How Nitrogen Fertilizer Affects Western N. Dak. Range Vegetation

Harold Goetz

Native grasslands constitute a major portion of the land area of the western one-third of the state. One of the largest sources of agricultural income in this region is from livestock products marketed in the form of meat from grazing beef cattle.

The major portion of the grazing land remaining as native grasslands is generally considered unsuitable for other agricultural purposes. Increasing the production of these native grasslands is important to the livestock industry of the region. A study to increase grass production by using nitrogen fertilization was carried out during the 1964-1966 growing seasons.

Study Methods and Procedures

For the fertilizer studies, four sites were selected which included common site differences normally found on native ranges in western North Dakota. The four sites were designated by their soil series names and included the following: Vebar (sandy hills), Havre (sagebrush flat), Rhodes (Solonetz-panspots), and Manning (high river-terrace). All sites were within a 35-mile radius of the Dickinson Experiment Station (Figures 1, 2).

Dr. Goetz is assistant professor, Department of Botany.

The experiment was designed as a random block with three rates of nitrogen fertilizer and check plots replicated four times on each site. The treatments consisted of 33, 67, and 100-pounds elemental nitrogen per acre. All treatments and check plots (no nitrogen) were randomly assigned within each replication.

Steel-wire cages were placed on the sites to protect portions of the vegetation from grazing in order to determine yields at the end of the growing season. The vegetation was clipped from the cages and hand separated into different components consisting of tallgrasses, shortgrasses, annual forbs and perennial forb species. The yield samples were oven-dried and weighed.

Grass Yields

Annual yield data are presented in Tables 1-3. The average yields for the 3-year period are summarized in Table 4. The data in the tables show all components of yield separately for various treatments on each range site.

In general, increases in grass yields were observed from all rates of nitrogen fertilization on all sites studied. The 33- and 67-pound treatments resulted in the greatest increases in yield per

Figure 1. General view of a typical Vebar range site in western North Dakota fertilized with nitrogen.

Figure 2. General view of a typical Manning range site in western North Dakota, situated along the Heart River.

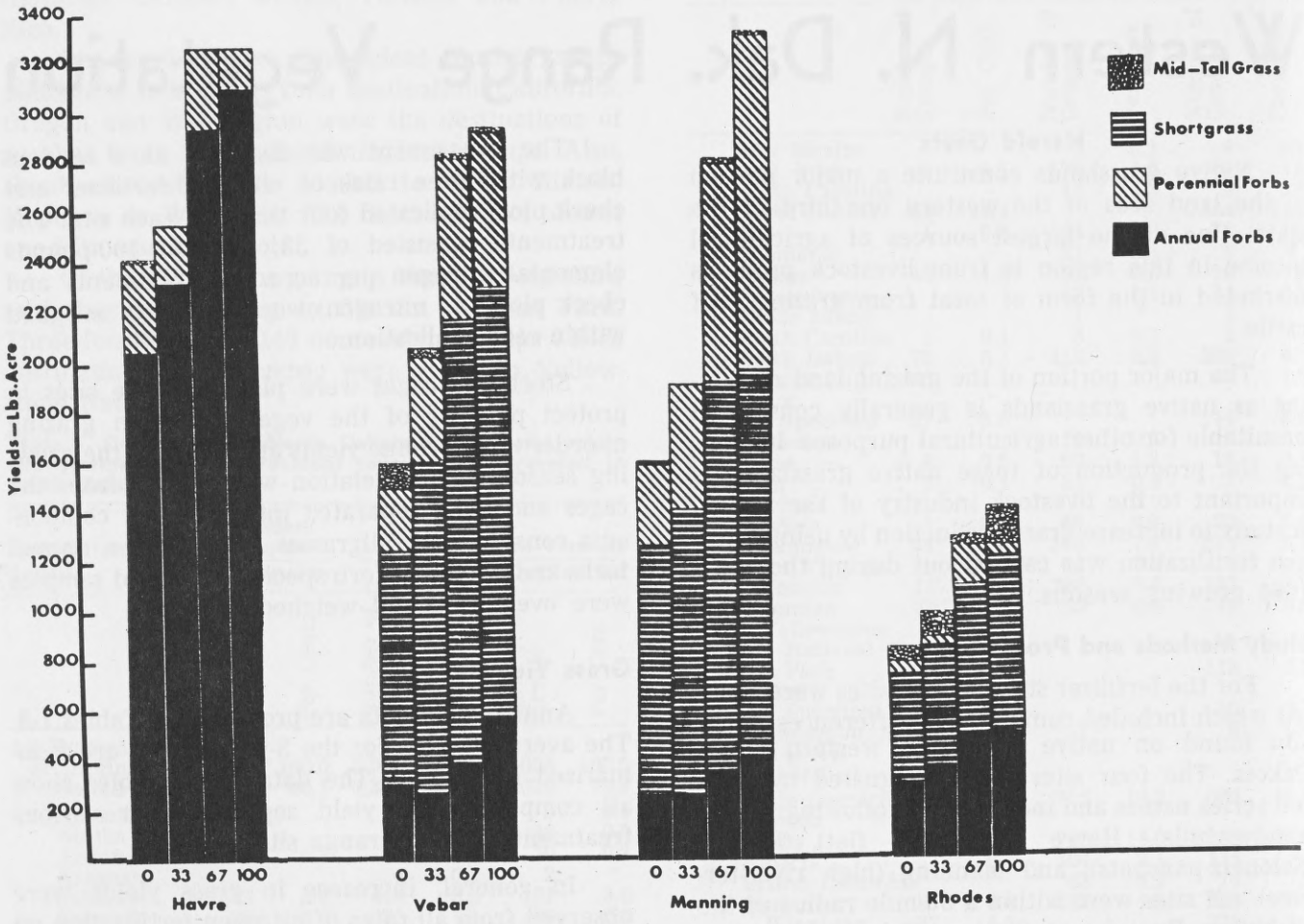

Figure 3. Average yields from four range sites fertilized at three different rates of nitrogen over the 3-year period, 1964-1966 seasons.

Table 1. Forage production on four native grass range sites fertilized with nitrogen at three rates — 1964 season.

Site	Treatment	Dry weight yield — Lbs./Acre						
		Mid grasses	Tall grasses	Short grasses	Total grasses	Perennial forbs	Annual forbs	Total yields
Vebar	0 lbs. N	174	48	928	1150	132	1	1283
	33 lbs. N	205	29	1322*	1556	187	5	1748
	67 lbs. N	272	35	[1]1706*	2013	349*	13*	2375
	100 lbs. N	357	63	1630*	2050	303	8	2361
Havre	0 lbs. N	1597	—	1	1598	122	—	1720
	33 lbs. N	2031	—	8	2039	223	3	2265
	67 lbs. N	**2677*[1]	—	12	2689	258	2	2949
	100 lbs. N	2997	—	55	3052	198	—	3250
Rhodes	0 lbs. N	222	—	394	616	25	3	644
	33 lbs. N	296	—	395	691	9	10	710
	67 lbs. N	372	—	649	1021	19	43	1083
	100 lbs. N	333	—	647	980	81	33	1094
Manning	0 lbs. N	204	—	1005	1209	313	2	1524
	33 lbs. N	293[2]	—	1119[2]	1412	458[2]	3[1]	1873
	67 lbs. N	392*	—	[1]1605*	1997	**683*	**11*	2693
	100 lbs. N	*486*	—	**1744*	2230	**1082*	12	3324

*Means differ significantly from check plot means at the 0.05% level as determined by Duncan's Multiple Range Test.
**Means differ significantly from check plot means at the 0.01% level as determined by Duncan's Multiple Range Test.
[1]Significant difference between 33- and 67-pound nitrogen treatment means at 0.05% level.
[2]Significant difference between 100- and 33-pound nitrogen treatment means at 0.05% level.
[3]Significant difference between 100- and 67-pound nitrogen treatment means at 0.05% level.

increment of added nitrogen. The 100-pound nitrogen rate did not greatly increase the yields beyond those obtained from the 67-pound treatment (Figure 3).

The highest total grass yields were observed on the Havre site. Increases in yield over check plots were noted for all fertilizer treatments although the highest increases in yields for an added amount of fertilizer were observed at the 67-pound rate. An average increase of 889 pounds of grass over check plot yields was noted at the 67-pound nitrogen rate with only small increases at the 33-pound nitrogen treatments. The 100-pound nitrogen treatment showed only a slight increase beyond the yields from the 67-pound nitrogen rates (Table 4). The major portion of the grass yield on this site was due to the midgrass component (Table 5).

The Vebar range site was the second highest grass producing site. It was considerably less productive than the Havre site and only slightly better than the Manning site (Table 4 and Figure 3). Increases in grass yields were noted at all rates of nitrogen fertilization with the highest increases for each increment of nitrogen over check plots at the 67-pound nitrogen treatment. An increase of 352 pounds of grass was observed at the 33-pound nitrogen rate, 915 pounds at the 67-pound rate

Table 2. Forage production on four native grass range sites fertilized with nitrogen at three rates — 1965 season.

Site	Treatment	Dry weight yield — Lbs./Acre						
		Mid grasses	Tall grasses	Short grasses	Total grasses	Perennial forbs	Annual forbs	Total yields
Vebar	0 lbs. N	442	45	1153	1640	296	288	2224
	33 lbs. N	380[2]	113	1455[2]	1948	705	**138*	2791
	67 lbs. N	778[1]	8	**1938*	2724	967*	** 29*[1]	3720
	100 lbs. N	912*	242	**1935*	3089	972*	** 49*	4110
Havre	0 lbs. N	2863			2863	455	2	3320
	33 lbs. N	3150		2	3152	300	T	3452
	67 lbs. N	4020		5	4025	280	2	4307
	100 lbs. N	4287		54	4341	89	5	4435
Rhodes	0 lbs. N	403		338	741	25	159	925
	33 lbs. N	467		502	969	17	270	1256
	67 lbs. N	661		569*	1230	382	** 21*	1633
	100 lbs. N	769		567*	1336	24	295*	1655
Manning	0 lbs. N	342		987	1329	384	9	1722
	33 lbs. N	259		[2]1059[1]	1318	[2]711	7	2036
	67 lbs. N	400		**1312*	1712	**1187*	36	2935
	100 lbs. N	412		**1300*	1712	**1761*	31	3504

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[1]Significant difference between 33- and 67-pound nitrogen treatment means at 0.05% level.
[2]Significant difference between 100- and 67-pound nitrogen treatment means at 0.05% level.
[3]Significant difference between 100- and 67-pound nitrogen treatment means at 0.05% level.

Table 3. Forage production on four native grass range sites fertilized with nitrogen at three different rates — 1966 season.

Site	Treatment	Dry weight yield — Lbs./Acre						
		Mid grasses	Tall grasses	Short grasses	Total grasses	Perennial forbs	Annual forbs	Total yields
Vebar	0 lbs. N	157	46	793	996	298	0	1296
	33 lbs. N	112[2]	3	[2]1195*	1311	**341*	1	1654
	67 lbs. N	156	8	**1628*	1794	**617*	1	2413
	100 lbs. N	190	35	**1558*	1784	**599*	3	2387
Havre	0 lbs. N	1689	—	25	1715	473	—	2189
	33 lbs. N	1804	—	2	1807	325	—	2132
	67 lbs. N	2128	—	—	2128	397	—	2526
	100 lbs. N	1854	—	35	1890	165	—	2055
Rhodes	0 lbs. N	301	—	567	868	51	25	945
	33 lbs. N	308	—	567[2]	875	62	45[2]	983
	67 lbs. N	429	—	600	1030	27	73	1131
	100 lbs. N	396	—	902*	1299	20	**134*	1454
Manning	0 lbs. N	248	—	993	1242	267	3	1513
	33 lbs. N	226	—	[2]1211[3]	1438	[1]359[2]	8	1806
	67 lbs. N	235	—	**1797*	2033	**766*	3	2804
	100 lbs. N	335	—	**1976*	2312	**831*	5	3148

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**Means differ significantly from check plot means at the 0.01% level as determined by Duncan's Multiple Range Test.
[1]Significant difference between 33- and 67-pound nitrogen treatment means at 0.05% level.
[2]Significant difference between 100- and 33-pound nitrogen treatment means at 0.05% level.
[3]Significant difference between 100- and 33-pound nitrogen treatment means at 0.05% level.

and 1046 pounds at the 100-pound nitrogen treatment. The major portion of the grass yield on this site was due to the shortgrass component. Approximately one-fourth of the grass yield was attributed to the midgrasses, with only a minor portion from the tallgrass component (Table 5).

Grass yields from the Manning site showed this site to be slightly less productive than the Vebar site but substantially greater than yields from the Rhodes site (Figure 3). Grass yields were highest for each increase in amount of fertilizer at the 67-pound nitrogen rate. Yield increases above check plots ranged from 130 pounds grass at the 33-pound nitrogen rate, 655 pounds at the 67-pound rate and 825 pounds increase at the 100-pound nitrogen treatment. The midgrass and shortgrass components contributed approximately one-third and two-thirds, respectively, of the total grass yields from the site (Table 5).

The Rhodes range site was the lowest producing site studied (Table 4, Figure 3). Increases in yield above check plot yields were observed with each added increase in nitrogen fertilizer. By comparison, the increases in yield at the 100-pound nitrogen rate on this site were lower than the grass yields on the check plots from the other three sites. Yields were highest at the 67-pound nitrogen treatment with an increase over check plots of 352 pounds. The fertilizer treatment showed increases of 103 pounds forage at the 33-pound rate and 564 pounds at the 100-pound nitrogen treatment. The components of yield showed the shortgrass component with only slightly greater yields than observed from the midgrasses on the site (Table 5).

Forb Responses

The forb component of the total yield was separately determined at the end of each growing

Table 4. Three-year average forage production on four native grass range sites fertilized with nitrogen at three different rates — 1964-1966 seasons.

Site	Treatment	Dry weight yield — Lbs./Acre						
		Mid grasses	Tall grasses	Short grasses	Total grasses	Perennial forbs	Annual forbs	Total yields
Vebar	0 lbs. N	258	46	958	1262	242	99	1603
	33 lbs. N	232	58	1324	1614	411	48	2073
	67 lbs. N	402	17	1758	2177	645	15	2837
	100 lbs. N	487	113	1708	2308	625	20	2953
Havre	0 lbs. N	2050	—	9	2059	350	0.7	2410
	33 lbs. N	2329	—	4	2333	212	3	2584
	67 lbs. N	2942	—	6	2948	312	1	3261
	100 lbs. N	3046	—	48	3094	151	2	3247
Rhodes	0 lbs. N	309	—	433	742	34	62	838
	33 lbs. N	357	—	488	845	29	109	983
	67 lbs. N	488	—	606	1094	143	46	1283
	100 lbs. N	500	—	706	1206	42	154	1402
Manning	0 lbs. N	265	—	995	1260	321	5	1586
	33 lbs. N	260	—	1130	1390	509	6	1905
	67 lbs. N	343	—	1572	1915	880	17	2812
	100 lbs. N	411	—	1673	2084	1225	16	3325

Table 5. Three-year average percentage composition of yields from native grass range sites fertilized with nitrogen at three different rates — 1964-1966 seasons.

Site	Treatment	Percent Composition of Yield				
		Mid Grasses	Tall Grasses	Short Grasses	Perennial Forbs	Annual Forbs
Vebar	0 lbs. N	16.1	2.9	59.7	15.1	6.2
	33 lbs. N	11.2	2.8	63.9	19.8	2.3
	67 lbs. N	14.2	0.6	62.0	22.7	0.5
	100 lbs. N	16.5	3.8	57.8	21.2	0.7
Havre	0 lbs. N	85.0	—	0.4	14.5	T
	33 lbs. N	91.4	—	0.2	8.3	0.1
	67 lbs. N	90.2	—	0.2	9.6	T
	100 lbs. N	93.8	—	1.4	4.7	0.1
Rhodes	0 lbs. N	36.8	—	51.7	4.1	7.4
	33 lbs. N	36.3	—	49.7	2.9	11.1
	67 lbs. N	38.0	—	47.3	11.1	3.6
	100 lbs. N	35.7	—	50.3	3.0	11.0
Manning	0 lbs. N	16.7	—	62.8	20.2	0.3
	33 lbs. N	13.6	—	59.4	26.7	0.3
	67 lbs. N	12.2	—	55.9	31.3	0.6
	100 lbs. N	12.4	—	50.3	36.8	0.5

season (Tables 1-3). Average forb yields and comparative yields are given in Table 4 and Figure 3. respectively. The degree of response by the forbs in the presence of the nitrogen fertilizer was closely associated with the site and species of forbs on the site. The greatest response was observed in the perennial sage species (**Artemisia sp.**) Responses were observed with each added increment of nitrogen fertilizer to the 100-pound nitrogen rate of application.

The yields from the Vebar site showed the increase in the forb component to be greatest at the 67-pound nitrogen rate. The actual forb yield at each level of nitrogen treatment was considerably greater than the midgrass component (Table 4). The growth and development of the sage species (**Artemisia ludoviciana**) was greatly enhanced by the nitrogen fertilizer. Forb yields from the Manning site showed consistent increases with each added increment of nitrogen fertilizer to the 100-pound nitrogen treatment. The species mainly responsible for the high yield increase was fringed sage (**Artemisia frigida**). Yield increases on the Havre and Rhodes sites were less consistent than on the Vebar and Manning sites, although nitrogen fertilizer generally showed some increase in the forb yields. The annual forb species were variously affected by the nitrogen and their development was closely associated with the precipitation pattern for any given year.

Changes in Yields

One of the most important factors in using nitrogen fertilizer on native grassland, which may be detrimental, is the possible shift in plant populations. In general, the relative proportions of grasses in the yield component have not changed appreciably on any of the sites at the various rates of fertilizer, while appreciable shifts in the forb yield have occurred on two of the sites (Table 5).

The Manning site showed a slight decline in proportionate grass yields with a substantial increase in the forb component. The per cent grass yields remained fairly constant on the Vebar site with a moderate increase in the forb component. The Havre site showed a slight increase in per cent grass yields with a corresponding decrease in percentage of forb yields at all rates of nitrogen fertilization. The data for the Rhodes site were highly inconsistent (Table 5).

Economic Feasibility

Data indicate that profitable returns can be realized from fertilized native grasslands when certain range site characteristics are known. Profitable increases in forage production were obtained on the better sites only at the 67-pound nitrogen treatment. Lower or higher rates of nitrogen did not increase the forage production capacity enough for it to be a profitable venture. The inherently poorer range sites did not produce a profitable return at any rate of fertilization.

The total yields of a site would indicate more profitable returns from more of the sites studied. The total yield, however, includes the forb component, which generally includes large amounts of unpalatable plant species and therefore does not add to the forage yield. This study indicates that the protein content of the grass species on poorer sites is considerably higher than on better sites, which would partially compensate for lower forage yields.

SUMMARY

Improvement of native range production by means of nitrogen fertilization may be realized in western North Dakota. The application of nitrogen fertilizer, however, must be carried out with discretion, as the vegetation of different range sites reacts differently when fertilizer is used. Considerably longer and detailed experiments are necessary to more adequately assess possible plant population changes which may be detrimental to the rangelands because of the increase in production of undesirable forb species.

The grass yield data showed that forage production was increased at all rates of nitrogen fertilization on all sites. The highest production for a given increment of fertilizer was at the 67-pound nitrogen treatment. The 33-pound nitrogen rate generally did not greatly increase the yield above the yield from the check plots (no nitrogen). The 100-pound nitrogen rate increased grass production only slightly above the yields from the 67-pound nitrogen treatment.

Increased perennial forb production from added nitrogen was mainly the result of an increase in sage (**Artemisia sp.**). Increases were observed with each increase in rate of nitrogen fertilizer on the Vebar and Manning sites. The highest production was observed on the Manning site, with variable responses to the nitrogen on the Havre and Rhodes sites. Annual forb production was not greatly affected by the nitrogen fertilizer.

But there were indications on the Vebar and Manning sites that a shift in the grass forbs proportion toward more undesirable forbs might be occurring.

The economic feasibility of fertilizer use may be restricted to fertilizing only the inherently high producing sites and only at the 67-pound nitrogen rate. While profitable use of fertilizer is further affected by cost of nitrogen, its application, growing conditions and beef prices, fertilizing native rangelands shows promise as a useful practice to increase production capacity of native grasslands.