PLANT POPULATION AND NITROGEN FERTILIZATION FOR SUBSURFACE DRIP-IRRIGATED ONIONS

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Summary

Onion yield and grade was tested in response to a combination of seven nitrogen fertilizer rates and four plant populations under subsurface drip irrigation on Owyhee silt loam. 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.

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 nitrogen and fertilizer nitrogen have the potential to be more 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 nitrogen 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.

Methods

The trial was conducted at the Malheur Experiment Station, Ontario, OR on an Owyhee silt loam previously planted to wheat. This field has a record of moderate productivity. In the fall of 1999, 20 lb of N, 100 lb of P_2O_5, and 1 lb of Boron/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 15, 2000 showed a pH of 7.2, 2.3 percent organic matter, 15 ppm NO_3 -N, 45 ppm P, and 180 ppm K.

Onions (cv. 'Vision', Petoseed, Payette, ID) were planted in two double rows, spaced 22 inches apart in 44-inch beds on March 29, 2000. Onions were planted at 210,000 seeds/acre. Nelson Pathfinder tape (Nelson Irrigation Corp., Walla Walla, WA) was laid simultaneously with planting at 6-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/minute/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 4, April 11, and on April 20 with a minisprinkler system for even stand establishment (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA). Risers were spaced 25 ft apart along the flexible polyethylene hose laterals, which were spaced 30 ft apart. Onions started emerging on April 13.

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 Uran on May 24, June 1, June 12, 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 arranged in a randomized complete block design replicated three times. Plant populations were split plots within each N plot. The plant populations (75,000, 100,000, 125,000, and 150,000 plants/acre) were achieved by hand thinning on May 15. Individual population plots were two beds wide and 50 ft long.

The soil water potential at 8-inch depth was maintained nearly constant at -20 kPa by 0.06 acre-inch/acre of water applied up to eight times a day based on automated soil water potential readings every 3 hours (Shock et al., 2000). The automated drip irrigation system was started on May 19.

Soil water potential was measured with one granular matrix sensor (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., 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 splitplot. Sensors were calibrated to soil water potential (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 (Wright, 1982) using data collected at the Malheur Experiment Station by an AgriMet weather station. Onion Et_c was estimated and recorded from crop emergence on April 13 until the final irrigation on August 31.

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 August 18. The plant samplings of August 18 had samples collected from all subplots. 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 three applications of combinations of Buctril, Poast, Goal, and Prowl. After lay-by the field was hand weeded as necessary. Thrips were controlled with three aerial applications of Warrior and Lannate (June 9, June 21, and August 3) and one aerial application of Warrior on July 10 in 2000. Microthiol Special at 8 lb ai/acre was broadcast aerially on August 31 for mite control.

On August 30, 10 onion plants from the border rows in each subplot were taken for 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 is being estimated by anaerobic incubation at 104°F for 7 days. The well water used for irrigation had a NO_3 concentration of 8.3 ppm. Nitrogen contribution from irrigation was calculated to be 0.43 lb N/acre/acre-inch 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 13 the onions in the central 40 ft of the middle two double rows in each subplot were topped and bagged to field cure. The bags were placed into storage on September 27. The storage shed was managed to maintain an air temperature of approximately 34°F. The onions were graded out of storage on December 15. Bulbs were graded according to their diameters: small (<2¼ inch), medium (2¼ -3 inch), jumbo (3-4 inch), colossal (4-4¼ inch), and supercolossal (>4¼ inch). Bulb counts of supercolossal onions were made during grading. Split bulbs were graded as No. 2 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 1992 through 2000. Average prices used were $2.68/cwt for medium onions, $5.38/cwt for jumbo onions, $8.76/cwt for colossal onions, and $11.06/cwt for supercolossal onions.

Results and Discussion

Onion populations of 125,000 and 150,000 plants/acre were not achieved (Table 1). Water applications over time closely followed, but were slightly lower than onion Et_c (Fig. 1). Onion Et_c for the 2000 season totaled 33 acre-inch/acre and irrigation water applied plus precipitation totaled 32 acre-inch/acre. Precipitation totaled 1.4 inches from onion emergence to the last irrigation. Soil water potential at 8-inch depth remained close to -20 kPa (Fig. 2). Soil water potential at 20-inch depth remained close to soil water potential at 8-inch depth. The potential for nitrate leaching was relatively low. The water applications were small, water applications were close to estimated Et_c, and the soil water potential did not undergo large oscillations.

Onion yield and grade were not responsive to N rate (Table 1). There were 120 lb/acre of NO_3-N and NH_4-N in the top 2 feet of soil on May 15 (Table 2). A total of 69 lb/acre of NO_3-N and NH_4-N were released in the top 2 feet of soil from N mineralization. The unfertilized check treatment in this trial had a total N supply of 247 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 critical level only for the three highest N rates (200, 250, and 300 lb N/acre, Fig. 3). 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 be maintained 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.

A plant population of 113,000 plants/acre resulted in among the highest total yield, marketable yield, and jumbo onion yield (Table 1). Onion gross returns were also highest with a plant population of 113,000 plants/acre. Supercolossal onion yield decreased with increasing plant population (Fig. 4). Increasing the plant population from 74,000 to 113,000 plants/acre resulted in a small, but significant, reduction in the number of supercolossal bulbs/50 lb of supercolossal bulbs. All plant populations resulted in a number of supercolossal bulbs/50 lb of supercolossal bulbs that was within the acceptable range (28-36 count/50 lb) for marketing. Increasing the plant population from 113,000 to 128,000 plants/acre significantly reduced the yield of colossal onions.

Literature Cited

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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, 2000.

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	73,389	797.3	729.6	29.4	132.1	357.5	200.4	39.5	3.9	27.9	10.0	5,785
	50	73,813	809.4	746.0	28.6	162.3	322.0	208.0	53.7	2.5	28.1	14.7	5,884
	100	84,220	840.9	720.7	31.0	128.4	314.8	236.4	41.1	6.9	51.5	12.7	5,568
	150	75,093	806.5	732.3	29.7	139.3	335.6	219.5	37.9	4.8	27.8	7.8	5,771
	200	69,753	796.8	642.9	27.3	130.3	283.0	188.1	41.4	13.1	42.2	11.6	5,050
	250	71,712	802.0	667.8	29.1	184.4	277.4	171.9	34.1	7.9	63.6	8.0	5,487
	300	71,040	792.1	668.6	31.5	116.9	312.2	216.0	23.5	9.3	48.4	5.4	5,261
Average		74,146	806.4	701.1	29.5	142.0	314.6	205.8	38.8	6.9	41.4	10.0	5,585
100,000	0	94,059	924.9	844.9	29.5	150.2	285.9	331.3	77.6	5.4	7.5	25.3	6,167
	50	99,083	915.7	818.9	29.0	52.9	295.4	353.5	117.1	5.2	25.1	24.7	5,406
	100	90,292	932.5	862.7	30.1	111.3	317.6	375.8	58.0	1.8	38.3	14.4	6,206
	150	88,813	912.1	832.7	31.7	90.2	315.9	358.6	68.0	5.6	18.0	11.1	5,892
	200	95,335	952.1	834.2	30.8	80.0	331.0	359.9	63.3	7.2	37.7	10.2	5,907
	250	100,899	983.8	889.1	30.5	112.3	331.6	370.4	74.8	5.2	27.5	16.9	6,356
	300	106,270	968.5	855.6	31.5	118.3	242.8	398.7	95.8	4.4	49.5	19.8	5,852
Average		96,393	941.4	848.3	30.4	102.2	302.9	364.0	79.2	5.0	29.1	17.5	5,998
125,000	0	106,957	996.3	934.0	31.3	59.9	323.4	420.0	130.7	1.8	20.6	24.1	6,127
	50	114,488	966.9	894.9	29.9	111.4	288.9	376.2	118.4	3.0	12.7	30.3	6,120
	100	108,962	1,060.9	1,023.1	31.7	146.1	343.3	417.5	116.2	1.0	8.6	18.5	7,197
	150	111,592	1,019.7	966.5	33.0	60.0	287.8	498.8	120.0	2.9	9.1	14.6	6,213
	200	118,077	1,113.3	1,037.8	31.4	86.4	317.2	489.3	144.9	2.5	24.0	24.5	6,777
	250	113,697	1,072.4	970.0	33.3	98.8	328.0	443.5	99.7	3.8	23.9	38.9	6,639
	300	116,584	1,044.8	941.4	30.6	54.5	275.9	504.7	106.4	4.5	32.7	24.4	6,043
Average		112,908	1,039.2	966.8	31.6	88.2	309.2	450.0	119.5	2.8	18.8	25.0	6,445
150,000	0	129,817	966.7	886.7	32.2	41.1	155.2	480.9	209.4	2.0	5.7	55.1	4,985
	50	121,540	1,003.3	920.8	29.3	48.1	253.8	468.7	150.3	1.8	15.6	48.7	5,702
	100	137,374	1,084.7	970.0	32.7	69.4	242.9	501.8	155.9	4.5	32.0	34.3	6,035
	150	118,529	1,070.1	968.7	32.0	89.4	316.9	458.6	103.8	4.4	28.4	25.4	6,531
	200	129,503	1,167.8	1,067.9	32.8	65.9	216.9	588.0	197.1	3.7	27.4	29.6	6,347
	250	123,647	1,068.2	967.9	31.1	46.2	223.2	565.9	132.6	4.4	31.6	21.6	5,892
	300	135,123	1,052.1	918.8	32.4	28.8	210.5	483.7	195.7	6.6	17.4	44.6	5,314
Average		127,933	1,059.0	957.3	31.8	55.6	231.3	506.8	163.6	3.9	22.6	37.1	5,799
LSD (0.05) N rate		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Popul.		5711	38.9	45.0	1.0	26.2	41.9	37.9	22.0	2.0	11.4	7.4	406
LSD (0.05) N X Pop		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Nitrogen budget for the upper 2 ft of soil for drip-irrigated onions with seven N rates. Malheur Experiment Station, Oregon State University, Ontario, OR, 2000.

	N supply					Fall nitrogen accounting			
N rate	Preplant soil NO_3+ NH_4-N	Fertilizer N	N in irrigation water	Estimated N mineralization	Total N supply	N uptake	Fall soil NO_3+ NH_4-N	Accounted N	Balance
	lb/acre								
0	120.4	0	57.8	68.6	246.9	176.9	118.6	295.6	48.7
50	120.4	50	57.8	68.6	296.9	172.8	175.6	348.4	51.5
100	120.4	100	57.8	68.6	346.9	209.5	194.9	404.3	57.5
150	120.4	150	57.8	68.6	396.9	185	287.9	472.9	76.1
200	120.4	200	57.8	68.6	446.9	214.3	313.6	527.9	81.1
250	120.4	250	57.8	68.6	496.9	221.6	277.9	499.6	2.7
300	120.4	300	57.8	68.6	546.9	216.8	292.4	509.3	-37.6
Average					396.9	199.6	237.3	436.9	40
LSD (0.05)						NS	95.5	99.5	NS

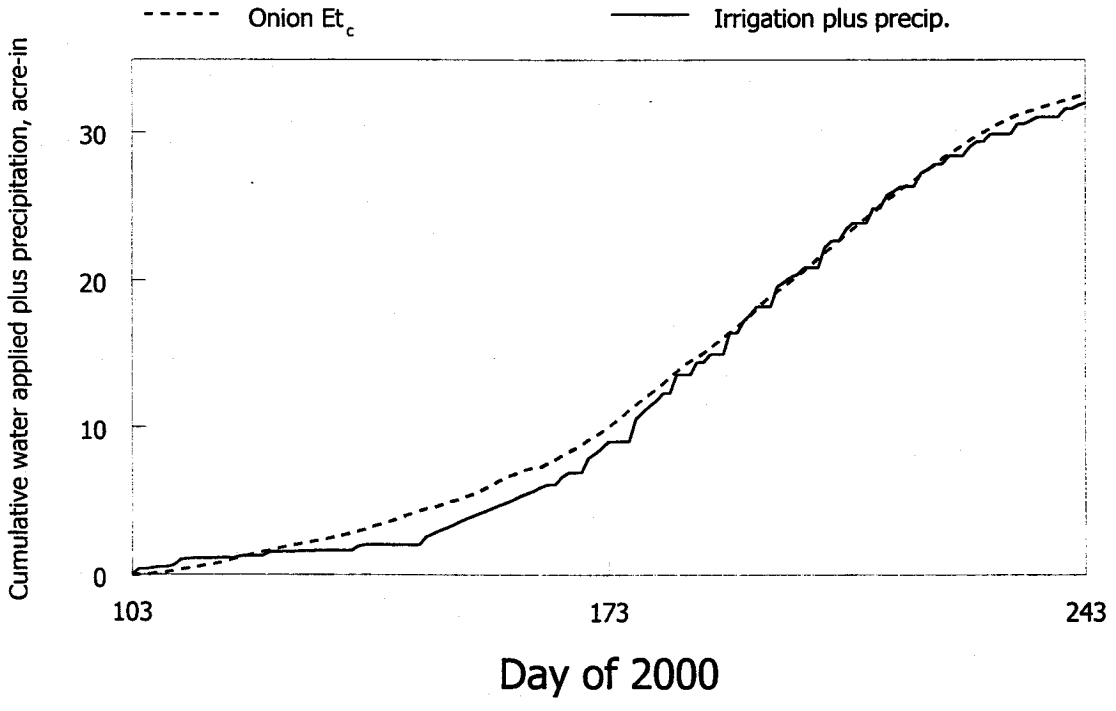

Figure 1. Cumulative water applied plus precipitation and Et_c for onions drip-irrigated at a soil water potential of -20 kPa compared with estimated onion evapotranspiration. Malheur Experiment Station, Oregon State University, Ontario, OR, 2000.

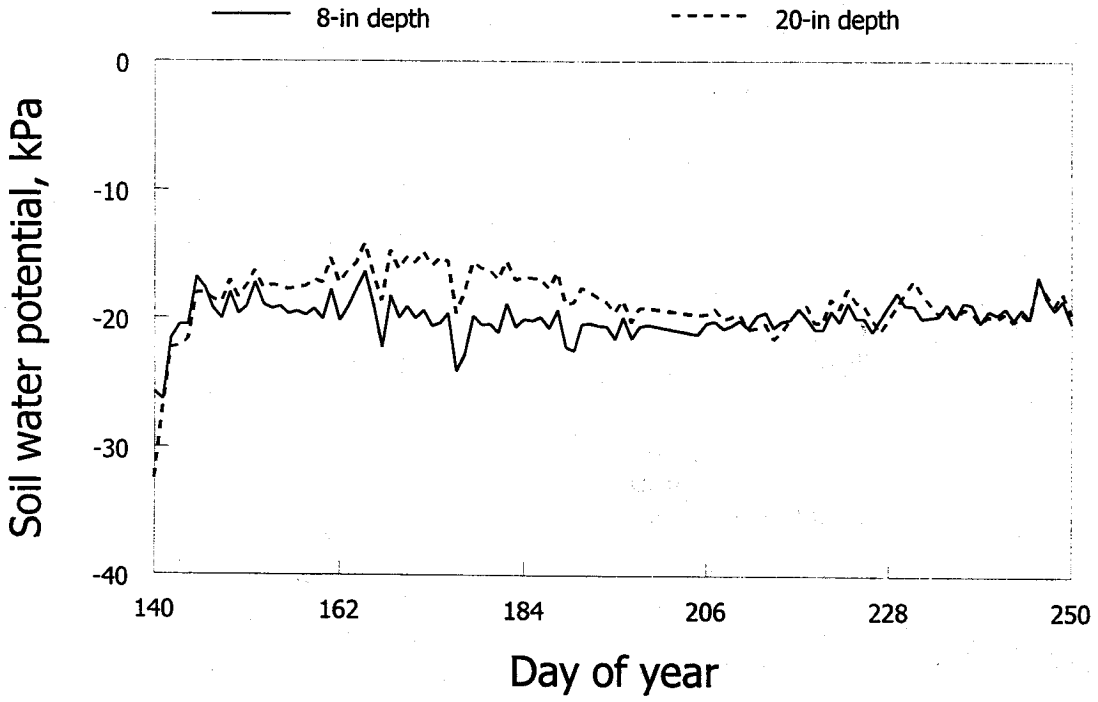

Figure 2. Soil water potential for drip-irrigated onions. Malheur Experiment Station, Oregon State University, Ontario, OR, 2000.

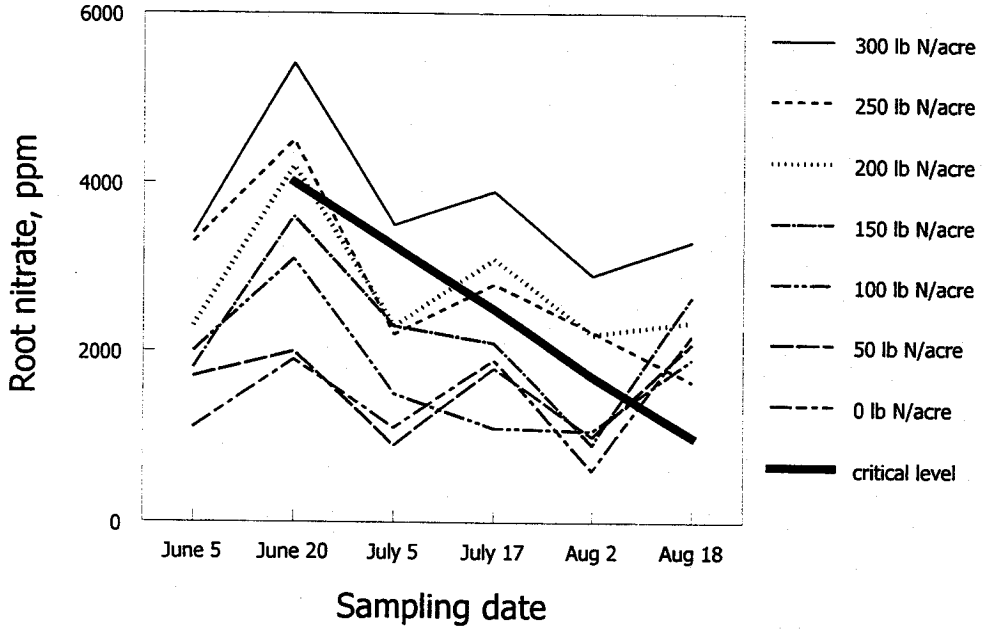

Figure 3. Onion root nitrate response to seven N rates applied through drip irrigation for onions at a plant population averaging 113,000 plants/acre. Malheur Experiment Station, Oregon State University, Ontario, OR, 2000.

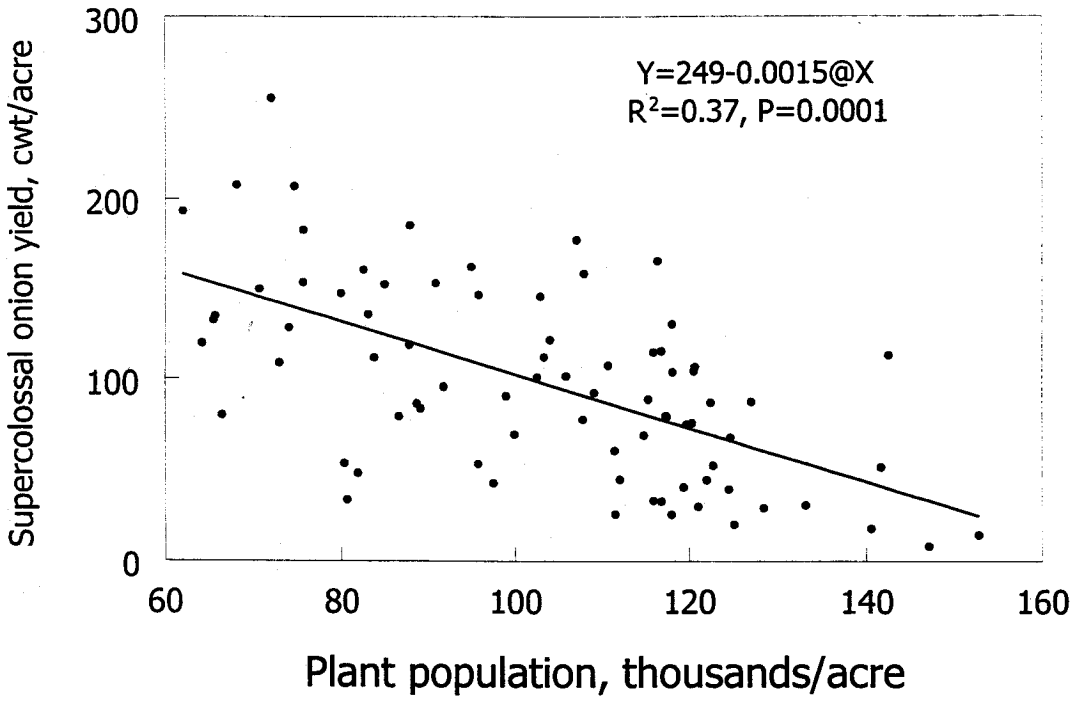

Figure 4. Response of supercolossal onion yield to plant population for onions drip-irrigated at a soil water potential of -20 kPa. Malheur Experiment Station, Oregon State University, Ontario, OR, 2000.