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ARID LAND PLANT RESOURCES

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Proceedings of the International Arid Lands Conference
on Plant Resources, Texas Tech University

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Sponsored by

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Published by

International Center for Arid and Semi-Arid Land Studies
Texas Tech University
Lubbock, Texas 79409, U.S.A.

July 1979

Seasonal Changes in Nutritional Quality of *Agropyron desertorum* Compared with Six Other Semi-Arid Grasses

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Desert wheatgrass, (*Agropyron desertorum* (Fisch.) Schult.) an introduced perennial grass, is widely used to improve the forage resources in semi-arid regions of the western United States and Canada. The use of this species is based on trials that have shown that it provides early forage, is drought tolerant, often produces greater yields and animal gains, and is able to withstand heavier use than many native species. The nutritional attributes of this species are compared to those of certain other grass species in this paper.

In southern Idaho, where this study was conducted, the native sagebrush-grass range was converted to a nearly pure stand of cheatgrass (*Bromus tectorum* L.) by repeated burning and heavy grazing. Desert wheatgrass was planted in the fall of 1959 on a portion of this cheatgrass range following a wildfire that summer. This afforded us an opportunity to compare the nutritional quality of desert wheatgrass with an introduced annual and five native perennial grasses on a common site.

Our objectives were to compare the trends (over the April - November grazing season) in nutrient content and digestibility for seven species {desert wheatgrass, streambank wheatgrass (*Agropyron riparium* Scribn. & Smith.), cheatgrass, Great Basin wildrye (*Elymus cinereus* Scribn. & Merr.), Sandberg's bluegrass (*Poa sandbergii* Vasey), bottlebrush squirreltail (*Sitanion hystrix* (Nutt.) Smith), and needle-and-thread grass (*Stipa comata* Trin. & Rupr.)}, and to develop equations which describe these trends and enable prediction of dates of probable mineral deficiencies.

The above species were selected for comparison because they are the principal grass species found in the study area. Their abundance on the range, except for desert wheatgrass, is dependent upon the degree of grazing abuse.

Experimental Area

All data were collected at the Saylor Creek Experimental Range located 15 km southwest of Glenns Ferry, Idaho. The range lies at an elevation of 957 m. This area is characterized by winter and spring precipitation periods and dry or low rainfall during the summer and fall. It receives less than 10% of annual precipitation during July, August, and September. Annual precipitation varies from 125 mm to 480 mm and averages 240 mm based on long-term records from Glenns Ferry. Winter temperatures may reach -32°C and summer temperatures frequently exceed 39°C.

Remnants of the original vegetation still present on some of the experimental range indicate that the former vegetation for the area was a Wyoming big sagebrush-needlegrass (*Artemisia tridentata* spp. *wyomingensis*-*Stipa thurberiana*) type. On sandier soils, needle-and-thread grass probably replaced Thurber's needlegrass in the climax. Natural invasion of cheatgrass, fire, and subsequent heavy grazing of native species have altered the type drastically, leaving a range dominated by cheatgrass-bluegrass with varying amounts of other species.

Soils of the experimental range were developed on gently undulating topography from Black Mesa gravels and aeolian sources (Malde and Powers, 1962). These soils are considered to be in the Minidoka silt loam series, a member of the course silty, mixed, mesic Xerollic Durorthid family and are calcareous throughout the profile.

Procedures

Plant material for forage quality characterization was harvested periodically at a 2 cm stubble height from random clones in the same nongrazed pasture between mid March and November during the 1962 through 1968 period. Plant material was oven dried 24 to 48 hours at 70°C and ground to pass a 40-mesh screen. Forage moisture content was determined on some samples.

Total nitrogen (N), with the salicylic acid modification for N-N and N-O linkages, was determined by semi-microKjeldahl procedures. Nitric-perchloric acid (3:1) digestion of forage samples preceeded analysis for phosphorus (P), sulfur (S), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), zinc (Zn), manganese (mn), copper (Cu), and iron (Fe). Phosphorus was estimated colorimetrically following the ammonium molybdate-ammonium metavanadate procedure. Sulfur content was determined by the modification of the turbidimetric procedure. All other elements were estimated by atomic absorption spectrophotometry.

Forage samples were also analyzed for neutral detergent fiber (NDF), and true dry matter digestibility (TDDM) following the procedures specified by Goering and Van Soest (1970). Rumen fluid inoculum was obtained from a donor cow maintained on a timothy grass (*Phleum pratense* L.) hay diet.

Linear and curvilinear regression techniques were used to summarize forage water, forage mineral concentrations, and forage quality data. All forage mineral and nutritive data were fit to each of the following curve forms: $a + bx$, ax^b, $a + b/x$, ae^{bx}, $x/(a+bx)$, $1/(a+bx)$ and $a + bx + cx^2$, where x = Julian date. The curve form selected was the one yielding the largest sum of the r^2 values for the seven species tested. Data are presented to illustrate the probable dates of mineral deficiency for the seven species. More specific data are given in Murray et al. (1978).

Results and Discussion

Forage moisture, certain mineral components, and certain ratios exhibited trends with advancing plant maturity. Forage moisture, N, P, S, K, Zn, Cu, N:S, and K/(Ca+Mg) declined. The Ca-P ratio increased, even though Ca contents were not related to forage maturity.

In most species Ca, Mg, Na, Mn, and Fe contents were not related to date of maturity. Iron concentration of the field collected plant tissue was much higher than can be attributed to iron absorption, and high levels are attributed to dust contamination.

Forage Moisture

Cattle grazing cheatgrass and desert wheatgrass pastures early in the spring generally gain less than in the late spring. The difference in gains may be attributed to the relatively high forage moisture content that restricts the animal's ability to ingest sufficient dry matter. Table 1 shows that five of the seven species had moisture contents in excess of 200% (33% dry matter) on April 15. Basin wildrye maintained a relatively high moisture content through July 15, whereas cheatgrass was completely dry by that date. Desert wheatgrass, in contrast, had a high moisture content early in the season, but dried slowly and reached 83% (55% dry matter) on July 15.

Table 1. Predicted forage moisture contents on a dry weight basis for the seven grass species. Species were collected on periodic dates for five years of a seven year period.

	Prediction Date			
Species	4/15	5/15	6/15	7/15
	-Per cent-			
Desert wheatgrass	220	175	128	83
Streambank wheatgrass	187	150	112	75
Cheatgrass	296	190	81	0
Basin wildrye	298	234	168	104
Sandberg's bluegrass	168	117	64	13
Bottlebrush squirreltail	238	176	113	51
Needle-and-thread grass	154	122	90	58

In one out of four years, adequate precipitation and moderate temperatures permit regrowth of perennial grasses and germination of cheatgrass in the fall. When this occurs, forage moisture contents and mineral contents increase to levels similar to those found in the spring.

Nitrogen

In all species, the total N content exceeded 3% (18.8% protein) in April, then declined exponentially to less than 1% (6.2% protein) by the end of the grazing season. According to NAS-NRC (1976), lactating cows require 1.47% N (9.2% protein) in the forage.

Nitrogen levels in desert wheatgrass fell below the maintenance level by early July; streambank wheatgrass reached that level in late July (Table 2). All species provided insufficient protein by August, indicating that protein supplements might be used to advantage after that date on desert wheatgrass pastures or on native rangelands.

Fig. 1 shows the trend of N content in desert wheatgrass and illustrates the variability in N content over time.

Phosphorus

The pattern of declining phosphorus levels in plant tissue was similar to that of N, but P levels were lower by a factor of 10. Cows with calves require forage containing 0.28% P (NAS-NRC, 1976). In most species and years the P level was below that recommended before the end of June. Table 2 shows the predicted dates when P would be expected to reach 0.28%, indicating that P levels reach the maintenance level before the first of May in all species.

Calcium and Ca:P Ratio

A better measure of the P requirement is the Ca:P (%/%) ratio. The ratios should be 2:1 under normal circumstances, but can be as wide as 7:1 when sufficient vitamin D is present (NAS-NRC, 1976).

Calcium concentrations were extremely erratic with time, but the Ca:P ratios tended to be less erratic and increased with plant maturity. Generally, the Ca:P ratio of 7:1 was exceeded by mid-August in all species, except for cheatgrass and desert wheatgrass (Table 2). The latter two species maintained satisfactory levels throughout the grazing season. Trends are shown for desert wheatgrass and needle-and-thread grass in Fig. 2.

Yearling cattle given added P did not show an increase in weight (Olsen, 1971), but P supplements may be helpful for lactating cows grazing on native ranges.

Surfur and N:S Ratio

Sulfur contents varied from 0.25% to 0.05%, declining most rapidly between April and June. NAS-NRC (1976) requirements are listed as 0.1% in the forage. Table 2 shows that dates of probable S deficiencies may occur as early as late May in cheatgrass. The S levels may remain above the minimum level through September in needle-and-thread grass. The trend of S in desert wheatgrass is compared to that of annual cheatgrass in Fig. 3.

Allaway (1969) believed that the S requirement for ruminant animals was best expressed as the ratio of N:S in forage, with the optimum range between 10:1 and 15:1. When the ratio is wider or narrower than 10 - 15:1 the animal may have a reduced protein conversion efficiency. The data indicate that for some species (desert wheatgrass, needle-and-thread grass, and bottlebrush squirreltail) the N:S ratios are narrower than those presumed to be adequate before the end of the grazing season. The trends are shown for N:S ratios in desert wheatgrass and cheatgrass (Fig. 4).

Potassium

The K concentration in early spring varied considerably among species.

Table 2. Probable date when forage mineral content or ratio falls out of range of the requirement for lactating cows (based on prediction equations and NAS-NRC (1976) requirement levels). Desert wheatgrass (Agde), Streambank wheatgrass (Agri), Cheatgrass (Brte), Great Basin wildrye (Elci), Sandberg's bluegrass (Posa), bottlebrush squirreltail (Sihy), and needle-and-thread grass (Stco).

		SPECIES						
Mineral	Requirement	Agde	Agri	Brte	Elci	Posa	Sihy	Stco
		Date						
N	1.47 %	Jun 08	Jul 25	May 31	May 27	June 03	Jun 15	Jun 09
P	0.28 %	Apr 12	Mar 25	Apr 28	Apr 26	Apr 04	Apr 10	Mar 26
S	0.10 %	Jul 04	Jul 12	May 25	Jun 21	Jun 13	Jul 17	Sep 29
K	0.60 %	Oct 05	All yr	Jul 20	Aug 13	Jul 04	Sep 12	Oct 05
Zn	20 ppm	Mar 30	Mar 23	Apr 20	May 02	Mar 09	Apr 03	Apr 20
CA:P	> 7:1	Never > 7:1	Aug 01	Oct 27	Aug 16	Jul 27	Aug 07	Aug 06
N:S	>15:1	Jun 02	May 19	May 28	Jun 16	1/	May 23	Mar 30
N:S	<10:1	Jul 19	Aug 24	Sep 21	Sep 15	1/	Jul 25	Jun 18
TDDM	<65% [2/]	Aug 21	Sep 03	Nov 29	Aug 02	Nov 17	Aug 02	Sep 13

1/ Correlation of N:S with Julian date was not significant.

2/ This is equivalent to 50-52% TDN. Fifty-two % TDN is required by lactating beef cows.

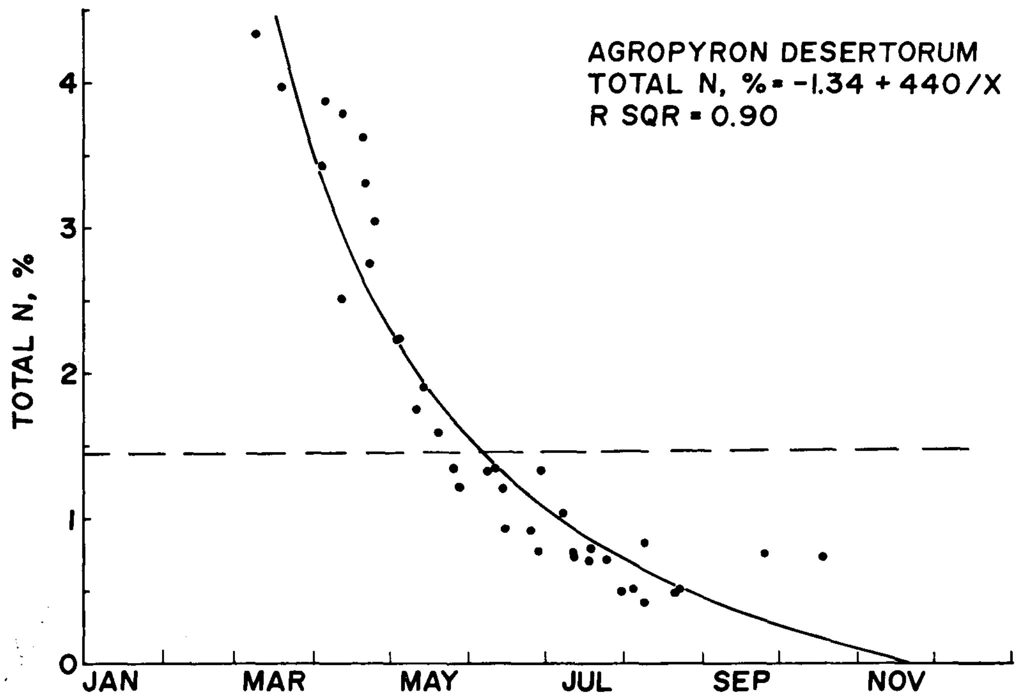

Figure 1. Nitrogen content of desert wheatgrass.

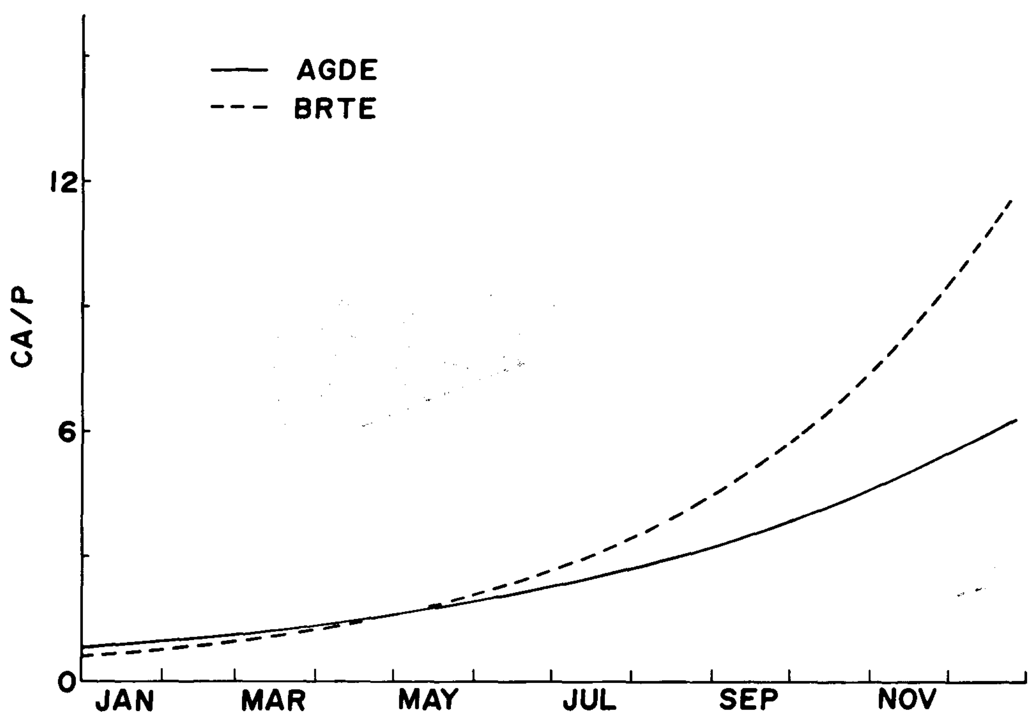

Figure 2. Trends in the Ca:P ratios of desert wheatgrass and cheatgrass.

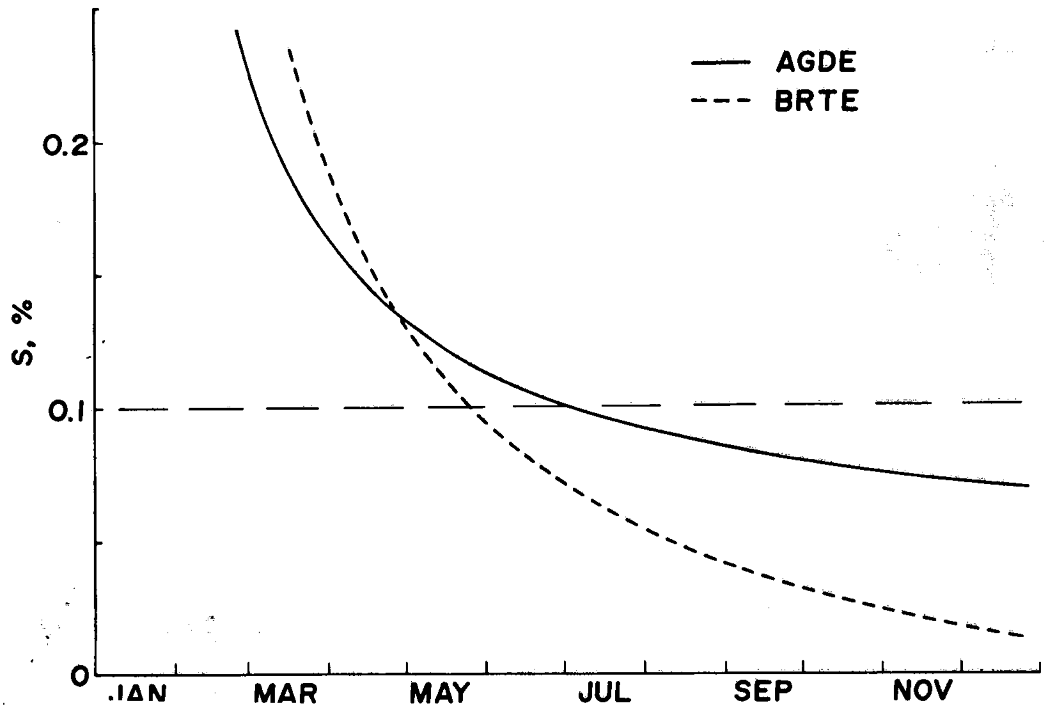

Figure 3. Trends in sulfur contents of desert wheatgrass and cheatgrass.

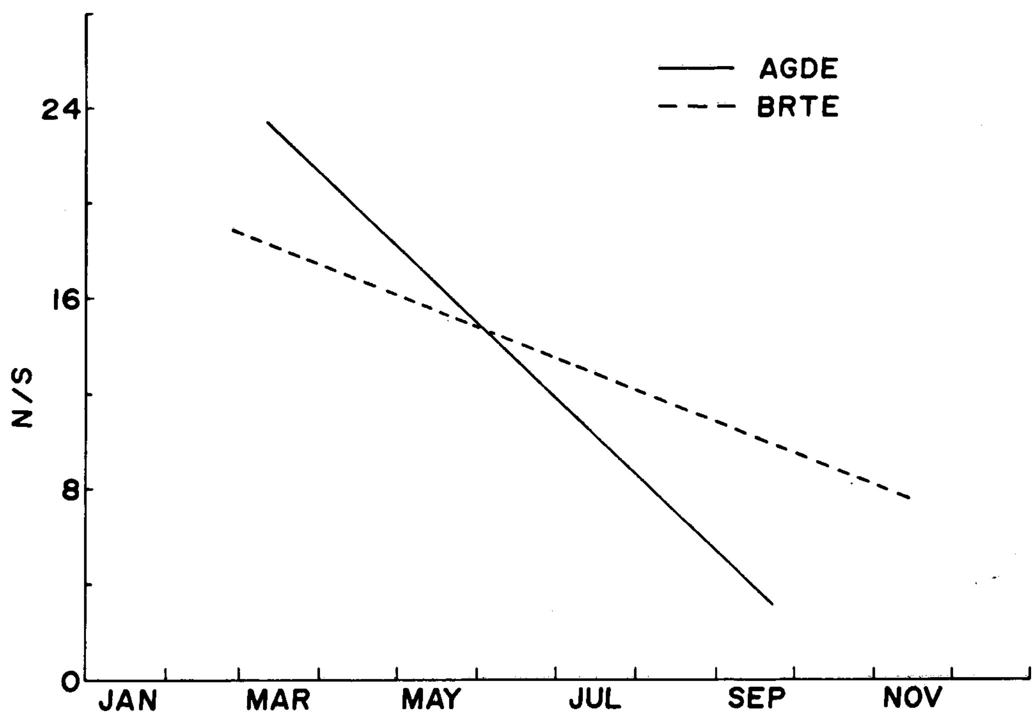

Figure 4. Trends in N:S ratios of desert wheatgrass and cheatgrass.

Basin wildrye had values in excess of 4%, whereas needle-and-thread grass contained less than 2% K. The decrease in the K level was rapid and by late July, most species had values of less than 1 percent. Table 2 compares the dates when the K level would be expected to reach the 0.6% requirement level. With the exception of Sandberg's bluegrass and cheatgrass, most species contained adequate K through most of the grazing season.

Magnesium & K/(Ca+Mg) Ratio

Levels of magnesium in plant tissue varied between 0.1 and 0.2% and most samples were below the NAS-NRC (1976) requirement of 0.18% for lactating cows. Trends were erratic in all species except cheatgrass which showed an exponential decrease in Mg content with plant maturity.

When the ratio of K/(Ca+Mg) on an equivalent basis is wide and Mg is less than 0.2%, grass tetany may become a problem (Allaway, 1969). There are few incidences of tetany when the ratio is less than 2.2:1 according to Kemp and 't Hart (1957).

Both desert wheatgrass and basin wildrye have ratios of K/(Ca+Mg) wider than 2.2:1 during the early spring. Grass tetany problems have been experienced when cattle graze desert wheatgrass pastures in the spring, but few problems have arisen on cheatgrass or native range.

Other Minerals

Sodium, Mn and Fe concentrations in forage were erratic with respect to maturity, but were above the recommended levels (500 ppm Na, 20 ppm Mn, and 80 ppm Fe) in most samples.

Copper exhibited downward trends in all species except cheatgrass and streambank wheatgrass. Nearly all samples contained greater than the recommended 4 ppm (NAS-NRC, 1976) forage tissue levels. When molybdenum (Mo) is in excess of 6 ppm in the tissue, the Cu requirement is increased two to three times. However, a few samples analyzed for Mo were found to contain less than 3 ppm; therefore, it is not likely to be a problem with these species at this location.

NAS-NRC (1976) suggests that forage Zn be at least 20 ppm to be adequate. Only in the very early spring (Table 2) were Zn values in excess of 20 ppm, and by May all species were below that level. Supplementing Zn on cheatgrass range results in increased calf gains (Mayland, 1975 unpublished). The trend in Zn concentration between desert wheatgrass and cheatgrass is compared in Fig. 5.

Digestibility Components

The methods of Van Soest (1966) lead to a measure of digestible dry matter.

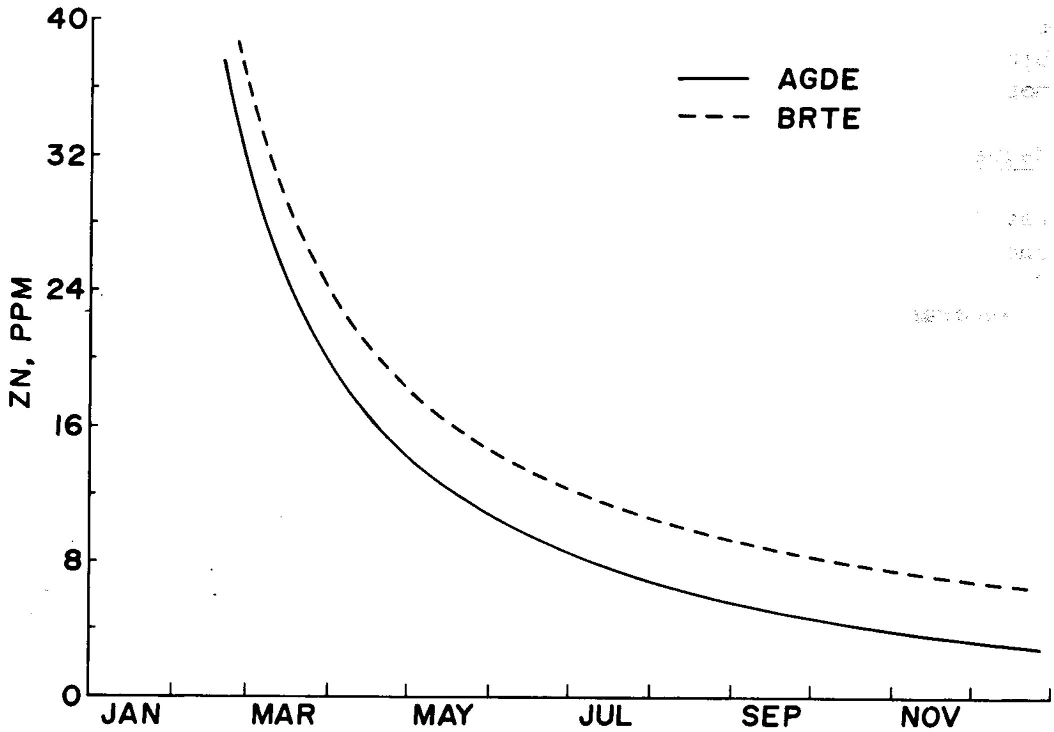

Figure 5. Trends in Zn contents of desert wheatgrass and cheatgrass.

We present data for neutral detergent fiber (NDF) and total digestible dry matter (TDDM). The NDF is a measure of total fiber content, whereas TDDM is a measure of the digestible cell wall contents and digestible lignified cell wall corrected for silica content.

The NDF % in all species increased with plant maturity. The rate of increase among species is similar, and by mid-June reaches approximately 60 percent. However, Great Basin wildrye reaches this level 15 days earlier, whereas desert wheatgrass does not reach the 60% level until early July. This indicates that for this fraction, desert wheatgrass maintains its quality for a longer period than do other species. On the other hand, TDDM decreases linearly with plant maturity and by September is generally less than 65 percent. This is equivalent to about 50-52% TDN (total digestible nutrients.)

The levels of NDF and TDDM probably differ among species because of changes in the proportion of heads and stems compared to leaves. For example, cheatgrass and Sandberg's bluegrass are both fine leaved and stemmed compared to the other species which could account for the fact that they maintained higher TDDM levels throughout the grazing season (Table 2).

Conclusions and Recommendations

Plants growing in regions receiving winter and spring precipitation, but having dry summers, cure as soil moisture content declines in the summer. Under these conditions, the nutritive quality of desert wheatgrass and other native species declines as the season progresses. In the Northern Great Plains where summer moisture is prevalent, desert wheatgrass provides more nutritious forage during the summer grazing season.

Desert wheatgrass in many areas of southern Idaho provides the only forage for livestock. In such situations, desert wheatgrass was generally planted to displace cheatgrass. The latter species invades burned and abused ranges. The yield of cheatgrass fluctuates widely from year-to-year depending on available moisture, is a fire hazard, and reaches maturity earlier than desert wheatgrass. Desert wheatgrass is more dependable in that its yields fluctuate less widely than cheatgrass.

In this study the nutritional quality of desert wheatgrass paralleled that of cheatgrass and the native perennial grasses. For most species, mineral contents were below the requirement for lactating cows before the end of the grazing season. The data suggest that mineral supplements should be a part of the grazing management program on desert wheatgrass pastures and on native ranges in this climate to maximize animal performance.

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