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*The
fascinating
tale of* **tall fescue**

by Tracy Hmielowski

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Decades of scientific collaboration helped mitigate the toxicity problem of this 'wonder grass'...yet challenges remain

Tall fescue (*Festuca arundinacea*) covers an estimated 35 million ac in the eastern United States. This cool-season perennial grass has been planted as cattle

forage and turfgrass and for erosion control since the 1940s. It is a very widespread pasture grass even though a fungus living within the plant produces toxic compounds that have negative impacts on grazing animals. Unfortunately, the endophytic (meaning between the plant's cell walls) fungi and the compounds it produces were not understood until well after tall fescue had been planted across the country.

It took decades of research and collaboration across scientific disciplines from animal sciences to crop sciences, biochemistry, and mycology to identify the endophyte and determine the mechanisms causing health problems in grazing animals. Since the discovery of the endophyte in the 1970s, researchers have found ways to mitigate or eliminate the effects of what has become known as the "toxic" tall fescue, but these changes have been slow in comparison to how rapidly fescue was spread.

Wonder Grass

To understand why toxic tall fescue is so widespread, you need to picture how the Mid-Atlantic looked in the 1920s and 1930s. ASA and CSSA Fellow Henry Fribourg, Emeritus Professor of Crop Ecology at the University of Tennessee, describes it as a landscape that had "essentially very poor pastures in the Midsouth and adjoining areas because of the lack of fertility and exhaustion of the soils from cotton."

When lush green grass growing on a farm in Kentucky was pointed out to ASA Fellow E.N. Fergus in 1931, it was like nothing else growing in the region at the time. The grass was tall fescue, which is native to Europe and likely brought to the U.S. in the 1800s. Fergus took a sample of the grass and worked with colleagues at the

University of Kentucky to develop the Kentucky-31 (KY31) cultivar. This cultivar, released in 1942 and registered in 1972, is the most common cultivar of fescue found in the U.S.

Tall fescue was particularly well suited to the "transition zone," the area between the subtropical Southeast and temperate Northeast. Given the lack of forage in this area at the time, fescue was viewed as a wonder grass that would grow on a wide variety of soil types, resisted drought and winter cold, and was a quality forage for cattle. Fribourg says, "[Fescue] was much better than what was there before for cattle to graze. Eventually, after World War II... the Midsouth came into its own of having cow-calf enterprises that could benefit from having this grass that grew 9, 10 months a year."

However, as fescue rapidly spread across the Mid-Atlantic and into the southeastern U.S., so did the reports of livestock experiencing health problems.

Toxicosis Symptoms

"The first case was observed in Middle Tennessee... in the wintertime when the whole herd of cattle came out with what was known then as fescue foot," Fribourg recalls.

Fescue foot was not the only problem reported. Cattle grazing on fescue did not lose their winter coats and would have elevated body temperatures, which would make them prone to standing in ponds or seeking shade, and they would stop grazing and subsequently not put on weight at the expected rate. There were reports of fat necrosis (where fat deposits would develop along the digestive tract of animals), low milk production, and birthing difficulties.

Horses and other grazers were also sensitive to the toxins. ASA and CSSA Fellow Garry Lacefield, Professor

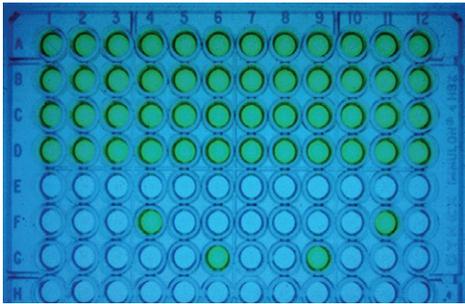
Emeritus at the University of Kentucky, says, "We didn't know what we were dealing with." Laboratory analysis of the grass showed the nutritional quality was high, and yet, animals were showing symptoms across the region.

Researchers now know that all of the symptoms, collectively called fescue toxicosis, are the result of animals ingesting ergot alkaloids, compounds produced by an endophyte commonly found in tall fescue. The alkaloids bind to vascular receptors and cause vasoconstriction in the animals. Re-



Top: Cattle leg suffering from fescue foot. Photo courtesy of Dr. David Bohnert, Oregon State University.

Middle: Steer after grazing endophyte-infected tall fescue. Note the retained winter haircoat and unthrifty appearance compared with the sleek and shiny haircoat of steer. **Bottom:** Steer after grazing endophyte-free tall fescue.



From left to right: Qualitative analysis of ergot alkaloids in *Epichloë coenophiala* endophyte infected seed; non-endophyte-infected (*left*) vs. infected (*right*) KY31 tall fescue (photo by J. Bouton); endophyte mycelia being inserted into a tall fescue seedling to introduce a novel endophyte (photo by B.N. Stearns); endophyte-infected seedlings of tall fescue are germinating from seed carried in hay fed on a non-endophyte-infected pasture—careless management has accelerated endophyte contamination in the new pasture seeding (photo by D. Barker); and (l to r) Don Ball, Henry Fribourg, Garry Latch, Carl Hoveland, Joe Bouton, and Gary Lacefield pose for a picture (photo courtesy of H. Fribourg).

stricted blood flow to the extremities can cause gangrene in cold conditions and an inability for animals to cool well in the summer heat. One of the compounds, ergovaline, reduces blood prolactin levels that reduce milk production and can interfere with pregnancy in grazing animals.

When these symptoms were first described, researchers realized the similarities with ergotism. However, an examination of fescue seed heads did not reveal the presence of ergot, a fungus that grows on the seed heads of cereal grains, leading many scientists to seek other explanations.

Unexpected Results

In search of a solution to the problems with fescue, researchers set up grazing experiments. ASA and CSSA Fellow Carl Hoveland, Emeritus Professor at the University of Georgia, was one person working on this problem. For one experiment, Hoveland planned to set up an experiment comparing fescue to other forage grasses. When workers ran out of seed, they simply planted the remaining paddocks using KY31 tall fescue. Cattle in these paddocks did not exhibit classic symptoms of fescue toxicosis. Hoveland reflects, “[the seed had] been stored for a year or so, but I didn’t know that at the time.”

Hoveland was not the first to observe differences in animal performance among fescue pastures. Several researchers noted instances where cattle had dramatically different outcomes grazing on the same grass. Microscopic examination of

the grasses showed the presence of the fungal endophyte where cattle were doing poorly and no endophyte where cattle showed good health. This provided strong evidence that the endophyte was causing the observed health problems.

As they continued to work with tall fescue, Hoveland and his colleagues realized the endophyte was sensitive to storage conditions. When tall fescue seed was stored and exposed to hot, humid conditions, the endophyte would die, but the seed was still viable. Interestingly, the high demand for KY31 meant that most of the seed harvested in the summer was sold and planted within months, facilitating the spread of seed infected with the toxic endophyte.

Understanding that the endophyte was causing the symptoms, and having a way to remove the endophyte, Hoveland worked with plant breeders at Auburn University to develop a new fescue cultivar. “We were so excited about all this, what we’re going to do with a new [cultivar which] would be fungus free and nontoxic.” They moved quickly to develop and release this endophyte-free cultivar, and farmers replaced toxic pastures and planted new fields with the endophyte-free seed. But, Hoveland says, “It was about two to three years later when farmers started complaining bitterly about losing stands of this stuff. It just wasn’t holding up.”

A Novel Answer

The endophyte-free fescue lacked the tolerance to drought and heavy

grazing that KY31 was famous for. “We tried to develop more fungus-free varieties that were more persistent, but we couldn’t do it. This endophyte made it Superman. When [fescue] didn’t have the endophyte, it was Clark Kent,” explains ASA and CSSA Fellow Joe Bouton, Emeritus Professor at the University of Georgia.

In the late 1980s, Bouton heard Gary Latch, from New Zealand, give a talk about endophytic fungi in perennial ryegrass, a close relative of fescue. After the talk, Bouton and Latch discussed the similarities in their research, and Latch mentioned that he had found endophytes that did not produce toxic alkaloids. Upon hearing this, Bouton says he “grabbed a hold of [Latch] and didn’t let him go!”

Bouton was able to visit New Zealand on sabbatical several years later. While in New Zealand, he worked with Latch and other collaborators to replace the toxic endophyte in tall fescue with some of the non-toxic endophytes. One of these non-toxic, or novel, endophytes did particularly well in tall fescue and was used as the basis for developing a new cultivar. The first non-toxic endophyte-infected tall fescue, Jesup-MaxQ, was released in 2000.

With the release of Jesup-MaxQ, Bouton says, “We felt really good because we showed we could remove the toxins and keep some of the agronomic benefits with these things. . . but the big problem is nobody planted [the non-toxic seed]—I mean not in any appreciable amount.”



No Simple Solution

Researchers and extension agents have many ideas as to why producers do not replace existing tall fescue pastures, even those known to be infected with the toxic endophyte.

“Expectations for the novel endophyte were exceptionally high,” explains Lacefield, and finding out that these cultivars require careful management may make some producers hesitant to switch. Once established, non-toxic pastures are “a high quality product that’s very palatable ... so the animals will eat it into the ground if you let them,” Bouton says. And, if landowners have a mix of toxic and non-toxic fescue cultivars, they need to take care when moving equipment and animals around. Moving seed, be it in equipment, via cattle, or in hay can introduce toxic seeds into a non-toxic pasture.

There is also the up-front cost of replacing a pasture. The non-toxic endophyte-infected cultivars are more expensive, mainly because of the quality control required to ensure seed contains the non-toxic fungus. And farmers need to take a pasture out of use for about two years to ensure removal of fescue with the toxic endophyte. This may require farmers to reduce their herd size or lease land to make up for a pasture taken out of production, further impacting their bottom line.

And for some farmers, they simply do not see enough problems to justify replanting pastures. In the Shenandoah Valley of Virginia, where Matt Booher works, he hears few complaints about problems related to tall fescue. Booher, an Extension Agent with Virginia Cooperative Extension, says, “You’ve got several things that have to line up in order for you to actually have a visible problem with fescue toxicosis.” The weather, alkalo-



loid content of the pasture, and cattle genetics all interact, and producers may go years without seeing a case of fescue foot or severe symptoms in the summer.

Curious to see if toxic tall fescue was prevalent in the region, Booher and his colleagues sampled 25 farms in 2013 to quantify the presence of the endophyte. Given his personal observations in the region, he was, “very surprised to see the levels of toxicity that we recorded.” Booher and colleagues found 65% of the pastures they sampled were 100% infected with toxic endophyte. The lowest infection rate, observed for a single pasture, was 50%. Additional sampling, to determine alkaloid levels throughout the season and in different parts of the plant, showed the lowest levels to be above 1,000 parts per billion. But what does a number like that mean for a cattle producer?

When talking to farmers about testing the level of alkaloids in fescue, Bouton compares it to a doctor testing your blood pressure. “What we try to tell them now is if you can sample for these ergot alkaloids, and if it’s below 150 parts per billion, we feel like that’s normal. That’s like the normal blood pressure. If you’re starting to creep up into the low hundreds—200, 300, 400 [parts per billion]—that’s where we start worrying,” Bouton says. And, just like a physician can suggest lifestyle changes or prescribe medication to prevent further health

problems, producers can take action to mediate the effects of toxic tall fescue. This may include inter-planting other species, especially clovers, in pastures showing lower alkaloid levels, but if the alkaloid levels are high (upper 100s), then killing the toxic stand and replacing it with a non-toxic cultivar is really the only safe option according to Bouton.

Management Strategies

Depending upon the extent of the problem, and the ability of the farmer to make changes, there are best practices that can be used to manage for fescue to minimize toxicosis symptoms.

One method is to prevent fescue from developing seed heads, which typically have a higher concentration of alkaloids, through grazing, mowing, or herbicide. Producers can also rotate cattle off fescue pastures when alkaloid levels are highest or cattle are more sensitive to problems. Diversifying diet, by interseeding other forage species, can also mitigate some of the symptoms of fescue toxicosis.

“We always recommended interseeding clovers into fescue,” says ASA and CSSA Fellow Glen Aiken, Director of the USDA-ARS Forage-Animal Production Research Unit, as a way to dilute the ergot alkaloids. But clover may have a more important impact. Recent work by Aiken and his colleagues has demonstrated that iso-

Tall Fescue Endophyte Research

CSSA member Carolyn Young, Associate Professor at the Samuel Roberts Noble Foundation, is a mycologist who works with grass endophytes. In particular, her research has focused on *Epichloë coenophiala*, the endophyte found in tall fescue. *Epichloë coenophiala* is the same endophyte described by Charles Bacon as *Epichloë typhina* in 1977.

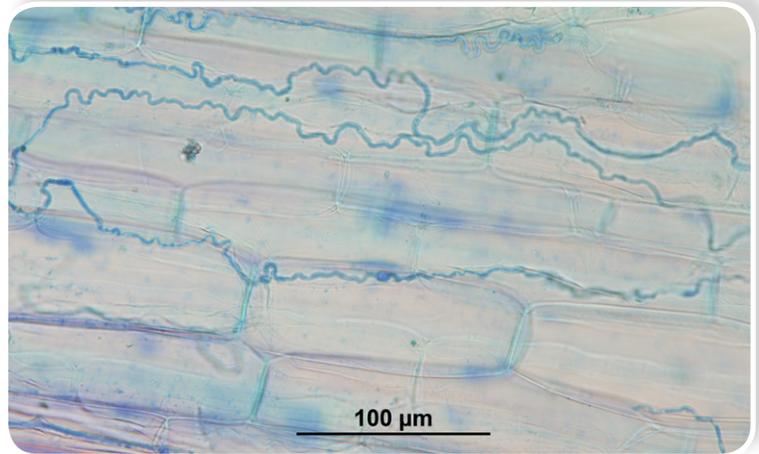
Young started at the Noble Foundation in 2006, after the release of the first novel-endophyte cultivars of tall fescue. “The potential for non-toxic endophytes is enormous, so when I came to Noble, one of the things I really wanted to do was make sure we had a good quality assurance pipeline as we develop our elite breeding material,” she comments. The endophyte lives its entire life within the plant and is transmitted to future generations through the seed, but the exterior appearance of tall fescue does not indicate what endophyte (good or bad) is present.

Just like the landowners who should carefully manage pastures that are a mix of toxic and non-toxic fescue cultivars, it is important within grass breeding to do the same. The Noble Foundation grass breeding group is extremely careful not to move seeds between cultivars. “When we are harvesting or cleaning seed, we are careful not to go from a toxic field to a non-toxic field,” Young says, “since you could still have a little bit of seed leftover in the equipment,” which might be enough to contaminate a breeding line. Her lab can identify the different endophytes, and they work closely with the grass breeder, Michael Trammell (an ASA, CSSA, and SSSA member), to ensure the purity of their future endophyte-infected tall fescue varieties.

Part of Young’s research is to investigate new non-toxic endophyte isolates, which she says are “not genetically modified. They are natural isolates.” What makes them non-toxic to grazers is that they do not have the genes that encode for the production of alkaloids. These genetic differences are also of interest to Young. “We need to understand this at a genetic level as well. So, it’s great that the isolate doesn’t do that, but why? Could toxicity turn up at some stage? Not if they don’t have the genes.”

By attending events like those hosted by the Alliance of Grassland Renewal, Young has had the opportunity to talk with cattle producers about their needs and also hear from those who have implemented non-toxic endophyte-infected tall fescue.

“It is great to hear how producers manage fescue toxicosis and to hear about the benefits that non-toxic endophyte-infected tall fescue provides,” Young says. “It’s like seeing the endophytes in action through the eyes of a producer.”



Light micrograph of the tall fescue endophyte (*Epichloë coenophiala*) in a tiller. The endophyte mycelium is stained with alanine blue. Photo courtesy of Carolyn Young.

flavones produced by clovers function as beta-agonists—compounds that reduce muscle contraction and are commonly used to treat asthma symptoms. Similar to opening constricted airways, Aiken says, “[the isoflavones] will open up the vascular system of these cattle that have alkaloid-induced constriction.”

In addition to managing the landscape, producers can manage the herd genetics. ASA and CSSA Fellow Craig Roberts, State Forage Specialist at the University of Missouri, discussed one method that can be used to identify

genetic differences between cattle. Roberts is part of AgBotanica¹, the company responsible for developing T-Snip, a genetic test that can distinguish cattle that are highly susceptible to the alkaloids from those that are tolerant.

From a simple blood or hair sample, cattle producers are given a score from 0 (highly susceptible) to 5 (toler-

¹ T-Snip is not affiliated with the University of Missouri but is technology owned by the start-up company, AgBotanica, LLC, of which Dr. Roberts is a partner (www.agbotanica.com).

ant) for each animal. Roberts describes the difference: “Tolerant cows, they only lose half of what the susceptible cows do” in terms of weaning weight of their calves compared with cows on non-toxic feed.

“It’s not the only selection tool, but it is one selection tool that allows the cattlemen to cull the herd for tolerance,” Roberts says, and although the difference between susceptible and tolerant cattle is impressive, he emphasizes, “There is no such thing as resistance.” Tolerant cattle are still underperforming, which leads



Above: The Alliance for Grassland Renewal assists producers with successfully converting Kentucky 31 tall fescue to novel endophyte varieties. *Photo by Kyle Spradley (© 2014—Curators of the University of Missouri).* **Right:** Craig Roberts discussing strategies to reduce toxicity levels in endophyte-infected tall fescue at a field day. *Photo courtesy of the University of Missouri College of Agriculture, Food, and Natural Resources.*



to a loss in potential profit for cattle producers.

Slow Progress

Working with individuals, rather than trying to make broad recommendations, is one way to educate farmers about fescue toxicosis. "It's a good tactic to work people into things slowly and encourage them to use [mitigation] strategically until they get comfortable with it," Booher says. Seeing the positive results of diversified forage or non-toxic pasture grass firsthand is one way to convince people to make a change, but working with producers one at a time is a slow process.

To connect with more people, The Alliance for Grassland Renewal, which promotes the conversion of toxic

tall fescue to non-toxic endophyte cultivars, holds one-day workshops. These workshops combine field demonstrations, peer-to-peer learning, and practical instruction on the best practices for converting pastures.

Considering that the annual economic loss to U.S. cattle producers is likely in the hundreds of millions of dollars, converting fescue pastures to non-toxic endophyte cultivars would have a substantial economic impact. With continued collaboration and communication among researchers, extension specialists, and cattle producers, the widespread problem of fescue toxicosis may be minimized,

leading to increased production and profits for cattle producers in the U.S.

T. Hmielowski, Science Editor for CSA News

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Dig Deeper

Read more about this topic in the following publications from ASA, CSSA and SSSA, available in the ACSESS Digital Library (<http://dl.sciencesocieties.org>):

- Tall Fescue for the Twenty-first Century. See <http://bit.ly/2foZLul>
- Fescue Toxicosis and Management. See <http://bit.ly/2fDU6nS>

