Grass Seed Straw – Considerations for Use as a Forage Source for Ruminants

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Introduction

The vast majority of U.S. grass seed production occurs in the states of Oregon, Washington, and Idaho. These states produce approximately 90% of all Kentucky bluegrass (*Poa pratensis* L.) grown in the United States, with 70 to 80% grown in northern Idaho and eastern Washington. In addition, Oregon produces approximately 99% of all ryegrass and orchardgrass (*Dactylis glomerata* L.) seed and 64% of all fescue seed harvested in the United States (Oregon Agricultural Statistics Service, 2001-2002). Estimated annual U.S. grass seed production derived from the 1997 U.S. Agricultural Census was approximately 462.5, 392.4, 15.6, and 69.7 million pounds for ryegrass, fescue, orchardgrass, and Kentucky bluegrass (U.S. Department of Agriculture - National Agricultural Statistics Service, 1997). We estimate the value of this production to be 482 million dollars.

A byproduct of grass seed production is straw. In 1999, approximately 900,000 tons of grass seed straw were available in Oregon (86%), Idaho (6%), and Washington (8%) (Fiber Futures, 2003). The traditional manner of grass seed straw disposal is open-field burning. This management technique removes the residue and is instrumental in controlling disease problems (Hardison, 1960; Hardison, 1964; Conklin and Fisher, 1973; Hardison, 1976; Chilcote et al, 1981). However, the large amount of smoke produced causes adverse impacts upon the environment and has created situations dangerous and/or fatal to humans (Hovermale and Craig, 2001). As a result, legislation in Oregon, Washington, and Idaho has been enacted that dramatically curtails or eliminates burning as a management alternative for post-harvest removal of grass seed straw. Consequently, the amount of post-harvest grass seed residue that needs to be contended with is continually increasing.

Several ideas have been investigated in the search for alternative means of straw disposal. One technique is to flail chop the residue and return it to the soil. However, concerns have been expressed regarding disease proliferation. Some producers compost the straw residue and market it as a soil conditioner (Edgar, 1996). Other producers have marketed it as a mulch product to berry farms, Christmas tree farms, mushroom producers, and vineyards. Additionally, the Oregon Department of Transportation annually utilizes straw residue as a soil erosion preventative at construction sites. Several other alternative uses of grass straw, including production of paper and insulation board, have been investigated (Conklin et al., 1989). However, concern over a stability of supply has hampered progress in this direction. Other research has been conducted evaluating grass seed straw as an alternative fuel source; however, this has proved to be cost prohibitive (Conklin et al., 1989). An alternative disposal

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technique that has exceeded the potential of other alternatives is utilization of grass seed straw as a forage source for ruminants.

While grass seed straw is generally a low-quality forage source, the ruminant animal and its microbial population can utilize it with proper nutritional management. Straw is a major feed source for ruminants in Third World countries (Van Soest, 1994), yet in the United States, it is estimated that less than 1% of the total straw supply is used as a forage resource (Han, 1978). Consequently, the current major market for U.S. grass seed straw as a ruminant feedstuff is export to the Pacific Rim, primarily Japan, Korea, and Taiwan. These countries imported 613,175 tons of Oregon's grass seed straw (perennial ryegrass [*Lolium perenne* L.] tall fescue [*Festuca arundinacea* Schreb.], orchardgrass, and bentgrass [*Agrostis* L.]) during the 2002 – 2003 market year (Young, 2003). However, grass seed straw has potential as an alternative to traditional sources of low-quality forage (meadow hay, sorghum hay, cornstalks, etc.) that are used to maintain cow herds in areas of the U.S. and Canada requiring harvested or stockpiled forage for extended periods of time.

Nutritional Quality of Grass Straw for Ruminants

Comparison to Other Low-Quality Forages

In general, grass seed straw is comparable in nutritional quality, on a crude protein (**CP**) basis, to most meadow hays and superior to most cereal grain straws (Table 1). However, there are usually nutritional quality differences (CP basis) among species of grass seed straw. Based on the nutritional grass seed straw data presented in Table 1, a nutritional ranking of grass seed straw species is provided in Table 2. Briefly, bluegrass is the highest quality followed by perennial ryegrass, tall fescue, bentgrass, orchardgrass, other fescues (not including tall fescue), and annual ryegrass (*Lolium multiforum*). However, variety differences and harvest conditions can affect grass seed straw quality and, thereby, alter these rankings. Consequently, grass seed straw should be tested for forage quality by a certified lab prior to purchase and/or use as a forage source for ruminants.

Comparison to Animal Requirements

In most instances, feeding grass seed straw as a major component of the diet should only be practiced with non-lactating, mature cows. The nutritional requirements of various classes and stages of production of cattle are listed in Table 3. Crude protein and total digestible nutrient (**TDN**) requirements are highest for growing animals and lactating cows. When used as the major component of the diet, grass seed straw does not have the digestible CP and/or TDN to support optimal performance in these classes of livestock. Simply stated, beef cattle in high nutrient requirement production stages cannot consume enough grass seed straw to meet nutrient demands (Table 3; NRC, 1984). Therefore, grass seed straw will normally require some form of supplementation, usually CP and energy, to be used efficiently by beef cattle. Providing a CP supplement to meet a CP deficiency will also, in most instances, meet energy requirements. Protein supplementation will be discussed further under methods to improve nutritional quality of grass seed straw.

Alkaloid Concerns

Some species of grass seed straw contain alkaloids, which can cause animal health and/or neurological concerns if the alkaloids are present in high concentrations. Consequently, concern over alkaloid concentration in grass seed straw has hampered its use as a forage source for ruminants. The two most common species of grass seed straw that can contain high levels of alkaloids are tall fescue and perennial ryegrass. The alkaloid most often associated with tall fescue straw is ergovaline while perennial ryegrass straw can have ergovaline and lolitrem B (Stamm, 1992). Alkaloids are produced by endophytic fungi that exist in a symbiotic relationship with their plant host (Aldrich-Markham and Pirelli, 1995; Hannaway et al., 1997; Hannaway et al., 1999). The causative fungi thought to produce ergovaline and lolitrem B are *Neotyphodium coenophialum* and *Neotyphodium lolli*, respectively.

Tall fescue. Alkaloids in tall fescue have caused fescue foot, summer syndrome or fescue toxicosis, fat necrosis, agalacticia (decreased milk production), and reproductive problems in ruminants consuming tall fescue (Hemken and Bush, 1989; Hemken et al., 1984; Stuedemann and Hoveland, 1988).

Fescue foot results in gangrene of the extremities, particularly tails, hooves, and ears, and occurs during cold temperatures, particularly in the late fall and winter. Fescue foot begins with a reduction in animal performance (Hemken and Bush, 1989), with animals having a rough hair coat, arched back, and soreness in one or both rear limbs (Hemken et al., 1984). Hyperemia of the coronary band occurs, with some swelling and, if the animals continue consuming infected tall fescue, eventually the hooves may be sloughed (Hemken and Bush, 1989).

Symptoms of summer syndrome or fescue toxicosis include reduced performance, reduced milk production, decreased feed intake, rough hair coat, elevated body temperature, increased respiration rate, decreased serum prolactin, excessive salivation, and reduced reproductive performance (Hemken et al., 1984). This condition normally occurs in the summer months when environmental temperatures are greater than 73°F.

Fat necrosis is characterized by hard fat masses located primarily in the adipose tissue of the abdominal cavity (Stuedeman et al., 1975). Other symptoms include elevated body temperature, rough hair coat, lameness, and seeking of shade or water (Hemken et al., 1984).

Reproductive problems include increased time to conception, reduced conception and calving rates, and increased embryonic mortality compared with animals not consuming high-alkaloid tall fescue (Bond et al., 1982; Hoveland, 1993).

The aforementioned research was conducted with tall fescue hay or pasture – not tall fescue straw. To date, we are aware of only one study that has evaluated the affect of increasing alkaloid (ergovaline) concentration in tall fescue straw on physiological response variables and animal performance in ruminants (Stamm et al., 1994). Stamm et al. (1994) offered tall fescue straw containing increasing levels of ergovaline (0, 158, 317, and 475 ppb) to steers supplemented with alfalfa pellets at 0.5% of body weight and reported no health problems, no negative affects on dry matter intake or nutrient digestibility, and no reductions in animal performance. However, a problem with feeding tall fescue straw (containing approximately 400 ppb ergovaline) to spring-calving beef cows was noted during the winter of 2001-2002 in Eastern Oregon (D. Bohnert, Eastern Oregon Agricultural Research Center). Producers on three ranches were utilizing tall fescue straw as a forage source when colder temperatures (two weeks of constant temperatures below 32°F) occurred. It is believed that decreased peripheral blood flow to the extremities caused many of the cows to suffer severe frostbite to their feet, resulting in the sloughing of their hooves. Approximately 600 cows had to be destroyed due to this incident. Total long-term losses from the three ranches approached an estimated 1.25 million dollars.

Perennial ryegrass. Perennial ryegrass can contain ergovaline (an alkaloid present in tall fescue) in addition to lolitrem B. Stamm (1992) reported the ergovaline concentration of 136 samples of perennial ryegrass and 122 samples of tall fescue straw. She noted that the mean concentration was 86 ppb for tall fescue samples and 214 ppb for perennial ryegrass samples. Also, she stated that of the tall fescue fields sampled, 14% had ergovaline levels greater than 200 ppb while 42% of perennial ryegrass fields contained ergovaline levels greater than 200 ppb. Therefore, perennial ryegrass can cause health disorders normally associated with tall fescue, as well as a neurological disorder associated with consumption of lolitrem B called "Perennial Ryegrass Staggers". This disorder normally manifests itself in ruminants after consuming lolitrem B infected perennial ryegrass for 7 to 14 days. Clinical symptoms include incoordination, staggering, tremors, head shaking, and collapse (Aldrich-Markham and Pirelli, 1995; Cheeke, 1995). While death can result from "perennial ryegrass staggers", death is normally associated with misadventure (stumbling off a cliff, entering a pond to cool off and drowning, etc.; Cheek, 1998). Animals demonstrating clinical symptoms should be removed from the causative feed source, whereby symptoms normally subside in 2 to 14 days.

As noted with tall fescue straw, there is limited information available concerning the feeding of perennial ryegrass straw with increasing levels of lolitrem B to ruminants (Fisher, 2003). Fisher (2003) noted no adverse effects on nutrient intake and digestibility, physiological response variables, animal performance, or milk production in ruminants consuming perennial ryegrass straw with increasing lolitrem B concentration (< 100 to 2017 ppb). However, Fisher (2003) did report that 13 of 24 (54%) cows consuming perennial ryegrass straw containing 2017 ppb lolitrem B exhibited clinical symptoms of perennial ryegrass staggers.

Management Recommendations Concerning Alkaloids

Livestock consuming grass seed straw in the Pacific Northwest have become increasingly more at risk to alkaloid toxicity due to the increasing restriction on end-of-the-season burning of grass seed straws. In addition, the grass seed industry has been developing turf-type varieties of tall fescue and perennial ryegrass because of the potential to increase plant hardiness, pest resistance, and drought tolerance. However, turf-type varieties can have high concentrations of alkaloids (Hannaway et al., 1999).

Grass seed straws are being purchased and fed to livestock without a knowledge of the concentration of ergovaline or lolitrem B present in them. This increases the potential for incidences of fescue toxicity and/or perennial ryegrass staggers. Consequently, the first step in feeding potentially alkaloid infected grass seed straw is to have it tested for alkaloids. It should be noted that perennial ryegrass straw should be tested for lolitrem B and ergovaline.

Once the concentration of alkaloids in a grass seed straw is known, proper nutritional management can be carried out. Table 4 lists the estimated threshold levels of ergovaline and lolitrem B in the diet of cattle and sheep. These values can be used to minimize the chance of causing clinical symptoms of fescue toxicosis and perennial ryegrass staggers when feeding alkaloid infected grass seed straw. The threshold levels for ergovaline may vary because environmental factors and stress also play a role in the development of clinical disease. Specifically, the threshold levels for ergovaline decrease in colder weather. This is especially important to remember when feeding grass seed straw during periods of severe weather (freezing temperatures and snow).

Grass seed straws that contain alkaloid (ergovaline and/or lolitrem B) concentrations above the recommended threshold levels can be effectively used as forage resources. However, this will require increased nutritional management and diligent observation of livestock consuming the residue. The most common and effective means of feeding alkaloid infected grass seed straw is to blend it with non- or low-alkaloid infected forage. The "rule of thumb" is to use a 50:50 mix of infected and non- or low-alkaloid infected forage. This will normally be sufficient to eliminate, or greatly decrease, the chance of developing symptoms of alkaloid toxicity. In addition, providing a crude protein supplement (often necessary with grass seed straw) will dilute the concentration of alkaloid(s) in the diet. Knowledge of alkaloid concentration, and associated threshold level(s), allows livestock producers, Extension agents, and/or nutritionists to make safe decisions concerning the feeding of alkaloid-infected grass-seed residues.

Methods to Improve Nutritional Quality

The major advantage of ruminants over other livestock species is their ability to effectively use low-quality roughages such as grass seed straw. Beef cattle producers have a number of management alternatives that can be used to enhance the ability of ruminants to use grass seed straw. These include supplementation with CP, physical and chemical modification of grass seed straw, and use of fibrolytic enzymes.

Crude Protein Supplementation

Protein is normally the first limiting nutrient in grass seed straw diets and, therefore, is usually the most beneficial nutrient to supplement when an adequate quantity of grass seed straw is available. Because protein is required by both the animal (for normal growth and production) and ruminal microorganisms (for microbial growth and ruminal digestion), a protein deficiency can severely depress animal performance and productivity. Most responses to protein supplementation are observed when the CP content of the grass seed straw is less than 6 to 8% (dry matter basis). This was illustrated in studies by Horney et al. (1996), Currier et al. (2002), and Bohnert et al. (2003). In each of these studies, CP supplementation of ruminants consuming grass seed straw containing less than 5% CP resulted in increased total dry matter intake and nutrient digestibility compared with no CP supplementation. Therefore, CP supplementation not only adds CP to the basal diet but can also improve the total intake and digestibility of nutrients (TDN) available to ruminants consuming grass seed straw.

Physical Modification of Grass Seed Straw

Physical modification (grinding and pelleting) has been shown to increase intake of forage while decreasing digestibility because of a faster passage rate through the gastrointestinal tract (King et al., 1963; Barton et al., 1992; Merchen and Bourquin, 1994). Barton et al. (1992) noted that steers consuming pelleted tall fescue straw consumed approximately 21% more straw compared with steers consuming long stem tall fescue straw. However, dry matter digestibility was decreased approximately 10% for pelleted straw compared with long stem straw (45% vs. 50%); nevertheless, the increased intake of pelleted tall fescue straw resulted in approximately 9% greater total digestion of nutrients compared with long stem straw. Based on these results, physical modification of grass seed straw improves the availability of nutrients for use by the ruminant animal.

Chemical Modification of Grass Seed Straw

Application of caustic chemicals has been observed to enhance ruminal degradability of low quality forages (Berger et al., 1994). Of the compounds investigated, hydroxides (Na and Ca) and anhydrous ammonia have been found to be most effective. Particularly in North America, anhydrous ammonia is the chemical of choice as it is effective and available in almost any rural community from fertilizer suppliers. In addition, application of anhydrous ammonia to low-quality forage provides a supplemental source of non-protein nitrogen that increases the CP content of the straw. Application of 2.5 to 3.5% anhydrous ammonia is the economic optimum level of ammoniation (Sundstol and Coxworth, 1984); however, our research group found that 3% ammoniation of bluegrass was not as effective as 5% (Szasz et al., 2001). Van Soest et al. (1984) suggested that variability in effectiveness is a problem with ammonia treatment. It is possible that differences in bale density, moisture content, and ammonia level could account for much of the variation in ammoniation response. Grass seed straw is typically harvested during an extremely arid time of the summer and usually contains less than eight percentage units of moisture. This low level of moisture may negatively affect ammoniation response as ammonia requires moisture to swell and effectively alter the plant cell wall. Grove et al. (2002) reported that 3% ammoniation of dry (92% dry matter), high density bluegrass straw bales was largely ineffective; however, 3% ammoniation of moist (83% dry matter) bales resulted in a substantial improvement in ruminal in situ degradability. These data suggest that grass seed straw harvested with the intention of ammoniation should be harvested with at least 17% moisture such as that often provided from an over-night dew.

Some studies have also reported improved intake and digestibility of low-quality forage by the addition of exogenous fibrolytic enzymes (Beauchemin et al., 1995). Szasz et al. (2002) observed no benefit from the addition of fibrolytic enzymes when bluegrass straw was fed to growing beef heifers. In theory, exogenous fibrolytic enzymes will have the greatest benefit when the ruminal environment is in someway compromised, resulting in less-than-optimal production of ruminal microbial fibrolytic enzymes. Especially when protein supplementation is provided, the ruminal environment within grass straw-fed ruminants is likely to be quite healthy. Current literature does not support the addition of these enzymes to grass straw diets.

Economics of Straw Feeding

Cost Comparison and Crude Protein Supplementation

The first step in determining if grass seed straw is an economical option for use as a forage source is to calculate the cost of the straw and compare it to other available forage sources on a dry matter basis. Once this is determined, the cost of CP supplementation must be estimated to determine the total cost comparison between the grass seed straw and the alternative forage source. For example, a cattle producer has a cow herd that averages 1200 lb and is in the last third of gestation (nutrient requirements listed in Table 3). The forage resources available for purchase include a grass seed straw and a meadow grass hay. In addition, the producer uses alfalfa hay (18% CP; $100/ton; $0.05/pound) as a CP supplement. The grass seed straw has a CP and neutral detergent fiber (**NDF**) concentration of 4.5 and 74%, respectively, and is available for $35/ton ($0.0175/pound). The meadow hay containing 6% CP and 60% NDF is available for $65/ton ($0.0325/pound). If we assume the cows will consume 1.6% (19.2 lb) or 2.0% (24.0 lb) of body weight per day, respectively, of the grass seed straw or meadow hay (intake as a percentage of body weight estimated as 120/NDF%), feeding grass seed straw will result in a shortage of 0.84 lb of CP with grass seed straw and 0.26 lb CP with meadow hay. Therefore, the grass seed straw will require supplementation with 4.7 (0.84/0.18) lb of alfalfa hay, while the meadow hay will require 1.4 (0.26/0.18) lb of alfalfa hay to eliminate the shortage in CP. The cost of grass seed straw and meadow hay will be $0.336 and $0.780 per day, respectively. Also, alfalfa supplementation will cost $0.235 per day with grass seed straw and $0.070 per day with meadow hay. As a result, the total daily cost of feeding grass seed straw and meadow hay will be $0.571 (0.336 + 0.235) and $0.850 (0.780 + 0.070) per cow, respectively. This equates to approximately $17.13 compared with $25.50 for one month of feeding. Therefore, in this situation, feeding grass seed straw will reduce the monthly feed cost by 33% compared with feeding the meadow hay.

The above calculations are pertinent to the consideration of ammoniating grass seed straw. The cost of ammoniation must be compared against the value of the increased energy and protein achieved by ammoniation. Importantly, the cost-benefit of ammoniation should be weighed against the cost of nutrients (energy and protein) provided by supplements (as described above). The cost of ammoniation includes the expenses for the anhydrous ammonia, plastic to cover the stack of straw, and a modest expense for labor. The cost of the anhydrous ammonia usually parallels natural gas prices and is typically the most prohibitive of the costs associated with ammoniation. Currently the cost of ammoniation would be $18 to $22 per treated ton and the "rule of thumb" would be that ammoniation increases digestibility (energy content) by 12%. Also, a 3% level of ammonia treatment would increase the CP content by five to six percentage units. Again, it is important to weigh this cost and the expected improvement in energy and protein content of the grass straw with the cost of energy and protein supplements available in a given region.

Conclusion

Given the availability of grass seed straw, and its ability to lower the cost of a ration, grass seed straw has the potential to be an economical management tool for most winter-feeding programs. However, it is recommended that when purchasing grass seed straw, a producer obtain a nutrient analysis and determine if the straw contains toxic levels of alkaloids. Listed below are a series of questions and recommendations that a ruminant livestock producer should use before feeding grass seed straw.

1) Determine nutritive value (CP, NDF, acid detergent fiber, and TDN) using a certified lab.
2) How does the price of grass seed straw compare with other forage sources? Evaluate cost per ton of dry matter and cost of supplementation, physical modification, and or chemical treatment.
3) What is the species of grass seed straw (tall fescue, perennial ryegrass, bluegrass, etc.)

and does it have the potential to contain toxic levels of alkaloids?

4) If the grass seed straw has the potential to contain elevated levels of alkaloids, have it tested for ergovaline (tall fescue and perennial ryegrass varieties) and/or lolitrem B (perennial ryegrass varieties).
5) Be aware of the recommended threshold levels for ergovaline and/or lolitrem B.
6) If the grass seed straw is considered acceptable for use, develop a nutritional management plan for its safe and effective use (contact your county Extension agent, Extension specialist, or nutritionist for assistance).

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Table 1. Nutritional comparisons of some low-quality meadow hays, grass seed straws, and cereal grain straws.[1]

Reference by Forage Type	Description	Nutritional Quality, Percentage Dry Matter Basis			
		CP	NDF	ADF	TDN
A. Low-Quality Meadow Hay					
Hunt et al., 1989	Meadow Fescue	6.6	65.4	39.0	58.1
Sanson and Clanton, 1989	Warm- and Cool-Season Grasses	5.2	70.8	46.1	52.5
		7.0	74.4	45.6	52.9
Sanson et al., 1990	Warm- and Cool-Season Grasses	4.3	72.9	46.2	52.4
Waggoner et al., 1979	Native Meadow (Brome, Fescue, and Crested Wheatgrass)	8.2	66.3	42.1	55.6
Worrell et al., 1986	Warm- and Cool-Season Grasses	8.5	68.1	34.3	61.8
Bohnert et al., 2002	Cool-Season grasses	5.2	60.1	32.0	63.6
		5.0	57.7	32.1	63.5
B. Grass Seed Straws					
Church and Champe, 1980	Annual Ryegrass	3.4	—	44.9	53.4
Guggolz et al., 1971	Fescue	5.1	—	53.0	47.0
Ralston and Anderson, 1970	Perennial Ryegrass	5.5	—	50.6	48.9
	Bluegrass	8.9	—	43.7	54.4
	Bentgrass	4.6	—	45.6	52.9
	Annual Ryegrass	4.8	—	49.7	49.6
Kellems et al., 1984	Perennial Ryegrass	6.9	71.7	42.5	55.3
Fisher, 2003	Perennial Ryegrass	4.6	63.0	33.0	62.8
		5.5	64.0	34.0	62.0
Kellems, 1985	Perennial Ryegrass	4.2			
68.8	44.0	54.1			
Phillips et al., 1975	Bluegrass	5.5	—	—	—
	Red fescue	3.7	—	—	—
Phillips and Vavra, 1979	Perennial Ryegrass	8.9	—	43.2	54.8
Grove et al., 2002	Bluegrass	5.9	—	—	—
Currier et al., 2002	Hard Fescue	4.3	73.8	32.0	63.6
Youngberg and Vough, 1977	Bluegrass	7.7	73.2	43.6	54.5
	Perennial Ryegrass – Turf type	6.7	68.1	42.4	55.4
	Tall Fescue	5.7	69.3	42.5	55.3
	Bentgrass	5.2	67.7	41.1	56.4
	Perennial Ryegrass – Forage type	4.9	72.1	45.5	53.0
	Orchardgrass	4.8	79.0	49.6	49.7
	Annual Ryegrass	3.7	75.6	50.5	49.0
	Chewings and Red fescue	3.1	81.1	51.5	48.2
Stamm et al., 1994	Tall Fescue	6.3	67.4	44.6	53.7
		5.3	71.1	49.2	50.0
C. Cereal Grain Straws					
Church and Santos, 1981	Wheat	3.8	—	49.0	50.2
		2.6	—	53.1	47.0
Herrera-Saldana et al., 1982	Wheat	2.9	—	50.1	49.3
Horton, 1978	Wheat	2.3	—	—	—
	Barley	3.8	—	—	—
	Oat	2.2	—	—	—
Horton and Steacy, 1979	Barley	3.9	—	—	—
	Wheat	2.5	—	—	—
	Oat	2.6	—	—	—
Kernan et al., 1979	Wheat	3.6	—	—	—
	Oat	3.8	—	—	—
	Barley	4.9	—	—	—
Males et al., 1982	Wheat	3.4	82.6	56.7	44.1
Pritchard and Males, 1982	Wheat	2.5	78.5	55.1	45.4

[1]Adapted from Stamm (1992); CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; TDN = total digestible nutrients (calculated as 88.9 – (0.79*ADF%)).

Table 2. Nutritional ranking (CP basis) of select grass seed straws by species.[1]

Grass Seed Straw Species	Average CP (%)	Ranking
Bluegrass	7.0	1
Perennial ryegrass	6.0	2
Tall fescue	5.7	3
Bentgrass	4.9	4
Orchardgrass	4.8	5
Other fescues (not including tall fescue)	4.0	6
Annual ryegrass	4.0	7

[1]From data presented in Table 1.

Table 3. Nutrient requirements of beef cattle (NRC, 1984; dry matter basis).[1]

Production Stage	Intake, lb	CP, %	CP, lb	TDN, %	TDN, lb
700 lb Steer, gaining 1.0 lb/day	15.8	8.6	1.4	58.5	9.2
1200 lb Mature Cow					
Mid-Gestation	20.8	6.9	1.4	48.8	10.1
Late-Gestation	22.3	7.8	1.7	52.9	11.8
Early Lactation	23.0	9.3	2.1	55.5	12.8

[1]lb = pounds; CP = crude protein; TDN = total digestible nutrients.

Table 4. Estimated alkaloid threshold levels (parts per billion; ppb) for fescue toxicosis and perennial ryegrass staggers in cattle and sheep (adapted from Tor-Agbidye et al., 2001).

Species	Ergovaline (ppb)[1]	Lolitrem B (ppb)
Cattle	400-750	1800-2000
Sheep	500-800	1800-2000

[1]Threshold level is environmentally dependent and decreases in colder weather.

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