

The Role of Nitrogen Fertilization in the Management of Grasslands in North Dakota

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Perhaps the most universally present, yet limiting, plant nutrient in the growth and maximum production of grasses throughout the world is nitrogen. Nearly everywhere natural grasslands or planted pastures occur a positive response to added nitrogen has been reported. A voluminous literature exists on the subject although tremendous variations in degree of response are reported. This is due to the large differences in inherent productive capacity of naturally occurring soils, precipitation and temperature regimes, individual grass and other species differences, and cultural management. The lack of application of proven management techniques to fertilized pastures is perhaps the major factor in not realizing the full potential positive effect of applied nitrogen.

Nitrogen fertilization has been carried out in various locations throughout the Northern Great Plains beginning in the early 1950's (Houston 1952, Carter 1955, Whitman et al. 1957, Kilcher 1958, Smika et al. 1960, Rogler, et al. 1962). Early investigations involved primarily tame seeded pastures and included mainly cool-season grass species such as smooth brome grass (*Bromus inermis*), crested wheatgrass (*Agropyron cristatum*), and Russian wildrye (*Elymus junceus*). Substantial increases in hay and forage production and grazing animal gains were generally reported. Other benefits recognized were higher nutrient contents, especially protein, earlier spring grazing, and extended period of use. In North Dakota some of the early cool-season grass spring pastures grazing trials were carried out by George A. Rogler and Russell J. Lorenz at the Northern Great Plains Station at Mandan, and by Warren C. Whitman at the Dickinson Experiment Station. The early growing cool-season tame grass species were soon recognized as a means of delaying the early spring use of native grass pastures, allowing them to develop more fully before grazing commenced. Likewise, regrowth from the early growing grasses in late fall may be substantial for extending the grazing period, or in the case of Russian wildrye, allowing natural curing during summer and grazing only in the fall. The tame pasture, early spring, cool season, crested wheatgrass-native range-Russian wildrye pasture sequence is well known in most of the Northern Great Plains grazing schemes.

The response of native grasslands (rangelands) to nitrogen fertilization also has been investigated. Some early research was carried out by essentially the same scientists as initiated the tame grass pasture trials. Results from these experiments generally indicated highly differential responses by the various plant species found in a natural occurring grassland. Early growing cool-season species (mid-grasses) responded differently than the later-growing warm-season grasses (shortgrasses) or forbs (broadleaf species). While a positive response was nearly always obtained, it was soon recognized that the fertilization of native grassland was a complex and not well understood undertaking. A totally different and more intensive level of management was necessary to optimize production and maintain the natural character of the native rangeland. While the tame grass pastures involve essentially a single plant species, the native rangelands may involve a dozen or more grass and sedge species along with several times as many forb species. Each individual species generally differs to some degree in terms of response to added nitrogen and other fertilizers within a given environment. Studies to elucidate all of the major controlling factors are still in progress.

Some specific studies at the North Dakota Agricultural Experiment Station at Dickinson will be alluded to to illustrate the effect of nitrogen and other fertilizers upon forage production and animal performance. Studies elsewhere in the state and region are recognized as already indicated, but will not be included at this time due to restriction of space.

Considerable information is available regarding early spring grazing by yearling animals on fertilized tame grass pastures. Increased production of forage and improved animal gains have nearly always been reported with recommendations for the use of fertilizer for improved beef production on a per acre basis. Recent interest has been directed towards the cow-calf unit since our major cattle production systems revolve around this basic unit. Preliminary data indicate substantial increases in forage production were realized in a recently initiated (1977) three pasture grazing system for cow-calf production involving fertilized and unfertilized pastures of crested wheatgrass, Russian wildrye grass, and native grassland (Table 1). In addition to the increased forage production, there was a large increase in number of grazing days and forage remaining on the ground following the much longer grazing

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Table 1. Forage production and utilization during the grazing periods on crested wheatgrass, native grass, and Russian wildrye pastures - 1978.

Pastures	Pasture size acres	Period grazed	Days in period	Forage produced lbs/acre	Forage utilized lbs/acre	Forage left on ground lbs/acre	Per cent utilization
Crested wheatgrass (unfertilized)	16	5/22- 6/19	28	2030	1068	962	53
Crested wheatgrass +50 lbs N/A	8	5/15- 7/10	56	5060	3426 ^{1/}	1634	68
Native grass (unfertilized)	18	6/19- 8/14	56	1954	1141	813	58
Native grass +50 lbs N/A	12	7/10- 9/15	67	3943	2270	1673	58
Russian wildrye (unfertilized)	16	8/14- 9/29	46	1760	1320	440	75
Russian wildrye +50 lbs N & 30 lbs P ₂ O ₅ /A	16	9/15-11/9	55	2727	1963	764	72

^{1/} 625 lbs/acre of hay was removed in early September.

period. Animal performance is likewise considerably greater on fertilized versus nonfertilized grasses in both tame and native pastures (Tables 2 and 3). A summary statement of the information presented shows that cows and calves produced nearly 300% more beef per acre on fertilized vs unfertilized crested wheatgrass. Calves showed a slightly higher average daily gain per acre but also indicated a much higher gain per acre on the fertilized forage. A similar performance for both cows and calves was evident in the

Russian wildrye and native grassland pastures although substantial variation existed between the two grass types and the different ages of animals as experimental groups. Total cow beef produced from the fertilized pasture system during the 1978 grazing season was 221% more than those on the unfertilized system, while calves gained 85% more from the fertilized system. Total gains for the 130 days on the unfertilized system were 65 lbs/acre, while those for the 178 days on the fertilized system was 146 lbs/acre. (Botany Department Annual Report, 1978.)

Table 2. Pasture systems grazing trial, weights and gains of calves on crested wheatgrass, native grass and Russian wildrye pastures - 1978.

Pastures	Period grazed	Days in period	No. of calves	Avg. initial wt./calf lbs	Avg. final wt./calf lbs	Avg. gain/hd lbs	Avg. daily gain/hd lbs	Avg. gain/A
Crested wheatgrass (unfertilized)	5/22- 6/19	28	10	180	228	48	1.7	30
Crested wheatgrass +50 lbs N/A	5/15- 7/10	56	10	152	255	103	1.8	129
Native grass (unfertilized)	6/19- 8/14	56	10	228	328	100	1.8	56
Native grass +50 lbs N/A	7/10- 9/15	67	10	255	342	87	1.3	73
Russian wildrye (unfertilized)	8/14- 9/29 ^{1/}	46	10	328	410	82	1.8	51
Russian wildrye +50 lbs N & 30 lbs P ₂ O ₅ /A	9/15-11/ 9	55	10	342	426	84	1.5	52

^{1/} One calf died 9/24/78.

Table 3. Pasture systems grazing trial, weights and gains of cows and one bull on crested wheatgrass, native grass, and Russian wildrye pastures - 1978.

Pastures	Period grazed	Days in period	No. of cows & bull ^{1/}	Avg. initial wt./cow lbs.	Avg. final wt./cow lbs.	Avg. gain/hd lbs.	Avg. daily gain/hd lbs.	Avg. gain/A lbs.
Crested wheatgrass (unfertilized)	5/22- 6/19	28	10 (0)	990	1044	55	2.0	34
Crested wheatgrass +50 lbs N/A	5/15- 7/10 6/12- 7/10	56 (28)	10 (1)	958 (885)	1066 (1000)	108 (115)	1.9 (4.1)	135 (14)
Native grass (unfertilized)	6/19- 8/14	56 (56)	10 (1)	1044 (115)	1069 (1145)	25 (30)	0.4 (0.5)	14 (2)
Native grass +50 lbs N/A	7/10- 9/15 (7/10- 8/ 7)	67 (28)	10 (1)	1066 (1000)	1008 (1040)	-58 (40)	-0.9 (1.4)	-5 (3)
Russian wildrye (unfertilized)	8/14- 9/29	46	10	1070	1084	14	0.3	9
Russian wildrye +50 lbs N & 30 lbs P ₂ O ₅ /A	9/15-11/ 9	55	10	1008	1092	84	1.5	52

^{1/} () indicates data pertaining to bulls.

Production and ecologic performance of native grasslands

Native rangeland grass, sedge, and forb species show a wide range of response to nitrogen and other fertilization dependent upon species present, cool-season versus warm-season types, soil type (site), precipitation, temperature, and past history of use. The ecologic condition, or relative status of the present plant community (combination of species) compared to what it potentially could be without any adverse effects of past grazing, is the prime key to determining amounts of nitrogen to apply for maximizing forage production. Being able to apply only certain amounts at critical times will allow not only maximum forage production but also often effect a desirable change in relative amounts between the cool-season and warm-season grasses. In many of our present ranges, the low-growing warm-season species like blue grama grass (*Bouteloua gracilis*) predominate over the higher producing, early growing cool-season grasses and sedges such as western wheatgrass (*Agropyron smithii*), needle-and-thread (*Stipa comata*), green needlegrass (*Stipa viridula*), needleleaf sedge (*Carex eleocharis*), threadleaf sedge (*Carex filifolia*), and numerous others. In addition, forb species of the sage group respond very positively to applied nitrogen and may become dominant if not controlled by good management. Fringed sage-wort (*Artemisia frigida*) and white sage (*Artemisia ludoviciana*) are perhaps the most common (Goetz, 1969).

Data from past studies in western North Dakota show the general shift from a blue grama grass dominated range to one of having a cool-season dominance, mainly western wheatgrass. The degree of relative shift (balance) and changes in production may be observed from Table 4. The data were taken from different range sites (soil types) over a three year period and demonstrate differences in plant response due to the inherent potential of different soils coupled with the ecologic condition or species dominance

of each site. The increase in production due to nitrogen fertilization and changes in plant species composition are readily apparent from the information in the table.

A more recently completed, but not yet published, 8-year study of nitrogen alone and combined with other fertilizers was carried out on a single range site at Dickinson in western North Dakota. Table 5 shows the production information from this experiment over the period of the study. Table 6 shows the per cent change in production as measured against the production from plots not receiving any nitrogen treatment. Production was substantially increased from all nitrogen treatments and when combined with phosphorus. A single one-time application of 200, 300, and 400 lbs/N per acre at the beginning of the study demonstrates the change effected in the plant community by this procedure. The blue grama was nearly totally eliminated in favor of the early growing cool-season western wheatgrass.

Manipulation of the native range plant community with nitrogen fertilizer can be viewed as a powerful management tool. Positive changes in the different plant groups (composition changes) can be achieved by judicious application as to time of year, amount of fertilizer, and grazing practice. In addition to this capability, the relative condition or health of the entire plant system can be improved by way of improved root systems, water use efficiency, nutrient content of plants (especially protein), and overall productivity (Goetz, 1970 and 1975, Barker, 1978). Realization of these potential benefits, however, is very closely tied to more a highly intensive and well managed grazing program than is generally applied to most of our rangelands at the present time. As the acquisition of additional grazing land becomes increasingly more prohibitive for the average ranch operator, the institution of more sophisticated and intensive management systems will become a reality.

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						Total yields
		Mid grasses	Tall grasses	Short grasses	Total grasses	Perennial forbs	Annual forbs	
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	2548
	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. Average forage production from native mixed grass prairie with nitrogen alone and in various combinations with phosphorus and potassium at different rates near Dickinson, North Dakota - 1970-78 seasons.

Treatment	Dry weight yield - lbs/acre						Total yields
	Mid grasses	Short grasses	Total grasses	Perennial forbs	Annual forbs	Total forbs	
Check (no fertilizer)	1245	745	1990	209	45	254	2244
100 N every other year ^{1/}	1659	565	2224	460	54	514	2738
100 N every year	2111	543	2654	436	29	465	3119
200 K ^{1/}	1173	809	1982	259	60	319	2301
200 N	1512	595	2107	278	41	319	2426
300 N	1783	691	2474	362	30	392	2866
400 N	1745	620	2365	419	33	452	2817
50 P	1069	718	1787	338	110	448	2235
50 P-67 N	2069	664	2733	421	22	443	3176
50 P-67 N-200 K ^{1/}	2191	394	2585	418	43	461	3046
67 N every other year ^{1/}	1440	633	2073	417	35	452	2525
67 N every year	1940	547	2487	451	35	486	2973

^{1/} 8 year average - all others are 9 year averages.
200 N, 300 N, and 400 N treatments applied as a one-time treatment in 1970.

Table 6. The per cent increase (+) or decrease (-) in production of the different categories of grasses and forbs at the various treatments when compared to plots receiving no treatment - 1970-78 seasons.

Treatment	Dry weight yield - lbs/acre						
	Mid grasses	Short grasses	Total grasses	Perennial forbs	Annual forbs	Total forbs	Total yields
Check (no fertilizer)	1245	745	1990	209	45	254	2244
100 N every other year ^{1/}	+33.2	-24.1	+11.7	+120.1	+ 20.0	+102.3	+22.0
100 N every year	+69.5	-27.1	+33.3	+108.6	- 35.5	+ 83.1	+39.0
200 K ^{1/}	- 5.8	+ 8.6	- 0.4	+ 23.9	+ 33.3	+ 25.6	+ 2.5
200 N	+21.4	-20.1	+ 5.9	+ 33.0	- 8.9	+ 25.6	+ 8.1
300 N	+43.2	- 7.2	+24.3	+ 73.2	- 33.3	+ 54.3	+27.7
400 N	+40.1	-16.8	+18.8	+100.5	- 26.7	+ 77.9	+25.5
50 P	-14.1	- 3.6	-10.2	+ 61.7	-144.4	+ 76.4	- 0.4
50 P-67 N	+66.2	-10.9	+37.3	+101.4	- 51.1	+ 74.4	+41.5
50 P-67 N-200 K ^{1/}	+76.0	-47.1	+29.9	+100.0	- 4.4	+ 81.5	+35.7
67 N every other year ^{1/}	+15.6	-15.0	+ 4.2	+ 99.5	- 22.2	+ 77.9	+12.5
67 N every year	+55.8	-26.6	+25.0	+115.8	- 22.2	+ 91.3	+32.5

^{1/} 8 year average - all others are 9 year averages.

200 N, 300 N, and 400 N treatments applied as a one-time treatment in 1970.

Summary:

Nitrogen fertilization of tame and native range pastures has been carried out in various locations in North Dakota and adjacent Northern Great Plains for many years. Response by both the tame and native rangeland species has generally been positive and resulted in substantially higher forage yields and animal gains on a per acre basis. Grazing schemes which incorporate tame grass and native range pastures have demonstrated a high potential for greatly improved, long-term production. The successful integration of the pasture types and realization of benefits due to nitrogen fertilization is totally dependent upon the degree of management imposed on the system. Optimizing benefits from this practice requires a knowledge of plant response and general ecologic requirements, especially in native rangelands. Nitrogen fertilizer is a powerful tool for improved tame and native rangeland production, improving deteriorated native rangelands by bringing about positive changes in plant species composition, improving plant quality, extending grazing periods both early spring and late fall, and greatly increased gains of animal products from each acre grazed.

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