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Grass Tetany Hazard of Cereal Forages Based upon Chemical Composition

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ABSTRACT

The occurrence of grass tetany in cattle grazing small grains pastures led us to examine the forage chemical composition and to suggest the relative risk of grass tetany to cattle grazing each forage.

Early spring vegetative growth of wheat (*Triticum aestivum* L.) and crested wheatgrass (*Agropyron desertorum* (Fisch.) Schult) was periodically sampled from 3 × 20 m plots established on a fertile Portneuf silt loam (Durixerollic calciorthid). In addition, wheat, oats (*Avena sativa* L.), barley (*Hordeum vulgare* L.), and rye (*Secale cereale* L.) were grown in pots containing Portneuf silt loam in the greenhouse and were harvested once while still vegetative.

Forage samples were freeze-dried and the following parameters determined: total N (Kjeldahl); NO_3^- (electrode); Na, K, Mg, and Ca (atomic absorption); S and Cl (x-ray); P (vanadomolybdate); aconitic acid (polarography); higher fatty acids and ash alkalinity (both by titration). Estimated blood-serum Mg values were calculated from a generally unavailable Dutch nomograph of forage N × K and Mg values. The nomograph is included in this paper to enhance its availability.

Wheat forage seemed to pose a greater tetany hazard than the wheatgrass because wheat had lower values for Ca and higher values for K, K/(Ca + Mg), aconitic acid, ash alkalinity, and HFA. The estimated tetany hazard of the cereal forages was wheat > oats = barley > rye. This ranking corresponded to the other of blood-serum Mg levels predicted from the Dutch nomograph. Wheat forage was lowest in Mg, while rye forage was highest in Mg and Ca, and lowest in K and N. Aconitic acid represented a large portion of the total organic acids in oats, rye, wheat, and wheatgrass, but only traces were found in barley.

The frequent occurrence of grass tetany in cattle grazing wheat forage may result because of lower Mg and Ca levels and higher K, N, ash alkalinity, and HFA levels in this forage compared to other cereal forages.

Additional index words: Hypomagnesemia, Barley, Oats, Rye, Wheat, Crested wheatgrass.

WHEAT (*Triticum aestivum* L.) and other small grains constitute a major source of winter pasture for both cattle and sheep in the Southern High Plains and Southern Coastal Plains. Small grain forages may also be grazed in fall and spring in other areas of the U.S. Animals gain well on these nutritious forages (5) but there may be death losses from bloat, milk fever, nitrate toxicity, and wheat pasture poisoning. Wheat pasture poisoning is known as grass tetany, or hypomagnesemia, which results from a simple dietary Mg deficiency or from an impairment in Mg utilization and absorption by the animal. The severity of Mg tetany may be further aggravated by low forage Ca levels.

Grass tetany occurs much more frequently in lactating cattle than in stocker cattle (100 to 200 kg calves) or in nonlactating cows. It is, therefore, more of an economic problem when livestockmen also use the small grain forages for their pregnant or lactating cows.

This study, based upon the forage chemical composition, was made to estimate the relative tetany hazard to cattle grazing wheat and other cereal forages.

METHODS AND PROCEDURE

'Nordan' crested wheatgrass (*Agropyron desertorum* (Fisch.) Schult) established the previous fall and 'Thatcher' hard red spring wheat seeded during mid-March, were grown in 3 × 20 m plots on a fertile Portneuf silt loam soil (Durixerollic calciorthid). Soil characteristics include: pH = 7.7; 3% $CaCO_3$ equiv.; CEC = 20 meq/100 g; 1, 5, and 15 meq/100 g K, Mg, and Ca, respectively by NH_4OAc extraction. Forage from randomly selected clones was clipped at a 5-cm stubble at regular time intervals bracketing the early spring tetany period. The chemical composition of wheat was compared to that of wheatgrass because of the authors' familiarity with the composition of wheatgrass coincident to the occurrence of grass tetany (6, 7). Five-day moving means were calculated for average daily air temperatures [(min + max)/2] obtained from the Kimberly Climatological Stn. adjacent to the plots.

In a second experiment, three cultivars of wheat (Thatcher and 'Moran' hard red spring, and 'Lemhi' soft white spring), rye (*Secale cereale* L.), 'Vale' barley (*Hordeum vulgare* L.), and 'Overland' oats (*Avena sativa* L.) were seeded in pots containing 3-kg

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Table 1. Mean air temperature, plant height, and chemical composition of Nordan crested wheatgrass and Thatcher wheat forages.

Date sampled	Mean air temperature†	Plant height	K	Mg	Ca	P	N	K‡ / (Ca+Mg)	Aconitic acid§	Ash alkalinity	HFA
	C	cm	%						meq/kg		
					Nordan Crested Wheatgrass						
26 Mar. 1968	6.9	13	2.1	0.15	0.47	0.22	4.9	1.5	280	600	120
16 Apr. 1968	4.3	20	2.0	0.12	0.46	0.22	4.3	1.6	300	600	110
30 Apr. 1968	11.2	26	2.0	0.12	0.39	0.22	3.4	1.7	250	530	70
14 May 1968	11.6	30	1.9	0.10	0.29	0.19	3.2	2.1	260	470	85
28 May 1968	14.1	35	1.6	0.12	0.31	0.19	2.7	1.6	135	440	70
					Thatcher Hard Red Spring Wheat						
16 Apr. 1968	4.3	24	3.1	0.15	0.39	0.25	4.9	2.5	570	730	140
30 Apr. 1968	11.2	28	3.4	0.13	0.32	0.21	4.8	3.2	555	700	130
14 May 1968	11.6	33	3.3	0.14	0.29	0.19	4.4	3.2	480	660	120
28 May 1968	14.1	48	2.0	0.13	0.21	0.24	2.3	2.5	130	450	80

† Calculated as moving 5-day mean. ‡ Calculated on equivalent basis. § (meq/kg)(0.0058) = % aconitic acid.

Portneuf silt loam (no added N fertilizer) and incubated in the greenhouse during August and September at a mean temperature of 21 C. The wheat, barley, and oat forages were harvested 22 days after seeding, while the rye forage was harvested 40 days after seeding to obtain comparable dry matter production. The greenhouse experiment was replicated twice.

All samples were freeze-dried shortly after harvesting. Chemical methods included: Na, K, Mg, and Ca in a HNO_3-$HClO_4$ digest and determined by atomic absorption and P by the vanadomolybdate method; S and Cl by x-ray; NO^-_3 by electrode; and total N by Kjeldahl. Ash alkalinity values were obtained after ignition at 550 C for 2 hours and were corrected for NO_3-N. Cations minus anions (C − A) were calculated on an equivalent basis as ($Na^+ + K^+ + Mg^{++} + Ca^{++}$) minus ($Cl^-$ + total P as $H_2PO^-_4 + NO^-_3 + SO^=_4$). Sulfate sulfur (meq/kg) was calculated as (% total S) (623.8) − [38.56 (% total N − % NO_3-N)]. The ratio K/(Ca + Mg) was calculated on an equivalent basis. Total aconitic acid was determined by polarography and higher fatty acids (HFA) were determined by titration. More details on the methodology are available in a previous publication (6). The hypothetical blood-serum data were calculated from forage N, K, and Mg data using the Dutch nomograph (4). Chemical data from the greenhouse study were analyzed by the analysis of variance and Duncan's multiple range test.

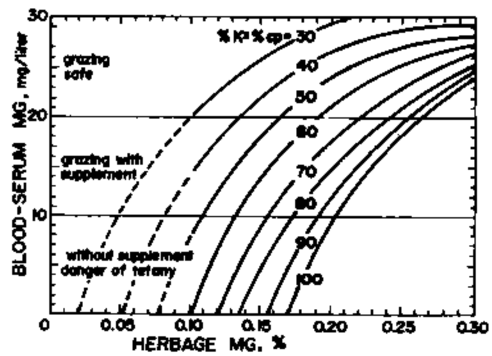

Fig. 1. Relation between blood-serum Mg of producing dairy cows and forage Mg, K, and crude protein (CP = 6.25 N). Isolines are products of % K and % crude protein. The figure is taken from Hartmans (4) with permission of the Centre for Agricultural Publishing and Documentation, Wageningen, The Netherlands.

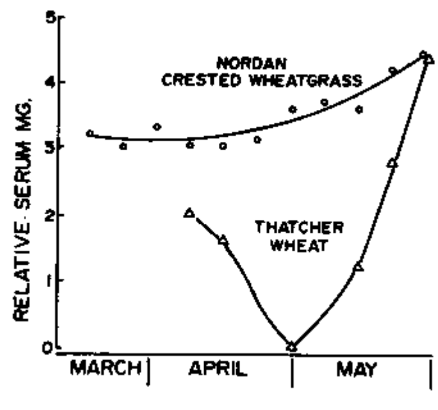

Fig. 2. Relative blood-serum Mg levels predicted for lactating cows grazing Nordan crested wheatgrass or Thatcher wheat.

RESULTS AND DISCUSSION

Spring wheat forage produced under field conditions contained higher K levels but lower Ca levels than did crested wheatgrass (Table 1). The Mg levels were similar for the two forages but the K/(Ca + Mg) values of wheat were nearly twice those of wheatgrass and greater than the 2.2 ratio above which the incidence of tetany increases rapidly (3). Ash alkalinity, an indirect measure of organic acid content, was higher in wheat forage than in the perennial wheatgrass forage. The organic acids (e.g., citrate, aconitate) may be a contributing factor in the cause of tetany (7). Wheat contained higher organic acid levels than did wheatgrass. It should be noted that a larger fraction of the organic acids in wheat occurred as aconitic acid when compared to wheatgrass (Table 1). Total N levels of wheat tended to be greater than those for wheatgrass. The high total N and nonprotein nitrogen (NPN) of wheat have been associated with grass tetany (1). Wheat in this study also had higher NO_3-N levels than did wheatgrass but these levels did not exceed 0.16%. Fatty acid (HFA) (e.g., palmitic, linolenic) concentrations were higher in wheat than in wheatgrass forage. HFA increases the tetany hazard by forming Mg and Ca soaps within the rumen, thereby reducing the availability of these cations to ruminants (2, 3). The forages provide adequate Ca but slightly marginal P levels for nursing beef cows (9).

Attempts to assess the grass tetany hazard of forage, based only on the chemical composition, have not been entirely adequate because of interacting factors that reduce dietary Mg availability. These factors in the forage include high N, K, and HFA, and low Mg, Ca, and soluble carbohydrates (see references 1 through 4 and 6 for more discussion). Hartmans (4),

Table 2. Yield and chemical composition of cereal forages grown in a greenhouse.*

Forage cultivar	Yield	K	Mg	Ca	P	N	K† / (Ca+Mg)	Aconitic acid	C – A‡	Serum Mg §
	g/pot	%					meq/kg			mg/liter
Thatcher wheat	3.7	4.7 ab	0.21 b	0.80 c	0.22 b	2.9	2.1 ab	740 a	1,410 a	15 d
Lemhi wheat	3.8	4.1 ab	0.21 b	0.69 d	0.20 b	2.8	2.0 ab	720 a	1,190 b	19 c
Moran wheat	3.8	3.7 b	0.21 b	0.68 d	0.21 b	2.8	1.8 bc	780 a	1,100 b	21 bc
Vale barley	4.3	5.0 a	0.27 a	0.61 d	0.22 b	2.8	2.4 a	20 b	1,560 a	22 bc
Overland oats	3.9	4.9 ab	0.28 a	0.95 b	0.21 b	2.9	1.8 bc	720 a	1,610 a	24 b
Rye	3.5	4.0 ab	0.29 a	1.13 a	0.28 a	2.0	1.3 c	840 a	1,470 a	29 a

* Column means not followed by the same letter are different at $P < 0.05$.
† Calculated on equivalent basis.
‡ Cations – anions = (Na + K + Mg + Ca) – (Cl + NO_3-N + PO_4-P + SO_4-S).
§ Predicted from nomograph of Henkens (4).

surveying data on dietaary N, K, and Mg, and resulting blood-serum Mg, developed a nomograph for use with high producing dairy cows maintained on grass in The Netherlands. The nomograph is reproduced here (Fig. 1) to enhance its availability. The figure shows the relationship between blood-serum Mg levels and the K times crude protein (N $\times$ 6.25) and Mg values in the forage. The chance of grass tetany increases as forage Mg levels decrease or as the product of K and CP increases because of the reduced availability of dietary Mg. This relationship is a dynamic one, especially in early spring, and if used in a grazing management program, necessitates sampling weekly to give current information on the potential hazard to grazing livestock.

Attempts to utilize the nomograph may, at times, result in values that go off scale and extrapolation may be necessary. Analyzing the forage N, K, and Mg data given in Table 1 necessitated extrapolation and then coding to have positive values (Fig. 2). Nonetheless the data emphasize the increased tetany hazard to high producing dairy cows grazing wheat forage on 30 April. The Mg requirement of lactating beef cattle would not be as high as that of dairy cattle for which the nomograph was developed, but the nomograph should be useful in defining a relative hazard.

Winter wheat forage in Kansas often has 3.6 to 5.0% K, and 4 to 5% N in November and March (8). That minimal levels of total carbohydrate (TC) coincide with these high N and K values greatly increases the tetany hazard (6). Nitrogen fertilization further increases the tetany hazard (7).

The chemical composition of crested wheatgrass coincident to grass tetany has been extensively documented (6, 7). Comparison of the chemical composition of wheat to that of wheatgrass strongly supports our contention that under similar circumstances the tetany hazard to livestock grazing wheat would be greater than to those grazing wheatgrass.

A comparison of the chemical composition of several cereal forages may provide helpful information for those who are in a position to field-check these forages. Cereal rye contained the highest concentrations of Mg and Ca (Table 2) but it also had a high C – A value and high aconitic acid concentration. The high Mg level may more than offset these negative factors and, therefore, rye forage may have a low tetany hazard. The low K/(Ca + Mg) ratio for rye forage may not be important since the high Ca concentration has so much more influence on the ratio, in this case, than does the Mg concentration.

The three wheat cultivars had the lowest concentrations of Mg and Ca (Table 2). Barley and oats had high K and C – A levels, the latter indicating a high organic acid concentration. Oats contained much aconitic acid, as did wheat and rye, but barley contained only a trace, therefore accumulating its organic acids in forms other than aconitic.

Each of the forages seems to have at least one chemical parameter which would tend to impose a risk of tetany. There are some differences in the chemical composition within the three wheat cultivars used in the study. Perhaps such differences could be used in a selection and breeding program to reduce the tetany hazard of wheat forage.

The predicted blood-serum Mg level for each forage is shown in Table 2. While the nomograph by Hartmans (4) was developed for high producing dairy cattle in The Netherlands, the relative ranking of the forages in Table 2 should still apply to beef cattle. Based on the data shown in Table 2, the estimated tetany hazard is wheat > oats = barley > rye.

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