Potato Physiological Disorders—Internal Heat Necrosis[1]

Lincoln Zotarelli, Christine M. Worthington, Chad M. Hutchinson, Seth Byrd, Douglas Gergela, and Diane Rowland[2]

Potatoes are planted in North Florida beginning in late December when day length is short and soil temperature is relatively cool. As the season progresses, daylight hours lengthen and soil and air temperatures increase as the potato plant reaches key developmental stages (emergence, vegetative growth, tuber initiation, and full flower). Florida potatoes are typically grown in sandy, coarse-textured soils with a low water-holding capacity and high potential for nutrient leaching. Heavy rainfall potential during the growing season can cause mobile nutrients like nitrate-N to leach, often resulting in nutritional stress of the potato plant and initiation of physiological defects, such as brown center, hollow heart, and internal heat necrosis.

Internal heat necrosis (IHN) is a physiological disorder that causes an unacceptable browning of the tuber tissue and can cause economic losses to the grower (Stevenson et al. 2001). The three leading suspected causes of IHN in tubers are high soil temperature, inadequate soil moisture, and suboptimal plant nutrition, or a combination of these factors.

IHN is described as a physiological disorder caused by elevated soil temperatures during the latter stages of tuber growth and development (Stevenson et al. 2001). IHN is most common in sandy soils (O'Brien and Rich 1976). It can be especially severe and symptoms can worsen as the growing season progresses (Stevenson et al. 2001). Tubers growing near the soil surface may experience high temperatures before vine death or harvest and thus are very susceptible to development of the disorder (Hardy 1996; Stevenson et al. 2001). If the vines and leaves are still actively growing and green during this period of elevated temperatures, water and nutrients are actually translocated out of the tuber to supply the plant. This mass export of water and nutrients stresses the vascular system within the tuber tissue until the vascular ring eventually deteriorates and becomes necrotic. This leads to oxidative conversion of organic phenolics to guinone in the tuber flesh and results in the browning of the internal tuber tissue.

Low levels of calcium may also play an important role in IHN occurrence. Several studies have found a link between reduced calcium levels in tubers and increased

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2. Lincoln Zotarelli, assistant professor, Horticultural Sciences Department; Christine M. Worthington, former graduate student, Horticultural Sciences Department; Chad M. Hutchinson, former associate professor, Horticultural Sciences Department; Seth Byrd, graduate student, Agronomy Department; Douglas Gergela, research coordinator, Florida Partnership for Water, Agriculture & Community Sustainability at Hastings; and Diane Rowland, associate professor, Agronomy Department; UF/IFAS Extension, Gainesville, FL 32611.

IHN incidence (Davies 1998; Sterrett and Henninger 1991). Calcium is transported to the tubers through the phloem while leaves receive it through the xylem. The xylem is the primary transport pathway for calcium in the plant. Therefore, the calcium content is often higher in leaves compared to tubers (Davies 1998), thus possibly contributing to IHN development. Reduced soil moisture could also play a role in IHN occurrence as it would decrease the plant's overall water use, thus restricting calcium transport (Stevenson et al. 2001).

In tubers, necrotic areas are mostly found in and around the vascular ring, usually coalescing and radiating to the center (pith). The symptoms are more prevalent at the bud (apical) end of the tuber than at the stem end (Figure 1). The exterior of the tuber in some varieties may exhibit symptoms along with internal necrosis, but this is not always the case, and some varieties never exhibit visible exterior symptoms (e.g., 'Atlantic' potatoes) (Sterrett, Henninger, and Lee 1991).

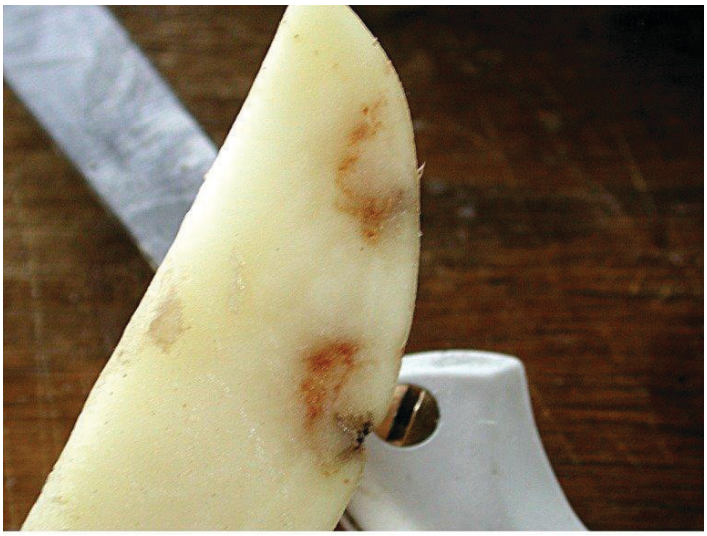

Figure 1. Internal heat necrosis symptoms in fresh market potato 'Red LaSoda'.
Credits: Chad Hutchinson, UF/IFAS

'Atlantic' is the prevalent chip potato variety planted in North Florida, making it economically vital to the area. Major chipping processors request 'Atlantic' for its chipping qualities, such as its light chip color, relatively high yield, and high specific gravity (Webb et al. 1978). However, 'Atlantic' is susceptible to IHN. In a study by Henninger, Sterrett, and Haynes (2000) about the relationship between IHN and potato characteristics, larger tubers experienced greater occurrence and severity of the disorder. Of the 19 cultivars involved in the study, 'Atlantic' was found to be most inclined to the development of the disorder and had the most severe IHN cases (Henninger, Sterrett, and Haynes 2000).

Internal necrosis has also been referred to as internal brown spot (IBS), chocolate and rust spot, internal browning, and internal brown fleck (Sterrett and Henninger 1997). Though they have several similarities, internal heat necrosis and internal brown spot are recognized as two separate disorders (Christ 1998; Stevenson et al. 2001). Unlike IBS, which is reported to occur throughout the growing season, IHN of 'Atlantic' has been reported to occur during the mid to late bulking period of the tuber. Worthington et al. (2007) demonstrated that IHN in Florida production is triggered by heavy rainfall events that could result in leaching and nutritional conditions that stress the plant early in the season, combined with relatively high minimum daily temperatures late in the season (Yencho et al. 2008).

In 2003, 'Harley Blackwell' was released by the USDA, which may provide chip potato growers an alternative to 'Atlantic'. During 12 seasons of evaluation, marketable yield of 'Harley Blackwell' was 6% lower than 'Atlantic' (287 and 304 cwt. acre^{-1}, respectively). Additionally, the specific gravity of 'Harley Blackwell' (1.075) was slightly lower than 'Atlantic' (1.081) but was still acceptable, according to chipping standards (BARC/USDA 2004; USDA 1978), and 'Harley Blackwell' was resistant to IHN as well as hollow heart (Sterrett 2009). Other IHN-resistant clones are currently being evaluated at the University of Florida's Partnership for Water Agriculture and Community Sustainability in Hastings, Florida. The "Chipping Potato Variety Trial" (2010) showed that the 'Snowden' variety also has a lower IHN incidence, along with hollow heart and brown center, compared to 'Atlantic'. 'Snowden' also had a higher total and marketable yield, as well as specific gravity, than 'Atlantic' ("Chipping Potato Variety Trial" 2010).

Although adverse weather conditions during the growing season cannot be avoided, growers do have options that can help reduce the incidence of tubers with IHN. Nutrient balance should be properly managed to reduce plant stress early in the season, particularly during rapid growth and development. This is especially true for calcium, which should be supplied at the depth at which rooting and tuber development occur (Stevenson et al. 2001). Planting IHN-resistant clones also helps reduce IHN incidence. 'Harley Blackwell' can be planted for late-season contracts when warmer, wetter weather conditions are prevalent and IHN development in 'Atlantic' is exacerbated. Preventing shallow tubers from being exposed also helps prevent IHN occurrence, while optimal irrigation amounts and increased soil cover can reduce the excess temperatures that shallow tubers experience (Stevenson et al. 2001). However, if irrigation is being used, soil moisture should be monitored

carefully so that favorable conditions are not provided for other disorders or diseases (Stevenson et al. 2001). Stevenson et al. (2001) also states that the presence of an adequate vegetative canopy is beneficial in reducing the IHN incidence perhaps because of the shading effect and the lowering of the temperature above the tubers. Lastly, harvesting the tubers so that exposure to high temperatures is avoided or minimized and storing tubers in appropriate conditions are also methods to help reduce IHN incidence (Stevenson 2001).

Additional Resources

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