NITROGEN REQUIREMENTS FOR NEW POTATO VARIETIES UNDER FURROW IRRIGATION

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Summary

Nitrogen requirements for potato varieties were tested under furrow irrigation on an Owyhee silt loam soil (bottom soil) in 1994 and 1995, and on a Nyssa silt loam (bench soil) in 1996. Potatoes followed soy beans in 1994, and wheat in 1995 and 1996. Potatoes were treated to four total N supply rates; soil residual N only, 120, 180, and 240 lb N/ac. The N rates included the spring soil residual available N. In 1996 an additional 30 lb N/ac as water run urea was applied to all plots except the check plots, due to low petiole nitrate values. The unfertilized potatoes had the highest yield in 1994. In 1995 tuber yield was maximized by 84 lb N/ac. Potato yields (US Number One yield and marketable tuber yield) in 1996 were highest with 234 lb N/ac. Varieties did not differ significantly in their response to N fertilizer. The new varieties Umatilla Russet and Legend Russet performed as well or better than Shepody in terms of marketable tuber yield, over the three years. Nitrogen fertilization in 1994 resulted in darker frying tubers and in reduced tuber specific gravity. Neither tuber stem-end fry color nor specific gravity were affected by N fertilization in 1995 and 1996.

Introduction

The development of new potato varieties has made it possible to achieve good tuber yield and quality under furrow irrigation on silt loam soils. These new varieties might differ from each other in their nitrogen requirements. Previous studies under sprinkler irrigation showed that the optimum N rate was less than the rate recommended by either the Oregon or Idaho fertilizer guides (Feibert et al., 1995). The present study compared Russet Burbank, Shepody, Frontier Russet, Ranger Russet, Agria (a yellow fleshed, processing variety), two new processing varieties; Umatilla Russet (formerly AO82611-7) and Legend Russet (formerly COO83008-1), and the experimental line NDTX 8-731-1R (a fresh market, red variety) as to their nitrogen requirements under furrow irrigation.

Procedures

The 1996 trial was conducted on a Nyssa silt loam with approximately 1.5 percent slope, following wheat at the Malheur Experiment Station. The field had been leveled in the past. Topsoil from the top half of the field had been removed over 30 years ago, in order to fill a gully running through the center, resulting in large areas of low fertility. In

addition, the field was deep plowed in 1985, inverting the soil profile. Nitrogen at 22 lb/ac and phosphorus at 103 lb/ac were broadcast and then the field was bedded into 36-inch hills in the fall of 1995. A soil sample taken from the top foot on April 23, 1996 showed a pH of 7.8, 1.1 percent organic matter, 18 meq per 100 g of soil cation exchange capacity, 9 ppm nitrate-N and 4 ppm ammonium-N, 11 ppm phosphorus, 793 ppm potassium, 4,500 ppm calcium, 299 ppm magnesium, 474 ppm sodium, 1.9 ppm zinc, 8.2 ppm iron, 9.1 ppm manganese, 1.1 ppm copper, 23 ppm sulfate-S, and 0.8 ppm boron.

Two-ounce seed pieces were planted April 20 at 9-inch spacing. On May 6, Thimet 20G insecticide at 3 lbs ai/ac was shanked-in at the same time that urea for the nitrogen treatments was applied. The shanks were adjusted to place the urea in bands on both sides of the hill, located at the same depth as the seed piece and offset 9 inches from the hill center. The hills were remade with a Lilliston cultivator. The herbicides Prowl at 1 lb ai/ac and Dual at 2 lbs ai/ac were broadcast on the entire soil surface on May 8 and incorporated with the Lilliston cultivator.

The experimental design had four N treatments as main plots and the eight potato varieties as split-plots within the main plots (Table 3). The main plots were six rows wide and 50 feet long. The four nitrogen treatments were replicated six times.

Nitrogen fertilizer rates were 0, 114, 174, and 234 lb N/ac (Table 1). Pre-emergence N fertilizer was applied as urea on May 6. The post-emergence nitrogen applications consisted of urea applied to the furrow bottom immediately before an irrigation to simulate water-run nitrogen. The N supplies for the fertilized plots in 1996 exceeded the planned levels by 30 lb N/ac. Probably due to the low soil fertility of the 1996 site, low petiole nitrate levels for all treatments indicated the need for the N supplement on July 16.

Table 1. Nitrogen rates applied to eight potato varieties. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1996.

Treatment	Spring nitrate plus ammonium N 0-1 feet	Pre-emergence N (May 6)	Post-emergence "water-run" N		Total available nitrogen supply*
			June 29	July 16	
	lbs N/ac				
1	36	0	0	0	36
2	36	60	24	30	150
3	36	100	44	30	210
4	36	140	64	30	270

* Does not include nitrogen mineralized during the season.

Wheat straw at 800 lb/ac was applied on May 31 to the furrow bottoms by hand to reduce irrigation induced erosion and to improve irrigation efficiency.

A total of 36 granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200, Irrometer Co., Riverside, CA) were installed in the top foot of soil and six GMS were placed in the second foot of soil to monitor soil water potential. The GMS in the top foot of soil were offset 6 inches from the hill top and centered 8 inches below the hill surface. The GMS in the second foot of soil were placed in the hill center and centered 20 inches below the hill surface. Half of the sensors in the first foot of soil were located on the wheel traffic side of the potato hill and the other half were located on the non-wheel traffic side of the hill. Sensors were read five times per week at 8 AM from July 10 to September 1. The daily sensor readings were used to schedule irrigations. Irrigations were started when the average soil water potential in the first foot of soil dried to -50 to -60 kPa. At each irrigation, every other furrow was irrigated, with the irrigated furrows alternating from irrigation to irrigation. Sixteen irrigations of 24-hour duration were applied from June 7 to August 28.

Petiole samples were collected every two weeks from June 27 to August 15 from Russet Burbank, Shepody, Frontier Russet, Ranger Russet, and Legend Russet plants in each plot, and analyzed for nitrate. A complete petiole analysis of composite samples from Russet Burbank and Shepody plants on July 12 showed deficiencies of nitrogen, potassium, sulfur, magnesium, manganese, and copper.

The fungicides Bravo at 0.56 lb ai/ac and Manex at 1.2 lb ai/ac were ground sprayed on June 19 and July 19, respectively, for preventive control of late blight. Zinc chelate at 0.02 lb Zn/ac and Copper sulfate at 0.12 lb Cu/ac were added to the Manex application on July 19 for correction of the nutrient deficiencies. Manex, at 1.2 lb ai/ac, contains 0.26 lb Mn/ac.

Plant available-N contributed from organic matter mineralization was determined by the buried bag method (Westermann and Crothers, 1980). A composite soil sample from each of the top two feet of soil from the whole field was taken at the end of April and placed in plastic bags. The bags were sealed and placed back in the field at the appropriate depth. Every month a subset of the bags was removed for NO_3-N and NH_4-N analysis to determine a profile of N release over time. The available N content in the soil in the bags is a result of organic matter decomposition due to microbial activity, without the effects of leaching and plant uptake. When crop residues having a high carbon to nitrogen ratio are decomposed, microorganisms will use the available soil N, causing N immobilization and a negative N mineralization value.

Tubers from the central 40 feet of row in each plot were harvested on September 26 and evaluated for yield and grade. A subsample was stored and analyzed for tuber specific gravity and stem-end fry color in early November.

Data were analyzed by analysis of variance. Means separation was determined by the protected least significant difference test.

Results and Discussion

The soil remained generally wetter than -60 kPa at the 8-inch depth during the season, except for a brief period in late July (Figure 1).

Petiole nitrate levels for all varieties on all sampling dates were below the sufficiency range (Jones and Painter, 1974), except for fertilized Ranger Russet plants on July 30.

Total tuber yield and large US Number One tuber yield (>10 oz), over all varieties, increased with increases in N rate up to 234 lb N/ac (Table 2). In 1995, tuber yield was maximized by 84 lb N/ac of applied fertilizer, while in 1994, potato yield was relatively unresponsive to N fertilization (Table 3).

Varieties Russet Burbank and Agria had among the highest total and marketable tuber yield. Following the red variety NDTX 8-731-1R, Agria, Ranger Russet, and Umatilla Russet had among the highest US Number One tuber yield. Following the red variety NDTX 8-731-1R, Frontier Russet, Umatilla Russet, and Agria had among the highest large US Number One tuber yield.

Nitrogen fertilization did not have any effect on either tuber stem-end fry color or specific gravity (Table 4). Varieties Agria and Legend Russet had among the lightest frying tubers. Varieties Ranger Russet and Frontier Russet were among the highest in specific gravity.

Nitrogen mineralization in the top two feet of soil released 105 lbs N/ac between May 1 and September 24 (Table 5). However, from May 1 to July 31 (main period of potato N uptake) N mineralization released only 34 lb N/ac.

The higher amount of N fertilizer needed to maximize tuber yields in the 1996 trial compared to the 1994 and 1995 trials (Table 6), could be due to the lower amount of N mineralization occurring during the main period of potato N uptake in 1996 compared to 1994 and 1995 (Table 5). In the 1994 and 1995 trials, tuber yield was maximized by substantially less N fertilizer than recommended by either the Oregon or the Idaho fertilizer guides (Anonymous, 1985; McDole et al., 1987). The N rate maximizing total tuber yield in 1996 was in accordance with the fertilizer guides. Low N mineralization was expected at this site in 1996 due to the removal of topsoil decades ago.

In addition, the lower fertility of the 1996 site could also be a factor in the lower total tuber yields in 1996 at all N rates. The low soil test results for magnesium, moderate level of phosphorus, the very high test result for sodium, and the low petiole analyses for potassium, sulfur, and some micronutrients could have had a negative influence on tuber yield.

Conclusions

The N rate necessary for maximum total tuber yield in 1996 was in accordance with the university fertilizer guides. In 1994 and 1995, total yield, marketable yield and US Number One yield were maximized by lower N rates than recommended by the fertilizer guides.

Averaged over all N rates, the new processing varieties Legend Russet and Umatilla Russet, performed as well as, or better than the commercial varieties in total US Number One yield and large US Number One yield. The yellow-fleshed, processing variety Agria had more marketable yield and US Number One yield than several other commercial varieties in this one test in 1996.

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Table 2. Yield response of eight potato cultivars to four nitrogen fertilizer treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1996.

Variety	Nitrogen fertilizer rate	Potato yield by market grade											
		US Number One				US Number Two				Marketable	Undersize	Rot	Total
		4-6 oz	6-10 oz	>10 oz	total	4-6 oz	6-10 oz	>10 oz	total				
	lb N/ac	cwt/ac											
Russet Burbank	0	29.5	58.0	67.8	155.0	25.2	67.2	91.4	183.9	338.9	43.1	20.6	402.7
	114	28.8	83.6	49.5	161.9	23.7	71.2	105.3	200.3	362.2	30.4	21.6	414.2
	174	35.4	94.1	98.9	228.4	21.4	58.0	120.8	200.2	428.6	31.2	8.1	467.8
	234	32.2	114.9	170.8	317.9	18.6	37.7	119.8	176.1	494.0	23.7	5.3	523.0
	Average	31.5	87.6	96.8	215.8	22.2	58.5	109.3	190.1	405.9	32.1	13.9	451.9
Shepody	0	29.0	73.6	123.1	225.7	10.1	15.0	44.9	70.0	295.7	19.5	6.0	321.3
	114	35.1	71.0	123.4	229.5	4.5	11.1	22.7	38.3	267.8	15.5	34.2	317.5
	174	25.2	84.9	165.8	275.8	12.1	22.8	68.3	103.1	379.0	18.2	10.5	407.6
	234	31.6	75.5	180.7	287.8	4.5	6.3	38.6	49.4	337.2	14.5	36.8	388.6
	Average	30.2	76.2	148.2	254.7	7.8	13.8	43.6	65.2	319.9	16.9	21.9	358.7
Frontier Russet	0	25.2	82.5	134.0	241.7	3.3	11.9	50.4	65.7	307.4	16.7	9.1	333.3
	114	20.9	66.1	170.1	257.0	11.5	13.2	65.3	90.1	347.1	20.9	8.2	378.2
	174	16.8	66.9	204.7	288.3	6.0	12.4	79.6	98.0	386.3	22.0	2.1	410.4
	234	16.4	54.7	202.0	273.0	4.3	8.9	72.7	85.9	358.9	18.2	7.1	384.2
	Average	19.8	67.5	177.7	265.0	6.3	11.6	67.0	84.9	349.9	19.5	6.6	376.0
Ranger Russet	0	30.1	99.7	144.3	274.1	14.0	29.0	48.7	91.7	365.8	28.5	4.1	398.3
	114	24.6	94.5	134.7	253.8	14.3	37.3	43.9	95.5	349.2	24.0	5.8	379.1
	174	23.7	88.5	150.5	262.7	14.6	32.9	30.8	78.3	341.0	19.5	2.1	362.6
	234	19.5	85.8	193.8	299.0	8.8	24.7	35.4	68.9	367.9	20.9	5.1	393.9
	Average	24.5	92.1	155.8	272.4	12.9	31.0	39.7	83.6	356.0	23.2	4.3	383.5
Umatilla Russet	0	35.9	96.0	116.1	248.0	21.4	40.6	51.0	113.1	361.1	38.5	3.9	403.6
	114	29.4	77.0	131.1	237.5	12.3	23.4	71.4	107.1	344.6	21.3	11.5	377.3
	174	24.7	73.2	175.1	273.0	12.8	15.3	79.5	107.6	380.6	24.1	21.4	426.1
	234	22.8	80.5	217.5	320.8	8.1	26.4	66.3	100.8	421.6	24.8	7.1	453.6
	Average	28.0	81.3	160.7	270.0	13.6	25.9	67.6	107.2	377.1	27.1	11.5	415.7
Legend Russet	0	19.0	58.2	109.0	186.2	5.2	13.9	34.3	53.4	239.6	13.2	6.2	259.0
	114	29.6	79.0	126.6	235.2	6.3	12.3	46.1	64.7	299.9	17.4	8.7	325.9
	174	23.2	76.2	132.1	231.5	6.5	15.4	34.5	56.4	287.9	13.8	0.4	302.2
	234	14.9	61.9	155.3	232.0	7.5	15.9	37.0	60.4	292.4	14.0	14.1	320.5
	Average	21.6	68.6	130.7	220.9	6.4	14.3	38.1	58.8	279.7	14.6	7.6	301.9
NDTX 8-731-1R	0	34.6	115.7	167.9	318.2	0.0	0.9	1.3	2.1	320.4	23.1	7.2	350.8
	114	39.9	121.4	250.2	411.5	0.0	0.0	0.0	0.0	411.5	24.5	4.3	440.3
	174	35.8	124.4	239.2	399.4	0.0	0.0	0.0	0.0	399.4	25.3	6.3	431.0
	234	43.1	108.3	272.5	423.9	0.0	0.0	0.0	0.0	423.9	26.5	8.9	459.3
	Average	38.4	117.5	232.4	388.3	0.0	0.2	0.3	0.5	388.8	24.9	6.7	420.3
Agria	0	43.1	90.2	112.2	245.4	8.8	34.9	71.5	115.2	360.6	29.1	1.7	391.4
	114	41.6	103.3	114.9	259.8	10.5	34.6	81.2	126.2	386.0	32.5	11.9	430.4
	174	28.0	85.4	180.9	294.3	14.5	29.1	86.8	130.4	424.8	21.4	0.8	446.9
	234	25.1	100.3	212.3	337.8	10.3	29.1	122.2	158.3	496.0	25.0	6.9	527.9
	Average	34.4	94.8	155.1	284.3	11.0	31.1	90.4	132.5	416.9	27.0	5.3	449.2
All varieties	0	30.4	83.4	121.6	235.5	10.7	26.1	48.8	85.6	321.2	25.9	7.0	354.5
	114	31.2	87.0	137.4	255.7	10.3	25.2	54.0	89.4	345.1	23.2	13.0	381.6
	174	26.6	86.7	168.4	281.7	11.0	23.2	62.5	96.8	378.5	21.9	7.0	406.8
	234	25.5	84.8	199.3	309.7	7.8	18.0	60.9	86.6	396.3	20.7	12.0	428.6
LSD (0.05) Trt		5.9	ns	58.3	32.8	3.5	5.6	ns	ns	38.8	5.3	ns	70.7
LSD (0.05) Variety		6.0	13.8	29.2	61.0	3.9	7.5	18.1	21.8	78.9	4.5	ns	34.5
LSD (0.05) Trt X Var		ns	ns	ns	ns	ns	ns	ns	ns	ns	9.0	ns	ns

Table 3. Tuber yield response to N supply in 1994, 1995, and 1996. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1996.

Variety	Nitrogen supply*	1994			1995			1996		
		US #1	Marketable	Total	US #1	Marketable	Total	US #1	Marketable	Total
	lb N/ac	cwt/ac								
Russet Burbank	residual	164.0	316.2	423.8	422.3	454.4	548.6	155.0	338.9	402.7
	120	159.4	292.5	379.4	432.3	480.9	567.6	161.9	362.2	414.2
	180	204.9	363.1	468.4	428.8	480.9	561.5	228.4	428.6	467.8
	240	231.2	375.4	478.8	391.5	438.0	522.0	317.9	494.0	523.0
	Average	189.8	336.8	437.6	418.7	463.5	549.9	215.8	405.9	451.9
Shepody	residual	221.5	315.8	373.4	415.6	423.2	440.4	225.7	295.7	321.3
	120	235.4	349.8	399.9	449.8	470.7	492.8	229.5	267.8	317.5
	180	267.1	363.5	414.0	437.4	470.7	489.9	275.8	379.0	407.6
	240	303.9	410.6	463.3	453.4	496.4	512.5	287.8	337.2	388.6
	Average	257.0	359.9	412.6	439.0	465.3	483.9	254.7	319.9	358.7
Frontier Russet	residual	285.9	324.9	392.1	435.2	456.5	513.0	241.7	307.4	333.3
	120	282.7	337.7	403.5	437.7	460.5	523.6	257.0	347.1	378.2
	180	306.3	358.0	416.0	401.3	432.8	485.3	288.3	386.3	410.4
	240	332.6	395.6	461.2	385.6	418.7	478.2	273.0	358.9	384.2
	Average	301.9	354.0	418.2	414.9	442.1	500.0	265.0	349.9	376.0
Ranger Russet	residual	286.5	373.5	422.9	373.5	403.1	433.2	274.1	365.8	398.3
	120	289.6	353.1	424.4	449.3	481.7	508.1	253.8	349.2	379.1
	180	305.5	396.1	451.0	424.3	458.1	485.3	262.7	341.0	362.6
	240	363.2	445.4	488.9	392.7	440.3	472.3	299.0	367.9	393.9
	Average	311.2	392.0	446.8	409.9	445.8	474.7	272.4	356.0	383.5
Umatilla Russet	residual	249.1	377.3	442.1	438.8	456.1	505.1	248.0	361.1	403.6
	120	277.6	347.4	409.4	460.2	488.2	526.7	237.5	344.6	377.3
	180	302.1	426.3	471.2	477.1	508.6	552.2	273.0	380.6	426.1
	240	303.2	419.2	476.9	504.0	531.4	574.8	320.8	421.6	453.6
	Average	284.2	394.1	451.5	470.0	496.1	539.7	270.0	377.1	415.7
Legend Russet	residual	283.8	390.6	434.2	389.0	421.0	440.2	186.2	239.6	259.0
	120	289.6	353.5	387.8	449.2	498.9	512.7	235.2	299.9	325.9
	180	302.9	376.5	415.1	445.0	477.2	497.8	231.5	287.9	302.2
	240	296.4	367.0	399.3	450.5	489.5	510.7	232.0	292.4	320.5
	Average	292.4	371.1	408.3	433.4	471.6	490.4	220.9	279.7	301.9
NDTX 8-731-1R	residual	330.4	366.6	429.1	401.9	401.9	444.3	318.2	320.4	350.8
	120	427.2	474.2	518.8	454.8	454.8	500.2	411.5	411.5	440.3
	180	379.6	409.8	469.4	419.6	419.6	460.1	399.4	399.4	431.0
	240	417.7	473.7	545.3	398.8	398.8	441.1	423.9	423.9	459.3
	Average	388.8	431.1	490.7	418.8	418.8	461.4	388.3	388.8	420.3
All varieties	residual	261.1	352.5	416.6	410.9	430.9	475.0	235.5	321.2	354.5
	120	280.8	358.4	416.2	447.6	476.5	518.8	255.7	345.1	381.6
	180	295.3	383.5	442.8	433.4	464.0	504.6	281.7	378.5	406.8
	240	321.2	412.4	473.4	425.2	459.0	501.7	309.7	396.3	428.6
LSD (0.05) Treatment		37.2	32.3	34.8	21.5	21.5	20.8	32.8	38.8	70.7
LSD (0.05) Variety		36.6	38.4	39.9	28.3	29.2	29.2	61.0	78.9	34.5
LSD(0.05)Trt X Var		ns	ns	ns	ns	ns	ns	ns	ns	ns

*Spring soil NO_3-N + NH_4-N in 0-1' depth plus fertilizer N

Table 4. Tuber stem-end fry color and specific gravity response of seven potato cultivars to four nitrogen treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1996.

Variety	Nitrogen fertilizer rate	Stem-end fry color	Specific gravity	Variety	Nitrogen fertilizer rate	Stem-end fry color	Specific gravity
	lb N/ac	% reflectance			lb N/ac	% reflectance	
Russet Burbank	0	20.1	1.087	Ranger Russet	0	34.9	1.097
	114	24.8	1.087		114	34.8	1.094
	174	24.2	1.087		174	37.4	1.096
	234	23.4	1.084		234	38.6	1.096
	Average	23.0	1.086		Average	36.4	1.096
Shepody	0	39.9	1.093	Umatilla Russet	0	38.9	1.088
	114	42.2	1.094		114	41.5	1.091
	174	40.8	1.091		174	34.0	1.092
	234	32.2	1.090		234	39.3	1.091
	Average	38.6	1.092		Average	38.2	1.091
Frontier Russet	0	34.0	1.096	Legend Russet	0	39.7	1.093
	114	32.6	1.097		114	39.8	1.090
	174	32.7	1.095		174	41.7	1.093
	234	32.4	1.095		234	40.2	1.093
	Average	32.9	1.095		Average	40.3	1.092
All varieties	0	33.3	1.092	Agria	0	42.8	1.087
	114	33.6	1.091		114	41.9	1.085
	174	34.4	1.092		174	43.3	1.088
	234	33.8	1.091		234	44.5	1.088
					Average	43.1	1.087
LSD(0.05) Trt		ns	ns				
LSD(0.05) Variety		3.1	0.002				
LSD (o.05)Trt X Var		ns	ns				

Table 5. Nitrogen mineralization over time for furrow irrigated potatoes estimated by the buried bag method. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1996.

Month	Mineralized N (NO_3-N + NH_4-N)					
	1994		1995		1996	
	0-1 feet	1-2 feet	0-1 feet	1-2 feet	0-1 feet	1-2 feet
	---------- lb/ac ----------					
May	-4.4	12.0	10.0		8.0	8.0
June	13.8	19.4	46.0	41.4	-1.0	-10.0
July	27.1	25.6	-24.0	-21.5	22.0	7.0
August	12.7	20.7	35.7	37.1	17.0	15.0
September	52.8	30.2	2.9	-4.0	31.0	8.0
Total	102.0	107.9	70.6	53.0	77.0	28.0
From May 1 to July 31	36.5	57.0	32.0	19.9	29.0	5.0

Table 6. University N fertilizer recommendations compared to actual sidedressed N fertilizer needed to maximize furrow irrigated potato yield. Malheur Experiment Station, Ontario, Oregon, 1996.

Year	Soil nitrate & ammonium, 0-24 inches at planting	University recommendation		Lowest N rate tested achieving top yield
		Oregon	Idaho	
	---------- lb/ac ----------			
1994	108	80	110	0
1995	75	236*	220**	84
1996	74	236*	220**	234

* 176+ 60 (20 lb N/ac per ton of wheat straw residue)

** 175+45 (15 lb N/ac per ton of wheat straw residue)

Figure 1. Soil water potential over time for furrow-irrigated potatoes. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1996.