# Petiole Nitrate Trends Across Eight Potato Cultivars

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## INTRODUCTION

When new cultivars are released to the industry, little is known about their cultural management needs. Recent research and grower experience with new releases like Alturas and Premier Russet (A93157-6LS) have demonstrated that reducing in-season nitrogen below what is commonly applied on Russet Burbank may actually provide a higher economic yield for some varieties. In addition, concerns over escalating fertilizer prices and water quality (nitrate leaching) have placed pressure on growers and researchers to avoid excess fertilizer applications and develop precise fertility recommendations for each new and existing variety.

Growers are more likely to utilize recommendations coming from research that mimics operations similar to theirs. For in-season fertilizer application, most Washington potato growers deliver nutrients to plants via their irrigation systems. This method is commonly referred to as fertigation or chemigation. Beyond the issues of year to year crop growth variations and regional differences, the largest difficulty in developing in-season potato fertility recommendations has been the inability to conduct trials with a large number of fertilizer treatments while utilizing irrigation water as the treatment carrier. The objectives of this research trial were 1) to develop a reliable research method that closely mimics fertigation and allows for a large number of treatments, 2) identify new and existing varieties that produce economically superior yields with an in-season level of nitrogen that is reduced below current recommendations for Russet Burbank, 3) determine if petiole nitrate values from several new and existing varieties respond similar to Russet Burbank, and 4) utilize cues and application method from this preliminary trial to design future trials in an effort to fine-tune the fertility requirements for commonly grown varieties.

## MATERIALS AND METHODS

Two field experiments in the Columbia Basin of Washington were conducted during 2005-06 to compare the effects of two in-season N rates on eight potato cultivars. The potato cultivars included: 'Russet Burbank', 'Ranger Russet', 'Umatilla Russet', 'Alturas', 'Defender', 'GemStar', A93157-6LS ('Premier Russet'), and 'A95109-1'. The two in-season N rates were: 1) 100% of typical Russet Burbank in-season needs and 2) 50% of typical. A soil test was used to determine pre-plant fertilizer needs across the trial sites. One rate of pre-plant N and adequate quantities of P, K, S, Boron, and Zinc, were broadcast across the trial areas each year prior to planting. Pre-plant N was 67 lbs soil N + 50 lbs applied granular (46-0-0) in 2005 and 80 lbs soil N + 75 lbs applied granular (46-0-0) in 2006. Nutrient applications were based on recommendations in the 1999 Washington State University Extension Bulletin No. 1871 "Potato Nutrient Management for Central Washington" and from the recommendations of several local consultants. Between 49 days after planting (DAP) (just prior to 100% ground cover) and 132 DAP, 10 petioles were collected weekly from each plot to determine nutrient needs for each cultivar. Nitrogen was applied weekly during the same time period and rates were adjusted according to the petiole and soil N concentrations. A pull-type sprayer (fertigation simulator) fit with a 500 gal tank and flood-nozzles was calibrated to deliver urea ammonium nitrate solution 32-0-0 (UAN 32) in 0.15 in/A water on each plot. The in-season application rates were adjusted in an attempt to keep the 100% treated-Russet Burbank's petiole nitrate concentration between 20,000 - 25,000 and soil N above 50lbs/A until approximately 80 DAP. Beyond 80 DAP, the petiole and soil N concentrations were allowed to slowly decline.

Each experiment was arranged in a randomized complete block design with four replications. Certified seed tubers were hand-cut into pieces between 43 and 85 g and planted using a custom-built assist feed planter. Planting depth from the top of the seed piece to the top of the hill was 8 inches and in-row seed piece spacing was 10 inches. Furrows were ripped 16 inches deep using a dammer-diker implement with no change to final seed-piece depth. Row width was 34 inches with plots 4 rows by 15 feet. The center two rows were used to collect all data and petioles. To apply competition to the end plants, each plot end was guarded with the potato cultivar, 'All Blue'. All experiments were planted near Othello, Washington in a Shano silt loam soil and grown with overhead sprinkler irrigation under regional-standard practices for Russet Burbank. Planting dates were April 6, 2005 and April 11, 2006.

Plant emergence counts and aboveground stem numbers were recorded at 60 DAP. To assess in-season plant development, data were collected from one hand harvest at 126 and 127 DAP during 2005 and 2006, respectively. Three intact plants from one center row of each plot were harvested; the plant nearest the end was discarded. Main stem number, fresh plant (aboveground) weight, tuber number, weight and specific gravity, and harvest index ((tuber weight/tuber weight + above-ground fresh plant weight) x 100) were recorded.

Plots were harvested 174 DAP in 2005 and 163 DAP during 2006 using a one-row mechanical harvester. Vines were removed with a flail 5 to7 days prior to harvest. Each harvested tuber was washed, weighed and counted. Total tuber yield was partitioned into U.S. No. 1, U.S. No. 2, malformed, and green categories. Five 340 to 397 gram tubers from each plot were evaluated for hollow heart, internal brown spot, and brown center defects. Length and width of five 227 to 397 g tubers from each plot were measured and the length to width ratio was calculated. A composite of 20 tubers weighing between 227 to 397 g was used for weight-in-water/weight-in-air specific gravity determination.

Fresh and process gross income minus the fertilizer expense for each treatment and variety was determined. Fresh market gross income was determined using four-year regional-average fresh-market values for 1999/00 to 2003/04 market periods (USDA Federal-State Market News Service 2000-2004). A mock processing contract was used to determine gross process market income and was based on actual regional values. During the gross income calculations, the nitrogen expense was calculated using a value of $0.47 lb. All data were analyzed using analysis of variance and the means statistically separated using Fisher's Protected Least Significant Difference Test at the 0.05 level of probability.

**RESULTS**

The actual quantities of in-season N applied were 100% = 281 lbs/A (288/lbs/A in 2006) and 50% = 180 lbs/A. Combined with the pre-plant N (soil residual + broadcast), the season totals for the 100% treatments were 348 lbs/A and 368 lbs/A for 2005 and 2006, respectively. Total-season N for the 50% treatments were 232lbs/A and 262 lbs/A for 2005 and 2006 respectively. Based on the values above, 34% and 42% of the total season N was available to the plants prior to emergence during 2005 and 2006, respectively.

The 2006 petiole and soil values for each cultivar and treatment are shown in Figure 1. Although 2005 values are not shown, the trends were similar to those in 2006. Both the petiole and soil values for all cultivars indicated that the application method was successful in providing quantifiably different N rates. There was a visible separation of the 100% and 50% treatments in petiole and soil values for all cultivars, although some cultivars had greater differences than others. Across both years and treatments the petioles of several cultivars tracked closely to Russet Burbank (data not shown), but in 2005 (Figure 2), A95109-1, Defender, Ranger, GemStar, and Umatilla were typically higher than Russet Burbank. These trends were mostly consistent across both years, but a third year of testing is needed to better understand these cultivars.

The reduced N treatment typically produced a higher harvest index than the 100% N treatment for most cultivars across both years (Figure 3). This indicates that the reduced N treatment partitioned more dry matter to the tubers than to the above-ground plant components (vines, leaves, stems). Excess nitrogen delays tuber maturity, leads to excessive vine growth, and reduces tuber yield. Therefore, the higher the harvest index, the better.

Across all cultivars and years, the reduced N treatment significantly reduced total and processing yield compared to the 100% treatment (Table 1). However, carton yield and gross returns (fresh and process markets) from the reduced N treatment were not significantly different from the 100% treatment (Table 1). Vine senescence occurred earlier but specific gravity values were typically higher coming from plants grown under the reduced N rate treatment (data not shown). Additionally, A93157-6LS (Premier Russet) had less hollow heart when grown with the reduced rate (data not shown).

## DISCUSSION

All eight cultivars typically yielded less with the reduced rate of N, but the ECONOMIC yield was not significantly different, and was often higher, after accounting for the N expense. The reduced N rate increased the harvest index, tuber dry matter (specific gravity), and reduced internal defects. Moreover, lower N rates likely reduced the chances of ground water contamination from leached nitrates.

The key to success with the reduced in-season N is that the plants get adequate pre-plant or up-front N. After sufficient pre-plant N (approx. 125-150 lbs, soil residual + applied), the in-season water-run N can be reduced below what is typical for RB. For these 8 cultivars, total season N (including pre-plant soil residual) between 240–260 lbs/A N should suffice. Starting just prior to row-closure, the water-run spoon-fed N should be applied in 10 to 30 lbs/A increments at weekly/bi-weekly intervals until mid/late July, depending on harvest date and market. However, where certain diseases afflict cultivars like RB we recommend N rates of around 300–350 lbs full season because there is some indication that more vigorous vines aid against diseases like verticillium wilt. With Alturas, A93157-6LS, and A95109-1 the reduced rate may be best; A93157-6LS tends to have less hollow heart, A95109-1 tubers are a more marketable size, and Alturas does fine with reduced N. The nutrient requirements for these eight cultivars needs to be better defined, especially for the newest releases. Because this new application method appeared to work well, more detailed research will be conducted on each cultivar in the near future. This research will be updated and reported during the 2008 Washington State Potato Conference following the third and final year of research. For a more complete evaluation, readers should review the 2008 proceedings. Because it is likely the recommendations for each cultivar will become more specific in the future, growers should contact their local extension personnel or the authors of this paper for the latest nutrient recommendations.

**Table 1.** Effects of in-season nitrogen rate on yield and economic value of eight potato cultivars, averaged across 2005 and 2006. The abbreviation "ns" indicates the differences between the two treatments were not significant.

| ENTRY | FERT RATE % | TOTAL YIELD (CWT/A) | US # 1's* > 4 oz % of Total Yield | US # 2's* > 4 oz % of Total Yield | Culls* & < 4 oz % of Total Yield | CARTON YIELD 100-50 count (US 1's 7-18 oz) % of Total Yield | CARTON YIELD 100-50 count (US 1's 7-18 oz) (CWT/A) | PROCESS YIELD US 1's and 2's > 6 oz % of Total Yield | PROCESS YIELD US 1's and 2's > 6 oz (CWT/A) | Adjusted Fresh $ Gross $ | Adjusted Process $ Gross $ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Alturas | 50 | 889 | 81 | 7 | 12 | 55 | 493 | 73 | 648 | 6492 | 3967 |
| Alturas | 100 | 917 | 82 | 6 | 12 | 56 | 510 | 71 | 653 | 6650 | 3926 |
| | p-Value | ns | | | | | ns | | ns | ns | ns |
| Defender | 50 | 740 | 80 | 7 | 14 | 50 | 369 | 67 | 495 | 4711 | 3075 |
| Defender | 100 | 801 | 80 | 6 | 14 | 50 | 404 | 66 | 531 | 5091 | 3181 |
| | p-Value | ns | | | | | ns | | ns | ns | ns |
| Gemstar | 50 | 660 | 92 | 2 | 6 | 61 | 400 | 72 | 476 | 4800 | 2980 |
| Gemstar | 100 | 739 | 95 | 0 | 5 | 59 | 435 | 71 | 523 | 5276 | 3263 |
| | p-Value | ns | | | | | ns | | ns | ns | ns |
| Ranger | 50 | 706 | 86 | 6 | 8 | 57 | 405 | 73 | 515 | 5210 | 3155 |
| Ranger | 100 | 731 | 87 | 5 | 8 | 58 | 425 | 74 | 542 | 5366 | 3185 |
| | p-Value | ns | | | | | ns | | ns | ns | ns |
| RB | 50 | 669 | 74 | 8 | 19 | 47 | 316 | 64 | 427 | 4315 | 2615 |
| RB | 100 | 703 | 72 | 9 | 19 | 44 | 310 | 64 | 447 | 4319 | 2678 |
| | p-Value | ns | | | | | ns | | ns | ns | ns |
| Umatilla | 50 | 689 | 81 | 3 | 16 | 49 | 340 | 63 | 435 | 4783 | 2864 |
| Umatilla | 100 | 740 | 82 | 4 | 14 | 51 | 374 | 66 | 486 | 5150 | 3109 |
| | p-Value | ns | | | | | ns | | ns | ns | ns |
| A93157-6LS | 50 | 789 | 89 | 2 | 9 | 63 | 500 | 76 | 597 | 6117 | 3557 |
| A93157-6LS | 100 | 829 | 89 | 3 | 9 | 59 | 492 | 73 | 603 | 6023 | 3632 |
| | p-Value | ns | | | | | ns | | ns | ns | ns |
| A95109-1 | 50 | 692 | 92 | 2 | 6 | 66 | 457 | 79 | 550 | 5656 | 2888 |
| A95109-1 | 100 | 746 | 91 | 3 | 6 | 61 | 456 | 75 | 559 | 5484 | 2685 |
| | p-Value | ns | | | | | ns | | ns | ns | ns |
| All Varieties | 50 | 739 | 84 | 5 | 11 | 58 | 429 | 71 | 525 | 5330 | 3169 |
| All Varieties | 100 | 784 | 85 | 4 | 11 | 53 | 415 | 70 | 547 | 5469 | 3220 |
| | p-Value | 0.0014 | | | | | ns | | 0.0501 | ns | ns |

* Percent values may not total 100% due to rounding.

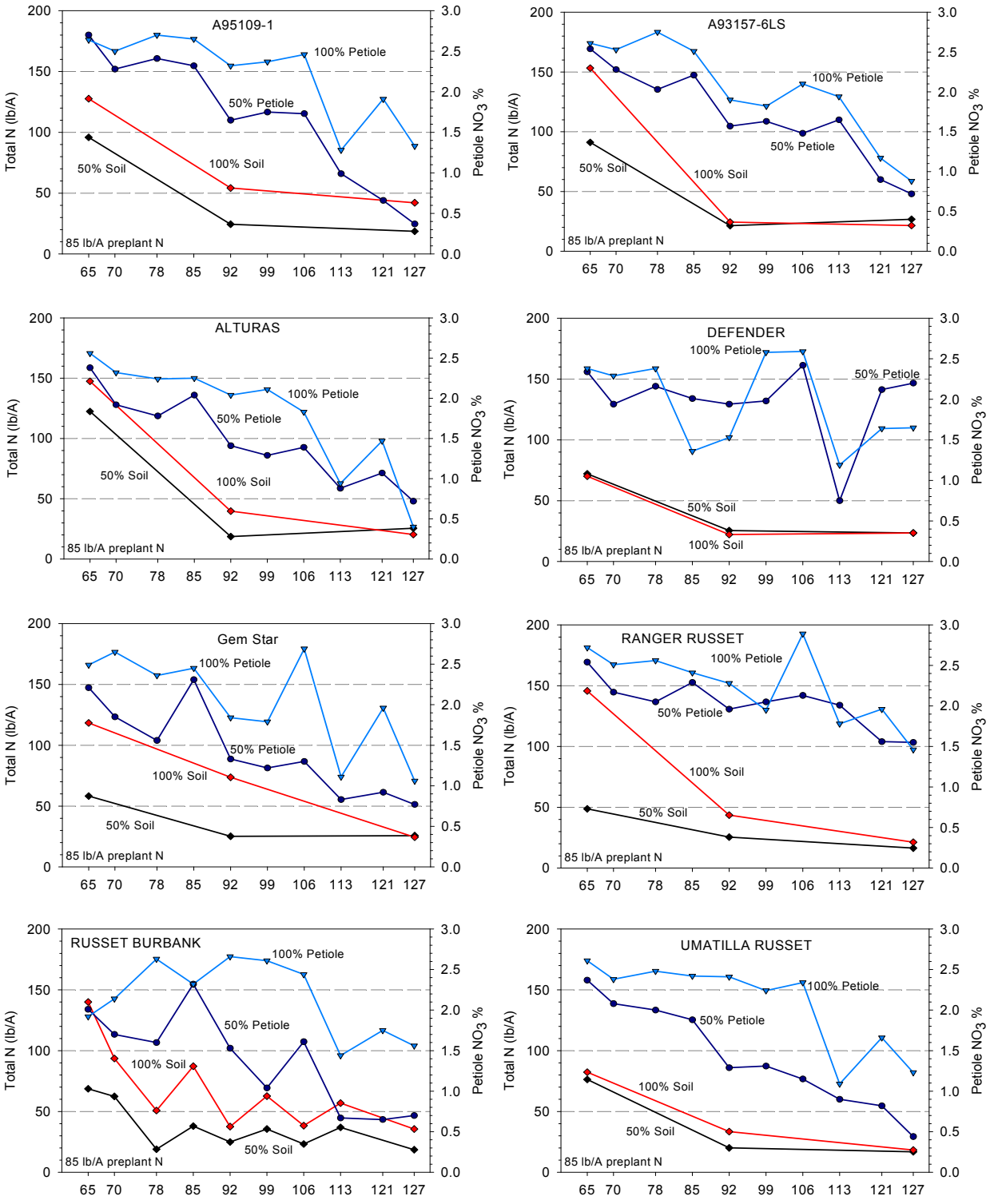


**Figure 1.** Effect of two nitrogen rates on soil and petiole $NO_3$ for eight potato cultivars during 2006. Nitrogen application rates were 100% and 50% of standard practices for Russet Burbank when grown in the Columbia Basin of Washington State. Nitrogen was applied once per week for eight weeks.

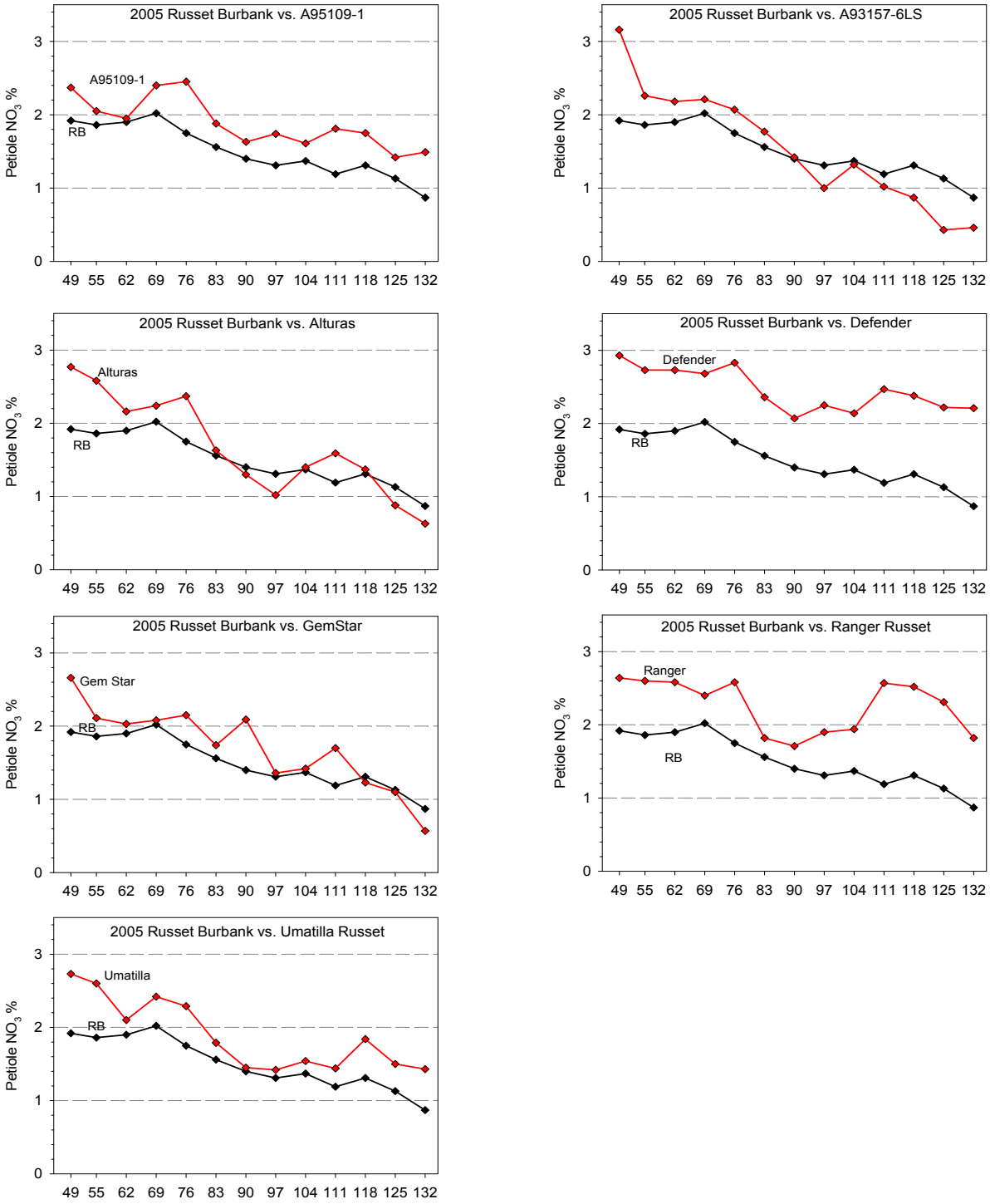


**Figure 2.** Petiole $NO_3$ trends of the 100% N treatment for each potato cultivars compared with Russet Burbank during 2005.

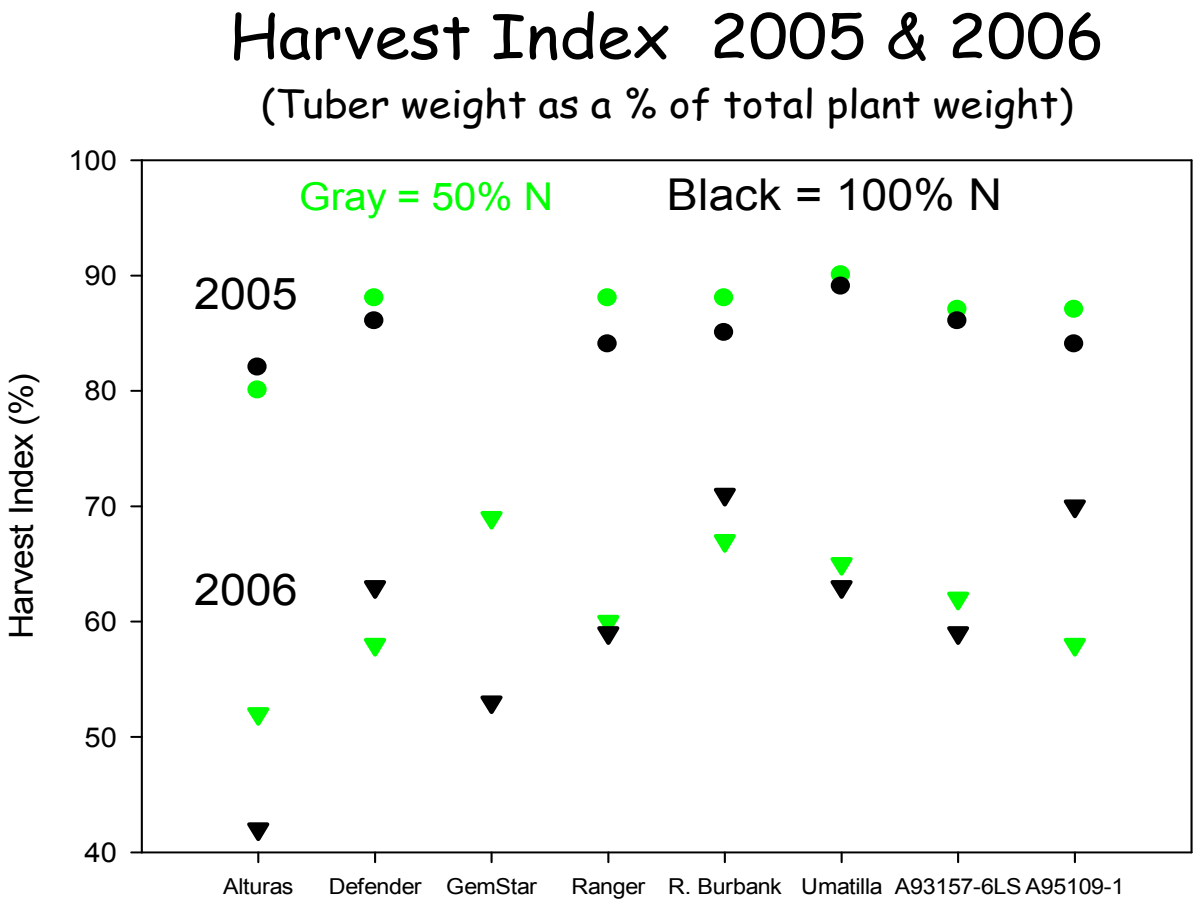


**Figure 3.** Effect of two nitrogen rates on the harvest index of eight potato cultivars during 2005-06. The harvest index is calculated using the following formula: (tuber weight/tuber weight + above-ground fresh plant weight) x 100) and indicates what portion of the total plant weight is tuber weight. Nitrogen application rates were 100% and 50% of standard practices for Russet Burbank when grown in the Columbia Basin of Washington State. Nitrogen was applied once per week for eight weeks.