Forage quality of crested wheatgrass (*Agropyrum cristatum* Bess.) in relation to rainfall and level of forage utilization

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NASTIS (A. S.). Qualité fourragère du chiendent à crête (*Agropyrum cristatum* Bess.) en relation avec la pluviométrie et le degré de pâturage. *Rev. Elev. Méd. vét. Pays trop.*, 1987, **40** (3) : 293-297.

La variation de la production et de la qualité fourragère du chiendent à crête ensemencé (*Agropyrum cristatum* Bess.) sous l'effet du broutage a été étudiée pendant deux années consécutives. Les pâturages ont été broutés à la fin de l'été en fin de croissance végétative après nettoyage des refus. La première année a été considérée comme sèche (317 mm/an) avec des précipitations de 50 p. 100 inférieures à celles de la seconde (577 mm/an). La production fourragère a été déterminée à partir de coupe d'échantillons pris avant et après les essais, durant lesquels les parcelles étaient en pâturage continu avec des génisses. Les échantillons représentatifs de chaque période ont été analysés pour déterminer leur valeur nutritionnelle. La production a été de 474 kg MS/ha pour l'année sèche et de 929 kg MS/ha pour l'année humide. La digestibilité *in vitro* s'est échelonnée de 46,2 à 52,8 p. 100 pour l'année sèche et de 32,9 à 40,2 p. 100 pour l'année humide. Pour tous les échantillons de toutes les dates la teneur en matières azotées totales (MAT) s'est révélée plus importante et la teneur en fibres détergent-neutres (NDF : *neutral-detergent fiber*) plus basse pour l'année sèche que pour l'année humide. L'écart va de 4,4 à 7,5 p. 100 pour les MAT et de 1,9 à 6,3 pour les NDF. La digestibilité n'a pas significativement changé lors de la diminution du fourrage, pendant l'année sèche, alors que durant l'année humide une augmentation s'est marquée pendant la dernière période, au moment de la repousse. La teneur en MAT suit le même schéma que la digestibilité. La teneur en NDF ne change pas pendant l'année sèche au fur et à mesure du pâturage, mais augmente significativement pendant l'année humide. *Mots clés* : Plante fourragère - *Agropyrum cristatum* - Valeur fourragère - Pâturage - Production fourragère - Etats-Unis.

INTRODUCTION

The cattle and sheep farming industry depends to a large extent on range forage. Range forage production, though, varies greatly from year to year, depending mainly on the amount and the distribution of precipitation (1, 14). Although variation in forage production is occasionally greater than threefold between any two consecutive years, there is not such a great animal product fluctuation. On the contrary, some ranchers insist that cattle performance is better during dry than during wet years, when there is sufficient grazing space per animal. This indicates that quality may play a more important role than forage abundance within some limits. It indicates also how little factual information exists to document animal performance in relation to forage resource.

This discrepancy between quantitative forage production and animal production may be partially explained by forage quality. Biomass produced in various years does not have the same nutritional value throughout. Heavy grazing is expected to bring to the surface more clearly existing differences between years. The purpose of this study was to examine the variation in forage quality of seeded crested wheatgrass (*Agropyrum cristatum* Bess.) pastures under intensive grazing during wet and dry years.

MATERIAL AND METHODS

The study was conducted during the summers of 1977 and 1978 on the Tintic experimental area near Eureka, Juab County, in central Utah. The first year (1977, 329 mm) was a dry year and the second (1978, 603 mm) was considered a wet year. Average annual precipitation in Eureka (approximately 10 km from the study area) during the last 45 years has been 400 mm. Precipitation is distributed more or less evenly throughout all the months of the year. Records for precipitation and temperature were obtained on the study site during the course of the experiment.

Two crested wheatgrass-dominated pastures (pasture 17 and 18), both with sandy loam soil, served as experimental units. During 1977, samples were taken from a 28 ha area which was grazed by 20, one and a half year old Angus heifers. This pasture was sampled between August 9 and September 18. There was a total of four successive sampling periods. Samples for determining forage quality were collected by hand clipping forage similar to that grazed three times a day. All samples collected during a period were composited to form the sample of the period. The average stocking rate was 1 Animal Unit Month (AUM*)/ha (10). During 1978, 10 ha of uniform vegeta-

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(*) AUM = The amount of feed or forage required by a mature cow with calf or their equivalent for one month.

tion in the adjacent pasture 17 were sampled and grazed by 16 experimental animals and, periodically, by 18 other animals all similar to those used in 1977. The additional animals were used to achieve desired levels of forage utilization. The average stocking rate was 3.7 AUM/ha. This 10 ha pasture was sampled between August 9 and September 20. Sampling was repeated on the same periods as above and on an additional one in late autumn.

Forage biomass and height were determined by means of a systematic sampling scheme, along equally spaced parallel lines across the entire pasture (12). The sample size was determined (16) so that experimental error would be within 10 p. 100 of the mean with a probability of $\leqslant$ 90 p. 100. The first sampling position, randomly selected, consisted of a circular 1 m^2 quadrat ; hence, every 40 meters along the lines other such positions were marked. Sampling was carried out every 10 days during 1977 and every 5 days during 1978 (Table I).

Forage biomass was determined by harvesting all plant material within the circular 1 m^2 sampling quadrats at aproximately 1.0 cm above ground level with hand shears. Plant height was measured at two hit points on either side of every square-meter circle.

Biomass subsamples were divided into species so as to determine forage composition by weight. The same subsamples were divided into stems and leaves. Regrowth within each experimental period was measured by protecting 30 clipped plots with exclosure cages and reclipping them at the end of the period. All samples were dried for 24 h at 105 °C and weighed to determine the dry weight of the total forage available.

TABLE I Herbage available (kg/ha) during 1977 and 1978 in a crested wheatgrass pasture.

Dates	Mean Yield	SD
1977 *		
Aug – 9	474	13.6
Aug – 19	359	14.3
Aug – 29	272	12.1
Sept – 8	236	12.8
Sept – 18	170	9.4
1978 **		
Aug – 9	929	39.5
Aug – 13	909	32.7
Aug – 18	864	34.1
Aug – 23	652	21.6
Aug – 28	562	23.8
Sept – 2	507	20.8
Sept – 8	382	21.6
Sept – 12	241	12.9
Sept – 23	173	4.7
Sept – 28	114	6.6

(*) N = 100. 1.0 m^2 quadrats at each sampling date.
(**) N = 35. 1.0 m^2 quadrats at each sampling date.

Organic matter digestion coefficients were determined through an *in vitro* analysis of hand-harvested forage samples, similar to the grazed forage, according to the procedures of TILLEY and TERRY (17). Inoculum for the *in vitro* procedure was obtained from heifers grazing the crested wheatgrass pastures. Four animals were each tranquilized with 5 cc Rompun (Haver-Lockhart Laboratories, Shawnee, Kansas). Inoculum was then obtained by vacuum aspiration via a stomach tube and pooled into two preheated 1-liter thermos bottles. The inoculum was immediately transferred to the laboratory, where the *in vitro* digestion trials were conducted.

Similar forage samples were analyzed for nitrogen content by a macro-Kjeldahl procedure (7) and for NDF contents (18).

The data relating to forage nutritional measurements (crude protein, NDF contents and *in vitro* digestibility) were analyzed according to a completely randomized design (15). Comparisons between years were made for *in vitro* OM digestibility, crude protein content and NDF contents using a « t » test.

For evaluating significant differences between means, Duncan's New Multiple Test was used (16). Differences between means at the $\alpha \leqslant 0.05$ level of probability were considered statistically significant.

RESULTS AND DISCUSSION

Production of forage biomass was 474 kg/ha during 1977 and 929 kg/ha during 1978 (Table I). Forage per unit area for 1978 was twice that for 1977. This was mainly due to differences in amounts and distribution of precipitation ; total precipitation between October and September were 317 and 577 mm for the years 1976-1977 and 1977-1978 respectively (*).

Forage grazed in pasture during 1977 was composed of 88 p. 100 crested wheatgrass and 12 p. 100 western wheatgrass (*Agropyrum smithii*). It did not reach full phenological development and was prematurely cured by droughty conditions.Before the initiation of grazing, the forage had an average plant height of 15 cm while 56 p. 100 of its weight was leaves. Forage during 1978

(*) Precipitation potentially used for the yearly production different from the calendar annual precipitation.

was 56 p. 100 crested wheatgrass, 36 p. 100 western wheatgrass, and 8 p. 100 Indian ricegrass (*Oryzopsis hymenoides*). During this year, forage reached full phenological development. Before the initiation of the experiment, average plant height was 31 cm and leaves comprised 42 p. 100 of its weight.

A substantial amount of regrowth (62 kg DM/ha) occurred during the study period in 1977 and a small amount of regrowth (25 kg DM/ha) was observed the following year. The amount and distribution of precipitation (1, 14) in relation to air temperatures (13) had a definite impact on crested wheatgrass growth.

Comparison of digestibilities (table II) between the two years resulted in significantly higher digestibility for 1977 (averaging 49.3 p. 100) than for 1978 (averaging 35.3 p. 100). Samples from both years were digested in the same trial with the same inoculum source. Hence, the difference between years was attributed to differences in forage quality.

COOK and HARRIS (4), working with sheep, reported *in vivo* digestibility for crested wheatgrass ranging between 57.0 and 53.0 p. 100 during the spring season, while FIERRO (5) and HANDL (6) reported slightly higher *in vitro* digestibility values for crested wheatgrass during the spring growth. The above findings were for immature or partially mature but not cured grass. Therefore, it was not suprising that digestibilities were higher than those found in the present study.

Differences in digestibilities between the two years have to be partially attributed to the difference in plant composition (13 p. 100 more western wheatgrass and 7 p. 100 more Indian ricegrass in 1978 than in 1977) partially to the lower leaf-stem ratio and to the more mature stage of development during the second year. Digestibility increased when regrowth occurred, but this increase was significant only for 1978.

Crude protein content (Table II) of forage was significantly higher during the dry than during the wet year. Increased CP content during dry years in comparison to wet years has also been reported by HEDRICK *et al.* (9). These findings ranged between 9.6 and 13.2 p. 100 during the dry year and between 5.7 and 9.5 p. 100 during the wet year. These differences were attributed :

— to the dry conditions which caused cessation of growth before full phenological development,

— to the regrowth in the third sampling period during the first year and in the fifth sampling period during the second year and,

— to the difference in botanical composition.

FIERRO (5) reported that the crude protein content of regrowth may vary between 15 and 25 p. 100 depending on the proportion of regrowth within the sample. Even a small increment of regrowth can alter the overall crude protein content of standing cured forage with low crude protein content.

No significant difference in NDF contents was found in forage samples collected during the grazing trials in 1977 (Table II). However, NDF contents increased significantly as grazing progressed during 1978. Forage had significantly lower NDF contents during 1977 than during 1978. Immature cured forage during 1977 had a lower and more even distribution of NDF contents within the plant biomass. Additionally, regrowth occurring during the third trial contributed

TABLE II Crude protein content, neutral-detergent fiber (NDF percent of DM) and in vitro digestibility (percent of OM) of hand harvested crested wheatgrass forage.

Constituents	Periods				
	Aug. 9-13	Aug. 19-23	Aug. 29-Sept. 2	Sept. 8-12	Sept. 24-28
	1977				
CP	10.3 ± 0.7b (1)	9.6 ± 0.8b	13.2 ± 0.8a	11.2 ± 0.7b	—
NDF	60.0 ± 1.2a	59.6 ± 0.3a	60.2 ± 0.7a	60.1 ± 1.7a	—
IVOMD	46.2 ± 0.7a	47.7 ± 1.8a	52.8 ± 4.3a (2)	48.4 ± 2.4a	—
	1978				
CP	5.9 ± 0.6b	6.2 ± 0.4b	5.7 ± 0.5b	5.8 ± 0.9b	9.5 ± 2.0a
NDF	61.9 ± 2.6a	61.9 ± 2.2ab	64.8 ± 2.5bc	67.4 ± 2.1c	67.3 ± 2.1c
IVOMD	34.9 ± 1.6a	34.5 ± 1.7a	32.9 ± 2.0a	33.5 ± 2.0a	40.2 ± 4.8b (3)

(1) Means ± SD in the same row followed by a common letter are not significantly different ($P \leq 0.05$).
(2) The regrowth improved the overall quality of diet less than in 1977 (cf. 3) since the first growth of forage was of better quality (immature).
(3) The diets of animals contained relatively high proportions of regrowth. Indeed, the regrowth of 25 kg/ha was an average over the entire area, but most of it occurred in the swales where the animals concentrated during this last grazing period.

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negatively to the NDF contents (regrowth was mainly leaves low in NDF contents). Therefore, NDF contents were maintained at about 60 p. 100 throughout the grazing trials. By contrast, an increase in NDF contents from 61 p. 100 during the first trial to 66 p. 100 during the fourth and fifth trials was measured during 1979 (Table II). This indicates that grazing was selective even in the botanically simple pasture. Selective grazing (2, 3) typically removes leaves in preference to stems. However, no significant difference in the present study in leaves/stem ratios by weight was found between trials in either year. This limited selection of leaves is primarily attributed to the physical structure of the plant community studied. Crested wheatgrass typically grows in dense bunches and has relatively short leaves. Additionally, its stems are relatively soft and small in diameter compared with other grass species such as *Phalaris* evaluated by ARNOLD (2). Secondly, heifers are generally less selective as regards leaves versus stems as compared with sheep, used in the experiments conducted by COOK and HARRIS (3) and ARNOLD (2).

CONCLUSION

It is generally understood that animal performance depending on intake is highly related to forage quantity and quality. Forage production is undoubtedly lower when rainfall is limited. However, forage quality is generally higher and can compensate for the limited quantity. Furthermore it was measured (8, 11) that intake by heifers was maintained constant by altering animal behavior when forage availability ranged between 173 kg/ha and 929 kg/ha. Consequently, animal performance is expected to be superior during the dry years when there is sufficient grazing space per animal.

ACKNOWLEDGEMENTS

The author is grateful to Dr. J. C. MALECHEK, Professor of Range Science at Utah State University for his support and consultation during the conduct of this research.

NASTIS (A. S.). Forage quality of crested wheatgrass (*Agropyrum Cristatum* Bess.) in relation to rainfall and level of forage utilization. *Rev. Elev. Méd. vét. Pays trop.*, 1987, **40** (3) : 293-297.

Forage production and quality variation with defoliation of seeded crested wheatgrass (*Agropyrum cristatum* Bess.) were studied during two consecutive years. Pastures were grazed in late summer when growth had ceased and forage was cured. The first year was considered dry (317 mm/year), with 50 p. 100 less precipitation than the second one (577 mm/year). Forage production was determined by clipping adequate samples, before and after each trial, while the pastures were grazed continuously by heifers. Representative samples for each period were analyzed so as to determine their nutritional value. Forage production was 474 kg DM/ha during the dry year and 929 kg DM/ha, during the wet year. *In vitro* digestibility ranged from 46.2 to 52.8 p. 100 for the dry year and from 32.9 to 40.2 p. 100 for the wet year. On all sampling dates, CP content was higher and neutral-detergent fiber contents (NDF, percent of DM) lower for the dry year than for the wet year. Their difference ranged from 4.4 to 7.5 p. 100 for CP and 1.9 to 6.3 p. 100 for NDF. Digestibility did not change significantly during the dry year as forage diminished, while during the wet year an increase was found in the last period when regrowth occurred. Crude protein (CP) content had the same pattern as digestibility. NDF contents did not change significantly during the dry year as grazing progressed but did increase significantly during the wet year. *Key words* : Fodder plant - *Agropyrum cristatum* - Fodder value - Grazing - Fodder production - United States.

NASTIS (A. S.). Cualidad forrajera de *Agropyrum cristatum* Bess. en relación con la pluviometria y el nivel de pastoreo. *Rev. Elev. Méd. vét. Pays trop.*, 1987, **40** (3) : 293-297.

Se ha estudiado durante dos años consecutivos la variación de la producción y de la cualidad forrajera de *Agropyrum cristatum* Bess. pastoreado. El pastoreo tuvo lugar a fines del verano cuando terminado el crecimiento vegetativo después de la eliminación de los residuos.

Se consideró el primer año como seco (317 mm/año) con precipitaciones de 50 p. 100 inferiores a las del segundo (577 mm/año). Se determinó la producción forrajera a partir de corte de muestras tomadas antes y después de los ensayos, durante los cuales los pastos estaban pastoreados de modo continuo por becerras.

Se analizaron las muestras representativas de cada periodo para determinar su valor nutricional. Fué de 474 kg MS/ha la producción durante el año seco y de 929 kg MS/ha durante el año húmedo. La digestibilidad *in vitro* llega de 46,2 a 52,8 p. 100 para el año seco y de 32,9 a 40,2 p. 100 para el año húmedo. La proporción de materias nitrogenadas totales (MNT) de todas las muestras fué más importante y la de fibra detergente neutra (NDF : *neutral-detergent fiber*) más baja para el año seco que para el año húmedo. Es de 4,4 a 7,5 p. 100 la diferencia para las MNT y de 1,9 a 6,3 para los NDF. La digestibilidad no se modificó significativamente al momento de la disminución del forraje durante el año seco mientras que durante el año húmedo se observó una aumentación durante el último periodo durante el rebrote. Es lo mismo para la MNT. La cantidad de NDF no cambia durante el año seco a medida del pastoreo sino aumenta significativamente durante el año húmedo. *Palabras claves* : Planta forrajera - *Agropyrum cristatum* - Valor forrajero - Pastoreo - Producción forrajera - Estados Unidos.

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