KINETICS OF RUMINAL DISAPPEARANCE OF WHEAT FORAGE NITROGEN IN STEERS GRAZING WHEAT PASTURE OF TWO STAGES OF MATURITY

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Story in Brief

Experiments were conducted to measure the kinetics of in situ ruminal disappearance of nitrogen of wheat forage at two stages of forage maturity. In each of three years, 8 multi-cannulated steers were used in a split plot design in which steers grazed wheat pasture during the immature and mature stages of growth. Wheat forage nitrogen existed kinetically as two distinct nitrogen pools. In immature wheat forage, 73.9% of total nitrogen disappeared at a fractional rate of 17.5 %/hr which was greater than the second nitrogen pool (26.1% of total nitrogen) that disappeared at 3.1 %/hr. With advanced forage maturity, less nitrogen was present in the rapidly disappearing pool (55%). Extent of ruminal nitrogen disappearance (%) was greater for immature (69.6) than mature (56.8) wheat forage. These data indicate that wheat forage protein is very rapidly degraded in the rumen, and that large quantities of dietary N may not reach the small intestine because of loss of protein. Performance of rapidly growing cattle on wheat pasture may be improved by feeding protein supplements of low ruminal degradability.

(Key Words: Wheat Forage, Nitrogen Disappearance, Rumen Degradability.)

Introduction

Wheat and other small grain forages are high quality forages commonly containing 24 to 30% crude protein. Rate of degradation of forage protein in the rumen affects microbial protein synthesis and therefore the amount of protein which flows to the small intestine. Recent research (Lee, 1985; Horn et al., 1987) has demonstrated a beneficial response from supplementation of stocker cattle on wheat pasture with "high bypass" protein supplements. Very limited information is available on rate of ruminal degradation of wheat forage protein. Therefore, the objective of this research was to determine the kinetics of ruminal disappearance of wheat forage nitrogen in stocker cattle grazing wheat pasture of two stages of forage maturity.

Experimental Procedure

In each of three years, 8 multi-cannulated Hereford and Hereford x Angus steers were used in a split plot design with two grazing periods. The mean weight of the steers was 1267 + 24 lb, 978 + 29 lb and 1153 + 30 lb in year 1 (1985), year 2 (1986) and year 3 (1987), respectively. Grazing periods represented the period of rapid spring

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growth (immature, March 8 to March 20) and the "grazeout" period (mature, April 18 to May 4) on wheat pasture. As a part of other experiments relative to site and extent of digestion of wheat forage, steers were randomly allotted to two treatments each year. In year 1 (1985) steers received either 0 or 300 mg of lasalocid daily. In years 2 and 3 steers received either a corn-based (control) or a 16 to 20% crude protein (CP) supplement that contained 18 to 25% meat meal.

Duplicate dacron bags containing approximately 10 g of fresh hand-clipped wheat forage cut to an average particle length of 1 inch were incubated in situ in the rumen of each steer for 4, 8, 12, 18, 24, 36, 48 and 60 hr during the last three days of each grazing period. In years 2 and 3, the 18 and 60 hr incubation times were deleted. Residual contents in the bags were analyzed for nitrogen (N) by the Kjeldahl procedure. Estimates of N disappearance were analyzed using the "curve peeling" technique of Shipley and Clark (1972). A "break point" (i.e., the point where the contribution from the more rapidly disappearing pool becomes insignificant) was determined by visual inspection of plots of the natural logarithm of the percent N remaining vs time. Break points of 24 and 12 hr incubation were used for the immature and mature forages, respectively. After the break point was determined, the slope (K_2) and intercept (A_2) for the more slowly degraded pool were determined by linear regression of the natural logarithm of the percent N remaining vs time. The contribution of this pool to the earlier data points was then subtracted and the slope (K_1) and intercept (A_1) of the more rapidly disappearing pool were then determined by linear regression. Nitrogen pool sizes were estimated from the anti-logarithm of the intercepts and were set equal to one (i.e., $A_1+A_2=1$). The time required for one-half of the N to disappear from each pool was estimated as .693/rate of N disappearance (i.e., slope).

Ruminal N disappearance (RD) of wheat forage was estimated using the equation of Broderick and Craig (1980) where:

$$RD = ((A_1*K_1)/(K_p+K_1)) + ((A_2*K_2)/(K_p+K_2))$$ where K_p represents rate of passage obtained from the concurrent site and extent of digestion trials using ytterbium-labeled wheat forage.

In each grazing period, rumen fluid samples were obtained approximately 3 hours after supplements were offered and the steers were returned to pasture. Samples were subsequently analyzed for ammonia by the MgO distillation procedure. Triplicate hand clipped wheat forage samples were also taken to characterize forage composition. Clipped forage samples were immediately frozen by suspension over liquid nitrogen, and were subsequently lyophilized and analyzed for total N by the Kjeldahl procedure, non-protein N (NPN) by sodium tungstate precipitation and soluble N following a 1 hour incubation in the mineral mixture (2% v/v; pH = 6.5) of the "Ohio" in vitro fermentation media (Johnson, 1969). In vitro dry matter digestibility (IVDMD) was also determined.

Results and Discussion

The chemical composition of the grazed wheat forage is shown in table 1. Differences in forage maturity were reflected in differences in crude protein and IVDMD. With increasing forage maturity mean crude protein content decreased by 85% (23.7 vs 12.7%) while IVDMD decreased by 12.4% (79.1 vs 70.3%). These differences were most likely due to the decreased proportion of leaf-to-stem and the increased content of

Table 1. Chemical composition of grazed wheat forage during the immature and mature stages of forage growth.

	Year 1		Year 2		Year 3		
Forage maturity:	Immature	Mature	Immature	Mature	Immature	Mature	SEM[a]
Dry matter (DM), %	23.30	27.06	24.76	28.32	27.68	24.85	.51
Soluble carbohydrate, % of DM	31.48	34.70	15.87	19.65	30.24	21.43	1.98
Crude protein, % of DM	24.44	13.19	27.19	11.38	19.31	13.75	1.39
Nitrogen, % of DM							
Total N	3.91	2.11	4.35	1.82	3.09	2.20	.22
Soluble N	1.42	.98	1.71	.79	1.50	.76	.08
NPN[b]	.45	.32	.66	.37	.28	.37	.03
Soluble N, % of total N	36.19	46.29	39.22	43.70	48.52	34.22	1.19
NPN, % of total N	11.39	15.17	15.14	19.44	8.89	17.16	1.28
IVDMD[c]	76.19	65.67	76.40	64.43	84.69	80.92	1.90

[a]Standard error of the mean.
[b]Non-protein nitrogen.
[c]In vitro dry matter digestibility.

structural carbohydrates which are normally observed with advancing forage maturity. Soluble N (% of DM) decreased with advancing forage maturity and comprised from 1.42 to 1.71 and from .76 to .98% for the immature and mature forages, respectively. Nonprotein nitrogen (NPN) followed a similar trend and comprised from .28 to .66% and from .32 to .37% of DM, respectively. When these values were expressed as a percent of total N, approximately 36 to 48% of total N was soluble and NPN accounted for 9 to 19% of total N. In general, losses of N from the rumen would be expected to increase with increasing amounts of soluble N.

The main effect due to treatment (i.e., lasalocid or protein supplementation) was not significant (P>.25) in any of the three experiments for the in situ data. Therefore, the data were pooled across treatments. Visual examination of the data of figures 1 and 2 and significant (P<.05) lack of fit tests revealed that two distinct N pools were present in wheat forage. In immature wheat forage, different rates of N disappearance were obtained between 4 and 24 hr and 24 and 60 hr while in mature wheat forage, different rates of disappearance were obtained between 4 and 12 hr and 12 and 60 hr. For immature wheat forage, 73.9% of total N disappeared at a fractional rate of 17.5 %/hr which was greater (P<.05) than the second N pool (26.1% of total N) which disappeared at the rate of 3.1 %/hr (table 2). With increasing forage maturity, there was a shift in the size of each N pool. In mature wheat forage the rapidly disappearing pool decreased to approxi-

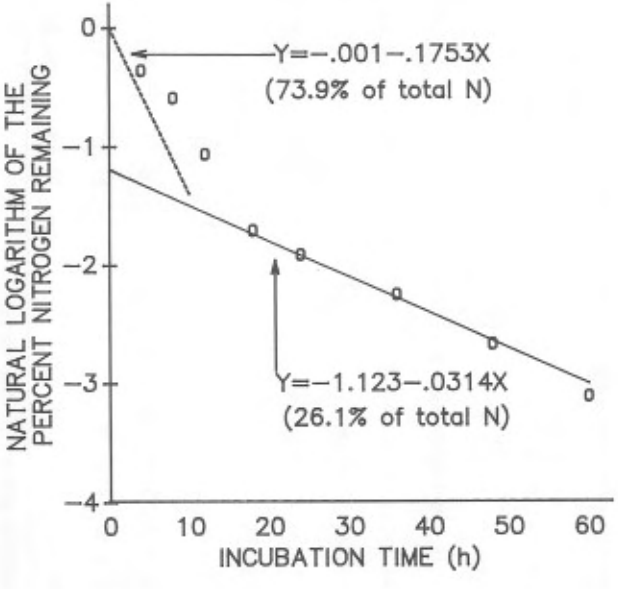

Figure 1. In situ nitrogen disappearance (O) of two nitrogen pools in immature wheat forage.

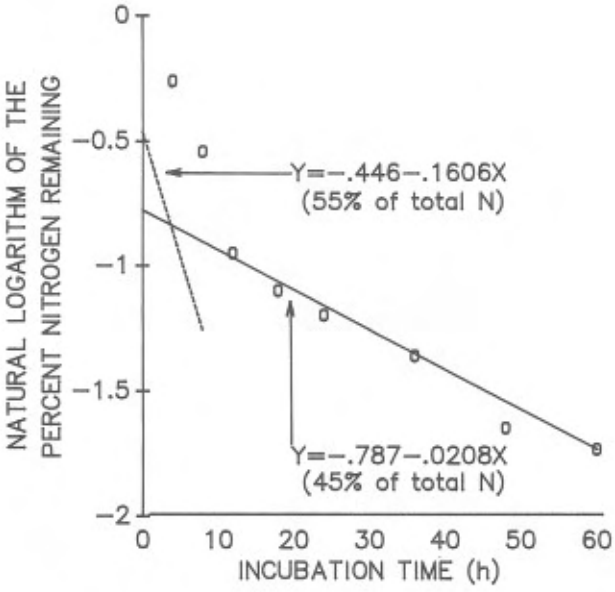

Figure 2. In situ nitrogen disappearance (O) of two nitrogen pools in mature wheat forage.

mately 55% of total N. However, this pool was still larger (P<.10) than the less soluble N pool. Nevertheless, the fractional rate of disappearance for the more rapidly disappearing pool in mature wheat forage was 8-fold greater (P<.05; 16.1 vs 2.1 %/hr). Similar results have been reported by Zorrilla-Rios et al. (1985a) who reported that 50 to 75% of wheat forage N disappeared at rates of 13 to 28 %/hr.

Estimates of ruminal N disappearance indicated that approximately 69.6% of the N present in immature forage was degraded ruminally (table 2) while ruminal disappearance decreased (P<.05) to 56.8% with advanced maturity. Similar values were reported by Zorrillo-Rios et al. (1985b) who reported that true rumen N disappearance was 72.2 and 44.6% for immature and mature wheat forage, respectively.

Ruminal ammonia concentrations of steers are presented for each year in table 3. Rumen ammonia concentrations were highly variable and ranged from 65.44 to 7.40 mg/dl. The value for immature forage of year 1 is atypically high, and an explanation for the value is not apparent. Except for year 3, ammonia concentrations decreased (P<.05) with advancing maturity.

These data indicate that wheat forage protein is very rapidly degraded in the rumen, and that large quantities of dietary N may not reach the small intestine because of loss of ammonia-N from the rumen that is not incorporated into microbial protein. Performance of rapidly growing cattle on wheat pasture may be improved by feeding protein supplements of low ruminal degradability which may compensate for the N lost from the forage during fermentation.

Table 2. Kinetics of nitrogen disappearance and in situ ruminal degradability of wheat forage in steers grazing wheat pasture of two stages of maturity.

	Stage of forage maturity					
	Immature			Mature		
Item	4-24 h	24-60 h	SEM[a]	4-12 h	24-60 h	SEM[a]
Rate of N disappearance, %/hr	17.53[b]	3.14[c]	1.01	16.06[b]	2.08[c]	1.38
N pool size, %	73.87[b]	26.13[c]	2.23	55.21[d]	44.79[e]	4.22
Half-life of N pool, hr	4.48[b]	25.63[c]	1.87	6.16[b]	40.33[c]	2.56
Ruminal degradability of N, %		69.57[f]			56.75[g]	1.93

[a]Standard error of the mean.
[b,c,d,e]Means in the same row within forage maturity with different superscipts differ: bc ($P<.05$); de ($P<.10$).
[f,g]Means in the same row with different superscripts differ ($P<.05$).

Table 3. Rumen ammonia concentrations (mg/dl) in steers grazing wheat pasture of two stages of maturity.

Item	Forage maturity		SEM[a]
	Immature	Mature	
Year 1	65.94[b]	10.21[c]	1.77
Year 2	29.64[b]	7.40[c]	2.60
Year 3	19.95[c]	36.10[b]	3.59
Mean	37.17[b]	18.24[c]	1.64

[a]Standard error of the mean.
[a,b]Means in the same row with different superscripts differ (P<.05).

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