# NITROGEN FERTILIZATION AND PLANT POPULATION FOR SUBSURFACE DRIP-IRRIGATED ONIONS

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## Summary

Onion yield and grade were tested in response to a combination of seven nitrogen fertilizer rates and four plant populations under drip irrigation on an Owyhee silt loam soil. All treatments were irrigated by a soil water potential criterion of -20 kPa at 8-in depth using high frequency, automated irrigations. Onion yield and grade were not very responsive to the N fertilizer rate. A combination of pre-plant soil available N, N mineralization, and N in irrigation water provided a total of 205 lb N/acre to the crop with no applied N fertilizer. Onion yield and grade were highly responsive to plant population. A plant population of 129,000 plants per acre resulted in the highest marketable yield and in the lowest yield of colossal onions.

## Introduction

Nitrogen fertilizer applied through drip irrigation has the potential to be more efficient than nitrogen fertilizer applied broadcast, sidedressed, or water run in a furrow irrigated field. Crop nitrogen applications with drip irrigation could be reduced compared to furrow irrigation as a result of the lower nitrogen leaching and the higher application efficiency. Onion production with subsurface drip irrigation has been tested at the Malheur Experiment Station since 1992. 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 N rate. The objective of this trial was to determine the optimum N rate and plant population combination for drip irrigated onions to maximize yield and quality.

## Procedures

The trial was conducted at the Malheur Experiment Station on an Owyhee silt loam previously planted to wheat. Twenty pounds of N and 100 lb of $P_2O_5$ per acre were applied in the fall of 1998. On March 24, 1999, the field was plowed, groundhogged twice, and bedded on 22-in centers with a bed harrow and roller. A soil sample taken from the top foot on June 1, 1999 showed a pH of 7.3 and 1.4 percent organic matter.

Onions (cv. Vision, Petoseed, Payette, ID) were planted in two double rows, spaced 22 in apart in 44-in beds on April 8. Onions were planted at 153,000 seeds/acre. Drip tape (Nelson Irrigation Corp., Walla Walla, WA) was laid simultaneously with planting at 6-in depth between the two double onion rows. The drip tape had emitters spaced 12 in 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 14 and on April 16 with a microsprinkler system (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA) before onion emergence. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals, which were spaced 30 ft apart. Onions started emerging on April 25.

The seven N rates ranged from 0 to 300 lb N/acre in 50 lb N/acre increments. The nitrogen for each treatment was split into five equal amounts (Table 1). The N treatments were applied as Uran on May 18, June 1, June 10, June 22, and July 6. Fertilizer solutions were applied through the drip lines with venturi injector units (Mazzei Injector Model 287) installed in each plot. Nitrogen treatments were replicated three times and 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 June 3 and 4. Individual population plots were 2 beds wide and 50 ft long.

The soil water potential at 8-in depth was maintained constant at -20 kPa by 0.06 acre-in/acre of water applied up to eight times a day based on soil water potential readings every 3 hours. The automated drip irrigation system was started in early June.

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 plot. In addition, each 125,000 plants/acre subplot had a GMS installed at 18-in depth below an onion row. Sensors were calibrated to SWP (Shock et al., 1998b). 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 in each plot every 3 hours and, if the average 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 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 June 1 through August 15. The plant samplings of August 1 and August 15 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.

Post-emergence 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 four aerial applications of Warrior and Lannate. A brown wheat mite infestation in early August was controlled by Microthiol Special at 8 lb ai/acre.

The onions were lifted on September 13. On September 20, the onions in the central 40 ft of the middle two double rows in each subplot were topped and boxed. The boxes were placed into storage on September 24. The storage shed was managed to maintain an air temperature of approximately 34°F. The onions were graded out of storage on December 14. Bulbs were graded according to their diameters: small (<2¼ in), medium (2¼ -3 in), jumbo (3-4 in), and colossal (>4 in). Split bulbs were graded as Number 2's regardless of diameter. Marketable onions were considered perfect bulbs in the medium, jumbo, and colossal 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 medium onions with $4.05/cwt, jumbo onions with $6.80/cwt, and colossal onions with $9.63/cwt. These prices are the average of prices paid to the grower from early August through January for the years 1992 through 1999.

The soil was sampled in 1-foot increments down to 2 ft in each replicate before planting and in each 125,000 plants/acre subplot after harvest, and was analyzed for nitrate and ammonium. Nitrogen contribution from the irrigation water was estimated to be 2.3 lb N/acre-in/acre of water infiltration. Nitrogen contribution from organic matter mineralization was estimated by anaerobic incubation at 104°F for 7 days.

## Results and Discussion

Onion populations of 125,000 and 150,000 plants per acre were not achieved (Table 1). Water applications over time closely followed, but were slightly lower than, onion $Et_c$ (Figure 1). Soil water potential at 8-in depth remained close to -20 kPa except for a brief period in mid-July, when a datalogger malfunction caused a brief suspension of irrigations (Figure 2). Soil water potential at 20-in depth remained close to soil water potential at 8-in depth. The potential for nitrate leaching was low based on the water applications being slightly less than $Et_c$ and the soil water potential not undergoing large oscillations.

Onion yield and grade were not responsive to N rate (Table 1). There were 79 lb/acre of $NO_3$-N and $NH_4$-N in the top 2 ft of soil on June 4 (Table 2). A total of 69 lb/acre of $NO_3$-N and $NH_4$-N were released in the top 2 ft of soil from N mineralization. Onion root nitrate in all treatments was substantially higher than the critical level in mid-June (Figure 3). Thereafter, root nitrate levels dropped, with the three highest N rates being at or above the critical level and the other treatments being below the critical level. Onion N uptake in past trials at the Malheur Experiment Station has ranged from 120 to 250 lb/acre. The unfertilized check treatment in this trial had a total N supply of 205 lb/acre in the top 2 ft of soil.

The highest plant population tested (129,000 plants per acre) resulted in among the highest total and marketable yield, and in the highest jumbo onion yield (Table 1). Colossal onion yield was highest at the lowest plant population tested. The highest plant population tested (129,000 plants per acre) resulted in among the highest gross returns, but a statistically significant increase was obtained only when plant population increased from 75,000 to 98,000 plants per acre. The highest plant population tested (129,000 plants per acre) was close to the population of 133,000 plants/acre that maximized yields and gross returns of drip irrigated onions (cv. Vision) at the Malheur Experiment Station in 1995 (Feibert et al., 1995).

## Literature cited


Feibert, E., C.C. Shock, and M. Saunders. 1995. Plant Population for Drip-Irrigated Onions. Oregon State University Agricultural Experiment Station Special Report 964:45-48.

Shock, C.C., J. Barnum, and M. Seddigh. 1998a. Calibration of Watermark soil moisture sensors for irrigation management, pp. 139-146. In: Proc. Irrigation Assoc., Intl. Irr. Show.

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, Oregon, 1999.

| Target plant population | N rate | Harvested bulbs | Total yield | Marketable yield by grade | | | | Non-marketable yield | | | Gross returns |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | > 4in | 3-4 in | 2¼-3 in | Rot | # 2's | Small | |
| plants/acre | lb/acre | bulbs/acre | cwt/acre | | | | | % | cwt/acre | | $/acre |
| 75,000 | 0 | 75,040 | 804.3 | 712.7 | 326.4 | 384.0 | 2.2 | 1.8 | 77.3 | 0.0 | 5,764 |
| | 50 | 80,188 | 808.0 | 682.6 | 320.7 | 358.5 | 3.4 | 2.9 | 101.8 | 0.5 | 5,540 |
| | 100 | 73,357 | 834.2 | 691.1 | 341.7 | 346.4 | 2.9 | 2.2 | 94.3 | 0.5 | 5,658 |
| | 150 | 77,911 | 792.5 | 702.1 | 290.3 | 406.5 | 5.3 | 1.5 | 78.8 | 0.0 | 5,581 |
| | 200 | 70,189 | 766.5 | 635.7 | 317.8 | 316.6 | 1.3 | 4.7 | 93.6 | 0.4 | 5,218 |
| | 250 | 73,951 | 801.8 | 656.0 | 309.8 | 344.8 | 1.3 | 4.8 | 107.1 | 0.3 | 5,334 |
| | 300 | 74,050 | 761.0 | 626.5 | 259.8 | 364.1 | 2.6 | 2.7 | 113.1 | 0.9 | 4,988 |
| Average | | 74,955 | 793.5 | 672.4 | 309.5 | 360.1 | 2.7 | 3.0 | 95.1 | 0.4 | 5,440 |
| 100,000 | 0 | 91,969 | 864.5 | 809.3 | 268.9 | 534.0 | 6.4 | 2.4 | 33.7 | 0.0 | 6,247 |
| | 50 | 100,978 | 960.0 | 868.2 | 316.6 | 539.2 | 12.5 | 3.3 | 60.8 | 0.5 | 6,766 |
| | 100 | 97,612 | 960.6 | 848.7 | 268.1 | 572.5 | 8.1 | 2.7 | 71.0 | 0.0 | 6,508 |
| | 150 | 101,968 | 956.6 | 866.9 | 307.5 | 552.2 | 7.2 | 2.3 | 67.8 | 0.2 | 6,745 |
| | 200 | 97,414 | 873.1 | 780.4 | 214.4 | 554.6 | 11.4 | 3.0 | 66.7 | 1.2 | 5,882 |
| | 250 | 97,216 | 932.4 | 841.5 | 277.7 | 559.7 | 4.1 | 4.1 | 51.9 | 0.9 | 6,497 |
| | 300 | 99,988 | 855.1 | 777.5 | 221.1 | 549.2 | 7.1 | 2.3 | 58.5 | 0.0 | 5,893 |
| Average | | 98,163 | 912.3 | 827.5 | 267.8 | 551.6 | 8.1 | 2.9 | 58.6 | 0.4 | 6,362 |
| 125,000 | 0 | 112,857 | 942.3 | 897.5 | 197.3 | 680.6 | 19.6 | 1.6 | 30.5 | 0.0 | 6,607 |
| | 50 | 109,690 | 956.0 | 895.8 | 233.2 | 647.6 | 15.0 | 1.3 | 47.3 | 0.3 | 6,710 |
| | 100 | 114,738 | 1,035.7 | 927.3 | 223.5 | 689.7 | 14.1 | 2.6 | 32.1 | 1.8 | 6,900 |
| | 150 | 105,730 | 945.4 | 836.3 | 233.0 | 595.9 | 7.4 | 4.2 | 68.3 | 0.0 | 6,326 |
| | 200 | 112,857 | 963.7 | 898.9 | 202.0 | 681.0 | 15.9 | 2.4 | 39.6 | 1.1 | 6,640 |
| | 250 | 109,690 | 987.8 | 886.8 | 209.8 | 667.0 | 10.0 | 5.0 | 49.7 | 0.9 | 6,596 |
| | 300 | 102,760 | 916.1 | 844.0 | 247.9 | 589.6 | 6.4 | 3.0 | 45.3 | 0.0 | 6,423 |
| Average | | 109,760 | 960.3 | 883.8 | 221.0 | 650.2 | 12.6 | 2.9 | 44.7 | 0.5 | 6,600 |
| 150,000 | 0 | 116,025 | 904.8 | 849.1 | 136.1 | 690.9 | 22.2 | 2.7 | 30.1 | 0.0 | 6,098 |
| | 50 | 124,143 | 974.7 | 892.5 | 164.4 | 714.8 | 13.2 | 4.2 | 38.9 | 0.9 | 6,498 |
| | 100 | 127,509 | 1,028.2 | 931.4 | 174.6 | 736.4 | 20.5 | 3.9 | 30.7 | 0.0 | 6,771 |
| | 150 | 145,428 | 1,045.8 | 1,003.9 | 141.9 | 824.1 | 37.9 | 1.7 | 22.4 | 1.7 | 7,124 |
| | 200 | 130,875 | 1,030.7 | 980.3 | 201.6 | 753.1 | 25.6 | 2.2 | 27.2 | 0.6 | 7,166 |
| | 250 | 144,240 | 1,075.7 | 1,028.8 | 134.1 | 865.6 | 29.1 | 2.4 | 19.6 | 1.7 | 7,295 |
| | 300 | 112,659 | 917.8 | 843.3 | 183.7 | 645.8 | 13.8 | 2.8 | 47.2 | 1.1 | 6,216 |
| Average | | 128,697 | 995.2 | 932.8 | 162.4 | 747.2 | 23.2 | 2.8 | 30.9 | 0.9 | 6,738 |
| LSD (0.05) N rate | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| LSD (0.05) Popul. | | 2399 | 36.8 | 37.0 | 39.5 | 49.3 | 5.3 | NS | 12.6 | NS | 281 |
| LSD(0.05) N X Pop | | 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, Oregon, 1999.

| N rate | Pre-plant soil available N | Fertilizer N | N in irrigation water | Estimated N mineralization | Total N supply | Fall soil available N |
|---|---|---|---|---|---|---|
| | lb/acre | | | | | |
| 0 | 79.3 | 0 | 57.5 | 68.6 | 205.4 | 75.6 |
| 50 | 79.3 | 50 | 57.5 | 68.6 | 255.4 | 89 |
| 100 | 79.3 | 100 | 57.5 | 68.6 | 305.4 | 90.8 |
| 150 | 79.3 | 150 | 57.5 | 68.6 | 355.4 | 120.7 |
| 200 | 79.3 | 200 | 57.5 | 68.6 | 405.4 | 87.9 |
| 250 | 79.3 | 250 | 57.5 | 68.6 | 455.4 | 83.2 |
| 300 | 79.3 | 300 | 57.5 | 68.6 | 505.4 | 108.8 |
| LSD (0.05) | | | | | | NS |

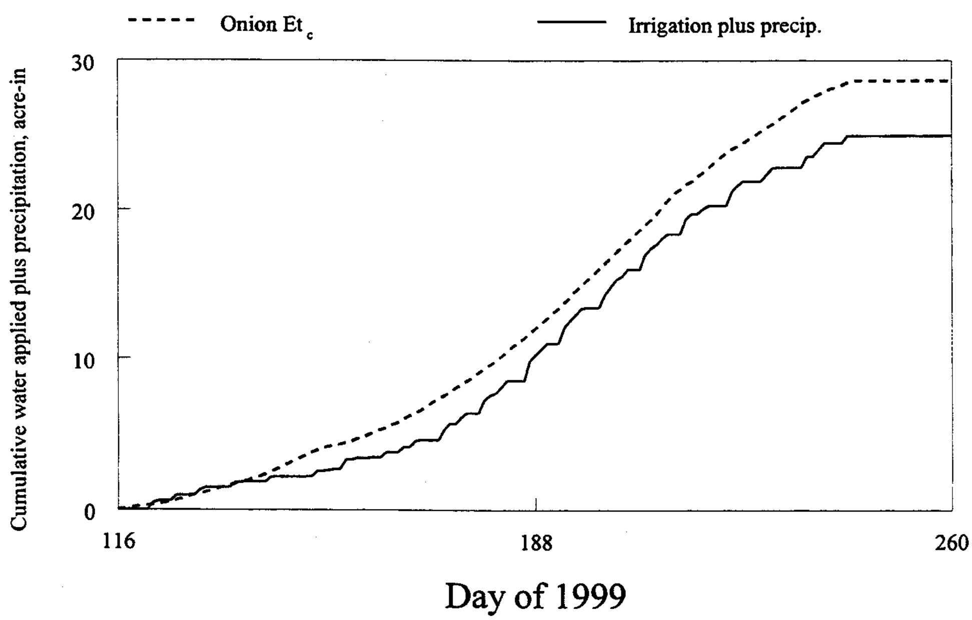


Figure 1. Cumulative water applied plus precipitation and $Et_c$ for onions drip-irrigated at a soil water potential of -20 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1999.

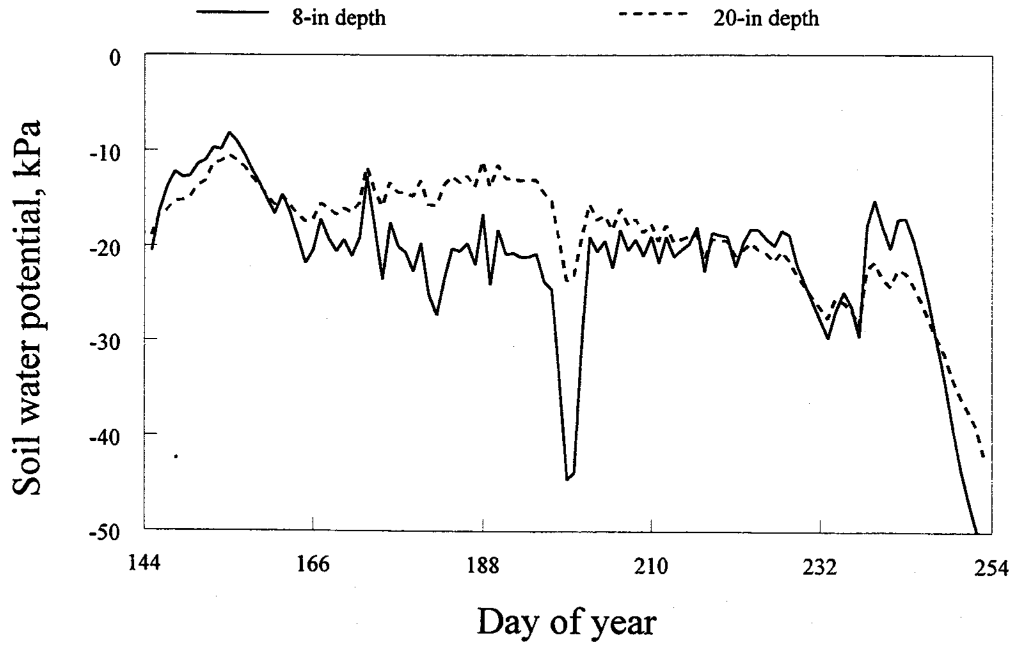


Figure 2. Soil water potential for drip irrigated onions. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1999.

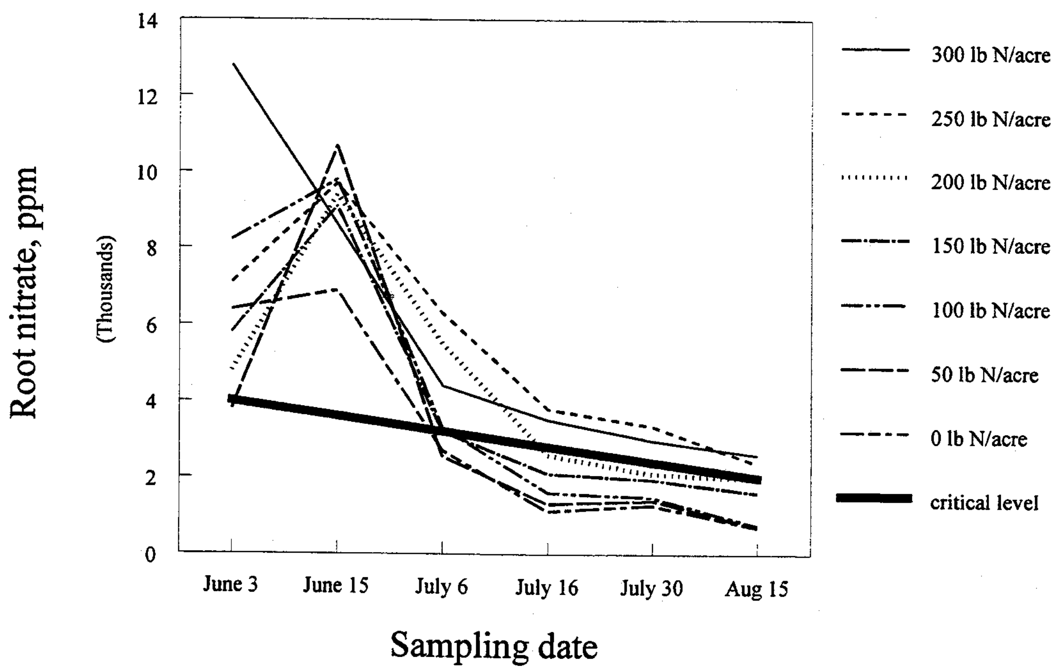


Figure 3. Onion root nitrate response to seven N rates applied through drip irrigation for onions at a plant population of approximately 110,000 plants per acre. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1999.