RESPONSE OF 'RANGER RUSSET' CULTIVAR TO DIFFERENT NITROGEN MANAGEMENT AND TILLAGE IN THE LOWER COLUMBIA BASIN

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Acknowledgments: The authors thank AgriNorthwest Company, Kennewick, WA for their cooperation by providing the field site for this study and substantial help in conducting the field experiment as well as analytical support for soil and plant analyses (Martin Moore). The authors also appreciate Bill Boge, Marc Seymour, Amber Moore, Tami Baugh, Megan Harrison, Louis Faro, and Hilde Velasco for their assistance during the study and preparation of this manuscript.

Abstract
Optimization of agricultural production inputs while maintaining high yields and quality of crop products is important to maximize high net returns for any agricultural system. Specialty crops are generally input intensive, therefore, careful attention to input optimization is highly desirable. High cost of fuel and fertilizers provide ample justification for reevaluation of tillage and nitrogen management practices for irrigated potato production in the Pacific Northwest. A three-year field study conducted in the lower Columbia basin production region using 'Ranger Russet' cultivar has shown total tuber yields were similar between the conventional tillage and reduced tillage practices. The latter resulted in elimination of four equipment passes, thus, provided savings in fuel, equipment depreciation, and labor costs. Potential benefits of reduced tillage on soil biology/quality as well as soil erosion are being evaluated. Optimal nitrogen management appears to be pre-plant application of 100 lbs/ac incorporated in the soil and in-season fertilization of 200 lbs/ac of nitrogen in five equal doses at two-week intervals as of four weeks after seedling emergence.

Introduction
Potato production in Washington, Idaho, and Oregon states accounts for 55% of the U.S. total production with $1.5 billion farm gate value (National Potato Council, 2006). The Columbia basin region provides an ideal environment for high yields of high processing quality potatoes. Up until the early 1990s, 'Russet Burbank' was the most popular potato cultivar in the U.S. Pacific Northwest (PNW) because of its long-term storability and high processing qualities. Much of cultural management studies on potatoes were done using 'Russet Burbank' cultivar (Joern and Vitosh, 1995; Lang et al., 1995; Westermann and Kleinkopf, 1985; Westermann et al., 1988). A new cultivar, 'Ranger Russet', released in 1992 has more resistance to Verticilium wilt, Fusarium dry rot, leafroll net necrosis, and potato X and Y viruses than 'Russet Burbank' (Pavek et al., 1992). The acreage of 'Ranger Russet' has steadily grown during recent years. Often different cultivars respond differently to nutrient management and production practices. The

application of reduced tillage has been investigated mostly in dryland farming. The potential benefits of reduced tillage are: improved soil biology/quality, improved residue management, reduced energy cost, and reduced soil erosion. Very few studies have been conducted on the potential application of reduced tillage for potatoes (Lanfranconi et al. 1993; Morse 1999; Mundy et al. 1999). The objective of this research was to investigate the effects of different nitrogen management practices and tillage systems on tuber yields, tuber quality, and nutrient removal in tubers of the ‘Ranger Russet’ cultivar.

Materials and Methods

This three-year field study was conducted at the USDA-ARS field experiment site in Paterson, Benton County, WA. Potato was grown following two years of sweet corn (*Zea mays*). ‘Ranger Russet’ cultivar was used with the following treatments: 1. main treatments: either conventional or reduced tillage; 2. sub treatments: four different nitrogen management practices. Industry standard pre-plant tillage operations were followed for the conventional tillage treatment, which accounted for about eight equipment passes including pre-plant fertilizer application, primary tillage (three passes), mark-out, planting, drag-off, and dammer dike. In the reduced tillage treatment, primary tillage and drag-off were eliminated which resulted in reduction of four equipment passes. Figures 1 and 2 show the residue level in the reduced tillage treatment and comparison of soil conditions and potato seedling stand in two tillage treatments. The study site was under a center pivot irrigation and scheduling of irrigation was to replenish the daily evapotranspiration (ET) losses. Industry standard pest, disease, and weed management programs were followed each year. Pre-plant nitrogen (Table 1) applied as urea broadcast at different rates over the entire plot area and incorporated in the top soil during the tillage operation. In-season nitrogen was applied using urea ammonium nitrate (UAN; 32% N) delivered in five equal doses at two-week intervals, which began four weeks after seedling emergence. Only in treatment 3 (Table 1), the frequency of in-season nitrogen was ten weekly applications (as of four weeks after emergence). Tubers were dug from the two middle rows in each plot (20 feet long/row). Total weight of the tubers from harvest area was measured, and total yield as ton/acre calculated. Electronic tuber size grading equipment was used to sort the tubers into: greater than 12oz, 8-12oz, 4-8oz, less than 4oz, and culls plus U.S. No. 2. A small sub-sample of representative tubers was used for tuber nutrient analyses in each treatment. Tubers were washed to remove all dirt particles, sliced (including the peel), dried to estimate biomass weight, ground concentrations of nitrogen, phosphorus, and potassium were determined in the tuber dry matter.

Results and Discussion

Tuber yield was less than 30 tons/ac in year I, while in the subsequent two years, tuber yield was greater than 35 tons/ac (Table 1). Across all three years, the total tuber yield was not significantly influenced by the tillage treatments. This was also true with respect to tuber yields in all different size grades in year II and year III. However, in year I tuber yield was greater in the 8-12oz and greater than 12oz size grades for the reduced tillage treatments as compared with that in the conventional tillage treatment. In contrast, the smaller size tubers (4-8oz and less than 4oz) were greater in the conventional tillage as compared with that in the reduced tillage treatments. The soil biology/quality as influenced by different tillage practices is being investigated (Hal Collins, unpublished data). The economic advantages by reducing the four equipment passes in the reduced tillage as well as soil quality benefits will ultimately determine the suitability and adaptation of reduced tillage for the high yielding potato production region in the irrigated U.S. PNW.

Total tuber yield was not significantly influenced by different nitrogen management practices in year II and year III (Table 1). In year I, however, total tuber yield was slightly lower with 50 lbs/ac nitrogen as pre-plant plus 250 lbs/ac nitrogen as in-season application as compared with the other three treatments. In-season nitrogen application of 300 lbs/ac was excessive, hence was not included in the subsequent two years. Likewise, ten applications of in-season nitrogen was not beneficial unlike the five applications at a given nitrogen rate.

Total quantities of nutrients in the tuber represent the net removal of nutrients from the soil-plant system on an annual basis. Table 2 shows tuber nutrient contents at different nitrogen management treatments (mean across two tillage treatments and replications). Mean tuber yield was 26.4 tons/ac. Total nitrogen in the tuber varied from 154 to 202.9 lbs/ac. Tuber nitrogen as percent of applied nitrogen was high (58 to 60%) for the 100 plus 200 lbs/ac pre-plant plus in-season nitrogen treatment, regardless of 5 or 10 frequency of applications. This percentage was low (51%) for the remaining nitrogen management treatments. Overall, about 55% of applied nitrogen was recovered in the tubers. The remaining quantity of applied nitrogen could be utilized for vegetative growth, some losses, as well as application efficiency. It is important to realize that in addition to fertilizer nitrogen applied as pre-plant and in-season applications, nitrogen input also comes from mineralization of nitrogen from crop residue from the previous crop in rotation, i.e. corn residue in this experiment. Studies conducted using in-situ column incubation techniques (Alva et al., 2005) have shown that mineralization of corn residue can account for 30 to 40 lbs/ac of nitrogen in the top 12 inch depth of the soil during the peak potato growing period, i.e. May through August, if the soil moisture and temperature conditions are ideal for nitrogen mineralization. Since this amount of nitrogen contributes as an input in addition to fertilizer nitrogen, the net nitrogen recovery, on an annual basis, by the tubers is lower than 50% of total nitrogen input to the soil-plant system.

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Table 1. Effects of different tillage and nitrogen management practices on total tuber yields, as well as yields of tubers in different size grades of ‘Ranger Russet’ cultivar grown in a Quincy fine sand in eastern Washington State.

	Treatments	Total Tuber Yield			> 12 oz			8-12 oz			4-8 oz			> 4 oz			No2+Cull		
		Year I	Year II	Year III	Year I	Year II	Year III	Year I	Year II	Year III	Year I	Year II	Year III	Year I	Year II	Year III	Year I	Year II	Year III
	I. *Tillage*	←-----							Tons / acre										-----→
1.	Conventional	27.2	37.7	36.8	1.6^{B}	15.7	15.9	6.8^{B}	11.4	10.0	14.9^{A}	8.8	7.3	3.7^{A}	1.4	1.1	0.2	0.4	2.5
2.	Reduced	26.6	36.0	35.5	3.2^{A}	13.7	16.0	7.8^{A}	11.5	9.7	12.8^{B}	8.9	6.6	2.5^{B}	1.5	0.9	0.3	0.4	2.2
		NS	NS	NS		NS	NS		NS	NS		NS	NS		NS	NS	NS	NS	NS
	II. *Nitrogen* (lbs/ac) Pre-plant & In-season																		
1.	50 + 250	23.9^{B}	36.3	35.0	1.0^{B}	14.5	14.9	5.6^{B}	11.8	9.6	14.0^{AB}	8.1	7.0	2.8	1.3	0.9	0.5	0.6	2.6
2.	100 + 200 (5)	27.3^{A}	37.5	36.8	2.5^{AB}	16.4	16.7	7.6^{A}	10.5	10.0	13.8^{AB}	8.5	6.8	3.3	1.5	1.2	0.1	0.6	2.1
3.	100 + 200 (10)[1]	28.5^{A}	38.1	35.8	2.2^{AB}	14.5	16.1	7.4^{A}	12.0	9.7	15.3^{A}	9.8	6.5	3.4	1.6	1.0	0.2	0.2	2.5
4.	100 + 100	--	35.7	37.0	--	13.4	16.2	--	11.3	9.9	--	9.3	7.6	--	1.3	0.9	--	0.4	2..4
5.	100 + 300	28.2^{A}	--	--	3.4^{A}	--	--	8.4^{A}	--	--	12.9^{B}	--	--	3.1	--	--	0.4	--	--
			NS	NS		NS	NS		NS	NS		NS	NS	NS	NS	NS	NS	NS	NS

[1] Only in this treatment was in-season nitrogen delivered in ten weekly applications beginning four weeks after seedling emergence. In the remaining treatments, in-season nitrogen was delivered in five applications at two-week intervals as of four weeks after emergence.

Means followed by similar letters are not significantly different at P = 0.05 by response variable, by year and by tillage or nitrogen management treatments.

NS = Non significant

Table 2. Total amounts of nutrients in tuber (mean across tillage treatments and replications). Data from year 1 of the study only.

N Treatments (lb/ac) Pre-plant & In-season	Tuber Yield (ton/ac)	Percent in Tuber DM			Total Nutrients in Tubers (lbs/ac)			N in Tubers as % of N Applied	Nutrients in Ton of Tubers (lbs/ton)		
		N	P	K	N	P	K		N	P	K
50+250	23.3	1.40	0.30	1.89	154.0	33.3	207.6	51	6.6	1.4	8.9
10+200 (5)	27.3	1.43	0.29	1.81	180.2	36.6	229.3	60	6.6	1.3	8.4
100+200 (10)	27.2	1.36	0.29	1.84	174.0	37.3	233.8	58	6.4	1.4	8.6
100+300	27.7	1.65	0.33	2.07	202.9	39.8	254.2	51	7.3	1.4	9.2
Mean	26.4	1.46	0.30	1.90	177.8	36.8	231.2	55	6.7	1.4	8.8

DM= Dry Matter; N=Nitrogen; P=Phosphorus; K=Potassium

Fig. 1. Amount of corn residue in the reduced tillage treatment following land preparation prior to planting potato.

Fig. 2. Comparison of soil condition and potato seedling stand in conventional and reduced tillage treatments.