

THE NUTRITIONAL VALUE OF OAT HAY HARVESTED AT SEVERAL STAGES OF MATURITY

D.O. Erickson, N.R. Riveland and E.W. French

ABSTRACT

The nutritional value of the oat varieties Dal (high protein) and Kelsey (high protein) harvested for forage at six growth stages from 50 percent headed to mature was determined. Protein, phosphorus, potassium, ash and potassium/calcium plus magnesium ratios decreased with advancing maturity. Calcium, magnesium and fiber levels were not affected by growth stage. Dal was higher in protein at each harvest stage and averaged about 2% higher at the fully headed and milk stages. Oats is a very good forage nutritionally and should be harvested at the late milk to early dough stage.

Procedure

Two oat varieties were selected for their inherent differences in grain protein content. Kelsey is considered to be low in grain protein. Dal is considered to have a high grain protein content.

The two varieties were planted on May 28, 1974 and May 15, 1975 with a grain drill having six-inch row spacing. Four replications were used each year. Planting rate was 48 pounds per acre. Fertilizer was applied according to soil test results. Soil type was a Williams loam. The varieties were harvested at the various growth stages shown in Table 1. Plant height, per cent moisture, and forage and grain yield were recorded. Whole plant samples were air dried, ground and analyzed for nutritional value according to standard laboratory procedures.

One of the major factors that affects the nutritional value of a plant to be used as a forage is the stage of maturity at which it is harvested. Whitman *et al.*

(1951) researched the nutritional value of some of the native grasses in western North Dakota and observed that protein, phosphorus and carotene decrease as the season progresses. Similar observations were reported by Erickson, Barker and Haugse (1977) on native grasslands in the Sheyenne National Grasslands in eastern North Dakota. Their work also indicated that not only protein and phosphorus decrease but also the digestibility decreases. This is directly related to the increases in fiber and lignin. The nutritional value of brome and alfalfa also decreases with advancing maturity (Ferebee *et al.* 1972). The nutritional changes, however, are different among the species, warm or cool season grasses, tall or short and legumes or grasses.

In western Canada, oat hay is the major annual forage. The nutritional value of varieties as affected by stage of maturity was reported by Kilcher and Troelsen (1972). They concluded that protein and energy decreased with advancing maturity and lignin increased as did yield of total dry matter. They also found no advantage in delaying harvest of oats for hay beyond the milk to soft dough stage. In order to help the producers of oat hay in North Dakota get the most out of the crop, this study was conducted to determine yield and nutritive value of oat forage harvested at various stages of growth.

Dr. Erickson is Professor, Department of Animal Science; Riveland is Associate Agronomist and French is Superintendent, Williston Experiment Station.

**Table 1: Annual and Average Forage Yields (12% Moisture)
For Two Oat Varieties Harvested at Various Growth Stages**

Growth Stage	Forage Yield - lb/A © 12% moisture					
	1974		1975		Avg. 1974-75	
	Kelsey	Dal	Kelsey	Dal	Kelsey	Dal
Late Boot	326	471	1500	1601	913	1036
Fully Headed	574	585	2157	2005	1366	1295
Milk	716	632	3140	2978	1928	1805
Soft Dough	701	652	3467	3464	2084	2059
Hard Dough	698	704	3942	3886	2320	2296
Mature	615	725	4328	3829	2472	2278
LSD 5%	95	95	418	418	213	213

**Table 2: Precipitation Data
Williston Experiment Station
1972-1975**

Month	Precipitation - Inches				
	1972	1973	1974	1975	Average 1957-75
April	1.87	1.78	0.78	2.39	1.32
May	4.60	1.20	3.84	1.55	2.15
June	1.80	2.84	0.98	4.85	2.73
July	2.28	1.39	1.49	1.88	2.05
Total	10.55	7.21	7.18	10.67	8.25

Table 3: Grain Yield of Two Oat Varieties

Variety	Grain yield - Bu./a		
	1974	1975	Average
Kelsey	16.9	70.1	43.5
Dal	14.0	54.8	34.4

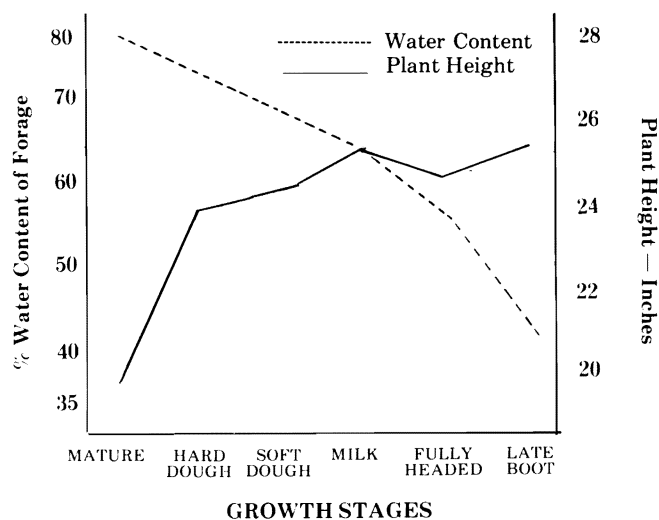


Fig. 1: Average water content and plant height of Oat forage harvested at various growth stages, 1974-75

Results and Discussion

Annual and average forage yields are shown in Table 1. Forage yields were very low in 1974 due to late spring planting and below normal rainfall in June (Table 2). Both varieties yielded more forage when harvested at the milk stage of growth or later than when harvested earlier than the milk stage of growth. This generally agrees with other studies (Larsen *et al.* 1970 and Stuthman *et al.* 1972), though there was a tendency in this study to maximize yields at the hard dough to mature growth stages similar to findings of Smith, 1960.

Average water content of harvested forage ranged from 78 percent at late boot to 42 percent at maturity (Fig. 1). In 1974 water content of forage at harvest was 10 to 15 percent lower than water content of

forage at harvest in 1975, even though stage of growth was approximately the same both years. Maximum plant height was attained at the soft dough stage of growth.

Grain yield of two varieties (Table 3) shows that 1974 was a poor year for oats and 1975 was a very good one. Grain yields of Dal were only 79 per cent of those yields obtained from Kelsey.

The results of the nutritional studies includes all four years (1972 through 1975) of the oat hay experiments, but are confined to the varieties Dal and Kelsey. In the years 1974 and 1975 the oats were harvested at the milk-early dough stage of maturity and this accounts for the 49 observations, compared to 16 or 17 for the other growth stages (Table 4). The nutritional composition as affected by growth stage at

Table 4: The Effect of Growth Stage at Harvest of Dal and Kelsey Oats Cut For Hay*

Harvest Stage	Observ.	Per cent (100% DM)			
		Protein	Fiber	Lignin	Ash
50% Headed	16	15.6	34.0	3.23	8.48
Fully Headed	16	14.9	35.6	3.92	7.64
Milk	49	12.2	34.0	4.36	6.62
Soft Dough	16	12.2	35.1	4.63	6.47
Hard Dough	16	11.5	32.2	4.17	6.30
Mature	17	10.8	35.2	4.90	5.76
CV		10.5	8.3	19.4	15.8
P		.01	.05	.01	.01
LSD .05		.80	1.78	.50	.64
LSD .01		1.06	2.35	.67	.85

* Williston 1972-73-74-75

Table 5: The Effects of Growth Stage at Harvest of Dal and Kelsey Oats Cut For Hay*

Harvest Stage	Observ.	Per cent (100% DM)			
		P	Ca	Mg	K
50% Headed	16	.229	.318	.255	2.30
Fully Headed	16	.233	.329	.262	2.19
Milk	49	.191	.273	.233	1.63
Soft Dough	16	.175	.284	.260	1.58
Hard Dough	16	.177	.310	.264	1.47
Mature	17	.172	.280	.263	1.24
CV		23.1	18.4	17.7	27.1
P		.01	.01	.05	.01
LSD .05		.027	.032	.026	.283
LSD .01		.035	.042	.035	.374

* Williston 1972-73-74-75

harvest is shown in Tables 4 and 5, and these are the results of varieties Dal and Kelsey combined. Protein decreased from 15.6 percent to 10.8 percent from the 50 percent headed stage to the mature stage. Lignin increased with advancing maturity, but there was no predictable trend with fiber. Ash decreased as the oats become more mature. Oats harvested for hay prior to the soft dough stage contained over .18 percent phosphorus, which would meet the requirements for gestating cows. The phosphorus decreased with advancing maturity. Potassium levels are quite high at the early stages but steadily decreased. Similar observations were reported by Mayland, Grunes and Lazar (1976) in a study with wheat for forage. There were no apparent relationships of stage of growth and the calcium and magnesium levels. The potassium to calcium plus magnesium ratios ranged from 1.60 at the earliest cutting to .89 at the last cutting (Table 6). None of the levels approached the potentially toxic ratio of 2.2.

Dal oat hay was significantly higher in most chemical fractions analyzed compared to Kelsey oat hay. The comparisons of protein for each growth stage are shown in Table 7, and Dal is higher in all cases. Dal is about 2 percent higher in protein at the fully headed and the milk stage compared to Kelsey.

Morrison (1956) suggest that oats be cut for hay in the milk to soft dough stage. He also indicates an increased digestibility at this stage compared to early stages because of the formation and development of the seeds. Also, at the milk to early dough stage the leaves are still green and the stems are still palatable and not too high in lignin to appreciably affect digestibility. The protein and phosphorus levels are still very acceptable.

Table 6: The Effect of Growth Stage on the Concentrations of Calcium, Magnesium and Potassium and the Ratios of Potassium to Calcium plus Magnesium.

Growth Stage	Milli-equivalents/Kilogram			Ratio
	Ca ^(a)	Mg ^(b)	K ^(c)	K/Ca + Mg
50% Headed	159	209	588	1.60
Fully Headed	164	215	560	1.48
Milk	136	192	417	1.27
Soft Dough	142	214	404	1.13
Hard Dough	155	217	376	1.01
Mature	140	216	317	.89
P	.01	.01	.01	.01

(a) $1/40.08 (1000 \times 100 \times 2) = 499 \times \% = \text{meq. of Ca}$

(b) $1/24.32 (1000 \times 100 \times 2) = 822.4 \times \% = \text{meq. of Mg}$

(c) $1/39.1 (1000 \times 100) = 255.8 \times \% = \text{meq. of K}$

Summary

Oats should be cut for forage at the late milk to early dough stage of growth for maximum forage and nutrient production. Maximum plant height was attained in the soft dough stage. Kelsey yields more grain than Dal but is not as high in protein. Oat hay is a very good forage for ruminants.

Table 7: A Comparison of Dal and Kelsey Oat Hays Harvested at Six Growth Stages*

Harvest Stage	Per cent (100% DM)	
	Protein	
	Dal	Kelsey
50% Headed	16.3	15.0
Fully Headed	16.0	13.9
Milk	13.2	11.4
Soft Dough	12.8	11.7
Hard Dough	11.7	11.3
Mature	11.0	10.6

*8 Ovserv. $P < .01$ for variety
 $P < .01$ for growth stage of each variety

LITERATURE CITED

1. Erickson, D.O., W.T. Barker and C.N. Haugse. 1977. Nutritional variations of native range as affected by site. Am. Soc. of An. Sci. 69th meeting (Abstract) p. 117.
2. Erickson, D.E., W.T. Barker and C.N. Haugse. 1977. Comparisons of selected nutritional parameters of several native grasses. Am. Soc. of An. Sci. 69th Meeting (Abstract) p. 118.
3. Ferebee, D.B., D.O. Erickson, C.N. Haugse, K.L. Larson and M.L. Buchanan. 1972. Digestibility and chemical composition of brome and alfalfa throughout the grazing season. North Dakota Farm Research 30:1 pp. 3-7.
4. Kilcher, M.R. and J.E. Troelson. 1972. Contribution and nutritive value of the major plant components of oats through progressive stages of development. Can. J. Plant Sci. 53:251-256.
5. Larsen, Kenneth L., and Jack F. Carter. 1970. Harvesting cereals for forage in North Dakota. North Dakota Farm Research 27:4.
6. Mayland, H.F., D.L. Grunes and V.A. Lazar. 1976. Grass tetany hazard of cereal forages based upon chemical composition. Agron. J. 68:665.
7. Morrison, F.B. 1956. Feeds and feeding. 22 Edition, p. 370.
8. Smith, Dale. 1960. Yield and chemical composition of oats for forage with advance in maturity. Agron. J. 52:637-638.
9. Stuthman, D.D. and G.C. Marten. 1972. Variation in yield and quality of oat forage. Crop Sci. 12:831-833.
10. Whitman, W.C., D.W. Bolin, E.W. Klosterman, H.J. Klosterman, K.D. Ford, L. Mooman, D.G. Hoag and M.L. Buchanan. 1951. Carotene protein and phosphorus in range and tame grasses in western North Dakota. North Dakota Ag. Exp. Sta. Res. Bull. 370.