IN SITU DISAPPEARANCE OF DRY MATTER AND NITROGEN OF WHEAT FORAGE, CORN GLUTEN MEAL, COTTONSEED MEAL AND SOYBEAN MEAL IN STEERS GRAZING WHEAT FORAGE AT TWO STAGES OF MATURITY

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Story in Brief

Eight rumen fistulated Hereford steers (average body weight, 1000 lb), were used to measure the extent of ruminal digestion and kinetics of dry matter and nitrogen from wheat forage and three conventional plant protein supplements (soybean meal, cottonseed meal and corn gluten meal) in the rumen of steers grazing wheat forage at two stages of maturity (immature and mature).

Extent of dry matter and nitrogen disappearance during 24 h of in situ ruminal incubation was, respectively, 145 and 33 percent higher ($P<.01$) for immature wheat forage than for mature forage. Wheat forage nitrogen existed kinetically as two distinct pools with different rates of disappearance over time ($P<.01$; 3-24 h, 13.0 percent/h and 24-48 h, 2.2 percent/h for immature; $P<.01$; 3-12 h, 28.0 percent/h and 12-48 h, 2.8 percent/h for mature). By 48 h of incubation, 95 and 84 percent of the initial N from the immature and mature forage had disappeared in situ indicating that wheat forage nitrogen degradation within the rumen is dependent largely upon its retention time in the rumen. The extent and rate of ruminal nitrogen disappearance was lower for corn gluten meal than for cottonseed and soybean meals. Because of the rapid and extensive ruminal degradation of wheat forage protein, post-ruminal protein supply for growth of stocker cattle on wheat pasture may be limiting and weight gains of stocker cattle on wheat pasture might be increased by supplementation with feeds of low ruminal protein degradation.

(Key Words: In Situ, Nitrogen Disappearance, Wheat Pasture, Oilseed Supplements, Cattle.)

Introduction

Extent and kinetics of dietary dry matter and nitrogen disappearance within the rumen of animals grazing forages needs to be examined to properly supplement with nutrients and to select the best protein source for supplementation.

Wheat forage has a high nutritive value, often containing over 20 percent protein and 75 percent digestible organic matter on a dry matter basis. A substantial amount of information is available concerning the cultural and managerial aspects of grazing wheat pasture (Horn, 1984). But information on digestion and utilization of wheat forage within the animal is lacking. The objectives of the present study were to: 1) determine the extent and rate of disappearance of wheat forage dry matter and nitrogen within the rumen of cattle grazing

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wheat forage at two stages of maturity and 2) estimate ruminal disappearance of nitrogen from three conventional plant protein supplements known to differ considerably in their ruminal availability of nitrogen under different dietary regimes. The plant protein supplements were corn gluten meal (CGM), cottonseed meal (CSM) and soybean meal (SBM).

Materials and Methods

During the spring of 1984 (March to May), eight rumen fistulated steers (average body weight 1000 lb) grazed a single paddock of wheat forage (var. TAM-105) and had free access to a commercial salt block. At the immature stage (March 7 to March 27), wheat forage dry matter (DM) available was 1642 lb/acre versus 1565 lb/acre at the mature stage of growth (April 22 to May 14). Samples of wheat forage during both stages of maturity were hand clipped and cut to an average particle length of 1 1/2 inches. Subsamples (20 g fresh basis) were placed in duplicate nylon bags and incubated in the rumen of each animal for 3, 6, 12, 24 and 48 h. Extent of disappearance of dry matter and nitrogen at each incubation time was estimated as the difference between initial and final dry weight or nitrogen content, respectively. Rates of ruminal dry matter and nitrogen disappearance were calculated as the slopes obtained by regressing the natural log of the percentage of residual dry matter or nitrogen against incubation time and with later slopes peeled from earlier slopes when the regression was obviously curvilinear. Time required for half the material in the pool described by the fractional rate of disappearance (slope) to be degraded ($T_{1/2}$, hours) was obtained by the equation: $T_{1/2}$ (h) = 2 ln/slope. Representative samples of wheat forage for each stage of maturity were freeze-dried for dry matter determination and subsequently analyzed for ash and total and soluble nitrogen. Approximately 10 g samples of CGM, CSM and SBM were also incubated in situ simultaneously with the wheat forage, and treated in the same manner, except that the longest incubation time was 24 h and subsamples for analysis were oven-dried.

Results and Discussion

Chemical composition of wheat forage at both stages of maturity is presented in Table 1. Stage of maturity of the wheat forage had a significant effect ($P<.01$) on the extent of in situ disappearance of wheat forage DM and N (Table 2). In the immature stage, 77 and 90 percent of the initial DM and N had disappeared after 24 h of incubation. These values were 145 and 33 percent higher, respectively, than for mature wheat forage. These differences were declined to 38 and 13 percent, respectively, at 48 h of incubation.

Visual examination of the plots of the natural log of the percent N remaining at each h of incubation on time revealed that two distinct pools were present. Statistical analysis of the slopes obtained between 3 and 24 h of incubation and 24 and 48 h for the immature wheat forage, and between 3 and 12, and 12 and 48 h for mature wheat forage, indicated that rate of disappearance differed ($P<.01$) between these two time intervals (Table 3; Figures 1 and 2). Two distinct pools were present. For nitrogen in immature wheat forage, one highly soluble pool of 75 percent of total N disappeared at a rate of 13 percent/h. A second pool of 15 percent of total N had a lower ($P<.01$) rate of dis-

Table 1. Chemical composition of wheat forage (var. TAM-105) during the immature (March 7 to March 27) and mature (April 22 to May 14) stage of growth (percent).

Nutrient	Stage of maturity	
	Immature	Mature
Observations	3	4
Dry matter	24.3	22.7
Organic matter	92.5	93.7
Nitrogen (N)		
Total	4.39	2.03
Soluble	1.184	.691
Nonprotein	.438	.201
Ratios		
Soluble N/total N	27.0	34.0
NPN/total N	10.0	9.9
In vitro dry matter digestibility, %	75.6	66.4
Forage available, (lb/acre)	1642	1565

Table 2. Wheat forage extent of in situ dry matter (DM) and nitrogen (N) disappearance in steers grazing wheat forage at two stages of maturity (percent of initial).

Stage of maturity[a]	Hours of incubation									
	3		6		12		24		48	
	DM	N	DM	N	DM	N	DM	N	DM	N
Immature	32.6	32.1	43.3	54.1	57.1	71.8	76.9	90.1	88.8	95.0
Mature	13.3	26.8	17.0	38.0	25.7	59.7	31.4	67.7	64.2	84.3
SE	.9	1.9	1.0	1.4	1.4	2.0	1.6	2.7	1.1	1.5

[a]Stage of maturity differed ($P<.01$) at all hours of incubation for dry matter and nitrogen.

appearance (2.2 percent/h). Both nitrogen pool were almost completely available with 90 percent of total N disappearing by 24 h of incubation.

In mature wheat forage, the more soluble N pool with 52 percent of total N disappeared at a rate of 28.1 percent/h, while the second pool, at 59 percent of total N, had a rate of disappearance of 2.8 percent/h. Extent of total nitrogen disappearance at 24 h was only 68 percent.

Table 3. Kinetics of wheat forage nitrogen disappearance from in situ ruminal measurements in steers grazing wheat forage at two stages of maturity.

Measurement	Stage of maturity			
	Immature		Mature	
	3-24 h	24-48 h	3-12 h	12-48 h
Rate of N disappearance (%/h)	13.0[a]	2.2[b]	28.1[a]	2.8[b]
Time for half of N to disappear, (h)	5.3[a]	31.6[b]	2.5[a]	24.8[b]
N pool size at 0 h (% of total N)[c]	75.2	15.6	52.2	58.7

[ab]Row means within same stage of maturity with different superscripts, are different (P<.01).
[c]Estimated from the intercepts of each slope.

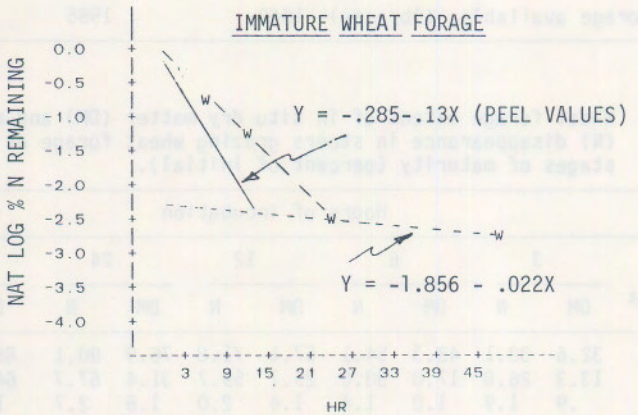

Figure 1. Description of the rate of in situ disappearance of two nitrogen pools identified in immature wheat forage.

Overall ruminal degradation of forage protein, particularly for the immature wheat forage, was very high. This means that the extent of ruminal digestion of wheat forage nitrogen will ultimately depend on its ruminal retention time. Therefore, cattle grazing immature wheat forage may have a low supply of bypass protein and might be greatly dependent on protein of microbial origin to meet their amino acid needs. For high levels of production, total true protein and/or specific amino acids available for absorption from the intestine might limit performance and supplemental protein with a high ruminal bypass may be useful.

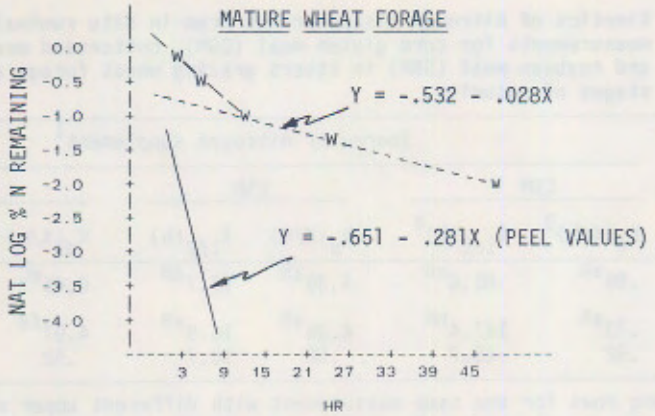

Figure 2. Description of the rate of in situ disappearance of two nitrogen pools identified in mature wheat forage.

In situ ruminal disappearance of nitrogen from plant protein supplements incubated for various times in the rumen is shown in Table 4. Extent of N disappearance at all times of incubation was the lowest for CGM while SBM had the highest disappearance with CSM being intermediate. Two pools of nitrogen were not detected with these feeds, but extent of disappearance at 24 hours appeared slightly greater in the rumen of steers receiving immature than those receiving mature forage for SBM and CSM. Nitrogen from SBM had the fastest rate of disappearance (6.45 percent/h, $P<.01$), CGM had the lowest (.89 percent/h) and CSM was intermediate (4.39 percent/h; Table 5).

Table 4. Extent of nitrogen disappearance in situ of corn gluten meal (CGM), cottonseed meal (CSM) and soybean meal (SBM) in steers grazing wheat forage at two stages of maturity (percent of initial).

Stage of maturity	Substrate	Hours of incubation			
		3	6	12	24
Immature	CGM	16.9	19.8	24.1	31.2
	CSM	35.7	42.6	55.5	73.2
	SBM	32.9	44.0	58.6	81.4
Mature	CGM	17.3	19.0	20.7	28.6
	CSM	28.5	31.7	50.7	69.9
	SBM	26.7	30.5	41.8	67.2
SE		1.9	1.4	2.0	2.7

Table 5. Kinetics of nitrogen disappearance from in situ ruminal measurements for corn gluten meal (CGM), cottonseed meal (CSM) and soybean meal (SBM) in steers grazing wheat forage at two stages of maturity.

Stage of maturity[2]	Source of nitrogen supplement[1]					
	CGM		CSM		SBM	
	K_d(%/h)[3]	$T_{1/2}$(h)[4]	K_d(%/h)	$T_{1/2}$(h)	K_d(%/h)	$T_{1/2}$(h)
Immature	$.89^{aA}$	81.6^{aA}	4.39^{aB}	17.7^{aB}	6.45^{eC}	11.5^{aB}
Mature	$.73^{aA}$	147.4^{bA}	4.39^{aB}	16.9^{aB}	4.97^{fB}	21.9^{aB}
SE	.52	15.7	.52	15.7	.52	15.7

[1]Means along rows for the same measurement with different upper case superscripts are significantly different at P<.01.
[2]Means in each column with different lower case superscripts, are significantly different at: a,b P<.01; e,f P<.10.
[3]Rate of N disappearance (kd, %/h).
[4]$T_{1/2}$ is time for half of N to disappear (h).

Time for half of the nitrogen to disappear within the rumen was therefore lowest for SBM and highest for CGM. Data indicate that ruminal degradation of CGM nitrogen is much lower than either CSM or SBM which may make CGM more useful as a feedstuff to supplement protein for cattle grazing wheat pasture if supplemental amino acids are needed. The effect of these nitrogen sources on animal performance remains to be investigated. Greater benefit would be expected with immature than mature forages and with younger, rapidly growing cattle with higher protein requirements and limited capacity to consume wet feeds.

Literature Cited

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