PLANT POPULATION AND NITROGEN FERTILIZATION FOR SUBSURFACE DRIP-IRRIGATED ONIONS

Clinton C. Shock, Erik B. G. Feibert, and Lamont D. Saunders
Malheur Experiment Station
Oregon State University
Ontario, OR 2001

Summary

Onion yield and grade was tested in response to a combination of seven nitrogen fertilizer rates (0 to 300 lb N/acre) and four plant populations (75,000 to 139,000 plants/acre) under subsurface drip irrigation on Owyhee silt loam. Onion was planted on two double rows on 44-inch beds with one drip tape in the bed center. All treatments were irrigated automatically with 0.06 inches of water up to eight times a day. Irrigations were started when the soil water potential reached -20 kPa at 8-inch depth. The N fertilizer was applied through the drip tape. Onion yield and grade were not responsive to N rate in this trial. The unfertilized check treatment in this trial had a total N supply of 303 lb/acre in the top 2 ft of soil during the season, counting the initial residual soil nitrate and ammonium, mineralized N, and nitrate and ammonium in the irrigation water.

Total marketable yield increased with increasing plant population up to 109,000 plants per acre. The highest supercolossal and colossal onion yields were achieved with the lowest plant population tested of 79,000 plants per acre. In 1999 supercolossal yield was not measured, and gross returns increased with increasing plant population. In 2000 and 2001, with supercolossal yield being taken into account, onion gross returns did not show a response to plant population. Within the range of plant populations tested in this study, increasing or decreasing the plant population did not affect the gross returns when supercolossal onions were included.

Introduction

Onion production with subsurface drip irrigation has been tested at the Malheur Experiment Station since 1992. While good guidelines for irrigation scheduling are known, the optimum N fertilization practices for subsurface drip-irrigated onions are unknown. The plant population that optimizes yield and size of onions could be different under drip irrigation and could interact with the N fertilizer rate.

Residual soil N and fertilizer N have the potential to be used more efficiently when applied through drip irrigation than when applied broadcast, sidedressed, or water run in a furrow irrigated field. Nitrogen applications with drip irrigation might be reduced compared to furrow irrigation as a result of the lower N leaching and the higher N use efficiency.

The objective of this trial was to determine the optimum N rate and plant population

combination for drip-irrigated onions to maximize yield, quality, and economic return.

Materials and Methods

The trial was conducted at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. This field has a record of moderate productivity, perhaps due to the removal of much of the topsoil decades in the past during land leveling. In the fall of 2000, 200 lb P_2O_5, 55 lb K, 150 lb S, 28 lb Mg, 10 lb Zn, and 5 lb Cu per acre were broadcast and the field was plowed and groundhogged twice. The field was fumigated on October 25 with Telone C-17 at 24 gal/acre and bedded on 22-inch centers. A soil sample taken from the top foot on May 16, 2001 showed a pH of 7.9, 0.6 percent organic matter, 4 ppm NO_3 -N, 47 ppm P, and 381 ppm K. Onions (cv. 'Vision', Petoseed, Payette, ID) were planted in two double rows, spaced 22 inches apart in 44-inch beds on March 30, 2001. Onions were planted at 210,000 seeds/acre. Nelson Pathfinder tape (Nelson Irrigation Corp., Walla Walla, WA) was laid simultaneously with planting at 4-inch depth between the two double onion rows. The drip tape had emitters spaced 12 inches apart and a flow rate of 0.22 gal/min/100 ft. Immediately after planting the onion rows received 3.7 oz of Lorsban 15G per 1,000 ft of row (0.82 lb ai/acre), and the soil surface was rolled. The trial was irrigated on April 9, April 17, April 24, April 27, and April 30 with a minisprinkler system (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA) for even stand establishment. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals that were spaced 30 ft apart. Onions started emerging on April 21.

The seven N rates ranged from 0 to 300 lb N/acre (0, 50, 100, 150, 200, 250, 300 lb N/acre). The nitrogen for each treatment was split into five equal amounts. The N fertilizer was applied as urea-ammonium nitrate (Uran) on May 24, June 4, June 14, June 26, and July 3. Fertilizer solutions were applied through the drip lines with venturi injector units (Mazzei injector Model 287) installed in each plot. Nitrogen treatments were the main plots and were replicated three times. Nitrogen treatments were arranged in a randomized complete block design. Plant populations were split plots within each N plot. The plant populations (75,000, 100,000, 125,000, and 150,000 plants per acre) were achieved by hand thinning on May 17. Individual population plots were two beds wide and 50 ft long.

The soil water potential at 8-inch depth was designed to be maintained nearly constant at -20 kPa by applying 0.06 acre-in/acre of water up to eight times a day as needed based on automated soil water potential readings every 3 hours (Shock et al. 2000). The automated drip irrigation system was started on May 14.

Soil water potential (SWP) was measured with one granular matrix sensor (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co. Inc., Riverside, CA) at 8-inch depth, below an onion row in each split plot. In addition each main plot had a GMS installed at 18-inch depth below an onion row in the 125,000 plants/acre split plot. Sensors were calibrated to SWP (Shock et al. 1998). The GMS were connected to a datalogger (CR 10 datalogger, Campbell Scientific, Logan, UT) via five multiplexers (AM

410 multiplexer, Campbell Scientific, Logan, UT). The datalogger was programmed to read the GMS every 3 hours and, if the average of the sensors at 8-inch depth was less than -20 kPa, irrigate the field. The irrigations were controlled by the datalogger using a solenoid valve. The pressure in the drip lines was maintained at 10 psi by pressure regulators in each main plot. The amount of water applied to the field was recorded daily at 8:00 a.m. from a water meter installed downstream of the solenoid valve.

Onion evapotranspiration (Et_c) was calculated with a modified Penman equation using data collected at the Malheur Experiment Station by an AgriMet weather station (Wright 1982). Onion Et_c was estimated and recorded from crop emergence on April 21 until the final irrigation on September 5 and compared with evapotranspiration.

Ten plants from the border rows in each 125,000 plants/acre subplot were sampled for nutrient analyses every 2 weeks from early June through mid August. The plants were washed, the roots were analyzed for nitrate-N, phosphate-P, K, and sulfate-S, and the leaves were analyzed for micronutrients by Tremblay Consulting of Jerome, Idaho. The root nitrate levels for each N rate were compared to a critical level for onion root nitrate (Brown and Hornbacher 1988).

Postemergence weed control was obtained by an application of Buctril (0.08 lb ai/acre) and Poast (0.19 lb ai/acre) on May 9, Goal (0.031 lb ai/acre), Buctril (0.16 lb ai/acre), Poast (0.26 lb ai/acre) and Prowl (0.83 lb ai/acre) on May 19, Goal (0.05 lb ai/acre) on May 30, and Goal (0.12 lb ai/acre) on June 8. After lay-by the field was hand weeded as necessary. Thrips were controlled with four aerial applications of Warrior (0.03 lb ai/acre) and Lannate (0.26 lb ai/acre) on June 30, July 20, August 1, and August 18 and one aerial application of Warrior (0.03 lb ai/acre) on June 11.

On August 23, ten onion plants from the border rows in each subplot were taken for total N content determination. The tops were weighed, dried, weighed and ground. The bulbs were weighed and shredded. A shredded bulb subsample was weighed, dried, weighed, and ground. The ground top and bulb samples were analyzed for total N content. Nitrogen contribution from organic matter mineralization was estimated by anaerobic incubation at 104°F for 7 days. The well water used for irrigation was analyzed for NO_3-N and NH_4-N on June 29, and August 23. The well water used for irrigation had an average NO_3 and NH_4 concentration of 10.4 ppm and 1 ppm, respectively. Nitrogen contribution from irrigation was calculated to be 2.37 lb N/acre per acre-in of water. The soil was sampled in 1-ft increments down to 2 ft in each replicate before planting and in each 125,000 plants/acre subplot after harvest and analyzed for nitrate and ammonium.

On September 11 the onions were lifted to field cure. On September 18, onions in the central 40 ft of the middle two double rows in each subplot were topped and bagged. The bags were placed into storage on September 21. The storage shed was managed to maintain an air temperature of approximately 34°F. The onions were graded out of storage in mid-December. Bulbs were graded according to their diameters: small (<2¼

inches), medium (2¼ -3 inches), jumbo (3-4 inches), colossal, (4-4¼ inches), and supercolossal (>4¼ inches). Bulb counts of supercolossal onions were made during grading. Split bulbs were graded as No. 2s regardless of diameter. Marketable onions were considered perfect bulbs in the medium, jumbo, colossal and supercolossal size classes. Bulbs from all subplots were counted during grading in order to determine the actual plant population at harvest.

Gross economic returns were calculated by crediting the onion size classes with the average of prices paid to the grower (F.O.B. prices minus $3.13/50 lb for packing cost) from early August through January for the years 1992 through 2001.

Results and Discussion

Water applications over time closely followed, but were slightly higher than onion Et_c (Fig. 1). Onion Et_c for the 2001 season totaled 32 acre-inch/acre and irrigation water applied plus precipitation totaled 38 acre-inch/acre. Precipitation totaled 1.4 inches from onion emergence to the last irrigation. The field used for the 2001 study required slightly more water to keep the sensors at -20 kPa than the 2000 field. Soil water potential at 8-inch depth remained close to -20 kPa (Fig. 2), except for brief periods due to technical problems with the automated irrigation system. Soil water potential at 20-inch depth remained close to soil water potential at 8-inch depth.

Onion yield and grade did not respond to N rate (Table 1). There were 171 lb/acre of NO_3-N and NH_4-N in the top 2 ft of soil on May 15 (Table 2). A total of 45 lb/acre of NO_3-N and NH_4-N were released in the top 2 ft of soil from N mineralization. The unfertilized check treatment in this trial had a total N supply of 236 lb/acre in the top 2 ft of soil during the season, counting the initial residual soil nitrate and ammonium, mineralized N, and nitrate and ammonium in the irrigation water.

Onion root nitrate during most of the season remained close to or above the established nitrate “critical” level only for the four highest N rates (150, 200, 250, and 300 lb N/acre; Fig. 3). Onions with root nitrate below the “critical level” supposedly need more N to optimize yield. For the other N rates onion root nitrate remained below the critical level during most of the season. The N fertilizer in this trial was applied in small increments as opposed to conventional sidedressing of N. Under low leaching conditions, sources of N other than fertilizer can make significant contributions to the N supply for onions. When the onion plants receive N in small increments, root nitrate levels might remain low despite the plant having adequate N. The lack of onion yield response to N in this trial was inconsistent with the root nitrate critical line. These results cast doubt on the accuracy of the critical root nitrate function for drip-irrigated onions.

Onion populations of 125,000 and 150,000 plants per acre were not achieved (Table 1). The highest total yield and jumbo onion yield were achieved with the highest plant population tested of 127,000 plants per acre (Table 1). Total marketable yield increased with increasing plant population up to 109,000 plants per acre. The highest

supercolossal and colossal onion yield were achieved with the lowest plant population tested of 79,000 plants per acre. All plant populations resulted in numbers of supercolossal bulbs per 50 lb of supercolossal bulbs, which were within the acceptable range (28-36 count per 50 lb) for marketing as supercolossal. Gross financial returns were not responsive to plant population in 2001, within the populations tested.

Regressions for onion yield in response to plant population show that medium and jumbo onion yield increased whereas colossal and supercolossal onion yield decreased with increasing plant population (Fig. 4). This is the third and final year of this trial. In 1999 supercolossal yield was not measured, and gross returns increased with increasing plant population (Fig. 5). In 2000 and 2001, with supercolossal yield being taken into account, onion gross returns were not responsive to plant population. Within the range of plant populations tested in this study, increasing or decreasing the plant population did not affect the gross returns when supercolossal onions were included.

References

Brown, B.D., and A.J. Hornbacher. 1988. Sulfur-coated urea as a slow-release nitrogen source for onions. J. Amer. Soc. Hort. Sci. 113:864-869.

Shock, C.C., J.M. Barnum, and M. Seddigh. 1998. Calibration of Watermark Soil Moisture Sensors for irrigation management. pages 139-146 in Proceedings of the International Irrigation Show, Irrigation Association, San Diego, CA.

Shock, C.C., E.B.G Feibert, and L.D. Saunders. 2000. Irrigation criteria for drip-irrigated onions. HortScience 35:63-66.

Wright, J.L. 1982. New evapotranspiration crop coefficients. J. Irrig. Drain. Div., ASCE 108:57-74.

Table 1. Onion yield and grade response to N rate and plant population after 2½ months of storage. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Target plant population	N rate	Harvested bulbs	Total yield	Marketable yield by grade						Non-marketable yield			Gross returns
				Total	>4¼ in	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Rot	No. 2	Small	
plants/acre	lb/acre	bulbs/acre	-- cwt/acre --		#/50 lb	---------- cwt/acre ----------				%	- cwt/acre -		$/acre
75,000	0	87,514	882.0	823.0	34.6	78.8	317.9	408.0	18.2	5.2	10.6	5.2	5,667
	50	81,673	835.4	801.1	33.5	56.5	310.4	420.0	14.3	2.3	10.5	3.9	5,414
	100	75,832	858.8	779.9	32.9	134.4	339.7	292.3	13.6	6.2	24.3	1.8	5,845
	150	76,327	875.7	785.7	32.6	124.0	377.7	271.3	12.7	7.1	24.5	3.0	5,941
	200	80,980	909.2	831.9	33.3	110.4	412.5	300.0	8.9	5.8	22.6	1.9	6,224
	250	72,466	829.2	765.7	32.6	126.8	345.1	289.0	4.8	4.1	30.2	0.0	5,770
	300	76,822	892.0	841.7	33.5	136.7	400.0	296.1	8.8	3.9	14.0	2.3	6,384
Average		78,802	868.9	804.1	33.3	109.6	357.6	325.2	11.6	4.9	19.5	2.6	5,892
100,000	0	96,028	921.9	850.2	36.8	24.1	292.6	517.2	16.3	6.0	12.8	2.8	5,418
	50	101,869	958.2	922.4	35.8	50.4	300.0	549.5	22.4	2.2	9.5	5.1	5,948
	100	98,602	969.5	931.8	35.0	58.2	342.6	513.7	17.4	2.3	11.0	5.0	6,192
	150	104,146	953.7	872.6	35.2	55.8	238.9	562.4	15.4	6.9	14.1	4.3	5,544
	200	91,078	935.3	883.4	34.5	83.5	376.1	411.9	12.0	4.6	7.4	1.5	6,210
	250	101,176	942.3	883.5	39.2	31.1	247.3	591.0	14.1	4.2	12.2	6.0	5,490
	300	99,691	973.2	900.1	35.3	62.0	308.8	515.9	13.4	6.2	10.5	3.4	5,952
Average		98,941	950.6	892.0	36.0	52.2	300.9	523.1	15.9	4.6	11.1	4.0	5,822
125,000	0	103,849	935.3	870.4	35.2	43.7	249.7	552.2	24.8	5.0	11.0	7.0	5,472
	50	111,076	970.1	947.2	36.9	36.2	246.5	630.7	33.8	1.5	1.5	7.2	5,791
	100	116,322	1050.2	976.1	37.1	34.7	286.9	625.3	29.2	5.0	14.7	7.7	6,074
	150	103,849	967.0	914.0	37.1	38.7	284.2	570.3	20.8	3.8	11.5	3.5	5,791
	200	110,878	1060.8	1021.4	39.4	46.1	337.2	621.5	16.5	1.7	16.0	5.4	6,569
	250	109,096	1022.1	973.7	37.4	43.4	322.3	586.9	21.1	2.0	22.1	5.6	6,248
	300	106,324	1026.4	976.9	35.0	52.5	327.0	579.6	17.8	3.3	12.3	3.4	6,341
Average		108,770	1004.6	954.2	36.9	42.2	293.4	595.2	23.4	3.2	12.8	5.7	6,041
150,000	0	138,696	1009.1	983.0	44.2	6.8	87.2	819.3	69.7	1.2	4.6	9.7	5,195
	50	123,054	959.8	934.9	40.3	11.1	158.3	710.1	55.4	1.4	2.6	8.6	5,240
	100	128,202	1082.9	1034.8	38.5	23.6	214.2	763.4	33.6	2.9	9.1	7.4	6,066
	150	133,350	997.3	915.6	42.9	14.4	136.1	716.7	48.4	6.7	3.9	7.0	5,107
	200	122,262	1045.4	1009.1	39.0	17.3	235.9	720.9	34.9	1.6	10.5	8.5	5,964
	250	129,390	1101.8	1063.1	38.9	28.0	206.6	796.1	32.5	2.0	10.2	6.7	6,216
	300	117,906	1036.0	966.6	36.5	28.2	238.8	674.8	24.7	4.9	11.9	5.2	5,845
Average		127,552	1033.2	986.7	40.0	18.5	182.4	743.0	42.8	3.0	7.5	7.6	5,662
LSD (0.05) N rate		NS	NS	NS	NS	NS	48.2	NS	10.5	NS	NS	NS	NS
LSD (0.05) Popul.		5559	28.5	37.5	1.6	16.8	36.4	43.8	7.9	NS	4.7	2.1	NS
LSD (0.05) N X Pop		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Nitrogen supply for the upper 2 ft of soil for drip-irrigated onions with seven N

rates in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

N rate	N supply				
	Pre-plant soil NO_3 + NH_4-N	Fertilizer N	N in irrigation water	Estimated N mineralization	Total N supply
	---------- lb/acre ----------				
0	170.8	0	86.7	45.3	302.8
50	170.8	50	86.7	45.3	352.8
100	170.8	100	86.7	45.3	402.8
150	170.8	150	86.7	45.3	452.8
200	170.8	200	86.7	45.3	502.8
250	170.8	250	86.7	45.3	552.8
300	170.8	300	86.7	45.3	602.8

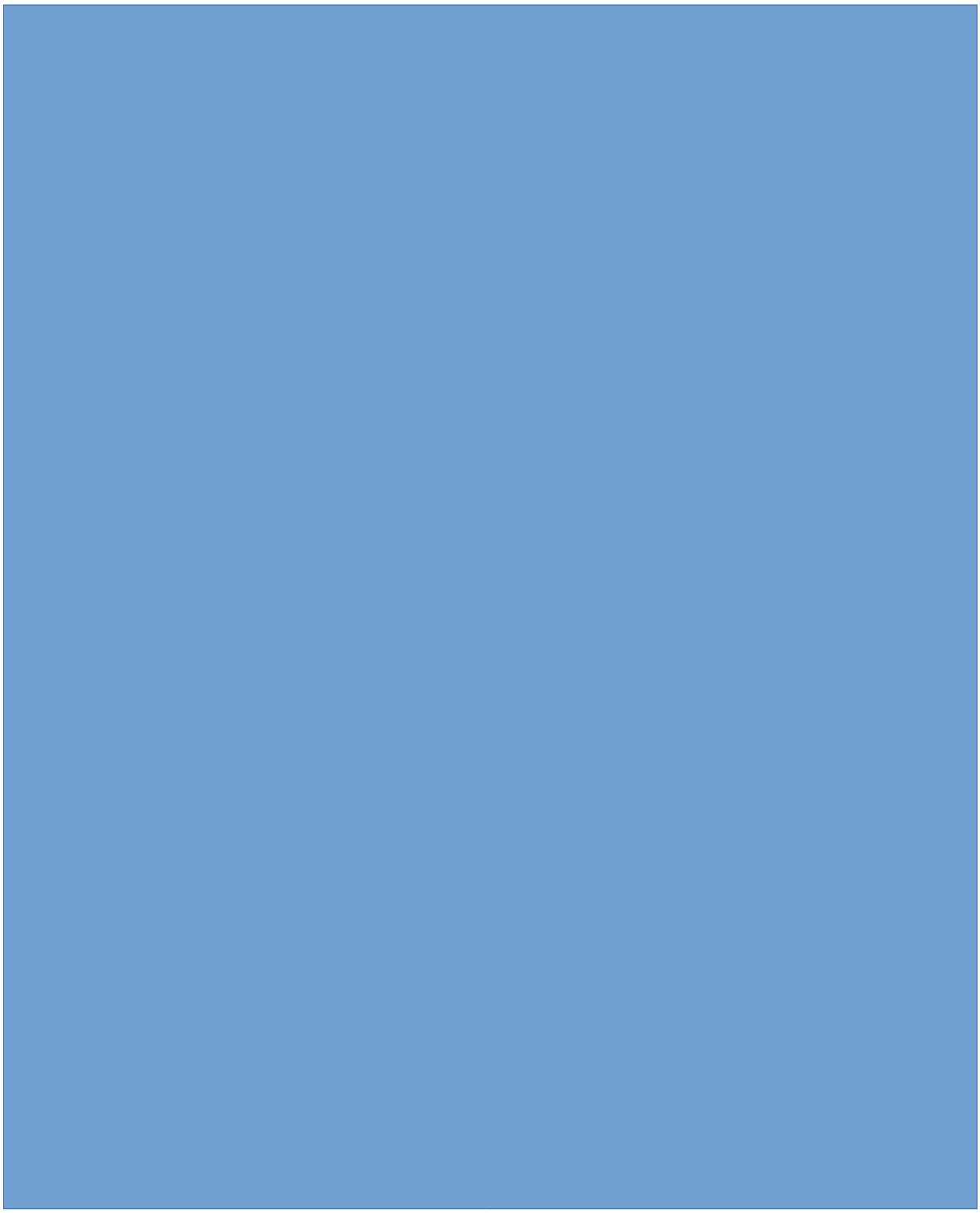
Figure 1. Cumulative water applied plus precipitation and Et_c for onions drip-irrigated at a soil water potential of -20 kPa compared with estimated onion evapotranspiration in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.
Figure 2. Soil water potential for drip-irrigated onions in 2001. Malheur Experiment

Station, Oregon State University, Ontario, OR.

Figure 3. Onion root nitrate response to seven N rates applied through drip irrigation for

onions at a plant population averaging 106,000 plants per acre in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 4. Onion yield response to plant population in 2001. Malheur Experiment Station,



Oregon State University, Ontario, OR.

Figure 5. Onion gross return response to plant population in 1999. Malheur Experiment

Station, Oregon State University, Ontario, OR.