Digestibility and Chemical Composition of

BROME and ALFALFA

Throughout the Growing Season

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Alfalfa and bromegrass are two of the major tame forages produced in North Dakota for livestock feed. Approximately 1.3 million acres of alfalfa and 0.8 million acres of brome are produced annually in the state, according to the North Dakota Crop and Livestock Reporting Service. Forages are of little or no value unless marketed through livestock. According to Leistritz and Dunn (1971), 25 per cent of North Dakota's total receipts for all farm products is from the sale of cattle and calves.

Chemical composition of plants changes with growth stage, and many of these chemical constituents are directly or indirectly related to the value as a livestock feed. This study was conducted to determine some of the major changes in chemical composition of alfalfa and brome from May through October, and to utilize some of these chemical fractions to estimate digestibility.

Procedure

Alfalfa and brome plots at the Fargo Station were sampled approximately 15 times from May to October each year for a three-year period (1967 to 1969) as indicated in Table 1. Alfalfa was categorized into 12 physiological growth stages and brome into eight. Samples were taken by hand clipping the forage about two inches above the ground, then refrigerating until freeze-dried. Prior to chemical analysis, the samples were ground through a 40-mesh screen. The samples were chemically analyzed for dry matter, ash, protein (AOAC 1960), acid detergent fiber, lignin, cell wall constituents, silica (Goering and Van Soest 1970) and phosphorus (Bolin and Stamberg 1944). Estimated **in vitro** digestible dry matter was determined by the "summative equation" derived by Van Soest (1967). This equation is based on the relationship of acid detergent fiber, lignin, cell wall and silica to digestibility.

Results and Discussion

Analysis of some of the more meaningful chemical fractions of alfalfa and the estimated digestibilities for cattle are shown in Table 2. Fiber, lignin and cell wall increase with advancing maturity. All of these fractions reduce the digestibility of a forage. Usually, consumption of the forage decreases as these fibrous fractions increase due to a slower rate that material passes through the digestive tract. The statement that "animals eat on their energy requirement basis" refers primarily to rations used for fattening animals. As the value or digestibility of a feed goes down, the animal will consume more of this feed to get its needed energy. However, when feed quality is poor, consumption actually decreases because the fibrous or low quality feed passes along the digestive tract more slowly than a feed with low fiber. Since passage rate is slower, the digestive tract becomes full (fill) and increased feed intake is not possible. When animals

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Table 1. Description of growth stage and dates.

Alfalfa			Brome		
Growth Stage No.	**Description**	**Dates[1]**	**Growth Stage No.**	**Description**	**Dates**
1	vegetative (prebud 4-20")	5-3 to 6-2	1	vegetative 5-12"	5-3 to 5-28
2	budding	6-2 to 6-17	2	jointing 12-18"	5-28 to 6-6
3	bloom, 25%	6-17 to 7-3	3	boot 18-27"	6-6 to 6-16"
4	bloom, 50%	7-3 to 7-10	4	early heading	6-16 to 6-26
5	bloom, 75%	7-10 to 7-16	5	heading to anthesis	6-26 to 7-3
6	bloom, 100%	7-16 to 7-26	6	milk	7-3 to 7-16
7	podding, early	7-26 to 8-7	7	dough	7-16 to 7-30
8	podded, 10% leaf loss	8-7 to 8-16	8	mature to overripe	7-30 to 10-10
9	podded, 25% leaf loss	8-16 to 9-12			
10	podded, 50% leaf loss	9-12 to 9-25			
11	podded, 75% leaf loss	9-25 to 10-1			
12	ripe seed, mostly stems	10-1 to 10-30			

[1]These dates include all three years of data collection.

consume rations that are of a quality where fill limits intake, the lower the quality the less the feed consumption. With low quality roughages such as mature range, mature prairie and grass hays and straw, fill or reduced intake must be considered.

Concentrations of protein and phosphorus steadily decline during the season. This results from a combination of factors such as leaf loss, increased fibrous material and a return of nitrogen and phosphorus to the root system. Alfalfa furnishes considerable quantities of protein for ruminants when it is cut within the limits of the normal harvest season (early bloom to full bloom). The level of phosphorus would be on the border line of deficiency for ruminants in most cases. Silica is included in the chemical analysis because it reduces digestibility, but the content of silica in alfalfa is generally low and variable and does not significantly increase during the growing season.

If brome is used for pasture, it would generally be grazed when it is in the vegetative and jointing stages (growth stage 1 and 2). Forages at this time are low in fiber and should contain about 65 per cent digestible dry matter (Table 3). Based on the

Table 2. Chemical Fractions and Digestibilities of Alfalfa as Affected by Growth Stage.

	Percentage						
Growth Stage	**Protein**	**Fiber**	**Lignin**	**Cell Wall**	**Silica**	**Phosphorus**	**Digestibility[1]**
1	23.4±3.0	16.3±3.5	3.0±0.8	23.1±3.9	0.68±0.16	0.28±0.60	70.9±2.7
2	**19.6±1.3**	**24.2±3.6**	**4.3±0.8**	**29.7±4.2**	**0.40±0.00**	**0.20±0.10**	**68.1±4.1**
3	**16.6±2.0**	**26.9±4.5**	**5.6±1.3**	**35.5±5.8**	**0.46±0.09**	**0.17±0.02**	**61.8±5.3**
4	**14.8±1.5**	**29.8±2.7**	**6.1±0.5**	**38.6±1.5**	**0.56±0.17**	**0.14±0.04**	**59.6±2.3**
5	**14.4±0.6**	**33.6±2.4**	**7.6±0.5**	**43.5±1.9**	**0.35±0.06**	**0.15±0.01**	**55.3±1.2**
6	**14.1±2.5**	**34.4±4.1**	**7.7±1.8**	**46.6±4.0**	**0.58±0.29**	**0.15±0.02**	**52.5±4.4**
7	**12.1±1.8**	**38.5±3.3**	**9.6±2.4**	**51.3±4.2**	**0.53±0.13**	**0.12±0.02**	**47.1±5.0**
8	10.6±2.1	40.7±6.2	9.2±1.8	52.9±4.4	0.60±0.26	0.12±0.04	4.73±4.5
9	10.7±3.1	42.8±9.6	9.9±2.3	56.3±2.7	0.72±0.22	0.09±0.03	44.0±6.9
10	9.6±2.9	43.8±10.2	10.4±3.0	60.5±6.9	0.75±0.00	0.09±0.02	39.8±7.9
11	9.8±1.9	40.9±9.2	10.6±2.8	59.4±10.6	0.72±1.14	0.07±0.01	37.8±16.3
12	10.0±0.9	46.9±1.8	11.0±2.9	62.0±0.7	0.95±0.15	0.06±0.00	38.8±7.4

[1]Estimated apparent digestibility for cattle (Goering and VanSoest, 1970)
Bold typed values indicate the growth stage within the limits of normal harvest.

Table 3. Chemical Fractions and Digestibilities of Brome as Affected by Growth Stage.

Growth Stage	Protein	Fiber	Lignin	Cell Wall	Silica	Phosphorus	Digestibility[1]
				Percentage			
1	20.2±2.3	20.9±2.4	2.0±0.4	36.8±3.8	**2.2±0.34**	0.28±0.04	67.2±4.2
2	15.8±3.4	26.0±1.4	2.6±0.5	40.7±1.5	2.8±0.59	**0.23±0.02**	63.1±4.6
3	**11.3±1.2**	**29.4±0.9**	**2.7±0.1**	**48.3±0.1**	**3.2±0.00**	**0.24±0.10**	**59.5±0.5**
4	**10.2±1.9**	**33.7±1.9**	**3.6±0.7**	**54.8±2.7**	**3.2±0.32**	**0.19±0.02**	**54.6±4.9**
5	**7.4±1.1**	**35.8±2.0**	**4.0±0.9**	**58.6±2.2**	**3.9±0.61**	**0.15±0.07**	**48.5±6.8**
6	**6.1±0.8**	**36.8±1.3**	**4.7±1.3**	**57.0±1.9**	**3.6±0.16**	**0.13±0.02**	**47.1±3.4**
7	5.4±0.8	36.9±2.9	4.8±1.7	59.8±3.1	4.6±0.02	0.12±0.03	**42.4±8.0**
8	4.4±0.9	39.4±4.7	5.3±1.3	61.6±5.3	5.9±1.06	0.10±0.03	34.4±9.4

[1]Estimated apparent digestibility for cattle (Goering and VanSoest, 1970)
Bold typed values indicate the growth stage within the limits of normal harvest.

nutritional level of the forages, performance of cattle in terms of gain, efficiency and reproduction (conception rate) should be very good. Protein and phosphorus levels are high enough to meet the ruminant requirements. Quality of brome cut for hay is much better during the boot to early heading stages (growth stages 3 and 4) compared to the anthesis and milk stages (growth stages 5 and 6). Digestibility, protein and phosphorus from growth stages 5 and 6 (heading to anthesis and milk) to maturity fall below suggested requirements for certain stages of the reproductive cycle and normal growth of ruminants. Supplemental sources of energy, protein and phosphorus would be needed for ruminants when brome reaches the mature stages.

The fibrous fractions (fiber, lignin and cell wall) increase with advancing maturity and protein and phosphorus decrease. Concentrations of silica are higher in brome than alfalfa and increase with growth stage and significantly reduce digestibility.

To determine the relationships of these various chemical fractions to each other and to digestibility, correlation analyses were run with the results presented in Tables 4 and 5.

Relationships of fiber, lignin and cell wall to each other are highly significant, and all of these are negatively correlated to protein, phosphorus and digestibility. As lignin in alfalfa and brome increases, digestibility decreases with correlation coefficients of −.928 and −.911 respectively. Previous work at this Station indicates that forage acid detergent lignin and the resulting fecal acid detergent lignin can be used as a satisfactory internal indicator to determine digestibility (Erickson, Bolin and Dinusson, 1966 and Erickson **et al**, 1970).

It appears that acid detergent lignin, acid detergent fiber, cell wall constituents and protein could be used to estimate digestibility of alfalfa and brome. The relationships between selected chemical fractions and digestibility are shown graphically in Figure 1. Simple regression equations to predict digestibility of alfalfa and brome for cattle along with the correlation coefficients are presented in

Table 4. Correlation Coefficient[3] Matrix for Alfalfa[1] Including Growth Stages 2 through 7.

	Growth Stage	Ash	Fiber	Lignin	Protein	Cell Wall	Silica	Phosphorus	EADC[2]
Growth Stage	1.000								
Ash	−.544	1.000							
Fiber	.807	−.659	1.000						
Lignin	.760	−.692	.837	1.000					
Protein	−.783	.676	−.873	−.767	1.000				
Cell Wall	.871	−.647	.883	.808	−.858	1.000			
Silica	.278	.086	.086	.018	−.053	.155	1.000		
Phosphorus	−.737	.546	−.584	−.626	.685	−.666	.262	1.000	
EADC[2]	−.851	.675	−.820	−.928	.805	−.939	−.164	.703	1.000

[1]77 observations
[2]Estimated apparent digestibility for cattle
[3]Values over .226 and .295 are significant at the 5% and 1 % level respectively

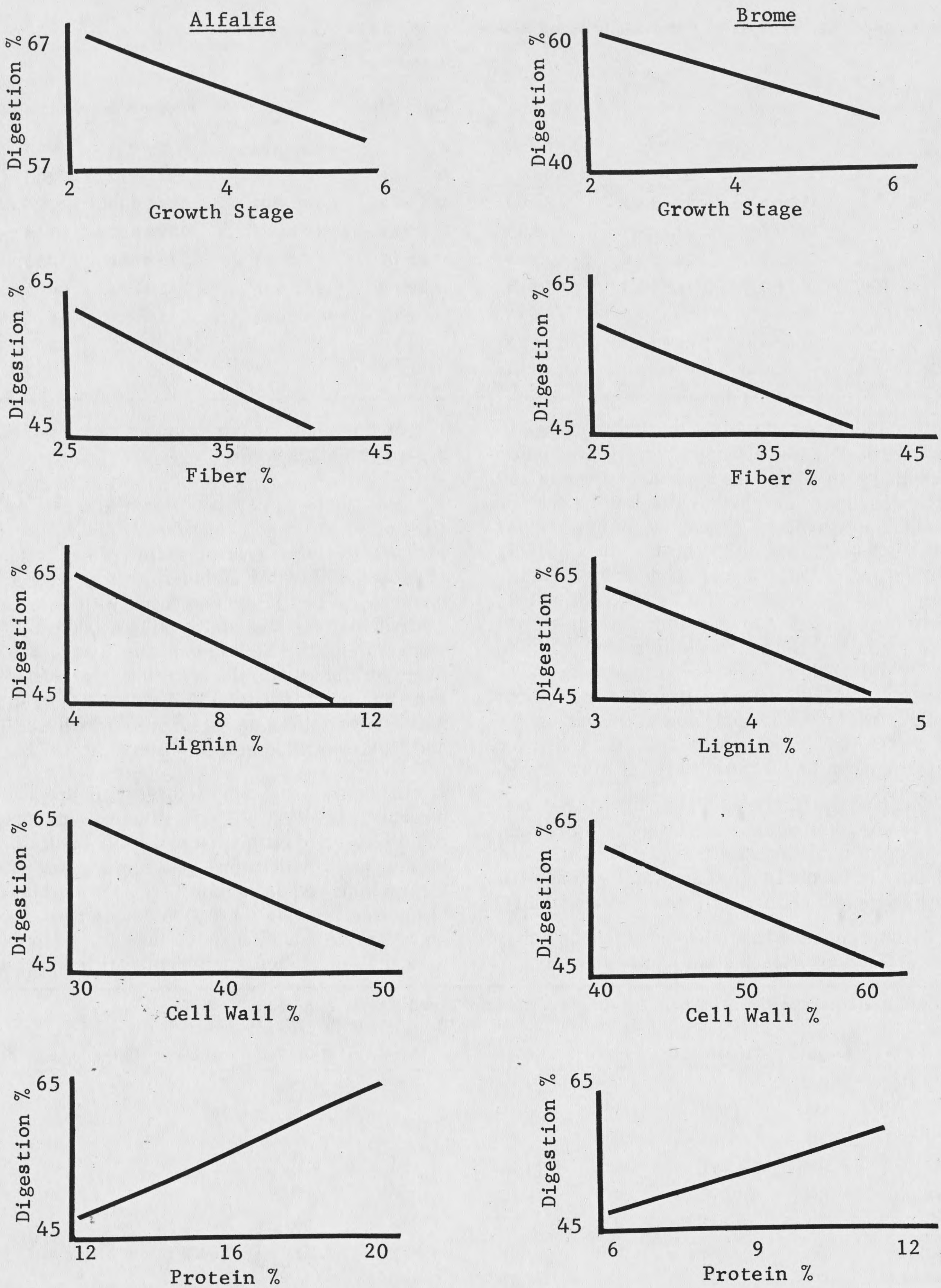

Figure 1. Estimated digestibility of alfalfa and brome based on simple linear equations.

Table 5. Correlation Coefficient[3] Matrix for Brome[1] Including Growth Stages 3 through 6.

	Growth Stage	Ash	Fiber	Lignin	Protein	Cell Wall	Silica	Phosphorus	EADC[2]
Growth Stage	1.000								
Ash	.080	1.000							
Fiber	.694	.191	1.000						
Lignin	.586	.379	.631	1.000					
Protein	−.782	−.063	−.764	−.544	1.000				
Cell Wall	.581	.029	.762	.460	−.607	1.000			
Silica	.401	.236	.275	.287	−.419	.298	1.000		
Phosphorus	−.565	.431	−.321	−.028	.502	−.338	−.266	1.000	
EADC[2]	−.583	−.372	−.530	−.911	.529	−.528	−.594	.096	1.000

[1]56 observations
[2]Estimated apparent digestibility for cattle
[3]Values over .261 and .338 are significant at the 5% and 1% level respectively

Table 6. The equations are based on data collected between growth stages 2 and 7 and 3 and 6 respectively for alfalfa and brome. These stages would encompass normal harvest time except when these forages are used for grazing.

Summary

Alfalfa and brome produced at the Fargo Station were sampled throughout three growing seasons. Several of the chemical fractions related to forage value were analyzed. Relationships of these fractions to each other and to digestibility were determined. The changes in chemical fractions as affected by physiological growth stage were also studied.

Fiber, lignin and cell wall constituents are highly correlated to each other and increase steadily with advancing maturity. Each of these fractions have a negative effect on digestibility. Protein and phosphorus are highly related to each other and decrease steadily with maturity of the forage to a point of deficiency for ruminants. Silica in brome steadily increases with maturity and reduces digestibility, while silica levels in alfalfa were low and quite variable throughout the season.

The chemical composition of alfalfa and brome change significantly with physiological growth stage, and these changes should be considered in the grazing and harvesting management of these forages.

Table 6. Regression equations for predicting the estimated digestibilities of alfalfa[1] and brome[2] and the correlation coefficients.

Independent variable	Regression equation	Correlation Coefficient
	Alfalfa	
Growth stage	y = 74.79 − 3.887(x)	−.85**
Ash	y = 10.72 + 5.349(x)	.67**
Fiber	y = 91.43 + 1.089(x)	−.82**
Lignin	y = 80.42 − 3.358(x)	−.93**
Protein	y = 24.02 + 2.190(x)	.80**
Cell wall	y = 94.20 − 0.901(x)	−.94**
Phosphorus	y = 32.92 + 158.503(x)	.70**
Silica	y = 62.20 − 8.071(x)	−.16
	Brome	
Growth stage	y = 71.26 − 4.258(x)	−.58**
Ash	y = 69.14 − 2.355(x)	−.37**
Fiber	y = 97.15 − 1.320(x)	−.53**
Lignin	y = 75.95 − 6.305(x)	−.91**
Protein	y = 38.40 + 1.523(x)	.53**
Cell wall	y = 106.11 − 0.977(x)	−.53**
Phosphorus	y = 49.35 + 10.914(x)	.09
Silica	y = 76.75 − 7.214(x)	−.59**

[1]77 observations
[2]56 observations
**Significant at the 1% level

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