

NITROGEN AND WATER USE EFFICIENCY IN ONION PRODUCTION UNDER DRIP AND FURROW IRRIGATION

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ABSTRACT

Groundwater sampling in Washington County indicates that nitrate nitrogen (NO₃-N) concentrations are frequently above health standards and increasing. The objective of this project was to demonstrate research based onion production practices that can increase water and fertilizer use efficiency, and reduce ground water contamination potential from NO₃-N while maintaining production. Non-replicated demonstration plots were installed from 2003-2007 in onion fields, and used either furrow or drip irrigation. Following standard practices, furrow (control) plots received an average of 275 lb nitrogen (N)/acre/year. Drip irrigation plots received an average of 162 lbs N/acre/year following N fertilizer recommendation rates from University of Idaho and Pacific Northwest onion fertilizer guides, with irrigation scheduling based on soil moisture sensor data. A furrow treatment plot was added in 2005, using a reduced average N rate of 161 lb N/acre, again using recommendations from university fertilizer guides. Production inputs were measured and soil nitrate, onion tissue nitrate, water use, fertilizer application, soil N mineralization, crop yield, and bulb sizes were determined. Water use efficiency (WUE) and N use efficiency (NUE) were calculated and compared for all plots. The furrow treatment plots used approximately 40% less N fertilizer than the furrow control, and still produced yields that were only 4.1% to 5.2% less than the control. The drip plot produced the best WUE and NUE when compared to the furrow control. Furrow treatment yield for 2007 fit close to the high range of the Preplant Yield Response Curve from the Pacific Northwest onion fertilizer guide, indicating sufficient N availability. The project showed that high onion yields can be produced with reduced N fertilizer application. Demonstration of efficiency through these plot comparisons can help growers keep production costs down, maintain high yields, and minimize N leaching into water supply.

INTRODUCTION

Groundwater sampling in Canyon County indicates that NO₃-N concentrations are currently within health standards, but are on the rise. Groundwater sampling in Washington County indicates that NO₃-N concentrations are frequently above health standards and increasing. Deep percolation of irrigation water containing nitrogen from cropland is recognized as a contributor to groundwater contamination. Onion production has been determined to have one of the highest NO₃-N leaching potentials. Approximately 9,000 acres of onions are grown in the Treasure Valley of Idaho.

Beginning in 2003, applied research and demonstration plots were installed within commercial onion fields that used either furrow or drip irrigation. Plots from these furrow and drip irrigated fields were sampled and compared each year until project completion in 2007.

The objective of this project was to demonstrate research-based onion production practices that can increase water and fertilizer use efficiency, and reduce ground water contamination potential from NO₃-N while maintaining production.

METHODS

Soil moisture monitoring equipment was installed in furrow and drip irrigated commercial onion fields in both Canyon and Washington Counties at the start of each production season. Moisture monitoring equipment was used to help schedule irrigations and to help keep onion soil moisture within recommended levels. Data recorded by the monitors was used to compare irrigation efficiency of furrow and drip systems.

Throughout the growing season additional data were collected including soil nitrate (NO_3), onion tissue NO_3 , water use, fertilizer application, soil N mineralization, crop yield and bulb sizes. The data were used to calculate N use efficiency (NUE) and water use efficiency (WUE) between the furrow and drip irrigated treatments. In addition to data collection for comparisons, specific treatments were introduced within the plots during the last three years. These treatments included: 1. Furrow irrigation (Furrow Control) using the grower's customary fertility and irrigation practices; 2. Furrow irrigation (Furrow Treatment) using research based fertility recommendations (PNW 546 and CIS 1081); and 3. Drip irrigation (Drip) using research based fertility recommendations (PNW 546 and CIS 1081), and irrigation scheduling based on soil moisture sensor data

RESULTS AND DISCUSSION

Water Management

Applied irrigation water and soil moisture status of the plots differed greatly by irrigation system. Furrow irrigated onions averaged more water application than drip irrigated plots (Figure 1), and soil moisture oscillated to a greater extent. Washington County soil moisture graph examples shown in Figures 2 & 3.

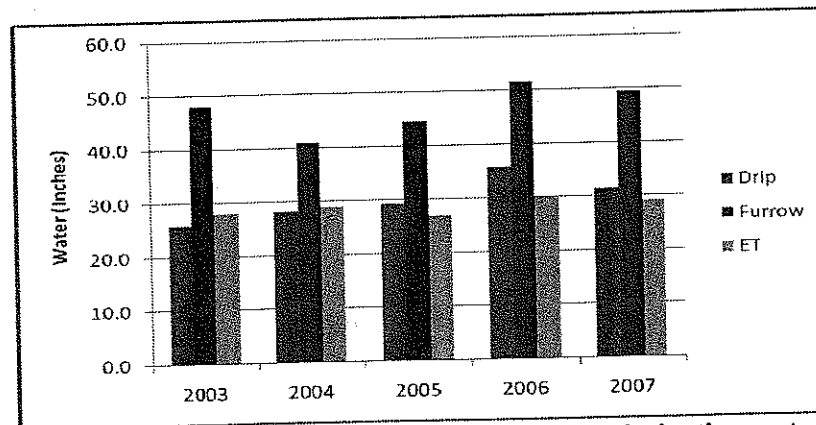


Figure 1. Seasonal water applications to onion plots by irrigation system vs. ET

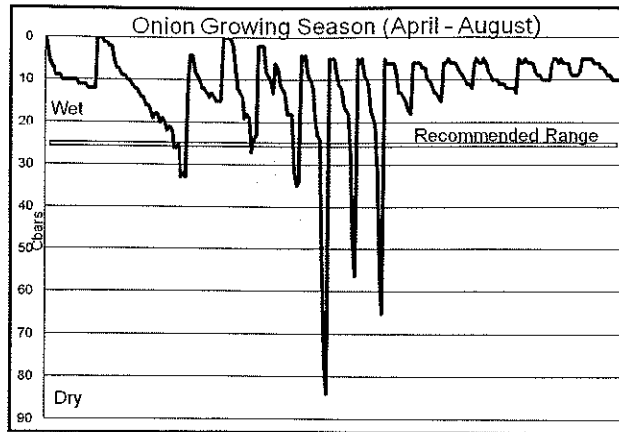


Figure 2. Soil graph (Cbars) of furrow irrigated onions showing great moisture variation.

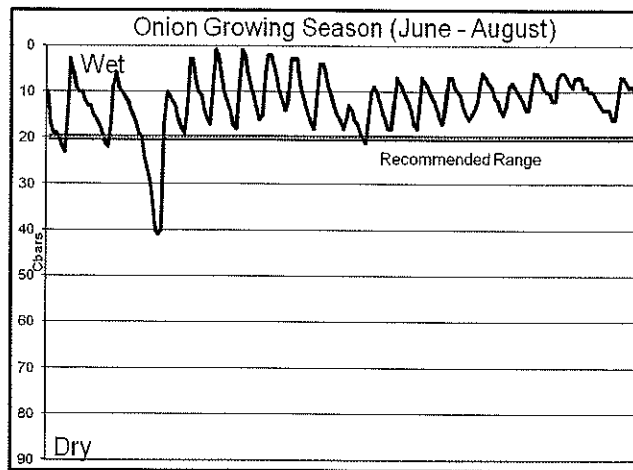


Figure 3. Soil graph (Cbars) of drip irrigated onions showing small moisture variation.

Water use efficiency (WUE) of the plots under differing irrigation systems and treatments were compared (Figure 4). WUE is defined as the hundred-weight (Cwt) of onions produced per inch of water applied, including rainfall. The Drip plots consistently showed the highest WUE while the Furrow Control WUE and Furrow Treatment WUE were very similar, but much less.

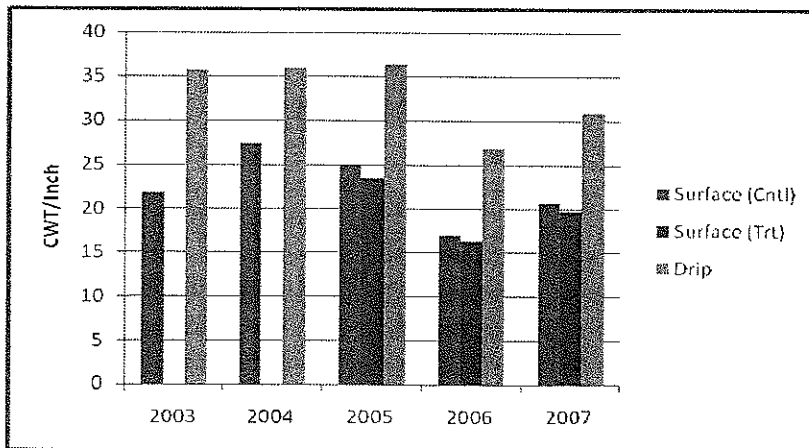


Figure 4. WUE of onion plots by irrigation system. (Surface = Furrow)

Nitrogen Management

Nitrogen fertilizer recommendations for the Furrow Control and Drip plots were calculated using early season soil samples along with estimated yield, estimated N mineralization, and estimated N uptake efficiencies. For example, in the 2006 study, yield goals of 950 Cwt/ac were established, and N uptake efficiencies of 40% and 60% were assumed for furrow and drip irrigated onions respectively (PNW 546). A recommendation of 325 lbs N/ac was calculated for the furrow plots and 171 lbs N/ac for the Drip plot (Table 1). The Furrow Control actually received a fall application plus two side-dressings for a total of 283 lbs N/ac. The Furrow Treatment received a fall application plus one side-dressing for a total of 158 lbs/ac, as was recommended. This reduction in N was due to monthly soil testing that indicated sufficient N was present. Soil mineralization tests revealed approximately 120 lbs N became available from May through August. The 2006 Drip plot received a total of only 155 lbs N/ac, of which 115 lbs was applied through multiple drip irrigations.

Although the 2006 Drip plot received comparatively less N per acre, it produced a yield very close to the furrow plots. This is consistent with research showing N can be applied in small amounts frequently and produce high yields.

Table 1. Fertilizer recommendations and actual applications for onion plots.

Year	Lbs N	Lbs N	Lbs N	Lbs N	Lbs N
	Recommended	Applied	Applied	Recommended	Applied
	Furrow Control	Furrow Control	Furrow Treatment	Drip	Drip
2003	226	258	----	54	165
2004	226	255	----	81	150
2005	250	285	160	110	150
2006	325	283	159	171	155
2007	267	295	165	128	190
<i>Average</i>	259	275	161	109	162

High N fertilizer recommendations were anticipated in 2006 due to wet weather and expected N leaching. However, actual N fertilizer applications were similar to 2005. In both 2005 and 2006, soil testing indicated adequate N in the Furrow Treatment (>20 ppm), and a second fertilizer application was not needed. Similar recommendations were calculated in 2007. The 2007 Furrow Treatment received two side-dressings of only 62.5 lbs N each. The Drip plot received 62 lbs N fertilizer above the recommendation due to extreme inconsistencies in soil sample results.

Yield

These demonstration plots were replicated only by year, so statistical analysis of yields could not be measured. Yields were consistently high, and were reasonable considering the irrigation systems used and inputs applied (Figure 5). The 2006 furrow irrigated yields were down 20 percent from 2005 due to hot summer weather. However, yields from 2005 to 2006 drip irrigated plots were down only 10 percent. The yield reduction was smaller in the drip irrigated plots, possibly due to soil moisture management closer to the optimum range (-20 to -25 Cbars) through the growing season (Figure 3).

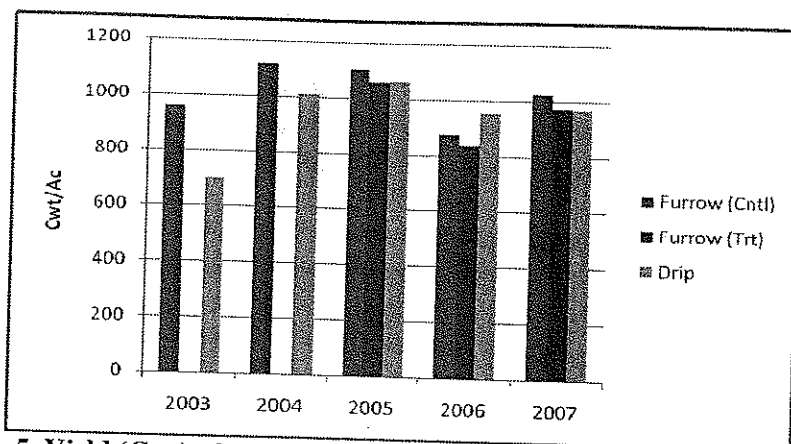


Figure 5. Yield (Cwt) of onions by Control and Treatment over 5 year study

In both 2005 and 2006, the Furrow Treatment yields were 4.1 % less than the Furrow Control yields. This slightly lower yield resulted despite 41% less N fertilizer applied to the Treatment than the Control. In 2007, the Furrow Treatment yield was 5.2 % less than the Furrow Control. This yield resulted despite 44% less N fertilizer applied to the Treatment than the Control. Root tissue analysis from 2005 through 2007 showed both Furrow Treatment and Furrow Control N levels within, or close to, adequate levels. In addition, the yield from the 2007 Furrow Treatment fit very closely to the high range of the Preplant Yield Response Curve (PNW 546) (6).

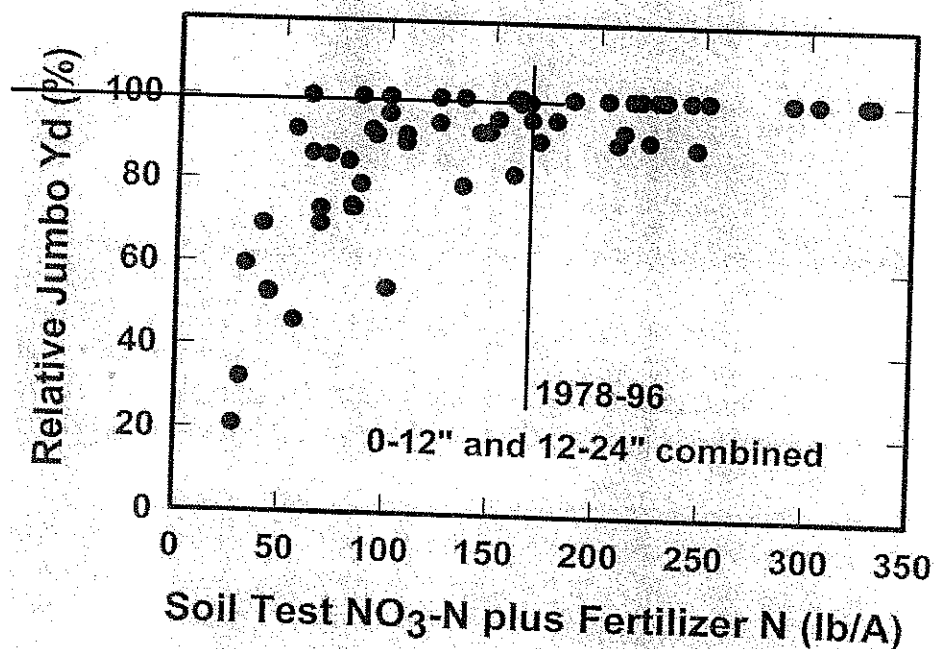


Figure 6. 2007 Furrow Treatment yield compared to research based Preplant Yield Response Curve. Intersection of red lines indicates location of Furrow Treatment within the curve.

Nitrogen Use Efficiency (NUE)

Nitrogen Use Efficiency (NUE) is defined here as the lbs of N used per Cwt of onions produced. Research estimates that a Cwt of onion bulbs requires 0.19 Lbs N (with 100% uptake efficiency). However, N uptake efficiency for furrow irrigated onions is only about 40%. Consequently, it takes 0.475 lbs N/Cwt for furrow irrigated onions to get the required 0.19 lbs N/Cwt. With drip irrigation and an estimated 60% uptake efficiency, 0.317 lbs N/ac is needed to get 0.19 lbs N/ac to the onions.

In 2006, the NUE of the Furrow Control was 0.65 lbs N/Cwt indicating inefficient use of N (Fig 7). This was the poorest NUE recorded during the project, and was the result of high N fertilizer application in combination with a comparatively low yield. The Furrow Treatment NUE was 0.47 lbs N/Cwt, and the Drip was 0.39 lbs N/Cwt of onion bulbs. Both the Furrow Treatment and Drip plots had NUE measurements that came very close to research predictions.

The Drip plot NUE was slightly higher than values mentioned in the literature, so opportunities may remain for growers to further reduce their N inputs. In 2007, the NUE of the Drip plot was much higher than the Furrow Treatment. This aberration reflects unusual soil sample results that led to more N fertilizer applied than was recommended. The best NUE was produced by the 2005 Furrow Treatment plot. This could partly be explained by a combination of reduced N fertilizer, well timed N application, and high yield.

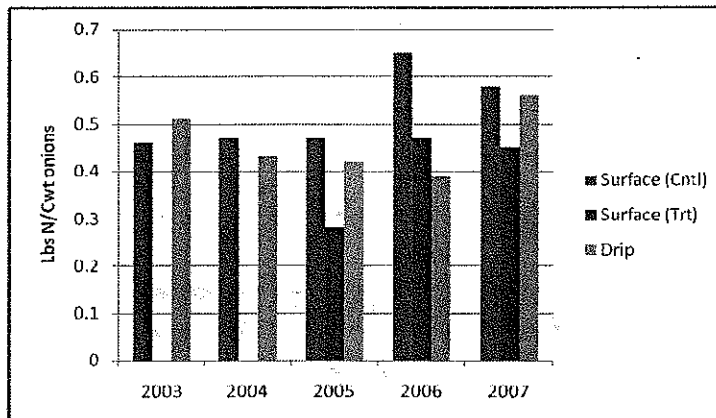


Figure 7. NUE (Lbs N/cwt onions) for all plots. (Surface = Furrow)

Onion production under different irrigation systems was compared over a five year period. Production inputs were measured while soil, water, and root tissues were sampled for N content. Application of N fertilizer on a Furrow Treatment and Drip plot were determined from initial and monthly soil samples. Finally, onion yields and bulb sizes from different irrigation systems were compared.

It was shown that N fertilizer applications can be reduced while maintaining high yields. This information is important to growers who want to improve efficiency of furrow irrigated onions, and especially to growers who may want to transition from furrow to drip irrigation.

With more efficient use of irrigation water and N fertilizer, production costs can be held down, yields can be maintained, and leaching of N into water resources can be minimized. With about 9,000 acres of onions grown in the Treasure Valley of Idaho this could have implications for future groundwater quality.

REFERENCES

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