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Affect of Nitrogen and Phosphorus Fertilizers on Irrigated Cool Season Grass Hay Production – Vignaroli Ranch

A demonstration to determine cost/benefit of nitrogen (N) and phosphorus (P) fertilizers for irrigated grass hay production was conducted in 2006, 2007 and 2008 at the Larry Vignaroli Ranch along lower Clear Creek in Johnson County. Replicated plots of Bozoisky Russian wildrye (RWR); Hycrest crested wheatgrass (CWG); NewHy hybrid wheatgrass (HWG); Luna and Mandan pubescent wheatgrass (PWG); Rosana western wheatgrass (WWG); Manchar smooth brome grass (SBG); and Regar meadow brome grass (MBG) planted in May 2003 were subjected to four fertilizer treatments: No fertilizer (Check); single N application (N1); split-N application (N2); and single N and P application (N+P).

Fertilizers and Application Rates

In 2006 the nitrogen fertilizer applied was liquid ammonium sulfate (21% N, 24% S); and the phosphorus fertilizer used was liquid ammonium phosphate (9% N, 24% P, 3% K). Actual amount of N applied to the N1 and N2

treatments on 12 May was 30 lb/ac, and the actual amount of N and P applied to the N+P treatment was 32 and 19 lb/ac, respectively. On 23 August the actual amount of N applied to the N2 treatment was 33 lb/ac. It was intended to apply 100 lb/ac actual N and 50 lb/ac actual P but a calibration error resulted in the lower application rates.

In 2007 the nitrogen fertilizer applied was ammonium sulfate (dry wettable powder – 21% N, 24% S), and the phosphorus fertilizer applied was ammonium phosphate (dry wettable powder – 15% N, 30% P, 15% K). Actual amount of N applied to the N1 and N2 treatments on 1 May was 100 lb/ac, and the actual amount of N and P applied to the N+P treatment was 100 and 58 lb/ac, respectively. On 11 July the actual amount of N applied to the N2 treatment was 100 lb/ac.

In 2008 the nitrogen fertilizer applied was sprayed grade urea (46% N) at a rate of 100 lb

actual N/ac on 7 May to the N1, N2, and N+P treatments; and again on 15 July to the N2 treatment. No phosphorus fertilizer was applied in 2008.

The amount of fertilizer to apply per acre is based on the amount of nutrient that is desired and the amount contained in the fertilizer. For example: Spray grade urea contains 46 lb of N per 100 lb of fertilizer and ammonium sulfate contains 21 lb of N per 100 lb of fertilizer. If the desired amount of N is 100 lb/ac then 217 lb of urea ($100 \div 0.46$) or 476 lb of ammonium sulfate ($100 \div 0.21$) would need to be applied per acre.

Irrigation

April – June 2006 precipitation was lacking thus irrigation water was applied the third week of May. Precipitation during this period in 2007 and 2008 was sufficient to forego irrigation. Because the grass plots are within an alfalfa field irrigations occurred in July and again in August. Irrigation method is flood.

Data Collection

Grass herbage from each fertilizer treatment was harvested on 26 June 2006, 20 June 2007, and 24 June 2008 to determine potential hay yields (10% moisture). In addition, regrowth of each grass by fertilizer treatment was harvested on 3 October 2007 and 7 October 2008 to determine potential grazable forage on a hay yield basis. An October 2006 harvest was planned but due to not communicating this to the rancher cattle were put on the hay field a few days prior. Rosana WWG was not harvested in 2008 due to its stands being overtaken by other grasses.

Soil samples collected on 12 May 2006 prior to fertilizer application and on 24 October 2006 and 1 October 2007 from each fertilizer treatment were analyzed for pH, nitrate-N, P, K, and organic matter by the University of Nebraska's Soil and Plant Analytical lab.

Results and Discussion

26 June 2006

The grasses produced an average of 0.4 T/ac more hay from the N1, N2, and N+P treatments compared to the Check (Table 1). The application of phosphorus did not appear to affect grass hay yields. Nitrate-N content of the soil was 3.0 ppm prior to fertilization, thus application of N fertilizer was warranted, whereas soil P content was 22 ppm, 7 ppm greater than the threshold level.

The application of 30 lb N/ac resulted in an average increase in net income of \$24/ac over the Check treatment (Table 2). Luna and Mandan PWG had the highest average net income from the N1, N2, and N+P treatments at \$245/ac, \$39/ac compared to the Check.

21 June 2007

Grass hay yields averaged 0.8, 1.0, and 1.0 T/ac more from the N1, N2, and N+P treatments compared to the Check (Table 1). Soil nitrate-N levels in late October 2006 (2.9, 3.7, 3.5, and 3.0 ppm for the Check, N1, N2, and N+P treatments, respectively) would indicate that the 33 lb N/ac applied in August 2006 (N2) was used by the grasses for late summer/early fall growth. However, Manchar SBG and Regar MBG may have benefitted from this N application.

Early May application of 100 lb N/ac resulted in a net income of \$410/ac for Mandan PWG, followed by Luna PWG and Manchar SBG at \$400 and \$396/ac, respectively (Table 2). However, net income for Manchar SBG and Regar MBG from the N2 treatment averaged \$443/ac, \$91/ac more compare to the N1 and N+P treatments indicating there may have been some carry over benefit to these two grasses from the August 2006 N fertilizer application. In addition, average net income for Mandan and Luna PWG from the N+P treatment was \$432/ac.

3 October 2007

The grasses produced an average of 0.9, 0.8, and 0.7 T/ac more hay from the N2 treatment compared to the Check, N1, and N+P treatments, respectively (Table 1). However, the slightly greater average hay yields from the N1 and N+P treatments would indicate that there may have also been some residual N available for grass growth from the May application. In addition, applied P in the N+P treatment may have also been benefitting late summer/early fall grass production.

Rosana WWG apparently had the greatest amount of late summer/early fall growth from the Check treatment resulting in a potential net income of \$156/ac (Table 2). Whereas, NewHy HWG produced the most net income from the N1, N2, and N+P treatments at an average of \$197/ac.

Total Hay Yields for 2007

Grass hay yields averaged 3.8, 4.8, 5.8, and 5.0 T/ac from the Check, N1, N2, and N+P treatments, respectively (Table 1). Thus the application of 100 lb N/ac in early May resulted in an average hay yield increase of a 1.0 T/ac. The application of another 100 lb N/ac in mid-July resulted in an additional 1.0 T/ac of hay. Phosphorus fertilizer with N appeared to increase grass hay yields by an average of 0.2 T/ac compared to N alone.

The highest net incomes would have been received for NewHy HWG, Mandan PWG, Manchar SBG, and Luna PWG from the Check, N1, N2, and N+P treatments, respectively (Table 2).

24 June 2008

Grass hay yields, excluding Rosana WWG, averaged 1.8, 1.8, and 2.0 T/ac more from the N1, N2, and N+P treatments compared to the Check (Table 1). Early October 2007 soil nitrate-N levels were 2.4, 1.4, 6.7, and 2.0 ppm for the Check, N1, N2, and N+P

treatments, respectively. The additional soil nitrate-N from the N2 treatment apparently did not carry over to the spring. It is possible that this additional nitrate-N leached out of the root zone as it is very mobile. Soil P levels for the Check, N1, N2, and N+P treatments were 12, 10, 14, and 20 ppm, respectively. The greater amount of soil P in the N+P treatment compared to the other treatments could be the reason for the higher average hay yields from this treatment.

Grass hay yields from the Check treatment averaged 0.8 T/ac less in 2008 compared to 2007, were similar for the two N treatments, and was 0.2 T/ac more for the N+P treatment (Table 1). Thus, it would appear that not replacing soil N removed by hay harvesting resulted in reduced grass growth. In addition, it would appear that the added P was having a positive effect on grass growth. However, see below discussion on October 2008 hay yields.

Hay income was similar among Manchar SBG, NewHy HWG, Regar MBG, and Rosana WWG from the Check treatment at an average of \$237/ac (Table 2). Even with higher fertilizer prices there was a positive cost/benefit for applying 100 lb N/ac in early May for all the grasses. Manchar SBG had the highest average net income from the N1, N2, and N+P treatments at \$434/ac.

7 October 2008

The grasses, except Hycrest CWG, produced an average of 0.5, 0.2, and 0.3 T/ac more hay from the N2 treatment compared to the Check, N1, and N+P treatments, respectively (Table 1). Why Hycrest CWG did not produce at least as much hay from the N2 treatment compared to the other treatments is not known, the result could just be an outlier. In addition, there appeared to be no further benefit to the grasses from the May 2006 and 2007 applications of phosphorus fertilizer.

Regar MBG had the greatest net income from the N1 and N+P treatments at an average of \$129/ac (Table 2). The higher cost of N fertilizer and the lower hay yields as compared to 2007 resulted in lower net incomes from the N2 treatment compared to the other treatments with Hycrest CWG and Mandan PWG actually having a negative cost/benefit. NewHy HWG had the highest net income at \$63/ac.

A probable continued depletion of soil N would at least partially explain the lower October hay yields in 2008 compared to 2007 for the Check treatment. However, soil was not sampled for analysis in the fall of 2008 to verify this. The form of N fertilizer used in 2008 (urea) compared to that used in 2007 (ammonium-sulfate) may explain the lower hay yields from the N treatments, especially for the N2 treatment. The following is from Chapter 24, page 360, Forages: The science of grassland agriculture, Vol. II, 6th edition.

“Ammonia losses from urea-containing N sources can be large when used in late spring through summer under humid conditions. Urea and urea-ammonium nitrate solutions are about 80%-90% as effective as ammonium nitrate or ammonium sulfate. Volatilization losses from urea-containing N sources vary with weather conditions, thus yields can be as much as one-third less than those from the same amount of N as ammonium nitrate.”

This would explain why grass hay yields averaged only 0.2 and 0.3 T/ac from the N2 and N+P treatments, respectively, compared to the N1 treatment (Table 1). Application of a urea fertilizer would not be recommended during the summer months due to the above.

Total Hay Yields for 2008

The application of 100 lb N/ac in early May resulted in an average hay yield increase of 2.0 T/ac (Table 1), whereas the application of another 100 lb N/ac in mid-July using urea as

the N-source resulted in only an additional 0.2 T/ac of hay.

The highest average net income for 2008 was received from the N+P treatment indicating that the application of P fertilizer the previous two springs was warranted, especially with respect to Manchar SBG and Regar MBG (Table 2). These two grasses averaged \$270, \$104, and \$119/ac more income compared to the Check, N1, and N2 treatments.

Total June 2006, 2007, and 2008 Hay Yields

The application of a nitrogen fertilizer at 30, 100, and 100 lb N/ac in May 2006, 2007, and 2008, respectively, resulted in an average total hay yield of 10.0 T/ac compared to 6.8 T/ac for Check treatment (Table 1). This resulted in an average increase in net income of \$164/ac (Table 2).

Net income from the June hay crops fertilized with N was greatest for Manchar SBG at an average total of \$1022/ac, \$294/ac more compared to the Check treatment (Table 2). For Regar MBG, Mandan and Luna PWG total net income from the N fertilized treatments averaged \$935, \$948, and \$928/ac, respectively, \$236, \$206, and \$174/ac more than the Check treatment.

Total October 2007 and 2008 Hay Yields

Although 100 lb N/ac in summer 2007 and 2008 resulted in an average total grass hay yield of 1.3 T/ac more compared to the Check treatment (Table 1), this increase did not result in additional income per acre (Table 2). However, there was an additional economic benefit from the application of N fertilizer in May with an average net total income of \$38/ac more for the N1 and N+P treatments compared to the Check. NewHy HWG and Regar MBG had the highest average total net income from the N1 and N+P treatments at \$273 and \$245/ac, respectively, \$91 and \$83/ac more than the Check.

Table 1: Fertilizer treatment grass hay yields (tons/acre) in 2006, 2007, and 2008.

<u>Grasses</u>	<u>Check</u>	<u>Fertilizer Treatments</u>		
		<u>N1</u>	<u>N2</u>	<u>N+P</u>
26 June 2006:				
Bozoisky Russian wildrye	1.5	1.8	1.4	1.6
Hycrest crested wheatgrass	2.1	2.7	2.0	2.2
NewHy hybrid wheatgrass	1.2	2.3	1.2	1.8
Luna pubescent wheatgrass	2.0	2.6	2.5	2.6
Mandan pubescent wheatgrass	2.0	2.8	2.3	2.6
Rosana western wheatgrass	1.6	1.7	2.2	1.9
Manchar smooth brome grass	1.6	2.0	2.3	2.2
Regar meadow brome grass	1.3	1.5	1.8	1.9
<i>Average</i>	<i>1.7</i>	<i>2.2</i>	<i>2.0</i>	<i>2.1</i>
20 June 2007:				
Bozoisky Russian wildrye	2.4	2.8	3.3	3.3
Hycrest crested wheatgrass	2.8	3.7	4.1	3.2
NewHy hybrid wheatgrass	3.3	3.6	3.8	3.6
Luna pubescent wheatgrass	3.4	4.1	4.3	4.9
Mandan pubescent wheatgrass	3.2	4.9	3.8	4.4
Rosana western wheatgrass	2.0	2.8	2.3	3.1
Manchar smooth brome grass	2.9	3.8	4.6	4.0
Regar meadow brome grass	3.1	3.6	4.7	4.1
<i>Average</i>	<i>2.9</i>	<i>3.7</i>	<i>3.9</i>	<i>3.8</i>
3 October 2007:				
Bozoisky Russian wildrye	1.1	1.3	1.9	1.4
Hycrest crested wheatgrass	0.7	0.6	1.2	0.5
NewHy hybrid wheatgrass	1.1	1.7	2.5	1.8
Luna pubescent wheatgrass	0.6	1.0	1.5	0.9
Mandan pubescent wheatgrass	0.9	0.8	2.3	1.1
Rosana western wheatgrass	1.4	1.3	1.9	1.3
Manchar smooth brome grass	1.2	1.4	2.2	1.7
Regar meadow brome grass	0.8	1.0	1.9	1.1
<i>Average</i>	<i>1.0</i>	<i>1.1</i>	<i>1.9</i>	<i>1.2</i>
2007 Totals:				
Bozoisky Russian wildrye	3.4	4.0	5.1	4.7
Hycrest crested wheatgrass	3.5	4.3	5.2	3.7
NewHy hybrid wheatgrass	4.3	5.3	6.3	5.4
Luna pubescent wheatgrass	4.0	5.1	5.9	5.8
Mandan pubescent wheatgrass	4.2	5.6	6.1	5.5
Rosana western wheatgrass	3.4	4.1	4.2	4.4
Manchar smooth brome grass	4.1	5.1	6.8	5.7
Regar meadow brome grass	3.8	4.6	6.6	5.2
<i>Average</i>	<i>3.8</i>	<i>4.8</i>	<i>5.8</i>	<i>5.0</i>

<u>Grasses</u>	<u>Check</u>	<u>N1</u>	<u>N2</u>	<u>N+P</u>
24 June 2008:				
Bozoisky Russian wildrye	1.7	2.9	3.4	4.4
Hycrest crested wheatgrass	2.0	3.2	3.7	3.4
NewHy hybrid wheatgrass	2.4	3.8	3.9	3.1
Luna pubescent wheatgrass	1.8	3.9	3.2	3.5
Mandan pubescent wheatgrass	1.9	4.5	3.5	3.4
Rosana western wheatgrass	2.3	2.4		2.8
Manchar smooth brome grass	2.4	4.6	5.4	5.5
Regar meadow brome grass	2.3	4.3	4.5	5.6
<i>Average (wo/Rosana)</i>	<i>2.1 (2.1)</i>	<i>3.7 (3.9)</i>	<i>(3.9)</i>	<i>4.0 (4.1)</i>
7 October 2008:				
Bozoisky Russian wildrye	0.7	0.8	1.1	0.7
Hycrest crested wheatgrass	0.6	0.8	0.4	0.7
NewHy hybrid wheatgrass	0.7	0.8	1.5	0.9
Luna pubescent wheatgrass	0.4	0.5	0.9	0.4
Mandan pubescent wheatgrass	0.4	0.6	0.7	0.5
Rosana western wheatgrass	0.7	0.9	1.1	0.8
Manchar smooth brome grass	0.5	0.8	1.2	0.7
Regar meadow brome grass	0.8	1.3	1.4	1.3
<i>Average</i>	<i>0.6</i>	<i>0.8</i>	<i>1.0</i>	<i>0.7</i>
2008 Totals:				
Bozoisky Russian wildrye	2.5	3.7	4.5	5.1
Hycrest crested wheatgrass	2.6	4.0	4.1	4.1
NewHy hybrid wheatgrass	3.0	4.6	5.3	4.0
Luna pubescent wheatgrass	2.2	4.3	4.1	3.9
Mandan pubescent wheatgrass	2.3	5.1	4.2	3.9
Rosana western wheatgrass	3.1	3.4	1.1	3.6
Manchar smooth brome grass	2.9	5.5	6.6	6.2
Regar meadow brome grass	3.1	5.6	5.9	6.9
<i>Average (wo/Rosana)</i>	<i>2.7 (2.7)</i>	<i>4.5 (4.7)</i>	<i>4.5 (5.0)</i>	<i>4.7 (4.9)</i>
Accumulative Totals:				
Bozoisky Russian wildrye	7.4	9.5	11.1	11.4
Hycrest crested wheatgrass	8.2	10.9	11.3	10.1
NewHy hybrid wheatgrass	8.6	12.2	12.9	11.2
Luna pubescent wheatgrass	8.2	12.0	12.4	12.2
Mandan pubescent wheatgrass	8.4	13.6	12.6	12.0
Rosana western wheatgrass	8.1	9.1	6.4	9.9
Manchar smooth brome grass	8.7	12.7	15.8	14.1
Regar meadow brome grass	8.2	11.6	14.3	14.0
<i>Average (wo/Rosana)</i>	<i>8.2 (8.3)</i>	<i>11.5 (11.8)</i>	<i>12.1 (12.9)</i>	<i>11.9 (12.1)</i>

Table 2: Grass hay income (\$/acre) after fertilizer costs¹ subtracted for each fertilizer treatment.

<u>Grasses</u>	<u>Fertilizer Treatments</u>			
	<u>Check</u>	<u>N1</u>	<u>N2</u>	<u>N+P</u>
June 2006 (Hay \$103/T²):				
Bozoisky Russian wildrye	158	168	131	140
Hycrest crested wheatgrass	218	258	190	209
NewHy hybrid wheatgrass	128	217	109	164
Luna pubescent wheatgrass	208	248	241	241
Mandan pubescent wheatgrass	204	277	219	243
Rosana western wheatgrass	167	158	211	171
Manchar smooth brome grass	169	193	221	201
Regar meadow brome grass	131	133	171	174
<i>Average</i>	<i>173</i>	<i>207</i>	<i>187</i>	<i>193</i>
June 2007 (Hay \$109/T²):				
Bozoisky Russian wildrye	257	241	296	284
Hycrest crested wheatgrass	304	342	382	272
NewHy hybrid wheatgrass	357	336	355	309
Luna pubescent wheatgrass	367	388	411	458
Mandan pubescent wheatgrass	352	471	348	405
Rosana western wheatgrass	219	244	194	261
Manchar smooth brome grass	319	351	440	359
Regar meadow brome grass	334	328	446	369
<i>Average</i>	<i>314</i>	<i>338</i>	<i>359</i>	<i>339</i>
Oct. 2007 (Hay \$109/T²):				
Bozoisky Russian wildrye	117	138	143	148
Hycrest crested wheatgrass	75	60	67	56
NewHy hybrid wheatgrass	116	183	209	199
Luna pubescent wheatgrass	66	104	104	93
Mandan pubescent wheatgrass	102	83	195	118
Rosana western wheatgrass	156	140	143	138
Manchar smooth brome grass	128	148	183	182
Regar meadow brome grass	84	113	148	120
<i>Average</i>	<i>106</i>	<i>121</i>	<i>149</i>	<i>132</i>
Total 2007 (Hay \$109/T²):				
Bozoisky Russian wildrye	374	379	438	432
Hycrest crested wheatgrass	380	402	449	328
NewHy hybrid wheatgrass	473	519	564	507
Luna pubescent wheatgrass	433	492	516	551
Mandan pubescent wheatgrass	454	554	543	523
Rosana western wheatgrass	375	384	337	399
Manchar smooth brome grass	447	499	623	541
Regar meadow brome grass	418	441	594	489
<i>Average</i>	<i>419</i>	<i>459</i>	<i>508</i>	<i>471</i>

Grasses	<u>Check</u>	<u>N1</u>	<u>N2</u>	<u>N+P</u>
June 2008 (Hay \$100/T²):				
Bozoisky Russian wildrye	174	205	258	352
Hycrest crested wheatgrass	199	236	286	249
NewHy hybrid wheatgrass	238	297	299	228
Luna pubescent wheatgrass	179	301	233	262
Mandan pubescent wheatgrass	186	361	265	254
Rosana western wheatgrass	234	157		197
Manchar smooth bromegrass	241	379	456	467
Regar meadow bromegrass	234	342	363	478
<i>Average (wo/Rosana)</i>	<i>207</i>	<i>303</i>	<i>309</i>	<i>327</i>
Oct. 2008 (Hay \$100/T²):				
Bozoisky Russian wildrye	73	80	19	72
Hycrest crested wheatgrass	63	77	(50)	73
NewHy hybrid wheatgrass	66	77	63	87
Luna pubescent wheatgrass	44	47	5	39
Mandan pubescent wheatgrass	41	62	(13)	51
Rosana western wheatgrass	73	93	20	78
Manchar smooth bromegrass	51	83	34	70
Regar meadow bromegrass	77	132	51	126
<i>Average</i>	<i>61</i>	<i>81</i>	<i>16</i>	<i>74</i>
Total 2008 (Hay \$100/T²):				
Bozoisky Russian wildrye	247	285	277	424
Hycrest crested wheatgrass	241	314	235	323
NewHy hybrid wheatgrass	304	375	362	314
Luna pubescent wheatgrass	222	348	238	301
Mandan pubescent wheatgrass	227	423	251	304
Rosana western wheatgrass	307	249	20	275
Manchar smooth bromegrass	292	462	490	538
Regar meadow bromegrass	311	473	414	604
<i>Average (wo/Rosana)</i>	<i>264</i>	<i>383</i>	<i>324</i>	<i>401</i>

¹Fertilizer costs for each hay crop based on urea (46-0-0) as N source and triple superphosphate (11-52-0) as P source:

June 2006 – N1 and N2 treatments 65 lb urea/ac @ \$375/T = \$12.23; N+P treatment 56 lb urea/ac + 38 lb triple super phosphate/ac @ \$375/T = \$18.26. Check no costs.

June 2007 – N1 and N2 treatments 217 lb urea/ac @ \$525/T = \$57.07; N+P treatment 189 lb urea/ac @ \$525/T + 115 lb triple super phosphate/ac @ \$450/T = \$75.16. October 2007 – N2 treatment 217 lb urea/ac @ \$525/T = \$57.07. Check no costs.

June 2008 – N1, N2, and N+P treatments 217 lb urea/ac @ \$745/T = \$80.98; no P fertilizer in 2008. October 2008 – N2 treatment 217 lb urea/ac @ \$745/T = \$80.98.

Fertilizer application costs = \$4/ac in 2006 and 2007, \$5/ac in 2008. Check no costs.

²Hay prices – 2006 and 2007 from Wyoming Agricultural Statistics 2008, USDA NASS; 2008 from USDA-WY Dept Ag Market News, Torrington, WY

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