EFFECTS OF IRRIGATION AND NITROGEN MANAGEMENT ON FIVE POTATO CULTIVARS

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Understanding the individual management needs of a potato cultivar is necessary to realize its yield and quality potential. It is also important to maximize the efficiency of management practices. This research was conducted to compare patterns of growth and development of five main-season potato cultivars and to test their response to preplant nitrogen fertility and in season irrigation management.

Materials and Methods

Field trials were conducted in 1998 and 1999 at WSU's IAREC station in Othello, WA under the linear move irrigation system. Two standard cultivars, Russet Burbank and Ranger Russet, two recently released cultivars, Umatilla Russet and Bannock Russet, and NatureMark's genetically modified NewLeaf Russet Burbank were included in the trials. Plants were subjected to one of two levels of irrigation; a standard level of irrigation and a drier deficit level maintained with longer intervals between water application (Fig. 1). Differential irrigation treatments were initiated six weeks after planting. Two preplant nitrogen fertility levels were created each season. Urea (46-0-0) was broadcast over plots at rates to bring the total available nitrogen at the start of the season (residual N + preplant applied N) to levels of 200 and 300 lbs. N per acre in 1998 and 100 and 200 lbs. N per acre in 1999. Plant growth and tuber development were monitored at several dates during the growing season. Final harvest occurred 150 days after the planting date. Tuber yield (US #1 and US #2) and specific gravity were assessed after the harvest.

Cultivar Main Effects

Plant populations recorded at 25 and 35 days after planting in 1999 indicate significant differences in the emergence of the five cultivars (Fig. 2). Russet Burbank, NewLeaf, and Ranger were the first plants to emerge. At 25 days Umatilla and Bannock were not yet emerged. At 35 days Russet Burbank, NewLeaf, and Ranger had the highest plant populations, followed by Umatilla, and lastly Bannock. Emergence of cultivars in 1998 followed a similar pattern but occurred earlier. The cool spring weather of 1999 delayed plant emergence.

Seed handing greatly influenced NewLeaf emergence. In 1998 seed was cut and planted directly out of storage. In 1999 seed was warmed a week prior to cutting and planting. NewLeaf plant populations recorded at 34 days in 1998 were lower than those of Russet Burbank (data not shown). Plant populations of NewLeaf and Russet Burbank were not significantly different in 1999 with warmed seed (Fig. 2).

Figure 3 shows the fresh weight of vines for each of the five cultivars recorded at five dates over the growing season. The data are averaged over two seasons, two irrigation levels, and three preplant nitrogen rates to allow comparison of cultivar main effects. Several

differences in cultivar vine development were noted. Umatilla and Bannock vines were initially small compared to the cultivars with earlier emergence. They soon caught up in size, however, by maintaining the highest early vine growth rates. Overall, Bannock produced the largest vines, followed by Umatilla and Ranger, Russet Burbank, and lastly NewLeaf. Vine weight was maximum by 90 days for Russet Burbank, NewLeaf, and Umatilla. Ranger and Bannock had sufficient vine growth to maintain and even increase the size of their vine through 110 days. With no data beyond 110 days it is not possible to know when Ranger and Bannock vines began to decline in size.

Tuber yield per plant, number of tubers per plant, and the average weight of tubers per plant at 45 days after planting are shown in Figure 4. These graphs illustrate cultivar differences in early tuber development. Ranger at 45 days had the highest yield of tubers per plant, more tubers per plant, and the largest tubers per plant compared to the other four cultivars. The average tuber size of Ranger was twice as large as that of Russet Burbank. Umatilla had a lower yield of tubers compared to Russet Burbank due to smaller per tuber size, but a similar number of tubers per plant. Bannock had the lowest yield of tubers per plant, the fewest tubers per plant, and the smallest tubers at 45 days.

Figure 5 shows the fresh weight of tubers for each of the five cultivars at five dates over the growing season. The data are averaged over two seasons, two irrigation levels, and three preplant nitrogen rates to allow comparison of cultivar main effects. Russet Burbank, NewLeaf, and Ranger had a similar tuber-bulking pattern. Umatilla tubers were slower to develop initially. Umatilla tuber bulking rates increased later in the season so that yields were equal to those of Russet Burbank and Ranger nearing the end of the growing season. Bannock tuber development was much delayed compared to the other cultivars. Bannock produced the lowest tuber yield at all five in-season harvest dates due to slow development and late bulking.

Figure 6 shows tuber yields for each of the five cultivars at 150 days after planting. To compare cultivar main effects, the data are averaged over two seasons, two irrigation levels, and three preplant nitrogen rates. Russet Burbank, Ranger, and Umatilla tended to produce the highest total yields. Bannock was the lowest yielding cultivar in both 1998 and 1999. Ranger, Umatilla, and Bannock tended to produce a higher percentage of US #1 grade tubers compared to Russet Burbank and NewLeaf (Fig. 6).

Tuber specific gravities for each of the five cultivars are presented in Figure 7. Tubers of Ranger, Umatilla, and Bannock had higher specific gravities than Russet Burbank and NewLeaf. Ranger and Umatilla consistently produced the highest tuber specific gravities.

Effects of Season

Differences in the weather of 1998 and 1999 resulted in some interesting effects on the crop. Figure 8 shows the average daily maximum air temperatures of 1998 and 1999. The second half of the 1998 season was unusually warm. The 1999 season started with an unusually cool spring. For the most part, the cultivars tested had a similar response to season. Rather than present the individual results of the five cultivars, data were averaged to demonstrate the main effect of season. Figure 9a shows vine growth profiles for the 1998 and 1999 growing seasons. Early vine growth was much slower in 1999 compared to 1998. This is undoubtedly an effect of the cool spring weather of 1999. Vines in 1998 reached their maximum weight earlier in the season compared to vines in 1999. More vines were produced in 1998.

Figure 9b shows tuber growth profiles for the 1998 and 1999 growing seasons. Tuber development began earlier in 1998 compared to 1999. The yield of tubers 45-90 days was greater in 1998 versus 1999. The yield of tubers at 110 days was greater in 1999. Tubers maintained higher growth rates in the latter part of the season in 1999 versus 1998.

Despite the late start, the final yield of tubers was higher in 1999 versus 1998 (Fig. 10). Moreover, a greater proportion of the total yield in 1999 was US #1 grade (Fig. 10). Specific gravities were higher in 1999 compared to 1998 (Fig. 7). The high temperatures experienced during the tuber bulking months in 1998 explain much of the reduction in yield and quality (Fig 8).

Irrigation Main Effects

For the most part, the cultivars tested had a similar response to irrigation. Rather than present the individual results of the five cultivars, data were averaged to demonstrate the main effect of irrigation level. Figure 11a shows vine growth profiles with standard and deficit levels of irrigation. Deficit irrigation tended to reduce the rates of vine growth, primarily in the first half of the growing season. Vine growth tended to peak earlier in the season with the standard level of irrigation compared to deficit irrigation.

Figure 11b shows tuber growth profiles with standard and deficit levels of irrigation. Tuber yields were higher with standard irrigation at all of the hand harvest dates. Tuber growth rates between 60 and 90 days tended to be higher with standard irrigation. From 90 to 110 days tuber growth rates tended to be higher with deficit irrigation.

Figure 12 shows the final yield of tubers with standard and deficit irrigation levels. By the time of the final harvest there was little difference in yield (average of four cultivars) with the two irrigation levels. The greatest difference between irrigation treatments was in the percent yield of US #1 grade tubers (Fig. 12). Standard irrigation resulted in a higher percentage of US #1 grade tubers compared to deficit irrigation. Ranger, Umatilla, and Bannock produced a larger percentage of US #1 grade tubers than Russet Burbank and NewLeaf with both deficit and standard irrigation treatments (data not shown).

Specific gravities were lower with deficit irrigation for all cultivars (Fig. 13) (NewLeaf and Bannock not shown).

Effects of Preplant Nitrogen Rates

Russet Burbank: Smaller vines (at maximum) were produced with decreasing rates of preplant nitrogen (data not shown). Vine growth continued later into the growing season with increasing rates of preplant nitrogen. Tuber yields were highest with the lowest rate of preplant nitrogen and lowest with the highest rate of preplant nitrogen up to 90 days (Fig. 14). At final harvest (150 days after planting) total tuber yields were similar with the three rates of nitrogen (Fig. 15). Tuber specific gravity was lower with the highest rate of preplant nitrogen compared to the other rates (Fig. 20). Specific gravities with 100 and 200 lb. N/ac were not different.

Ranger Russet: Smaller vines were produced with decreasing rates of preplant nitrogen (data not shown). Plants maintained higher rates of vine growth later into the growing season with increasing rates of preplant nitrogen. Tuber yields were highest with the lowest rate of preplant nitrogen and lowest with the highest rate of preplant nitrogen only up to 75 days (Fig. 16). At final harvest total tuber yields were similar with all three rates of nitrogen (Fig. 17).

Tuber specific gravity was lowest with the 300 lb. N/ac treatment and highest with the 200 lb. N/ac treatment (Fig. 20).

Umatilla Russet: Smaller vines were produced with decreasing rates of preplant nitrogen (data not shown). Vine weight at maximum declined more rapidly with the lower rates of preplant nitrogen. Tuber yields at all in-season data collection dates were higher with decreasing rates of preplant nitrogen (Fig. 18). Total tuber yields at final harvest did not differ with the three nitrogen rates (Fig. 19). Tuber specific gravity was highest with the 200 lb. N/ac treatment (Fig. 20). Specific gravities with the lowest and highest nitrogen rates were similar.

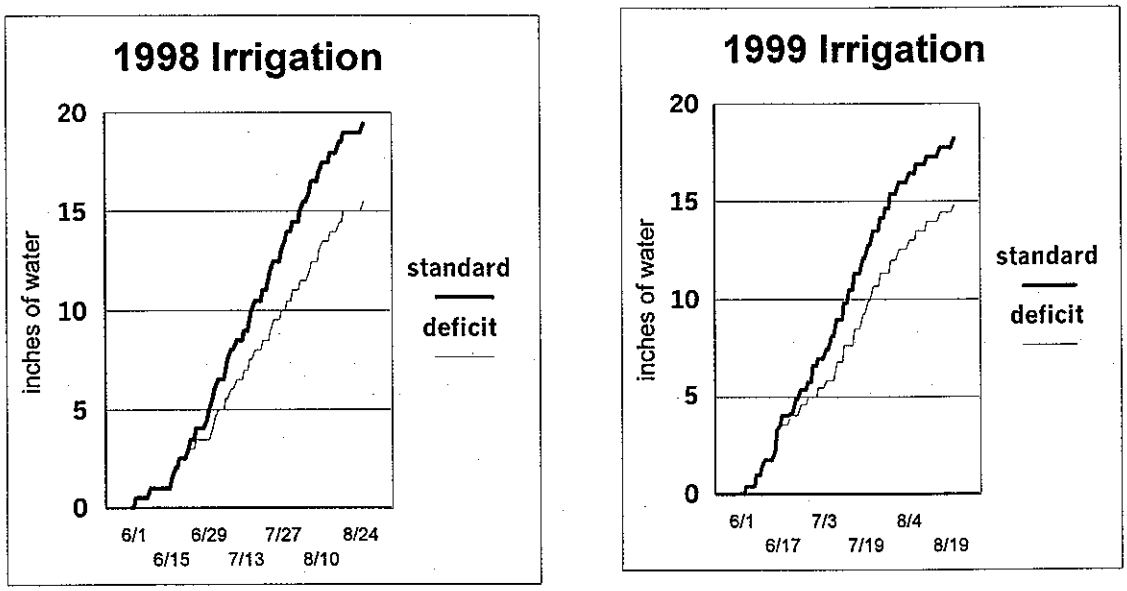


Fig. 1. Water applied with standard and deficit levels of irrigation in 1998 and 1999.

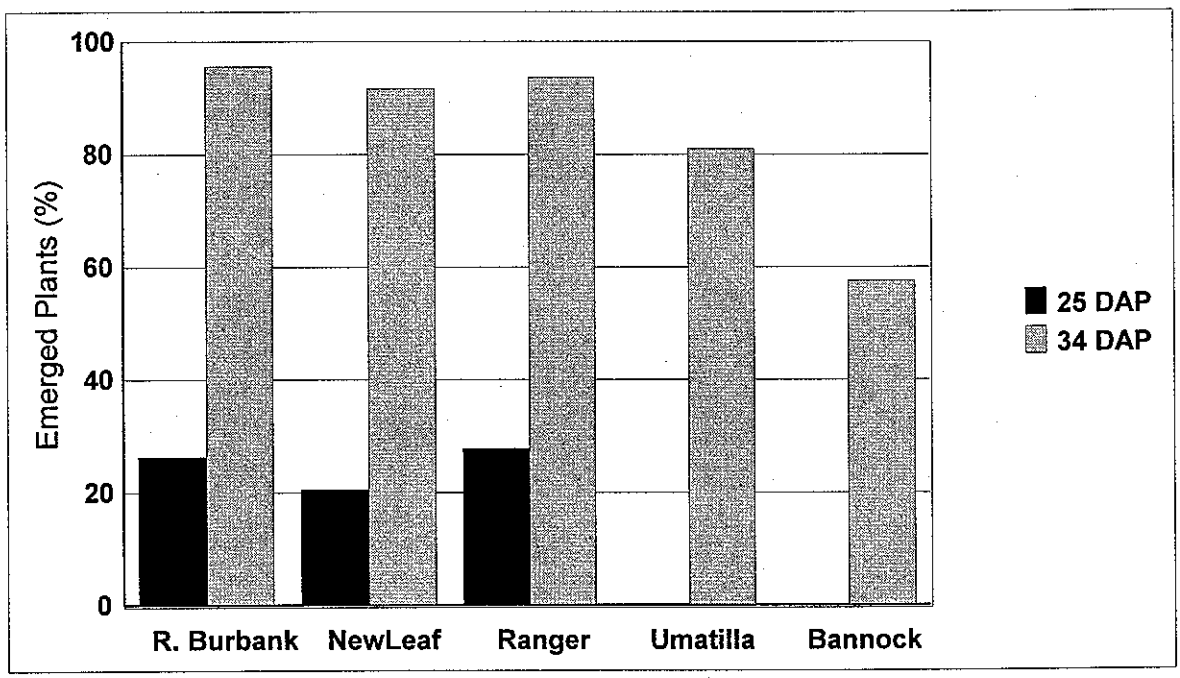


Fig. 2. The percentage of emerged plants at 25 and 34 days after planting in 1999.

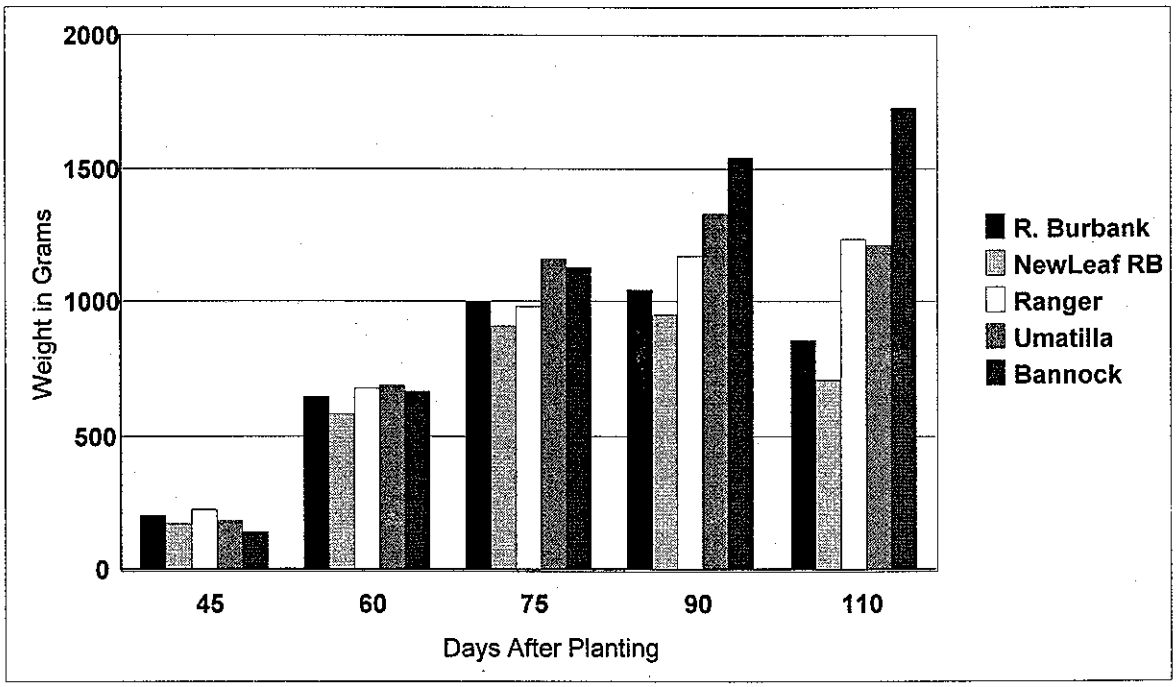


Fig. 3. Vine fresh weight for each of five cultivars recorded at five dates over the growing season. Averaged over two seasons, two irrigation levels, and three preplant nitrogen rates

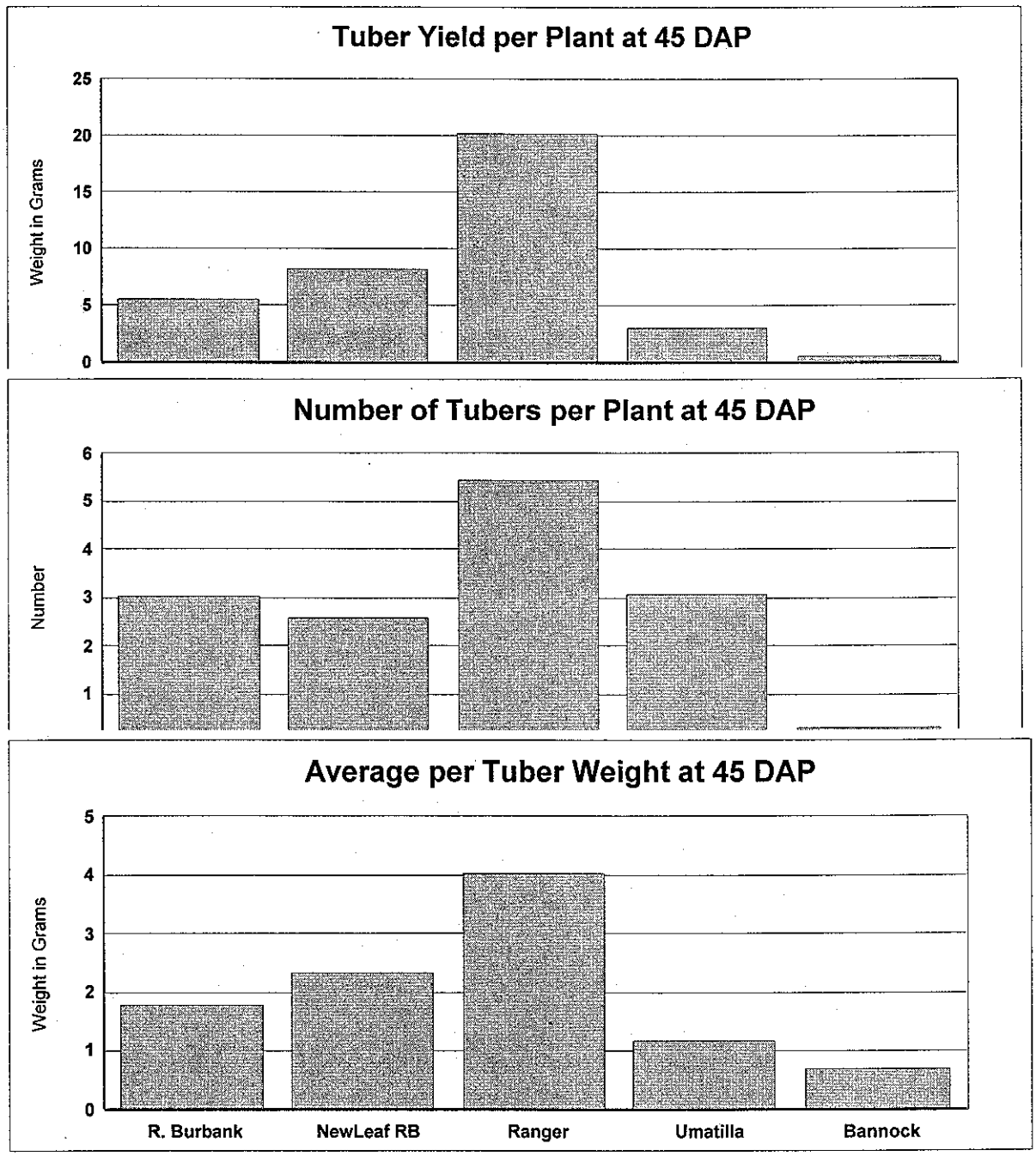


Fig. 4. Tuber yield per plant, number of tubers per plant, and the average weight of tubers per plant for each of five cultivars at 45 days after planting. Averaged over two seasons, two irrigation levels, and three preplant nitrogen rates.

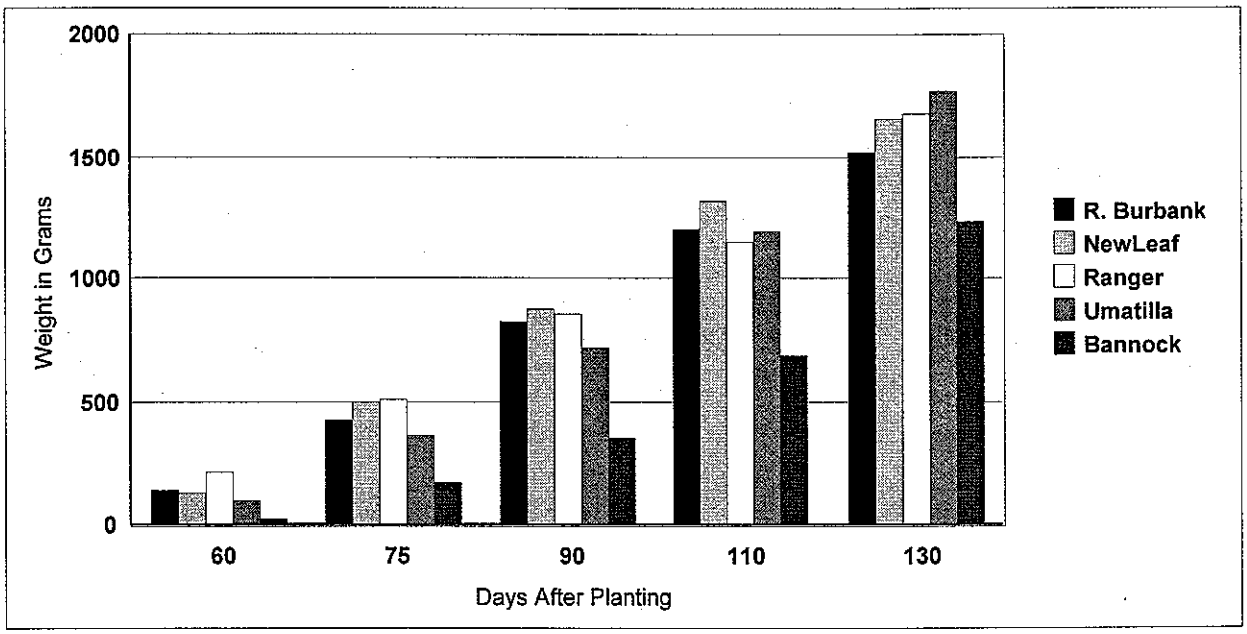


Fig. 5. Tuber fresh weight for each of five cultivars recorded at six dates over the growing season. Averaged over two seasons, two irrigation levels, and three preplant nitrogen rates.

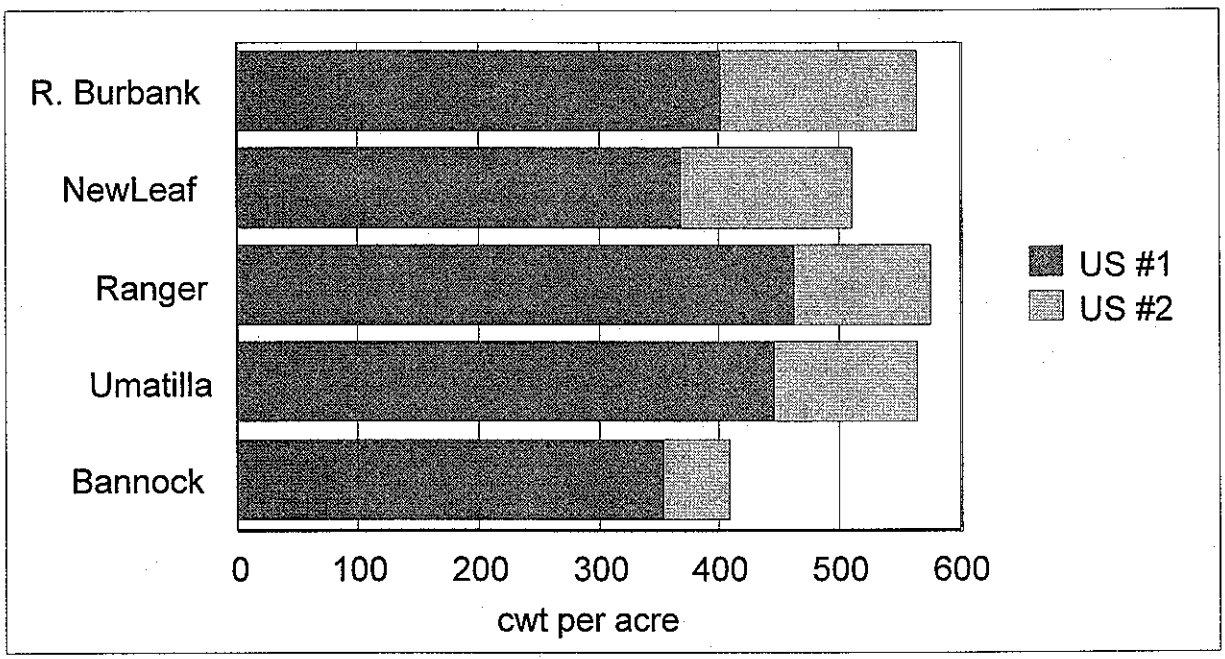


Fig. 6. Tuber yield for each of five cultivars at 150 days after planting. Yield of US #1 and US #2 grade tubers. Averaged over two seasons, two irrigation levels and three preplant nitrogen rates.

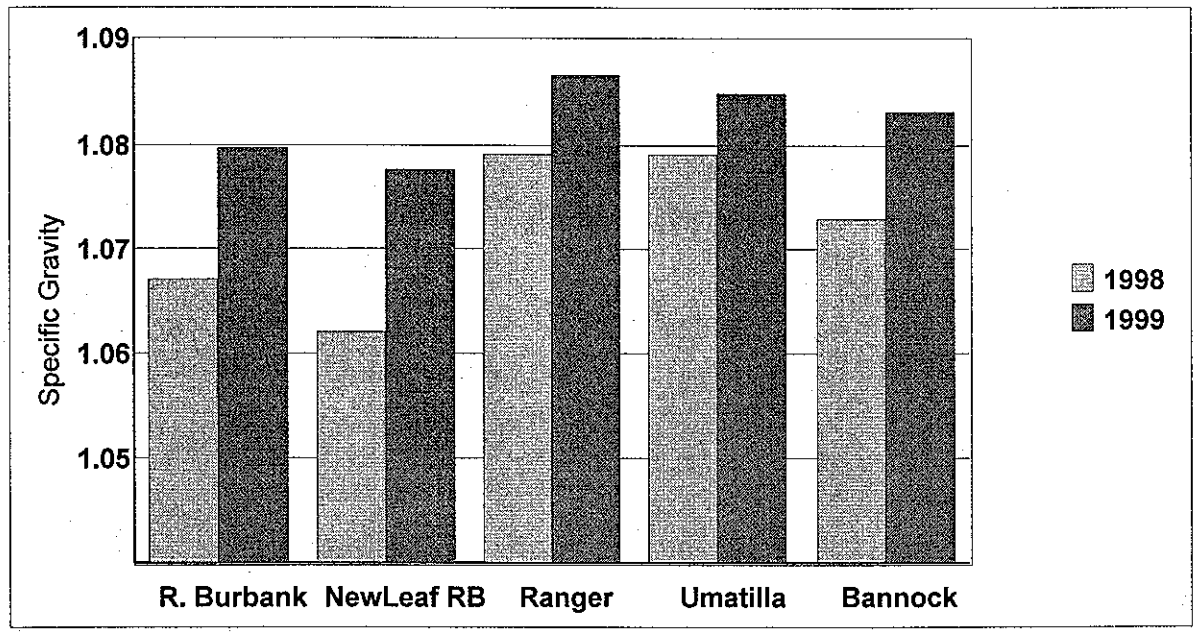


Fig. 7. Tuber specific gravities for each of five cultivars in 1998 and 1999. Averaged over two irrigation levels and three preplant nitrogen rates.

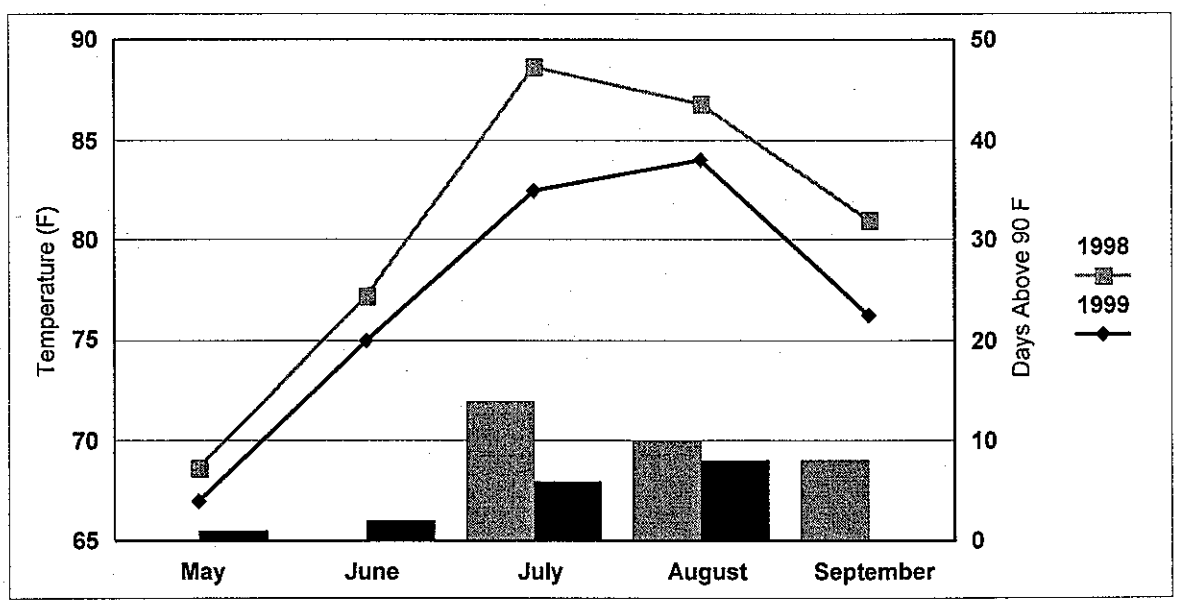
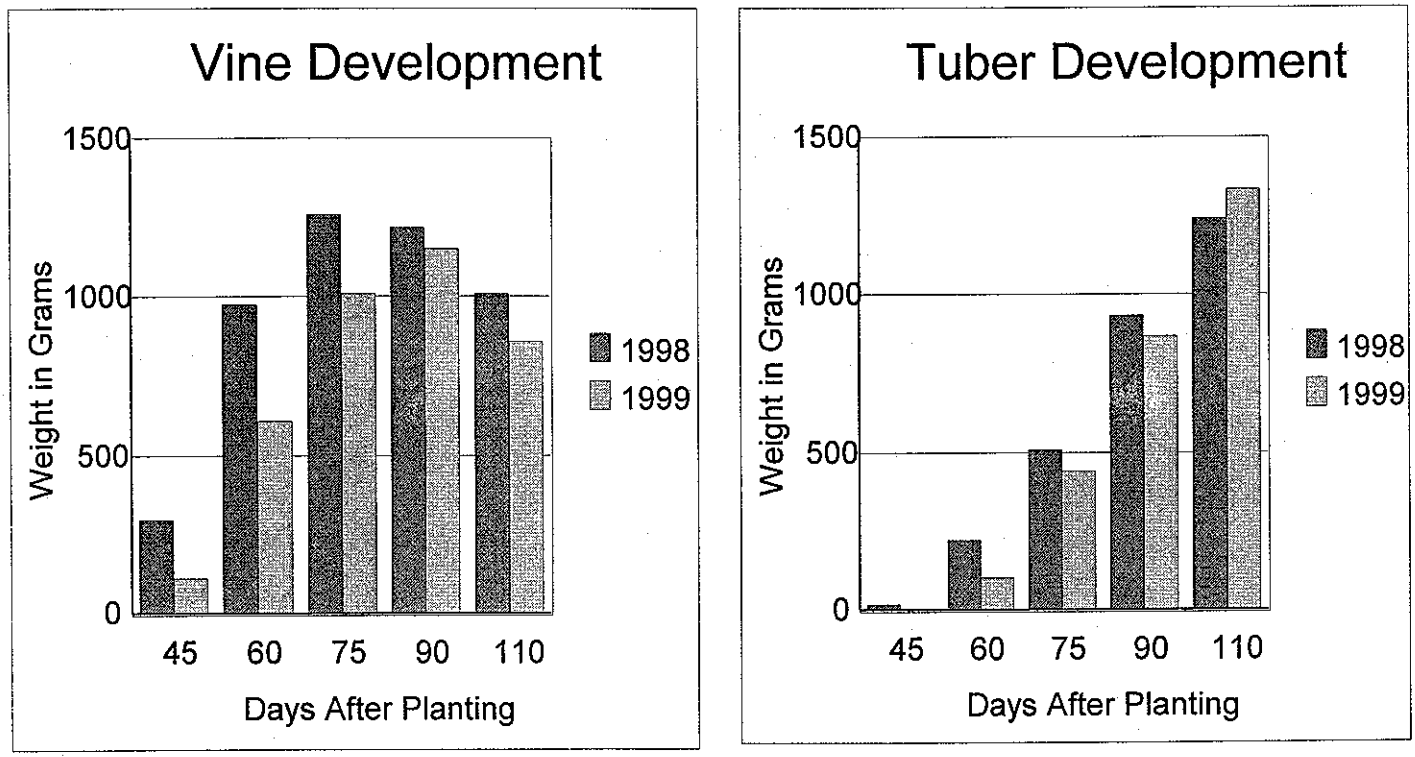


Fig. 8. The average daily maximum air temperatures (line graph) of 1998 and 1999. The number of days per month temperatures exceeded 90 F (bar graph) in 1998 and 1999.



Figs. 9a and 9b. Fresh weight of vines and tubers at five dates over the growing season in 1998 and 1999. Averaged over four cultivars, two irrigation levels, and three preplant nitrogen rates.

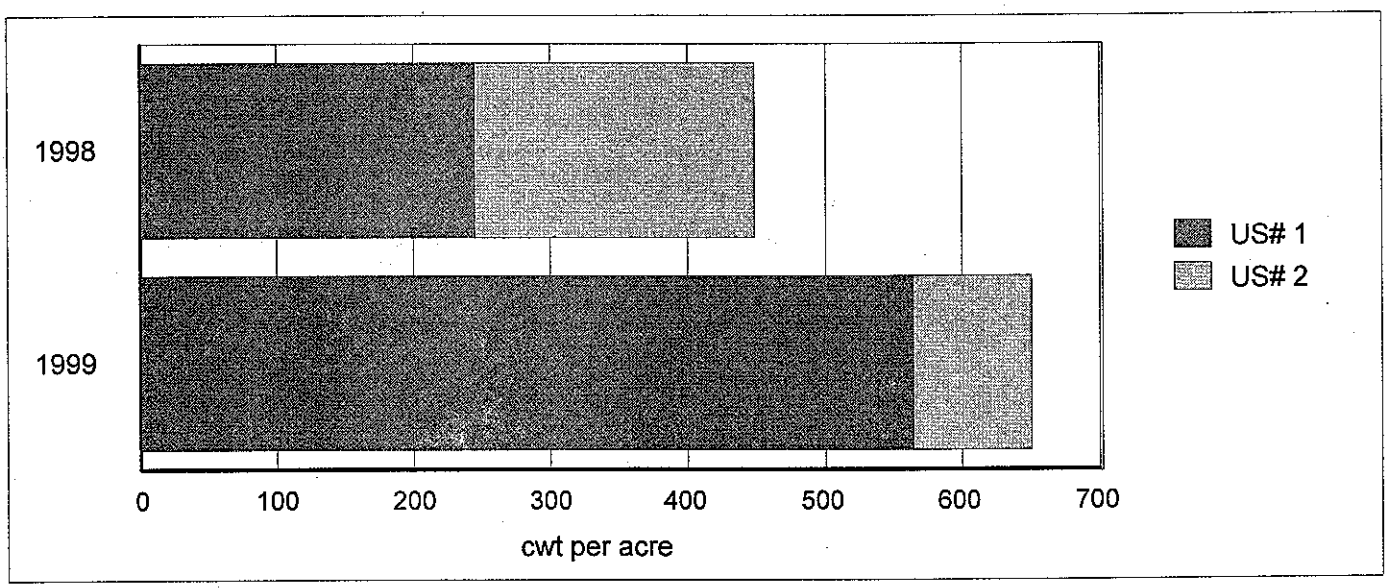
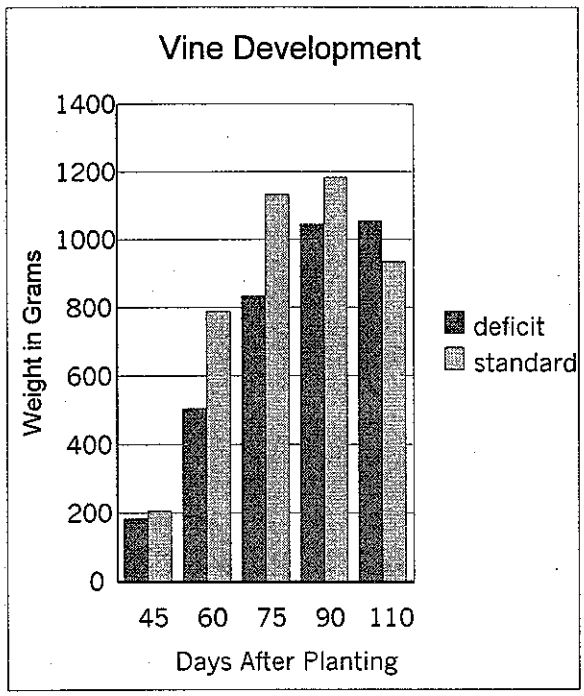
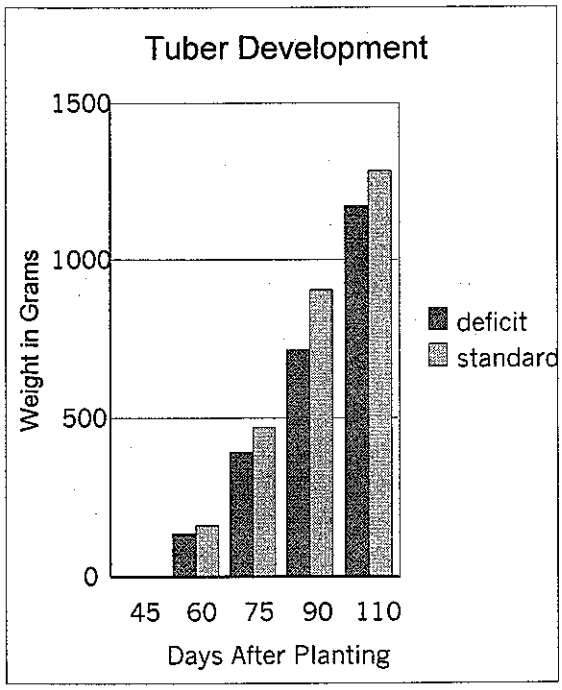


Fig. 10. Tuber yield at 150 days after planting in 1998 and 1999. Yield of US #1 and US #2 grade tubers. Averaged over four cultivars, two irrigation levels, and three preplant nitrogen rates.





Figs. 11a and 11b. Fresh weight of vines and tubers at five dates over the growing season with deficit and standard irrigation. Averaged over four cultivars, two seasons, and three preplant nitrogen rates.

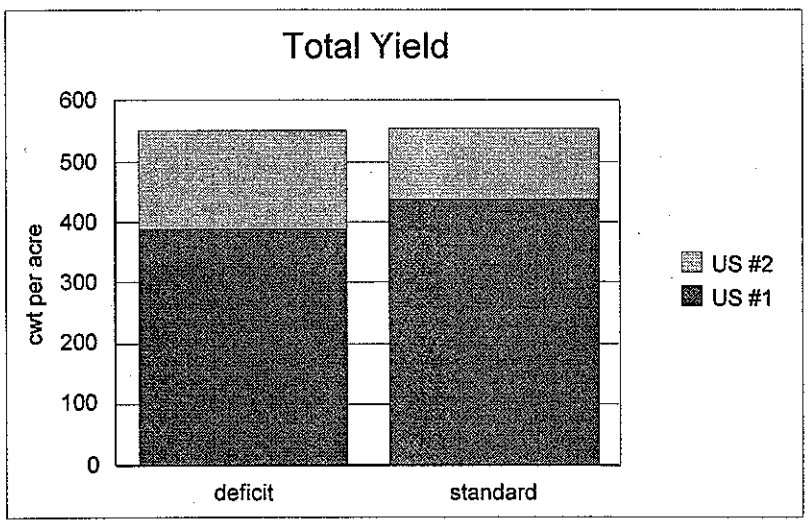


Fig. 12. Tuber yield at 150 days after planting with deficit and standard irrigation. Averaged over four cultivars, two seasons, and three preplant nitrogen rates.

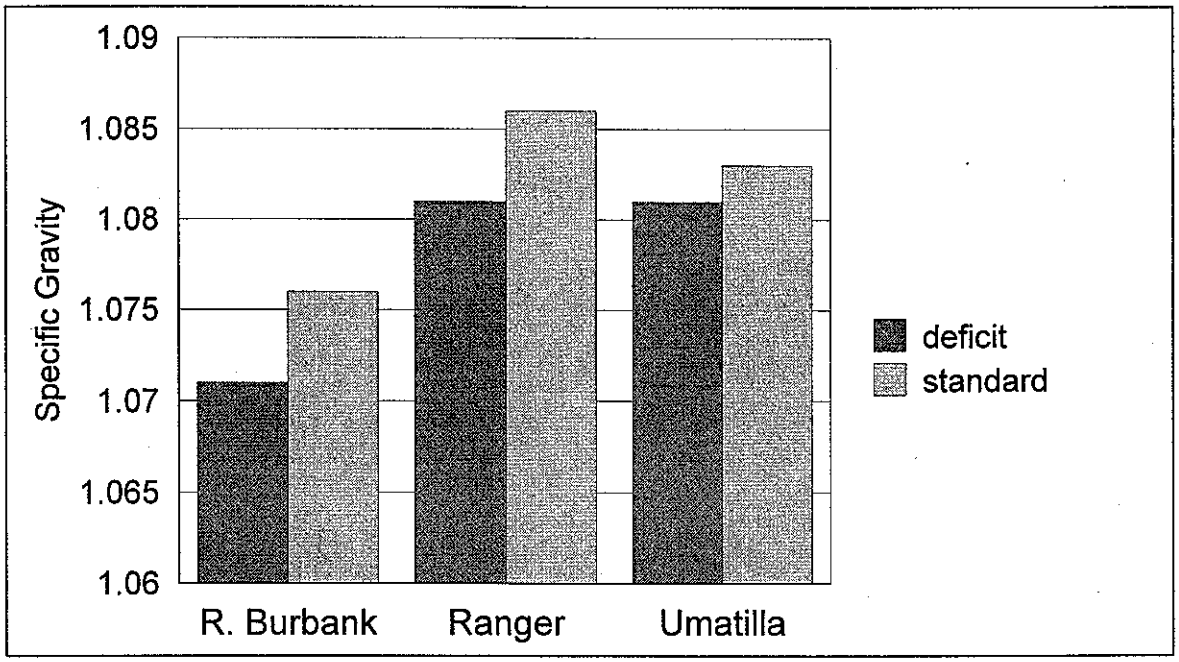


Fig. 13. Tuber specific gravities with deficit and standard levels of irrigation for three cultivars. Averaged over two seasons and three preplant nitrogen rates.

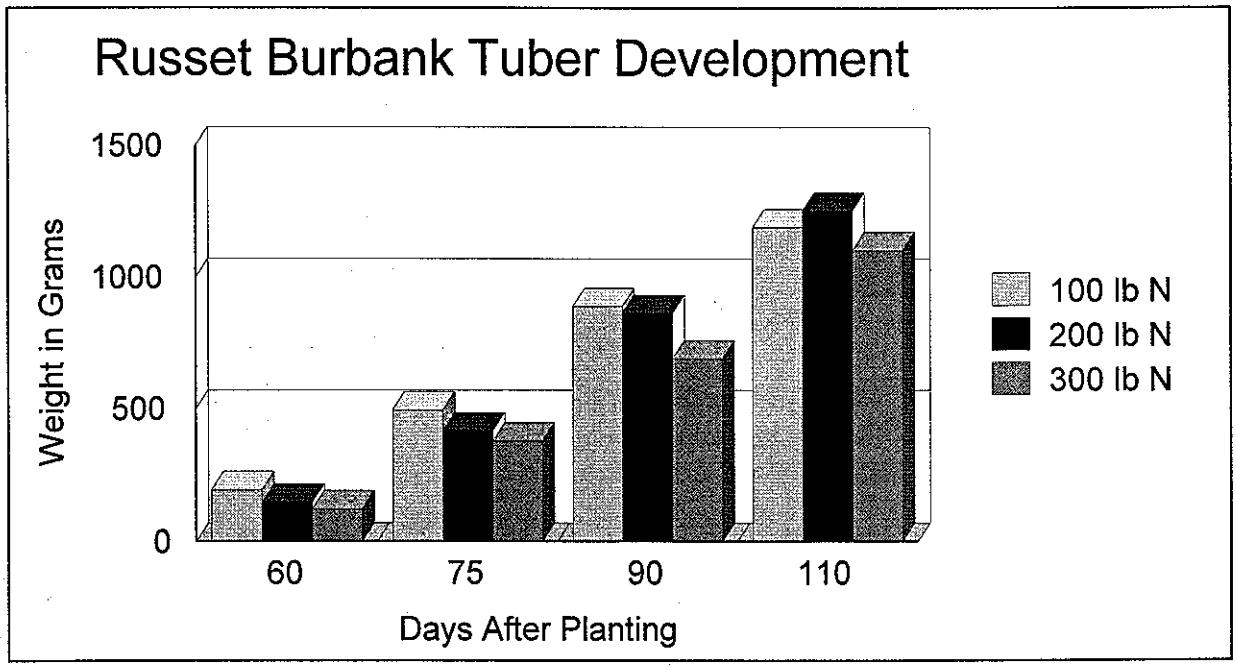


Fig. 14. Fresh weight of tubers at four dates over the growing season for Russet Burbank with three rates of preplant nitrogen. Adjusted for variation in two seasons. Averaged over two irrigation levels.

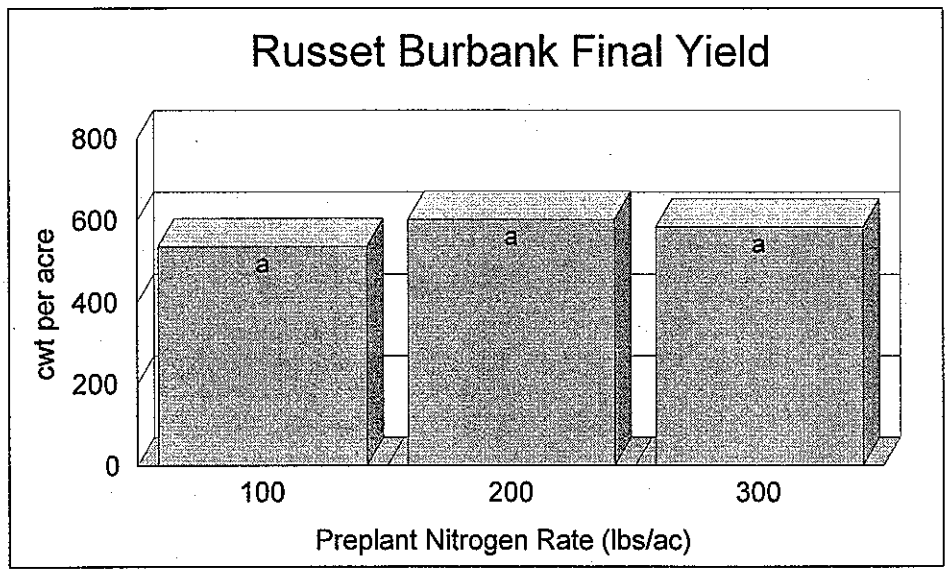


Fig. 15. Tuber yield at 150 days after planting for Russet Burbank with three rates of preplant nitrogen. Adjusted for variation in two seasons. Averaged over two irrigation levels.

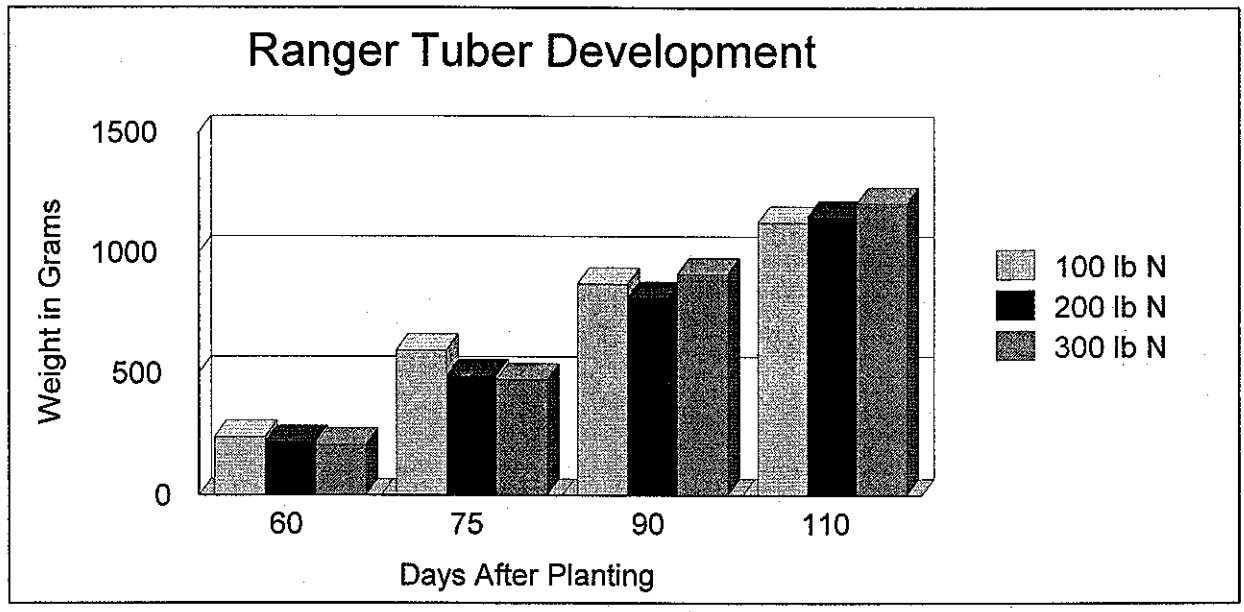


Fig. 16. Fresh weight of tubers at four dates over the growing season for Ranger with three rates of preplant nitrogen. Adjusted for variation in two seasons. Averaged over two irrigation levels.

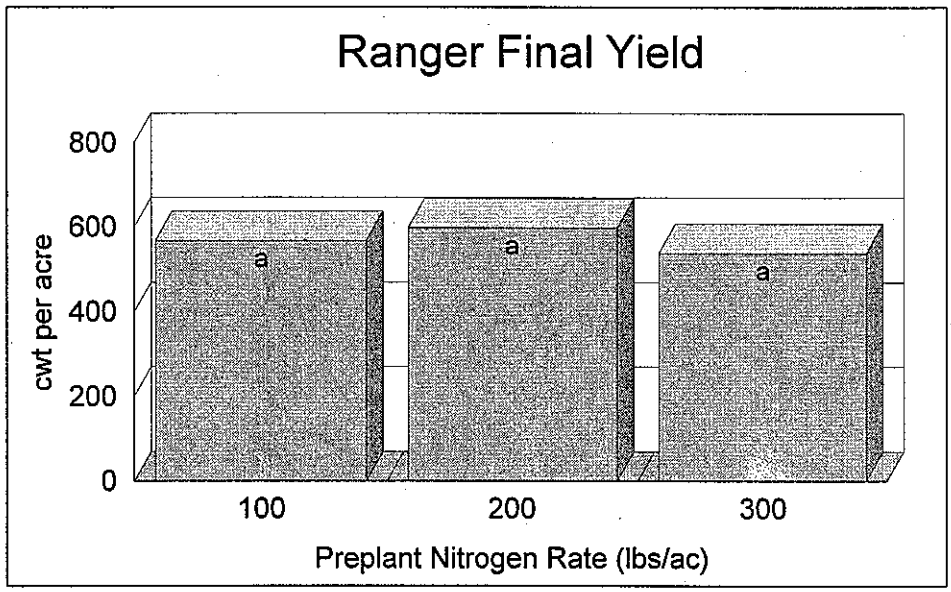


Fig. 17. Tuber yield at 150 days after planting for Ranger with three rates of preplant nitrogen. Adjusted for variation in two seasons. Averaged over two irrigation levels.

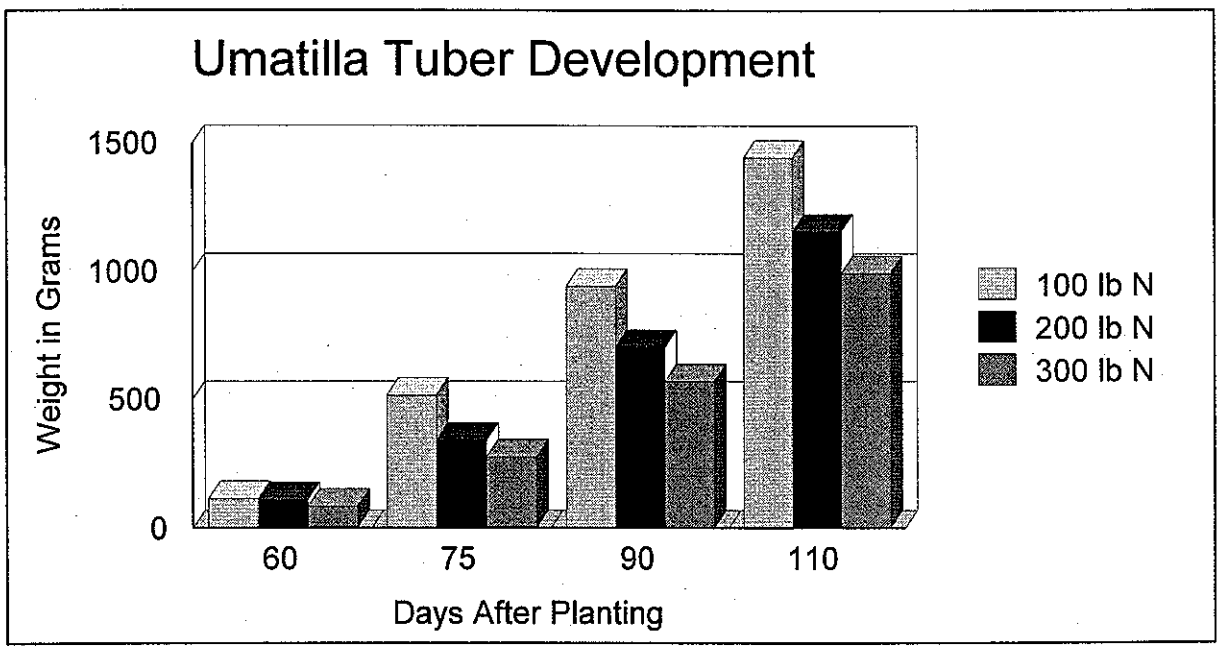


Fig. 18. Fresh weight of tubers at four dates over the growing season for Umatilla with three rates of preplant nitrogen. Adjusted for variation in two seasons. Averaged over two irrigation levels.

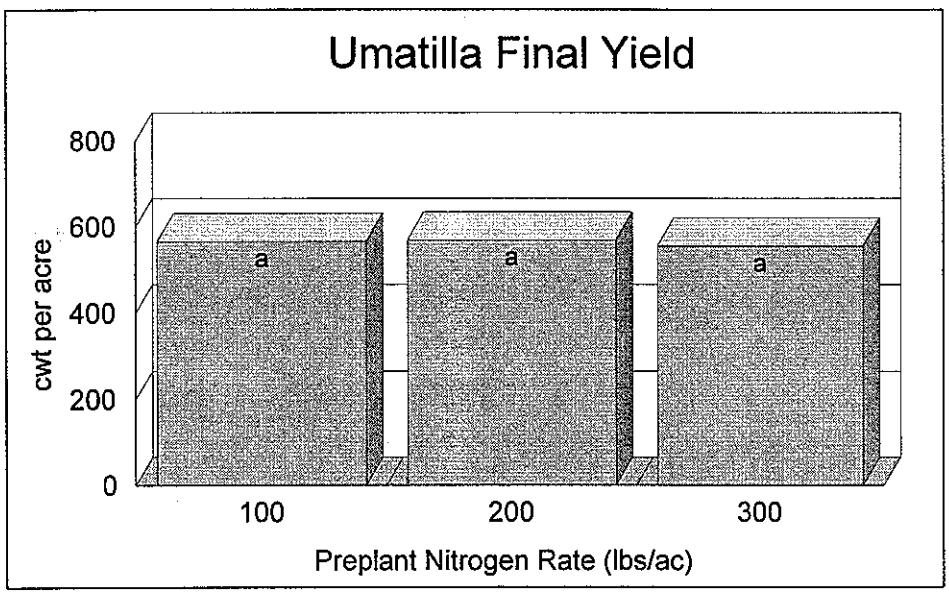


Fig. 19. Tuber yield at 150 days after planting for Umatilla with three rates of preplant nitrogen. Adjusted for variation in two seasons. Averaged over two irrigation levels.

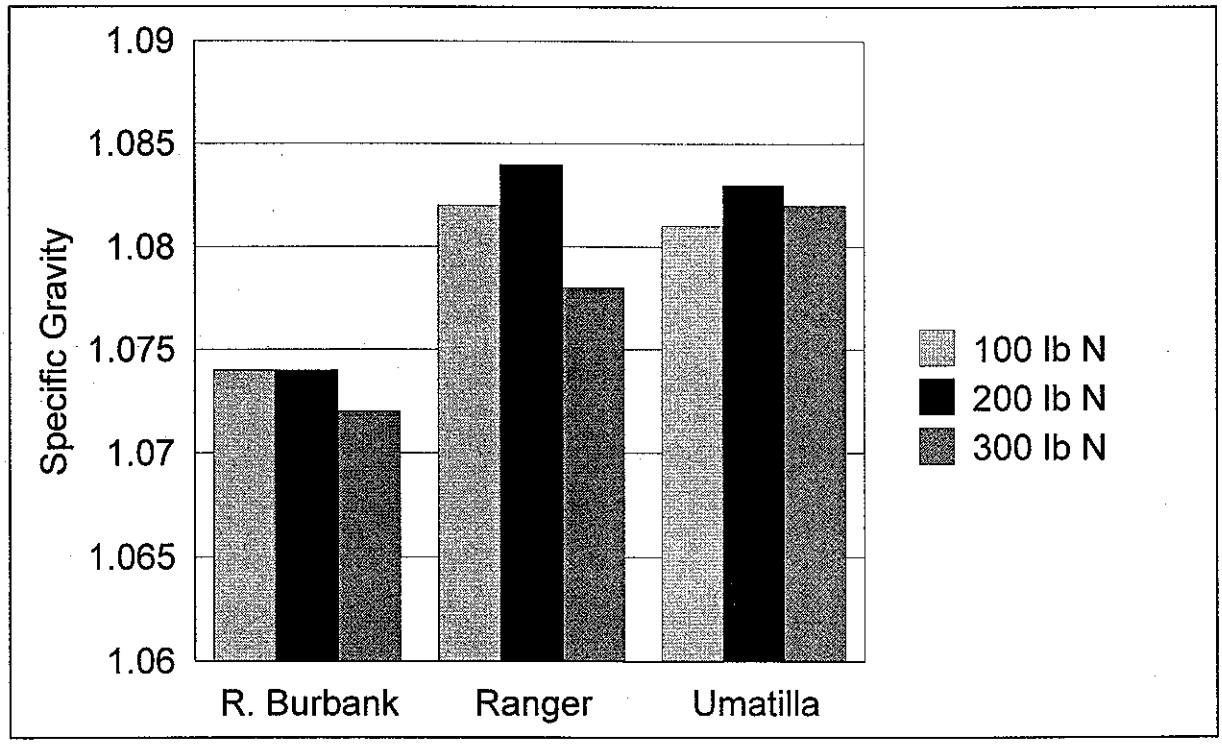


Fig. 20. Tuber specific gravity for three cultivars with three rates of preplant nitrogen. Adjusted for variation in two seasons. Averaged over two irrigation levels.