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Effect of Irrigation Allocation on Perennial Grass Production and Quality

Gary W. Hergert
University of Nebraska–Lincoln Panhandle Research and Extension Center, ghergert1@unl.edu

Karla H. Jenkins
University of Nebraska–Lincoln, kjenkins2@unl.edu

James Margheim Margheim
University of Nebraska–Lincoln Panhandle Research and Extension Center

Alex Pavlista
University of Nebraska–Lincoln Panhandle Research and Extension Center, apavlista@unl.edu

Rex Nielsen
University of Nebraska–Lincoln Panhandle Research and Extension Center, rnielsen1@unl.edu

See next page for additional authors

Authors
Gary W. Hergert, Karla H. Jenkins, James Margheim Margheim, Alex Pavlista, Rex Nielsen, and Murali Darapuneni

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Gary W. Hergert
Karla H. Jenkins
James Margheim
Alex Pavlista
Rex Nielsen
Murali Darapuneni[1]

Summary

Cool-season grass mixtures and warm-season grass mixtures were evaluated in 2010, 2011, and 2012 under varying irrigation levels to determine dry matter yield, CP, and TDN for beef cattle in the Nebraska Panhandle. As a generalization, when seasonal precipitation was average, irrigation levels over 10 inches resulted in no significant increase in either grass production or quality. Cool-season grasses produced more dry matter yield and maintained greater CP and TDN than warm-season grasses. In all three years, a mixture of wheatgrasses had greater forage yield than an orchardgrass monoculture or a mixture dominated by bromegrasses. In 2010 and 2011, treatments containing switchgrass yielded more DM than a big bluestem/indiangrass mixture.

Introduction

The Nebraska Panhandle is a low rainfall area (14-16 inches annually). Many producers in western Nebraska face reduced irrigation amounts because of drought (reservoir water) and NRD groundwater allocations. This makes it difficult for producers to grow crops with high water needs such as corn. Additionally, there are many years when rainfall is below the long-term average, limiting native grass production and forages grown on dryland acres. These drought conditions often force beef cattle producers to locate and purchase additional feed resources. Therefore, irrigated pastures can be an important resource; however, there is very little data for the Panhandle on the production potential of cool- and warm-season perennial grasses under different irrigation levels. The objectives of this research were to determine the production and forage quality of perennial cool- and warm-season grasses (monoculture and mixtures) from dryland to fully irrigated conditions in a semi-arid climate.

Procedure

Plots were established in 2009 on a Tripp fine sandy loam soil at Scottsbluff, Neb. Cool-season grasses included: orchardgrass (OG); a bromegrass-based mixture (meadow and smooth bromegrass, orchardgrass, and creeping foxtail) (BM); and a wheatgrass mixture (western, intermediate, and pubescent wheatgrass) (WM). Warm-season grasses included: switchgrass (SG), big bluestem plus indiangrass (BBI), and switchgrass plus big bluestem and indiangrass (SBBI). Nitrogen fertilizer rates for limited irrigation treatments were developed from dry matter and N relationships from published dryland and full-ET research. Weed control was required for both cool- and warm-season grasses. Data were collected in 2010, 2011, and 2012. In 2010, irrigation levels included 5, 10, 15, and 20 inches. In 2011 and 2012, irrigation levels were 0, 5, 10, and 15 inches. Plots were harvested with a tractor-mounted, flail-type chopper. Samples were weighed with the chopper's scale, subsampled, and dried in a 100° F forced air oven for 48 hours. Dry matter production was calculated based on the size of the harvested area. The dried subsamples were ground and sent to a commercial laboratory for crude protein and TDN (calculated from wet chemistry ADF analysis.) Harvest dates were early July and again in September for cool season grasses and October for warm-season grasses with the exception of 2012 when cool season grasses were only harvested in July and warm-season grasses were harvested in late August. Data were analyzed using the GLM procedure of SAS.

Results

In 2010, dry matter yields of BM and OG were not significantly higher ($P < 0.05$) with 20 inches of irrigation than with 10 inches (Table 1). However, there was an apparent trend that confirms increased dry matter production of BM and OG from 5 to 15 inches and a slight decreased trend thereafter from 15- to 20-inch irrigation. Meaning, under given experimental conditions, the optimum irrigation level for maximum dry matter production for these two grass species was 15 inches. The trend was not consistent with WM. The WM had similar yields with 15 or 20 inches of irrigation but both resulted in greater yields than at 10 inches ($P < 0.05$). Regardless of irrigation level, WM produced more DM yield than BM or OG ($P < 0.05$). Providing 20 inches irrigation did not increase DM yield ($P > 0.05$) compared to the 15 inch irrigation for SG, BBI, or SBBI (Table 2). All irrigation levels resulted in similar DM yields for SBBI. DM yield was less for BBI than for SG or SBBI which were similar ($P < 0.05$). Unlike cool-season grasses, the trend of DM production for warm-season grasses was increased linearly with the increased irrigation levels. The CP and TDN values were not significantly impacted ($P > 0.05$) by irrigation level in either the cool- or warm-season grasses (Table 3). However, both CP and TDN were higher for cool-season grasses than warm-season grasses

Table 1. 2010 growing season yield of cool-season grasses at Scottsbluff, Neb., harvested in June and September.

Irrigation Level[1]	Brome Mix	Orchardgrass	Wheatgrass Mix	Irrigation Mean
	------------------------ tons of dry matter per acre------------------------			
5 inches	2.70[b]	1.58[b]	4.20[b]	2.83
10 inches	3.63[ab]	3.12[ab]	3.76[b]	3.50
15 inches	4.76[a]	4.38[a]	5.27[a]	4.80
20 inches	4.33[a]	3.93[a]	5.55[a]	4.60
Grass production average[2]	3.86[b]	3.29[b]	4.69[a]	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2] Means with superscripts in a row that differ are different ($P < 0.05$).

Table 2. 2010 fall (Oct. 20, 2010) yield of warm-season grasses at Scottsbluff, Neb.

Irrigation Level[1]	Switchgrass	Big Blue/ Indian Mix	Sw + Big Blue + Indian	Irrigation Mean
	------------------------ tons of dry matter per acre------------------------			
5 inches	1.94[b]	1.09[b]	1.85	1.63
10 inches	2.28[ab]	1.35[b]	1.96	1.86
15 inches	2.79[a]	1.61[a]	2.37	2.26
20 inches	2.79[a]	2.19[a]	2.93	2.64
Grass production average[2]	2.44[a]	1.56[b]	2.28[a]	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2] Means with superscripts in a row that differ are different ($P < 0.05$).

Table 3. 2010 crude protein and TDN of cool- and warm-season grasses at Scottsbluff, Neb.

	Brome Mix		Orchardgrass		Wheatgrass Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
5 inches	10.4	60.8	10.5[a]	57.7[a]	10.7[a]	59.3	10.5	59.3
10 inches	12.5	61.0	12.8[bc]	60.7[ab]	13.0[b]	60.5	12.8	60.7
15 inches	12.5	60.2	14.2[b]	62.1[b]	13.0[b]	61.3	13.2	61.2
20 inches	11.9	58.6	12.2[ac]	59.0[ab]	11.5[ab]	59.8	11.9	59.1
Grass production mean[2]	11.8	60.1	12.4	59.9	12.1	60.2		
	Switchgrass		**BB /Indian Mix**		**Switch/BB/ Indian Mix**		**Irrigation Mean**	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
5 inches	4.0	55.3	5.3	54.0	4.4	57.0[a]	4.6	55.4
10 inches	4.0	53.8	7.5	53.2	5.8	51.6[b]	5.8	52.9
15 inches	3.3	54.6	5.1	52.3	3.8	54.9[ab]	4.1	53.9
20 inches	3.5	52.5	6.4	53.5	3.8	52.7[ab]	4.6	52.9
Grass production mean[2]	3.7[a]	54.1	6.1[b]	53.2	4.4[a]	54.0		

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 4. 2011 growing season yield of cool-season grasses Scottsbluff, Neb., harvested in July.

Irrigation Level[1]	Brome Mix	Orchardgrass	Wheatgrass Mix	Irrigation Mean
	------------------------ tons of dry matter per acre------------------------			
0 inches	2.94[c]	2.48[d]	4.38[c]	3.27
5 inches	5.81[b]	4.29[c]	6.06[b]	5.39
10 inches	6.24[ab]	5.53[b]	7.40[a]	6.39
15 inches	7.24[a]	6.62[a]	7.91[a]	7.26
Grass production mean[2]	5.55[b]	4.73[c]	6.44[a]	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

($P < 0.05$). Had the warm-season grass been harvested earlier, quality may have been improved.

Due to consistent lack of significant improvement in DM production and quality for 20-inch irrigation across all grass species in 2010, the irrigation treatments were limited to 15 inches in 2011 and 2012. In 2011, all irrigation levels significantly increased DM yield of the cool-season grasses over the 0 irrigation treatment (P < 0.05). The 15 inch level did not increase DM yield for BM and WM over the 10 inch level, but did for OG (Table 4). Regardless of irrigation level, WM had the greatest DM yield. DM yield was also greater for BM compared to OG ($P < 0.05$). There were no significant differences in DM yield for SG regardless of irrigation level ($P > 0.05$). There were no differences in DM yield of BBI for 5, 10, or 15 inches, but DM yield was greater for 5, 10, and 15 inches compared to 0 inches. The DM yield was greater for 10 and 15 inches in SBBI than 0 inches (Table 5). Overall yield was similar for SG and SBBI (4.37 and 4.46 ton/ac, respectively) which was significantly greater than BBI (3.35 ton/ac) ($P < 0.05$). Crude protein and TDN were unaffected by irrigation level in BM (Table 6) ($P > 0.05$). The TDN was greater for the 5, 10, and 15 inch levels compared to the 0 level for OG and WM while CP was unaffected by irrigation ($P < 0.05$). When irrigation treatments were combined, CP and TDN were similar for BM, OG, and WM. Irrigation level had no significant effect on CP or TDN for SG, BBI, or SBBI.

A severe drought coupled with extreme heat plagued the Nebraska Panhandle in 2012, reducing forage growth substantially. Each level of irrigation increased DM yield for BM, OG, and WM ($P < 0.05$) (Table 7). The greatest DM yield across all irrigation levels was WM (2.61 ton/ac) followed by BM (2.06 ton/ac), which was greater (P < 0.05) than OG (1.70 ton/ac). Similarly, the irrigation level increased DM yield for the warm-season grasses ($P < 05$) (Table 8). However, no significant difference in yield was detected

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among SG, BBI, or SBBI when irrigation level was combined. Crude protein was not affected by irrigation level in BM, OG, or WM ($P > 0.05$) (Table 9). However, TDN was decreased at the 10 and 15 inch levels in OG and WM and at the 15 inch level in BM ($P < 0.05$). When averaged over irrigation level, BM had the greatest CP (13.8%) and WM (11.8%) was greater than OG (10.2%). BM also had greater TDN (62.4%) than OG (59.7%), while the TDN of WM was similar to BM and OG (61.1%) ($P < 0.05$). The TDN of the warm-season grasses was lowest for the 15 inch level ($P < 0.05$), but similar for the other levels. The 10 and 15 inch levels were lower in CP than the 0 and 5 inch levels, most likely due to increased DM yield. The greater CP and TDN values for SG, BBI, and SBBI in 2012 compared to 2010 and 2011 was most likely due to the earlier harvest date (August vs. October). The warm-season grasses were fertilized with a nitrogen rate that was 70% of that for cool season. Further research with N rates on warm seasons may be required.

Grass yields in 2010 for cool-season grasses were over 5 tons per acre. Yields of warm-season grasses were generally less than 55% of cool-season grasses (Table 10). The cool-season grass yields were excellent during 2011 maximizing at over 7 dry tons per acre which was a 40% increase over 2010. Warm-season grass production in 2011 increased significantly and was over 60% higher compared to 2010 levels and maximum yield was near 5 dry tons per acre. Warm-season grass productivity versus cool season improved in 2011, but still did not match cool season productivity. At the 0 irrigation level in 2011, warm season yield equaled cool season. With even the lowest irrigation level, cool-season grasses outperformed warm-season grasses. More weed control was needed for warm season than cool season due to the lack of competitiveness of the

Table 5. 2011 yield of warm-season grasses harvested Oct. 14, 2011, Scottsbluff, Neb.

Irrigation Level[1]	Switchgrass	Big Blue/Indian Mix	Sw + Big Blue + Indian	Irrigation Mean
	------------ tons of dry matter per acre ------------			
0 inches	3.61	2.42[b]	3.64[b]	3.22
5 inches	4.52	3.97[a]	4.59[ab]	4.36
10 inches	4.70	3.72[a]	4.72[a]	4.38
15 inches	4.64	3.71[a]	4.94[a]	4.43
Grass production mean[2]	4.37[a]	3.35[b]	4.46[a]	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 6. 2011 crude protein and TDN of cool- and warm-season grasses at Scottsbluff, Neb.

	Brome Mix		Orchardgrass		Wheatgrass Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
0 inches	9.4	54.3	7.5[a]	49.8[a]	7.7[a]	51.4[a]	8.2	51.8
5 inches	12.0	59.0	11.3[ac]	57.8[b]	11.3[a]	57.7[b]	11.5	58.2
10 inches	11.9	58.7	11.5[bc]	58.2[b]	11.0[ab]	57.0[ab]	11.5	58.0
15 inches	11.8	55.4	10.8[ab]	56.8[b]	12.9[b]	58.5[b]	11.8	56.9
Grass production mean[2]	11.3	56.8	10.3	55.6	10.8	56.1		
	Switchgrass		BB /Indian Mix		Switch/BB/ Indian Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
0 inches	5.3	51.4	5.5	49.4	5.5	52.3	5.4	51.0
5 inches	3.8	48.4	7.2	51.1	4.5	50.1	5.2	49.9
10 inches	3.3	49.0	4.9	49.1	4.0	49.9	4.1	49.3
15 inches	4.4	49.2	6.0	48.0	3.7	49.5	4.7	48.9
Grass production mean[2]	4.2	49.5	5.9	49.4	4.4	50.4		

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 7. 2012 growing season yield of cool-season grasses Scottsbluff, Neb.

Irrigation Level[1]	Brome Mix	Orchardgrass	Wheatgrass Mix	Irrigation Mean
	------------ tons of dry matter per acre ------------			
0 inches	0.12[d]	0.12[d]	0.30[d]	0.18
5 inches	1.06[c]	0.66[c]	0.96[c]	0.89
10 inches	2.25[b]	1.31[b]	3.06[b]	2.21
15 inches	4.81[a]	4.51[a]	6.28[a]	5.20
Grass production mean[2]	2.06[b]	1.70[c]	2.61[a]	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 8. 2012 yield of warm-season grasses harvested Aug. 30, 2012, Scottsbluff, Neb.

Irrigation Level[1]	Switchgrass	Big Blue/Indian Mix	Sw + Big Blue + Indian	Irrigation Mean
	------------ tons of dry matter per acre ------------			
0 inches	0.26[d]	0.19[d]	0.27[d]	0.24
5 inches	1.63[c]	1.31[c]	2.08[c]	1.67
10 inches	4.01[b]	3.12[b]	3.91[b]	3.68
15 inches	5.64[a]	5.44[a]	6.09[a]	5.72
Grass production mean [2]	2.89	3.04	3.15	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 9. 2012 crude protein and TDN of cool- and warm-season grasses at Scottsbluff, Neb.

	Brome Mix		Orchardgrass		Wheatgrass Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
0 inches	14.3	63.7[a]	11.1	61.6[a]	13.7[a]	64.1[a]	13.0	63.1
5 inches	13.3	63.6[a]	11.3	62.6[a]	11.2[ab]	63.4[a]	11.9	63.2
10 inches	14.1	62.2[ab]	9.1	57.8[b]	10.5[b]	59.1[b]	11.2	59.7
15 inches	13.6	60.2[b]	9.3	56.7[b]	11.6[ab]	57.8[b]	11.5	58.2
Grass production mean[2]	13.8[a]	62.4[d]	10.2[b]	59.7[e]	11.8[c]	61.1[de]		

	Switchgrass		BB /Indian Mix		Switch/BB/ Indian Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
0 inches	12.1[a]	65.7[a]	9.8[a]	62.1[a]	12.4[a]	65.2[a]	11.4	64.3
5 inches	9.7[b]	65.7[a]	8.6[ab]	61.8[ac]	10.4[a]	67.0[a]	9.6	64.8
10 inches	7.7[c]	62.8[a]	7.1[b]	60.8[a]	7.7[b]	63.0[a]	7.5	62.2
15 inches	7.1[c]	55.6[b]	7.1[b]	56.3[bc]	6.7[b]	57.2[b]	7.0	56.4
Grass production mean[2]	9.2[ac]	62.4[ab]	8.1[bc]	60.2[a]	9.3[a]	63.1[b]		

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 10. Ratio of warm-season to cool-season grass yields at Scottsbluff, Neb.

Irrigation Level	2009 WS/CS	2010 WS/CS	2011 WS/CS	2012 WS/CS
0 inches	—	—	99%	133%
5 inches	30%	57%	81%	187%
10 inches	27%	53%	69%	167%
15 inches	27%	43%	61%	110%
20 inches	37%	53%	—	—

different warm-season grasses with the weed spectrum in the Nebraska Panhandle. These data suggest irrigated cool season perennial grasses have an advantage over irrigated perennial warm-season grasses in the Nebraska Panhandle. However, in extreme drought and heat, the warm-season grasses out yielded the cool-season grasses. Additionally, unless the season's precipitation is drastically below normal, irrigation levels over 10 inches do not provide significant improvements in DM yield, CP, or TDN.

[1]Gary W. Hergert, professor, agronomy; Karla H. Jenkins, assistant professor, animal science; James Margheim, research technician; Alex Pavlista, professor, agronomy; Rex Nielson, research technician; Murali Darapuneni, post doctorial research associate, University of Nebraska–Lincoln Panhandle Research and Extension Center, Scottsbluff, Neb.