Compendium of Beet Diseases and Pests

SECOND EDITION

Edited by

Robert M. Harveson
University of Nebraska
Scottsbluff

Linda E. Hanson
USDA ARS
East Lansing, MI

Gary L. Hein
University of Nebraska
Lincoln

The American Phytopathological Society
Part III. Postharvest Deterioration of Sugar Beet

In climates that permit extended harvests, roots are processed shortly after harvest with little or no stockpiling. However, a short harvest during the autumn and the processing of stockpiled roots during the winter is typical in most regions where sugar beet is grown. Typical processing campaigns range from 100 days in areas with moderate winters up to 250 days in northern regions with cold winters. Most of the European crop is stored in on-farm clamps and delivered to the factory or a collection site shortly before processing. In North America, the harvested crop is delivered directly to central piling stations maintained by the processors and most of the crop is stored in outdoor piles 5–8 m high, 55–70 m wide, and up to 400 m long. During storage, diseases frequently cause significant sucrose loss. Most postharvest deterioration, however, is caused by respiration and the conversion of sucrose to nonsucrose carbohydrates.

Sugar loss begins at harvest and rapidly increases while a large portion of the crop is in storage. Although beets at the end of the campaign are in much poorer condition, one-half to two-thirds of the total postharvest sugar lost occur during the first 40 days of storage when storage piles are cooling and ambient temperatures are relatively high. In addition to the direct loss of sucrose during storage, sugar recovery rates decrease, factory slice rates decline, and the cost of producing a unit of sugar increases.

Storage Rots

Postharvest losses attributable to storage rots are erratic but can be considerable. Inoculum is abundant in the environment and frequently present in soil adhering to roots after harvest. Rot organisms not only degrade and consume sucrose but also produce compounds that interfere with sucrose extraction. *Phoma betae*, *Botrytis cinerea*, and *Penicillium claviforme* are widely acknowledged as storage rot pathogens. Fungi of lesser or local importance include species of the genera *Aspergillus*, *Alternaria*, *Chaetomium*, *Fusarium*, *Macor*, *Rhizopus*, *Sclerotinia*, *Stenphyllum*, *Pythium*, and additional *Penicillium* spp.

Bacterial storage diseases are rare, occurring only when conditions are unusually warm and oxygen has been depleted.

*Phoma betae* is an especially threatening storage rot pathogen because of a close association between its life cycle and the life cycle of sugar beet. It can be introduced on infected seeds and, once established, it survives on crop residue in fields and at piling sites. *Phoma betae* is capable of causing seedling blight, a leaf spotting disease, and a crown and root rot during the growing season (see Phoma Leaf Spot, Seedling Diseases, and Phoma Root Rot). The development of the sexual stage of *Phoma betae* (*Pleospora bjoerlingii*) on seed stalks allows the fungus to survive in seed production areas and could lead to the development of new virulent strains of the pathogen (see Phoma Leaf Spot: Fig. 15). Phoma storage rot may develop soon after the crop is harvested and placed in storage but usually is not a problem until the roots have been in storage for 10–12 weeks. Phoma storage rot typically begins in the center of the crown and spreads downward in a cone-shaped pattern into the taproot (Fig. 240). Rotted tissue is black and sometimes contains pockets with white mycelium. Spores are exuded from small, black, fruiting bodies (pycnidia) in a sticky, gelatinous matrix and disseminated by water and insects.

*Botrytis cinerea* is a widely distributed, aggressive storage pathogen that is capable of quickly rotting tissue over a wide temperature range. *Botrytis* storage rot can be identified by the presence of gray spore masses (Fig. 241 left and right) and dark brown to black, round sclerotia. The 2- to 5-mm-diameter sclerotia form in groups on grayish brown to black, rotted tissue (Fig. 242). *Botrytis cinerea* also produces dry spores that are disseminated by air movement through storage piles.

*Penicillium claviforme*, *Penicillium cyclopium*, *Penicillium funiculosum*, and *Penicillium variabile* have been identified as sugar beet storage pathogens. In most environments, *Penicillium claviforme* is the most prevalent. *Penicillium claviforme* can be identified by columnar tufts (coremia) tipped with green spore masses produced on brown, rotted tissue (Fig. 243). Spores are disseminated on air currents. Penicillium storage rot is frequently associated with wounds. *Penicillium claviforme* is not as aggressive as *Phoma betae* or *Botrytis cinerea*; however, extensive dissemination within a storage pile can compensate for the low pathogenicity and make it more destructive than *Phoma betae* or *Botrytis cinerea* in some environments.

Conditions before and after harvest and interactions among storage rot pathogens determine which pathogens predominate
and the storage rot severity. Warmer conditions generally favor rot development; however, each species and strains within species have an optimum temperature for development and are active over unique temperature ranges. *Phoma betae* strains differ by as much as 50% in the rate they destroy tissue, depending on temperature and storage period. *Botrytis cinerea* is only slightly influenced by temperatures ranging from 5 to 30°C. In contrast, rot caused by *Rhizopus* spp. is negligible at 5°C but more virulent than that caused by *Botrytis cinerea* at higher temperatures. *Penicillium claviforme* is able to decay roots at lower temperatures than is *Penicillium variabile*, giving it a competitive advantage under most storage conditions. *Aspergillus fumigatus* is capable of rapidly rotting roots following metabolic heating or composting but rarely causes problems under normal storage conditions. A bacterium, *Leuconostoc mesenteroides*, which produces gums that interfere with sugar refining, is often associated with *Aspergillus fumigatus*. Under moist storage conditions, rot caused by *Pythium ultimum* increases in severity, and the development of storage rot caused by *Pythium* spp. can be retarded by dry conditions. Desiccation during storage accelerates rot caused by *Phoma betae* when temperatures are above 10°C but has little effect at lower temperatures. Drought prior to harvest also may increase Phoma storage rot severity. *Penicillium claviforme* is an antagonist of *Botrytis cinerea*. This relationship may explain the low frequency of Botrytis storage rot in some areas. In contrast, *Penicillium* storage rot may occur in conjunction with rot caused by *Phoma betae*, and *Botrytis cinerea* and *Phoma betae* may occur together.

**Respiration**

Typically, 60–80% of the sucrose lost during storage is lost to respiration. Respiration rate is strongly influenced by temperature, and the respiration rate of stored roots generally declines with decreasing pile temperature until the roots freeze and respiration stops. Respiration rate is also influenced by temperature fluctuations near the freezing temperature of roots, -2 to -5°C, and transient increases in respiration rate have been reported when root temperatures were raised or lowered past -1 to 0°C.

Storage diseases and diseases present at harvest may exert an equal or greater impact on respiration rate than does temperature, if sufficiently severe. Elevated respiration rates have been documented in roots infected by the storage rot pathogens *Botrytis cinerea* and *Penicillium* spp. and in roots exhibiting symptoms of Aphanomyces root rot or rhizomania at the time of harvest. Generally, diseases increase respiration in proportion to their severity. Other storage and production diseases probably increase the respiration rate of stored roots, although their impact has not been determined.

Injury also increases storage respiration rate, with the increase in respiration rate directly related to the severity of the injury. Injury is typically incurred from harvest and piling operations but can also occur from frost damage. Frost injury occurs when ice crystals perforate cellular membranes. Damaged tissue is yellow to light tan with a water-soaked appearance (see Freeze Damage under Other Disorders; Fig. 228). Respiration rate typically increases within 24–48 h after injury and remains elevated for the duration of the storage period. Sucrose loss is greatest, however, during the first 7–10 days after injury when wound-induced respiration is maximal. Injury also impacts respiration rate by increasing the susceptibility of roots to opportunistic pathogens. Injury is a prerequisite for infection by *Botrytis cinerea* and *Penicillium* spp., and infection by *Leuconostoc mesenteroides* is facilitated by the cellular damage associated with frost injury.

**Nonsucrose Carbohydrate Accumulation**

Nonsucrose carbohydrates, including the invert sugars (glucose and fructose), raffinose, and the polysaccharide gums (dextran and levan), can accumulate during storage and decrease extractable sucrose yield. The formation of nonsucrose carbohydrates is directly responsible for reduced sugar yield since these compounds are synthesized from sucrose. Their impact on sucrose yield, however, is greatest during processing. Nonsucrose carbohydrates increase the loss of sucrose to molasses, increase color formation during juice purification, impede sugar crystallization and filtration, and slow factory operation.
Elevated invert sugar concentrations have been associated with infections of Leuconostoc mesenteroides and other opportunistic bacteria after frost injury and of the storage rot pathogens Botrytis cinerea and Penicillium spp. Invert sugar concentrations also increase during the storage of roots that exhibited symptoms of Aphanomyces root rot or rhizomania at harvest. Storage temperature and leaf regrowth affect invert sugar accumulation during storage, but these factors typically have a smaller influence than does disease. Invert sugars typically accumulate in roots stored at temperatures above 5°C and in roots exhibiting leaf regrowth.

Accumulation of raffinose, a trisaccharide formed by the enzymatic attachment of a galactose residue to sucrose, is promoted by nonfreezing storage temperatures of 3°C or less. Temperatures above 7°C typically cause raffinose content to decline.

The polysaccharide gums, dextran and levan, are high-molecular-weight polymers of glucose and fructose, respectively, that are formed by opportunistic bacteria, especially Leuconostoc mesenteroides, that infect frost-damaged or anaerobically stressed roots. In frost-damaged roots, gum formation typically occurs 3–14 days after frost injury and is preceded by an increase in invert sugars concentrations.

**Minimizing Postharvest Losses**

The success of sugar beet storage operations hinges on the condition of the crop, cultural practices employed during production, weather conditions at harvest and during storage, and pile management practices that require constant vigilance and the ability to respond to short-term environmental fluctuations and weather patterns that change from year to year.

**Management**

Cultural practices that produce uniform, adequate stands should be utilized. Uniform stands make it easier to adjust defoliators and harvesters so that all leaf material is removed, mechanical damage is minimized, and roots are adequately cleaned.

The use of disease-resistant varieties, appropriate cultural practices, crop rotations, and fungicides help minimize production diseases. When possible, roots from fields with severe disease problems should be piled separately and processed early in the campaign.

Roots should be harvested at temperatures below 13°C when possible. High temperatures increase respiration rate, storage rot prevalence and severity, and the time and pile ventilation required to attain the temperatures needed for sustained long-term storage.

Roots with little or no frost damage should be harvested. Frost-damaged roots should be allowed to "heal" for a few days at temperatures above freezing before being defoliated and harvested. The interval between defoliation and harvest should be minimized during periods of potential frost.

Mechanical damage should be minimized. Proper harvester adjustment and operation can minimize root damage.

If topping is practiced, only a small portion of the crown should be removed; the cut surface should have a diameter of 2.5–4.0 cm.

Piling operations should prevent concentrations of trash and dirt that may restrict airflow in portions of a storage pile.

Pile height should be limited. Pile height influences cooling rate and sugar loss in unventilated piles, with losses in tall (8.5 m) piles greater than those in short (6 m) piles.

Storage piles should be leveled immediately after piling. Leveling storage piles reduces their surface area and results in more uniform ventilation throughout the pile.

Pile temperatures should be lowered to 1.5–5°C by ventilation to reduce respiration losses and slow fungal growth. Spraying piles with lime or other coatings that reflect heat may also reduce pile temperatures. Aerial thermal (infrared) imaging can be used to identify hotspots, small areas in the pile with elevated temperatures that should be removed to minimize damage to adjacent roots.

A relative humidity of 95–98% should be maintained. High humidity minimizes storage deterioration but may be difficult to maintain.

Root exposure to direct sunlight or prevailing winds should be minimized. Piles should be oriented in a north–south direction. Pile coverings may be used to reduce the damage caused by freeze–thaw cycles and the desiccation of roots near pile surfaces.

In areas where winters are sufficiently cold, processors may extend their campaigns by freezing storage piles destined for processing late in the campaign. Thawing prior to processing must be avoided at all costs.

**Selected References**


(Prepared by K. Fugate and L. Campbell)