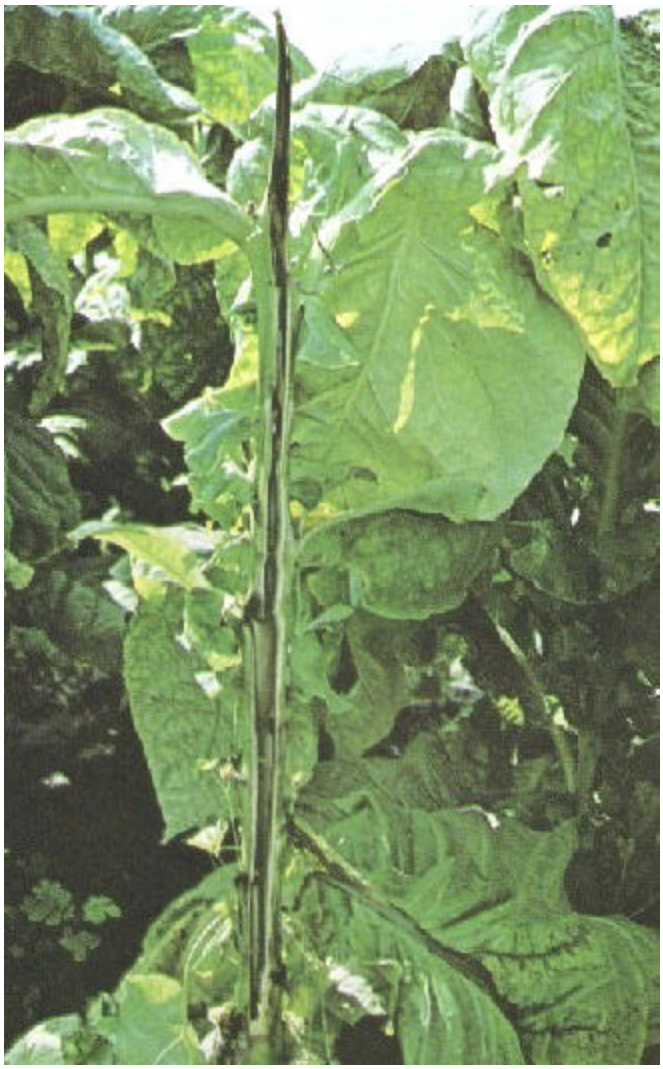

Figure 3. Soft rot in tobacco stems and leaves.

Figure 4. Bacterial stalk rot of corn.

Figure 5. Bacterial stalk, tassel, and leaf rot of corn.

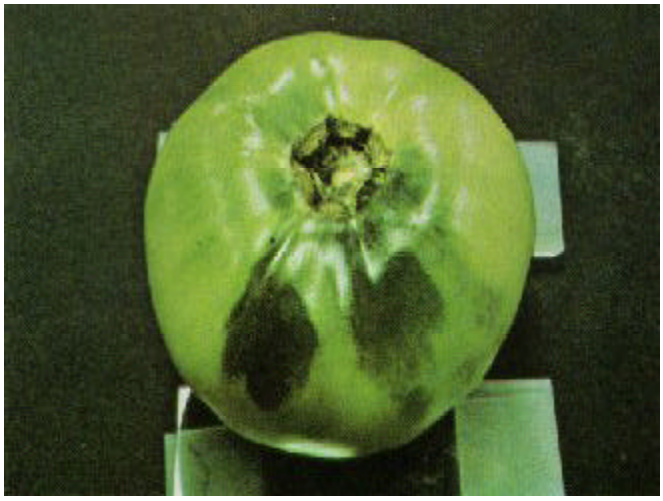

Figure 6. Early soft rot symptoms on tomato fruit.

Figure 7. Soft rot inside tomato fruit.

Figure 8. Soft rot in potato tubers.

Figure 9. Soft rot in lettuce leaf.