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Russet Potato Variety Response to Applied Irrigation

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Proper irrigation scheduling and application is critical to the production of high yielding, high quality potato crops. Potato yields decline precipitously when the crop is under irrigated. Yields may also be significantly reduced with over irrigation, particularly in the presence of serious foliar, wilt or tuber rotting diseases. Potato crop quality is also impacted by periods of either deficit or excessive soil moisture. Alternating periods of too-wet and too-dry result in misshapen tubers and severe loss in crop value.

Over and under irrigation can be avoided by tracking weather based estimates of crop use. This method is highly accurate but, requires the development and use of locally adapted crop water use coefficients. In this method, estimates of daily evapotranspiration from a reference crop (ET_o) are calculated from detailed local weather information. These ET_o estimates are then multiplied by a crop coefficient (K_c) to calculate the daily water use of the crop (ET_c).

$$ET_c = ET_o \times K_c$$

Such coefficients (K_c's) are well established for Russet Burbank potatoes and are used to accurately predict crop water needs of that cultivar. However, there is little information to confirm that Russet Burbank coefficients are appropriate for newer potato varieties. Certainly, crop water use coefficients need to be adjusted for earlier maturing varieties, which should use less water because of a shortened growing season. Appropriate K_c's for the standard early variety Russet Norkotah have been developed by the Intermountain Research and Extension Center (IREC).

Field research was conducted to determine if water use requirements of new late season russet varieties are similar to Russet Burbank under Klamath Basin conditions. Likewise, research was conducted to compare crop water use of the early standard variety Russet Norkotah to water requirements of four Russet Norkotah strains. If water use requirements are similar to the standard varieties, then K_c's developed for the standards may be used in scheduling irrigations for the newer varieties.

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Procedures

Field irrigation research was conducted in 2002, 2003 and 2004 at IREC in Tulelake, California. Specifically designed irrigation laterals were installed in the field such that decreasing amounts of irrigation water were applied to potato rows located at increasing distances from the laterals. Irrigation water was applied to target rows in amounts consistent with estimated water requirements of the Russet Burbank variety. Rows on either side of the target row received greater or lesser amounts of water depending on distance from the lateral (figure 1). Each year, one trial was established for late maturing varieties with a second trial conducted for early season cultivars. In 2002, the late season varieties included Russet Burbank, Klamath Russet and Gem Russet. In 2003, the new variety GemStar Russet was substituted for Klamath Russet because of a short-age of Klamath Russet seed. In 2004, the late varieties tested were Russet Burbank, Klamath Russet and GemStar Russet. In 2002 and 2003, the early season varieties tested were Russet Norkotah and Russet Norkotah selections, 112 and 223. In 2004, two new Russet Norkotah selections, 3 and 8 were evaluated along with Russet Norkotah as the

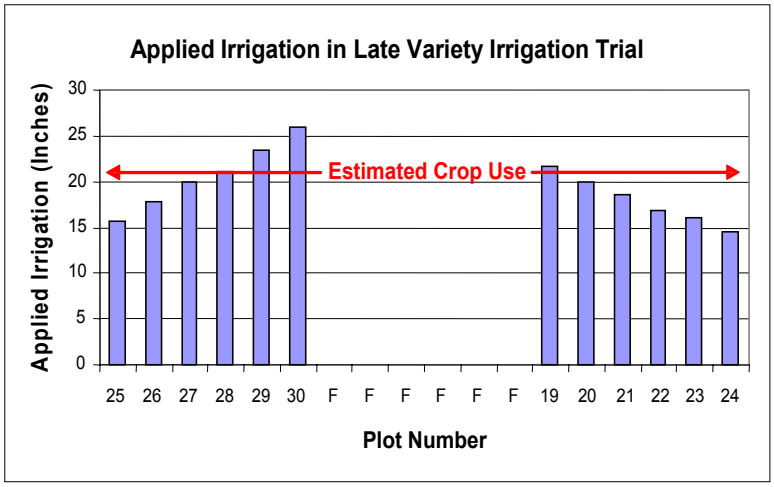

Figure 1. An example of the seasonal irrigation treatment in line source experiments.

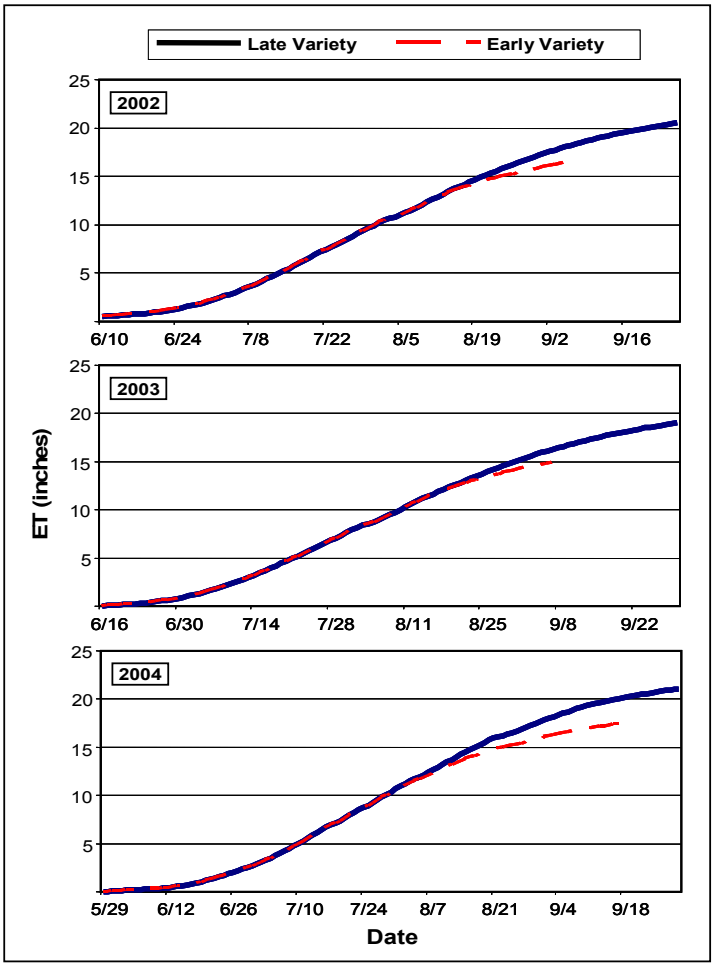

Figure 2. Estimated evapotranspiration (crop water use) for late (Russet Burbank) and early (Russet Norkotah) potato varieties planted May 21 in 2002, May 28 in 2003, and May 12 in 2004.

standard early variety. Daily reference crop evapotranspiration (ET_o) estimates were calculated using California Irrigation Management Information System (CIMIS) weather data for Tulelake. Potato crop water use was estimated using IREC developed crop coefficients for Russet Burbank (for late varieties) and Russet Norkotah (for early varieties). The resulting estimates of accumulated evapotranspiration (ET_c) are plotted in figure 2 for each year. In 2002, total seasonal ET_c was estimated at 20 inches for the late varieties and 16 inches for the early season varieties. In 2003, the trials were planted a week later and estimated seasonal ET_c accumulations totaled 19 inches for late varieties and 14.5 inches for the early varieties. In 2004, the evapotranspiration estimates were 21 inches and 17 inches for the late and early variety trials, respectfully.

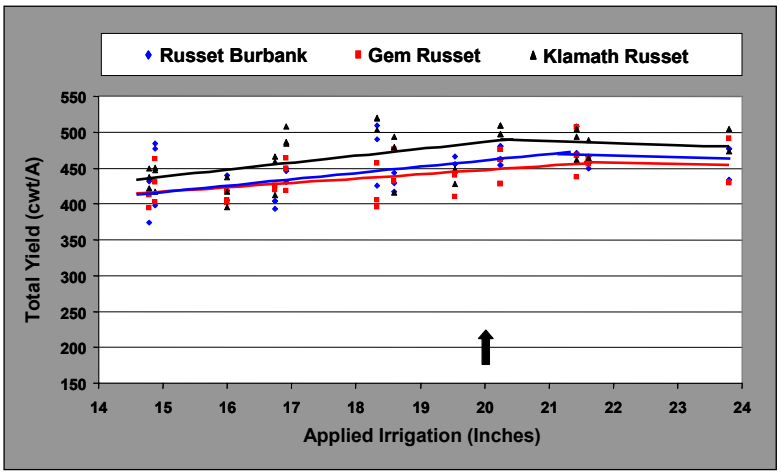

Figure 3. Total yield response of late potato varieties to applied water in 2002 line source experiment. Arrow at estimated crop Et_c of 20 inches.

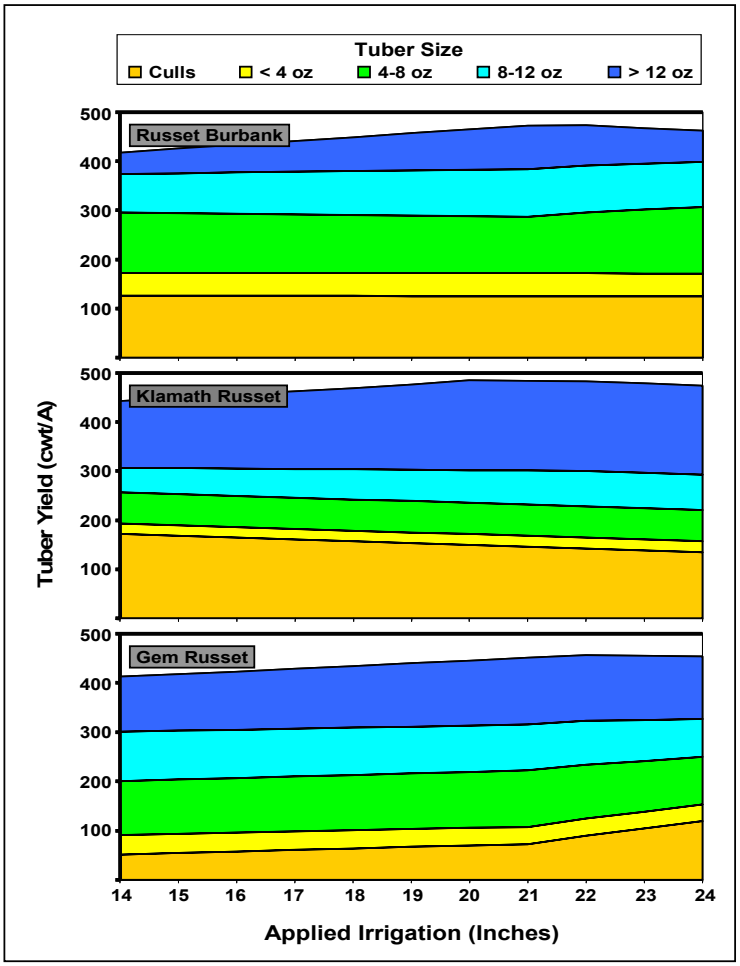

Figure 4. Tuber yield, size and grade for late potato varieties in the 2002 line source experiment.

In each of the experiments, four replicated plots of each variety were planted parallel to the line source irrigation system. Each plot consisted of six, 45 foot long, 36 inch wide potato rows with each row receiving a differential measured amount of water per irrigation. Potatoes were grown to maturity using standard fertilizer, cultural and pest management practices for the area. At maturity, tubers were harvested from each row in

each plot and sorted for yield, size and grade. Relationships between seasonal totals of applied water and tuber yield and grade were evaluated using linear regression analysis.

Results

2002

Total yield responses of the late varieties to applied water are summarized in figure 3. The affect of irrigation on Russet Burbank yield was similar to the responses recorded in previous research trials. Total yields increased with each increment of applied water up to the point that crop ET_c needs were fully met. Yields then de-clined slowly with water applica-tions above 20 inches per season. Klamath Russet and Gem Russet responded in a similar fashion with peak yields occurring at or near the 20 inch full season water applica-tion. The highest total yields were produced by Klamath Russet followed by Russet Burbank and Gem Russet. The use of accepted crop coefficients for Russet Burbank resulted in reasonably accurate prediction of Russet Burbank water needs and appeared to work equally well for the other late varieties.

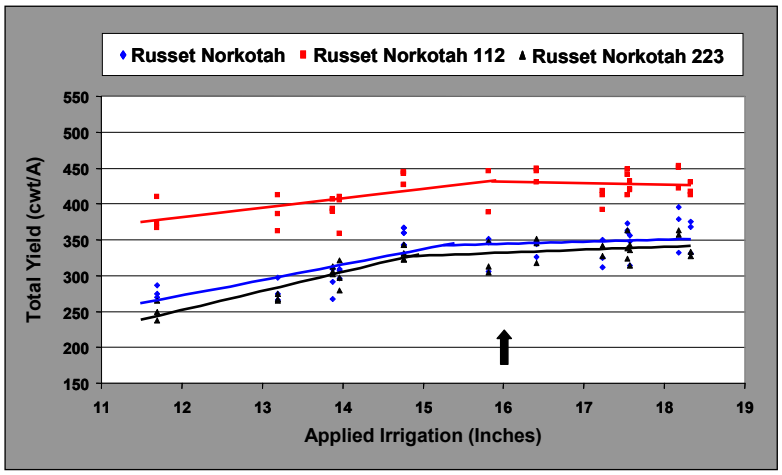

Figure 5. Total yield response of early potato varieties to applied water in 2002 line source experiment. Arrow at estimated crop Et_c of 16 inches.

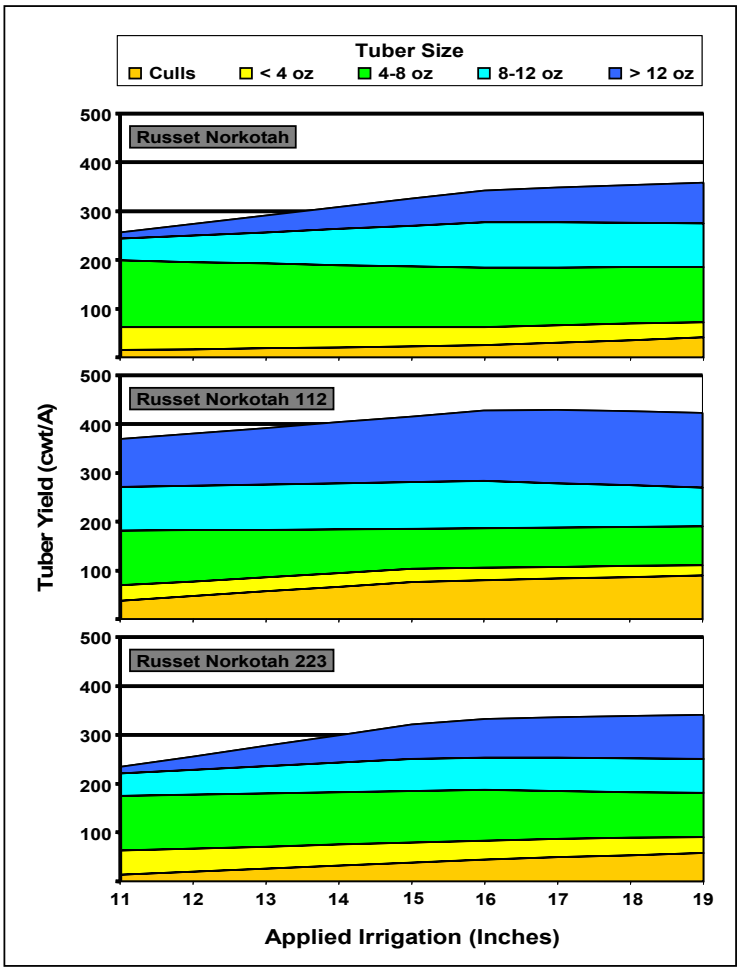

Figure 6. Tuber yield, size, and grade for early potato varieties in the 2002 line source irrigation experiments.

In figure 4, tuber size and grade responses to applied water are illustrated for Russet Burbank, Gem Russet and Klamath Russet. The primary effect of increased applied water on tuber grade was a significant increase in the

yield of large tubers (>12 oz). This was particularly true for Klamath Russet. This variety probably should have been planted at a plant density higher than the 10.5 inch in-row seed piece spacing used in this trial.

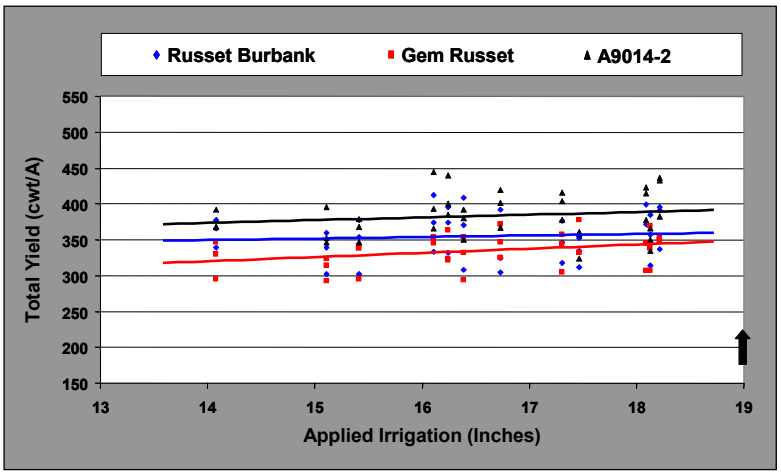

Figure 7. Total yield response of late potato varieties to applied water in 2003 line source experiment. Arrow at estimated crop Et_c of 19 inches.

The total yield response to irrigation by the early varieties is plotted in figure 5. Yield responses followed similar patterns as the late varieties, but with lower irrigation thresholds. Total yields of the early varieties tended to peak between 15 and 16 inches of applied water. The best yields were produced by Russet Norkotah selection112 with significantly lower yields by Russet Norkotah and Russet Norkotah selection 223. Verticillium wilt was prevalent in the trial and may have affected the relative yields of these varieties. Interestingly, the yields of Russet Norkotah and selection 223 tended to increase slightly with water applications over the apparent 15 to 16 inch threshold. This reaction may have been a response to heavy Verticillium infection.

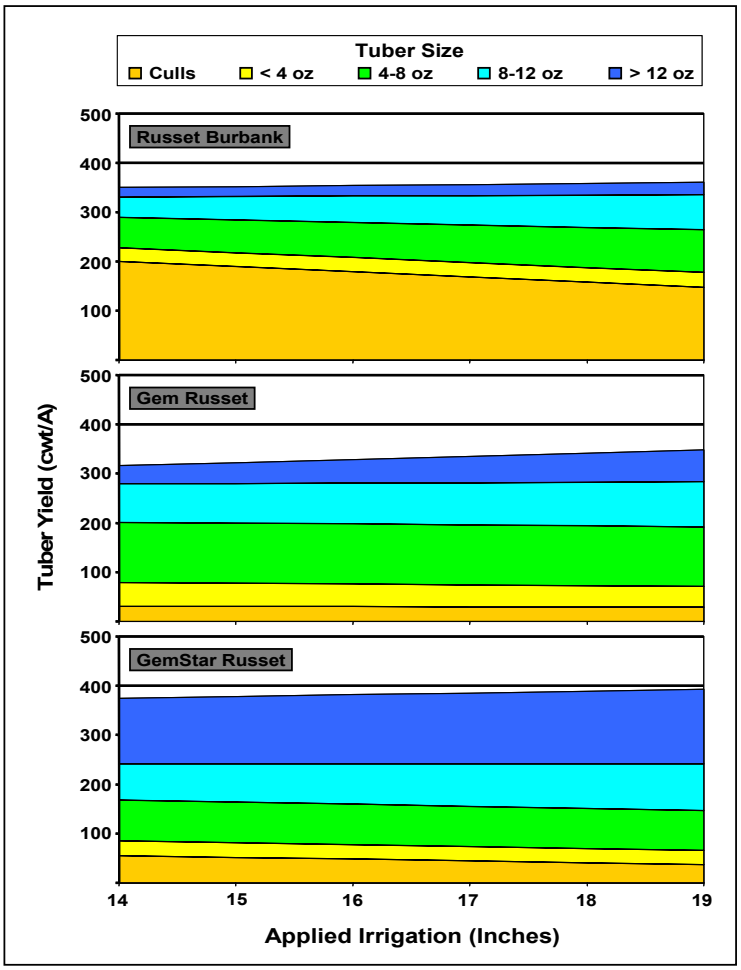

Figure 8. Tuber yield, size, and grade for late potato varieties in the 2003 line source irrigation experiments.

The effects of irrigation on early variety tuber size and grade are illustrated in figure 6. Like the late variety response, the major yield effect of irrigation was to increase the yield of large sized tubers (>8 oz and > 12 oz).

2003

While the estimated water use for potato crops was similar in 2002 and 2003 (figure 2), the yield response in the early and late variety trials was quite different between the two years. The change in response was due to difficulties encountered in the conduct of the 2003 studies. Basically, 2003 was a difficult year. A very wet and late spring forced field tillage when the soil was too wet and resulted in soil compaction and a late planting date (May 28 and 29). The Verticillium wilt problems in the field were even more severe than in 2002. To make matters worse, the irrigation district had a major problem with water backing up in the field drain next to the IREC fields. This led to perched soil water moving up into the plots in mid August. To mitigate for these problems, we reduced the irrigation amounts applied in the month of August. This resulted in few plots being intentionally over irrigated and reduced the range of irrigation rates that could be evaluated.

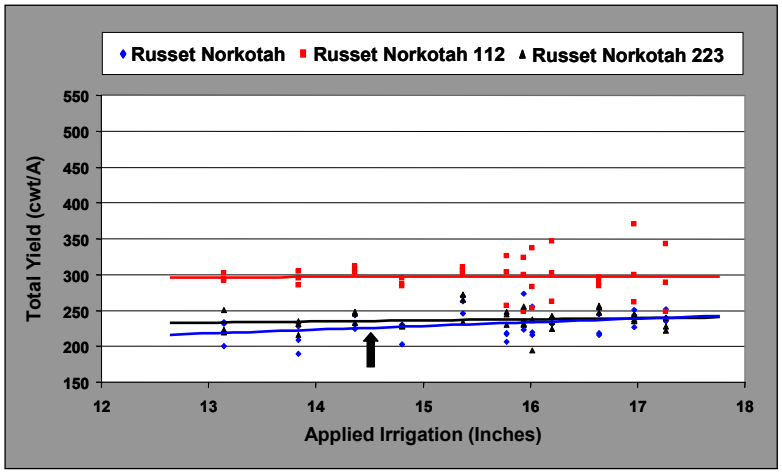

Figure 9. Total yield response of late early potato varieties to applied water in 2004 line source experiment. Arrow at estimated crop Et_c of 14.5 inches.

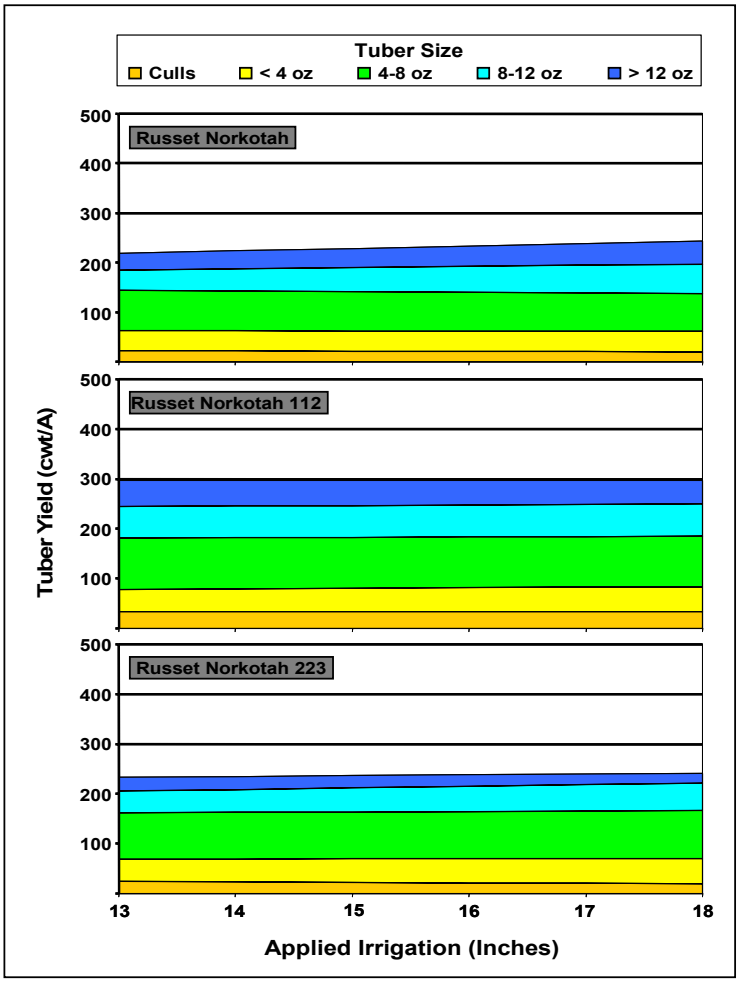

Figure 10. Tuber yield, size, and grade for early potato varieties in the 2003 line source experiment.

The 2003 total yield results for the late varieties are shown in figure 7. As in 2002, yields increased with increased irrigation applications; but unlike 2002, we did not reach threshold application levels where yields began to decline with added water.

Because of trial management problems, we did not end up applying irrigation treatments in excess of the expected crop water needs. Because of a seed shortage, Klamath Russet was replaced by a new russet cultivar, GemStar Russet, in the 2003 trial. GemStar Russet produced the highest yields in the test, followed by Russet Burbank and Gem Russet. The 2003 late variety tuber size and grade results are shown in figure 8. Like the 2002 study, most of the yield increases with applied water were due to increased yield of the larger sized tubers.

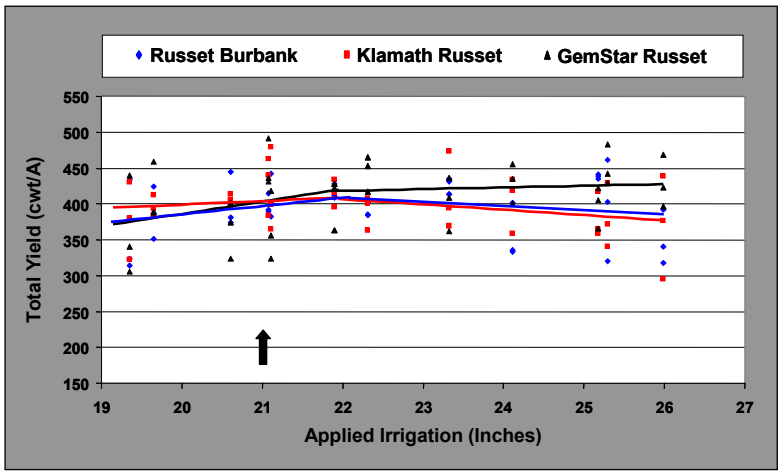

Figure 11. Total yield response of late potato varieties to applied water in 2004 line source experiment. Arrow at estimated crop Et_c of 21 inches.

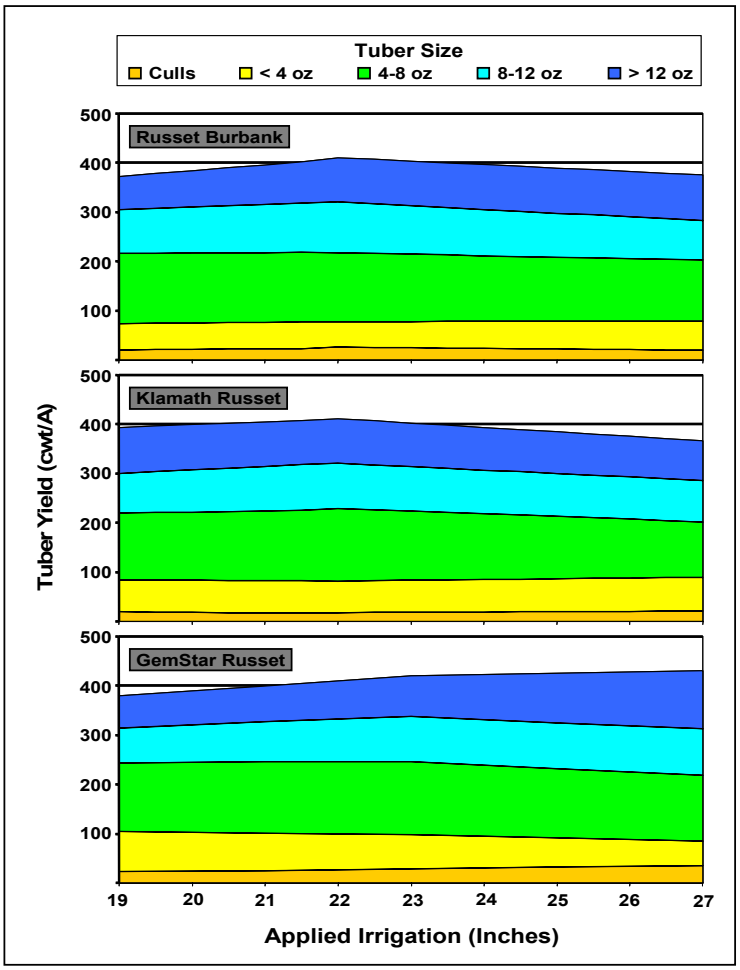

Figure 12. Total yield response of late potato varieties to applied water in 2004 line source experiment. Arrow at estimated crop Et_c of 21 inches.

The early varieties were surprisingly unresponsive to changes in applied irrigation in the 2003 trial (figure 8). This, in all likelihood, was due to the high incidence of Verticillium wilt in the trial. Yields of all three varieties were significantly suppressed by the disease. Selection 112 again produced the highest yields of the three early varieties; but, its yields were more than 100 cwt below yields in 2002. In addition to little effect on total yield, there was little observed effect of irrigation amounts on tuber size or grade (figure10).

2004

Plot layout and management for the 2004 studies was very similar to 2002 and 2003 except for changes in varieties evaluated. In 2004, the late variety trial included Russet Burbank, Klamath

Russet and GemStar Russet. The early trial consisted of Russet Norkotah and two new Russet Norkotah selections, 3 and 8.

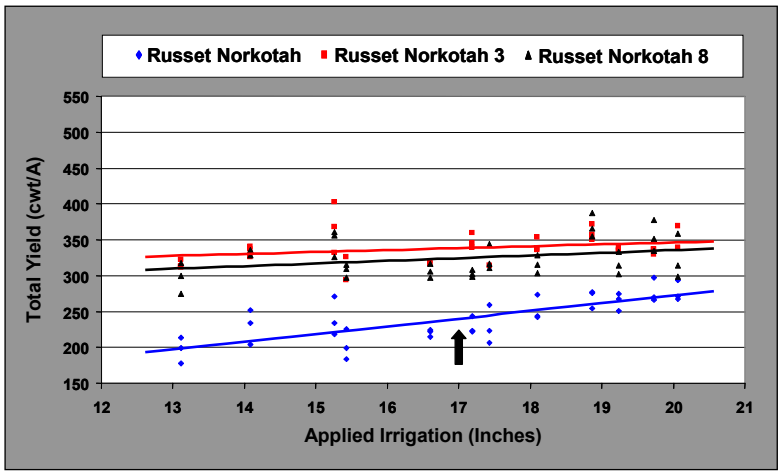

Figure 13. Total yield response of early potato varieties to applied water in 2004 line source experiment. Arrow at estimated crop Et_c of 17 inches.

The yield response of the late varieties to applied water was very similar to the results measured in the 2002 test. Yields increased linearly with increased irrigation up to the point that crop needs were fully met. Then yields leveled off or declined with additional irrigation amounts (figure 11). The effect of increasing irrigation on tuber size and grade was also similar to the previous years. Most of the irrigation caused yield increase was due to increased yields of large sized tubers (figure 12). Estimated ET_c for the late trial was 21 inches.

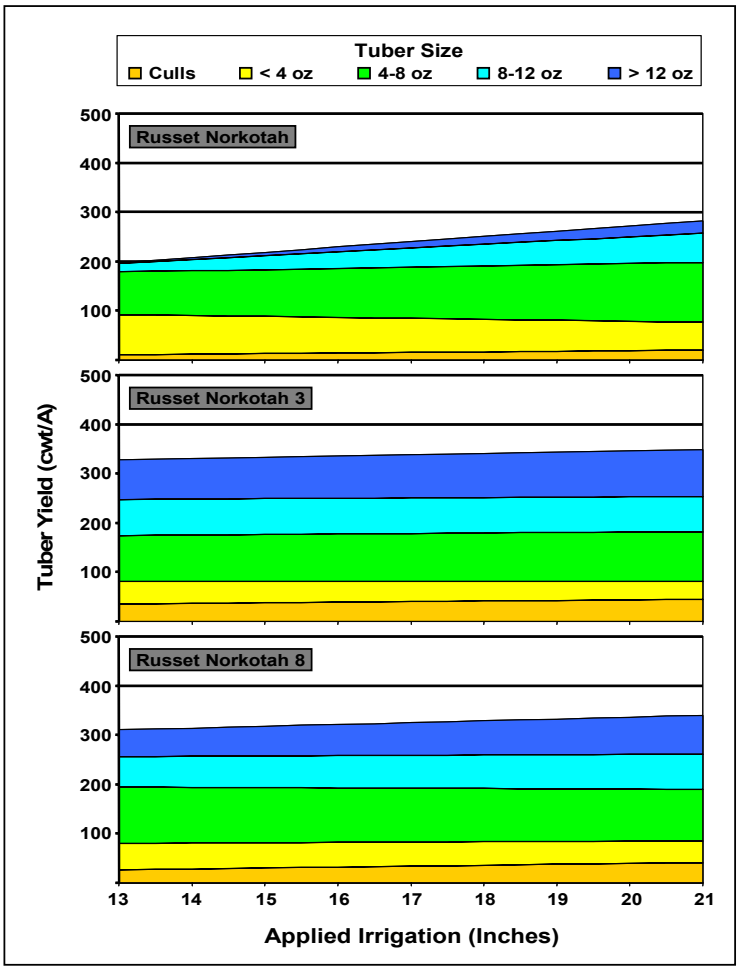

Figure 14. Tuber yield, size, and grade for early potato varieties in the 2004 line source experiment.

The yield response of all the early varieties was fairly flat, much like the response in 2003 (figure 13 and 14). Norkotah Russet was slightly more responsive than the two selections. Even more interesting was the lack of a plateau to applied water. Yields continued to increase gradually, even with applications greater than the 17 inch estimate of ET_c. Yields of the two selections were consistently higher than Russet Norkotah, although none of the varieties yielded particularly well. Again, Verticillium wilt and early blight disease were likely causes of the poor yields and may have affected the early variety response to irrigation.

Discussion

The primary question addressed in this research was "can irrigation recommendations developed for the standard Russet Burbank and Russet Norkotah varieties be extrapolated to new varieties coming into commercial production?" In the case of late, full season, russet varieties, the answer appears to be "Yes". The yield response of each tested late variety to irrigation was very similar to the response of Russet Burbank.
Despite confusion caused by problems in the 2003 experiment, irrigation crop coefficients developed for Russet Burbank worked fairly well in predicting crop water requirements of all the late varieties. None-the-less, some improvement may be possible. Based on a graphic interpretation of the 2002 and 2004 late variety yield results, the computer generated ET_c estimates appeared to be approximately 5% low, or about one inch below the full season irrigation amounts that produced peak crop yields (figures 3 and 11). While this is a pretty close estimate, the fact that the estimate was low in both years may be sufficient reason to further review potato crop coefficients used in the Klamath Basin. In 2005, research is proposed for IREC, which will directly measure evapotranspiration of a Russet Burbank potato crop.

As for overall yields of the late varieties, Klamath Russet yielded nearly the same or slightly better than Russet Burbank with better grade out percentages. Yields of Gem Russet were lower than Russet Burbank, while yields of GemStar were generally greater.

The use of standard irrigation recommendations for Russet Norkotah and Russet Norkotah selections is problematic. The lack of an apparent threshold to irrigation response in the 2003 and 2004 trials makes it difficult to assess the accuracy of ET_c estimates for the early clones (figures 9 and 13). On the other hand, in the 2002 experiment there was an apparent irrigation threshold, which was close to the estimated ET_c (figure 5). But, even in that study yields of Russet Norkotah and selection 223 continued to increase at a low level with additional irrigation.

The relatively flat yield response to irrigation and apparent lack of an irrigation threshold for the Russet Norkotah clones is likely related to heavy disease pressures encountered in these trials. Verticillium wilt and early blight were prevalent. Norkotah is notoriously susceptible to both of these diseases and yields in the early variety trials were poor in all three years. Verticillium wilt plugs the vascular tissue in the stem thereby slowing water transport in the plant. It is likely that in the presence of late season Verticillium wilt pressure, keeping the plants well watered may produce yield benefits. This data supports the local grower axiom that for top Norkotah yields one needs to do everything possible to keep Norkotah green and growing for a few more days late into the season, even if it means over irrigation, heavy fertilization and heavy fungicide use. Irrigation of Russet Norkotah and clonal selections using estimates of crop evapotranspiration may help avoid over irrigation early in the season; but, results of these experiments suggest that irrigation above estimated crop needs may increase yields later in the season particularly in fields with Verticillium wilt. Of course, over irrigation will be accompanied by increased risk of foliar and tuber rot diseases and therefore cannot generally be recommended.

Under disease pressures, the switch to Russet Norkotah selections makes good sense. Selections 112, 3 and 8 all significantly out performed the standard Russet Norkotah variety.