Defining In-Season Nitrogen Needs for Alturas and Premier Russet

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Proper nitrogen management is a crucial component of potato cropping systems. Insufficient N can lead to reduced growth (Harris, 1992), reduced light interception, limited yield (Chase *et al*., 1990; Laurer, 1986; Santerre *et al* .,1986) delayed tuber set (Harris, 1992), and reduced dry matter content (Yungen, *et al.*, 1958; McDole, 1972; Painter and Augustin, 1976; MacKerron and Davies, 1986; Westerman *et a,*., 1994; Love *et al.*, 2005). Too much N may reduce tuber N uptake efficiency, can delay tuber initiation, and promote overgrowth of vines (Pavlista and Bloomenthal, 2000). Improper nitrogen management can also lead to increased incidences of disease and have adverse environmental effects such as run-off and leaching.

Traditionally N recommendations for Columbia Basin potato production have been based on requirements of the well known Russet Burbank cultivar. However different potato cultivars have unique morphological and developmental characteristics that may differ from Russet Burbank and may have unique requirements. It is no longer appropriate to make blanket N fertilizer recommendations in potato cropping systems.

The recent release of new cultivars from the Tri-State Breeding Program, such as Alturas and Premier Russet, has necessitated the development of appropriate N fertilizer recommendations tailored to each cultivar. The purpose of this study was to identify in-season N rates for Alturas and Premier that maximize grower revenue by optimizing field performance and post-harvest quality attributes with the following specific objectives: (1) to develop a cultivar specific understanding of N response as it relates to yield, quality, and economics, (2) to define specific petiole and soil critical concentrations for each cultivar for maximum economic yields, and (3) increase grower bottom lines. In addition, we wish to understand the effects of in-season N on whole plant morphology and physiology in an effort to improve our ability to make management recommendations for these and other cultivars.

MATERIALS AND METHODS

This experiment was conducted at the WSU Othello Research Station in Othello, WA, on a Shano silt loam during the 2007 and 2008 growing season. Each cultivar was planted in a randomized complete block design with five row plots, 25 ft long, with 5 ft borders and 10 inch spacing between plants. Plots were treated with five in-season N rates: 0%, 25%, 50%, 100%, and 150%. Treatments are expressed as a percentage of the current in-season N recommendations for Russet Burbank. All treatments received the same pre-plant fertilizer during a particular year. Pre-plant, in-season and total season N rates and associated in-season N expense are shown in Tables 1 and 2.

In-season N (UAN-32) was applied weekly between 50 days after planting (DAP) and 100 DAP via a custom designed fertigation simulator that delivered 0.15 in. of water (Table 3). Petioles were collected weekly from center data rows between 60 DAP and 120 DAP and soil samples were collected bi-weekly at one and two foot levels. Hand digs were initiated at 70 DAP and performed every eighteen days. Data on stem number, tuber number, vine weight, tuber weight and tuber number were collected. At the end of the season, tubers were harvested via a two row digger and graded and sized using a custom two lane electronic sizer. An economic evaluation was performed on both cultivars via a mock processing contract modeled after contracts currently in use in the Columbia Basin.

RESULTS

Soil and petiole analysis for both cultivars across the growing season illustrated definite trends among the treatments (Figure 1).For the most part, the petiole and soil N values from each treatment were distinctly different from each other (Figure 1) demonstrating that petiole and soil analysis is sensitive enough to detect minor differences in tissue N concentrations and in-season N rates. The application timing and rate (100% treatment rates) are shown in Figure 1 with arrows and corresponding numbers. The effect of in-season N rate became increasingly visible late in the season as the canopies of the low N rate treatments started to senesce earlier than those receiving the higher rates (Figure 2). Visual ratings of vine senescence were highly correlated with in-season N rate at 141 days after planting (Figure 3).

In-season N rate had a significant effect on total yield of both Premier and Alturas (Figure 3). Premier total yield continued to increase as in-season N rates increased and the yield difference between the 0% and the 150% treatments was more than 100 CWT/A (Figure 3). Total yield peaked in Alturas between the 100% and 150% with a 140 CWT/A difference between the 0% treatment and the 150% treatment (Figure 3).

Tuber specific gravity was highly correlated with N rate for both cultivars (Figures 3). As N levels increased, specific gravity decreased significantly. The economic analysis resulted in significant non-linear trends for both cultivars (Figure 3). Premier showed inverse trends between 2007 and 2008. The 150% treatment was the most profitable in 2007. In 2008, revenue was optimized at an in-season rate close to 90% of what is typical for Russet Burbank; this was equivalent to about 200 lbs N in-season and 125-150 lbs/A N pre-plant. We believe 2008 was the more typical response from this cultivar and hope that another year of data (2009) will confirm this. A non-linear regression projected the economically optimum n-season N rate for Alturas at approximately 96% of the current in-season nitrogen recommendations for Russet Burbank, or about 220 lbs/a of in-season nitrogen and 125-150 lbs/A N pre-plant (Figure 3).

DISCUSSION

This study confirms the well known concept that maximum biological yield does not always equate into maximum economic return. The higher 150% treatment did in fact increase total and market yield (> 6oz) across both years and cultivars, but maximum economic yield was produced with rates between 90% and 100% of what is typically recommended for Russet Burbank. The exception was Premier during the 2007 season where adjusted gross income was marginally higher at the 150% rate than at the 100%. For the most part, yields from N rates greater than 100% became to expensive to achieve; the potential economic gain from the yield increase seen from the 150% treatment was offset by the cost of the extra N used to achieve the yield.

At the lower N rates, harvest index (tuber weight as a proportion of total plant weight (data not shown) and specific gravity increased as expected. The higher N rates delayed vine senescence and lead to an increase in plant longevity and vine weights. Gravities such as those found at the 0% and the 150% treatments were not within the ideal range of a typical processing contract, and both would likely result in contract penalties.

These data illustrate that careful N management can be a valuable tool for tailoring crop maturity to maximize processing incentives and profits. Based on two years of data, we recommend in-season rates of 200 to 220 lbs N for both varieties with at least 125 lbs N available prior to plant emergence. Recommended petiole ranges for the growing season are displayed in Table 4. A well maintained and carefully monitored N fertilizer regime, coupled with adequate pre-plant N and soil and tissue sampling, can maximize profits and reduce N costs.

Table 1. Preplant, in-season, and total season nitrogen for 2007 and associated in-season N expense for five rates of in-season N applied to Premier and Alturas

Treatment as a % of standard	Preplant N + soil resid.	Fertigated in-season N	In-season N From Phos applications	Total in-season N	Total Season N	In-season N Fert expense ($0.80/lb)
%	--	--	lbs/A	--	--	
0	125	0	30	30	155	0
25	125	58	30	88	213	46
50	125	115	30	145	270	92
100	125	230	30	260	385	184
150	125	345	30	375	500	276

Table 2. Preplant, in-season, and total season nitrogen for 2008 and associated in-season N expense for five rates of in-season N applied to Premier and Alturas

Treatment as a % of standard	Preplant N + soil resid.	Fertigated in-season N	In-season N From Phos applications	Total in-season N	Total Season N	In-season N Fert expense ($0.80/lb)
%	--	--	lbs/A	--	--	
0	150	0	9	9	155	0
25	150	58	9	67	217	46
50	150	115	9	124	274	92
100	150	230	9	239	389	184
150	150	345	9	354	504	276

Table 3. Rate scheme for five in-season N rates for 2007-2008

Treatment as a % of RB Standard Rate	Number of Applications*			
	Two	**Four**	**Two**	**Two**
	----------------------------	**N lbs/A**	**----------------------------**	
0%	0	0	0	0
25%	5	7.5	6	3
50%	10	15	13	5
100%	20	30	25	10
150%	30	45	38	15

***Applications started approximately 10 days after >90% emergence**

Table 4. Recommended petiole values at 60-, 90-, and 120-days after planting (DAP) for Alturas and Premier Russet.

Variety	End Tuber Initiation Mid June 60 DAP	Mid Bulking Early July 90 DAP	Late Bulking Late July 120 DAP
	(ppm NO3)	**ppm (NO3)**	**(ppm NO3)**
Alturas	24,000	16,000	8,000
Premier	23,000	15,000	7,400

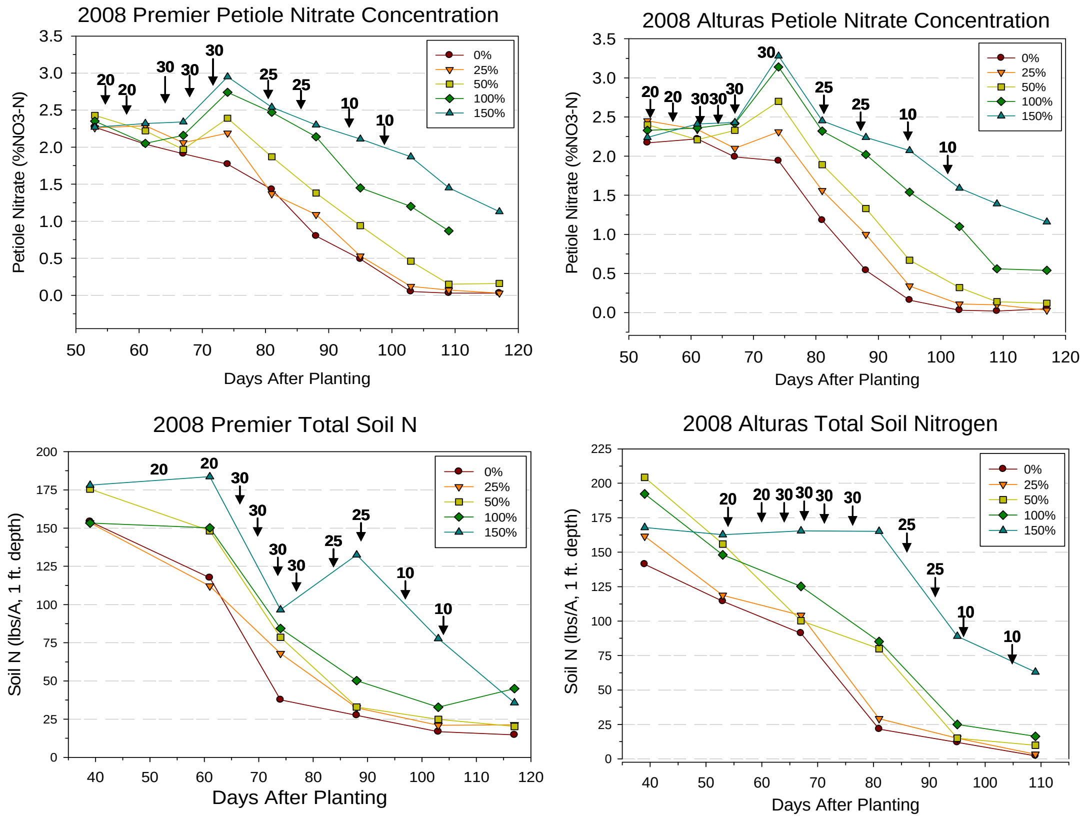

Figure 1. Petiole and soil N for Premier Russet and Alturas during 2008 for each of five in-season N rates. The 100% treatment application timing and rates (lbs/A) are shown with arrows.

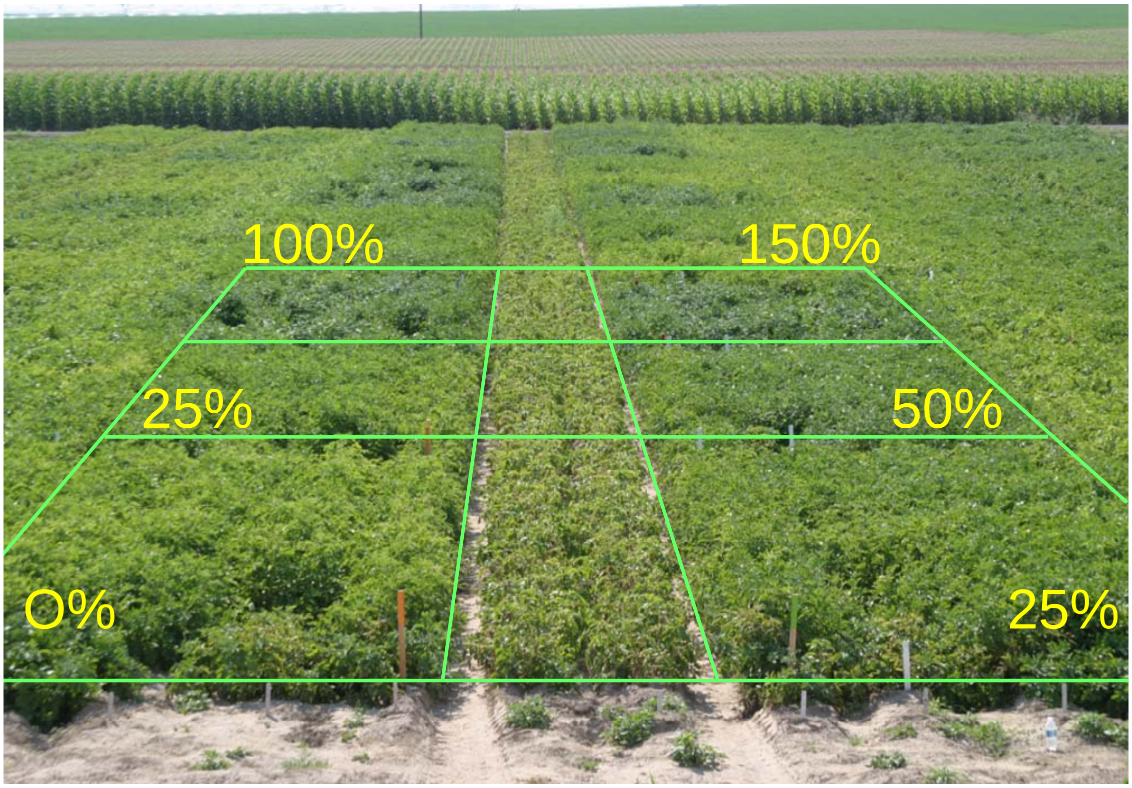

Figure 2. Alturas canopy appearance late July 2007 for each of five in-season N rates (shown as percentages).

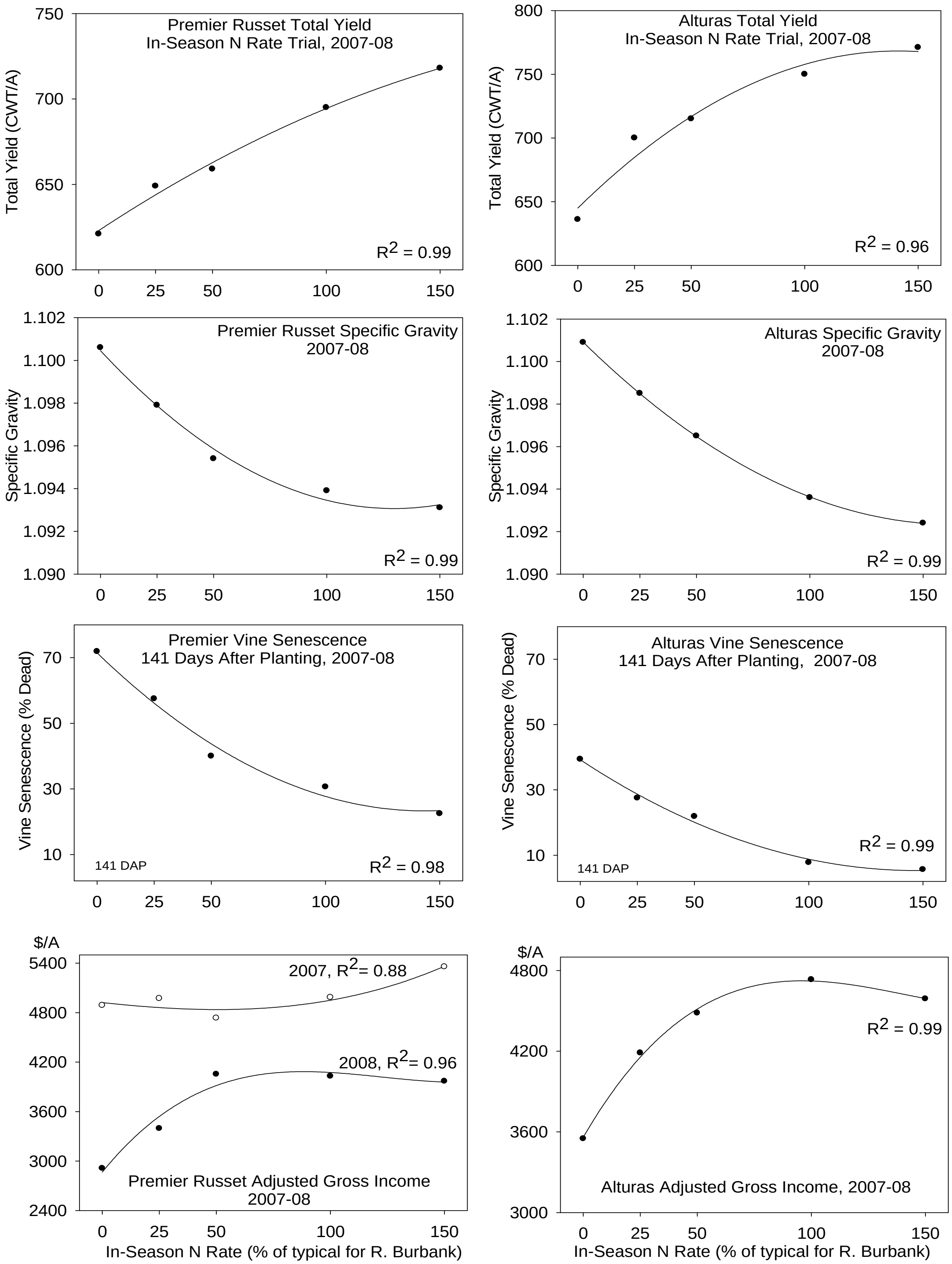

Figure 3. Total yield, specific gravity, vine senescence, and fertilizer-price-adjusted gross income for Premier Russet and Alturas during 2007-08 for each of five in-season N rates. All R^2 values were significant at the 5% level of significance.