Evaluation of a Fertilized 3-pasture System Grazed by Yearling Steers

PAUL E. NYREN, WARREN C. WHITMAN, JAMES L. NELSON, AND THOMAS J. CONLON

Abstract

A grazing trial comparing fertilized and unfertilized 3-pasture systems has shown that the addition of 56 kg nitrogen (N)/ha substantially improved forage and beef production. Forage production from the fertilized system was increased by 46% over the unfertilized system while per acre beef gains were increased 35%. Each 3-pasture system utilized crested wheatgrass for spring and early summer, native mixed grass prairie for mid and late summer and Russian wildrye for fall grazing. Comparison of Hereford and Angus-Hereford crossbreds indicated a slight gain advantage for the crossbred animals, although the increase was not statistically significant. The addition of the biuret supplement Kedlor was found to improve gains of steers grazing the native pastures in late summer but resulted in decreased gains on fall-grazed Russian wildrye pastures. Analysis of the forage samples showed that in all samples except one, the addition of N fertilizer increased the protein content.

Studies in western North Dakota have shown that the application of nitrogen (N) fertilizer can improve the production of native mixed grass prairie as well as introduced range grasses. Goetz (1969) in a study of 4 range sites in southwestern North Dakota found that N fertilizer application gave increases in dry-matter yields on all range sites. Whitman and associates (1957) found that on old crested wheatgrass *(Agropyron desertorum)* stands 56 kg/ha of N gave the most economical returns when the crested wheatgrass was cut for hay. Other studies at Dickinson, N. Dak., have shown that the use of crested wheatgrass for early spring grazing could lengthen the grazing season and increase gains per acre from yearling steers (Whitman 1962, 1966). Six years of study showed that crested wheatgrass pastures given yearly applications of 56 kg N/ha increased beef production 44% per similar untreated pastures.

Rogler and Lorenz (1965) compared 3 rates of N fertilization on native mixed prairie grazed season-long by yearling steers at Mandan, N. Dak. The authors found that the application of 45 kg N/ha increased the gains per acre by 88% and the forage yield by 49%.

A study in Nebraska comparing unfertilized season-long and rotational grazing systems with similar systems under continous fertilization with 33.6 kg/ha N showed increases in kg/ha beef production of 33 and 51% from the rotation and continuous fertilized range respectively (Stubbendieck 1977).

The data of Whitman (1962, 1966) and Rogler and Lorenz (1965) would indicate that higher gains per acre and increased grazing capacity might be achieved by combining early spring grazing of crested wheatgrass with summer grazing of native mixed prairie. This idea is not new. (Sarvis (1941), Rogler (1944), Williams and Post (1945), and Campbell (1952) in separate studies in the United States and Canada proposed grazing systems which included crested wheatgrass-native in this type of rotational deferment.

This system of rotational deferment can be carried one step further by the inclusion of Russian wildrye *(Elymus junceus)* for late summer and fall grazing. This system allows each of the respective pastures to be grazed when it can provide the most benefit to the system. Smoliak (1968) found that yearling ewes grazing a rotational system of crested wheatgrass-native-Russian wildrye gained 2.0 times as much as similar animals grazing season long native. In a study utilizing yearling steers Smoliak (1974) found that a similar rotation produced 1.3 to 1.8 times as much gain per acre as native range. In the spring of 1972 a 3-pasture trial was undertaken at the Dickinson Experiment Station to study fertilized and unfertilized systems, the performance of Hereford and Hereford-Angus crossbred (BWF) yearling steers and the addition of biuret to late summer and fall pastures.

Methods and Materials

Each fall Hereford and BWF calves were selected from the station herd and placed in drylot. While there they were fed a limited grain-high roughage growing ration to produce gains of 0.51 to 0.68 kg/day. In late April or early May the steers were moved to the crested wheatgrass pastures where they remained until mid-summer. The native pastures were grazed in mid and late summer and the Russian wildrye in the fall. The number of animals were kept the same on the fertilized and unfertilized systems, and varied only between years and between pastures within the systems to maintain proper utilization. Ten head in 1972, and 12 head in 1973 and 1974 grazed on each pasture during the season. In 1975 and 1976, 13 head grazed the crested wheatgrass pastures with one animal being removed from each set before turning onto native. The crested wheatgrass and native grass pastures were each divided into 2 parts. One part was fertilized with 56 kg N/ha from ammonium nitrate each spring while the other part was left unfertilized. The Russian wildrye pastures were all fertilized with 56 to 168 kg N/ha and 34 kg P_2O_5/ha. All Russian wildrye pastures were fertilized in an attempt to improve establishment and production of the new established stand.

The crested wheatgrass and Russian wildrye pastures were located on previously cropped, gently sloping land with sandy to sandy loam soils. The fertilized and unfertilized crested wheatgrass pastures were 3.2 ha and 6.5 ha respectively, while the Russian wildrye pastures were 3.2 ha each. The 4.8 ha fertilized and 7.3 ha unfertilized native pastures were situated on a strongly rolling upland site with a predominantly sandy loam soil.

The dominant species on the native mixed grass pastures were western wheatgrass *(Agropyron smithii),* a needle-and-thread *(Stipa comata),* plains reedgrass *(Calamagrostis montanensis),* green needlegrass *(Stipa viridula),* needleleaf sedge *(Carex eleocharis),* Pennsylvania sedge *(Carex pennsylvanica),* and blue grama *(Bouteloua gracilia).* The forbs included red mallow *(Spaeralcea coccinea),* fringed sage *(Artemisia frigida),* white prairie aster *(Aster ericoides),* goldenrods *(Solidago* spp.), and many others.

Exclosure cages were systematically located on the pastures with one cage being placed on every .30 ha. Forage samples were clipped to ground level inside a .75 × 1.5 M frame placed inside and outside the exclosure cages. The forage samples were oven dried at 65° C. The samples were then ground in a Wiley Mill using a .5-mm

Authors are superintendent, Central Grasslands Research Station, NDSU, Streeter, ND 58483; professor emeritus, Botany Department, North Dakota State University, Fargo 58105; animal husbandman and superintendent, Dickinson Experiment Station, Box 1117, Dickinson, N. Dak. 58601.

Manuscript received February, 1981.

Table 1. Average annual forage production (oven-dry weight), stocking rate and percent utilization.

Year	Grazing period	Stocking rate (AUM/ha) and forage production (kg/ha): Unfert.				Fert.		Days grazed	% Utilization: Unfert.		Fert.
		Stocking rate	Forage prod.	Stocking rate	Forage prod.	Stocking rate	Forage prod.				
1972:											
Crested wheat	5/12-7/7	2.2	2483			4.3	4671	56	36		43
Native	7/7-9/1	1.9	3540			2.9	4963	56	30		35
Russian wildrye	9/1-10/26			2.2	1710			56		59	
1973:											
Crested wheat	4/26-6/21	2.6	1834			5.2	2228	56	59		68
Native	6/21-8/23	2.6	2652			3.9	3864	63	43		48
Russian wildrye	8/23-11/1			3.3	1826			71		96	
1974:											
Crested wheat	5/1-6/21	2.5	2185			5.1	2650	55	46		58
Native	6/25-9/4	2.9	3450			4.4	5906	71	44		42
Russian wildrye	9/4-11/11			3.2	1818			70		82	
1975:											
Crested wheat	5/13-7/8	2.8	2480			5.6	4046	56	68		76
Native	7/8-9/3	2.3	2759			3.5	4560	57	29		43
Russian wildrye	9/3-11/25			2.6	2558			54		78	
1976:											
Crested wheat	5/6-6/28	2.7	2873			5.3	3192	53	60		62
Native	6/28-8/13	1.9	2594			2.8	3185	46	54		58
Russian wildrye	8/13-10/21			3.2	1843			69		78	
5-Year Average:											
Crested wheat		2.4	2371			4.8	3357	55.2	53.8		61.4
Native		2.3	3000			3.5	4496	58.6	40.0		45.2
Russian wildrye				2.9	1951			64.0		78.6	

screen. Nitrogen content determinations were made by the Kjeldahl method and multiplied by 6.25 to obtain crude protein content.

The steers were weighed before being placed on the pastures, at 4-week intervals during the grazing period and when transferred to the next set of pastures.

In late summer, while the animals were grazing native grass, the steers on each pasture were divided into 2 equal sized groups with one group being fed Kedlor[1], a biuret product, to test whether gains on mature native grass could be improved through the use of this supplement. When the animals were moved to the Russian wildrye they were again separated and those receiving Kedlor on the native grass were fed the supplement on the Russian wildrye. The steers were fed a 101% protein equivalent block at the rate of one 15-kg block per 6 steers. A new block was added when the old one was 90% utilized.

Results and Discussion

Forage Production

Forage production on the unfertilized and crested wheatgrass averaged 2371 kg/ha for the 5 years of the trial (Table 1). The yields fluctuated from a low of 1834 kg/ha in 1973 to a high of 2873 kg/ha in 1976. The fertilized crested wheatgrass produced an average of 3357 kg/ha during this same period, an increase of 42% over the unfertilized pasture. The fluctuations in the yield of fertilized crested wheatgrass were also greater, ranging from a low of 2228 kg/ha to a high of 4671 kg/ha, nearly 2465 kg/ha difference.

The average forage production on the native mixed grass pastures was 3000 and 4496 kg/ha for the unfertilized and fertilized, respectively. This represents a 50% increase in yields from the application of 56 kg N/ha. The increased fluctuation between years was again apparent with the fertilizer application. This response to fertilization seems to result from the plant's ability to take advantage of the added nutrient. When other factors, such as soil moisture, are not limiting, the response is good. However, when other factors limit plant growth, the added nutrient cannot be adequately utilized and therefore the response is much smaller.

Forage yields from the Russian wildrye were less than the crested or native pasture, but the increased utilization of the Russian wildrye tended to offset this somewhat (Table 1).

The annual fluctuations in forage production are due in a large part to the amount and timing of the precipitation. The precipitation was 12.5 and 4.8 cm above the 80-year average in 1972 and 1975, respectively. In these 2 years, forage production increased 14% in 1972 and 8% in 1975 over the 5-year average. The 2 years with below-average precipitation, 4.3 cm less in 1973 and 8 cm less in 1976, produced 18% and 17% less forage respectively than the 5-year average. While the precipitation in 1974 was 4.3 cm below average, forage production was 5% above the 5-year mean. Closer examination of the precipitation distribution throughout 1974 shows below-average precipitation in the first 3 months of the year as well as August, September, October, and December, but above-average amounts in April and May the 2 most critical months during the growing season.

Beef Production

In general steer gains were similar on fertilized and unfertilized grass, which might be expected as long as the total available forage supply was adequate on both sets of pastures (Table 2). The 5-year average does show a slight advantage .11 kg ADG for the unfertilized over the fertilized crested wheatgrass.

Because of the differences in size between the fertilized and unfertilized pastures, per acre gains give a more accurate analysis of the differences in gain between the systems (Table 3). When per

[1]Gopher State Pro-101-Block. Guaranteed analysis: Not more than 105% equivalent protein from biuret, triuret, cyanuric acid and urea, of which not more than 14% is from urea, calcium 6.9-8.4%, salt 6.3-7.8%, phosphorus (not less than) 5.00% and iodine (not less than) 0.03T. Vitamin A 45,400 USP units per kg and vitamin D_3 90,000 USP units per kg.

Table 2. Average daily gains in kg/hd/day of steers grazing the fertilized and unfertilized 3-pasture system.

Pasture	1972		1973		1974		1975		1976		5-year avg.	
	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.
Crested wheatgrass	.96a[1]	1.01a	.60b	.75a	.65b	.78a	.57a	.53a	.36b	.64a	.63b	.74a
Native	.34a	.35a	.82a	.73a	.82a	.69a	.88b	1.06a	.89a	.88a	.75a	.74a
Russian wildrye	.68a	.66a[2]	.51a	.38a	.16a	.23a	.17a	.23a	.22a	.06b	.35a	.31a
Average	.66a	.67a	.64a	.61a	.54a	.55a	.56b	.63a	.45a	.47a	.57a	.59a

[1]Means in the same row and for the same year followed by the same letter are not significant at the $P<.05$ level.
[2]All Russian wildrye pastures were fertilized. Those gains listed under unfertilized Russian wildrye are for those animals previously grazing unfertilized crested wheatgrass and native.

acre gains are considered, the advantage of the fertilized system becomes apparent. The fertilized crested wheatgrass pasture produced 68% more beef than the unfertilized crested wheatgrass during the 5-year trial whereas the fertilized native pasture showed a 53% increase over the unfertilized.

While season-long grazing of native mixed prairie was not included in the trial due to limited facilities, other studies have shown smaller per acre gains and a shorter grazing season from this type of grazing system. In 21 years of data from native mixed grass pastures moderately grazed by yearling steers, Rogler et al. (1962) show lower per acre gains as well as a shortened grazing season. On moderately grazed native mixed prairie gains were 46 kg/ha, 25% less than was obtained in the present study. The stocking rate for the present study was slightly heavier than the moderate rate reported by Rogler and associates, although no evidence of overgrazing was observed. In addition to higher per acre gains the grazing season averaged 178 days, 35 days longer than the season-long system reported by Rogler.

Average per acre gains for the 5-years of the trial on the 3-pasture systems show that whereas the unfertilized system produced 60 kg of beef per acre the fertilized system produced 81 kg, an increase of 35% (Table 3). It is reasonable to assume that if half the Russian wildrye pastures had been unfertilized, beef production from these pastures would have been less, thus making the percentage increase from fertilization even greater.

Forage Protein Content

In 4 years of the trial the forage samples collected on the pastures were sent to the laboratory for analysis of protein content. Figure 1 shows the results of these analyss for each pasture and the date the forage sample was taken. The fertilized pastures consistently produced forage with higher protein content than that of the unfertilized pastures. The only exception to this was on the native pastures on September 14, 1972, when the unfertilized pasture had 1.9% more protein than the fertilized.

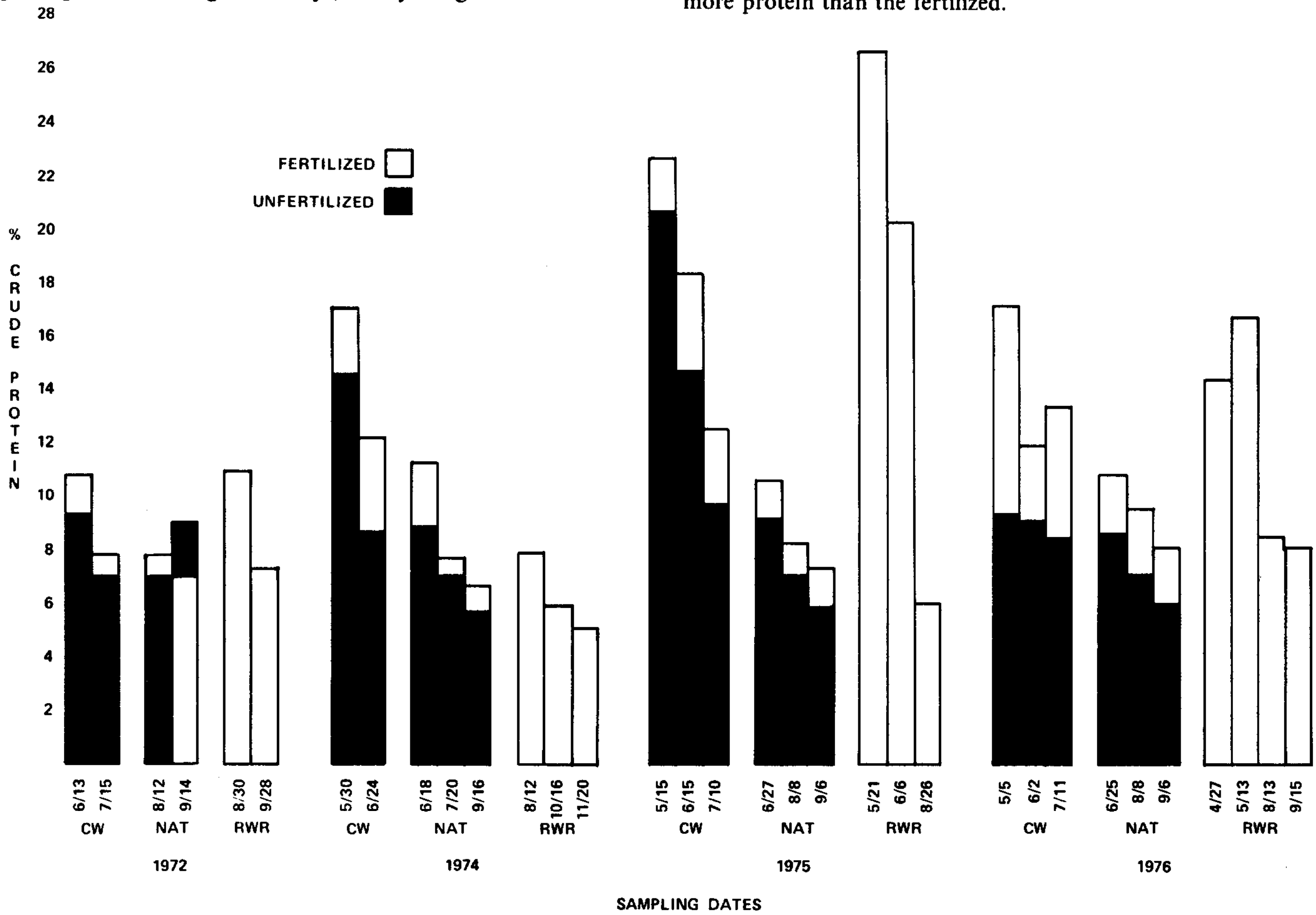

Figure 1: Percent crude protein of forage samples collected on the fertilized and unfertilized crested and native, and the fertilized Russian wildrye pastures in 1972, 1974, 1975 and 1976. On the crested and native the height of the lower bar shows the crude protein content of forage samples collected from that respective pasture while the extended height of the top bar shows the total crude protein content of the other pasture.

Table 3. Total beef production in kg/ha for each pasture in the fertilized and unfertilized 3-pasture system.

Pasture	1972		1973		1974		1975		1976		5-year avg.	
	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.
Crested wheatgrass	165.5a[1]	87.5b	124.0a	78.1b	133.1a	79.8b	128.8a	59.9b	77.7a	68.6a	125.8a	74.8b
Native	39.2a	26.8a	127.4a	76.0b	144.7a	80.9b	124.7a	98.8b	100.8a	66.6b	107.4a	70.1b
Russian wildrye	58.5a	57.4a[2]	67.2a	50.8a	20.6a	29.8a	17.2a	23.5a	28.0a	8.4b	38.3a	34.0a
Average	75.8a	56.0b	99.9a	68.6b	87.0a	64.2b	77.8a	62.7b	63.3a	48.6b	80.8a	60.0b

[1]Means in the same row and for the same year followed by the same letter are not significant at the $P<.01$ level.
[2]All Russian wildrye pastures were fertilized. Beef production values listed under unfertilized Russian wildrye are for those animals previously grazing unfertilized crested wheatgrass and native.

Table 4. Average daily gains (kg/hd/day) for Hereford and Hereford-Angus crossbred (BWF) steers on the fertilized and unfertilized pastures in the 3-pasture system (1972-1976).

Pasture	Fertilized		Unfertilized	
	BWF	Hereford	BWF	Hereford
Crested wheatgrass	.61a[1]	.62a	.75a	.71a
Native	.81a	.72a	.76a	.75a
Russian wildrye[2]	.35a	.32a	.34a	.27a
Average	.59a	.55a	.62a	.58a

[1]Means in the same row under the same fertility rate followed by the same letter are not significantly different at the $P<.05$ level.
[2]All Russian wildrye pastures were fertilized. The beef production values listed under unfertilized Russian wildrye are for those animals previously grazing the unfertilized crested wheatgrass and native.

The National Acadamy of Sciences (1976) suggests that growing 350 kg steers need 8.5% protein from forage to maintain body weight. Figure 1 shows that on July 15, 1972 the crested wheatgrass had fallen below the 8.5% limit. In 1972 the unfertilized native pasture was below 8.5% on August 12, but its protein increased 2 percentage points by September 14 so that it was then above 8.5%. In all the other years the unfertilized native had less than 8.5% by the middle of the grazing period. In 1972 the fertilized native grass was below the 8.5% level the entire season. In 1974 and 1975 the fertilized native grass fell below 8.5% protein content by the middle of the grazing period and in all years was below this level by the final clipping date. In 1974 the Russian wildrye never contained 8.5% protein. In all other years it too had fallen below the 8.5% level by the final clipping date.

BWF vs. Hereford

Half the steers on each pasture system were Herefords and half were Angus × Hereford cross (BWF). These animals were used in the study in an effort to determine if there would be any gain advantage with the crossbred animals. Table 4 shows the 5-year averages for the BWF and Hereford animals on each pasture in the 2 systems.

These data suggest that BWF animals did show slightly higher per acre gains on all pastures except the fertilized crested. While these increases seemed to be rather consistent, they were not statistically significant at the 5% level. The 5-year averages show the BWF's gained .04 kg/hd/day more than the Herefords on both the fertilized and unfertilized pastures.

Supplement

During the years of 1973–1975 half of each lot of animals were fed the biuret supplement Kedlor. The gains on the native were consistently higher for the supplemented animals than for the unsupplemented (Table 5). The 3-year average shows a 38% increase in ADG for those animals receiving Kedlor.

The data from the Russian wildrye pastures show that the advantages of the supplement on the native pastures was lost on the Russian wildrye. These animals consumed abnormally high amounts of the supplement, yet gained less than the unsupplemented animals.

Conclusions

The use of nitrogen fertilizer on a 3-pasture grazing system improved total seasonal forage production 46% and per acre gains of yearling steers 35% over a similar unfertilized 3-pasture system. In addition to the improved beef production carrying capacity was also improved. On the unfertilized system 10 to 12 head of steers grazed 20.2 ha for an average of 178 days, while on the fertilized pastures the same number of animals required only 14.6 ha during a similar grazing period.

The performance of Hereford and BWF animals on the 2-pasture systems was similar with the BWF animals having a slight

Table 5. Average daily gains (kg/hd/day) of supplemented and nonsupplemented yearling steers on native and Russian wildrye pastures (1973-1975).

Year	Native[1]		Russian wildrye	
	Supplemented[2]	Nonsupplemented	Supplemented	Nonsupplemented
1973	.74a	.26b	.31b	.58a
1974	.96a	.79a	.21a	.18a
1975	1.03a	.92a	.28a	.12b
3-year avg.	.91a	.66b	.27a	.29a

[1]The steers were fed the biuret supplement Kedlor for approximately the last half of the total time on the native pastures.
[2]Means in the same row for the same pasture followed by the same letter are not significantly different at the $P<.05$ level.

but nonsignificant advantage.

Feeding a biuret supplement to half of each lot of steers during the late summer and fall had no significant advantage. The addition of the supplement on the native pastures did show some improvement but they were more than offset by the losses incurred when the animals were fed the supplement on the Russian wildrye pastures.

Laboratory analysis of the forage samples collected throughout the grazing period showed an increase in protein when N fertilizer was applied.

Literature Cited

Campbell, J.B. 1952. Farming range pastures. J. Range Manage. 5:252-258.

Goetz, Harold. 1969. Composition and yield of native grassland sites fertilized at different rates of nitrogen. J. Range Manage. 22:384-390.

Lawrence, T., and D.H. Heinrichs. 1966. Russian wildryegrass for western Canada. Canada Dep. Agr. Pub. 991.

Natl. Res. Council, Subcomm. on Beef Cattle Nutrient Requirements of Domestic Animals. No. 4. 1976. Nutrient requirements of beef cattle. Nat. Acad. Sci. Washington, D.C. 1970. (5th Rev. Ed.)

Rogler, G.A. 1944. Summer gains of yearling Hereford steers on native and cultivated pastures. N. Dakota Agr. Exp. Sta. Bimonthly Bull. 6:20-27.

Rogler, G.A., and R.J. Lorenz. 1965. Nitrogen fertilization of natural grasslands in the northern plains of the United States. Proc. Int. Grassland Congr. 9:1327-1330.

Rogler, G.A., and R.J. Lorenz. 1970. Beef production from Russian wildrye (Elymus junceus Fisch.) in the United States. Proc. Int. Grassland Congr. 11:835-838.

Roger, G.A., R.A. Lorenz, and H.M. Schaff. 1962. Progress with grass. N. Dakota Agr. Exp. Sta. Bull. 439.

Sarvis, J.T. 1941. Grazing investigations on the northern great plains. N. Dakota Agr. Exp. Sta. Bull. 308.

Smoliak, S. 1968. Grazing studies on native range, crested wheatgrass and Russian wildrye pastures. J. Range Manage. 21:47-50.

Smoliak, S. 1974. Beef production on native range, crested wheatgrass, and Russian wildrye pastures. J. Range Manage. 27:433-436.

Stubbendieck, J. 1977. Grazing systems and range fertilization. Nebraska Agricultural Extension Circular 77-218.p. 18-20.

Whitman, Warren C. 1962. Spring grazing on tame grass pastures. 13th Annual Dickinson Exp. Sta. Livestock Res. Roundup. Rep. Proc. Forage and Range Section 1-2 p.

Whitman, Warren C. 1966. Spring grazing of fertilized crested wheatgrass pastures. 17th Annual Dickinson Exp. Sta. Livestock Res. Roundup. Rep. Proc. Forage and Range Section.

Whitman, Warren C., Thomas J. Conlon, and Raymond J. Douglas. 1957. Response of old crested wheatgrass stands to nitrogen fertilizer in western North Dakota. N. Dakota Agr. Exp. Sta. Bimonthly Bull. 14 (5):141-148.

Williams, R.M., and A.H. Post. 1945. Dryland pasture experiments at the central Montana branch station. Montana Agr. Exp. Sta. Bull. 431.