Response of old *Crested Wheatgrass Stands to Nitrogen Fertilizer in Western North Dakota*

By Warren C. Whitman[1], Thomas J. Conlon[2] and Raymond J. Douglas[3]

MANY crested wheatgrass stands in western North Dakota were established 15 to 20 years ago. These fields are still used for hay and pasture, and many are still in excellent condition. One field at the Dickinson Experiment Station, seeded in 1938, has produced an average of 1,262 pounds of forage per acre (dry weight) over the past 12 years. However, there is good evidence that the productivity of these old stands may be improved by application of nitrogen fertilizer.

Rogler[4] and his associates at the Northern Great Plains Field Station, Mandan, have shown that old, close-drilled stands of crested wheatgrass can be expected to show substantial yield responses to application of nitrogen fertilizer, when moisture conditions are favorable.

Carter[5] found at Fargo the yield of crested wheatgrass hay was more than doubled by application of 100 pounds of nitrogen per acre. He points out that response of forage grasses to fertilizer applications depends on available soil moisture, and that increased forage and seed production from fertilizer will be more variable in western than in eastern North Dakota.

To determine the nature and magnitude of the response that might be expected from nitrogen applications to old crested wheatgrass stands in western North Dakota, a fertilizer trial was started at the Dickinson Experiment Station in 1951. E. B. Norum of the North Dakota Agricultural College soils department, aided in getting this trial started.

PROCEDURE

The trial was established on an old crested wheatgrass field seeded in 1938 on Morton sandy loam, the normal upland soil of the area. The crested wheat had been cut for hay or seed since 1939. The stand was in excellent condition, with practically no weeds in it. Most of the plants in the stand were of the Standard type of crested wheatgrass, although a small proportion of the plants showed Fairway characteristics.

All applications of nitrogen fertilizer were made in the spring, generally about mid-April, except one

[1]Botanist, North Dakota Agricultural Experiment Station and Dickinson Experiment Station.
[2]Agronomist, Dickinson Experiment Station.
[3]Superintendent, Dickinson Experiment Station.
[4]Unpublished material in annual reports sent to the director, North Dakota Agricultural Experiment Station.
[5]Carter, Jack F., 1955, N. D. Exp. Sta. Bimonthly Bulletin, Vol. XVII, No. 5, May-June 1955, pp. 188-197.

application in the fall of 1953. The treatments consisted of (1) check-no nitrogen added, (2) 50 pounds of nitrogen per acre, (3) 100 pounds of nitrogen per acre, and, (4) 150 pounds of nitrogen per acre. In these trials, ammonium nitrate, 33-0-0, was used as the fertilizer.

The fertilizer was applied **to a new section of the field each year.** The plots of the previous year were thus left for the determination of residual effects. The fertilizer was broadcast by means of a 7-foot double-disk drill with fertilizer attachment. Treatments were replicated four times, with plots 7-feet by 175-feet. Hay and seed yields were determined by harvest from randomized small plots within the larger plots.

Protein analyses of the 1954 and 1955 forage yield samples were made by the department of agricultural chemistry North Dakota Agricultural Experiment Station.

RESULTS

Initial Yields In Relation To Precipitation

The forage yields of the check plots and the amounts of forage produced on the fertilized plots above the yields of the checks for the period 1951-1955 are given in table I. The yields given are all from spring applications of fertilizer and are for the year in which the fertilizer was applied.

Total annual and April-June precipitation for each year also are given in the table. These latter data are included to give an indication of the approximate soil moisture status on the plots. The average precipitation for the 5-year period, 15.8 inches, is slightly over the 65-year annual average of 15.57 inches recorded at the Dickinson station.

The data of table I show that only in 1953 were initial yields substantially increased as the result of the fertilizer applications. In this year, 10.96 inches of rainfall were received in the period April through June, over twice the rainfall received during this period in any of the other years, except 1955.

In this outstandingly favorable year the check produced 2,778 pounds of dry hay per acre; plots with 50 pounds of nitrogen produced 4,436 pounds per acre. The plots receiving 100 pounds of nitrogen per acre produced 5,451 pounds of dry hay per acre; and the plots receiving 150 pounds of nitrogen per acre produced 5,561 pounds of hay.

TABLE I.—**Annual Precipitation and April-June Precipitation in Relation to Hay Yields* From Old Crested Wheatgrass Stands Fertilized in the Spring with Nitrogen, Dickinson, 1951-1955.**

Year	Total annual precipitation	Precipitation active fert. period (Apr.-June)	Yield of check lbs./acre	Forage produced over yield of check-lbs./acre-at different N rates		
				50lbs. N	100lbs. N	150lbs. N
1951	16.70	4.89	1627	349	596	623
1952	11.97	4.22	366	253	270	350
1953	19.39	10.96	2778	1658	2673	2783
1954	16.33	5.00	1243	710	840	1138
1955	14.65	9.06	1276	820	845	**
Average......	15.81	6.83	1458	758	1045	1224

*Yields are given as oven-dry weights.
**150 pound application of nitrogen not made in 1955.

TABLE II.—**Hay Yields from Old Crested Wheatgrass Stands as Influenced by Initial and Residual Effects of Nitrogen Fertilizer Applications. Dickinson, 1951-1955.**

Time of fertilizer application	Year of yield	Yield of hay—dry weight—lbs./acre			
		Check	50 lbs. N	100 lbs. N	150 lbs. N
Spring—1951.....	1951	1627	1976	2233	2250
	1952	467	492	720	841
	1953	3330	3532	4481	4485
3-year average yield		1808	2000	2478	2525
Spring—1952.....	1952	366	619	636	716
	1953	2897	4507	4635	5596
2-year average yield		1631	2563	2635	3156
Spring—1953.....	1953	2778	4436	5451	5561
Fall—1953.......	1954	1105	2098	2229	2362
Spring—1954.....	1954	1243	1953	2083	2381
	1955	1124	1227	1404	1782
2-year average yield		1183	1590	1743	2081
Spring—1955.....	1955	1276	2121	2494	*
Average by years, all trials...		1484	2078	2374	2479

*150 pound application of nitrogen not made in 1955.

The precipitation data (table I), indicate that 1955 also should have been an unusually favorable year, since 9.06 inches of precipitation were received in the April-June period. However, 2.75 inches of that total came on June 27, too late to have much effect on the production of the season's crop of crested wheatgrass hay.

The data of table I illustrate that in many years, precipitation in this area will not be timely nor adequate enough to permit crested wheatgrass to take full advantage of supplemental nitrogen added as mineral fertilizer.

With hay valued at $20 per ton, a high figure for grass hay in this area, and nitrogen at 15 cents a pound, the additional hay would have been produced economically by all levels of nitrogen fertilization only in 1953.

In all other years the fertilizer would have cost more than the value of the extra hay produced with the exception of the 50 pound rate in 1954 and 1955. The extra hay produced in these two years at this rate of fertilization would just pay for 50 pounds of nitrogen.

Yields Resulting From Residual Effects Of Nitrogen

Hay yields are given in table II for all forage harvests included in the trial. Yields were taken on the plots fertilized in 1951 for 3 years in succession—1951, 1952 and 1953. The plots fertilized in 1952 were harvested in 1952 and 1953, and plots fertilized in 1954 were harvested in 1954 and 1955. Residual yields were not determined from plots fertilized in the spring of 1953, fall of 1953 and spring of 1955.

If there were no readily apparent differences between the checks and the fertilized plots, the plots were not cut in subsequent seasons. For this reason it is probable that residual effects were actually somewhat greater than are indicated by the yields shown in tables II and III.

TABLE III.—**Total Additional Forage Produced Above Check Yields and Forage Produced per 50 Pound Increment of Nitrogen Fertilizer, Including Initial and Residual Effects—Dickinson, 1951-1955.**

Time of fertilizer application	Period in which yield was obtained	Total forage produced over production of check pounds per acre			Forage produced per 50 pound increment of N pounds per acre		
		50 lbs. N	100 lbs. N	150 lbs. N	1st 50 lbs.	2nd 50 lbs.	3rd 50 lbs.
Spring—1951....	1951-53 (3 years)....	576	2000	2152	576	1434	142
Spring—1952....	1952-53 (2 years)....	1863	2008	3045	1863	145	1041
Spring—1953....	1953 (1 year).....	1658	2673	2783	1658	1015	110
Fall—1953.......	1954 (2 years)....	993	1124	1257	993	131	133
Spring—1954....	1954-55 (2 years) ...	813	1120	1796	813	307	676
Spring—1955....	1955 (1 year).....	845	1218	*	845	373	*
Average—all trials		1125	1691	2207	1125	568	420

*150 pound application of nitrogen not made in 1955.

The data of table II show substantial residual effects from the 1951 and 1952 nitrogen applications. Rather large boosts in yield occurred in 1953. Some residual effects were noted in 1955 on the plots fertilized in the spring of 1954, although these effects were smaller than in the case of the 1951 and 1952 applications. Apparently, in these trials, some portion of the nitrogen not used in the year of application, remained in the soil available for use in subsequent years.

The total additional forage produced by the fertilizer treatments over the yield of the unfertilized plots, including the additional forage produced by residual nitrogen, is shown in table III. Forage produced per 50 pound increment of nitrogen, including initial and residual forage production, also is presented in table III.

When increased forage yields from response to residual nitrogen fertilizer are considered, the use of nitrogen fertilizer to increase production in old crested wheatgrass stands appears to be economical at the 50 pound rate. The 50 pound application of nitrogen considering all initial and residual responses, produced an average of 1,125 pounds of dry hay per acre more than the check during the period 1951-1955. If hay is valued at 1 cent per pound ($20 per ton), 750 pounds of hay are needed to pay for 50 pounds of nitrogen (nitrogen at 15 cents per pound). With hay valued at $15 per ton, 1,000 pounds of hay per acre are needed to pay for the nitrogen. Thus, the 50 pound rate of nitrogen with residual effects included, would be profitable to the operator.

The average increase in yield over the check, including initial and residual yields, with 100 pounds of nitrogen per acre was 1,691 pounds (table III). Here, again, the additional hay would pay for the cost of the nitrogen, if the hay is valued at $20 per ton. At $15 per ton, however, the additional hay produced would not pay for the nitrogen. At 150 pounds of nitrogen per acre the average extra production of 2,207 pounds of hay per acre just about pays for the nitrogen, with hay $20 per ton. It would not pay for it when hay is $15 per ton.

Effectiveness Of 50 Pound Increments Of Nitrogen

The total production of additional forage over the yield of the check plots per 50 pound increment of nitrogen also is given in table III. These data show that on the average the first 50 pound increment of nitrogen produces the largest response, 1,125 pounds of hay per acre. The second 50 pounds of nitrogen produced an average additional 568 pounds of hay, while the third 50 pound increment produced an average of only 420 pounds of additional hay per acre. Thus, this trial showed the second and third 50 pound increments of nitrogen did not produce enough additional hay to pay for the fertilizer used.

Comparison of the data of tables II and III will show that a large part of the **average** yield response from the second and third 50 pound increments of nitrogen is derived from residual yields obtained in 1953. Considering the rarity of a moisture situation such as prevailed in 1953 and the small responses from the second and third 50 pound increments, it would seem that there is no justification for the use of nitrogen fertilizer at the rate of 150 pounds per acre, and very little justification for the annual use of the 100 pound rate.

Crude Protein Content In Relation To Fertilizer Application

Crude protein in the crested wheatgrass hay samples was determined in 1954 and 1955. The crude protein content of forage samples from all treatments is given in table IV. In all cases crude protein content of the forage was increased by all rates of nitrogen fertilizer.

Table V shows the production of crude protein in terms of pounds of dry weight per acre. When both yield and crude protein content are taken into account, it is apparent that very substantial increases in production of crude protein per acre are obtained from fertilizer treatments at the 50 pound and 100 pound levels of nitrogen. Thus, the fall of 1953 application of 50 pounds nitrogen per acre resulted in the production of 183 pounds of crude protein per acre, while the unfertilized crested wheatgrass produced only 67 pounds per acre. The 100 pound rate of fertilization produced 234 pounds of crude protein per acre.

Increases in crude protein production from the spring of 1954 applications were of the same general order. The 50 pound rate resulted in a production of 2.3 times the crude protein that was produced by the unfertilized plots. Production of crude protein from the plots fertilized with 100 pounds of nitrogen was three times that of the check plots, while production of crude protein from the plots fertilized with 150 pounds nitrogen was 3.3 times that of the check. Increases in crude protein production obtained in 1955 were of the same general magnitude, but the yield of the unfertilized plots was larger, so that

TABLE IV.—**Crude Protein Content of Crested Wheatgrass Hay as Influenced by Nitrogen Fertilizer Applications—Dickinson Experiment Station.**

Time of application	Time of sampling	Crude protein content-percent			
		Check	50 lbs. N	100 lbs. N	150 lbs. N
Fall—1953	1954	6.1	8.7	10.5	11.5
Spring—1954	1954	6.1	8.9	10.7	10.6
Spring—1955	1955	7.8	8.3	9.7	....
Average (3 trials)	....	6.7	8.6	10.3	11.0

TABLE V.—**Production of Crude Protein in Crested Wheatgrass Hay as Influenced by Different Rates of Application of Nitrogen Fertilizer. Dickinson—1954-1955.**

Time of fertilizer application	Time of sampling	Crude protein production—lbs. per acre			
		Check	50 lbs. N	100 lbs. N	150 lbs. N
Fall—1953	1954	67	183	234	272
Spring—1954	1954	76	174	223	252
Spring—1955	1955	99	176	242	...
Average (3 trials)	....	80	178	233	262

the proportional increase was not as great in 1955 as in 1954.

On the basis of the average results of the three determinations, the crude protein of the hay from the fertilized plots was increased over the protein content of the unfertilized plots by 28 percent from 50 pounds nitrogen per acre, by 54 percent from 100 pounds nitrogen, and by 64 percent from 150 pounds nitrogen.

These increases in crude protein content of the forage resulted in increases of average total crude protein production of 123 percent for 50 pounds nitrogen, 191 percent for 100 pounds nitrogen, and 227 percent for 150 pounds nitrogen. On the average, the first 50 pounds of nitrogen produced 98 pounds of protein above the production of the check. The second 50 pound increment of nitrogen produced an additional 55 pounds of crude protein, and the third 50 pound increment of nitrogen only 29 pounds of additional crude protein.

Seed Production In Relation To Nitrogen Applications

Seed yields from the old close-drilled stands of crested wheatgrass were greatly increased by the nitrogen applications when moisture conditions were favorable, as shown by the data in table VI. However, in the period 1951 to 1955 moisture conditions were favorable to seed production only in 1953. Seed yields were not taken in 1954. Residual effects of the nitrogen fertilizer on seed production were not determined.

Seed production from both unfertilized and fertilized plots was very low in 1951 and 1952, and the use of even 50 pounds of nitrogen probably would not have been justified. In 1953 the use of either 50 or 100 pounds of nitrogen would have brought an excellent return, even if only modest prices for crested wheatgrass seed had prevailed. In the 1955 season 50 pounds of nitrogen would have meant the difference between getting a seed crop and not getting one. In farming practice the field probably would not have been harvested for a 45 pound yield, as was produced on the unfertilized plots. However, the yield of 151 pounds on the 50 pound nitrogen plots would have appeared to be a fairly good seed crop, and would have been harvested. As in the case of the forage yields, the 150 pound rate of nitrogen gave little if any real increase in yield over the 100 pound rate.

Results of this trial show that, under favorable moisture conditions, spring applications of 50 to 100 pounds of nitrogen can be expected to yield good returns of seed. However, in drier years the increases in seed production probably would not justify the expense of the fertilizer.

Other Observed Effects Of Fertilizer

Plots which received fertilizer applications were observed to green up earlier in the spring and make a more rapid growth than the unfertilized plots. The result of this earlier rapid growth was that on the average such plots would have been ready for grazing about 5 days earlier than the unfertilized plots. Furthermore the fertilized plots did not mature quite as rapidly as the unfertilized plots. In some seasons the fertilized plots remained green for a week to 10 days later in the summer than the unfertilized plots.

These effects indicate that nitrogen fertilizer should be of considerable value on old crested wheatgrass pastures. Fertilized pastures usually would have a 10 to 15-day longer grazing period than unfertilized, and the increased forage and crude protein production could perhaps be used better as pasturage by grazing animals than by animals getting hay in the feed lot. Furthermore, fluctuation in pasture yields from year to year would be somewhat reduced by the use of fertilizer.

Fall applications of nitrogen have been reported to be more effective in forage and seed production than spring application at Fargo (Carter, 1955[5]). The question of time of application was not investigated in this study. However, in the fall of 1953, fertilizer was applied for comparison with results from an application to be made in the spring of 1954. The results of this comparison are shown in table II. It appears there might have been a small advantage in this instance for the fall applied nitrogen. Late fall applications should give at least as good results as spring applications, and probably would give generally better results, providing the introgen was not removed by surface washing or blowing.

SUMMARY AND CONCLUSIONS

Forage and seed production of old stands of crested wheatgrass at the Dickinson station were increased by applications of nitrogen fertilizer. However, responses to fertilizer applications proved to be uncertain and uneconomical at higher rates. The amount of response to fertilizer applications was directly related to the favorableness of the moisture conditions.

Rates of 50 pounds nitrogen per acre, 100 pounds nitrogen and 150 pounds nitrogen were compared. On the basis of costs and returns, the 50 pound per acre rate of nitrogen fertilization appeared to be the most economical. The 100 pound rate should be profitable for seed production under favorable moisture conditions. There appeared to be no justification for the use of rates of nitrogen fertilization higher than 100 pounds per acre.

Responses in forage and seed production that were great enough to

TABLE VI.—**Seed Production in Relation to Nitrogen Fertilization of Old Crested Wheatgrass Stands—Dickinson Experiment Station.**

Year	Pounds per acre of clean seed at different treatments: Check	50 lbs. N	100 lbs. N	150 lbs. N	Percentage increase over check: 50 lbs. N	100 lbs. N	150 lbs N
1951	34	70	67	82	106	97	141
1952	12	24	21	16	100	75	33
1953	231	516	698	681	123	202	195
1955	45	151	180	...	235	300	...
4-year average	80	190	241	...	...	...	...

indicate near maximum utilization of the applied nitrogen occured in only 1 year of the five included in the period of study, 1951-1955. This was the 1953 season, when 10.96 inches of precipitation were received in the period, April- June, inclusive. All nitrogen applied to the plots apparently was not used in the drier seasons to produce additional forage or seed. Harvest of these plots in the second and third season after the fertilizer was applied showed that there were substantial residual effects on forage production. Residual effects were noticeable for as much as 3 years.

The results obtained thus far with nitrogen fertilizer at the Dickinson station do not justify a general recommendation for their use in this area to increase forage production of old crested wheatgrass stands. Whether to use nitrogen on crested wheatgrass stands for increased hay or pasture production is an individual decision, and requires individual testing. Total forage yields and crude protein production are increased but, because of limiting conditions, immediate apparent responses may not be obtained.

Trial rates and times of application that seem most promising so far are: 50 pounds nitrogen per acre each year applied in either early spring or late fall, and 100 pounds nitrogen per acre applied every second or third year in either early spring or late fall. In years when it appears that moisture conditions are likely to be favorable, the heavier rate of fertilization could be used to advantage.

Experiments are now in progress at the Dickinson station involving the use of both heavier and lighter rates of nitrogen fertilization than those used in this trial. Four varieties of grass are included in the new trials as well as grass and alfalfa mixtures.