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Forage Production and Botanical Composition of Mixed Prairie as Influenced by Nitrogen and Phosphorus Fertilization[1]

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ABSTRACT

Shortage of available nutrients is limiting productiveness of native range in portions of the northern Great Plains. The demand for increased forage production to support an increasing number of livestock will require use of intensive management practices, including range fertilization.

Response of mixed prairie vegetation to annual applications of 0, 45, 90, and 180 kg elemental N/ha and 0, 20, and 40 kg elemental P/ha was studied over an 8-year period near Mandan, N. D. At all P levels and for each harvest height used, increase in dry matter production in response to N was highly significant and nearly linear in nature for the 45-N and 90-N levels. Harvest at a height of 25 mm on August 1 produced 8-year average annual dry matter yields of 810, 1,938, 2,960, and 3,097 kg/ha for the 0-N, 45-N, 90-N, and 180-N levels, respectively. Harvest at the soil surface produced 6-year average yields of 2,047, 3,035, 3,898, and 4,205 kg/ha for the respective N levels. Response to P was often not significant during the first 3 years of the study; however, over the 8-year period, each increment of P produced a significant yield increase. Without N, response to P was small, but as N level increased, response to P increased. Density of western wheatgrass (*Agropyron smithii* Rydb.) increased and basal cover of blue grama (*Bouteloua gracilis* [H.B.K.] Lag.) decreased as N level increased under the harvest system used in this study.

Additional index words: **Grassland management, Range fertilization, Western wheatgrass, Blue grama.**

AVAILABLE soil moisture rather than available plant nutrients is generally considered to be the factor limiting productiveness of mixed prairie in the northern Great Plains. However, Westin et al (12) reported increased yields from application of 22.5, 45, and 90 kg N/ha to native pastures that had been grazed at heavy, moderate, and light intensities during the previous 10 years at the Range Field Station near Cottonwood, S. D. They found that N produced most of the increase in yield, although in some cases annual application of N over a 3-year period resulted in response to P. Highly significant yield increases were reported by Rogler and Lorenz (8) from fertilization of both heavily grazed and moderately grazed mixed prairie near Mandan, N. D. Application of 34 kg N/ha in October of each year to plot areas in both pastures, doubled the average yield over a 6-year period and 100 kg/ha more than tripled it. When cut for hay, annual forage yields averaged 838, 1,486, and 2,546 kg/ha for the 0-, 34-, and 100-N treatments, respectively, for plots in the heavily grazed pasture, and 735, 1,473, and 2,250 kg/ha for plots in the moderately grazed pasture. Increase in forage yield per kg N applied varied with seasonal precipitation, being less than 11 kg in 1952, a relatively dry year (April-September precipitation of 19 cm) and over 45 kg in 1953 (42 cm). Most of the yield increase was attributed to increase in western wheatgrass (*Agropyron smithii* Rydb.). Blue grama (*Bouteloua gracilis* [H.B.K.] Lag.) decreased in the cover at the heavier rates of N.

These reports of response by mixed prairie vegetation to N and P fertilization and the associated change in species composition led to the establishment of the following study in 1958. Since then a number of papers have reported favorable increases in mixed prairie production due to fertilization (1, 2, 3, 4, 6, 9, 10, and 11), while others have reported less favorable results (4, 5, and 6). Single rather than repeated applications of fertilizer were used in many of these studies.

PROCEDURE

The study area was selected for uniformity of topography, slope, and vegetative cover on a nearly level site located on the Missouri Plateau west of the Missouri River near Mandan, N. D. The Temvik soil series is a well-drained Chestnut soil formed from about 60 cm of calcareous silt-loam loess over a clay-loam glacial till. The glacial till has a pH of 8.0 to the 2-m depth. The 0- to 15- and 15- to 30-cm increments of the loess layer contained 0.266 and 0.147% total N, respectively. Sodium bicarbonate soluble P content was found to be 12 kg P/ha in the surface 15 cm of soil and about 5.6 kg/ha in each of the next three 15-cm depth increments.

The site was originally part of a school section, cut for hay in the years prior to 1915. Since 1916 it has been part of the grazing research area of the Northern Great Plains Research Center and has been grazed at a light to moderate intensity through the years. Rogler (7) described the vegetation of the experimental area as mixed prairie with blue grama, western wheatgrass, threadleaf sedge (*Carex filifolia*, Nutt.), and needle-andthread (*Stipa comata*, Trin. & Rupr.) as dominant species.

The 1915-1970 average annual precipitation at the Research Center was 40.3 cm, and the average growing season (April-August) precipitation was 28.6 cm. Annual precipitation averaged 39.1 cm and seasonal precipitation averaged 30.4 cm during the period of this study (1958-1965). Seasonal precipitation was near the long-term average each year during this period, except in 1959 (17.9 cm) and 1961 (18.3 cm), two unusually dry years. In 1960 high intensity showers on May 25 (4.1 cm) and on June 19 (10.1 cm) resulted not only in greater than seasonal-level precipitation (34.9 cm), but also in excessive runoff that reduced the effective precipitation to less than average for that year. The 1962 seasonal precipitation was 3.6 cm less than in 1960, but it came as gentle, effective showers, distributed well through the season. Thus, 1962 was one of the best grass-production seasons on record. Precipitation was slightly more than average in 1963 and 1964 and far above average (59.3 cm annual) in 1965, also one of the best years on record.

The study was initiated in the fall of 1957, using a randomized complete block design replicated three times. Fertilizer treatments included 0, 45, 90, and 180 kg elemental N/ha and 0, 20, and 40 kg elemental P/ha in a 4 by 3 factorial set. Fertilizer was applied on November 3, 1957 and about mid-October each year thereafter through 1964. Ammonium nitrate was the source of N and treble superphosphate was the source of P.

Plot size was 180 by 611 cm, and a 91-cm swath 611 cm long was cut with a sickle-bar-type mower on about August 1 of each year, 1958 through 1965. The mower was equipped with metal shoes to provide a cutting height of about 25 mm. In addition to the mower harvest, three 30.5- by 61.0-cm areas were clipped with grass shears at the soil surface. A record of the location of these surface harvest areas was maintained to prevent using the same area more than once in either the 1958 to 1960 period or in the 1963 to 1965 peirod. Harvest at the soil surface was omitted in 1961 and 1962 to provide a longer period between repeated use of the sample areas.

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Changes in botanical composition were evaluated by point-quadrat and list-count methods. A total of 100 points per plot was observed each year using a vertical-point frame of 10 3.2-mm-diameter pins spaced on 51-mm centers. The point-frame locations were permanently marked in each plot. Thus, the point contacts were very nearly in the same location each year. Hits were recorded as contacts at the soil surface for bare soil, mulch, and each of the major species, with the less common grasses and forbs combined in general categories. The results are reported as percent basal cover. Single-stalked species such as western wheatgrass are not adequately evaluated by the point method; thus, actual counts of the stems of these species were made in each of two permanently marked 30.5- by 61-cm areas in each plot, and the results are reported as number of stems per 0.5 m².

RESULTS AND DISCUSSION

Harvest by mechanical means and on a specific date has a different effect on vegetation than does grazing, which is the primary use for mixed prairie. However, removal of the forage by mechanical means at the end of the growth period does provide some valuable information on response of the vegetation to various treatments, fertility level in this case.

Dry Matter Production

Year-to-year variation in response to N was very large for both the 25-mm and the surface harvests, as shown in Fig. 1. It is evident that effective precipitation and other environmental factors have a large influence upon response to fertilizer within any one year. However, it is of importance that even in the dry years of 1959 and 1961, plots fertilized with N yielded significantly more than did those without N. From the practical standpoint, relatively small increases in yield are of more than usual value in a dry year.

Plots receiving 45-N produced more forage in 1962 than did plots receiving either 90-N or 180-N in any other year of the study. The tremendous yield increase in 1962 may have been caused by an accumulation of available N during the previous 3 years, when precipitation was either below normal (1959, 1961) or occurred as high-intensity showers (1960). If so, factors other than lack of N prevented yield increase by the last increment of N. It is unfortunate that 1962 was one of the 2 years in which yields were not determined by clipping at the soil surface.

Dry matter yields for each treatment when harvested at the 25-mm height each year are shown with the 8-year averages in Table 1. Average anual dry matter production per ha ranged from 570 kg in 1961 to 5,259 kg in 1962. Plots that received 180 kg elemental N and 40 kg elemental P/ha annually (180-40) produced 8,050 kg/ha in 1962, the highest average yield during the 8-year period. The lowest yield for this treatment was 844 kg/ha in 1959 when the 0-0 treatment produced only 241 kg. Average dry matter production as measured by harvest at the soil surface in 6 of the 8 years is shown in Table 2. The 6-year average yields obtained by harvest at the 25-mm height for the 6 years in which the surface harvests were made are also shown. Although the percentage of the total dry matter production below the 25-mm height decreased as N level increased, weight of the dry matter below 25-mm was influenced very little by N level, with averages of 1,332, 1,358, 1,263, and 1,379 kg/ha for the 0-N, 45-N, 90-N, and 180-N levels, respectively. Based on these averages, at least 1,300 kg/ha could be added to the unusually high yields from the 25-mm harvest in 1962. This would give an estimated surface harvest yield in 1962 of 3,000 kg/ha without fertilizer, and 9,300 kg for the 180-40 treatment, an increase in total dry matter production of 6,300 kg/ha in response to fertilizer.

Surface harvest yields in 1965, another very productive grass year, ranged from 2,476 kg without fertilizer to 6,084 kg for the 180-40 treatment, an in-

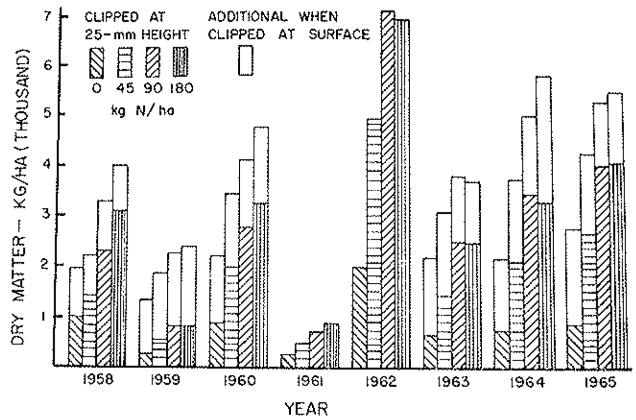

Fig. 1. Dry matter yield of mixed prairie when fertilized with N and harvested at two heights on August 1 each year.

Table 1. Average dry matter yields of mixed prairie fertilized annually with various rates of N and P when harvested at 25-mm height on August 1 of each year.

Fertilizer		Kilograms dry matter per hectare								
N	P	1958	1959	1960	1961	1962	1963	1964	1965	Avg
kg/ha										
0	0	785	241	689	165	1759	575	619	782	702
0	20	1000	266	792	251	1935	648	717	856	808
0	40	1105	254	1075	271	2208	747	770	943	921
45	0	1286	571	1880	379	4555	1286	1713	2279	1744
45	20	1354	470	1833	472	4887	1425	2134	2802	1922
45	40	1598	529	2201	584	5444	1550	2395	2895	2150
90	0	2180	600	2464	504	6361	2090	3009	3450	2582
90	20	2123	815	2592	789	7316	2594	3563	3839	2954
90	40	2602	1001	3272	846	7791	2782	3742	4723	3345
180	0	2739	733	2487	707	6029	1927	2739	3456	2602
180	20	3552	864	3965	1004	6774	2525	3273	3892	3231
180	40	2997	844	3273	872	8050	2943	3794	4864	3455
Average		1943	599	2210	570	5259	1758	2372	2898	2201
LSD 0.05		438	244	860	174	879	267	521	653	309
0.01		597	333	1171	237	1197	364	711	890	420
CV		13.4	24.2	23.0	11.9	9.9	9.0	13.0	13.3	8.30

Table 2. Average dry matter yields of mixed prairie fertilized annually with various rates of N and P when harvested at the soil surface, with the 6-year averages for the surface and 25-mm heights of cutting and the average production below 25 mm.

Fertilizer		Kilograms dry matter per hectare						Six-year average			
								Surface harvest	25-mm harvest	Production below 25 mm	
N	P	1958	1959	1960	1963	1964	1965				
kg/ha								kg/ha			%
0	0	1847	1179	1873	1920	1974	2476	1878	615	1263	67.3
0	20	2053	1350	2177	2355	2228	2985	2191	713	1478	67.5
0	40	1821	1261	2423	2089	2132	2704	2072	816	1256	60.6
45	0	1934	1809	2874	2679	3206	3812	2719	1502	1217	44.8
45	20	2210	1619	3265	2897	3705	4382	3013	1670	1343	44.6
45	40	2293	1899	4039	3528	4071	4424	3376	1862	1514	44.9
90	0	3062	1826	3460	3565	4377	4924	3536	2299	1237	35.0
90	20	3434	2039	3724	4191	5124	4902	3902	2588	1314	33.7
90	40	3160	2714	5018	3468	5338	5843	4257	3020	1237	29.1
180	0	3801	1907	3879	3022	3868	4554	3505	2347	1158	33.0
180	20	4212	2567	5310	4090	5621	5597	4566	3012	1554	34.0
180	40	3811	2516	5006	3766	6085	6084	4545	3119	1426	31.4
Average		2803	1891	3587	3130	3977	4391	3297	1964	1333	40.4
LSD 0.05		676	503	1233	800	757	935	518			
0.01		920	686	1680	1091	1031	1274	705			
CV		14.2	15.8	20.4	15.1	11.3	12.6	9.3			

crease of 3,608 kg dry matter/ha. Harvest at the 25-mm height produced only 4,864 kg for the 180-40 treatment in 1965, compared with 8,050 kg for that treatment in 1962. When cut at the 25-mm height, the 1965 yield was 60% of the 1962 yield, while the 1965 yield from the surface harvest was 65% of the 9,300 kg estimated 1962 surface yield, suggesting that the surface yield estimate for 1962 is probably low.

Production below 25 mm is important to proper management of the grassland. It was about the same for all treatments (Table 2); however, fertilizer increased total dry matter production, which resulted in large differences in the percentage of the total yield below this height. It ranged from 67% without N to about 33% with 180-N. Most of the increase in yield was above 25-mm and would be readily available to a grazing animal. To insure continued high production, grazing management must take into consideration differences in fertilizer response by the major species of the mixed prairie. Changes in species composition that occurred under the harvest system used in this study are discussed later in this paper.

Table 3. Summary of the response of mixed prairie vegetation to various levels of N and P as measured by average dry matter production over an 8-year period for a 25-mm harvest height, and in 6 of the 8 years for harvest at the soil surface.

	Kilograms dry matter per hectare		
	25-mm harvest height		Harvest at soil surface
Fertility level	8-year	6-year	6-year
kg/ha			
0-N	810	715	2047
45-N	1939	1678	3036
90-N	2960	2636	3898
180-N	3096	2826	4205
LSD 0.05	178	140	299
0.01	243	192	407
0-P	1908	1691	2910
20-P	2228	1996	3418
40-P	2468	2204	3563
LSD 0.05	155	122	259
0.01	210	166	353

A summary of the yield response to N and P is presented in Table 3. The values in this table are the 6- and 8-year averages of the three P levels for each N level and of the four N levels for each P level. Without N, yields averaged 810 kg/ha when harvested at the 25-mm height and 3,096 kg when 180-N was applied anually for the 8 years.

Sums of squares attributed to fertilizer response were split into linear and quadratic portions by regression methods to determine the character of the fertilizer response. F values from these analyses are presented in Table 4. They show a strong linear response to N (N_L) for both harvest heights. Although the quadratic effects (N_Q) were often significant, the relatively large F values for the linear effects indicate a close fit to the equation for a straight line. Significant F values for $N_L \times P$ in 1962, 1963, and 1965; and for the 8-year average for the 25-mm harvest; and in 1964 for the surface harvest, indicate that the linear effect for N was not of the same magnitude for each P level. A few examples of this effect are shown in Fig. 2. The first three increments of N resulted in near-straight-line increases in yield, but the fourth increment yielded less than the third for the 0-P and 20-P levels but slightly more than the third for the 40-P level. In all cases, the slope of the curve changed abruptly between the 90-N and 180-N levels.

Yields from the 25-mm harvest (Table 1) in 1958 show that plots receiving the 90-20 treatment yielded slightly less than those receiving the 90-0 treatment, and those receiving 180-20 yielded slightly more than did those receiving 180-40, which accounts for the significant $N_Q \times P$ interaction (Table 4). This was the only time the $N_Q \times P$ interaction was significant for either height of harvest. Significant F values for N_D occurred for the 25-mm harvest data in 1963, 1964, and for the 8-year average because the response from the second increment of N was greater than for

Table 4. F values from analysis of variance of the dry matter yield data for each year and for the 8-year and 6-year averages for the 12 fertilizer treatments when harvested at 25 mm and at the *soil surface* on August 1.

	Degrees of freedom	Significant F values		F values*								
		5%	1%	1958	1959	1960	1961	1962	1963	1964	1965	8-year / 6-year
Replication	2	3.44	5.72	3	5	1	3	2	4	2	5	6
				1	3	2			1	< 1	1	1
Fertilizer	11	2.26	3.18	35	10	12	21	56	86	44	41	89
				14	9	7			8	29	14	28
Nitrogen	3	3.05	4.82	120	31	38	66	193	283	152	137	303
				50	23	20			22	89	45	90
N_L	1	4.30	7.94	353	83	111	194	489	759	388	362	836
				145	66	59			55	249	121	258
N_Q	1	4.30	7.94	4	7	4	2	85	56	57	45	66
				3	4	1			11	19	12	11
N_D	1	4.30	7.94	2	2	< 1	< 1	4	35	11	2	8
				4	< 1	< 1			1	1	< 1	1
Phosphorus	2	3.44	5.72	5	2	4	15	16	35	14	15	28
				2	6	7			5	18	7	15
P_L	1	4.30	7.94	10	4	8	24	32	69	27	30	56
				< 1	12	13			5	33	13	27
P_Q	1	4.30	7.94	1	< 1	< 1	6	< 1	1	< 1	< 1	< 1
				3	< 1	< 1			5	3	< 1	3
N × P	6	2.55	3.76	3	2	2	2	1	5	1	2	2
				< 1	2	1			1	3	1	2
$N_L \times P$	2	3.44	5.72	2	1	3	2	4	14	3	5	6
				< 1	3	1			1	8	2	3
$N_Q \times P$	2	3.44	5.72	5	1	2	2	< 1	< 1	< 1	< 1	< 1
				< 1	3	2			< 1	1	1	2
$N_D \times P$	2	3.44	5.72	1	3	1	1	< 1	1	< 1	1	< 1
				< 1	1	< 1			3	1	1	< 1
$P_L \times N$	3	3.05	4.82	< 1	3	< 1	1	3	9	2	3	4
				< 1	3	< 1			1	5	1	2
$P_Q \times N$	3	3.05	4.82	1	< 1	3	2	< 1	< 1	< 1	1	1
				< 1	2	1			2	1	1	1

* Rounding to the nearest whole number did not change the interpretation. Values for the surface harvest data are underlined.

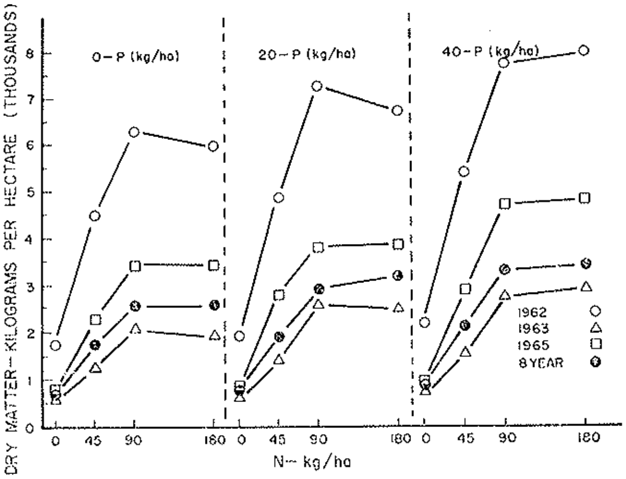

Fig. 2. The effect of N level at each of three P levels on dry matter production of mixed prairie in each of 3 years and for the 8-year average when harvested at 25-mm height on August 1.

either the first or the third, resulting in deviation from both the linear and the quadratic equations.

Response to P was erratic during the first 3 years of the study. When harvested at the soil surface, increase in yield due to P was not significant in 1958, but when harvested at the 25-mm height, the plots receiving P produced significantly more than did those without P, but the difference between the 20- and 40-P levels was not significant. In 1959, the 2nd year of the study, yield increases from application of P were not significant for the 25-mm harvest, but when harvested at the soil surface, application of 40-P resulted in a significant yield increase. The yield increase from application of P became greater as the study became older and in 1962, 1963, 1965, and for the 8-year average, yield increases from each increment of P were highly significant when harvested at 25-mm height. When yield was harvested at the soil surface, application of P produced highly significant increases in yield in 1963, 1964, 1965, and for the 6-year average; however, differences in yield between the two rates of P were not significant.

F values (Table 4) for the linear effect of P level on yield (P_L) were significant each year, except 1958, for the surface harvest and except 1959 for the 25-mm harvest; i.e., the linear effect was significant in all cases in which P response was significant. The quadratic effect of P level on yield (P_Q) was significant only in 1963 for the surface harvest and in 1961 for the 25-mm harvest. In these two cases, the degree of response to P decreased as N level increased. The significant F values for $P_L \times N$ for the 1963 25-mm harvest and for the 1964 surface harvest indicate that although the P response was primarily linear, as indicated by the relatively large F values for P_L, the linear effect was not of the same magnitude for each N level. This was also true for the 8-year average yield data from the 25-mm harvest. In general, the response was greater at the 90-N level than at the 0-N and 45-N levels, and at the 180-N level the response was less for the second increment of P than for the first.

The effects of P level on response to N for the 8-year average yields when harvested at the soil surface and at the 25-mm height are shown in Fig. 3. At all three levels of P, response to N was nearly as great for the second increment as it was for the first. This was followed by leveling off with little or no response to the third increment of N without P, and with 40-P, and some increase from the last increment of N at the 20-P level, especially when harvested at the soil surface. The N effects on P level for the same data are shown in Fig. 4. Small increases in dry matter production resulted from application of P without N and with 45-N; however, the increase was more pronounced when P was applied with 90-N and 180-N.

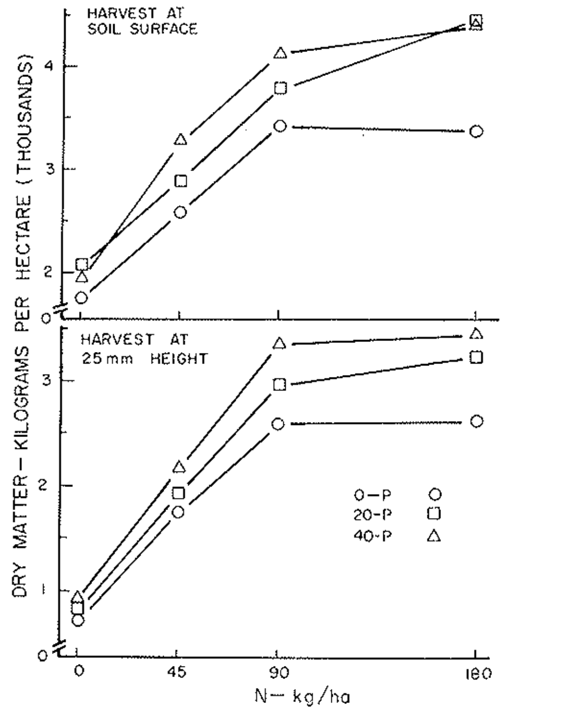

Fig. 3. The effect of P level on response to N by mixed prairie when harvested at the soil surface and at 25-mm height on August 1.

Botanical Composition

Fertilizer was applied in the fall of 1957, and by the time the first botanical data were gathered in July 1958, it was evident that some species change had already occurred. Using the plots that weren't fertilized as the base for comparing treatment-induced change in botanical composition is not very satisfactory because the variability of mixed prairie results in large differences between plots before the treatments are applied. Therefore, the botanical data can best be used to follow trends in species change due to treatment over a period of years.

The most obvious botanical changes and the ones having the greatest influence on dry matter production occurred in western wheatgrass density and blue grama cover. These changes occurred primarily in response to N. Under the harvest system used and over the period of years involved, western wheatgrass decreased in density from 1958 to 1965 without fertilizer, while a consistent increase occurred over this period when N was applied. A summary of the number of stems of western wheatgrass per 0.5 m² for

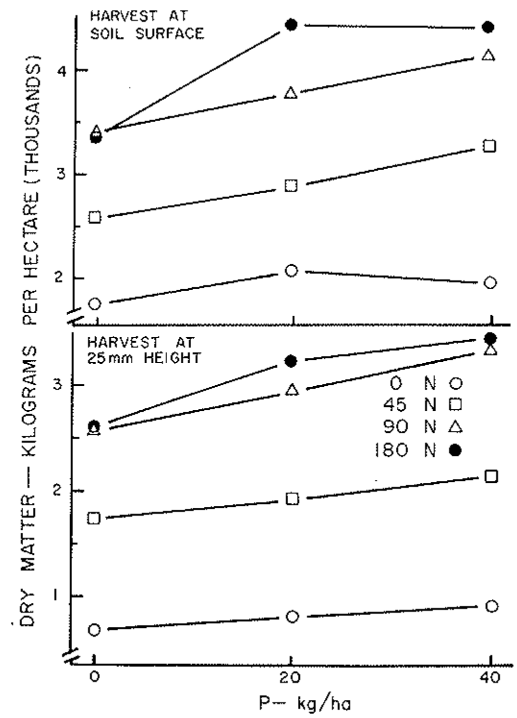

Fig. 4. The effect of N level on response to P by mixed prairie when harvested at the soil surface and at 25-mm height on August 1.

each N level without P and for each with 40-P and of the basal cover of blue grama for these treatments in each year is shown in Table 5. Without N or P, the number of stems of western wheatgrass ranged from 13 to 40, with an average of 25 per 0.5 m². When 40-P was applied without N, the range was from 15 to 44, with an average of 27. There was little difference in extremes and averages between 45-N and the 90-N treatments with and without P. But at the 180-N level western wheatgrass reached its greatest density when P was also applied. The greatest number of stems occurred in plots of this treatment in 1963 and in 1965 with 639 and 753 stems/0.5 m², respectively. The increase in number of stems with increasing N level within each year and the change in number of stems for a given N level with years, was quite consistent for all treatments, except 180-N without P. This treatment always had less stems of western wheatgrass than did 90-N without P, and far less than did 180-N with P. Western wheatgrass definitely responded to P at the 180-N level.

Basal cover of blue grama (Table 5) ranged from 19 to 45% without N and averaged 30% with and 34% without P. A slight decrease in basal cover occurred when 45-N was applied, especially after 1962. This coincides with the time of greatest increase in western wheatgrass density. As the level of N was increased to 90 and 180 kg/ha, basal cover of blue grama decreased sharply, particularly when 40-P was applied with the N. The basal cover was less than 7% in 1963, 1964, and 1965 for the 90-40 treatment and 3, 2, and 1%, respectively, in these 3 years for the 180-40 treatment. Without P, basal cover of blue grama was greater than 10% in all years except 1963, but decreased to 3 and 4% for the last 3 years for the 180-0 treatment.

Table 5. Average number of stems of western wheatgrass and average percent basal cover of blue grama in mixed prairie for each of four levels of N with and without P, when harvested at 25-mm height on August 1.

Year	Western wheatgrass (Stems per 0.5m²)				Blue grama (Percent basal cover)			
	0-N	45-N	90-N	180-N	0-N	45-N	90-N	180-N
				Without P				
1958	40	108	98	43	37	27	37	31
1959	35	161	100	65	45	42	36	42
1960	24	136	171	109	23	21	12	16
1961	22	94	137	70	29	23	17	24
1962	13	106	161	151	35	29	22	16
1963	22	233	435	327	27	16	6	3
1964	28	176	307	191	35	19	12	3
1965	17	245	369	219	37	22	10	4
Average	25	157	222	147	34	25	19	17
				With 40-P				
1958	44	106	83	106	43	24	50	31
1959	26	125	100	153	41	39	36	35
1960	40	108	89	176	19	22	15	15
1961	23	69	57	129	29	30	26	27
1962	26	175	215	386	27	26	23	12
1963	20	222	382	639	22	15	5	3
1964	16	166	235	357	27	21	7	2
1965	15	171	441	753	34	20	5	1
Average	27	143	200	337	30	25	21	16

During the last 3 years of the study dry matter production was often less at the highest level of fertilization than it was at the lesser levels. When blue grama remained as part of the stand, total dry matter production was increased by several hundred pounds per acre. Western wheatgrass is a rhizomatous cool season species that responds to N early in the season when soil moisture in the Northern Plains is usually at its best for the season and when soil temperatures are too low for growth of blue grama, a warm season species. Thus, the two major species in much of the mixed prairie are competitors for space and soil moisture. When fertilizer is applied, western wheatgrass is given a definite advantage over the less aggressive species, blue grama. The growth habits of these two species are such that total forage production is greater when they are growing in association than when either of them is grown alone. Western wheatgrass furnishes early spring growth, while blue grama furnishes green forage for the grazing animal during July and August, when western wheatgrass has matured and is less palatable. Thus, it is desirable to maintain a mixture of these two species, in order to provide maximum dry matter production of the mixed prairie and to provide desirable forage for the grazing animal. It is encouraging to note that at the 45-N level, blue grama remained in fair quantity and that yield increases were sizeable at this level of fertilization. Investigations are in progress to determine the actual cause of the blue grama loss and then to determine what management practices are needed to avoid its loss at higher levels of N fertilization.

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