ONION RESPONSE TO PHOSPHORUS APPLICATION STRATEGIES AND IN-SEASON NUTRIENT SUPPLEMENTATION

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Introduction

Germinating onion seed and new onion seedlings have difficulty obtaining adequate phosphorus (P) for ideal early growth. Low soil temperatures in Oregon and Idaho reduce soil P availability early in the growing season. In addition, soil fumigation to improve onion health can have negative effects, reducing mycorrhizal fungi which enhance nutrient absorption by onion roots. At-planting P fertilization could enhance early season growth. Nutrient supplementation through the drip irrigation system during the season could also result in yield enhancements. This trial tested P application at planting and nutrient supplementation during the season with two varieties and two plant populations.

Materials and Methods

Onions were grown in 2013 on an Owyhee silt loam. The field had been planted to wheat in 2012. In the fall of 2012, the wheat stubble was shredded and the field was irrigated. The field was then disked, moldboard plowed, and groundhogged. A soil analysis taken in the fall of 2012 showed a pH of 7.5, 1.49% organic matter, 125% base saturation, and 22 ppm of P. Based on the soil analysis, 49 lb of phosphate/acre, 200 lbs of sulfur/acre, and 1 lb of boron/acre were broadcast before plowing. After plowing, the field was fumigated with Vapam® at 15 gal/acre and bedded at 22 inches.

Seed was planted on March 13 in double rows spaced 3 inches apart at 9 seeds/ft of single row. Each double row was planted on beds spaced 22 inches apart. Planting was done with customized John Deere Flexi Planter units equipped with disc openers. Immediately after planting, the onions received a narrow band of Lorsban® 15G at 3.7 oz/1,000 ft of row (0.82 lb ai/acre), and the soil surface was rolled. Onion emergence started on April 4.

The field had drip tape laid at 4-inch depth between 2 onion beds during planting. The drip tape had emitters spaced 12 inches apart and emitter flow rate of 0.22 gal/min/100 ft (Toro Aqua-Traxx, Toro Co., El Cajon, CA). The distance between the tape and the center of each double row of onions was 11 inches.

The experimental design was a split-split plot randomized complete block with six replicates. There were six main treatments with variable fertilization, timing, and methods of application:

1. Check, no P sidedressed at planting, all nutrients, except nitrogen (N), added by fall soil analysis only. N added as uran through the drip tape (total of 100 lb/acre).

2. Check, no P sidedressed at planting, nutrients added by fall soil analysis, then nutrients added through the season based on root tissue analysis.

3. Check, no P sidedressed at planting, nutrients added by fall soil analysis, then nutrients added through the season based on both root tissue and soil solution analysis.

4. Phosphorus sidedressed at planting, nutrients added by fall soil analysis, then nutrients added through the season based on root tissue analysis.

5. Phosphorus plus Avail® sidedressed at planting, nutrients added by fall soil analysis, then nutrients added through the season based on root tissue analysis.

6. Phosphorus, Avail, and humic acid sidedressed at planting, nutrients added by fall soil analysis, then nutrients added through the season based on root tissue analysis.

Two onion varieties (‘Vaquero’, Nunhems, Parma, ID and ‘Avalon’, Crookham, Caldwell, ID) were planted as split plots within each main plot. Each variety split plot was divided into two plant population split-split plots (120,000 and 450,000 plants/acre). Main plots were 4 double rows wide by 54 ft long. Variety split plots were 27 ft long and plant population split-split plots were 13 ft long.

One week after planting (on March 21), treatments 4, 5, and 6 were sidedressed between the seed row and the drip tape at 3-inch depth. For treatment 4, P was applied as phosphoric acid (NUE 0-30-0, Bio-Gro, Mabton, WA) at 26 lb P/acre. For treatment 5, Avail (Simplot, Caldwell, ID) at 0.5% of the final volume was added to the phosphoric acid (26 lb P/acre). For treatment 6, 6 gal/acre of humic acid (CHB Premium 6, BioGro, 5% humic acid) was added to the phosphoric acid (26 lb P/acre) and Avail (0.5% of the final volume).

On May 16, split-split plots were thinned by hand to 120,000 plants/acre (4.75 inches between plants in each single row) and 450,000 plants/acre plots (1.4 inches between plants in each single row).

Starting on May 22 and every 2 weeks thereafter, plants with their bulbs and roots were sampled from the nonharvest rows of each plot of each treatment and the bulbs and roots were washed in deionized water. One composite sample from each treatment consisting of the roots from all plots in each treatment was sent to Western Labs (Parma, ID) for nutrient analysis. For treatments 2 to 6, nutrients were applied based on root tissue analysis. Each treatment had a separate mainline that supplied water to the drip tape in all plots within that treatment. Nutrients were injected into the drip irrigation system of each treatment using an Ozawa Precision Metering Pump (Ozawa R and D, Ontario, OR).

Every week starting on June 24, soil samples from each plot of treatments 1 and 3 were sent to Western Labs for soil solution analysis. Each sample consisted of a composite of 7 soil cores to 9-inch depth from nonharvested onion rows in each plot. Soil solution analysis used an extraction method that simulated the extraction capacity of plant roots. Soil solution analysis estimated the amount of each nutrient that the soil can supply to the crop per day. For treatment 3 only, nutrients were applied based on root tissue analysis and soil solution analysis.

Onions were irrigated automatically to maintain the soil water tension (SWT) in the onion root zone below 20 cb. Soil water tension was measured in each 450,000-plant/acre split-split plot in the Vaquero split plot in each main plot of replicate 3. Soil water tension in each split-split plot of replicate 3 was measured with 4 granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 8-inch depth in the center of the double row. Sensors had been calibrated to SWT (Shock et al. 1998). The GMS were connected to the datalogger via multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger read the sensors and recorded the SWT every hour. The datalogger automatically made irrigation decisions every 12 hours as previously described (Shock et al. 2002). The irrigation decisions were based on the average SWT of all plots.

The irrigation durations were 7 hours, 10 min to supply 0.48 inches of water per irrigation as have been previously shown to optimize onion performance (Shock et al. 2005). The irrigations were controlled by the datalogger using a controller (SDM CD16AC controller, Campbell Scientific, Logan, UT) connected to a solenoid valve. The water for the drip and sprinkler plots was supplied by a well that maintained a continuous and constant water pressure of 35 psi. The pressure in the drip lines was maintained at 10 psi by pressure regulators in each plot. The automated irrigation system was started on July 19. Prior to July 19, irrigations were run manually based on sensor readings. Irrigations were terminated on September 3.

The onions were managed to avoid yield reductions from weeds, pests, diseases, water stress, and nutrient deficiencies. Roundup® at 1 lb ai/acre was broadcast on April 2 prior to onion emergence. On May 3, Goal Tender® at 0.06 lb ai/acre (4 oz/acre), Buctril® at 0.25 lb ai/acre (16 oz/acre), and clethodim at 0.19 lb ai/acre (12 oz/acre) were applied for weed control. On May 26, Prowl® H_2O at 0.83 lb ai/acre (2 pt/acre) was applied for weed control. On June 10, Goal Tender at 0.09 lb ai/acre (6 oz/acre), Buctril at 0.31 lb ai/acre (20 oz/acre), and clethodim at 0.25 lb ai/acre (16 oz/acre) were applied for weed control. For thrips control, the following insecticides were applied: Movento® at 5 oz/acre on May 23 and 31, Agri-Mek® at 16 oz/acre on June 14, 27, and July 4, Radiant® on July 12, and Lannate® on July 18 and 24.

The onions were lifted on September 10 to field cure. Onions from the 9 ft of the middle 2 rows in each split-split plot were topped by hand and bagged on September 19. Onions were graded on September 25.

During grading, all bulbs from each split-split plot were counted. Bulbs were then separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), and bulbs infected with neck rot (*Botrytis allii*) in the neck or side, plate rot (*Fusarium oxysporum*), or black mold (*Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small (<2¼ inches), medium (2¼-3 inches), jumbo (3-4 inches), colossal (4-4¼ inches), and supercolossal (>4¼ inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading.

Treatment differences were compared using analysis of variance. Means separation was determined using Fisher's least significant difference test at the 5% probability level, LSD (0.05).

Results and Discussion

Soil water tension remained close to the target of 20 cb during the season, but became more consistent after the automated irrigation system was started on July 19 (Fig. 1).

Root tissue concentrations of N, P, potassium (K), zinc (Zn), magnesium, and boron went below the critical level at different times during the season for all treatments (Table 1). These nutrients were supplemented to all treatments, except treatment 1, which received only 100 lb N/acre (Table 2). The trial sought to improve P nutrition, but based on the root tissue analysis, the onions became K deficient by the third week of June (Table 1) and never recovered in spite of the application of 20 lb K/acre through the drip system every 2 weeks. Consequently, the failure of the treatments to respond to the phosphorus treatment is not surprising.

Soil solution analysis for treatments 1 and 3 showed that the untreated check (treatment 1) had higher levels of K and Z on some sampling dates (Table 3). There was no difference between treatments for the other nutrients with respect to the soil solution analysis. All nutrients remained above the critical levels all season, except for copper, which went below the critical level for both treatments 1 and 3 during the last 2 weeks of July and was supplemented.

There was no significant difference in any onion yield category between fertigation treatments for either variety or plant population (Table 4). Treatment 4 for Vaquero and treatment 6 for Avalon were among the treatments with the highest yield of small onions at the 450,000 plants/acre population. Treatment 5 for Avalon at the 450,000 plants/acre population was among the treatments with the highest total rot.

Averaged over varieties and treatments, supercolossal and colossal yield were higher with the 120,000 than with the 450,000 plants/acre population (Table 4). Averaged over varieties and treatments, total yield, jumbo yield, medium yield, small yield, and storage rot were higher with the 450,000 plants/acre population. There was no difference in marketable yield between plant populations. These differences in the proportion of yield by bulb size were expected based on previous studies on onion grade response to plant population (Shock et al. 2004, 2013).

References

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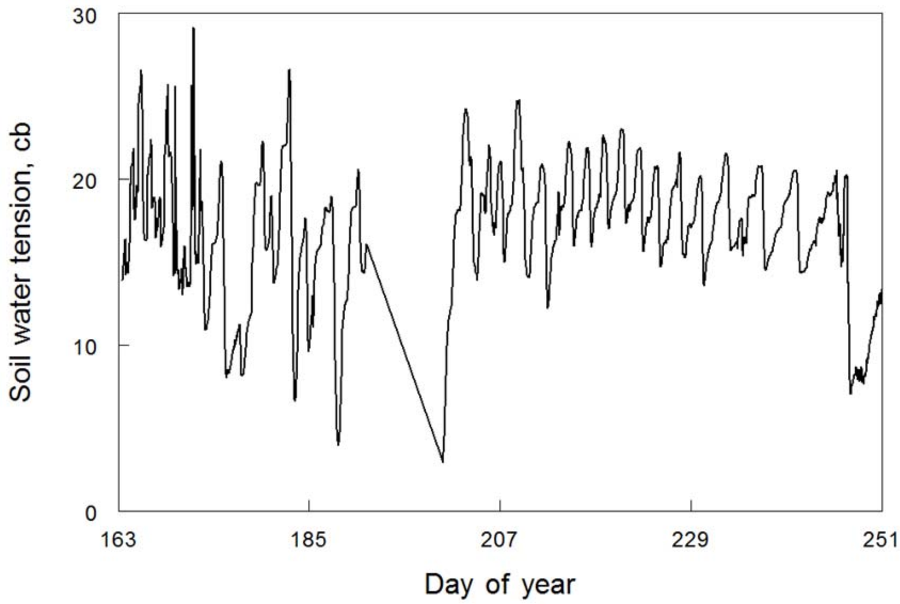

Figure 1. Soil water tension at 8-inch depth for onions irrigated at a soil water tension treatment of 20 cb. Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

Table 1. Onion root tissue analysis for six fertigation treatments for bi-weekly sampling. Malheur Experiment Station, Oregon State University, Ontario, OR, 2013. Continued on next page.

22-May		Treatment					
Nutrient	Sufficiency range	1	2	3	4	5	6
NO_3-N (ppm)	8848	3224	3152	3197	3165	3196	3301
P (%)	0.32 - 0.7	0.54	0.42	0.51	0.46	0.54	0.56
K (%)	2.7 - 6	2.73	2.44	2.40	2.35	2.46	2.59
S (%)	0.24 - 0.85	0.82	0.75	0.73	0.68	0.78	0.80
Ca (%)	0.4 - 1.2	0.52	0.58	0.54	0.49	0.54	0.53
Mg (%)	0.3 - 0.6	0.35	0.36	0.35	0.33	0.37	0.35
Zn (ppm)	25 - 50	45	39	41	36	39	45
Mn (ppm)	35 - 100	147	171	171	134	181	201
Cu (ppm)	6 - 20	10	9	9	8	9	10
Fe (ppm)	60 - 250	1887	2259	2336	2088	2147	2215
B (ppm)	19 - 60	20	16	17	15	17	17
7-Jun							
Nutrient	Sufficiency range	1	2	3	4	5	6
NO_3-N (ppm)	7978	1013	982	634	719	598	1136
P (%)	0.32 - 0.7	0.65	0.52	0.69	0.66	0.68	0.69
K (%)	2.7 - 6	3.22	3.32	3.40	3.28	3.04	3.26
S (%)	0.24 - 0.85	1.27	1.07	1.17	0.97	1.02	1.12
Ca (%)	0.4 - 1.2	0.41	0.42	0.43	0.47	0.44	0.40
Mg (%)	0.3 - 0.6	0.43	0.39	0.40	0.43	0.36	0.38
Zn (ppm)	25 - 50	60	50	60	57	60	55
Mn (ppm)	35 - 100	208	131	196	145	162	144
Cu (ppm)	6 - 20	10	7	10	11	11	8
Fe (ppm)	60 - 250	2430	1746	2143	2653	2210	2422
B (ppm)	19 - 60	17	19	17	17	17	17
19-Jun							
Nutrient	Sufficiency range	1	2	3	4	5	6
NO_3-N (ppm)	6934	4394	5418	5565	5268	5812	5398
P (%)	0.32 - 0.7	0.26	0.33	0.33	0.34	0.39	0.46
K (%)	2.7 - 6	1.91	1.91	1.95	1.92	1.90	2.00
S (%)	0.24 - 0.85	0.68	1.13	1.07	1.06	1.10	1.19
Ca (%)	0.4 - 1.2	0.45	0.71	0.59	0.60	0.55	0.56
Mg (%)	0.3 - 0.6	0.26	0.36	0.34	0.35	0.35	0.38
Zn (ppm)	25 - 50	34	34	38	30	30	39
Mn (ppm)	35 - 100	67	64	52	49	54	61
Cu (ppm)	6 - 20	7	7	8	7	7	8
Fe (ppm)	60 - 250	1834	1351	1605	1499	1197	1578
B (ppm)	19 - 60	5	9	10	8	8	9
2-Jul							
Nutrient	Sufficiency range	1	2	3	4	5	6
NO_3-N (ppm)	5803	5924	5662	6041	5588	6579	6865
P (%)	0.32 - 0.7	0.34	0.36	0.38	0.35	0.43	0.39
K (%)	2.7 - 6	1.78	1.80	1.75	1.48	1.75	1.65
S (%)	0.24 - 0.85	1.10	1.17	1.11	1.18	1.23	1.22
Ca (%)	0.4 - 1.2	0.94	0.86	0.82	1.20	0.71	1.06
Mg (%)	0.3 - 0.6	0.45	0.39	0.43	0.50	0.41	0.42
Zn (ppm)	25 - 50	34	48	58	39	36	34
Mn (ppm)	35 - 100	85	65	94	107	62	80
Cu (ppm)	6 - 20	11	9	11	12	10	9
Fe (ppm)	60 - 250	2311	1528	2698	3626	1542	1793
B (ppm)	19 - 60	20	17	18	19	17	16

Table 1. Continued. Onion root tissue analysis for six fertigation treatments for bi-weekly sampling. Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

16-Jul		Treatment					
Nutrient	Sufficiency range	1	2	3	4	5	6
NO_3-N (ppm)	4585	4838	4925	5807	5150	4857	5290
P (%)	0.32 - 0.7	0.24	0.24	0.25	0.25	0.26	0.35
K (%)	2.7 - 6	0.89	0.92	1.16	1.03	0.98	1.12
S (%)	0.24 - 0.85	1.14	1.14	0.89	0.99	0.95	1.13
Ca (%)	0.4 - 1.2	1.16	1.26	1.15	1.24	1.15	1.24
Mg (%)	0.3 - 0.6	0.35	0.41	0.38	0.37	0.38	0.33
Zn (ppm)	25 - 50	25	24	26	20	26	26
Mn (ppm)	35 - 100	49	61	56	48	65	60
Cu (ppm)	6 - 20	11	10	11	9	9	10
Fe (ppm)	60 - 250	1214	1269	1066	1096	1100	1369
B (ppm)	19 - 60	28	24	23	21	22	22
30-Jul							
Nutrient	Sufficiency range	1	2	3	4	5	6
NO_3-N (ppm)	3367	2064	1314	1938	1421	2081	2107
P (%)	0.32 - 0.7	0.09	0.09	0.19	0.09	0.22	0.21
K (%)	2.7 - 6	0.30	0.25	0.68	0.29	0.81	0.73
S (%)	0.24 - 0.85	0.49	0.48	0.83	0.39	1.13	1.28
Ca (%)	0.4 - 1.2	1.28	1.33	2.85	1.14	3.18	3.62
Mg (%)	0.3 - 0.6	0.18	0.19	0.32	0.18	0.37	0.37
Zn (ppm)	25 - 50	14	12	29	13	30	27
Mn (ppm)	35 - 100	36	37	99	38	96	99
Cu (ppm)	6 - 20	7	7	16	6	17	16
Fe (ppm)	60 - 250	917	866	1400	1008	1537	1774
B (ppm)	19 - 60	12	12	28	13	31	29
13-Aug							
Nutrient	Sufficiency range	1	2	3	4	5	6
NO_3-N (ppm)	2149	1774	2557	2306	3158	1553	2588
P (%)	0.32 - 0.7	0.17	0.19	0.17	0.20	0.17	0.17
K (%)	2.7 - 6	0.49	0.58	0.49	0.62	0.62	0.57
S (%)	0.24 - 0.85	0.92	1.09	1.00	1.20	0.99	1.05
Ca (%)	0.4 - 1.2	1.66	2.74	3.60	2.72	4.07	3.45
Mg (%)	0.3 - 0.6	0.31	0.37	0.33	0.38	0.36	0.39
Zn (ppm)	25 - 50	32	32	37	50	40	33
Mn (ppm)	35 - 100	124	104	109	98	135	104
Cu (ppm)	6 - 20	13	13	15	15	16	14
Fe (ppm)	60 - 250	3326	3055	3086	3159	3776	3290
B (ppm)	19 - 60	19	19	18	20	17	18

Table 2. Soil solution analysis for fertigation treatments 1 and 3 for weekly sampling. Data represent the amount of each plant nutrient per day that the soil can potentially supply to the crop. Numbers following each nutrient are the critical levels. Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

	P, 2		K, 10		Ca, 8		Mg, 2		Zn, 3		Cu, 2		Mn, 3	
Date	1	3	1	3	1	3	1	3	1	3	1	3	1	3
	lbs/day								oz/day					
24-Jun	2.8	3.2	26.3	25.3	19.2	18.8	15.7	15.8	7.5	7.9	2.4	2.5	5.3	5.7
28-Jun	3.3	3.7	19.5	18.8	43.0	45.0	12.2	12.8	7.5	8.0	2.0	2.0	5.6	5.2
4-Jul	2.0	3.0	24.3	23.7	20.5	18.3	15.3	14.7	7.7	8.4	3.2	3.3	3.5	4.4
12-Jul	2.7	2.9	28.7	23.5	55.0	45.8	17.2	14.3	8.3	8.3	2.0	2.0	3.6	4.3
23-Jul	3.6	4.2	28.3	26.3	21.0	19.7	15.8	15.2	8.8	9.3	1.8	1.9	4.3	5.0
29-Jul	5.8	5.2	19.4	20.3	18.6	18.0	13.6	13.5	7.4	7.2	1.2	1.3	7.0	6.5
5-Aug	3.3	3.4	26.7	21.3	18.8	18.0	14.5	13.2	8.9	7.8	2.9	2.9	5.2	5.1
12-Aug	2.5	2.5	27.5	27.3	19.7	20.5	15.0	15.8	10.0	8.4	2.3	2.1	4.9	5.1
Average	3.3	3.5	25.1	23.3	27.0	25.5	14.9	14.4	8.3	8.2	2.2	2.2	4.9	5.1
LSD(0.05)														
Treatment	NS		1.3		NS		NS		NS		NS		NS	
Date	0.54		2.3		5.5		1.9		0.7		0.1		0.9	
Trt X Date	NS		3.2		NS		NS		1		NS		NS	

Table 3. Nutrients applied to onions (lb/acre) through drip tape during the season for six fertigation treatments. All nutrients applied to treatments 2 to 6 were based on root tissue analysis, except as indicated. Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

	Treatment																															
	1	2						3							4						5						6					
Date	N	N	P	K	Zn	Mg	B	N	P	K	Zn	Mg	B	Cu	N	P	K	Zn	Mg	B	N	P	K	Zn	Mg	B	N	P	K	Zn	Mg	B
28-May	40	40						40							40						40						40					
10-Jun	20	20					0.2	20					0.2		20					0.2	20					0.2	20					0.2
20-Jun	20	20		20			0.2	20		20			0.2		20		20			0.2	20		20			0.2	20		20			0.2
3-Jul	20	20		20			0.2	20		20			0.2		20		20			0.2	20		20			0.2	20		20			0.2
18-Jul			10	20	0.3				10	20						10		0.3				10	20						20			
30-Jul														0.6*																		
1-Aug		20	10	20	0.3	5	0.2	20	10	20	0.3	5	0.2		20	10	20	0.3	5	0.2	20	10	20	0.3	5	0.2	20	10	20	0.3	5	0.2
16-Aug			10	20					10	20			0.2			10	20					10	20			0.2		10	20			0.2
Total	100	120	30	100	0.5	5	0.8	120	30	100	0.3	5	1	0	120	30	80	0.5	5	0.8	120	30	100	0.3	5	1	120	20	100	0.3	5	1

* based on soil solution analysis

Table 4. Onion yield response to at-planting phosphorus applications and in-season fertigation for two varieties and two plant populations. Malheur Experiment Station, Oregon State University, Ontario, OR, 2013. Continued on next page.

		Plant population			Marketable yield by grade										
Variety	Treatment	target	actual	Total yield	Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	No. 2s	Small	Total rot	Neck rot	Plate rot	Bulb counts >4¼ in
		--- plants/acre ---		--- cwt/acre ---								--- % of total yield ---			#/50 lb
Vaquero	1	120,000	112,760	1,114.6	1,100.8	84.9	504.1	490.2	21.5	0.0	10.5	0.27	0.27	0.00	31.0
	2	120,000	119,587	1,173.0	1,159.0	86.9	451.2	598.9	22.0	0.0	8.3	0.48	0.25	0.23	31.3
	3	120,000	112,378	1,112.9	1,104.8	89.9	520.4	478.1	16.5	0.0	6.3	0.17	0.00	0.17	32.6
	4	120,000	109,063	1,127.7	1,123.0	116.3	460.6	526.0	20.2	0.0	4.7	0.00	0.00	0.00	31.1
	5	120,000	109,837	1,076.1	1,067.1	64.7	464.4	509.3	28.7	0.0	6.5	0.21	0.00	0.21	32.3
	6	120,000	107,581	1,170.1	1,166.6	131.7	520.5	497.0	17.4	0.0	3.5	0.00	0.00	0.00	32.3
	average		111,868	1,129.1	1,120.2	95.7	486.9	516.6	21.0	0.0	6.6	0.19	0.09	0.10	31.8
	1	450,000	309,773	1,294.6	1,159.9	0.0	20.9	770.2	368.7	0.0	129.2	0.41	0.34	0.07	
	2	450,000	264,703	1,227.6	1,104.6	0.0	57.3	760.9	286.4	0.0	112.5	0.85	0.51	0.34	
	3	450,000	292,034	1,160.9	1,015.1	0.0	21.6	668.4	325.1	0.0	130.9	1.19	0.22	0.97	
	4	450,000	346,235	1,246.7	1,068.0	0.0	8.6	654.0	405.4	0.0	176.2	0.20	0.00	0.20	
	5	450,000	316,785	1,324.9	1,166.9	0.0	48.7	814.9	303.3	0.0	155.1	0.22	0.22	0.00	
	6	450,000	336,297	1,309.0	1,140.5	0.0	20.8	753.0	366.7	0.0	161.2	0.57	0.13	0.44	
	average		310,971	1,260.6	1,109.2	0.0	29.6	736.9	342.6	0.0	144.2	0.57	0.23	0.34	
Avalon	1	120,000	98,794	1,120.4	1,108.6	130.9	526.2	411.3	40.2	0.0	5.1	0.61	0.23	0.38	31.8
	2	120,000	116,019	1,225.9	1,219.3	149.3	611.5	439.0	19.4	0.0	6.7	0.00	0.00	0.00	32.3
	3	120,000	96,462	1,103.4	1,095.7	159.8	551.5	371.8	12.6	0.0	3.5	0.33	0.33	0.00	30.2
	4	120,000	104,913	1,161.6	1,141.6	230.6	528.9	363.9	18.3	0.0	9.2	1.00	1.00	0.00	30.3
	5	120,000	108,831	1,207.0	1,202.8	168.3	596.8	427.1	10.6	0.0	4.2	0.00	0.00	0.00	31.5
	6	120,000	112,057	1,189.4	1,179.3	197.8	600.8	356.6	24.2	0.0	10.1	0.00	0.00	0.00	30.3
	average		106,180	1,167.9	1,157.9	172.8	569.3	394.9	20.9	0.0	6.4	0.32	0.26	0.06	31.1
	1	450,000	308,227	1,393.9	1,260.8	3.8	93.4	859.2	304.5	0.0	115.9	1.42	1.09	0.33	29.1
	2	450,000	295,763	1,312.4	1,182.1	0.0	29.4	837.4	315.3	0.0	123.2	0.54	0.34	0.19	
	3	450,000	289,375	1,281.8	1,144.3	0.0	54.0	797.6	292.7	4.6	126.3	0.51	0.37	0.14	
	4	450,000	282,563	1,216.3	1,092.2	0.0	39.6	753.7	299.0	0.0	118.7	0.69	0.07	0.62	
	5	450,000	288,286	1,285.6	1,138.1	9.5	56.2	779.4	292.9	0.0	121.3	2.26	1.99	0.27	33.9
	6	450,000	316,344	1,313.8	1,168.2	4.2	29.9	778.2	355.9	0.0	137.1	0.60	0.60	0.00	31.6
	average		296,760	1,300.6	1,164.3	2.9	50.4	800.9	310.1	0.8	123.8	1.00	0.74	0.26	31.5

Table 4. Continued. Onion yield response to at-planting phosphorus applications and in-season fertigation for two varieties and two plant populations. Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

Variety	Treatment	Plant population Target	Actual	Total yield	Marketable yield by grade Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	No. 2s	Small	Total rot	Neck rot	Plate rot	Bulb counts >4¼ in
		---- plants/acre ----		---------- cwt/acre ----------								--- % of total yield ---			#/50 lb
Average	1	120,000	105,777	1,117.5	1,104.7	107.9	515.2	450.8	30.9	0.0	7.8	0.44	0.25	0.19	31.4
	2	120,000	117,965	1,197.1	1,186.4	115.3	524.1	526.2	20.8	0.0	7.5	0.26	0.14	0.13	31.8
	3	120,000	104,420	1,108.2	1,100.3	124.8	535.9	424.9	14.5	0.0	4.9	0.25	0.17	0.08	31.5
	4	120,000	106,800	1,146.2	1,133.2	178.6	497.9	437.6	19.1	0.0	7.1	0.54	0.54	0.00	30.7
	5	120,000	109,380	1,135.6	1,128.8	111.8	524.6	471.9	20.5	0.0	5.4	0.12	0.00	0.12	31.9
	6	120,000	110,267	1,181.7	1,174.2	171.4	568.6	412.8	21.5	0.0	7.4	0.00	0.00	0.00	31.2
	average		109,102	1,147.7	1,137.9	135.0	527.7	454.0	21.2	0.0	6.7	0.27	0.18	0.09	31.4
	1	450,000	309,000	1,344.2	1,210.3	1.9	57.1	814.7	336.6	0.0	122.5	0.92	0.72	0.20	29.1
	2	450,000	280,233	1,270.0	1,143.4	0.0	43.3	799.2	300.9	0.0	117.8	0.69	0.42	0.27	
	3	450,000	290,584	1,226.9	1,085.6	0.0	39.3	738.9	307.4	2.5	128.4	0.82	0.30	0.52	
	4	450,000	311,505	1,230.1	1,081.2	0.0	25.5	708.4	347.3	0.0	144.9	0.47	0.04	0.43	
	5	450,000	301,240	1,303.4	1,151.2	5.2	52.8	795.5	297.7	0.0	136.6	1.33	1.18	0.15	33.9
	6	450,000	327,228	1,311.2	1,153.1	1.9	24.9	764.5	361.8	0.0	150.2	0.58	0.34	0.24	31.6
	average		303,298	1,281.0	1,137.5	1.5	40.5	770.2	325.3	0.4	133.4	0.80	0.50	0.30	31.5
		Average													
	1	285,000	207,389	1,230.9	1,157.5	54.9	286.1	632.7	183.7	0.0	65.2	0.68	0.48	0.20	31.2
	2	285,000	202,627	1,235.1	1,163.9	55.1	273.3	668.6	166.9	0.0	65.1	0.49	0.29	0.20	31.8
	3	285,000	193,455	1,164.9	1,093.2	65.1	298.4	575.1	154.6	1.2	64	0.52	0.23	0.29	31.5
	4	285,000	209,152	1,188.1	1,107.2	89.3	261.7	573.0	183.2	0.0	76	0.50	0.29	0.21	30.7
	5	285,000	205,310	1,219.5	1,140.0	58.5	288.7	633.7	159.1	0.0	71	0.72	0.59	0.13	32.2
	6	285,000	223,913	1,249.5	1,163.2	82.6	283.8	597.0	199.7	0.0	82.2	0.30	0.18	0.13	31.2
LSD (0.05)															
Treatment			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety			NS	NS	NS	NS	NS	NS	NS	NS	7.2	NS	NS	NS	NS
Population			9,532	55.2	NS	24.7	29.7	33.6	22.7	NS	6.8	0.31	NS	NS	NS
Variety X Population			NS	NS	NS	34.9	NS	47.5	NS	NS	8.1	NS	NS	NS	NS
Treatment X Population			NS	NS	NS	NS	NS	NS	NS	NS	16.5	NS	NS	NS	NS
Treatment X Variety X Population			NS	NS	NS	NS	NS	NS	NS	NS	19.7	1.07	NS	NS	NS