# Drip-Irrigated Onion More Responsive to Plant Population Than to Fertilizer Nitrogen

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Onion (*Allium cepa* L.) is usually fertilized with 300 lb/acre or more of N in furrow or sprinkler-irrigated fields in the Pacific Northwest. The use of drip irrigation is expanding for onion production and allows irrigation uniformity without leaching. Long day onion 'Vision' was subjected to a combination of seven nitrogen fertilizer rates (0 to 300 lb/acre in 50 lb increments) and four plant populations (75,000, 100,000, 125,000, and 150,000 plants per hectare) using drip irrigation in 1999, 2000, and 2001. Onions were grown on 44-in beds with two double rows centered 22 in apart with a drip tape buried 4 in deep in the bed center. Soil water potential was maintained nearly constant at -20 kPa by automated, high frequency irrigations based on soil water potential measurements at 8-in depth. Onions were evaluated for yield and grade after 70 days of storage. Onion yield and grade were not very responsive to the N fertilizer. Pre-plant soil available N, N mineralization, and N in irrigation water all contributed N to the crop. Onion yield and grade were highly responsive to plant population. Onion marketable yield increased with increasing plant population. Onion bulb diameter decreased with increasing plant population.

## Introduction

Onion production with subsurface drip irrigation has been tested at the Malheur Experiment Station since 1992. While good guidelines have been developed for irrigation scheduling (Shock et al. 2000a), 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 in the context of carefully managed drip irrigation. Nitrogen fertilizer applied broadcast, sidedressed, or water run in a furrow irrigated field may be less efficient. Nitrogen applications with drip irrigation might be reduced compared to furrow irrigation as a result of the lower N leaching and potentially higher N use efficiency.

The objective of these trials was to determine the optimum combination of N rate and plant population for drip-irrigated onions to maximize yield, quality, and economic return.

## Materials and Methods

Three trials were conducted at the Malheur Experiment Station, Ontario, Oregon on Owyhee silt loam in 1999, 2000, and 2001, each year following wheat. The fields had records of moderate productivity. In the fall 200 lb per acre of $P_2O_5$ plus other nutrients as required in the specific field (less N) were broadcast and the field was plowed and groundhogged twice. The field was fumigated in the fall prior to onions with Telone C-17 at 24 gal/acre and bedded on 22-inch centers. Onions (cv. 'Vision', Petoseed, Payette, ID) were planted in two double rows, spaced 22 inches apart in 44-inch beds in late March. 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 initially 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 in April.

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 and was applied as urea-ammonium nitrate (Uran) from late May through early July. 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 each year. 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 in May. 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. 2000a, 2002). The automated drip irrigation system was started in May.

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 onion emergence until the final irrigation and compared with onion evapotranspiration.

In late August, 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 (Waring and Bremner, 1964). The well water used for irrigation was analyzed for $NO_3$-N and $NH_4$-N. The well water used for irrigation had an average $NO_3$ and $NH_4$ concentration of 10.4 ppm and 1 ppm, respectively in 2001. Nitrogen contribution from irrigation was calculated to be 2.58 lb N/acre per acre-in of water in 2001, and lesser amounts in 1999 and 2000. 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.

In mid September the onions were lifted to field cure. A week later, 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. The storage shed was managed to slowly lower the temperature and then 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 onion $Et_c$. In 1999 and 2000, water applications plus rainfall were slightly less than onion $Et_c$ (Shock et al. 2000b, 2001), while in 2001 water applications plus rainfall were slightly more 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. All three years, the 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. Each year, the unfertilized check treatment had a total N supply of over 300 lb/acre in the top two feet of soil during the season, counting the initial residual soil nitrate and ammonium, mineralized N, and nitrate and ammonium in the irrigation water (Table 1).

Whereas medium, jumbo, and total marketable onion yield increased with increasing plant population, colossal and supercolossal onion yield decreased (Figure 3). Only the onion yield and grade results from 2001 are reported here because the results from 1999 and 2000 were similar (Shock et al. 2000b, 2001). In 2000 and 2001 gross returns were not responsive to plant population. Within the range of plant populations tested, the decrease in gross returns, resulting from the decrease in marketable yield with decreasing plant population, was offset by the increase in supercolossal onions which give the highest returns.

Calculated gross returns increased with increasing plant population only in 1999, when we failed to consider the supercolossal onion yield and value separate from the colossal class. Consequently we consider this result as an artifact of our error of calculating value.

## Acknowledgments

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Table 1. Nitrogen supply for the upper 2 ft of soil for drip-irrigated onions without considering any N fertilizer inputs. Malheur Experiment Station, Oregon State University, Ontario, OR.

| Year | N supply | | | |
|---|---|---|---|---|
| | Pre-plant soil $NO_3$ + $NH_4$-N | N in irrigation water | Estimated N mineralization | Total N supply |
| | -------------------------- lb/acre -------------------------- | | | |
| 1999 | 79 | 58 | 213 | 350 |
| 2000 | 120 | 58 | 228 | 406 |
| 2001 | 171 | 94 | 45 | 310 |

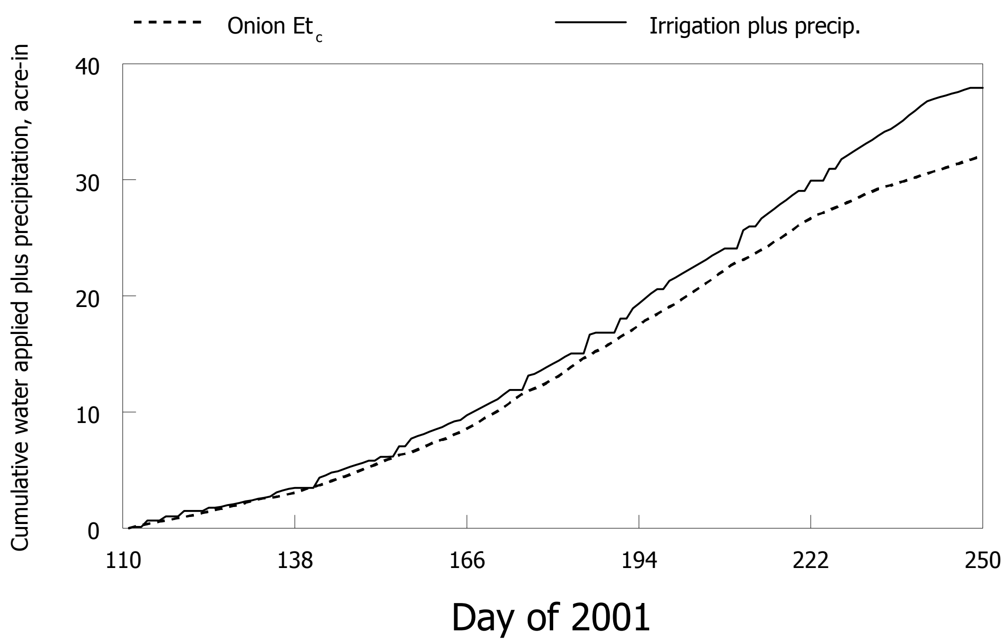


Figure 1. Cumulative water applied plus precipitation and $Et_c$ for onions drip-irrigated at a soil water potential of -20 kPa compared with estimated onion evapotranspiration in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

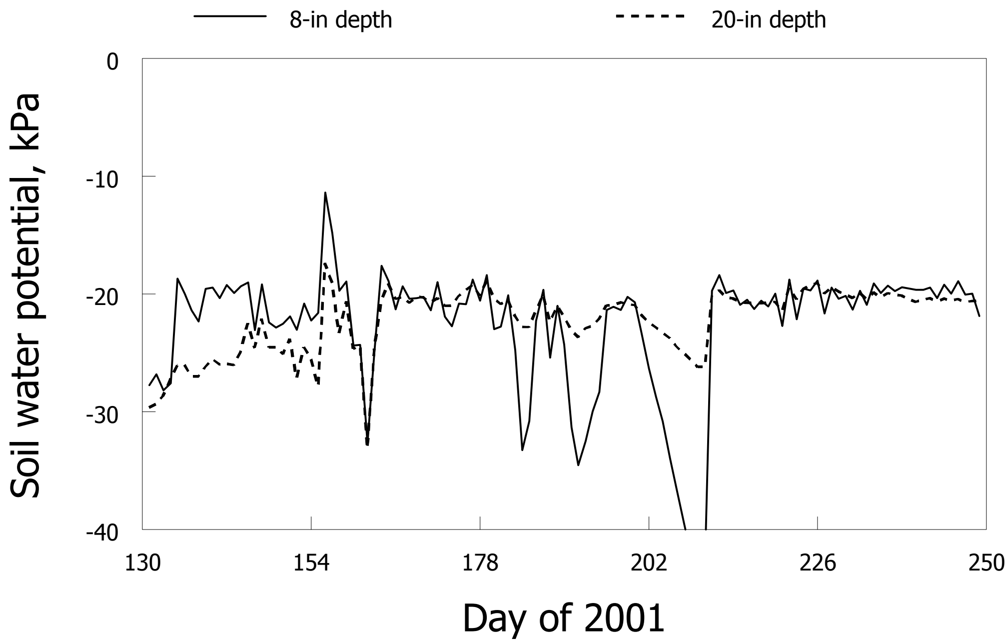


Figure 2. Soil water potential for drip-irrigated onions in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

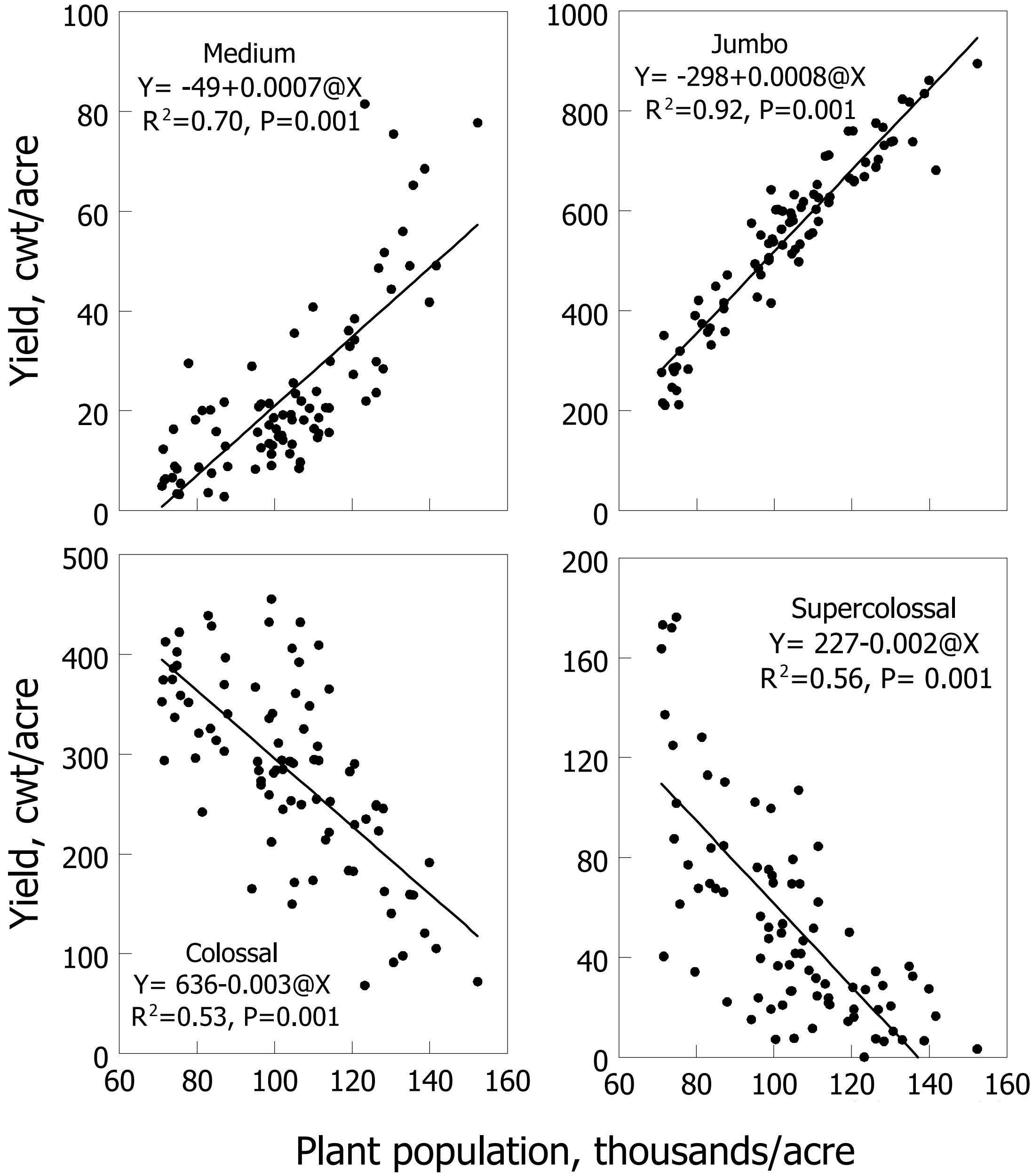


Figure 3. Onion yield response to plant population in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.