Heat Necrosis: A Hot Topic

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Introduction

Internal heat necrosis (IHN), also known as internal brown spot (IBS), is a physiological disorder of potato tubers. It is characterized by brown patches of tissue within the border of the vascular ring. The severity of IHN can vary, from small flecks that are difficult to distinguish from other internal disorders (such as virus-induced net necrosis), to large blotches encompassing nearly the entire tuber. Neither the tuber skins nor the vines of potatoes with IBS display any symptoms; tubers must be cut to observe IBS. The brown patches of tissue darken when potatoes are fried, making affected tubers unsuitable for processing into chips or fries. IBS is more of a problem in the mid-Atlantic and southeastern United States, but can also be a concern in the Pacific Northwest, particularly the southern Columbia River Basin. Many varieties have been shown to be susceptible to IBS in at least some years and locations, including the well-known 'Russet Burbank', 'Chieftain', 'Yukon Gold', and 'Atlantic', and the newly released 'Clearwater'.

Causes

Environment

The causes of IBS have been difficult to determine. The growing environment is certainly a major factor. High temperatures, particularly at night, seem to play the biggest role, although dry conditions, particularly early in the growing season, have also been implicated. Later harvests tend to have higher levels of IBS than earlier ones, suggesting that the stresses leading to IBS are cumulative. However, the research in this area is incomplete, and a reliable temperature screening regime would help breeders identify potential new varieties that are resistant to IBS. In any case, the environmental causes are the most difficult for the grower to control.

Calcium

A significant amount of research has been done on the role of calcium in the development of IBS. To date, the results have been rather conflicting. This is at least partly the result of using different varieties, different soils, and different methods of applying calcium. Recently, a genetic engineering approach was used to measure the effect of calcium on IBS. A calcium-binding protein (CBP) from corn has been shown to act as a calcium 'sponge', allowing plants to retain calcium, and better cope with certain types of stress. The gene for this protein was incorporated into 'Atlantic' potato through the use of *Agrobacterium tumefaciens*, a soil-dwelling bacterium that can insert DNA into the genomes of plants. Unexpectedly, CBP-transformed plants tended to have higher yields than normal 'Atlantic' potato (Figure 1). Two lines showed higher concentrations of calcium in *leaves* (Figure 2), but no differences were seen in tuber calcium levels. In addition, CBP-transformed lines tended to have *higher* levels of IBS (Figure 3). While further research is underway with the CBP plants, this experiment has certainly not been able to put the calcium question to rest. Calcium does seem to be involved in

the development of IBS, but the mechanism is unclear, and supplementing commercial plantings with calcium to avoid IBS is not recommended.

Genetics

The fact that some varieties are frequently observed to develop IBS, while others do not, suggests that genetics is an important factor. Recently, a three-year study was undertaken at North Carolina State University to attempt to quantify the genetic factors involved in IBS. In a breeding population derived from an IBS-susceptible and an IBS-resistant parent, the vast majority of progeny showed little to no symptoms, suggesting that development of IBS-resistant varieties should not be too difficult. In addition, we observed that early maturity (as measured by vine senescence) was associated with lower levels of IBS. Along with these encouraging signs, we also noted that some clones displayed significant yearly variability in IBS symptoms. Therefore, although genetic resistance to IBS should be relatively easy to incorporate into new varieties, screening in multiple years is important.

Conclusion

IBS can be a significant problem in certain production areas, especially with susceptible varieties. While all three factors (environment, nutrition, and genetics) influence the disorder, it is difficult to modify the growing conditions, and nutrient management is poorly understood, and may not have significant impact. For the grower, the genetic solution (i.e. resistant varieties) is the best option for limiting the potential impact of IBS. Information on the performance of various varieties and advanced breeding lines vis-à-vis IBS can be found at http://www.ars.usda.gov/main/docs.htm?docid=3019.

References

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Sterrett SB and MR Henninger. 1997. Internal heat necrosis in the mid-Atlantic region—influence of environment and cultural management. American Journal of Potato Research 74:233-243.

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Figures

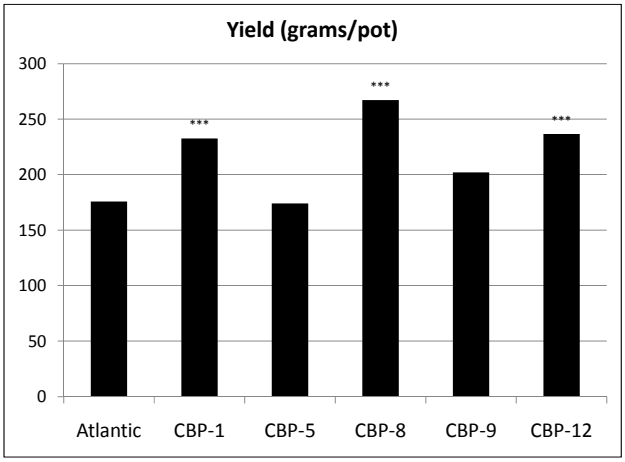

Figure 1. The effect of the calcium-binding peptide on yield.

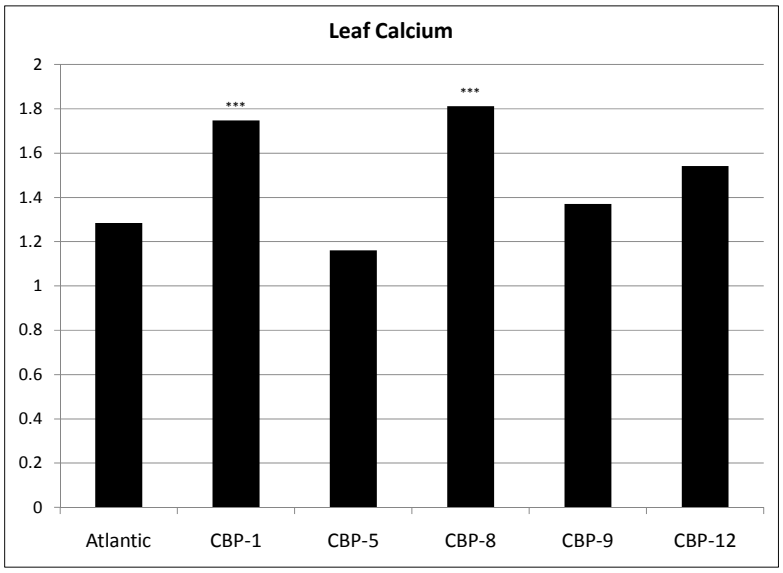

Figure 2. Effect of the calcium-binding peptide on *leaf* calcium.

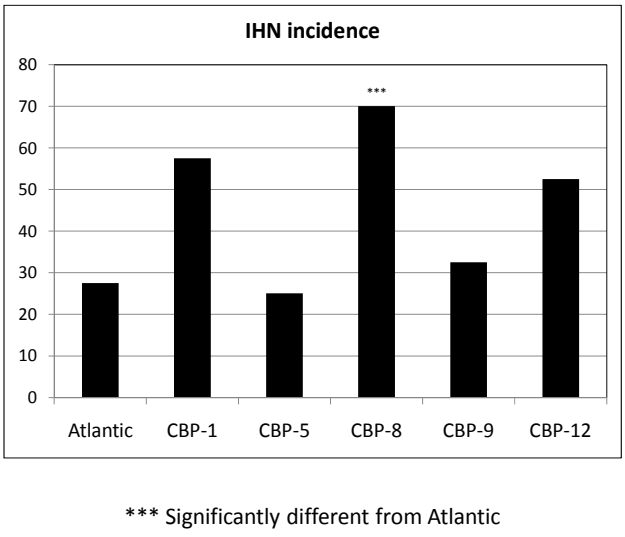

Figure 3. Levels of IHN incidence in normal and CBP-transformed 'Atlantic' tubers. Incidence is the percentage of a group of potatoes with IBS symptoms.