The Fescue Toxicosis Story - An Update

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Origin of Tall Fescue

Tall fescue (*Festuca arundinacea*) is the most important cultivated pasture grass in the USA, occupying over 35 million acres. It is a native of Europe but is of minor importance there. It is not known when tall fescue was first introduced into the USA but it was being tested in several states by the late 1800s (Buckner et al., 1979). However, tall fescue usage remained low until release of the Kentucky 31 cultivar. It is an ecotype found growing in a steep mountain pasture of eastern Kentucky which was known to have been there prior to 1890. Dr. E.N. Fergus, a professor at the University of Kentucky, saw this pasture in 1931 and was impressed that the grass remained green all winter so obtained seed for trials. Kentucky 31 was released as a cultivar in 1943 (Fergus, 1952). This grass was dependable, adapted to a wide range of soils, and provided grazing over much of the year. As news spread that this wonder grass persisted across the southern USA where no other cool season perennial grass was adapted, demand for seed exploded as it was widely planted during the 1940's and 1950's. This was a remarkable ecological change as tall fescue transformed the landscape which was previously mostly barren and brown during the winter season. In addition to the widespread planting of tall fescue for pasture and hay, it also became popular for roadside and turf use.

Fescue Toxicity Problems

Tall fescue soon gained a reputation for livestock health problems, resulting in poor performance (Pratt and Haynes, 1950). Over time, three separate syndromes were associated with tall fescue (Ball et al., 2002):
(a) Fescue foot. In the upper South and Midwest, cattle symptoms include elevated respiration rate, and gangrene that resulted in loss of hooves, tails, and ears. This syndrome occurs mainly during cold weather.
(b) Bovine fat necrosis. Hard fat accumulate along the intestinal tract, resulting in upset digestion and difficult births. It is associated with high rates of nitrogen fertilization mainly from poultry litter or other manure.
(c) Fescue toxicity. This syndrome is much more widespread over the entire tall fescue region with general symptoms in cattle of failure to shed the winter hair coat, intolerance to heat, poor animal gains, and reduced pregnancy rates. These symptoms are most severe in warmer weather. In horses, mares have serious reproduction problems with prolonged gestation, dystocia, agalactia, and abortions.

Determining the Cause of Toxicity Problems

J.K. Underwood and co-workers in Tennessee noted with great insight that the animal symptoms were similar to ergotism but they eliminated this possibility because there was no ergot in tall fescue seed heads (unpublished, 1954). Surprisingly, this clue was not followed up. Instead, research was concentrated on external plant fungi, plant alkaloids, anions, and toxins produced in the rumen during the 1950's-1970's (Bush et al., 1979). This consumed a great deal of scientific time and money with nothing to show for it. The breakthrough came when Dr. Joe Robbins, a toxicologist at the USDA Russell Research Laboratory in Athens, GA, examined a tall fescue pasture with cattle suffering fescue toxicity symptoms and found 100% of the plants infected with a fungal endophyte while pastures with cattle in good condition had a much lower infection rate (Bacon et al., 1977). This evidence of the fungal endophyte as the causal agent of toxicity was confirmed in two central Alabama replicated grazing trials having low and high endophyte infection levels (Hoveland et al., 1980; Hoveland et al., 1983).

Vasoconstriction with decreased blood flow to peripheral tissues and reduced blood serum prolactin, typical of fescue toxicity, suggested an alkaloid as the problem (Cross, 2000). A number of ergot alkaloids were isolated from endophyte-infected plants (Bacon and Siegel, 1988) and ergovaline was assumed to be the one most responsible for animal toxicity (Lane et al., 1997). However, research by Hill et al. (2001) indicates that transport of the ergopeptine alkaloid ergovaline across ruminal gastric tissue is low as compared to the simple ergoline alkaloids lysergic acid and lysergol. This indicates that we are closer to defining the toxic agent or agents responsible for fescue toxicity and possibly developing some blocking technique in the animal rumen.

Beef Cattle Response to the Endophyte

Beef steer gains in six grazing trials on low endophyte tall fescue were 30% to over 100% more than on grass with a high level of endophyte infestation (Stuedemann and Hoveland, 1988). Unfortunately, none of the grazing trials had endophyte-free (E-) and infected (E+) tall fescue from the same genetic source which may partially account for the large variation in animal response. Where the same seed source was used in a 3-yr central Georgia grazing trial, steers on the Jesup cultivar with 1% endophyte infection had an ADG of 2.27 lb but with 89% infection it was 0.81 lb, or only about one-third (Hoveland et al., 1997). Steers on E- tall fescue are tolerant of heat, graze throughout the day, shed their winter hair coats in spring, and are more active than steers on E+ grass. Visible signs of the syndrome increase with higher temperatures, but poor gains occur throughout the year on E+ tall fescue. The effects of grazing E+ versus E- tall fescue pasture during stockering on subsequent gains in the feedlot are not clear.
Several studies indicate that beef steers previously grazing E+ tall fescue had compensatory gains in the feedlot (Cole et al., 1987; McDonald et al., 1988; Lusby et al., 1990). However, other scientists (Hancock et al., 1987; Duckett et al., 2001) found no compensatory gains in steers previously grazed on E+ pastures.

Beef cows on E+ tall fescue are often thin and in poor condition, caked with mud, and spend excessive amounts of time in shade or water. Pregnancy rate of beef cows (especially first-calf heifers) may be reduced by 40 to 60% (Essig et al., 1989; Gay et al., 1988; McDonald, 1989; Porter and Thompson, 1992). Calf weaning weights may be decreased by 60 to 70 lb, a result of both reduced milk production by cows and consumption of toxic tall fescue forage by calves. Milk production of beef cows on E+ grass may be reduced by 30% or more. Beef cattle losses in the USA have been conservatively estimated at well over $600 million annually from reduced calf numbers and lower weaning weights (Hoveland, 1993).

Biology of the Fungal Endophyte

The fungus (*Neotyphodium coenophialum*) lives its entire life cycle within the plant, thus being called an endophyte. Unlike most fungi, this one is not visible externally on the tall fescue plant. Nearly all tall fescue pastures have a high level of infected plants. It is spread only through infected seed. This means that tall fescue pastures free of the endophyte will remain that way for a long time if well managed. However, invasion of an E- pasture can occur from introduction of infected seed in hay or by cattle that have previously grazed seed in an E+ tall fescue pasture. Storage of E+ seed under ambient temperature and humidity generally results in death of the endophyte within a year.

A mutualistic relationship exists between the endophyte and host plant, (Bacon and Siegel, 1988). The benefits for the endophyte include food, protection within the plant, and dissemination through the seed. In return, the host plant receives improved drought tolerance through better root development and better water conservation in the plant, tolerance to pests, improved utilization of nitrogen, and greater seedling vigor and growth potential (Latch, 1997). Dry matter intake by cattle grazing cattle E+ tall fescue is 24 to 44% less than for cattle grazing E- tall fescue, resulting in less severe grazing pressure (Stuedemann et al., 1989). In addition, crowns of E+ tall fescue plants are buried deeper in the soil than E- plants, giving added grazing protection (Hill et al., 1990) With all the benefits of the endophyte, it is obvious that E- tall fescue is handicapped in a stressful pasture environment and less competitive with other plant species.

Endophyte-free Tall Fescue Cultivars

When the first E- tall fescue cultivar, ‘AU Triumph’ was released, it appeared to offer a solution to the livestock toxicity problem (Hoveland et al., 1982). Animal performance was excellent but cattle producers who planted it reported that seedling vigor, grazing tolerance, and drought resistance were much less than typical Kentucky 31 E+ tall fescue, resulting in stand losses, especially when overgrazed in stressful environments. Improved cultivars are better but require careful management to avoid overgrazing during summer, a problem that is much worse in southern areas of tall fescue adaptation where heat and drought stress are often severe.

Novel Endophyte (Non-Toxic) Endophyte Tall Fescue

Bacon and Siegel (1988) first proposed that fungal endophytes might be modified to produce only beneficial properties such as improved stress tolerance when inserted into an E- tall fescue plant to produce a superior forage grass without any toxicity problems. The discovery in New Zealand (Latch, 1997) of non-toxic endophyte strains made this possible. The first novel (non-toxic) endophyte tall fescue cultivar for commercial use was developed in cooperative research between scientists in Georgia, USA and New Zealand (Bouton, 2000; Bouton et al., 2000). This is a difficult procedure as there are many strains of naturally occurring non-toxic endophytes, and they vary in their ability to work effectively with different tall fescue cultivars, making lengthy testing necessary to determine the stress tolerance of a particular endophyte/tall fescue cultivar combination.

Grazing trials to ascertain animal performance of particular endophyte/cultivar combinations are necessary but more important are grazing tolerance trials for 3 yr under stressful conditions to ascertain stand persistence and competitive ability. An effective method to do this is planting the various endophyte/cultivar combinations along with toxic E+ and E- tall fescue in replicated small plot trials into bermudagrass sod and imposing continuous close grazing by cattle throughout the growing season for a minimum of 3 yr (Bouton et al., 2002). Unless potential novel endophyte cultivars have been evaluated under rigorous testing over time, there is no assurance they will be durable in farm pastures where overgrazing and competition from other grasses is likely to occur.

MaxQ was the first novel endophyte tall fescue cultivar available to cattle producers. Grazing trials with lambs, beef steers, and beef cows have shown that animal performance is similar to that on E- tall fescue. Beef steers on MaxQ gained 0.9 lb/day and 200 lb/A more during spring than steers grazing toxic E+ grass in Georgia for 2 yr (Bondurant et al., 2001a). Grazing behavior on MaxQ, toxic E+, and E- tall fescue pasture were collected on steers equipped with automatic jaw and leg movement sensors, and data recorders (Bondurant et al., 2001b). Steers on MaxQ and E-, as compared to toxic E+ tall fescue, had 8% more time grazing, 25% more bites per day, and 25% higher intake. The E+ steers spent 28% more time idling in the shade and consumed 40% more water. With beef cows the calf weaning weights on MaxQ, as compared to toxic E+ tall fescue pasture, were 75 lb higher for steers and 60 lb for heifers (Watson et al., 2001).   MaxQ stand persistence in closely grazed bermudagrass in four trials at two Georgia locations have ranged from 80 to 90% of toxic E+ tall fescue as compared to 20% for E- tall fescue (Bouton et al., 2002; also unpublished data).

Marketing of Novel Endophyte Tall Fescue Seed

Distribution of novel endophyte tall fescue seed poses potential problems for the livestock producer and additional costs for seed firms. Endophyte survival in tall fescue seed gradually declines to about zero during normal storage in warehouses for a year. Thus, unsold seed which are carried over for sale the following year will, in addition to reduced vigor and germination, not contain the living novel endophyte with its benefits to the plant. For the buyer, it is imperative that he/she knows the level of living novel endophyte in the seed at time of purchase and that it be guaranteed by the seed firm. For the seed company to do this, the price of novel endophyte seed will need to be higher to cover losses from unsold carryover seed which can only be sold as cheaper common E- tall fescue seed with no claim to superiority. Seed companies unwilling to make such a guarantee should be avoided; however, it is likely that they will have customers because they can offer novel endophyte seed at a lower price.

Practical Solutions to the Toxicity Problem

Livestock toxicity problems on tall fescue pastures vary greatly among farms. Since most Kentucky 31 tall fescue pastures have a high level of endophyte infection, the main reason for this variation is probably a result of differences in amount of pasture dilution by other plant species. Tall fescue pastures may be mixed with varying amounts of bermudagrass, orchardgrass, timothy, Kentucky bluegrass, or white clover. Palatable winter weeds such as chickweed and little barley dilute pastures in late winter and early spring. During summer, volunteer crabgrass is often an important component of tall fescue pastures. There is no question that fescue toxicity problems would be much more serious if crabgrass were absent from pastures.

Various options can be used with a range in cost and effectiveness (Ball et al., 2002). The choice will depend on the type of livestock operation, expectations, and management ability. Some of the least expensive options are often adequate for beef cow herds and greatly ameliorate or eliminate cattle toxicity problems.

(a) Pastures can be managed to favor other grass species such as bermudagrass to dilute the toxic E+ tall fescue (Chestnut et al., 1991).
(b) Mowing of seed heads in spring will reduce intake of the highly toxic seed by cattle (Rottinghaus et al, 1991). Infected tall fescue seed are substantially more toxic than leaf tissue (Schmidt et al., 1982).
(c) Seeding of legumes such as white clover, red clover, annual lespedeza, or alfalfa into pastures will dilute the toxicity problem and greatly improve animal performance (Ellis et al., 1983; Hoveland et al., 1981; McMurphy et al., 1990).
(d) Moving cattle off toxic tall fescue pastures to warm season grasses during late spring and summer may be a viable alternative (Joost, 1995).
(e) Feeding hay other than toxic tall fescue such as orchardgrass, timothy, bermudagrass, alfalfa, or red clover greatly reduces the toxicity problem in winter.
(f) Ammoniation can reduce the alkaloid content of toxic E+ tall fescue hay and improve animal performance (Chestnut et al., 1987; Kerr et al., 1990).
(g) Grain feeding is also beneficial for cattle grazing toxic E+ tall fescue (Aiken and Piper, 1999; Crawford et al, 1989).
(h) The most effective but also the most costly solution is replanting pastures with novel endophyte (non-toxic) tall fescue (Ball et al., 2002). This is a major decision as it involves completely destroying existing toxic pastures and replanting them. The time required for destruction and establishment may prevent use of the pasture for six to nine months. Where pastures are being used for growing animals as in a beef stocker operation, replanting is highly desirable as the cost is quickly repaid.

Implications

Although tall fescue pastures support more beef cattle than any other grass in the USA, the fungal endophyte which contributes to its success in stressful environments adversely affects animal performance. The various syndromes caused by toxic alkaloids from the fungal endophyte are widespread and a serious economic problem in the USA beef cattle industry. Most cattle producers suffer losses and many accept them as a normal part of their operation. Fortunately, much progress has been made in research on this problem and finding solutions. Today, a number of options are available to cattle producers that can eliminate the problem or greatly ameliorate it.
Low cost options include diluting toxic pastures with clovers or other grasses, mowing off

seedheads, moving cattle to warm season grass pastures during summer, ammoniation of hay, or feeding hay other than toxic tall fescue. The most effective and most costly option is destroying toxic pastures and replanting with novel (non-toxic) endophyte tall fescue, a dependable solution to eliminate the toxicity problem.

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