CONSEQUENCES OF HEAT AND WATER STRESS

Mike Thornton, Bill Bohl and Kiran Shetty

Temperature and soil moisture content are two of the most important factors influencing potato plant growth, tuber yield and quality. Potato vines and tubers have a fairly low optimum temperature for growth (60 to 75 °F). Temperatures above the optimum may delay tuber initiation, reduce tuber bulking and speed the rate of vine senescence. High temperatures also greatly increases crop water use, resulting in rapid depletion of soil moisture. Therefore, under field conditions, heat stress is often accompanied by water stress. The combination of heat and water stress together can cause a greater reduction in tuber yield and quality than either stress alone.

When stress occurs, the incidence of physiological disorders and diseases tends to increase. Stress conditions that result in early vine death also expose tubers to prolonged periods of fluctuating temperatures, a condition that can result in tubers that are "overmature". Overmature tubers tend to accumulate more reducing sugars in storage, lose weight more rapidly, and tend to sprout sooner than tubers harvested shortly after vine death. Silver scurf is also more prevalent on tubers left in the ground for a long time after vine kill or vine senescence. Potatoes from fields that have been stressed require special attention in storage to reduce the incidence of decay and loss of processing quality.

Physiological Disorders

Malformed Tubers - Mid to late season stress increases the incidence of tubers shaped like dumbbells and tubers with pointed bud ends. Knobby tubers are also common when fluctuations in temperature and moisture conditions lead to periods where tuber growth stops and then starts again. Malformed tubers tend to sustain damage more easily than normal shaped tubers during harvest. This means that extra care is required to get the crop into storage without excessive damage.

Second Growth and Heat Sprouts - Second growth (many tubers on one stolon) and heat sprouts (leafy shoots) result when soil temperatures are above 75 °F. When stressed tubers are exposed to light, a heat sprout will be produced. Heat sprouts do not continue to grow after harvest. However, tubers with heat sprouts may break dormancy sooner than normal tubers. Tubers that express heat sprouts or second growth have low internal quality.

Presented at the Idaho Potato School January 26, 1995.

Elevated Sugars - Stressed tubers commonly have high sugars in the bud or stem ends. A high sugar level in one portion of the tuber will result in dark end or sugar end fries. Tubers with high sugars and low specific gravity are very difficult to recondition during storage. If tubers are exposed to low temperatures at harvest, the sugar problem will increase, resulting in unacceptable fry quality.

Blackspot and Shatter Bruise - Tubers grown in warm soils may be more susceptible to blackspot bruise because of the tendency to become dehydrated (limp). Tubers can be rehydrated after vine kill by applying a conditioning irrigation at least four days prior to harvest. If the tubers are highly hydrated (crisp) at harvest because of continuous high soil moisture conditions, shatter bruise susceptibility may increase. Under these conditions, shatter bruise damage can be very severe if tuber pulp temperatures fall below 50 °F.

Storage Management

One of the most critical periods in potato storage management is the initial 3 to 4 weeks following harvest. Several factors should be taken into consideration when making storage management decisions: **Crop maturity** (heat stressed and overmature tubers require special attention); **Harvest conditions** (high or low pulp temperatures can change the storage conditions required during the initial storage period); **End-use** (storage conditions required for optimizing tuber quality of fresh and processed potatoes may differ); **Potential for disease development** (presence of disease causing organisms will influence management during the early storage period); and **Disorders** (presence of tubers with either external or internal physiological disorders will influence early season storage management decisions). Unfortunately, no one set of initial storage conditions will be right for all situations.

Cooling Period

Overmature potatoes that are exposed to fluctuating initial storage temperatures have a tendency to develop high sugar levels. Fluctuations in storage pile temperature occur during the initial 3 to 4 weeks as a result of: 1) day to day fluctuation in incoming tuber pulp temperature, 2) supply air temperatures that change dramatically between day and night, 3) harvesting and storage loading being extended due to unexpected delays, and 4) storage doors staying open for extended periods of time.

Potato tubers that are overmature require a gradual stabilization of the pile temperature. Incoming tuber pulp temperatures should be monitored closely. An initial pulp temperature of 60 °F or less is preferred, with the supply air temperature set no lower than 55 °F. Stabilizing the pile temperature at 55 °F can be accomplished by selecting the number of fans to be run at any given time and the length of time fans are operated. The higher the incoming tuber pulp temperature, the higher the volume of air needed to stabilize the pile temperature. At times, fans may have to be run during the day. In large storage buildings it may be advantageous to run at least one or two fans continuously. It

is important to regularly check tuber temperature at the top and bottom of the pile. When the difference between tuber pulp temperature at the top and bottom of the pile is 1 to 2 °F the pile temperature has stabilized. The time required to bring the entire pile down to the initial curing temperature should be considered as part of the total 3 week time required for curing. Tuber respiration rates will increase with tuber temperature, tuber age and stress. Overmature tubers respire faster than mature tubers, even after wound healing has occurred. These conditions require special attention to ventilation and circulation during the holding period to prevent the occurrence of hot spots.

Wound Healing

Wound healing conditions of 55 °F and 95% relative humidity are especially critical for overmature potatoes because aging reduces the tuber's ability to heal wounds. Overmature potatoes wound heal slowly at temperatures below 55 °F. At temperatures above 60 °F, storage diseases increase at a rate much faster than the rate of wound healing.

Sprout Inhibition

Overmature potatoes are likely to sprout sooner than mature tubers. This is the result of the shorter dormancy than in potatoes that have not been stressed. Because of the shorter dormancy period, a sprout inhibitor may need to be applied soon after the curing period is complete. Application of a sprout inhibitor before the pile settles may also enable the chemical to be distributed more uniformly through the pile. Overmature potatoes should not be stored for long periods. If overmature potatoes must be placed in the same storage with mature potatoes, it would be advisable to place the overmature tubers at the end of the storage where they can be removed early if necessary.

References

Mikitzel, L. and R. Thornton. 1994. Harvest and storage of potatoes that have been exposed to high growing season temperatures. Spud Topics 40(7).

Ojala, J. 1987. Effect of water stress on potato growth and development. Proc. of the University of Idaho Winter Commodity Schools 19:151-161.

Thornton, M.K. 1989. Effect of heat stress on Russet Burbank growth and development. Proc. of the University of Idaho Winter Commodity Schools 21:147-150.