The relationship between internal brown spot and the calcium content of tubers

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The non-pathogenic tissue necrosis visible as brown flecks in parts of the tuber parenchyma can sometimes be confused with damage due to virus disease, but this physiological disorder is often the result of suboptimal growing conditions. It is also known as internal brown spot (IBS), internal browning, internal physiological necrosis and rust spot and similar to another disorder known as internal heat necrosis. The main difference is that IBS can appear at any time during tuber growth and internal heat necrosis occurs during the later stages of tuber bulking. This internal tissue damage, due to conversion of organic phenolics to quinone, negatively affects the tuber quality which can result in commercial losses. It is usually not apparent from the external surface of the tuber or detected through leaf analysis.

particularly important. This might also explain why internal brown spot is reported more often for crops grown in sandy soils as the water holding capacity of these soils are considerably lower and the potential of temperatures increasing rapidly is also higher.

Growth stage

The most critical period in terms of the occurrence of internal brown spot is during tuber initiation and the early stages of tuber development. With knowledge of the soil moisture levels and temperature during the first 60 days after planting the incidence of internal brown spot has been predicted fairly accurately. There also seems to be a link between the physiological age of tubers and their susceptibility to IBS with physiological ‘younger’ tubers showing symptoms more often. The symptoms also tend to increase in immature tubers stored at high temperatures.

Calcium

Of all the nutrient elements calcium seems to play the most important role in determining tubers’ susceptibility to the cell damage associated with IBS and a clear relationship between the calcium content of tubers and the prevalence of IBS is noticeable. Low tuber calcium levels are linked to a higher incidence of necrosis of the tissue. Increasing in-season application of calcium can increase the calcium content of tubers, both in the peel and inner parenchyma cells and this can decrease the incidence of IBS. Calcium is very important for maintaining the integrity and function of cell membranes and cell walls and adequate tuber calcium content will therefore enable plant cells to resist the cell damage due to stress conditions leading to IBS. The cells in the affected areas also have fewer starch granules than other cells in

Environmental factors

Besides the fact that there is large varietal difference with regards to the incidence of IBS, air and soil temperatures, soil type, soil moisture content and fertilization have also been associated with this disorder. The number of tubers affected by IBS are usually higher in years when the growing temperatures are for the most part high and the soil moisture levels low. Under these conditions water and nutrients can in fact be translocated from the tubers to the haulm, resulting in weakened and damage cells in the tuber cells. It is the soil temperature in particular that is important and it has been suggested that it is the number of consecutive days of high temperatures and also the night time temperature that is
the parenchyma. This is usually observed when the cell membrane integrity is compromised.

Factors other than the application level however will affect the uptake of calcium and specifically the uptake of calcium by the tubers, possibly explaining why in some instances supplementation with calcium fertilizers do not result in higher tuber calcium levels. This is where the relation between climate, calcium and IBS can be found. Calcium uptake is driven by transpiration. It is taken up and transported with water through the xylem predominantly to the leaves where the transpiration rate is highest. Tubers, having a considerably lower transpiration tempo will therefore usually have substantially lower Calcium tissue concentrations.

High calcium application levels when conditions are not optimal for calcium uptake, for instance waterlogged or drought conditions and high soil temperatures, will then not have the desired effect. Even when not stressed, more susceptible varieties tend to have lower tuber tissue calcium concentrations which link to the increased risk of tissue damage under sub-optimal growing conditions. There is even a difference in the incidence of IBS in the different tubers of the same plant. This can be explained if we consider that the calcium taken up by each tuber will be determined by conditions around that specific tuber since it is only the calcium taken up by the stolon roots closest to each tuber that ends up in that specific tuber. It also seems that the most important time for increasing the calcium content of tuber tissue is from tuber initiation to early tuber growth, correlating with the growth stage most sensitive to IBS. To increase the tuber calcium concentration we therefore need to focus on the correct placement and timing of supplemental calcium fertilizers. There are other nutrients, including phosphate, sulphate and manganese, which may be as important in reducing the incidence of internal brown fleck and warrants further research.

**Preventing internal brown spot**

Since affected tubers cannot be detected and removed through examining external symptoms, all possible precautions is necessary to prevent this disorder from downgrading the whole batch quality. Some of the most important factors to minimize losses due to IBS include:

- Adjusting the planting and harvesting time to avoid high soil temperatures during the tuber initiation phase.
- Avoid stress conditions during tuber initiation and early tuber development through adequate fertilization and irrigation.
- Enhance tuber calcium uptake by supplementing during tuber initiation and early tuber development.
- Avoid conditions that will limit the availability of calcium, including cation competition, low pH and any conditions that can damage root growth.
- High temperatures during storage can further increase the risk of tubers developing internal brown fleck.