ONION RESPONSE TO NITROGEN FERTILIZATION UNDER DRIP AND FURROW IRRIGATION

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ABSTRACT

Onion is a high cash value crop with a very shallow root system that is frequently fertilized with high N rates (>200 lb N/a) to maximize yield. In 2005, we applied six N rates (0, 40, 80, 120, 160, and 200 lb N/a) to existing N plots previously cropped to corn (2000-2003) and chile pepper (2004). The N source was a polycoated urea with a 90 to 120 day release period which was applied prior to planting. The N main plots were split in 2005 to allow irrigation by furrow (normal method) and by a drip system. At the end of the season, a total of 27 inches of irrigation water had been applied with the drip system and 96 inches with the furrow system. Total marketable fresh onion yield increased with increasing N rate in both systems, with less response of onion to N with the drip system compared to the furrow irrigation system. Significantly higher onion yields were obtained with the drip system. Averaged over irrigation system, the percentage of the onion crop that was of colossal size (>4 inch diameter) increased from 5% to 14% with increasing N rate, jumbo size (3-4 inch diameter) which made up 80% of the yield was not affected by N rate, and medium size (2-3 inch diameter) decreased from 14% to 5% with increasing N rate. Adjusted gross economic returns were greater with drip irrigation than with furrow irrigation. This work demonstrates that economic returns can be maintained by using the more efficient drip irrigation system for onion production rather than the inefficient furrow irrigation system. With the drip system, onion yields were maximized with a lower rate of N fertilizer and 72% less irrigation water than with the furrow irrigation system.

INTRODUCTION

High NO_3-N levels have been reported in groundwater in the Arkansas River Valley in Colorado (Austin, 1997; Ceplecha et al., 2004), which is a major producer of melons, onions, and other vegetable crops grown in rotation with alfalfa, corn, sorghum, winter wheat, and soybeans. High rates of N fertilizer (>200 lb N/a) are usually applied to onion to increase overall yield and bulb size, generally without regard to soil testing (Bartolo et al., 1997). Halvorson et al. (2002a) reported N fertilizer use efficiency (NFUE) by onion to be about 15%. Onion has a shallow rooting depth (<2 ft) and requires frequent irrigation to maintain market grade and quality. High N fertilization rates to shallow-rooted crops, shallow water tables, and excess water application to control soil salinity all contribute to a high NO_3-N leaching potential in this area (Halvorson et al., 2001, 2002a, 2002b). Irrigation, crop, and N management practices need to be developed to reduce NO_3-N leaching potential and improve N use efficiency (NUE). Halvorson et al. (2005) established a N fertility study in 2000 to evaluate the use of continuous corn to reduce the residual soil NO_3-N levels in the Arkansas River Valley in

Colorado. They found that residual soil NO_3-N levels were reduced significantly by corn with conservative N fertilizer application. These same N plots were planted to chile pepper in 2004 and to onion in 2005 to determine the effects of N fertilization on vegetable crop yields and residual soil NO_3-N.

The objective of the 2005 research reported here was to determine N fertilizer needs of onion under drip and furrow irrigation in Arkansas River Valley to optimize yield and bulb size following corn and chile pepper, and evaluate the influence of N fertilizer rate and irrigation system on residual soil NO_3-N and potential for groundwater contamination.

METHODS AND MATERIALS

A N source and rate study was initiated under conventional till, furrow-irrigated corn on a calcareous Rocky Ford silty clay loam soil at the Arkansas Valley Research Center (AVRC) in 2000 (Halvorson et al., 2005). The plot area had previously been in continuous corn for 4 years and chile pepper in 2004. Six N rates (0, 40, 80, 120, 160, and 200 lb N/a or N1, N2, N3, N4, N5, N6, respectively) were established on February 22, 2005. The N source was a controlled-release polycoated urea (Duration Type III produced by Agrium[3]; cost \$950/ton or \$1.10/lb N) with a 90 to 120 day release period. The N fertilizer was broadcast on February 22nd and incorporated with a harrow on February 28, 2005. Two irrigation systems were used, furrow irrigation (normal practice) and drip irrigation. A split-plot, randomized complete block design with N rate as main plots and irrigation system as subplots with 4 replications was used.

Onion (var. Ranchero) was planted on March 8, 2005 at a seeding rate of about 129,466 seeds per acre. At harvest, the plant population was 106,649 plants/a when averaged over all plots. Two rows of onion were planted on a 10 inch bed with a 30 inch row spacing (furrow to furrow). The onions were harvested on August 29th for fresh weight yield and graded for size. Marketable onion sizes were colossal (>4" diameter), jumbo (3 to 4" diameter), and medium (2 to 3" diameter). Onion yields are expressed as bags (one bag = 50 lbs) of fresh onion weight per acre. Estimated gross return per acre was calculated based on a harvest price of \$10/bag of colossal, \$8/bag of jumbo, and \$6/bag of medium size onions. Water cost was estimated at \$11 per acre-ft. The drip irrigation system was estimated to cost \$750 per acre (disposable drip tube used plus amortized cost for pump, filter, and set-up material used for more than one year). Labor costs were not considered in the economic analysis. Herbicides were applied for weed control, with the plots being relatively weed free during the study period. Soil NO_3-N levels in the 0-6 ft profile were measured before fertilization and after harvest. The spring soil NO_3-N levels on 22 February 2005 before applying N fertilizer were 40, 43, 50, 50, 62, and 81 lb N/a in the 0- to 2-ft soil depth, and 71, 71, 78, 66, 99, and 111 lb N/a in the 0- to 6-ft soil depth for the N1, N2, N3, N4, N5, and N6 treatments.

The onions under drip irrigation were irrigated 20 times during the growing season with a total water application of 27 inches (2.22 acre feet). The drip tape was located about 2-3 inches below the soil surface near the center of the bed between the two onion rows. Onions under furrow irrigation received a total of 96 inches (8.03 acre feet) of irrigation water in 13 irrigations. Under furrow irrigation, water was applied to every furrow (30 inch spacing) to obtain uniform wetting of both onion rows on the bed. The runoff water from the furrow irrigated plots was estimated using a flume placed in the furrow at the lower end of the field. Approximately 32.4

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[3] Trade names and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment of the product by the authors or the USDA, Agricultural Research Service.

inches (2.7 acre feet) of water ran off the end of the field in the furrow irrigated system. No water was lost off the end of the field with the drip system. The average NO_3-N level in the irrigation water for the season was 1.4 ppm, with about 8.6 lb NO_3-N/a was added to the soil with the drip system and 20.2 lb NO_3-N/a with the furrow irrigation system.

Precipitation during the growing season was 1.55” in March, 0.75” in April, 0.49” in May, 1.05” in June, 0.45” in July, and 2.17” in August. Total precipitation for the growing season was 6.46 inches, a rather dry season during April, May, June, and July.

RESULTS

Excellent onion yields were obtained in 2005 at Rocky Ford, CO. Onion yields increased with increasing N rate for both irrigation systems (Fig. 1), with the drip system having a significantly greater yield (1756 bags/a) than the furrow irrigation system (1556 bags/a). The N rate x irrigation system interaction shown in Fig. 1 was significant at P = 0.159. Marketable onion yields were near maximum with the application of 80 to 120 lb N/a with the drip system, whereas, the 200 lb N/a rate was needed in the furrow system to attain yields equal to those in the drip system. Differences in yield between the two irrigation systems were greatest at the lower N rates, with the difference diminishing as N rate increased.

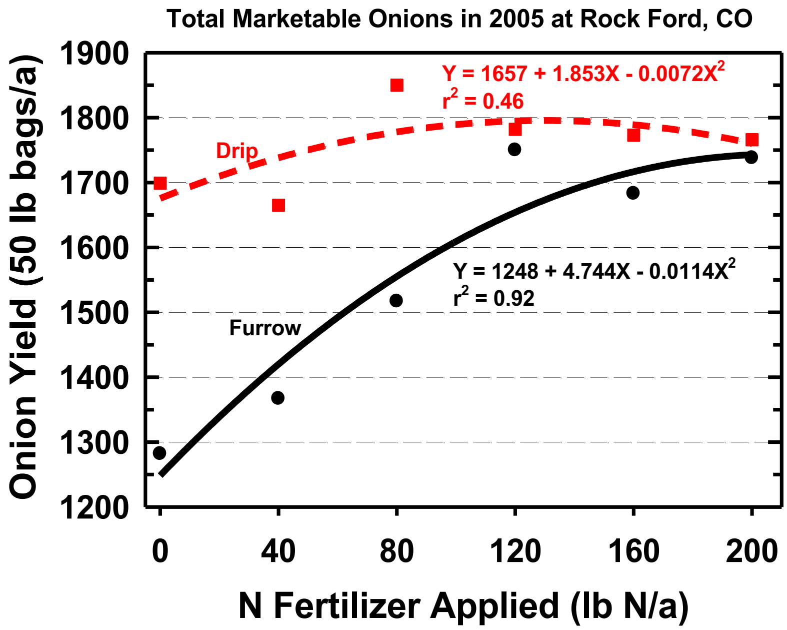


Figure 1. Onion yield as a function of N fertilizer rate and irrigation system.

The quantity of colossal size onion (P = 0.117) and jumbo size onion (P = 0.0223) increased with increasing N rate, but the quantity of medium size onion (P = 0.018) decreased with increasing N rate (Fig. 2) when averaged over both irrigation systems (N rate x irrigation system interactions were not significant, P > 0.5). The drip system had more colossal and jumbo size onions than the furrow system, but fewer medium size onions than the furrow system. Colossal size onions averaged 223 bags/a with the drip system and 161 bags/a with the furrow irrigation system (P = 0.191). The percentage of colossal size onions increased from 5% for the check plot (no N added) to a maximum of 14% of the marketable onions at the 120 and 160 lb N/a rates (P = 0.077). Jumbo size onion averaged 1403 bags/a with the drip system and 1245 bags/a with the furrow system (P = 0.0058). Increasing N rate did not change the percentage of jumbo size onion as a percentage of the total marketable onion yield, averaging 80 % over all N rates and irrigation systems. Medium size onions averaged 130 bags/a with the drip system and 150 bags/a with the furrow system (P = 0.317). Increasing N rate decreased the percentage of medium sized onions from 14 % at the lowest N level to 5% at the highest N level. This demonstrates the need to have adequate N available to maximize bulb size.

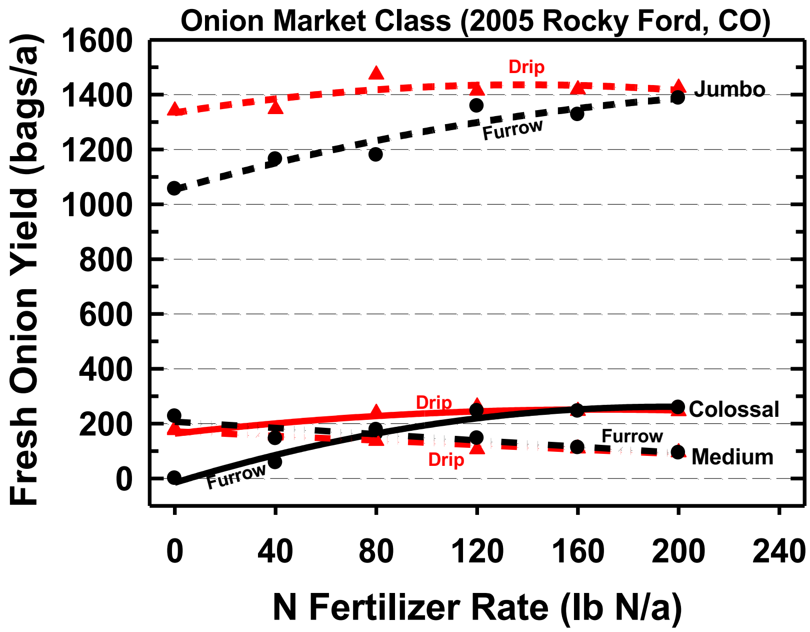
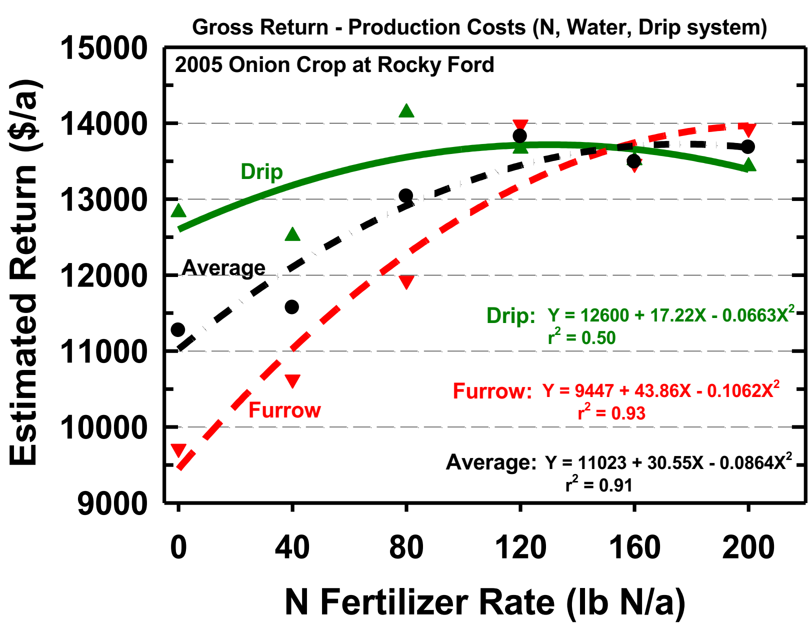
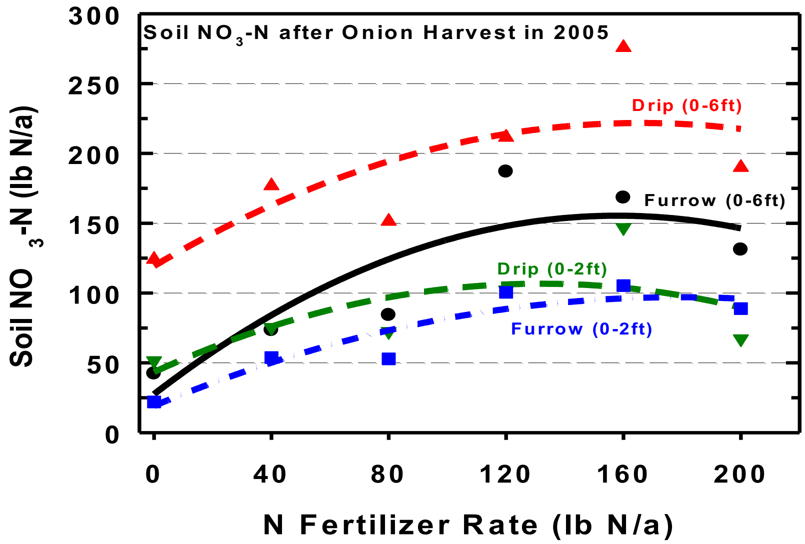


Figure 2. Onion market class distribution as a function of N fertilizer rate in 2005 at Rocky Ford, CO.



An adjusted gross dollar return per acre (gross return *minus* N fertilizer, water, and drip system costs) was calculated for each treatment. Adjusted gross returns were increased with increasing N rate in both irrigation systems (Fig. 3) and tended to be greater with the drip system than with the furrow system at lower N rates (N rate x irrigation system interaction significant at P = 0.21) similar to marketable onion yield shown in Fig. 1. The average adjusted gross return is also shown in Fig. 3.

Nitrogen uptake by the onion tops at harvest did not vary with N rate or irrigation system on August 30, 2005. At harvest the tops contained 28 lb N/a. Nitrogen uptake by the bulbs increased linearly with increasing N rate, with a significant N rate x irrigation system interaction (P = 0.03). Nitrogen uptake was greater with the drip system at the lower N rates than with the furrow system.



Analysis of soil samples collected after onion harvest for residual NO_3-N reveals residual soil NO_3-N was generally greater with the drip system than with the furrow irrigation system (Fig. 4). Residual soil NO_3-N generally increased with increasing N rate in both systems. These data show that the drip system reduced soil NO_3-N leaching compared with the furrow system. With more residual fertilizer N in the 0 to 6 ft soil profile after harvest, greater N uptake by the onion bulbs, and less fertilizer needed to maximize yields, the drip system appears to improve N use efficiency when compared with the furrow irrigation system.

Figure 4. Resiudal soil NO_3-N in the 0-2 ft and 0-6ft soil depth after onion harvest as a function of N rate and irrigation system.

The 2005 study demonstrates that economic returns can be maintained by using the more efficient drip irrigation system for onion production rather than the inefficient furrow irrigation system. With the drip system, onion yields were maximized with a lower rate of N fertilizer and 72% less irrigation water than with the furrow irrigation system. Less NO_3-N was lost from the soil profile with the drip system compared with the furrow irrigation system. Visually, soil erosion was also less with the drip system than with the furrow irrigation system.

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Figure 3. Adjusted gross return as a function of N rate and irrigation system and average of irrigation systems in 2005.

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