CLIMATE, IRRIGATION, AND NITROGEN RATE EFFECTS ON 1990 POTATO YIELDS

by
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New potato cultivars may have different nitrogen and irrigation requirements than Russet Burbank. A project began in 1990 to compare yields of Russet Burbank, HiLite Russet, Frontier Russet, and Century Russet subjected to different rates of irrigation, sprinkler-applied N, and sidedress N. HiLite Russet and Frontier Russet are early-season, determinate-growth type cultivars (vegetative growth essentially ceases soon after bulking begins) while Russet Burbank and Century Russet are long-season, indeterminate-growth type cultivars (vegetative growth continues throughout the season). The experiment was conducted on a Quincy sand near Paterson.

Experimental design:

The experimental structure (Fig. 1) consisted of 1) gradients of water and sprinkler-applied N with rates varying from about six inches of water and 40 lb/A N to a mean of 39 inches of water and 340 lb/A of sprinkler-applied N; 2) level water (about 39 inches applied water) and gradient N (40 lb/A to 340 lb/A sprinkler-applied N); 3) about 39 inches of water, and N at rates of a) 120 lb/A preplant granular formulation, b) 120 lb/A preplant + 110 lb/A sidedress, c) 120 lb/A preplant + 220 lb/A sidedress, and d) 120 lb/A preplant + 330 lb/A sidedress. The gradient water-nitrogen and level water-gradient N treatments also received the 120 lb/A preplant N application. Each cultivar was represented once in each treatment. There were two blocks of each treatment. Irrigations were applied at frequencies ranging from alternate days to every three days until mid-July, when irrigations were applied daily. Nitrogen as Uran-32 was injected into the irrigation once per week on the N-gradient treatments at rates calculated to apply 15 lb/A at the midpoint of the N gradient.

Tubers were harvested at five locations along the gradients of the water-N and level water-gradient N treatments. In the sidedress treatments, tubers were harvested from each of the four N-application levels.

Tubers were weighed and sorted for external growth defects and internal defects and diseases problems. Specific gravities were obtained for each sample.

Photosynthesis measurements were obtained several times during the growing season and correlated with leaf temperatures and N application rates.

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Soil temperature was measured on Aug. 5, 1990 at 2 inches below the surface of a potato hill planted to HiLite Russet using thermocouples inserted laterally into the hill.

Results:

Yields for the water-N gradient treatment were not discussed extensively. Total tuber yields decreased linearly with linear decrease in irrigation rates and water effects dominated any nitrogen-rate effects for the gradient water-N treatment.

Total tuber yields and percent No. 1 potatoes were presented with respect to rates of sprinkler-applied N and sidedress N. Highest total tuber yields in the level water-gradient N treatment (Fig. 2) were attained by Russet Burbank (24 T/A) and Century Russet (31 T/A at about 300 lb/A sprinkler-applied N + 120 lb/A preplant N). Frontier Russet and HiLite Russet total tuber yields ranged from about 18 T/A to 24 T/A with no response to increasing rates of N application. Century Russet was the only cultivar that showed increasing yields with increasing rates of sprinkler-applied N in this study. HiLite Russet and Frontier Ruseet percent No. 1 potatoes ranged from 60 to 80%, while Century Russet and Russet Burbank No. 1 potatoes ranged from 0 to 25 percent (Fig. 3).

Total tuber yields from the sidedress N treatment were highest for Century Russet (28 T/A at the 220 lb/A N rate) and Russet Burbank (26 T/A at the 340 lb/A rate) (Fig. 4). While HiLite Russet total tuber yield was highest at the 230 lb/A rate, Frontier Russet total tuber yields declined with increasing rates of sidedress N. Century Russet and Russet Burbank had many secondary growth problems, with No. 1 potatoes ranging from 0 to 20% (Fig. 5). Highest quality was attained at low N rates for Century Russet and Russet Burbank. HiLite Russet and Frontier Russet had 60 to 80 percent No. 1 potatoes.

Specific gravities were low in 1990, ranging from 1.06 to 1.082 (Fig. 6). There were no trends of specific gravity with increasing N rates except for Russet Burbank.

Photosynthetic rates ranged from 16 umol/mol to less than 1 umol/mol. Frontier Russet and HiLite Russet photosynthetic rates remained above 4 umol/mol and leaf temperatures never exceeded 31 degrees C for these cultivars. Leaf temperatures for Century Russet and Russet Burbank were slightly warmer than Frontier Russet and HiLite Russet, thus lowering photosynthetic rates for those cultivars.

Soil temperatures at 1400 on 5 Aug. 1990 at the 2 inch depth ranged from 37 degrees C to 26 degrees C (Fig. 7).

Discussion:

The high temperatures of 1990, accompanying water stress, and shifts in carbohydrate partitioning were likely responsible for the lower yields and the secondary growth defects observed in this experiment for Russet Burbank and Century Russet.

As nitrogen rates increase, indeterminate-growth cultivars are likely to shift more energy to vegetative growth rather than tuber growth. In our experiment, high temperatures likely exacerbated this problem, especially for Russet Burbank. Irrigation frequencies also contributed to the secondary growth defects observed for Russet Burbark and Century Russet. The determinate-growth cultivars, however, while showing somewhat suppressed yields, had few secondary growth defects compared to the indeterminate types. Because top growth virtually ceases in HiLite Russet and Frontier Russet after bulking begins, these cultivars preferentially move photosynthate products to the tubers while the demand for photosynthate in the indeterminate cultivar varies from top growth to tuber growth depending on environmental conditions. Cooler temperatures favor tuber growth, while top growth is favored by warmer temperatures in Russet Burbank.

Water stress accompanies high temperatures. Because increasing temperature increases plant demand for water, there is a point at which the plant cannot satisfy its need for water. Russet Burbank is known to be sensitive to water and temperature stresses.

The almost complete lack of response of Russet Burbank to the sprinkler-applied N may be partially attributed to the combination of temperature and water stress and the dynamics of photosynthate distribution for the existing environmental conditions. Another possibility is the placement of the sprinkler-applied N; other studies have shown that sprinkler-applied water and chemical are shed into the furrow where roots may not penetrate. Our observations during the growing season showed that Century Russet had an extensive root system which often penetrated into the furrow. Russet Burbank had a weaker, less extensive root system, so it is possible that it was unable to gain benefit from the sprinkler-applied N for that reason. The sidedress-N treatment showed an increase in Russet Burbank yield with a peak at the 340 lb/A rate. The sidedress N was placed at the side of the hill, very near the root zone. Another possibility is that the sprinkler-applied N moved away from the root zone before it could be obtained by the plant.

At higher sidedress rates, HiLite Russet and Frontier Russet plants were damaged. This contributed to the decrease in yield with increasing sidedress N rates for Frontier Russet. The damaged plants were so small that they could not effectively make enough photosynthate for good tuber growth.

The photosynthesis data suggested that the determinate cultivars may have intrinsic capabilities of maintaining lower leaf temperatures and higher photosynthetic rates. These data concur with other unpublished photosynthesis data collected by the author.

Because HiLite Russet is a determinate-growth type cultivar, it seldom has complete row cover. Therefore, the high soil temperatures result from direct incidence of solar radiation on the hill. Because Russet Burbank and Century Russet shade the hill, temperatures within the hill will be more moderate after row cover is complete.

Before Russet Burbank and Century Russet close over the row, however, high soil temperatures may affect tuber growth and development. Tuber growth is adversely affected at soil temperatures above 25 degrees C (77 F), and no growth occurs above 29 degrees C (84 F).

Conclusions:

The determinate-type cultivars, Frontier and HiLite Russet, had lower total tuber yields but higher percent No. 1 tubers than the indeterminate-type cultivars. Century Russet and Russet Burbank. These differences were attributed to the combination of heat and water stresses present in 1990 and to the complex interactions of the environmental factors and growth responses of the four cultivars.

I thank the Washington State Potato Commission, R. E. Yoder, and R. E. Thornton for supporting this research.

Figure 1. Experimental structure of the 1990 cultivar X irrigation X nitrogen project.

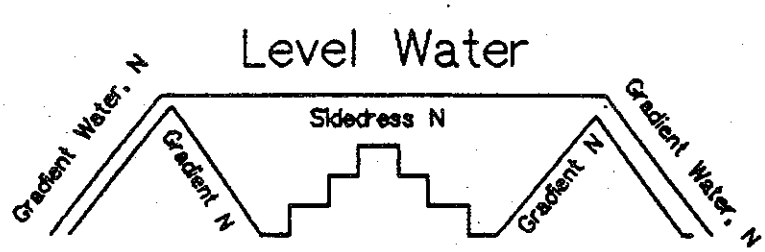

Figure 2. Response of total tuber weight to sprinkler-applied N.

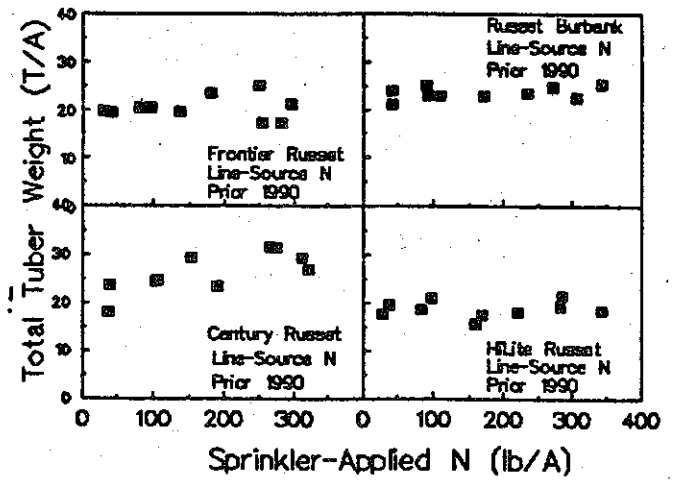

Figure 3. Response of percent No. 1 potatoes to sprinkler-applied N.

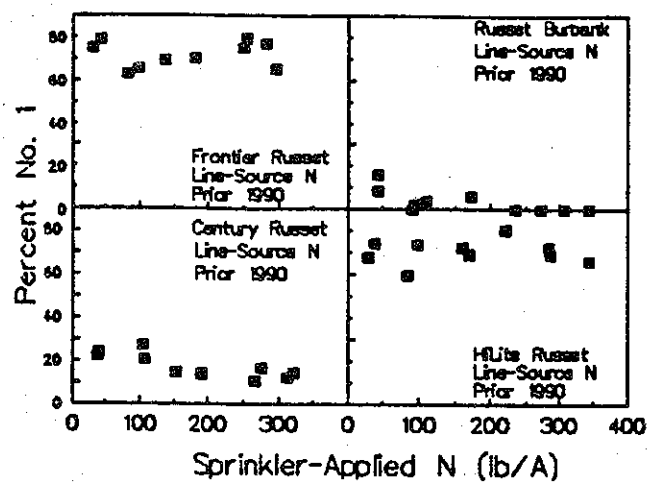

Figure 4. Response of total tuber yields to sidedress N.

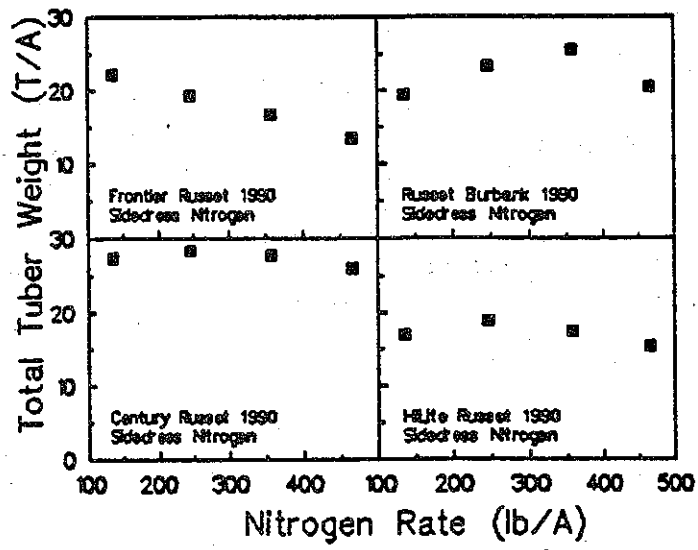

Figure 5. Response of percent No. 1 potatoes to sidedress N.

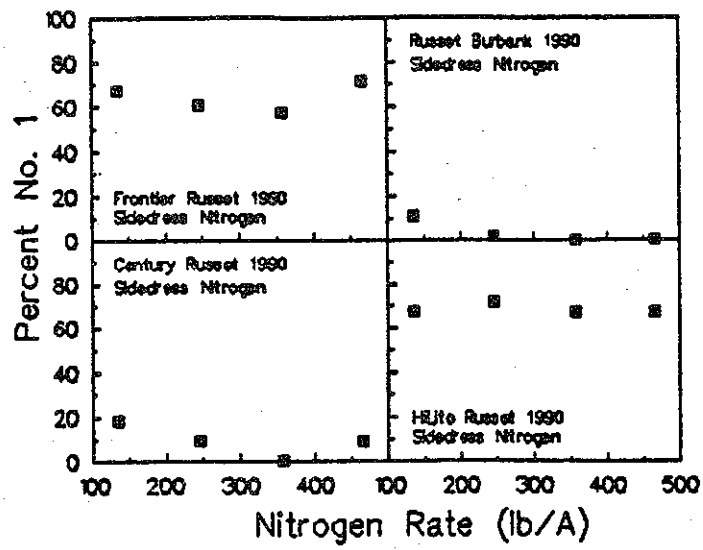

Figure 6. Specific gravity response to sprinkler-applied N.

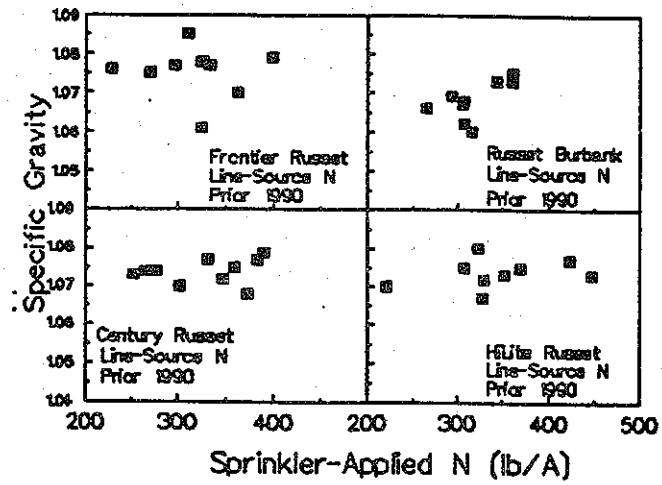

Figure 7. Soil temperature at 2 inches below the hill surface on E-W hills.