

POTATO VARIETAL RESPONSES TO NITROGEN RATE AND TIMING

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ABSTRACT

The cultivar Russet Burbank accounts for the majority of potato acreage planted in Idaho each year. With increasing demands on growers to produce a superior crop with minimal input, there are several new cultivars that are increasing in popularity. With these new cultivars, there has arisen a need to evaluate their specific nitrogen requirements. Applying the current fertilizer regimes used on Russet Burbank to these new varieties may not be maximizing their inputs for production. The discovery of optimal nitrogen rates and application times would help produce a superior crop, while potentially reducing production costs by maximizing fertilizer utilization. This study was undertaken to evaluate different nitrogen levels, applied primarily pre-season or primarily in-season, and their effects on yield, grade and internal quality.

INTRODUCTION

Current fertilizer guidelines for potatoes in Idaho are based on optimum fertility rates and potential yield for Russet Burbank (Stark and Westermann, 2001). As with most crops, potatoes will respond to an increase in available N by maximizing tuber growth and maintaining this growth throughout the growing season (Kleinkopf et al., 1987). However, too much available N can have negative effects on tuber yield and quality. Excess N at or before tuberization can reduce yield and specific gravity of indeterminate varieties such as Russet Burbank. Too much late season N may also delay tuber maturity and subsequently reduce storability and quality. These effects of N availability patterns on tuber growth, yield and quality have led to recommendations for split N applications, with lower levels applied pre-plant (Stark and Westermann, 2001).

Newer potato cultivars are becoming more widely grown because of improved characteristics such as earliness, yield, quality, and storability, and increased resistance to insects, pathogens and other environmental stresses. However, little information is available on the nutrient requirements of these newer cultivars. On Prince Edward Island, it was found that Butte, Frontier Russet and Russet Burbank all had a linear response to N applications, while Century Russet, Shepody and Ranger Russet had curvilinear responses. The curvilinear relationship suggests that the effect of N is reduced at the higher rates; while the linear relationship suggests that more N may be added without a loss of efficacy (Arsenault et al., 2001). This study illustrates that the N requirement of Russet Burbank may be different, either higher or lower, than those of the newer cultivars.

Cultivars with tuber growth periods that are longer or shorter than Russet Burbank may also require different patterns of N availability. Shorter season cultivars may set tubers more quickly, and therefore require less pre-season N to prevent delayed tuber development. Late season N may not need to be applied to these cultivars because they mature earlier, thus reducing the total seasonal N requirement. Finding the optimum N rate may reduce the total N applied and supply N at the appropriate times within the season, thus optimizing the yield and grade of the crop.

OBJECTIVES

The present study was undertaken to determine optimal N rates and application timings for some of the newer potato varieties. Determination of these optimum N rates should maximize yield and quality of the potato crop while improving N use efficiency and minimizing impacts on the environment.

MATERIALS AND METHODS

Experiments designed to determine optimum N rates and application timings for seven potato varieties were carried out at two sites, including Aberdeen, ID from 1999 through 2001 and Parma ID, in 2001 and 2002. At Aberdeen, N as NH_4NO_3 (34-0-0) was applied to four varieties (Russet Burbank, Gem Russet, Bannock Russet and Summit Russet) at four rates (0, 90, 180, or 270 lb N/A) using two seasonal N application patterns. Nitrogen was applied either 1) 2/3 pre-plant plus 1/3 in-season (early treatment), or 2) 1/3 pre-plant plus 2/3 in-season (late treatment). At Parma, N as NH_4NO_3 was applied to three varieties (Alturas, Ranger Russet and A8893-1) at five rates (0, 100, 200, 300, or 400 lb N/A), with two seasonal N application patterns. Nitrogen was applied either 1) 1/3 pre-season plus 2/3 in-season (during tuber bulking) or 2) 2/3 pre-season plus 1/3 in-season. All pre-season applications were broadcast applied and mechanically incorporated into the soil. All in-season N was hand-applied at 1 to 2 week intervals during tuber bulking and incorporated with 1/2 to 1 inch of water with sprinkler irrigation. All plots were irrigated with a solid set sprinkler system, maintaining 65% available soil moisture throughout the growing season.

All experiments were set up as a split block design, with fertilizer rates and timings as main plots and the varieties as sub-plots, with five replications. At the Parma site, the plots were four rows wide, set at 36-inch row spacing, and 50 feet long. The Aberdeen plots were six rows wide with 36-inch row spacing and 40 feet long. A 10-inch within row seed piece spacing was used at both sites. The soil type at the Parma site is a Greenleaf-Owyhee silt loam, while at the Aberdeen site the soil type is a Declo sandy loam. At both sites the two center rows of the plot were harvested and evaluated.

All plots were evaluated after harvest for yield, grade and internal quality. From the yield and grade data, relative yields were calculated and then run through quadratic regression models comparing relative yield with soil plus fertilizer N for each variety-N timing combination. Maximum yields were also calculated based on the optimal N rates generated by the regression models.

RESULTS AND DISCUSSION

Alturas is a late-season variety and produced a maximum yield of 570 cwt/A with the late N treatment at an optimum N rate (soil + fertilizer N) of 233 lbs N/A (Fig. 1). Results with Alturas for the early N treatment were similar with a maximum yield of 564 cwt/A at an optimum N rate of 244 lb N/A. Based on the relative total yield and relative US No.1 yield, a recommendation of 220 to 260 lbs N/A applied 2/3 pre-plant should maximize production of Alturas. By comparison, current recommendations for similar yields (550 to 600 cwt/A) of Russet Burbank potatoes would be about 300 to 320 lbs N/A of soil + fertilizer N (Stark and Westermann, 2001).

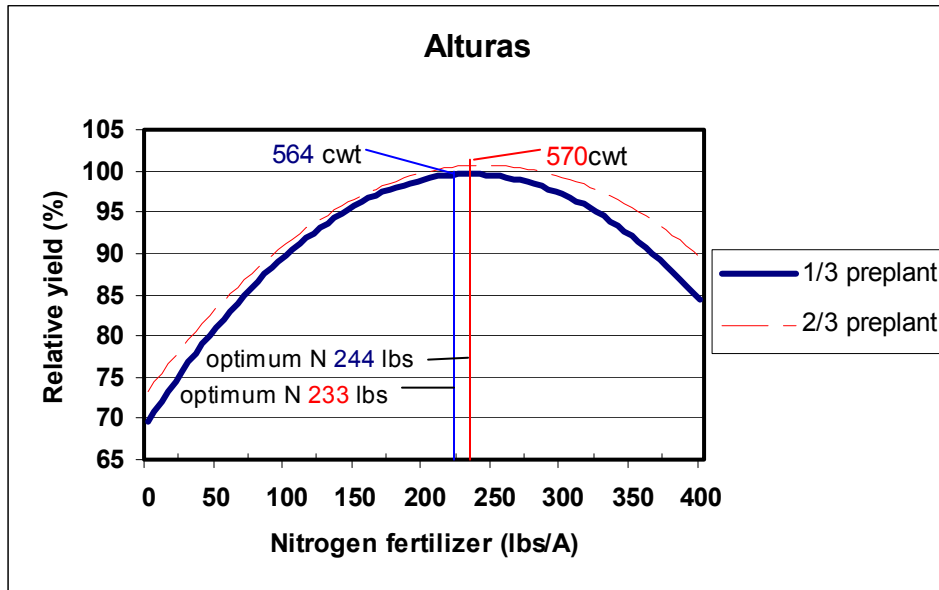


Figure 1. Alturas relative yield as affected by total nitrogen fertilizer.

Ranger Russet is also a late season variety and produced a maximum yield of 476 cwt/A with the early N treatment at an optimal N rate of 261 lb N/A, and a maximum of 473 cwt/A with the late N treatment at 282 lb N/A (Fig. 2). Based on the relative total yield and relative U.S. No.1 yield, a recommendation of 250 to 290 lbs N/A with 2/3 applied pre-plant will maximize the production of Ranger Russet. The current guidelines for similar yields of Russet Burbank are 260 to 280 lbs N per acre, which is similar to that observed for Ranger Russet.

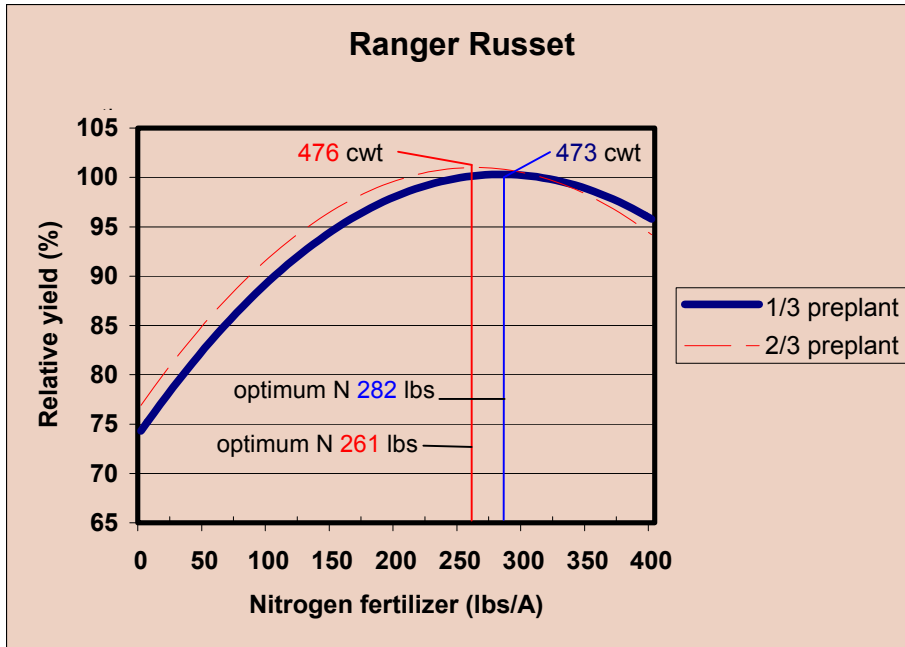


Figure 2. Ranger Russet relative yield as affected by total nitrogen fertilizer.

A8893-1 is a relatively early variety and showed the greatest response to N rate and timing. This variety produced a maximum of 466 cwt/A with the late N treatment at an optimum N rate of 243 lb N/A, and a maximum of 453 cwt/A with the early N treatment at 289 lb N/A (Fig. 3). Therefore, a recommendation of 240 to 280 lbs/A of soil + fertilizer N applied 1/3 pre-plant should maximize the production of A8893-1 within a yield range of 450 to 500 cwt/A. This recommendation is similar to the current guidelines for Russet Burbank at this yield level.

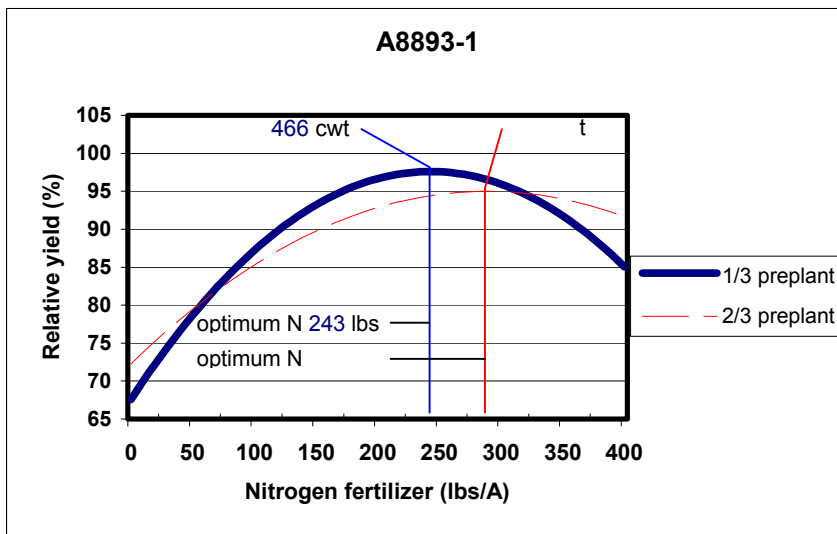


Figure 3. A8893-1 relative yield as affected by total nitrogen fertilizer.

Nitrogen timing had little effect on either maximum yield or optimum N rate for both Bannock Russet and Gem Russet grown at the Aberdeen location (Fig. 4 and 5).

Maximum yields for these two varieties were similar ranging from 341 to 353 cwt/A, while optimum N rates were 188 to 190 lb N/A for Bannock Russet and 229 to 235 lb N/A for Gem Russet.

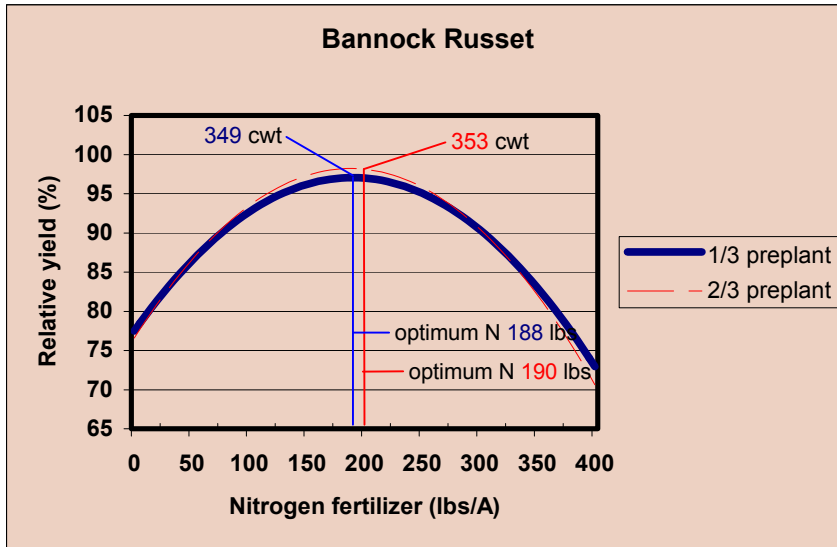


Figure 4. Bannock Russet relative yield as affected by total nitrogen fertilizer.

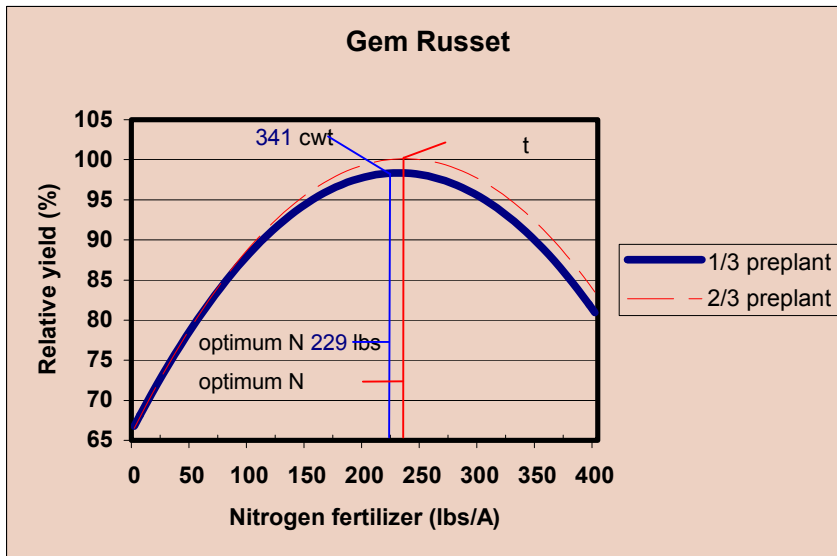


Figure 5. Gem Russet relative yield as affected by total nitrogen fertilizer.

By comparison, maximum yields for Russet Burbank were 336 and 328 cwt/A for the early and late N treatments, respectively (Fig. 6). Russet Burbank used the early-applied N more efficiently than late N with an optimal N rate of 214 lb N/A for the early N treatment compared to 248 lb N/A for the late N treatment. These optimal rates are fairly close to the recommended rates (210 to 230 lb N/A) from current UI guidelines for Russet Burbank for yields in the 330 to 350 cwt/A range.

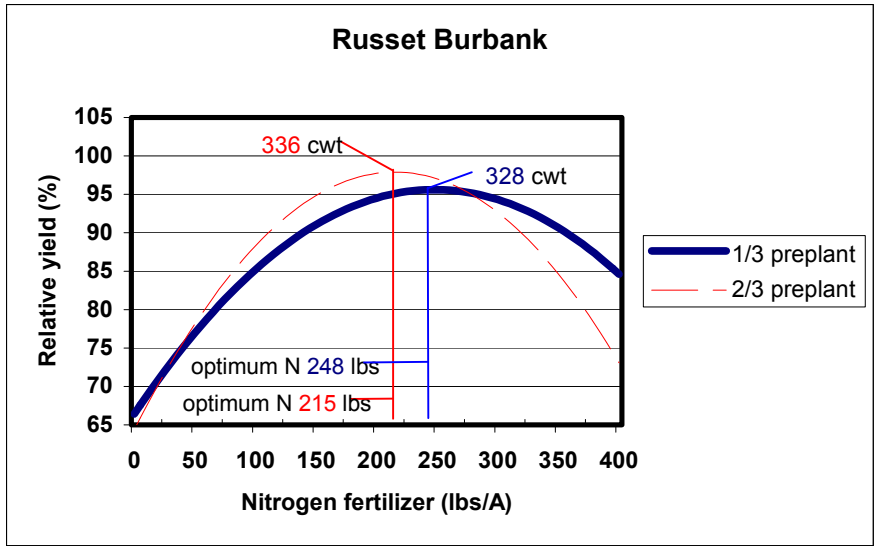


Figure 6. Russet Burbank relative yield as affected by total nitrogen fertilizer.

Maximum yields for Summit Russet were somewhat lower (295 to 302 cwt/A) than those for Russet Burbank (Fig. 7). However, the N responses for the two varieties were fairly similar (Fig. 7) with the early N treatment for Summit Russet having a much lower optimal N rate (204 lb N/A) than the late N treatment (261 lb N/A).

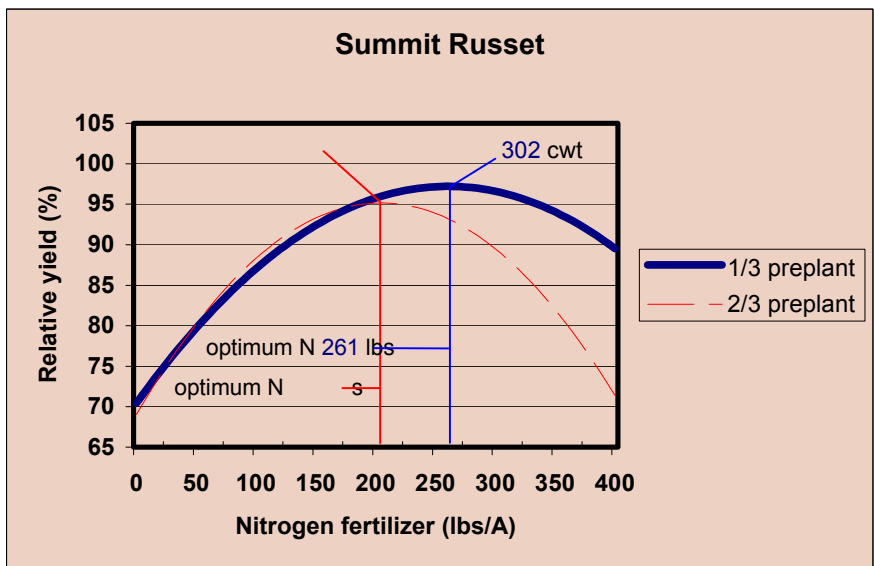


Figure 7. Summit Russet relative yield as affected by total nitrogen fertilizer.

Optimum N rates for the 7 varieties are summarized in Table 1. In general, the results from these studies indicate that Bannock Russet requires significantly less N than Russet Burbank, Gem Russet or Summit Russet, while the average optimal N rates for the latter three varieties were fairly similar. Nitrogen timing had relatively little effect on N utilization by Bannock Russet and Gem Russet, but early N was used more efficiently than late N by Russet Burbank and Summit Russet. Alturus and Ranger Russet also

preferred split-N applications with most of the N applied prior to planting. However, A8893-1 performed best with most of the N applied during tuber bulking.

Table 1. Nitrogen rate of varieties at maximum yield

Aberdeen	Applied	Applied
	Early	Late
	----- lbs/A -----	
Bannock Russet	188	190
Gem Russet	235	229
Russet Burbank	215	248
Summit Russet	205	261
Parma		
Alturas	233	244
Ranger Russet	261	281
A8893-1	289	243

FERTILIZATION TIPS FOR NEW VARIETIES

Presented here are brief tips on managing fertility for each of several new potato varieties. The information presented is based on a combination of research, grower experience, and general knowledge of production principles. As new information becomes available, some of these recommendations may be updated.

Ranger Russet:

- 1. Use similar amounts of N as for Russet Burbank.** Research has shown that Ranger Russet N requirements are similar to those of Russet Burbank. Grower experience has shown that seasonal nitrogen applications on Ranger Russet can be terminated a week or two earlier on Ranger Russet if the crop is maintaining adequate green vines.
- 2. Apply 1/4 to 1/3 N preplant.**
- 3. Design the fertility program to maintain green vines up until vine kill.**
- 4. Optimal petiole nitrate concentrations at each stage of growth:**
 - Prior to tuber set: 18,000 - 20,000 ppm
 - Tuberization: 17,000 - 19,000 ppm
 - Early bulking: 16,000 - 19,000 ppm
 - Late bulking: 14,000 - 17,000 ppm
 - Maturation: 11,000 - 13,000 ppm
- 5. Use soil and tissue testing to ensure adequate K availability.**

Russet Norkotah:

- 1. Use similar amounts to up to 20% more N than for Russet Burbank.** Amounts will depend on the field situation. Less is required after fumigation or long rotations. More is required if the field has any history of early die.
- 2. Apply 2/3 to 3/4 N preplant.**

3. **Apply 80 to 90% of N by the time the first flowering period ends** (row closure).
4. **Avoid N deficiency situations.** This may be caused by inadequate applications or overwatering on light soils.
5. **Optimal petiole nitrate concentrations at each stage of growth (based on grower experience):**
 - Prior to tuber set: 18,000 - 20,000 ppm
 - Tuberization: 17,000 – 19,000 ppm
 - Early bulking: 15,000 – 17,000 ppm
 - Late bulking: 12,000 – 15,000 ppm
 - Maturation: 8,000 - 10,000 ppm
6. **Use less N for the Russet Norkotah line selections.**
 - For CO#3, use 60 to 70% of recommendation for Russet Burbank, 1/2 to 2/3 preplant.
 - For CO#8 and the Texas strains, use 70 to 90% of Russet Burbank recommendations, 2/3 to 3/4 preplant.

Shepody:

1. **Use 20% less N than for Russet Burbank.** Shepody has similar nitrogen needs as Russet Burbank, but a shortened season typical of early harvest and a need to maintain high tuber solids dictates a lower recommendation.
2. **Apply 1/3 – 1/2 N preplant.**
3. **Avoid overapplication of N.** High levels of nitrogen fertilizer decrease tuber solids.
4. **Optimal petiole nitrate concentrations at each stage of growth:**
 - Prior to tuber set: 18,000 -20,000 ppm
 - Tuberization: 15,000 - 18,000 ppm
 - Early bulking: 12,000 - 15,000 ppm
 - Late bulking: 9,000 – 13,000 ppm
 - Maturation or vine kill: 5,000 - 8,000 ppm
5. **Monitor phosphorus season-long.** Inadequate phosphorus contributes to low tuber solids. Use rates recommended for Russet Burbank. Use soil tests to determine preplant application rates. Make foliar applications if the prediction curve appears to fall below optimum.

Umatilla Russet:

1. **Follow recommendations made for Ranger Russet.** Maintaining green vines up until vine kill is not as critical for Umatilla Russet as it is for Ranger Russet.
2. **Apply 1/3 to 1/2 N preplant.**
3. **Assume petioles nitrate critical levels are similar to Ranger Russet:**
 - Prior to tuber set: 18,000 - 20,000 ppm
 - Tuberization: 17,000 - 19,000 ppm
 - Early bulking: 16,000 -19,000 ppm
 - Late bulking: 14,000 – 17,000 ppm
 - Maturation: 11,000 -13,000 ppm

Alturas:

- 1. Use 30 to 50% less N than is recommended for Russet Burbank.** Alturas is very late maturing and prone to a delay in tuber set with excess nitrogen. Low levels of nitrogen are needed to counter these tendencies. Also, it is wise to avoid situations wherein large amounts of mineralized nitrogen is available late in the season, such as following alfalfa in rotation.
- 2. Apply 1/4 to 1/3 of N preplant.** Use lower amounts if soil residual N is high.
- 3. Complete all N applications by last week of July.** Late applications cause delayed tuber growth in Alturas and has a negative impact on yield.
- 4. Do not apply late applications of N in response to low petiole levels.**
- 5. Petiole nitrate critical levels:** Should start out 15,000 – 20,000 ppm prior to tuber set then consistently decline to a level less than 6,000 ppm by approximately 2 weeks prior to vine kill.

Gem Russet:

- 1. Use similar amounts of N as recommended for Russet Burbank.**
- 2. Apply 1/3 to 1/2 of N preplant.**
- 3. Optimal petiole nitrate concentrations at each stage of growth:**
 - Prior to tuber set: 18,000 - 20,000 ppm
 - Tuberization: 17,000 - 19,000 ppm
 - Early bulking: 16,000 - 19,000 ppm
 - Late bulking: 14,000 – 17,000 ppm
 - Maturation: 11,000 - 13,000 ppm

Bannock Russet:

- 1. Use 60 to 70% of the total N recommended for Russet Burbank.**
- 2. Apply 1/4 to 1/3 N preplant.** Do not apply extremely high levels of preplant N to avoid any delay in tuber set.
- 3. Optimal petiole nitrate concentrations at each stage of growth.**
 - Prior to tuber set: 20,000 - 22,000 ppm
 - Tuberization: 18,000 - 20,000 ppm
 - Early bulking: 11,000 - 16,000 ppm
 - Late bulking: 5,000 – 10,000 ppm
 - Maturation: 2,000 - 6,000 ppm

Summit Russet:

- 1. Use similar amount of N as recommended for Russet Burbank.**
- 2. Apply 1/4 N preplant.** Do not apply high rates of preplant N to avoid significant delays in tuber set. Research has shown that Summit Russet responds positively to having most N applied after tuber set.
- 3. Begin seasonal applications of N after tuber set.**
- 4. Optimal petiole nitrate concentrations at each stage of growth:**
 - Prior to tuber set: 20,000 – 25,000 ppm
 - Tuberization: 19,000 – 23,000 ppm

Early bulking: 15,000 - 18,000 ppm
Late bulking: 10,000 – 16,000 ppm
Maturation: 6,000 – 12,000 ppm

Chipeta:

- 1. Use 20 to 30% less N than recommended for Russet Burbank.**
- 2. Apply 1/4 N preplant.** In order to avoid a delay in tuber set, do not apply high rates of preplant N.
- 3. Begin seasonal applications of N after tuber set.**
- 4. Petiole nitrate sufficiency levels have not been experimentally determined.**
- 5. Grower experience dictates high application rates of phosphorus fertilizers.**
The claim for high levels of phosphorus is increased tuber set.

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