Reduced Irrigation Amounts on Durum Wheat and Barley Production in Northwest North Dakota

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Introduction: Irrigation is very important to agriculture in semi-arid regions such as western North Dakota. By providing water in times of deficient rainfall, irrigation improves the consistency of crop growth. Irrigation also allows the production of crops with water demands that exceed normal rain amounts. However, many challenges are facing farmers who irrigate. Increasing demands for water coupled with dwindling supplies is resulting in restrictions to water access. Increasing crop production costs and lower commodity prices are threatening economic sustainability. Improving irrigation management is critical. If irrigation amounts could be reduced without adversely affecting crop yield and quality, these challenges will be lessened. Water saved from reducing irrigation on land already being irrigated will allow additional land to be irrigated. The purpose of this project was to assess if irrigation amounts could be reduced on durum and barley while maintaining crop yield and quality.

Methods and Materials: This study was conducted by the North Dakota State University Williston Research Extension Center at its Nesson Valley Irrigation Research and Development Project site (N 48.163739°, W 103.104963°). The soil at the site is Lihen fine sandy loam (sandy, mixed, frigid Entic Haplustolls). Average annual precipitation is 404 mm and the average May 15 to August 15 precipitation is 203 mm. The two experimental crops (durum and barley) were grown as part of a 4-year crop rotation of durum–sugarbeet–barley–potato. The experimental design was a Randomized Complete Block Design (RCBD) with four replications of four treatments. Each plot was 15 m by 18 m. The treatments consisted of four irrigation amounts (100%, 67%, 33%, and 0%). Irrigation was applied with a linear-move overhead sprinkler system. The irrigator was fitted with a GPS-regulated variable rate control system that allowed for application of the different irrigation treatments. Irrigation amounts for the 100% treatment were determined to maintain the soil moisture level at field capacity. Irrigation amount determination was aided by soil moisture data (top 600 mm) collected weekly with a neutron depth moisture gauge and meteorological data obtained from the North Dakota Ag Weather Network (NDAWN [http://ndawn.ndsu.nodak.edu]). Rain gauges were placed within select plots to verify irrigation rates. All cultural practices other than irrigation amounts (tillage, fertilizer, planting populations, and fungicide applications) were the same for all treatments within crop.

Results (Durum): The effect of reduced irrigation on durum performance varied from year to year. During the 7-year study period, seasonal rain amounts (May 15 – August 15) ranged from 139 to 287 mm (Figure 1). Irrigation amounts (100% treatment) ranged from 81 to 264 mm (Figure 1).

For durum, reducing irrigation had the greatest effect on yield, a lesser effect on grain protein, and the least effect on grain test weight.

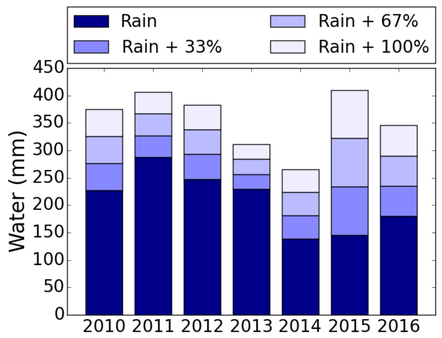

Figure 1: Rain + irrigation applied to durum.

Table 1: Durum grain yield. Within a column, values in non-shaded cells are not significantly different from the 100% treatment (LSD 5%).

Irrigation	2010	2011	2012	2013	2014	2015	2116
	---------- Mg/ha ----------						
100%	5.4	2.2	5.4	6.8	5.2	5.2	6.3
67%	5.1	2.1	4.4	6.5	5.6	4.5	6.1
33%	4.4	2.2	4.2	6.2	3.8	3.9	5.6
0%	3.4	2.0	3.7	5.2	3.3	2.7	4.2

Grain yield was unaffected five of seven years if irrigation was reduced to 67%, unaffected two of seven years if irrigation was reduced to 33%, and never unaffected if irrigation was eliminated (Table 1).

Table 2: Durum grain protein. Within a column, values in non-shaded cells are not significantly different from the 100% treatment (LSD 5%).

Irrigation	2010	2011	2012	2013	2014	2015	2116
	---------- % ----------						
100%	14.3	16.6	15.0	15.1	15.7	16.0	15.9
67%	14.8	16.2	15.6	15.4	16.1	16.7	15.8
33%	15.7	16.4	15.9	15.7	17.3	18.6	15.6
0%	17.4	17.5	16.9	16.1	18.3	19.6	15.8

Grain protein was unaffected six of seven years if irrigation was reduced to 67%, unaffected four of seven years if irrigation was reduced to 33%, and unaffected two of seven years if irrigation was eliminated (Table 2).

Grain test weight was unaffected seven of seven years if irrigation was reduced to 67%, unaffected five of seven years if irrigation was reduced to 33%, and unaffected four of seven years when if irrigation was eliminated (data not shown).

Results (Barley): The effect of reduced irrigation on barley performance varied from year to year. During the 7-year study period, seasonal rain amounts (May 15 – August 15) ranged from 139 to 287 mm (Figure 1). Irrigation amounts (100% treatment) ranged from 91 to 241 mm (Figure 2).

For barley, reducing irrigation had the greatest effect on yield, a lesser effect on grain protein and kernel plumpness, and the least effect on grain test weight.

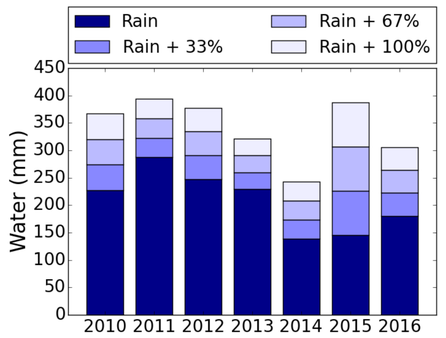

Figure 2: Rain + irrigation applied to barley.

Table 3: Barley grain yield. Within a column, values in non-shaded cells are not significantly different from the 100% treatment (LSD 5%).

Irrigation	2010	2011	2012	2013	2014	2015	2116
	---------- Mg/ha ----------						
100%	6.6	2.5	3.3	5.9	6.0	5.0	5.1
67%	5.8	2.7	3.1	5.4	5.7	5.0	5.3
33%	6.1	2.3	2.8	4.5	5.1	4.8	4.8
0%	5.7	2.2	2.8	4.0	4.4	4.1	5.1

Grain yield was unaffected seven of seven years if irrigation was reduced to 67%, unaffected four of seven years if irrigation was reduced to 33%, and unaffected one of seven years when irrigation was eliminated (Table 3).

Table 4: Barley grain protein. Within a column, values in non-shaded cells are not significantly different from the 100% treatment (LSD 5%).

Irrigation	2010	2011	2012	2013	2014	2015	2116
	---------- % ----------						
100%	13.6	11.9	11.1	14.3	11.3	11.8	11.4
67%	14.1	12.5	12.0	14.1	11.3	11.5	11.5
33%	14.0	12.4	12.6	14.0	12.0	11.8	11.0
0%	14.3	13.3	12.8	14.5	12.0	12.5	11.6

Grain protein was unaffected six of seven years if irrigation was reduced to 67%, unaffected six of seven years if irrigation was reduced to 33%, and unaffected four of seven years if irrigation was eliminated (Table 4).

Grain test weight was unaffected seven of seven years if irrigation was reduced to 67%, unaffected six of seven years if irrigation was reduced to 33%, and unaffected four of seven years when irrigation was eliminated (data not shown).
Kernel plumpness was unaffected six of seven years if irrigation was reduced to either 67% or 33% and unaffected four of seven years when irrigation was eliminated (data not shown).

Summary: The effects of reduced irrigation on durum and barley increased as the size of reduction increased. Durum was affected more by reduced irrigation than was barley. When reduced irrigation had an effect, it decreased grain yields, test weight, and kernel plumpness, and increased grain protein. With durum, farmers may receive a premium for greater protein content but this premium may not offset the loss from the accompanying reduced yield. With barley, increased protein levels may be disadvantageous as there is an upper limit imposed on protein in malting barley.

Our findings suggest that reducing irrigation by as much as one-third will not reduce the yield and quality of barley or the quality of durum, however, durum yield may be reduced some years. Water savings achieved by reducing irrigation amounts can help farmers comply with water restrictions or expand irrigated acreage without increasing total water demand.