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Cover photo: Reed canarygrass being mowed for hay at the Newell Field Station in 1965. The stand was spring fertilized annually with 100 pounds nitrogen per acre.

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INTRODUCTION

Livestock production in western South Dakota and other portions of the Northern Great Plains is a primary source of agricultural income. Maximum sustained livestock numbers are directly related to adequate forage production. Prior to recent advances in agricultural technology and application, maintenence of livestock numbers was difficult in periods of drought or heavy snowfall. With the advent of mechanized farming equipment, increased acreages of irrigated land, improved forage varieties, and better management practices, much has been done to increase and stabilize forage production, thereby stabilizing livestock production.

Some portions of the region, including the Belle Fourche Irrigation Project, have great potential for producing sustained abundant forage as hay, silage, and/or summer pasture. Although an estimated two-thirds of the irrigable land on the Project currently is devoted to forage production, little information is available concerning introduced grass yields, persistence, quality, and regrowth characteristics on irrigated Pierre Clay soils. This lack of information prompted a study to evaluate several characteristics of 11 common grasses grown without nitrogen, with commercial nitrogen, and with alfalfa.

LITERATURE REVIEW

Perennial Forage Production

The compatibility of species mixtures has been examined by Campbell (1963) in Saskatchewan. During a drought (1959-61) several advantages of legume-grass mixtures over straight grass were reported. The alfalfa-grass mixture gave greater forage yields, protein content, carrying capacity, live weight gains per ewe per acre, and required less forage consumption per pound of live weight gain.

Allred (1965) conducted a study in Utah to determine how to maintain a proper pasture mixture of orchardgrass, smooth brome, and alfalfa. He achieved a desirable 50:50 grass to alfalfa ratio by relatively frequent irrigation, frequent clipping, and heavy applications of nitrogen to stimulate the grass while reducing alfalfa vigor. In contrast, Carter and Scholl (1962) working in Iowa found a legume-grass balance could be maintained only if management practices favored the legume.

A dryland study in western South Dakota indicated that production from an old stand of crested wheatgrass and smooth brome could be increased by nitrogen and phosphorus application (Thomas and Osenbrug, 1964). Nitrogen improved vigor of the grasses, increased growth initiation by 6 to 10 days, and increased plant nitrogen. They also noted that increased precipitation decreased plant nitrogen.

A North Dakota publication (Lorenz and Rogler, 1961) reported on irrigated forage crops for that state. Ten of the grasses they tested were also examined in this study. Grass production and persistence in fertilized pure stands and with alfalfa were measured. They found smooth brome was the best adapted grass for pure stands or mixtures. Reed canarygrass also was adapted, but orchardgrass was not. Alfalfa was the highest yielding legume, the variety Vernal being one of the best. Pure grass stands, when fertilized with 160 pounds of nitrogen per acre annually, produced as much as alfalfa-grass combinations.

Wagner (1954a) found that orchardgrass or tall fescue grown with Ladino clover yielded more forage than either grass grown alone with 160 pounds of nitrogen annually. In a similar comparison using orchardgrass, smooth brome, and legumes, Carter and Scholl (1962) found that 240 pounds of nitrogen per acre on the pure grass stands was needed to equal production of the grass-legume stands.

A 3-year irrigated grass study in Colorado (Dotzenko, 1961) showed that at both the zero- and 80-pound rate of nitrogen the highest to lowest production came from tall wheatgrass, intermediate wheatgrass, tall fescue, orchardgrass, and smooth brome. The range in production was 2.2 to 4.2 tons for tall wheatgrass and 1.3 to 3.1 for smooth brome.

Regrowth production of nitrogen fertilized alfalfa was reduced when grown in combination with orchard grass, timothy, or smooth brome, but regrowth production of the grasses was increased (MacLeod, 1965). Interspecific competition of the grass-alfalfa mixture reduced regrowth production of the components when compared to pure stands.

Schmidt and Tenpas (1965) in Wisconsin compared regrowth ability of grasses and legumes as related to fertilizer application. In a wetter year, orchardgrass and smooth brome produced more mid-summer production than legume-grass mixtures. In a drier year, the legume-grass mixtures had greater regrowth production than fertilized smooth brome, but no greater than fertilized orchardgrass.

Wolf and Smith (1964), also in Wisconsin, found orchardgrass-alfalfa out-produced smooth brome-alfalfa and maintained a better balance of species after the first cuttings in both years. Similarly, MacLeod (1965) ranked regrowth potential of alfalfa above orchardgrass and orchardgrass above smooth brome.

Three grasses, Russian wildrye, intermediate wheatgrass, and crested wheatgrass, grown with alfalfa on dryland, were reported to vary in inter-specific competition (Kilcher and Heinrichs, 1966b). Production from the Russian wildrye with alfalfa was lower than the other two mixtures as the wildrye eventually depleted the alfalfa stand.

In another study (Kilcher and Heinrichs, 1966a) found crested wheatgrass or intermediate wheatgrass with alfalfa produced higher yields than Russian wildrye or smooth brome with alfalfa. The wildrye and brome reduced the alfalfa component resulting in reduced production from the mixtures.

Nitrogen fertilization has been shown to increase percent nitrogen of grasses (Dotzenko, 1961). The grasses, smooth brome, orchardgrass, intermediate wheatgrass, tall wheatgrass, tall fescue, and tall oatgrass showed increases in nitrogen at all levels of fertilization over the control. Earlier, Wagner (1954b) found protein percentage of orchardgrass and tall fescue was markedly increased by nitrogen fertilization.

Grazing Irrigated Pastures

An irrigated pasture rotation study on the Belle Fourche Project in western South Dakota compared production from smooth brome-orchardgrass to the same grasses with alfalfa (Nichols, *et al.,* 1968). Annually, both pasture combinations received 22 pounds of phosphorus (50 pounds of P_2O_5) per acre. In addition, the grass pastures were fertilized with 150 pounds of nitrogen per acre in three applications while the alfalfa-grass pastures received 50 pounds nitrogen. Forage production for 2 years averaged 5,307 pounds per acre for the grass and 7,027 for alfalfa-grass pastures when clipped three times each season. Approximately 50% of the production from the alfalfa-grass mixture was alfalfa. Steer gains over a 3-year period (grazing season of about 105 days each) averaged 275 pounds per acre for the grass and 334 for alfalfa-grass pastures. Average daily gains were similar for both pastures. None of the 86 animals suffered from bloat.

An irrigated pasture study in Washington compared steer production on six forage combinations of orchardgrass, tall fescue, Ladino clover, and alfalfa (Heinemann and Van Keuren, 1958). The largest beef gains over a 4-year period were from the orchardgrass-alfalfa mixture which was 40% grass by weight. Average daily gains for the alfalfa-grass pastures were 2.07 pounds contrasted to 1.74 pounds for the grass pastures. The degree of finish was superior for steers grazing alfalfa-grass. Returns per acre were greatest from legume-grass pastures. Comparing fertilized tall fescue with fertilized orchardgrass pastures, the fescue gave greater average daily gain, liveweight gain, animal days per acre, animal units per acre, and net return.

STUDY AREA AND METHODS

The Newell Irrigation and Dryland Field Station is located on the Belle Fourche Irrigation Project of western South Dakota in the west-central Northern Great Plains. Approximately 50% of the 15.5 inches of average annual precipitation during the last 55 years of the Station has fallen in March through June. Annual pan evaporation since 1949 has averaged 57 inches, 44 inches from May through October. The growing seasons, determined by killing frosts, have averaged 131 days. Temperature extremes of 100° F and −20° F both occur on the average of slightly more than three times a year (Spuhler *et al.,* 1968).

Soils in the study area were developed from Pierre Shale. Soil clay content normally exceeds 65%. Thomas and Osenbrug (1964) described the surface 6 inches of soil as slightly basic, low in organic matter (1.9%), high cation exchange capacity (37 meq. per 100 grams), and soluble phosphorus of 7.0 ppm. The study site was located on land that had been bench leveled for flood irrigation.

Eleven grasses believed adaptable to irrigation, heavy soils, and regional climate were selected for study. The grasses were Nordan crested wheatgrass, tall wheatgrass, Oahe intermediate wheatgrass, slender wheatgrass, pubescent wheatgrass, Lincoln smooth brome, Avon orchardgrass, Vinall Russian wildrye, Alta tall fescue, meadow fescue, and reed canarygrass.

On May 2, 1963, plots 9 by 25 feet were seeded with a grass drill. Each of the grasses was treated as follows: (1) grass grown alone without supplemental fertility, (2) grass grown alone with 100 pounds of inorganic nitrogen per acre annually, and (3) grass grown in association with Vernal alfalfa, seeded to approximate 50% of the stand. The 33 treatment combinations, in randomized blocks with five replications, comprised a 3 by 11 factorial design.

Good stands were obtained on all plots, and were irrigated on July 25, August 27, and October 9, 1963, with approximately 4 inches of water each application. Irrigation dates and rates in following years were similar. No water was available for irrigation before the first clipping harvest in any year. First harvest production may have been reduced in 1965 due to the absence of irrigation water and to low spring precipitation. The plots which received fertilizer were broadcast with ammonium nitrate prior to spring greenup beginning in 1964.

Forage production was estimated from plots 4.8 by 2 feet clipped near ground level, twice yearly from 1964 through 1967. The two clippings, about June 15 and August 20, were taken when alfalfa reached full bloom. In 1966 and 1967, grass and alfalfa, when grown together, were separated into two components to determine relative productivity. In all years, samples were oven dried, weighed, and converted to production in pounds of dry matter per acre. Production estimates were statistically compared by analysis of variance with years assumed random to give a valid error term for grasses, nitrogen sources, and tested interactions. Mean differences were detected utilizing Duncan's New Multiple Range Test (Steel and Torrie, 1960).

In 1966 and 1967 several grass plants in anthesis, from each plot, were clipped near ground level, combined into one sample per plot, and analyzed for total nitrogen (Chapman and Pratt, 1961). Conversions were made to percent crude protein (N% x 6.25). Protein differences were examined using analysis of variance for years, grasses, and nitrogen sources.

In 1965 and 1966 measurements of extended plant height were taken weekly for each of the grasses grown with 100 pounds of nitrogen to determine the relative date which the grasses would have been ready for grazing. Haying readiness was determined in the same years for the fertilized grasses by recording the dates of grass anthesis.

To evaluate persistence, stands were visually observed and rated in 1967 on a percentage basis, with 100% being a perfect stand. Initially, all stands were nearly perfect.

RESULTS

Production

All Nitrogen Sources

The three nitrogen treatments (no fertilizer, 100 pounds of nitrogen, and alfalfa with grass) had a greater influence on production than did the different grasses (Table 1). Production differences among grasses within each nitrogen source seldom varied from their respective production "total 1st + 2nd clip mean" by more than 500 pounds/acre. Differences for any particular grass between the nonfertilized grass treatment and the 100 pounds of nitrogen treatment always exceeded 2,100 pounds/acre and generally exceeded 3,600 pounds.

The overriding influence of nitrogen source on grass production grouped the grasses by nitrogen source treatment. The group of grasses with no supplemental nitrogen produced significantly less ($P<0.05$) forage than the grasses grown with 100 pounds of nitrogen or the combined production of grass and alfalfa (Table 1). Very few wide differences existed between any particular grass with 100 pounds of nitrogen or the same grass plus alfalfa when grown together, although mean production of grass plus alfalfa tended to be slightly higher, but not significantly different ($P>0.05$).

Further evidence that production differences were influenced more by nitrogen sources, than by differences among grasses, is seen in the "grass means" column of Table 1. In this comparison, when nitrogen sources were ignored, Russian wildrye was the only grass that was significantly lower ($P<0.05$) in production than the other grasses.

Grasses Grown Without Supplemental Nitrogen

When no supplemental nitrogen was available, the greatest total production (ranging from 2,228 to 2,968 pounds/acre) came from the wheatgrasses — tall, intermediate, slender, and pubescent — as well as smooth brome, tall fescue, meadow fescue, and reed canarygrass (Table 1). There was some overlap in nonsignificant ($P>0.05$) production differences, but Russian wildrye was definitely the lowest producer

Table 1. Production of 33 Treatment Combinations as Influenced by Nitrogen Sources and Grasses Averaged Over 4 Years (1964-1967)—production Is Ovendry Forage per Acre; Clipping Percentages Are Based on Production

	Grass with no nitrogen			Grass with 100 lb nitrogen			Combined production grass and alfalfa grown together			
Grasses	Total lb/A	1st clip %	2nd clip %	Total lb/A	1st clip %	2nd clip %	Total lb/A	1st clip %	2nd clip %	Grass means
Crested wheatgrass	1822ab*	87	13	6444b	91	9	6922cd	65	35	5063b
Tall wheatgrass	2968c	80	20	6515b	90	10	6743bcd	67	33	5409b
Intermediate wheatgrass	2853c	89	11	6464b	91	9	6738bcd	65	35	5352b
Slender wheatgrass	2228bc	88	12	6707b	91	9	7046d	65	35	5327b
Pubescent wheatgrass	2414bc	84	16	6783b	89	11	6958cd	64	36	5385b
Smooth brome	2658c	77	23	6838b	87	13	6390bcd	64	36	5296b
Orchardgrass	1680ab	60	40	5612b	76	24	5928ab	57	43	4410b
Russian wildrye	1302a	61	39	3480a	79	21	5270a	59	41	3350a
Tall fescue	2245bc	64	36	6464b	72	28	6016abc	60	40	4908b
Meadow fescue	2248bc	74	26	5963b	84	16	6177abcd	60	40	4796b
Reed canarygrass	2918c	60	40	6982b	77	23	5676a	58	42	5192b
Average percent		75	25		84	16		62	38	
Total 1st + 2nd clip mean	2303a			6205b			6351b			
1st clip mean		1742a			5276c			3966b		
2nd clip mean			561a			928a			2385b	

*Letter designations indicate significant differences ($P<0.05$) for Duncan's New Multiple Range Test. Comparisons are applicable only within nitrogen sources, within grass means, and within nitrogen source means, but not between the groups.

($P<0.05$), with crested wheatgrass and orchardgrass producing little more ($P>0.05$).

By far the greatest portion of the total production was attributed to the first clipping, averaging 75% of the total. Eighty percent or more of the total production for the wheatgrasses came in the first clipping, compared to the other grasses which had 77% or less of their total production in the first clipping. For those grasses which had similar total production, larger second clipping percentages would indicate better regrowth potentials.

Grasses Fertilized with Nitrogen

Total production of the grasses grown with 100 pounds of nitrogen (Table 1) were not significantly different ($P>0.05$), except Russian wildrye (3,480 (pounds/acre), which was significantly lower ($P<0.05$) than the other grasses (5,612 to 6,982 pounds/acre). Most of the production again was attributable to the first clipping, averaging 84%. For any particular fertilized grass, the percentage contributed by the second clipping was less than the percentage contributed by the second clipping for the same grass grown without supplemental nitrogen. However, in terms of forage produced, the second clipping production for the fertilized grasses was greater than the second clipping production for the nonfertilized grasses.

Grasses Grown with Alfalfa

Table 1 shows few production differences among grass and alfalfa combinations over the 4-year period. The five alfalfa-wheatgrass combinations were among the highest producers (6,738 to 7,046 pounds/acre), although their production was not significantly greater ($P>0.05$) than some of the other alfalfa- grass combinations. The next highest group produced from 5,928 to 6,390 pounds/acre, and included smooth brome, orchardgrass, tall fescue, and meadow fescue, which were similar to one another in production ($P>0.05$). The lowest producing alfalfa-grass combinations were with Russian wildrye (5,270 pounds/acre) and reed canarygrass (5,676 pounds/acre), but these two were not always significantly lower ($P>0.05$) than the preceding four grasses.

During the last 2 years, production differences among alfalfa-grass combinations were even smaller (Table 2), which may indicate that alfalfa contributed an increasingly large portion to the total production. The alfalfa-grass combination of Russian wildrye and to some extent, reed canarygrass, were notably less productive than other combinations.

Considering grass and alfalfa as separate components for any particular alfalfa-grass combination (Table 2), it was noted that where one of the components was a high producer, its complement was comparatively low in production. A notable exception was the Russian wildrye-alfalfa combination, which was the lowest in production for both separates.

Grasses which contributed the greatest portion to the combined alfalfa-grass production were pubescent wheatgrass and smooth brome (Table 2). Grasses which contributed the least were slender wheatgrass, Russian wildrye, and meadow fescue. Expressed as a percentage, grass composition by weight averaged 26% for the clippings of combined alfalfa-grass production, ranging from 16 to 36% (Table 2). Also of the combined production the grasses averaged 34 for the first and 14% for the second clipping. Of the grass portion only, an average of 19% of the grass production was from the second clipping. Of the alfalfa portion only, 44% of the alfalfa production was

Table 2. Production and Composition of 11 Grasses and Alfalfa when Grown Together, Averaged Over 2 years (1966-1967)—Production Is Expresed as Ovendry Forage per Acre. Composition Values, Expressed as Percentages, Are Based on Production

	Grass and alfalfa combined				Grass portion only			Alfalfa portion only		
		% Grass composition by weight								
Grasses	Total lb/acre	Both clip	1st clip	2nd clip	Total lb/acre	% in 1st clip	% in 2nd clip	Total lb/acre	% in 1st clip	% in 2nd clip
Crested wheatgrass	7085c*	24	33	8	1721bc	89	11	5364cd	59	41
Tall wheatgrass	6738bc	30	39	10	1996cd	88	12	4742abcd	58	42
Intermediate wheatgrass	6592bc	28	39	8	1844cd	89	11	4748abcd	54	46
Slender wheatgrass	6510bc	19	28	5	1253ab	91	9	5256cd	56	44
Pubescent wheatgrass	7120c	36	47	15	2559e	85	15	4562abc	53	47
Smooth brome	6774bc	35	43	21	2352de	78	22	4424abc	56	44
Orchargrass	6639bc	24	28	18	1604bc	71	29	5034bcd	58	42
Russian wildrye	4686a	18	24	9	862a	81	19	3822a	56	44
Tall fescue	6418bc	28	32	23	1817cd	68	32	4602abc	58	42
Meadow fescue	6736bc	16	22	8	1081a	81	19	5654d	56	44
Reed canarygrass	5920b	32	35	26	1862cd	66	34	4058ab	57	43
Average	6474	26	34	14	1723	81	19	4752	56	44

*Within a column, letters which are the same indicate no significant differences ($P>0.05$) by Duncan's New Multiple Range Test.

from the second clipping, indicating the superior regrowth of alfalfa over the grasses tested.

Table 3 shows that grass production (1,723 pounds/acre) in 1966 and 1967 averaged almost as much when grown with alfalfa as grass growing alone without supplemental nitrogen (1,884 pounds/acre). This means that most of the production (4,751 pounds/acre) for the alfalfa component was in excess of the nonfertilized grass productions.

Table 3. Forage and Protein Production by Nitrogen Source, Averaged over all Grasses for 2 Years (1966-1967)

	Average production in lb/acre		Lb protein produced per 100 lb forage produced*
	Forage	Protein	
Grass grown with no nitrogen	1884	176	9.3
Grass grown with 100 lb nitrogen	5414	591	10.9
Grass and alfalfa when grown together:			
Grass portion	1723	184	10.7
Alfalfa portion	4751	926	19.5
Combined	6474	1110	17.1

*These values are adjusted on the basis of forage produced by each grass in both years, and as such do not correspond with the average protein figures in Table 5.

Crude Protein

During 1966 and 1967, springs of diverse moisture conditions, crude protein percentages of the grasses were determined and used as indicators of nutritive value. From a factorial statistical analysis, grasses, nitrogen sources, and years, as well as two-way interactions, were found to have a highly significant effect ($P<0.01$) on crude protein percentages of the grasses. Details of this analysis are available (Johnson and Nichols, 1969).

Mean separations of protein percentages by grasses and nitrogen sources are presented in Table 4. Russian wildrye was consistently highest in protein, ranging from 11.2 to 16.5%, and frequently at a significant level ($P<0.05$) in each nitrogen source. Crested wheatgrass was also relatively high in protein, ranging from 10.8 to 13.9%. When fertilized or grown with alfalfa, smooth brome, orchardgrass, tall fescue, meadow fescue, and reed canarygrass were somewhat lower and had similar levels of protein. The wheatgrasses — tall, intermediate, slender, and pubescent — were generally among the lowest in protein percentage for all nitrogen sources, and frequently at a significant level ($P<0.05$). When all nitrogen sources were combined for evaluation (Table 5) the above ranking of the grasses remained virtually unchanged for the 2-year average. The four lowest wheatgrasses were always significantly lower ($P<0.05$) than any of the other grasses.

Table 4. Crude Protein Percentage of 11 Grasses at Anthesis in Three Nitrogen Sources, Averaged Over 2 Years (1966-1967)

Grasses	Percent crude protein: 0 lb nitrogen	100 lb nitrogen	With alfalfa
Crested wheatgrass	10.8cd*	13.9f	12.8ef
Tall wheatgrass	7.5a	8.3a	9.0a
Intermediate wheatgrass	8.2ab	10.0bcd	8.9a
Slender wheatgrass	8.2ab	8.5ab	9.3ab
Pubescent wheatgrass	8.7ab	9.0bc	9.4ab
Smooth brome	9.5bc	11.0de	10.7bcd
Orchardgrass	9.6bc	11.8e	10.3abc
Russian wildrye	11.2d	16.5g	14.0f
Tall fescue	8.2ab	11.1de	10.7bcd
Meadow fescue	9.7c	12.1e	12.0de
Reed canarygrass	11.0cd	10.4cde	11.8cde

*Values within a column followed by the same letter are not signficantly different ($P>0.05$) by Duncan's New Multiple Range Test.

Comparisons of protein percentages were made for 1966 and 1967 (Table 5). The lower portion of Table 5 shows protein percentages of the grasses, grouped by treatment. For the 2-year average, protein percentages of grasses grown with fertilizer (11.2%) or with alfalfa (10.8%) were significantly higher ($P<0.05$) than when grasses had no supplemental fertility (9.3%). In the drier year, 1966, average grass protein percentage was significantly different ($P<0.05$) for each nitrogen source; grasses with 100 pounds of nitrogen the highest (13.0%), those without supplemental nitrogen the lowest (9.8%), and grass grown with alfalfa midrange (11.8%). In the wetter year, 1967, the range was much narrower (8.9 to 9.7%) with grass protein highest when grass was grown with alfalfa and significantly greater ($P<0.05$) than when no supplemental nitrogen was available. When grass-

Table 5. Average Crude Protein Percentage of 11 Grasses at Anthesis with Three Nitrogen Sources Considered Collectively

Grasses	Percent crude protein: Average both years	1966	1967
Crested wheatgrass	12.5d*	13.9e	11.1c
Tall wheatgrass	8.2a	8.4a	8.0a
Intermediate wheatgrass	9.0a	10.7bc	7.4a
Slender wheatgrass	8.7a	9.7b	7.6a
Pubescent wheatgrass	9.1a	10.2bc	8.0a
Smooth brome	10.4bc	10.6bc	10.1bc
Orchardgrass	10.5bc	11.5cd	9.6b
Russian wildrye	13.9e	17.4f	10.4bc
Tall fescue	10.0b	10.5bc	9.4b
Meadow fescue	11.2c	11.5cd	11.0c
Reed canarygrass	11.1c	12.5d	9.6b
All 11 grasses with 0# nitrogen	9.3a	9.8a	8.9a
All 11 grasses with 100# nitrogen	11.2b	13.0c	9.2ab
All 11 grasses with alfalfa	10.8b	11.8b	9.7b
Average	10.4	11.6	9.3

*Within any column, values followed by the same letter are not significantly different ($P>0.05$) by Duncan's New Multiple Range Test.

es were grown with fertilizer, grass protein percent (9.2%), was not significantly different (P>0.05) from percentages in the other two sources.

Although no statistical comparisons could be made between years, protein percentages for each grass and each nitrogen source declined from the drier year, 1966, to the wetter year, 1967 (Table 5). In general, the values which were the highest in 1966 exhibited the greatest decrease.

For the 1966 and 1967 growing seasons, the protein production in pounds per acre and pounds protein produced per 100 pounds of forage produced was calculated (Table 3). In terms of protein produced per 100 pounds of forage produced, little difference was evident for the grasses among the three nitrogen sources (from 9.3 to 10.9 pounds). However, due mostly to the high protein percentage of the alfalfa (19.5%), the protein produced from the alfalfa-grass combination for every 100 pounds of forage amounted to 17.1 pounds.

Dates of Use

In 1965 and 1966 the grasses grown with commercial nitrogen were studied to detect differences in grazing and haying readiness. First grazing use was considered possible when extended plant height reached 4 to 6 inches, and first haying use was considered proper when the grasses flowered (Figure 1).

Grazing readiness was 9 to 24 days later in 1965 than in 1966 for all grasses. As an average in both years, crested wheatgrass was ready for first grazing by April 18, a week before any of the other grasses. In both years, tall wheatgrass, intermediate wheatgrass, slender wheatgrass, pubescent wheatgrass, and Russian wildrye were ready by April 25, a week later than crested wheatgrass. Reed canarygrass and smooth brome were also ready soon after most of the wheatgrasses. Tall and meadow fescue were not ready for use until May 2, two weeks later than crested wheatgrass in both years. With both years considered, orchardgrass was latest for grazing, about May 6.

Even though grazing readiness dates for any grass varied up to 24 days for the 2 years, grass flowering dates were quite uniform for a particular grass in both years. Grass flowering was reached earliest (June 6) in both years by crested wheatgrass, smooth brome, orchardgrass, and Russian wildrye. In most cases, intermediate wheatgrass, slender wheatgrass, pubescent wheatgrass, reed canarygrass, tall fescue, and meadow fescue had flowered by June 23. Tall wheatgrass flowered about June 29, making it the latest in terms of anthesis. Pubescent wheatgrass was equally as late in 1966.

Stand Evaluation

During 1967, the fifth growing season of the trial, stands were evaluated to give an estimate of the projected longevity of the grasses in each of the nitrogen source treatments (Table 6). Based on initial observations in 1963, all stands were considered optimum (100%) when the plants occupied the plots as fully as could be expected with the prevailing treatments. In the case of the alfalfa-grass combinations, both com-

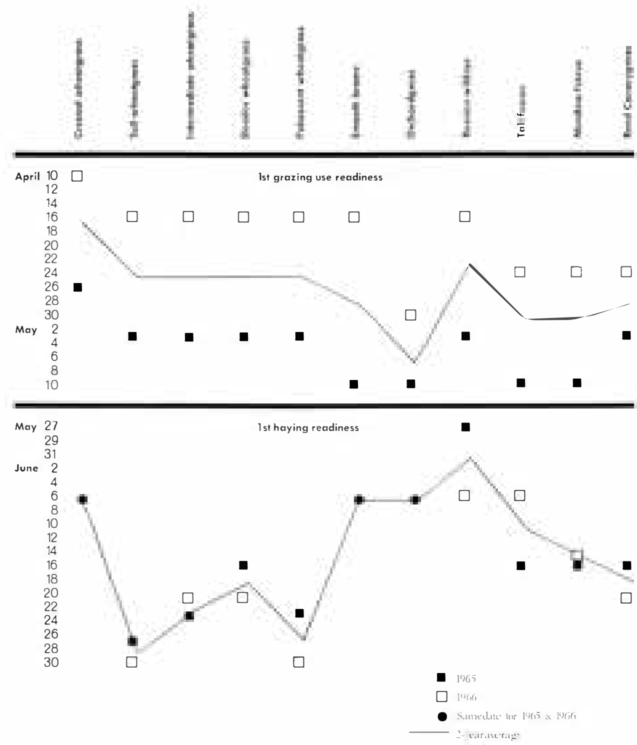

Figure 1. Readiness dates of earliest uses for grasses grown with 100 pounds of nitrogen per acre annually. First grazing readiness was when extended plant height reached 4 to 6 inches; first haying readiness was when grasses flowered.

Table 6. Stand Evaluation Rating in 1967 Showing the Percentage of Stand in Relation to What Was Considered a Perfect Stand (100%)

	Percentage of Original Stand			
	Grass grown with no nitrogen	Grass grown with 100 lb nitrogen	Grass grown with alfalfa	
	Grass	Grass	Grass	Alfalfa
Crested wheatgrass	74	98	80	97
Tall wheatgrass	84	75	53	96
Intermediate wheatgrass	78	79	55	94
Slender wheatgrass	44	60	37	103
Pubescent wheatgrass	87	90	92	100
Smooth brome	100	100	100	89
Orchardgrass	88	93	93	100
Russian wildrye	26	53	21	70
Tall fescue	94	98	93	97
Meadow fescue	94	97	67	104
Reed canarygrass	98	100	89	93
Average	79	86	71	95

Figure 2. (Upper) Crested wheatgrass when grown with no supplemental fertility in 1965. (Lower) Same grass fertilized with 100 pounds of nitrogen per acre annually. Production in 1965 from unfertilized crested wheatgrass averaged 1,834 pounds per acre; fertilized averaged 7,682 pounds.

Figure 3. Representative smooth brome plots from the study in 1965. Grass in upper photo was not fertilized; that in the lower photo was. Production in 1965 from the unfertilized brome was 2,250 pounds per acre, fertilized 7,943 pounds.

ponents potentially could have 100% ratings, although the number of plants per unit area that either component could have would logically be fewer than if the components were grown in pure stands.

In general, grass stand ratings were as good or somewhat better when the grasses were fertilized, averaging 86%, compared to 79% without fertilization. Competition between alfalfa and grass when grown together is suggested because the average value, 71%, for the grass component indicates poorer grass stands than in the other nitrogen sources. Alfalfa maintained excellent stands of greater than 85% with all grasses except with Russian wildrye, where the stand declined to 70% of the original.

Only a single grass, smooth brome, maintained a perfect stand (100%) under all nitrogen sources. Other grasses able to maintain excellent stands (greater than 85%) in all nitrogen sources were orchardgrass, reed canarygrass, tall fescue, and pubescent wheatgrass. Meadow fescue maintained excellent stands (greater than 85%) when grown in the two pure stands; but with alfalfa it had a good stand of 67%. Crested wheatgrass maintained a near perfect stand (98%) when fertilized, and good stands of 74% with no supplemental nitrogen and 80% with alfalfa. Tall wheatgrass and intermediate wheatgrass maintained good stands (greater than 75%) except when grown with alfalfa they declined to fair stands (near

55%). Slender wheatgrass with 100 pounds of nitrogen maintained a fair stand (60%), otherwise it had poor persistence with about a 40% stand. Russian wildrye was unable to maintain suitable stands without nitrogen (26%) or with alfalfa (21%) and only had a fair stand with 100 pounds of nitrogen (53%).

DISCUSSION

The need for supplemental fertility to obtain maximum grass production is obvious in this study and has been demonstrated repeatedly (Dotzenko, 1961; Thomas and Osenbrug, 1964; and others). Production increases are almost always found whether grasses are fertilized or grown in association with legumes (Wagner, 1954a; Lorenz and Rogler, 1961; and Carter and Scholl, 1962).

Response of grasses to nitrogen fertilization is clearly evident in Figures 2 and 3. In the study being reported, 100 pounds of nitrogen per acre applied annually to the grasses produced almost as much additional forage as the alfalfa-grass combinations (Table 1). This is in contrast to Wagner (1954a), who reported 160 pounds of nitrogen annually were necessary for the fertilized grasses to equal the yields of the legume-grass mixtures, and Carter and Scholl (1962), who found 240 pounds were necessary.

Differences (Table 1) in annual forage yields per acre were small between the fertilized grasses (6,205 pounds) and the alfalfa-grass combinations (6,351 pounds) compared to the nonfertilized grass (2,303 pounds). Production expenses and season of forage growth are widely divergent between the two higher producing treatments.

At 1969 prices, the grasses fertilized annually with 100 pounds of ammonium nitrate would cost about $10 a year to produce a minimum of 3,500 pounds of additional forage over the nonfertilized plots. In addition, just as much extra forage was produced with the alfalfa-grass combinations, and at no expense except for the initial cost of the alfalfa seed. Although alfalfa was not grown alone in the Newell study, it would not be expected to produce as much as many of the compatible alfalfa-grass combinations as has been shown by Wagner (1954a).

If a single large cutting of hay were the primary aim, the fertilized grass stands would be expected to greatly outproduce the other two treatments. First clipping of the fertilized grasses produced an average of 5,276 pounds per acre compared to the first clipping of the alfalfa-grass combinations which averaged 3,966 pounds per acre (Table 1). The first clipping productions of both of these supplemental nitrogen source treatments were considerably greater than the combined first and second clipping productions for the nonfertilized grasses which yielded an average 2,303 pounds per acre.

If multiple hay cuttings and/or grazing uses were the principal management objective, then the alfalfa-grass combinations would give better season-long growth and distribution of use. This is evidenced by the fact that 38% of the total production came from the second clipping for the alfalfa-grass mixtures compared to 25% for the nonfertilized and 16% for the fertilized grasses. These percentages may be somewhat misleading, however, since the second clipping production averaged 2,385 pounds per acre for the alfalfa-grass combination, 928 for the fertilized grasses, and 561 for the nonfertilized grasses. In terms of regrowth production, the alfalfa-grass combinations were by far the best, and the nonfertilized grasses were the poorest.

Reasonably good regrowth of pure grass stands has been reported for grasses having regrowth potential when fertilized with nitrogen several times during the growing season (Heinemann and Van Keuren, 1958, and others). However, as suggested by MacLeod (1965) and others, even with multiple nitrogen applications, pure grass stands can not be expected to equal regrowth yields of alfalfa-grass or pure alfalfa stands. Costs of multiple fertilizer applications to pure grass stands would increase production costs substantially, compared to alfalfa-grass mixtures which require less fertilizer per pound of forage produced. Satisfactory regrowth of grass pastures at Newell has been accomplished by multiple fertilizer applications (Nichols *et al.,* 1968).

Other management or cultural practices may be more desirable than those studied. For example, multiple applications of nitrogen fertilizer on pure grass stands may be better than a single application. In addition, grasses should be encouraged to produce a larger portion of the total production when grown with alfalfa, especially to minimize the hazard of bloat when used for grazing. Under the study conditions, grass made up an average of only 26% of the alfalfa-grass production (Table 2). A more desirable alfalfa to grass ratio would be near 50:50. For those grasses which have good regrowth potential, this could probably be achieved by frequent irrigation, frequent use, and applications of nitrogen to favor the grasses as has been suggested by Allred (1965). This is consistent with MacLeod (1965) who stated that nitrogen fertilizer could be expected to increase the grass component while reducing the alfalfa component. Under conditions similar to those at Newell, a favorable balance could possibly be achieved with a single summer application of 50 pounds of nitrogen after the initial use. A split application totaling 100 pounds, one in early spring followed by another after the first use, might be necessary.

Growing nonfertilized grasses, unless with alfalfa, under conditions similar to those of this study would not be recommended. The greatest production for the smallest cost would be from alfalfa-grass mixtures. Of the treatments tested, these mixtures would give the greatest season-long production at the lowest cost. If a single large cutting of hay were most important and/or the bloat hazard seemed too risky, fertilized grasses would be recommended. In most cases, those grasses having good production and regrowth should be strongly favored for use with irrigation. Considering production and regrowth only, the best selection would be reed canarygrass. On these bases, smooth brome, orchardgrass, tall fescue, and meadow fescue would also be suitable. For specialized uses, all of the wheatgrasses tested would be satisfactory when grown with alfalfa or in pure stands, if regrowth potential were not considered important. Russian wildrye would not be recommended for any use under conditions similar to this study due to low production resulting mostly from poor persistence.

Based on crude protein percentage, all grasses with any of the nitrogen sources would have provided adequate forage quality for grazing during the summer (Table 4). It has been shown (Heinemann and Van Keuren, 1958; and Nichols *et al.*, 1968), however, that greater carrying capacity, greater average daily gains, and larger net return, can be expected from alfalfa-grass pastures compared to fertilized grass pastures. In addition to most of these advantages, Campbell (1963) reported reduced forage consumption per pound of live weight gain when legumes were included in a pasture mixture.

The nonfertilized grasses had a 2-year average protein content of 9.3 pounds per 100 pounds of forage produced compared to the fertilized grasses which produced 10.9 pounds of protein per 100 pounds of forage (Table 3). By contrast, the alfalfa-grass combinations had 17.1 pounds of crude protein per 100 pounds of forage. Forage of this quality would be a valuable protein source for ruminants if stored for winter use. Russian wildrye and crested wheatgrass were among the highest in protein content, regardless of nitrogen source treatment (Table 5). The wheatgrasses, except crested wheatgrass, were the lowest in protein. Other grasses were intermediate between these extremes. The low protein content of some grasses may be explained by lack of leafiness.

Earliness and season of plant growth must be considered when spring or early summer grazing is of primary interest. Figure 1 shows the earliest relative grazing dates that could be expected for each grass when fertilized with 100 pounds per acre of nitrogen. When grown with alfalfa, the dates of readiness should be similar. Thomas and Osenbrug (1964) report fertilized grasses would start growth 6 to 10 days earlier than when not fertilized. Of the grasses tested in the current study, crested wheatgrass was ready for grazing a week earlier than the other grasses. This makes it the most desirable from a standpoint of providing forage early in the grazing season. The other wheatgrasses and Russian wildrye were ready for grazing about a week later. Reed canarygrass and smooth brome were about 10 days later than crested wheatgrass. Orchardgrass could not be expected to produce grazing until 18 days after crested wheatgrass.

Based on when the grasses flowered, the harvest dates varied by 3 weeks. This readiness difference could have considerable implication in a management scheme. As an example, the grasses reaching maturity earliest could potentially enable an extra hay cutting or longer grazing period after a hay harvest, assuming all possess good regrowth. Crested wheatgrass, smooth brome, and orchardgrass could be hayed earliest, followed closely by Russian wildrye. Intermediate and slender wheatgrasses, tall and meadow fescues, and reed canarygrass were about 12 to 18 days later than the earliest. Tall and pubescent wheatgrasses were 3 weeks later than the earliest.

Most of the grasses had sufficient persistence for sustained hay or pasture production in all of the nitrogen sources (Table 6). Russian wildrye and slender wheatgrass were the least persistent of all grasses under all treatments. Alfalfa maintained an adequate stand throughout, except when grown with Russian wildrye and possibly with smooth brome. A very strong competitive relationship is suggested for these two grasses when grown with alfalfa and has previously been observed by Kilcher and Heinrichs (1966a). Russian wildrye was the only grass considered totally unsuitable to persistence, with or without alfalfa.

SUMMARY AND CONCLUSIONS

Eleven grasses were studied to determine regional suitability based on production, crude protein percentage, season of growth, and persistence when grown with irrigation. Each of the grasses was treated in three ways: (1) grown without supplemental fertility, (2) grown with 100 pounds of nitrogen per acre annually, and (3) grown in association with alfalfa.

Total forage production from the grasses or alfalfa-grass combinations within a nitrogen source did not deviate widely from their respective nitrogen source treatment means. The greater production variation was attributable to the nitrogen source treatments. Mean production yields for 4 years were 2,303 pounds per acre for grasses grown with no supplemental nitrogen. When fertilized, average grass yield was 6,205 pounds per acre which compared favorably with the combined grass and alfalfa yield of 6,351 pounds per acre. Grass production alone from the alfalfa-grass combinations almost equaled grass production in the pure, nonfertilized grass stands. Production responses for all grasses, except Russian wildrye, where considered favorable.

The combination of grass and alfalfa provided the best distribution of production for multiple hay cuttings or growing season grazing. Bloat hazard could be reduced if management favored the grasses when grown with alfalfa. In this region 50 to 100 pounds of nitrogen in the spring, or in split application would produce a more desirable grass to alfalfa production ratio. Grasses which had the best potential to provide some regrowth when grown with alfalfa include pubescent wheatgrass, smooth brome, orchardgrass, tall fescue, and reed canarygrass.

Pure stands of fertilized grasses gave the largest single cutting of forage. This would be desirable for a single harvest. Average first clipping production for fertilized grasses was 5,276 pounds per acre compared to 3,966 pounds for the alfalfa-grass combinations. Orchardgrass, tall fescue, and reed canarygrass provided the greatest amount of regrowth production when fertilized, making them best suitable for summer grazing of the fertilized grasses. Additional applications of nitrogen fertilizer would help to keep their production up during the warmest part of the season.

The nonfertilized grasses probably could not compete economically with other irrigated crops in this region. This being the case, nonfertilized grass stands would not be a recommended practice unless the grasses were grown with a well adapted legume, probably alfalfa.

Protein percentage of the forages was enhanced by the nitrogen source treatments. The fertilized grasses were somewhat greater in protein than the nonfertilized grasses, and the alfalfa-grass combinations were considerably greater. The increased protein percentage would not be as important when the forages are grazed or fed green, but could be valuable as stored feed by reducing protein supplement costs. This would be particularly true in the alfalfa-grass combinations due to the consistently high protein percentage of the alfalfa. The wheatgrasses, except crested wheatgrass, were generally lowest in protein percentage in all nitrogen sources.

Earliest grazing use could be made by crested wheatgrass, followed by the other wheatgrasses. The earliest harvest of hay could be expected from the group including crested wheatgrass, smooth brome, orchardgrass, Russian wildrye, and tall fescue.

Russian wildrye and slender wheatgrass lacked persistence. When grown with alfalfa, tall and intermediate wheatgrasses, and meadow fescue did not maintain good stands after 5 years. All other grasses and alfalfa-grass combinations had adequate persistence, with some variation between nitrogen source treatments. It was evident that some pure grass stands were better maintained with nitrogen fertilizer than without.

Names of Plants Found in This Publication. Where a Variety Is Given, that Variety Was Used in the Study.

Agropyron desertorum	Nordan crested wheatgrass
Agropyron elongatum	tall wheatgrass
Agropyron intermedium	Oahe intermediate wheatgrass
Agropyron trachycaulum	slender wheatgrass
Agropyron trichophorum	pubescent wheatgrass
Arrhenatherum elatius	tall oatgrass
Bromis inermis	Lincoln smooth brome
Dactylis glomerata	Avon orchardgrass
Elymus junceus	Vinall Russian wildrye
Festuca arundinacea	Alta tall fescue
Festuca elatior	meadow fescue
Medicago sativa	Vernal alfalfa
Phalaris arundinacea	reed carnarygrass
Phleum pratense	timothy
Trifolium repens	ladino clover

APPENDIX

Grass Characteristics and Use

This appendix summarizes some of the most important characteristics of the grasses studied, both from the results of this study as well as from other literature and observations. Information is presented that may be helpful in making decisions about which grass meets the needs for a particular use or has adaptations for specific conditions.

Additional information on management, production, characteristics, and varieties is available in the publication, "Grass Performance in South Dakota," South Dakota Agricultural Experiment Station Bulletin 536. Another reference is "Grass Varieties in the United States," USDA, ARS, Agr. Handbook 170.

Crested wheatgrass is an introduced bunchgrass adapted to most normal well drained soils. Its primary area of use has been in areas receiving less than 15 inches of precipitation annually. Other grasses with greater production potential are often used in areas of higher rainfall. Stands have been maintained since seedings in the early 1930's, attesting to its longevity. Old, low vigor stands which have declined in productivity due to low soil fertility can be improved readily by the application of nitrogen. It is suitable for dryland or irrigation but has found its greatest use under dryland conditions for early spring grazing or hay production. Prolonged flooding or salty soil conditions are not tolerated by crested wheatgrass. Palatability decreases as plants approach maturity and it is often criticized for this reason. Surface soil in old stands often becomes rough due to its bunch growth form, thus making haying difficult.

With irrigation at Newell, forage production was not as great as the other wheatgrasses, but protein percentage was higher. When grown with alfalfa, an acceptable grass-alfalfa ratio was maintained, although the grass component could be expected to be greater with nitrogen fertilization. When grown in pure stands, its best use is for early spring and late fall grazing or as a single cutting hay crop. Date of grazing readiness was 2 weeks earlier than the other grasses tested, making it excellent for lengthening the grazing season. Regrowth after first use is minimal. With intensive irrigation and management, other grasses could be expected to yield more forage, primarily because of better regrowth.

Tall wheatgrass is an introduced bunchgrass known for its ability to tolerate wet areas with saline and alkali soil conditions. It can be grown successfully in these areas where many other grasses would fail. Coarseness of stems and leaf roughness makes tall wheatgrass low in palatability, especially as it approaches maturity. However, when seeded in pure stands to eliminate grazing animal preference, and grazed at a young stage of development, satisfactory animal performance can be realized.

At Newell, forage production of irrigated tall wheatgrass was at least equal to any of the grasses tested. When grown with alfalfa it did not contribute a large portion of the combined production due to depleted stand. Tall wheatgrass reached grazing readiness early in the season but was the latest of all grasses to mature. With the exception of intermediate wheatgrass, tall wheatgrass had slightly better regrowth than other wheatgrasses. Percent protein was among the lowest of the grasses under test. The selection of tall wheatgrass as a grazing or hay crop in preference to other grasses would be based on its ability to withstand wet, saline, alkali conditions.

Intermediate wheatgrass is an introduced sod grass with high production potential. Its greatest region of adaptability is in areas with greater than 15 inches of annual precipitation. It is valuable for either grazing or hay production. Stands without a legume should be fertilized with nitrogen if they are to remain productive. It is not ready for grazing as early in the spring as crested wheatgrass and is often used to follow crested wheatgrass in a grazing sequence. There is some evidence that intermediate wheatgrass stands may be difficult to maintain for longer than 6 years, but periodic seedset may aid in natural stand re-establishment. Abundantly available seed, ease of establishment, and high productivity can well compensate for its apparent short life span.

At Newell protein percentage was as high as the other wheatgrasses with the exception of crested wheatgrass. Regrowth ability was poor, which is typical of the wheatgrass group. It produced fairly well when grown with alfalfa even though its stand was reduced to 55% of the original in 5 years.

Slender wheatgrass is a native bunchgrass considered tolerant to alkali soil conditions but not of wet alkali sites where tall wheatgrass is well adapted. It is reported to be short-lived and is often seeded in a mixture in order that the void left by the decline in slender wheatgrass is filled by associated plants. Its ease of establishment and rapid growth can make it valuable in a seeding mixture.

At Newell slender wheatgrass failed to maintain adequate stands under any treatment, but stands were somewhat better at the end of 5 years when nitrogen fertilizer was applied. It contributed only a small portion of the total forage when grown with alfalfa. Due to leafiness, fineness of stem, and good palatability it could be used under alkali soil conditions in preference to tall wheatgrass as long as these sites are not wet.

Pubescent wheatgrass is an introduced sod grass suitable for both grazing and hay production under either irrigated or dryland conditions. It is similar to intermediate wheatgrass, both in appearance and use. It is sometimes considered to have better persistence because of more effective reproduction by rhizomes. Some reports have indicated that pubescent wheatgrass is more drought resistant, which would be important under dryland conditions, but that forage production may not be as great as for intermediate wheatgrass.

At Newell pubescent wheatgrass had good persistence and was one of the best producing grasses when grown in combination with alfalfa. It contributed a larger portion of the total forage than did most of the other grasses. With the exception of crested wheatgrass, protein percentage was at least equal to the other wheatgrasses analyzed. It would rank as one of the best grasses for seeding with alfalfa for hay production, but due to poor regrowth ability would not be as suitable for season-long use as some of the other grasses tested.

Smooth brome is a sod forming grass widely used in both irrigation and dryland conditions for grazing and hay production on most normal soils. Under dryland conditions its best use would be limited to areas of greater than 15 inches of precipitation annually. It is potentially highly productive, palatable, long-lived, and of good forage quality. Stands of low vigor (commonly called sod bound) can be expected to regain productiveness when fertilized with nitrogen.

Under irrigation at Newell smooth brome commenced growth about 2 weeks later than crested wheatgrass but was as early as the other wheatgrasses tested. It was the only grass to maintain near perfect stands in all treatments. Protein percentage was greatter than the wheatgrass group with the exception of crested wheatgrass. It made a substantial contribution to the total production when grown with alfalfa. Smooth brome is considered an excellent grass for either hay production or irrigated pastures. However, its regrowth ability during the hot part of the summer is not as good as orchardgrass.

Orchardgrass is an introduced bunchgrass which has not been recommended in South Dakota due to lack of winter-hardiness. However, with irrigation at Newell, excellent stands have been maintained both in plot trials and irrigated pastures. Winterkill is believed to be decreased by applying water in the fall and permitting plant regrowth prior to killing frost. Late fall regrowth should not be grazed. Orchardgrass is not recommended for dryland conditions. It is reported to have poor tolerance to flooding and drought. Forage is palatable and of good quality. Variety consideration is important to insure suitability for haying or grazing. The selections, Latar and Chinook, have shown good promise at Newell.

Its ability to regrow and produce green forage season-long makes orchardgrass a valuable irrigated forage. Although not previously recommended, results from trials at Newell indicate that it is one of the better irrigated pasture grasses for western South Dakota if properly managed.

Russian wildrye is an introduced bunchgrass that has received wide use in the Northern Great Plains for early spring and fall grazing. It is better suited for grazing than hay production because of its low leaf area. Where adapted it provides excellent quality forage and has high salt and drought tolerance.

Trials at Newell indicate that Russian wildrye apparently is not adapted to the heavy clay soils and conditions of this study. Persistence and production were very low. When grown with alfalfa, both components had poor persistence, suggesting incompatability. Protein percentage was the highest of the grasses analyzed, but its other disadvantages would rank it as the least desirable of the grasses tested.

Tall Fescue is an introduced sod grass grown primarily for pasture in the southeastern and northwestern portion of the United States. It is recognized for its ability to grow on poorly drained irrigated soils and will tolerate alkaline and saline soil conditions. Palatability is not considered high, but is adequate under most circumstances. It has not been used to any extent in the Northern Great Plains.

Under irrigation at Newell, yields, percent protein, and persistence were all good, and at least comparable to many of the grasses tested. Tall fescue does not commence growth as early as the wheatgrasses but has better regrowth. Its persistence on poorly drained soils and long green feed period could make tall fescue suitable for grazing under these conditions.

Meadow fescue is very similar to tall fescue in general appearance, differing primarily in smaller size and more prostrate growth form. It is considered to be somewhat more palatable, but neither adapted to as wide a range of growing conditions, nor as persistent as tall fescue.

Trials at Newell would indicate that meadow fescue did not regrow as well as tall fescue but did produce forage of higher protein percentage under some treatments. It did maintain excellent stands when grown alone and produced nearly as much forage as tall fescue. When grown with alfalfa, the portion of the total forage contributed by meadow fescue was low, which may have resulted from partial loss of stand.

Reed canarygrass is grown extensively for hay and pasture in the northern half of the United States and the southern half of Canada. It has a wide range of adaptation in that it is tolerant to prolonged flooding and yet is ranked among the most drought tolerant of the cool season grasses. It is not considered tolerant to salt marshes or alkali soils. Considerable variation in palatability and forage quality have been reported for reed canarygrass. Studies in eastern South Dakota have attributed these objections to late harvesting and/or low soil fertility.

At Newell reed canarygrass ranked among the highest of the grasses in protein percent, production, and persistence. When grown with alfalfa, combined production was not as great as some other grass-alfalfa combinations. Good regrowth ability would make reed canarygrass valuable for irrigated pastures or hay production.

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