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Brown Center and Hollow Heart in Potatoes

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Potatoes with brown center or hollow heart are considered poor quality for both fresh and processing markets. Potatoes with either of these disorders do not process well, are unattractive to the consumer and are not easily sorted from unaffected potatoes in the same lot. For these reasons, potatoes with brown center or hollow heart do not command high market prices.

Occasionally severe symptoms of brown center and hollow heart occur in particular fields or with certain varieties of potatoes and become a concern to growers. Crop management practices, such as soil temperature and moisture monitoring, seed spacing, fertilizer, variety selection and others, can be used to reduce or eliminate these disorders in potato crops.

This publication describes the symptoms and causal agents of brown center and hollow heart and discusses the management practices effective in controlling them.

Symptoms

Brown center is characterized by pith tissues near the center of the tuber turning a light to dark brown color (Fig. 1). The shape of the discolored tissue is circular to elliptical, usually with a smooth, diffuse border. The size of brown center discolorations in the tuber range from 1/8 inch to over 1 inch in length. Brown center may be present in tubers of all sizes. Larger tubers usually have more tuber pith tissue affected.

Electron microscopic studies have revealed that intense cellular changes occur in brown center tissues. Cellular cytoplasm is nearly gone, no distinguishable organelles, membranes or starch grains remain, and cell walls are inordinately thick and irregular. Tuber flesh afflicted with severe brown center consists of dead pith tissues.

Cells in the pith area of potato tubers that have brown center symptoms may eventually split apart to form a

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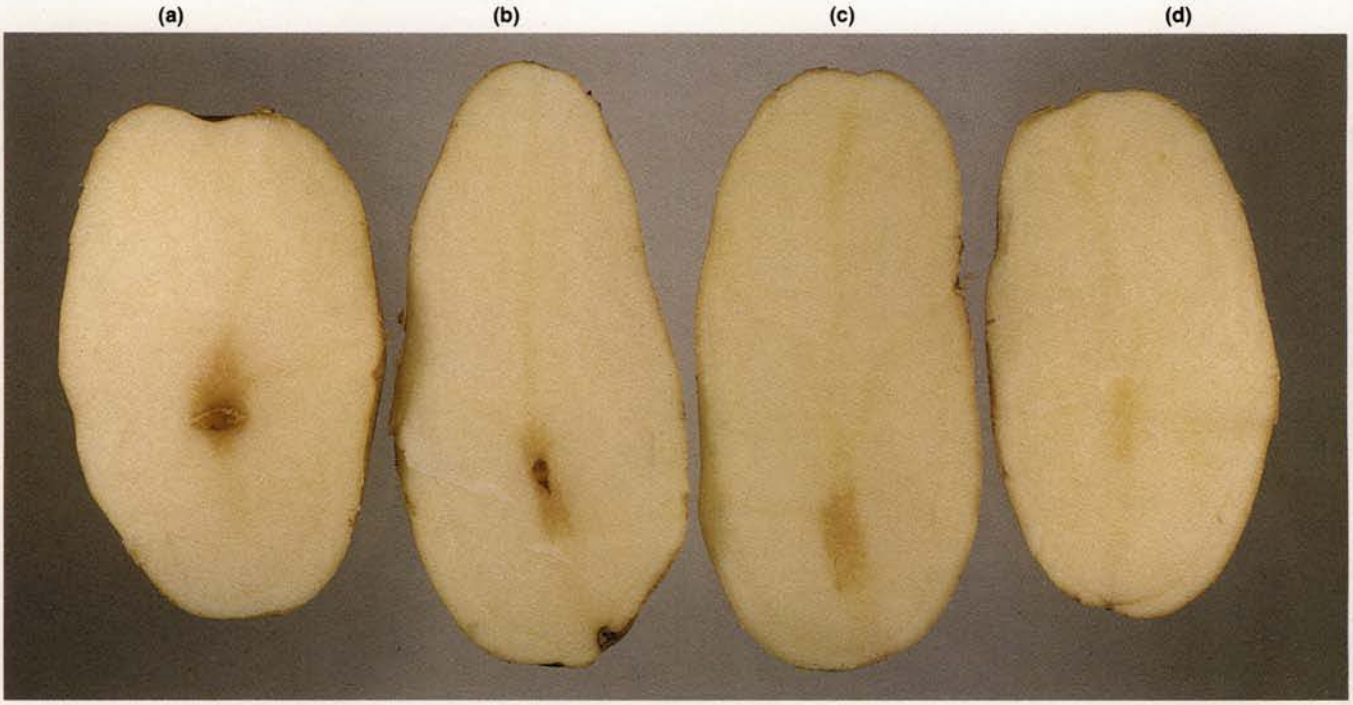

Fig. 1. Brown center and hollow heart disorders in Russet Burbank potatoes. From left, (a) stem-end hollow heart with a transverse cavity, (b) stem-end hollow heart with a longitudinal cavity, (c) and (d) brown center alone.

Fig. 2. Close up view of stem-end hollow heart. Brown center will always accompany stem-end hollow heart.

hollow cavity near the center of the tuber. For this reason, brown center is also called incipient hollow heart. These hollow cavities are called stem-end hollow heart and occur in tubers of all sizes. Hollow heart cavities may be either star-shaped or lens-shaped with transverse or longitudinal orientation (Figs. 1 and 2).

Stem-end hollow heart cavities are always surrounded by brown center-afflicted pith tissue. More than one cavity may appear in a tuber. Stem-end hollow heart arises from brown center tissues if adverse soil and environmental conditions, or rapid or uneven growth rates, continue after brown center develops. Often a tan layer of suberized tissue resembling a new periderm develops on the inside of hollow heart cavities within the tuber.

Similar cavities without the presence of brown center may occur later in the growing season closer to the bud-end in tubers. These are called bud-end hollow heart. Norgold Russet and Lemhi Russet potato varieties usually develop only bud-end hollow heart. Russet Burbank potatoes develop stem-end hollow heart much more frequently than bud-end hollow heart.

Causal Factors

Brown center and hollow heart are physiological disorders of potatoes. Physiological disorders are not directly caused by disease organisms but are initiated by varietal, climatic, soil or management factors. In addition, brown center and hollow heart are not transmitted from one potato to another and do not cause these disorders in progeny tubers if present in the seed.

Several specific factors have been identified as important in the formation of these two disorders, including soil temperature, soil moisture, tuber size and tuber growth rate. Other factors such as soil fertility and plant density appear more closely related to hollow heart and at present are thought only indirectly associated with brown center.

Two theories have been proposed to explain hollow heart initiation in potatoes. The first suggests that stresses after tuber initiation cause the potato plants to reabsorb water, minerals and carbohydrates from tubers, and then rapid enlargement of the tubers initiates hollow heart cavities. The second theory suggests that rapid tuber enlargement alone, without any stresses, initiates hollow heart. The mechanisms of both brown center and hollow heart formation and development are currently not well understood.

Temperature and Stage of Growth

Cool soil temperatures are a major factor initiating brown center in Russet Burbank potatoes. Soil temperatures ranging from 50° to 55°F continuously for 5 to 7 days during or for several weeks after tuber initiation are sufficient to begin brown center formation. Both brown center and hollow heart are more predominant when soil temperature is less than 60°F during and for 1 month after the start of tuber initiation.

Soils that are more likely to have low temperature during tuber initiation would therefore be more likely to have brown center develop in a potato crop. Cooler temperatures would probably occur on soils with northern aspect and high slope, light color or low organic matter content, heavy texture or high water content.

Soil Moisture

Soil moisture significantly affects brown center. The greater the percent available soil moisture during tuber initiation, the higher the incidence of brown center (Fig. 3). Research conducted in other states has demonstrated that soil moisture above 80 to 85 percent field capacity at tuber initiation increases both brown center and stem-end hollow heart. Brown center has been observed to be more severe in wetter, lower areas of potato fields. Fields with a history of these disorders in potato crops should have careful irrigation management to avoid excess water application during early plant development.

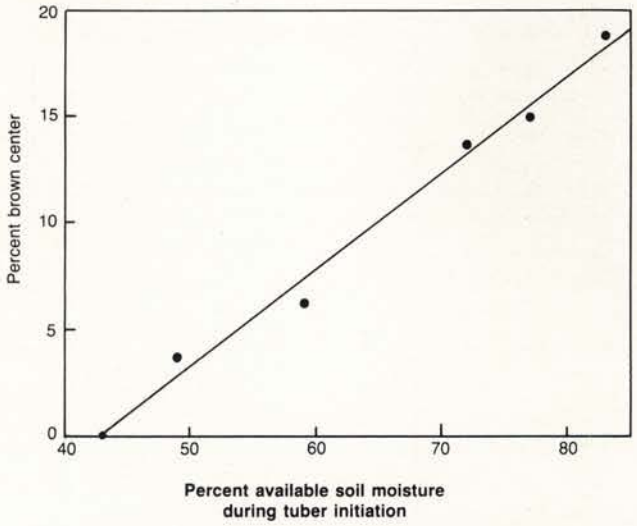

Fig. 3. Relationship between percent brown center and available soil moisture during tuber initiation in Russet Burbank potatoes. Higher amounts of available soil moisture may promote development of brown center in potatoes.

Soils that have dried to 20 to 40 percent of field capacity for a 3-week period after tuber initiation develop less brown center or stem-end hollow heart in potato tubers. Allowing fields to dry down to these low soil moisture levels is not recommended since potato plants will be severely stressed and secondary growth (knobbiness, pointed stem end) may be more severe. A better water management strategy would be to avoid excessive soil moisture from irrigations during early stages of plant growth, but also not to allow soil water reserves to fall below 65 percent available moisture.

Planting Date

Later planting dates usually result in less incidence of brown center, probably due in part to warmer soil temperatures during the tuber initiation phase of growth. Later planting dates produce less total yield, but higher yields are undesirable unless also accompanied by high quality. Idaho field trials have demonstrated that later planting dates may reduce the incidence of stem-end hollow heart (Fig. 4).

Bulking Rate

Tubers with fast bulking rates are more likely to develop brown center. Not all fields bulk at the same rate and neither do all tubers under a plant. During and shortly after tuber initiation, the larger tubers under each plant may have faster bulking rates than smaller tubers and are more likely to have brown center.

Tuber Size

The size of tubers is important in the initiation of brown center. Plants that are just hooking to those with golf ball size tubers are sensitive to brown center initiation in the Russet Burbank variety. Potatoes larger than this generally do not have much brown center development under field conditions, perhaps because soil temperatures are usually above critical levels at later stages of tuber growth.

Hollow heart is frequently found in larger or severely malformed tubers in the field. Both hollow heart and brown center can be found in small tubers, however, particularly if tuber growth rates are high. Tuber size is considered less important to the formation of hollow heart than tuber growth rate.

A field study was conducted in 1986 to observe the occurrence of brown center in potato grade sizes late in the growing season. Brown center was most abundant in 6 to 10 ounce U.S. No. 1 grade and undersize (less than 4 ounce) potatoes. These two sizes accounted for over 70 percent of this defect in all of the potatoes graded (Fig. 5).

Many growers have reported brown center dissipates as the growing season progresses. In this study, brown center that had initiated in small tubers did not dissipate during the bulking season in late August or September, but did dissipate during the maturation period in September (Fig. 6). The nature and causes of dissipation are not well understood or documented.

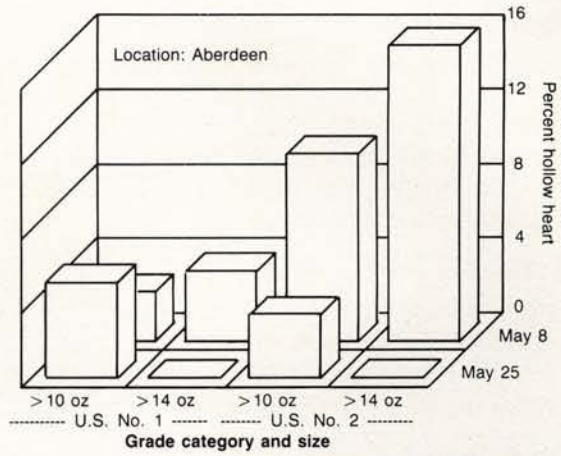

Fig. 4. Influence of planting date on incidence of hollow heart in Russet Burbank potatoes. Less hollow heart was present in potatoes planted at the later date. In this study, more hollow heart was found in U.S. No. 2 potatoes planted early.

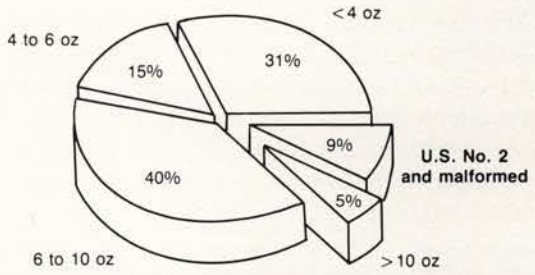

Fig. 5. Average distribution of brown center in Russet Burbank potatoes by grade size in a field survey taken from August 21 to September 19, in Aberdeen. Although brown center may occur in potatoes of all grades and sizes, over 70 percent of this disorder was found in undersize (less than 4 oz) and midsize (6 to 10 oz) U.S. No. 1 potatoes in this study.

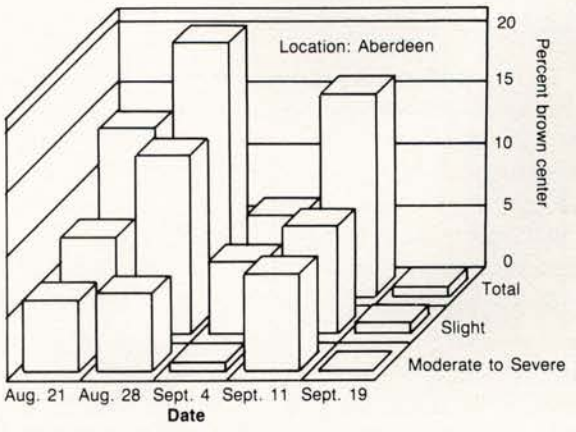

Fig. 6. Average distribution of brown center in Russet Burbank potatoes by sampling date in a field survey taken from August 21 to September 19, in Aberdeen. A slight rating would be a faint, light brown discoloration. A moderate to severe rating would be distinct, medium to dark brown discoloration. In this study, brown center appears to dissipate during tuber maturation in the fall.

Plant Density

Planting density also influences the occurrence of stem-end hollow heart. Larger drop spacing during planting increases the incidence of hollow heart (Fig. 7), probably due to the larger average size and bulking rate of each tuber compared to potatoes planted with smaller drop spacing.

Fertilizer

Nitrogen applied during the growing season influences the development of brown center and hollow heart. In a recent field trial, the same total amount of nitrogen was split-applied by several different methods: all preplant, 15 pounds N per week, 30 pounds N per week and 30 pounds of N every 2 weeks. Three irrigation regimes providing low (60 to 70 percent), normal (65 to 100 percent) and high (80 to 90 percent) available soil moisture levels for the entire growing season were superimposed onto the nitrogen application methods.

Incidence of brown center and hollow heart was greater when the nitrogen application rate was high (30 pounds N per acre) and injected less frequently (once every 2 weeks). Nitrogen fertilizer applied at lower rates and more frequently (15 pounds N per acre once each week) reduced the development of brown center and hollow heart even when soil moisture conditions were constantly high (Fig. 8).

Potatoes with hollow heart have been found to have significantly higher levels of calcium in the stem-end than the bud-end. Scientists believe, however, that this is an effect of hollow heart, and that this relocation of calcium is caused by stressful conditions. Foliar or soil applications of calcium fertilizer during the growing season are not considered effective control measures against hollow heart because this element is relatively immobile in plant tissue and therefore would not translocate into tubers. In addition, most soils in Idaho used for potato production already have abundant amounts of available calcium.

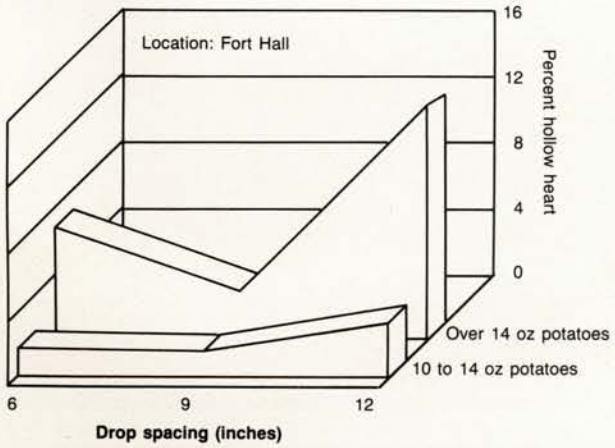

Fig. 7. Influence of planter drop spacing on incidence of stem-end hollow heart in Russet Burbank potatoes. Hollow heart develops more frequently in fields planted with large drop spacing and in large potatoes.

Field trials have been conducted to evaluate the effect of boron fertilizer on brown center and hollow heart. Control of these disorders with foliar-applied boron was erratic at best. This suggests other factors are more important in the initiation and control of these disorders. Boron fertilizer is not recommended as an effective method to reduce brown center or hollow heart under field conditions.

Potassium nutrition has been cited as a factor influencing the incidence of stem-end hollow heart. Potassium fertilization on marginally deficient soil has reduced hollow heart in field trials.

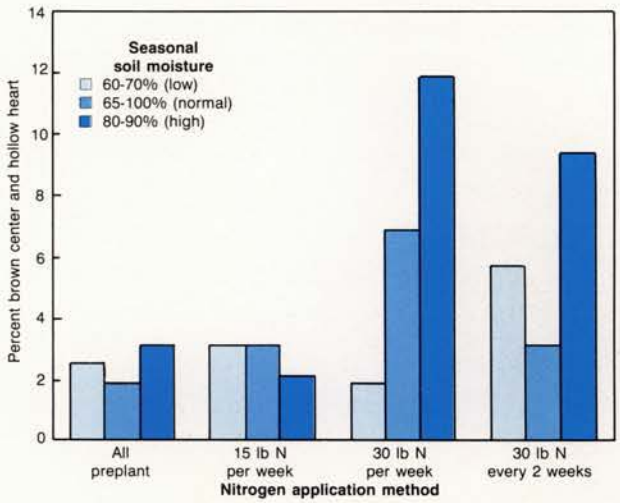

Fig. 8. Influence of nitrogen and soil moisture on development of brown center and hollow heart in Russet Burbank potatoes. Each treatment had the same total amount of nitrogen applied during the growing season. Frequent nitrogen applications applied at lower rates reduced the occurrence of brown center and hollow heart even under high soil moisture regime.

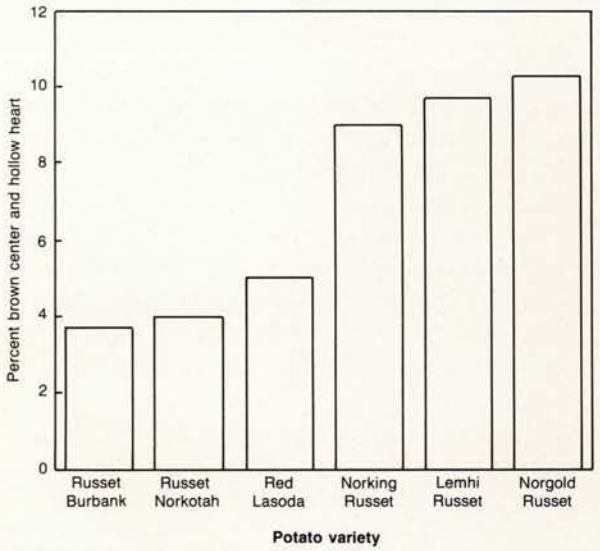

Fig. 9. Average percent hollow heart and brown center in potato varieties in the Western Regional potato variety trials, 1985-87.

Bud-end Hollow Heart

Rapid regrowth of fields that have been under water stress has resulted in large increases in bud-end hollow heart in Lemhi Russet potatoes. Gradual return to normal soil moisture levels, which slowly increases the bulking rate, is thought to be an effective method to avoid this type of hollow heart caused by soil water deficit. Bud-end hollow heart is not common in Russet Burbank potatoes in Idaho. The causal agents of bud-end hollow heart are not well understood.

Summary

The following management practices will help to reduce the incidence of hollow heart and brown center:

1. Choose later planting dates on fields prone to low soil temperature or excessive wetness.
2. Avoid having only a few rapidly growing tubers under each plant. When planting Russet Burbank potatoes, use healthy seed that will produce 2 to 3 stems and approximately 8 to 12 tubers under each plant. Check behind the planter during planting to make sure skips are not excessive. Closer drop spacing, large seedpieces and low incidence of seedpiece decay will promote uniform plant stands and help reduce hollow heart.
3. Maintain an even rate of tuber growth during the bulking season. Use proper fertilizer rates and timing. Avoid trying to stimulate high tuber bulking rates during or immediately after tuber initiation. Lower nitrogen application rates applied frequently during the growing season may help reduce the incidence of brown center and hollow heart.
4. If soil temperature is less than 60°F during tuber initiation, avoid excess irrigations that keep soil moisture above 80 percent field capacity. Allow soil moisture to drop to 65 percent field capacity before irrigating during this critical stage of plant growth.
5. Re-evaluate water management practices. Check nozzles and line pressures to ensure water is applied in the correct amount. Use alternative irrigation scheduling methods (for example: water balance, tensiometers and feel) simultaneously to ensure water is applied in the proper amount and at the proper time. Consider using reservoir basin tillage to reduce water runoff to lower elevation areas within the field. Provide uniform soil moisture and fertility to promote uniform tuber bulking rates.
6. Calcium or micronutrient fertilizer applications during the growing season are not considered an effective control measure for brown center or hollow heart. Boron foliar sprays are not recommended. Adequate, but not excessive, potassium fertilization may reduce hollow heart in some situations.
7. The Butte potato variety is resistant to hollow heart. Most other varieties grown in Idaho are at least moderately susceptible to this disorder. Norgold Russet, Lemhi Russet and NorKing Russet varieties are more susceptible to brown center and hollow heart than Russet Burbank. Advanced selections in the University of Idaho/USDA potato breeding program have demonstrated more resistance to hollow heart than the Russet Burbank variety.

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