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

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Introduction

Groundwater sampling in Canyon County, Idaho indicates that nitrate nitrogen (NO_3-N) concentrations are currently within health standards, but are on the rise. Groundwater sampling in Washington County, Idaho indicates that NO_3-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 NO_3-N leaching potentials. Some reasons include historically heavy fertilizer application, and numerous irrigations due to the shallow rooted nature of onions. Approximately 9,000 acres of onions are grown annually in Treasure Valley, Idaho.

Beginning in 2003, an applied research and demonstration project was installed within commercial onion fields that used either furrow or drip irrigation. The 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 (recommended in CIS 1081 and PNW 546) for increased water and fertilizer use efficiency, reduced potential for nitrate-nitrogen groundwater contamination, and maintenance of high yields.

Methods

At the start of each production season (April), Watermark soil moisture sensors were installed at 8 and 15 inch depths in the seed row of furrow and drip irrigated onion fields in both Canyon and Washington Counties. The soil sensors were connected by communication cable to Hansen data loggers which recorded and archived soil matric potential (in centabars) every 8 hours. Soil moisture data were then used to compare irrigation efficiencies of furrow and drip fields. Soil sensors and data loggers were also used to help schedule irrigations in the drip irrigated fields to keep soil moisture within recommended levels (-20 to -25 centabars for silt loam soil).

Through the growing season, additional data were collected including soil nitrate, onion tissue nitrate, water application, fertilizer application, soil nitrate mineralization, and crop yield. Water Use Efficiency (WUE) and Nitrate Use Efficiency (NUE) were calculated for the furrow and drip irrigated fields and then compared each season. WUE is defined as the hundred-weight (Cwt) of onions produced per inch of water applied, including rainfall. NUE is defined as the Lbs of nitrogen used per hundred-weight (Cwt) of onions produced. Research estimates that a Cwt of onion bulbs requires 0.19 Lbs nitrogen (with 100% uptake efficiency). However, nitrogen 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 uptake efficiency of 60%, only 0.317 lbs N/ac is needed to get 0.19 lbs N/ac to the onions.

The fields in this project were not replicated within a growing season so statistical comparisons were not made. In addition to the crop input comparisons, specific treatments were introduced during the last three years. These treatments included:

1. Furrow irrigation (Furrow Control) using the grower's customary fertility and irrigation practices. These practices included a fall fertilizer application (35N, 150P, 60K) and two fertilizer side dressings in the spring. Fertilizer applications were not based on soil sample analysis. Irrigation decisions were based on water availability rather than on a measure of crop need or soil moisture.
2. Furrow irrigation (Furrow Treatment) using research based fertility recommendations (PNW 546 and CIS 1081). Cultural practices here included the same fall fertilizer application and one spring fertilizer side dressing. A second fertilizer side dressing was applied if soil sample analysis indicted it was necessary.
3. Drip irrigation (Drip) using research based fertility recommendations (PNW 546 and CIS 1081), and irrigation scheduling recommended in Irrigation Criteria for Drip-Irrigated Onions (Shock 2000). Cultural practices included a fall fertilizer application (40N) and preseason soil sample analysis. Beginning in spring, nitrogen fertilizer was injected into the drip irrigation lines based on preseason soil sample recommendations as well as monthly soil sampling through the growing season.

Annual nitrogen fertilizer recommendations for all fields and treatments were estimated through the use of early season soil samples along with estimated yield, nitrate mineralization, and nitrogen uptake efficiencies. For example, in 2006, onion yield goals of 950 Cwt/ac were estimated and nitrogen uptake efficiencies of 40% and 60% were assumed for furrow and drip irrigated onions respectively (PNW 546).

Results and Discussion

Water Management

The soil moisture status and applied irrigation of the fields differed greatly by irrigation system. Furrow irrigated onions used on average 17 inches/ac more water than the drip irrigated onions (Figure 1). Soil moisture status oscillated to a greater extent on the furrow irrigated fields, especially in summer, compared to the drip irrigated fields. Examples of Washington County soil moisture graphs are shown in Figures 2 & 3.

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

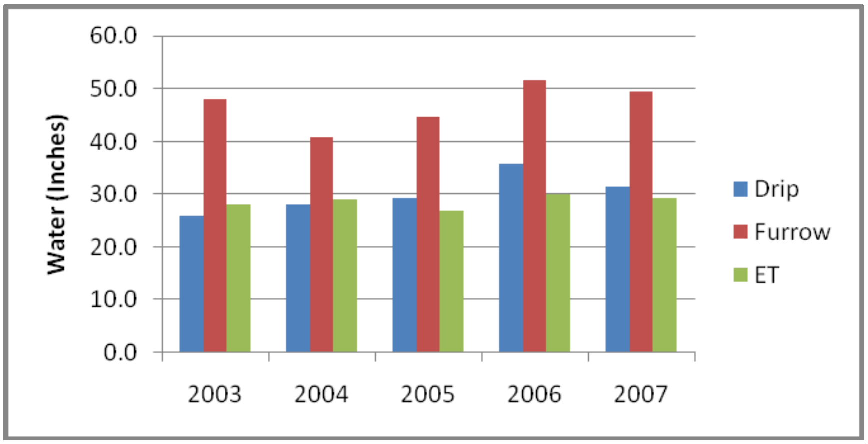
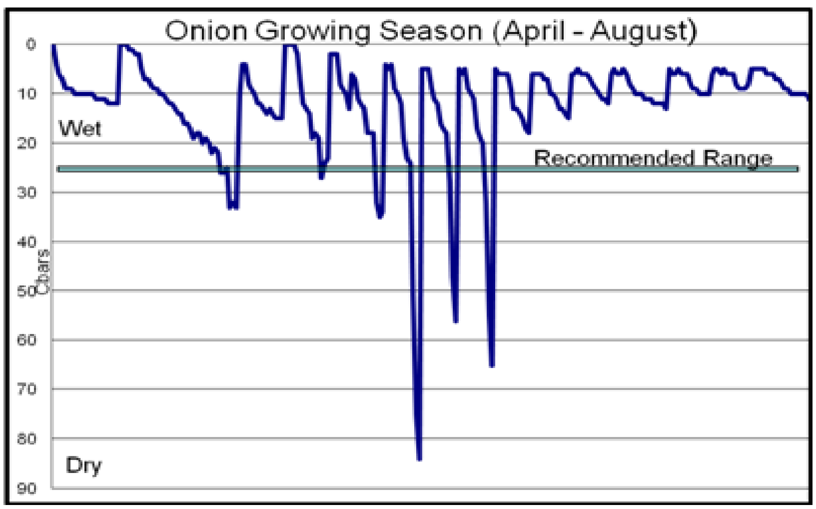
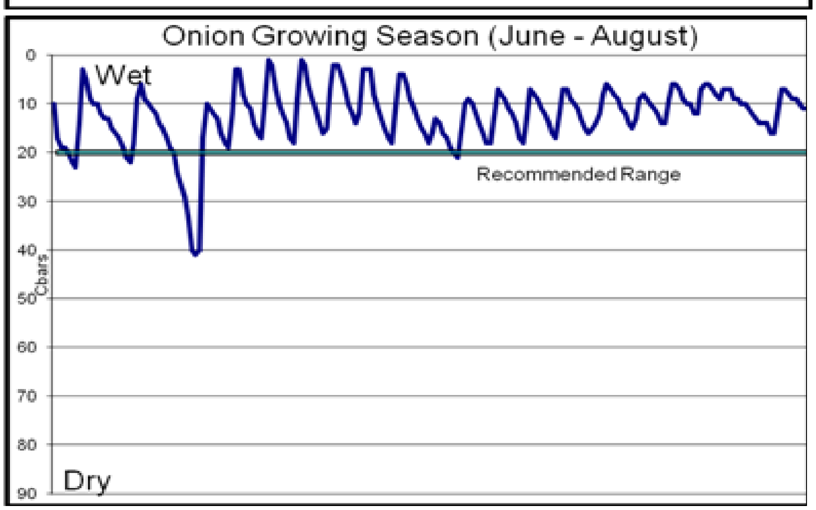


Figure 2. Soil graph (cbars) of furrow irrigated onions showing great moisture variation.

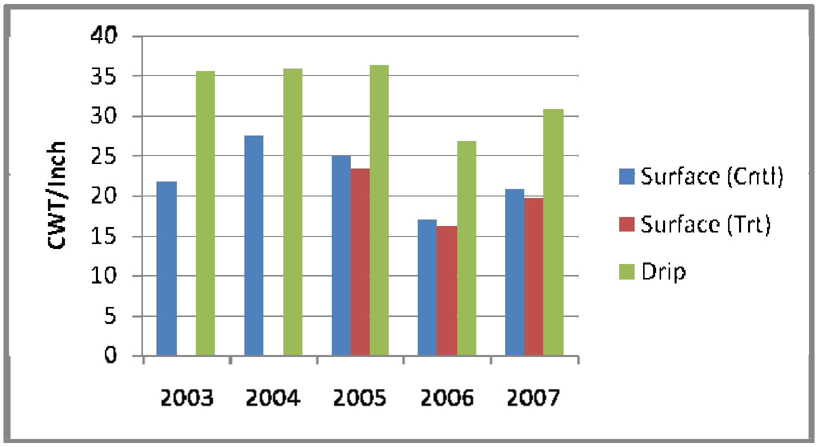
Figure 3. Soil graph (cbars) of drip irrigated onions showing small moisture variation.





Water Use Efficiency (WUE) of the fields under differing irrigation systems and treatments were compared and are shown in Figure 4. The Drip fields consistently showed the highest WUE while the Furrow Control and Furrow Treatment WUE's were similar, but much less.

Figure 4. WUE of onion plots by irrigation system.



Nitrogen Management

The preseason nitrogen recommendations and actual nitrogen fertilizer applications are shown in Table 1. The actual nitrogen applications for furrow irrigated fields are totals of fall applications and either one or two side dressings. In the drip irrigated fields, the actual nitrogen application totals include a small fall application and numerous drip line nitrogen injections.

Table1. N recommendations and actual N applications

	Lbs N Recommended Surface Control	Lbs N Applied Surface Control	Lbs N Applied Surface Treatment	Lbs N Recommended Drip	Lbs N Applied Drip
Year					
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
Avg	259	275	161	109	162

The average actual nitrogen applied to the Furrow Control fields exceeded the recommendations. The Furrow Treatment fields, however, had substantially less applied nitrogen than the Furrow Control and less than the preseason recommendations. The large reductions in actual applied nitrogen in the Furrow Treatments resulted from soil sample analysis indicating that additional applications were not necessary. Soil mineralization through the growing season could also explain the reduced need for nitrate fertilization. For example, during

2006, soil mineralization analysis revealed approximately 120 lbs of nitrogen became available from May through August.

The Drip field recommendations and actual applications were much less than those estimated for the furrow fields. Despite these reduced production inputs, the Drip fields produced yields very close to the furrow fields. This is consistent with research that shows nitrogen can be applied in frequent, small amounts to produce high yields.

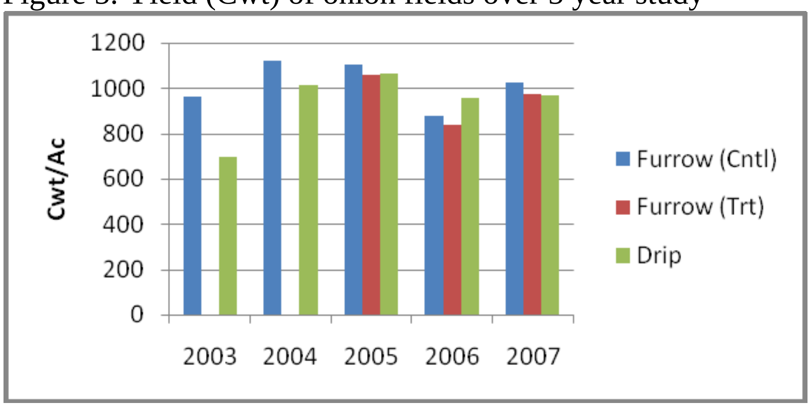
High nitrogen fertilizer recommendations were anticipated in 2006 due to wet weather and expected nitrogen leaching. However, actual nitrogen fertilizer applications were similar to 2005. In both 2005 and 2006, soil testing indicated adequate nitrogen (>20 ppm) in the Furrow Treatment field and a second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

Yield

Yields for all fields were consistently high and were reasonable considering the irrigation systems used and inputs applied (Figure 5). The 2006 Furrow Control and Furrow Treatment yields were down 20 percent from the previous year due to hot summer weather. During this same period, yield from the Drip field was down only 10 percent. The smaller yield reduction in the Drip field was probably due to the grower using soil sensors to maintain soil moisture closer to the optimum range (-20 to -25 cbars) through the growing season (Figure 3).

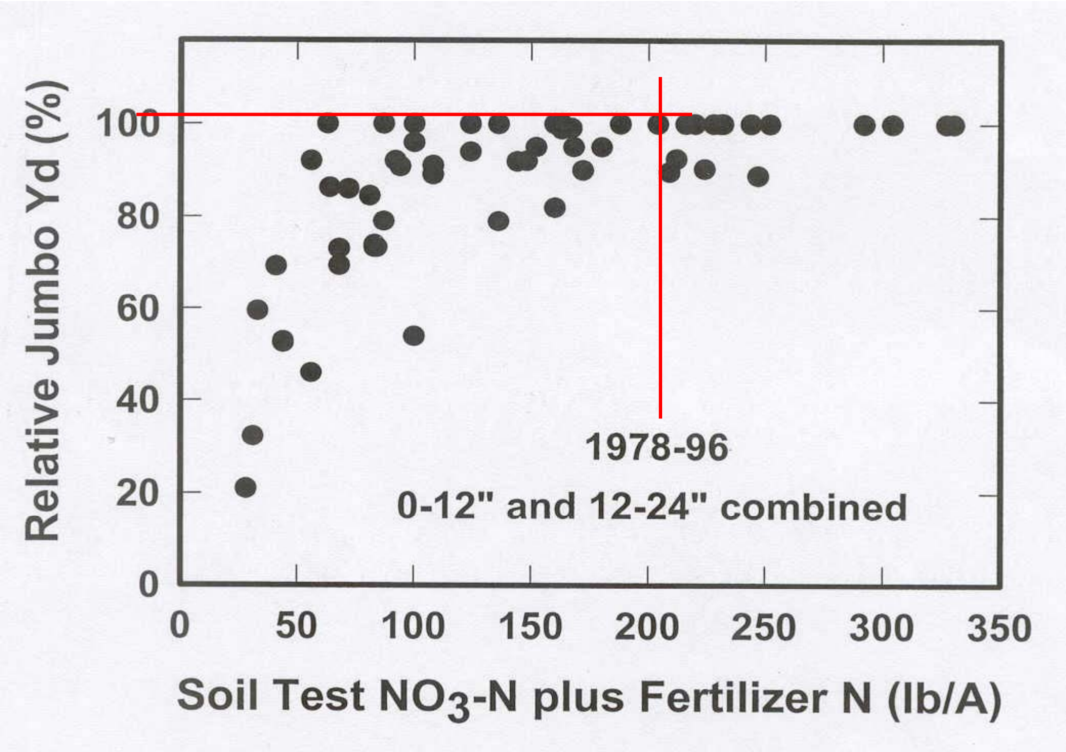
In 2005 and 2006, the Furrow Treatment yields were 4.1% less than the Furrow Control yields. This slightly lower yield resulted despite 41% less nitrogen fertilizer applied to the Treatment than the Control. In 2007, the Furrow Treatment yield was 5.2 % less than the Furrow Control. This yield resulted despite 44% less nitrogen fertilizer applied to the Treatment than the Control. Root tissue nitrogen analysis from 2005 through 2007 showed both Furrow Treatment and Furrow Control to be within, or close to, adequate levels.

Figure 5. Yield (Cwt) of onion fields over 5 year study



In addition, the 2007 Furrow Treatment nitrogen and yield data was applied to the Preplant Yield Response Curve shown in PNW 546 (Figure 6). The intersection of the red lines within Figure 6 shows the location of the 2007 Furrow Treatment data in the Yield Curve. The location of these lines indicates nitrogen was not limiting and yield was not reduced in the 2007 Furrow Treatment field.

Figure 6. 2007 Furrow Treatment yield compared to research based Preplant Yield Response Curve.

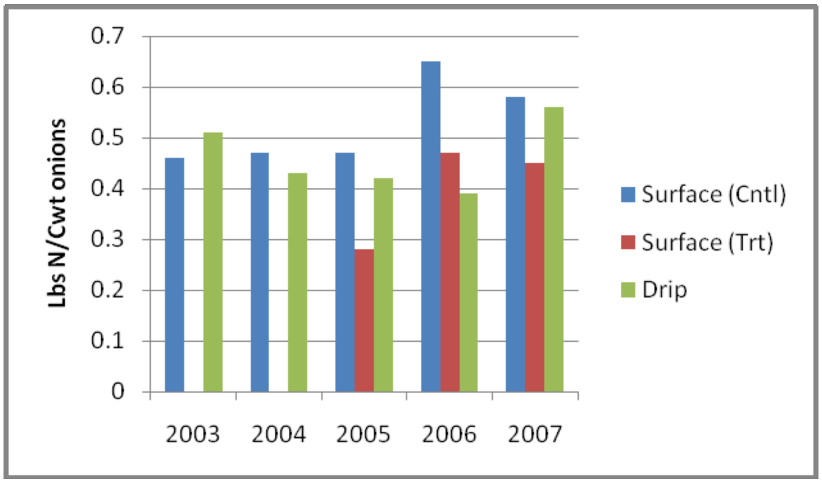


Nitrogen Use Efficiency

In 2006, the NUE of the Furrow Control was 0.65 lbs N/Cwt onions indicating inefficient use of nitrogen (Figure 7). This was the poorest NUE recorded during the project and was the result of high nitrogen 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 fields had NUE calculations that came very close to research predictions.

The Drip field NUE was slightly poorer than values mentioned in the literature, so opportunities may remain for these growers to further reduce their nitrogen inputs. In 2007, the NUE of the Drip field was poorer than the Furrow Treatment. This aberration is explained by the grower's decision to add more nitrogen fertilizer due to unusual and inconsistent soil sample results. The best NUE was produced by the 2005 Furrow Treatment field. A possible explanation includes a combination of sufficient soil nitrogen, reduced nitrogen fertilizer, well timed nitrogen application, and high yield.

Figure 7. NUE (Lbs N/cwt onions) for all fields



Conclusion

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

It was shown that nitrogen fertilizer applications can be reduced in commercial onions fields, while maintaining high yields, when recommendations are based on the Southern Idaho Fertilizer Guide for Onions (CIS 1081) and Nutrient Management for Onions in the Pacific Northwest (PNW 546). This information is important to growers who want to improve nitrogen efficiency of furrow irrigated onions and to growers who may be transitioning from furrow to drip irrigation.

With more efficient use of irrigation water and nitrogen fertilizer, production costs can be held down, yields can be maintained, and leaching of nitrogen into water resources can be minimized.

Literature Citation

Brown, B. 2000. Onions. Southern Idaho Fertilizer Guide. CIS 1081. University of Idaho. Moscow, ID.

Shock, C.C., Feibert, E.B.G., and Saunders, L.D. 2000. Irrigation Criteria for Drip Irrigated Onions. HortScience. 35:63-66.

Sullivan, D.M., Brown, B.D., Shock, C.C., Horneck, D.A., Stevens, R.G., Pelter, G.Q., Feibert, E.B.G. 2001. Nutrient Management for Onions in the Pacific Northwest. PNW 546. Oregon State University. Corvalis, OR.