EFFECT OF LATE SEASON SOIL MOISTURE ON RUSSET BURBANK TUBER MATURITY AND STORABILITY

by
Robert L. Wample, Robert E. Thornton, Cathryn A. Braue

A common practice in Washington late in the growing season is to store freshly harvested potatoes for 10 days prior to shipping to market. This practice is considered necessary to assure adequate tuber quality when they arrive at the market. Tuber quality in this case is defined as a tuber that has minimal fresh and dry weight loss, is resistant to decay organisms and therefore retains both the appearance and internal qualities necessary for consumer acceptance. Storage then is associated with the development of physical and perhaps biochemical characteristics which result in a more "mature tuber" which will withstand shipping and handling.

Weight loss following tuber harvest and during the early stages of storage is a major problem of the potato industry and is a component of tuber quality. Weight loss is attributable primarily to water loss from the tuber either through the skin or through wounds. It has been estimated that weight loss due primarily to water loss from "immature" or freshly harvested tubers may amount to as much as 30% of the original tuber weight in 10 days or less under relatively conservative evaporative demand conditions (Burton 1978). Therefore, even if the weight loss was considerably less than this, it is easy to recognize the economic implications of this problem. A critical factor then is the condition of the tuber at harvest with respect to its skin or periderm. A commercial definition of a "mature" tuber is one harvested from a senescent vine while another definition refers to tubers that have been stored for 2 weeks or longer. For our research and for the purpose of discussion in this paper we will use the former definition. The characteristics of a mature tuber harvested from a senescent vine vary somewhat but generally exhibit the following traits: 1) a fully developed periderm (skin); 2) are no longer growing, 3) are low in total sugars, and 4) the skin is "set" so that it is not easily separated from the cortex (Wilcockson et al. 1980, Yamaguchi et al. 1966). A tuber exhibiting these traits should show minimal weight loss, be resistant to diseases and withstand the shipping process with minimal damage. Current production practices in Washington are not conducive to the development of all of these characteristics. It was therefore of interest to us to examine the possibility of increasing tuber maturity by changing the production practices and hence reduce weight loss and wounding during and after harvest.

A survey of the literature indicates that a number of factors may contribute to tuber skin development and hence influence the development of a mature tuber. Included in these factors are: soil type, irrigation level, irrigation frequency and consequently soil moisture level, rates of fertilization, and condition (vigor) of the vines. Of these factors irrigation is one that can be manipulated and contributes directly or indirectly to the status of several other factors and was therefore chosen for study. The effect of reduced late season irrigation on potato skin development, thickness, resistance to water loss, and wound healing ability was the primary intent of the research.

Russet Burbank potatoes were grown in a greenhouse at 79°F day temperature and 59°F night temperature. Seed pieces were planted in 14 in. (diameter) x 10. (deep) pots filled with a soilless mix of peat:pumice:sand (55:30:15). A 20:20:20 fertilizer solution was applied to the plants daily through the irrigation water.

Eighty days after planting, the plants were segregated into seven blocks. During the next 45 days, half of the plants in each block were irrigated with the amount of water equivalent to that lost through evapotranspiration (full ET). The remaining plants in each block received

This Presentation is part of the Proceedings of the 1984 Washington Potato Conference and Trade Fair.

only 50% of the estimated ET (partial ET) for the first four harvests (90 to 111 days after planting). No water was applied after the fourth harvest (111 to 125 days) except to prevent excessive dehydration.

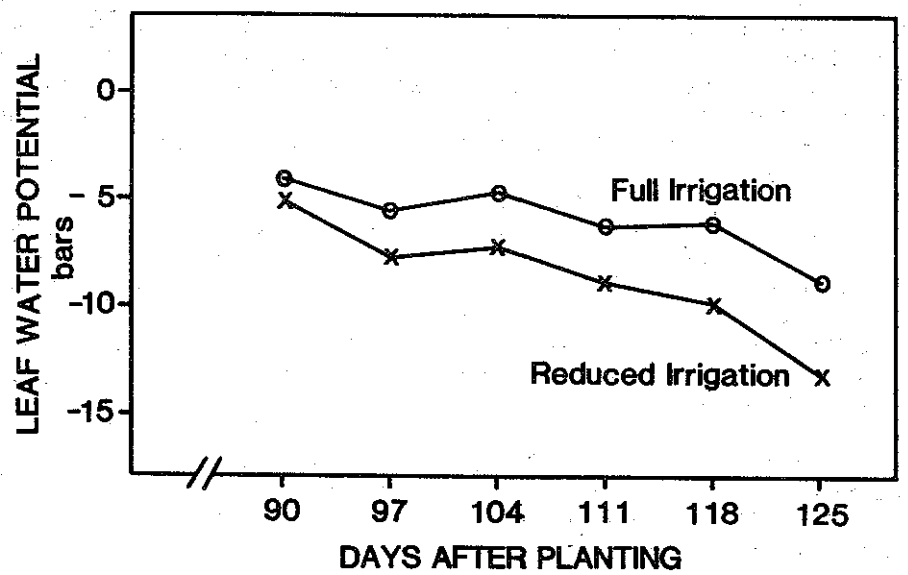
Evapotranspiration losses were determined gravimetrically. Four full ET plants were weighed each day, and the average weight loss over the 24 hour period was used to determine the daily evapotranspirational loss.

Plant stress during the six week harvest period was monitored by measuring soil water potential, leaf water potential, and leaf diffusive resistance. These measurements were taken one day prior to each harvest, the first set occurring 89 days after planting.

The first of six weekly harvests occurred 90 days after planting. To prevent periderm injury, the tubers were gently washed to remove the soil, then allowed to air dry on a rubber mesh. At each harvest, tuber native periderm resistance to water loss was determined by measuring the amount of weight loss which occurred over a four-hour time period. After measuring the native periderm resistance, four partial ET tubers and four full ET tubers were randomly selected from the total treatment population and stored for ten days at 40°F. Following storage, periderm resistance was measured again.

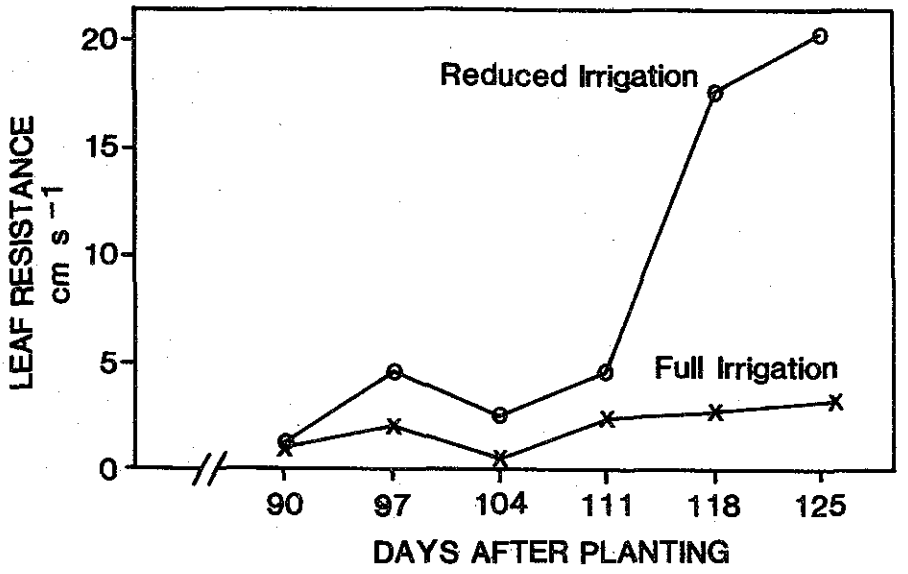
During the first 90 days of growth, all plants were maintained in a well watered condition and this is demonstrated in Figure 1 by the similarity of leaf water potentials for both treatments (ca. 5 bars). After this time as water stress began to develop in the reduced irrigation treatment the leaf water potential began to decline and reached a low point at 125 days after planting -13 bars indicating significant vine water stress. Other symptoms of water stress were the senescence of lower leaves and mid-day wilting with very slow recovery. Although fully irrigated plants showed a decline in leaf water potential, these plants did not show signs of leaf senescence or wilting.

Figure 1.



Leaf resistance to water loss shown in Figure 2 is an additional indicator of water stress. The rapid increase in leaf resistance 118 and 125 days after planting is the result of complete withholding of water after the 111 day harvest to induce vine dehydration and senescence. Thus the data in Figures 1 and 2 clearly show the development of plant water stress and the accompanying vine stress conditions.

Figure 2.



Tubers collected from plants harvested at these dates showed little change in resistance to water loss until severe water stress began to develop at 118 and 125 days after planting (Figure 3). At 118 days after planting tubers from stressed plants show approximately a 60% increase in resistance to water loss and at 125 days nearly 150% increase. Since these tubers were handled very carefully to prevent damage (wounding), this increase in resistance had to be the result of an increase in periderm (skin) thickness or chemical composition (deposition of suberin or waxes) which was stimulated by water stress. Using this information we can estimate the weight loss difference between these two types of tubers. An uninjured tuber weighing 8 ounces having a resistance similar to that for a tuber from a well-watered plant 125 days after planting (23.2 s/cm) would lose 0.27 ounces in the first 24 hours after harvest if stored at 60°F and 90% relative humidity. A tuber similar to the one at 125 days and reduced irrigation, under the same conditions would lose only 0.05 ounces in the same time. On an individual tuber basis this doesn't seem so significant but when calculated on the basis of 30 ton per acre and a 150 acre circle valued at $65.00 per ton the weight loss is equivalent to $9,872.00 from the well-watered tuber case and $1,828.00 from the reduced-water tubers for a difference in value of $8,044.00 per circle for the first 24 hours after harvest. If we make the assumption that weight loss diminishes to zero 10 days after harvest in both cases, the value of the loss would be $54,285.00 (835 tons/circle) for the well-watered tubers and $11,344.00 (174.5 tons/circle) for the tuber from the reduced irrigation treatment. These data and calculations demonstrate an ability to reduce weight loss by reduced irrigation that result in significantly higher dollar return from a given acreage.

Another possible benefit that was not examined was a reduction in wounding and/or skinning as a result of a better skin set in the tubers from plants treated with reduced irrigation. This possibility needs to be examined.

We did examine the wound healing ability of freshly harvested tubers from both treatments and the results are shown in Figure 4. There appears to be a general increase in the wound healing ability of discs cut from tubers from reduced irrigation plants.

Holding tubers in storage for 10 days reduced any differences in wound healing ability between tubers from full and partially watered plants (Figure 5). The variability between harvest dates was also reduced, supporting the use of the commercial practice of a 10 day storage after harvest prior to shipping.

Figure 3.

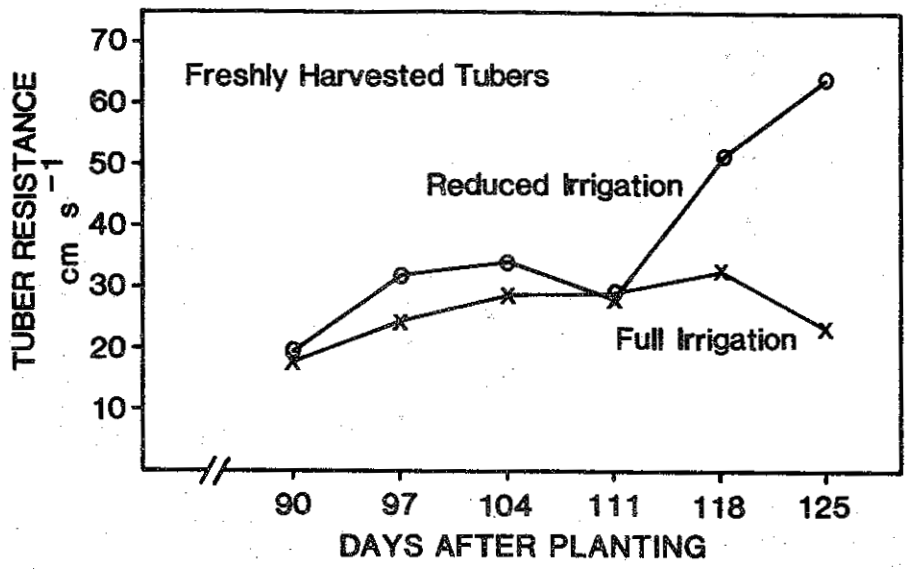


Figure 4.

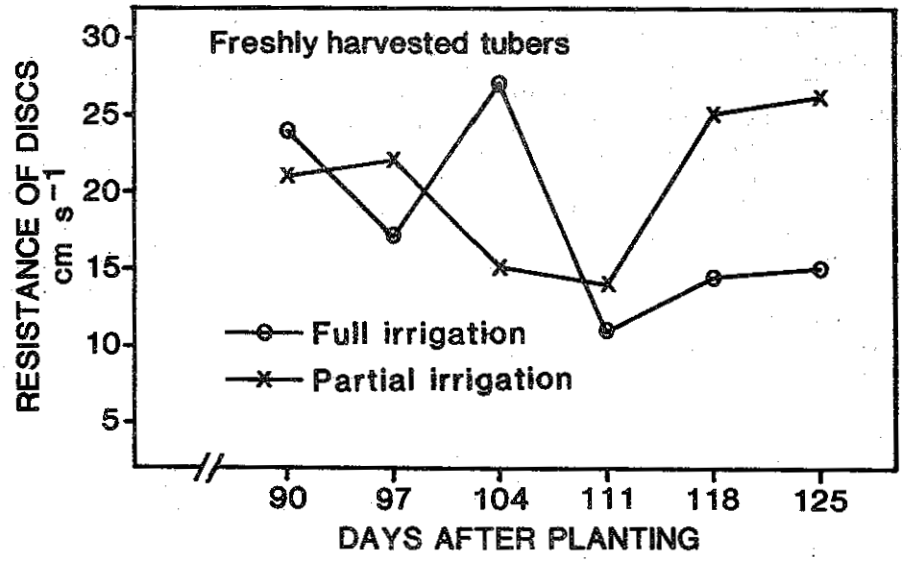
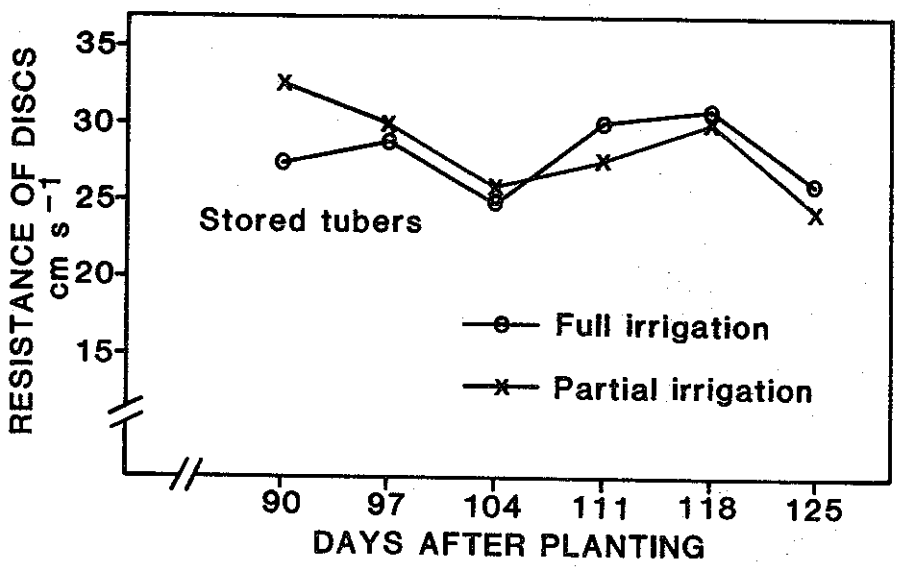


Figure 5.



In summary, it appears that reduced late season irrigation of potatoes may have a beneficial effect on tuber periderm resistance to water loss. This should result in higher shipping weights and thus greater profits to the grower and the shipper. Reduced irrigation did not significantly improve the wound healing ability of tubers while storage for 10 days did increase wound healing ability. Thus it would appear that a combination of reduced late season irrigation followed by storage may result in tubers that are more mature at harvest and which will store and ship better than those from fully irrigated plants.

Preliminary data not presented suggested that tubers from reduced irrigation plants developed better wound healing ability faster than tubers from fully irrigated plants. This, although not confirmed, might allow for reduced storage period after harvest and be of some economic value. If this is verified, reduced late season irrigation would seem to have a double benefit to potato production in Washington.