THE WONDER GRASS

The Story of Tall Fescue in the United States

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THE WONDER GRASS

The Story of Tall Fescue in the United States

PART ONE – EARLY HISTORY

PART TWO – REMARKABLE DEVELOPMENTS

PART THREE - INSIGHTS, IMPACTS, AND IMPLICATIONS

PREFACE

Tall fescue occupies an estimated 30 to 40 million acres in the United States, and is the most important forage grass in humid climate areas of the nation. It is widely adapted, it provides nutrition for millions of grazing animals via pastures, haylage, or hay, and it is an important turf and conservation plant. In this publication, the primary focus is on tall fescue as a food source for livestock.

The remarkable story of tall fescue in the United States had its beginnings in the mountains of eastern Kentucky in the latter part of the 19th century. Since then, the grass has regularly been in the news, and frequently a topic of widespread interest. It has been praised and promoted, as well as criticized and denounced. It has been the focus of countless research projects, including creative international collaboration. Key contributors to this story include farmers, seedsmen, scientists from numerous disciplines, and people associated with various agricultural agencies.

This story is unique, and even persons not involved in agriculture may find it interesting. For more than 40 years, each author of this book was closely involved with developments associated with this grass. Tall fescue has had a profound impact in the USA and in the world. The story of tall fescue in the United States is an important and fascinating part of agricultural history.

Note: A bibliography is provided. However, this topic is so multifaceted that providing a reference for every statement in this publication was deemed excessively cumbersome. Also, because so many people have contributed to this story, we could not mention every name or specific accomplishment.

PART ONE

EARLY HISTORY

CHAPTER 1

The Beginning

Forage/livestock production in the United States (USA) has come a long way. When the first European settlers arrived in North America, most humid-climate land in the eastern United States and in the Pacific Northwest was covered by forests.

In open areas, there were some productive volunteer native warm-season bunch grasses including eastern gamagrass, big bluestem, little bluestem, switchgrass, and indiangrass.* These grasses were grazed primarily by bison and deer that were hunted by native people. Unfortunately, while these species had significant value as forage crops, they were not tolerant of close continuous grazing, and did not provide pasture forage during the cooler months of the year.

Prior to the 20th century, there was relatively little forage seed production in the USA. European immigrants, most of whom were from cool-climate areas, brought seed of pasture grasses used in their home countries. Timothy, from northern Europe, was adapted only to colder areas of the USA. Perennial ryegrass, commonly grown in Europe because of its high nutritive quality and yield, was planted by colonists, but often failed, especially in southern areas with more stressful climatic conditions. Meadow fescue was successful in northern areas, but failed in the southern USA.

Photo Credit: Henry Dorough

Prior To European Settlement, Much Of The Eastern And Pacific Northwest Areas Of The United States Were Forested.

**Scientific names of plants mentioned in the text are provided on page 79.*

Until the late 1800s, seed of these grasses was imported, mainly from Europe. As a result, improved cool-season pastures in southern areas depended largely on annual grasses, especially annual ryegrass and three cereals: rye, wheat, and oats.

In the first half of the 20th century, the typical cattleman in the eastern USA had fewer than 25 cows, usually beef cattle, although most farms had at least one dairy cow that provided milk for the family. There was no specific calving season, frequent inbreeding, and dairy cattle genetics were often present in animals that were considered beef cattle. Dairying was of minor importance in the Southeast until the 1920s, but was an important industry farther north.

Most beef producers did not have a forage program; animals just grazed whatever was available. On most farms, volunteer native grasses usually included substantial presence of broomsedge (commonly called "sagegrass" and sometimes "broomstraw," "sedgygrass," or "sage"). Several other grasses in the same genus (*Andropogon)* that had more forage value were frequently present, as well as a few legumes in some areas, including white clover and/or annual lespedeza. Striate annual lespedeza was present in many areas in the latter part of the 19th century; Korean annual lespedeza, a separate species, was introduced early in the 20th century).

At this time, much of the land was forested or consisted of sparse woods under which some herbaceous plants could volunteer. A statement often made in those days was that "pastures consisted primarily of sagegrass, sawbriars, and sassafras." This referred to a native

The Soil Conservation Service Was Created To Address Soil Erosion Problems grass, a thorny weed, and a common tree, respectively, none of which had significant forage value. The statement was intended to be humorous, but contained much truth.[95]

Soil erosion was often a serious issue, especially in closely grazed pastures, and in areas with significant slopes. The magnitude of this problem led to the creation of the Soil Conservation Service (now the Natural Resources Conservation Service) by the federal government in 1935.

Kentucky is centrally located in a large geographical area now often referred to as "The Fescue Belt," that extends roughly from central Ohio to central Alabama and from eastern Oklahoma to eastern Virginia (**Figure 1**). Until the latter part of the 20th century, most pastures in this area were overgrazed, deficient in productive forage species, seriously eroded, and soil fertility was low. There was a great need for a productive, widely adapted, grazing-tolerant, cool-season perennial grass for use in pastures and hay fields.

FIGURE 1. The Fescue Belt

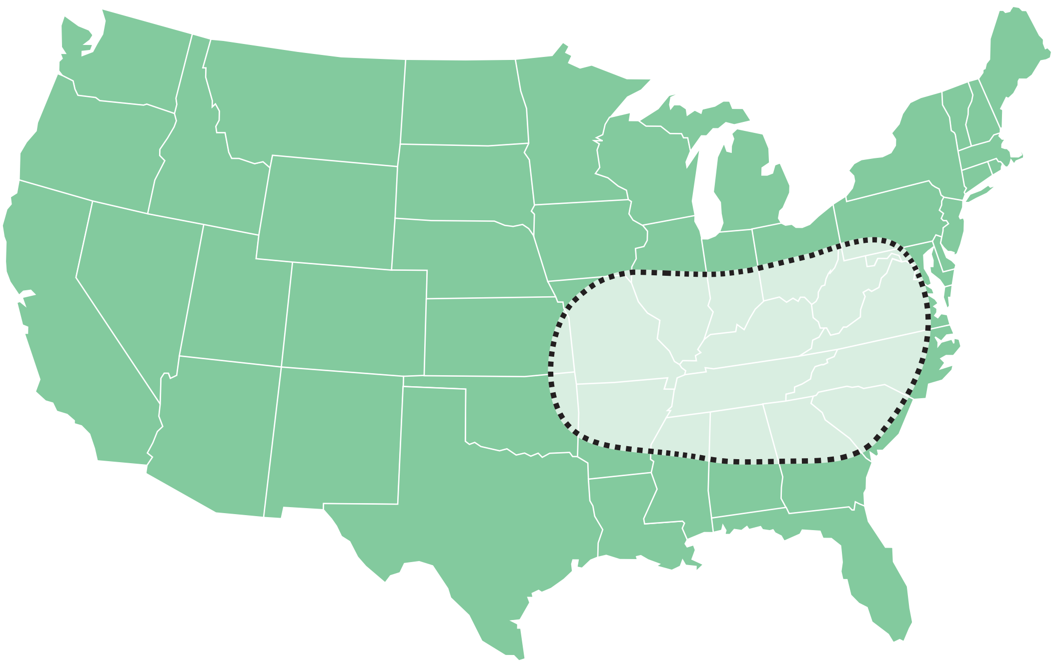


Photo Credit: Progressive Forage Magazine

__Note:__ Tall fescue can survive in many areas outside of the zone depicted, but this drawing shows the primary areas in which it is dominant and widely used, and to which the term "The Fescue Belt" generally applies. This area encompasses a good portion of what is often referred to as "the transition zone" (that lies between areas in the North where cool season species dominate, and areas in the South where warm season species dominate).

CHAPTER 2

An Unlikely Hero

A mountain farmer's observations and actions set in motion a remarkable agricultural change that ultimately led to wide-ranging commercial activities as well as multi-faceted scientific pursuits. While living on his small farm in eastern Kentucky in the latter part of the 19th century and the early part of the 20th century, this man made an important discovery, and followed that with some wise decisions and diligent actions.

William M. Suiter was born in 1861 in Bland County (southwestern Virginia), which borders Kentucky. Beginning in 1887, he purchased three tracts of land near the small town of Frenchburg in Menifee County, Kentucky. One of these tracts, about 56 acres in size and purchased in 1893, was locally known as the William Suiter farm.[50]

Around 1893, Mr. Suiter noticed a grass growing on his farm that attracted his attention. It remained green during the cooler months of the year when most other plants were dormant and brown. It was a perennial, it persisted well, and his cattle readily ate it. Furthermore, it had a good root system that reduced erosion, an important consideration for his mountain farm.

Initially, the grass was in patches, and only on one hillside. He decided to harvest seed, and used it to thicken the stand until the field was covered. He subsequently established the grass in other areas, and it eventually became the dominant grass on his property.

At first, Mr. Suiter sold only a small amount of seed to a few neighbors, mainly because his mountainside fields were so steep that seed had to be hand harvested and hand threshed, a time consuming, laborious process that initially offered little financial reward. But in later years when the potential of, and demand for, "Suiter's Grass" became more apparent to him and to others, he put more focus on seed production.[50]

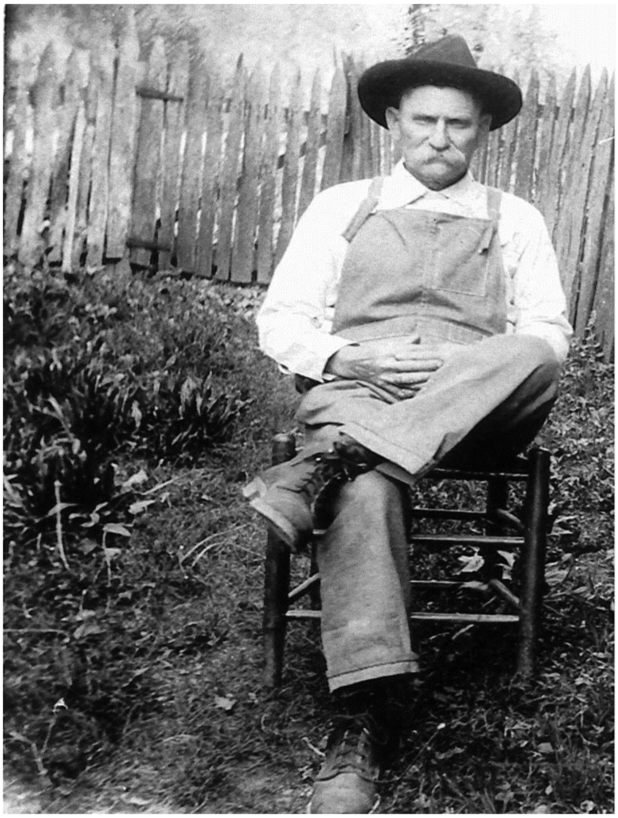


Photo Credit: Kentucky Cooperative Extension Service

William Suiter

Photo Credit: International Plant Nutrition Institute[10]

Historic Mountainside Pasture On The William Suiter Farm

William Suiter deserves much credit, because he recognized the potential value of the grass, and took actions that eventually led to it becoming a major pasture, hay, and conservation plant. He died in 1944, so did not witness the full significance of his efforts with the grass eventually identified as tall fescue, or the impact of the variety released as 'Kentucky 31.' However, he knew that "his" grass was widely recognized as being something special, and that the work he had done with it had benefitted society. Yet, he must have wondered about how the grass had arrived at his farm.

A plaque at the base of the mountainside on which he first propagated the grass honors him. It reads, *"Upon this farm William M. Suiter discovered and nurtured the outstanding strain of tall fescue known as Kentucky 31 fescue. In appreciation of the service he thus rendered to agriculture, his friends and neighbors, the farmers of Kentucky, have in the year 1948 erected this monument to his memory. Kentucky 31 fescue, through natural selection under the rugged conditions of the Kentucky mountains, developed a hardiness unknown in other grasses. Its wide adaptability and merits were recognized by the Kentucky Agricultural Experiment Station and the College of Agriculture, and these institutions have been instrumental in making it available to farmers everywhere."*

Menifee County Plaque Honoring William Suiter

CHAPTER 3

Mountain Mystery

Tall fescue is not native to the United States, or even to North America. It originated in Europe.[18] In the middle of the 18th century the name *Festuca elatior* (elatior means 'tall, high, or lofty' in Latin) was applied by the renowned early Swedish taxonomist Linnaeus to a grass that at that time encompassed both what is now called tall fescue and also what is now called meadow fescue.

Tall fescue was recognized as a distinct species (*Festuca arundinacea)* by the German botanist Johann Christian Daniel von Schreber in 1771. The grass is widely distributed in Europe and North Africa, and is present even in Siberia.[19] Interestingly, in these areas it is rarely planted for pasture and hay production, because other adapted cool-season forages have softer leaves, and are more palatable to grazing animals.

Tall fescue seed may have found its way to the United States with early settlers as a contaminant in seed of other forage species, but there is no record of tall fescue plantings prior to the 19th century. Reports from trials conducted in Kentucky[37] and Virginia[55] near the end of the 19th century mention the superior growth, height, competitive ability, and drought tolerance of tall fescue as compared to meadow fescue. One researcher described it as being "an exceedingly valuable grass for mowing or pasture."[59] Despite recognition of attributes of the species, it was not widely planted as a forage crop until the 1940s.

Given this scenario, there is mystery associated with this story. Two intriguing questions loom large. The first is: *How did tall fescue, a grass that had only been rarely planted even in test plots in the United States, find its way to the William Suiter farm, a truly remote location in the mountains of eastern Kentucky*? We can only speculate.

It may have been present in other grass seed planted on the farm. Meadow fescue, a closely related species, was introduced from England prior to 1800.[59,97] Seed of meadow fescue that contained some tall fescue seed as a contaminant may have been planted in Menifee County. Seed of the two species bear such close resemblance, this could easily have occurred without detection. It is also possible that tall fescue seed was present in hay or some other type of feed material brought to that location.

Photo Credit: Joel Reagan

Meadow Fescue Seed (top) And Tall Fescue Seed (bottom) Approximate Actual Size

A story passed by word of mouth in eastern Kentucky links the grass to a shipment of household china from Europe to Menifee County sometime during the 19th century. Legend has it that grass straw, at least some of which was tall fescue, was used as packing material to protect the china.[100] If true, the straw would likely have contained tall fescue seed.

Furthermore, grass *seed* alone was sometimes used as packing material as well. Any such seed associated with packing materials might have been carelessly discarded or intentionally taken to a place where it could have germinated and became established. The story about tall fescue being introduced via packing material has persisted for decades, despite seeming unlikely.

A second question is: *How long had tall fescue plants been present on the property William Suiter purchased*? He noticed the grass soon after he took ownership of the farm, probably in 1893.[50] Unfortunately, there is no way of knowing its history.

The term "ecotype" refers to a genetically distinct population within a species. Plant ecotypes develop over time because of various environmental influences that favor stress tolerance and survival of some plants over others of the same species. These influences can include amount and timing of rainfall, temperature extremes, amount and quality of sunlight, extent of defoliation (grazing or clipping), and competition from other plants.

In general, the harsher the climatic or other influences, and the longer a population of genetically unique plants is exposed to them, the more likely it will be that an ecotype will develop that is substantially different from other ecotypes or varieties within the species. Simply stated, an ecotype fits an environmental niche better than other plants of the same species.

Nature is an effective plant breeder. The tall fescue genetic population eventually released as the variety Kentucky 31 had decades of exposure to the harsh climatic conditions in the mountains of eastern Kentucky. In this case, nature had plenty of time to work on developing a population of tall fescue plants that exhibited persistence in a stressful environment.

Definitive answers to the two questions are unlikely to be revealed, but given the location at which the ecotype that was the forerunner of Kentucky 31 originated, it is not surprising that it proved to be a hardy variety. William Suiter and nature worked together: one developing, and the other preserving and propagating, a unique and tough tall fescue ecotype. However, numerous other people played critical roles in events that led to it becoming a variety, a commercial success, and a major contributor to the livestock and turf industries in the United States.

CHAPTER 4

A Professor's Historic Trip

Dr. E.N. Fergus, a professor in the Agronomy Department at the University of Kentucky, worked full time with forage crops in the 1930s and 1940s. A plant breeder by training, his research work primarily involved clovers.[95] As such, one of the important contributions he made was the release of 'Kenland' red clover, long considered the standard to which other red clovers are compared, and which has served as a source of genetics for other red clover varieties. However, his greatest and most noteworthy career achievement, one that he could not have foreseen when he joined the university faculty, resulted from work he did with a grass.

University of Kentucky Archives

Dr. E.N. Fergus

In the autumn of 1931, Dr. Fergus traveled to Menifee County, Kentucky to judge a sorghum syrup show. This type of activity was not mandatory for a faculty member, but generated good will between the university and the public. It was only about a 60-mile trip from the University of Kentucky campus in Lexington to Menifee County, and perhaps Dr. Fergus considered a brief trip to the mountains in autumn a pleasant escape from his usual routine on the university campus.

The outcome of the sorghum syrup show has been forgotten, but another aspect of that trip proved to be of immense importance. A farmer named W.K. Wells told Dr. Fergus about the grass on the Suiter farm, so the Professor asked if he could see it. He was favorably impressed, and obtained about a pound of seed that he took back to Lexington, Kentucky for evaluation.[31]

It is not uncommon for a faculty member to have numerous projects in progress, some of which receive relatively little effort and attention for a long time. This may have been the situation with the grass Dr. Fergus obtained from Menifee County. In spring of 1932, he established it on an experiment station in the vicinity of Lexington, Kentucky[30] and observed it for over a decade.

It is not known whether Dr. Fergus did any selection work with the grass. While it seems logical to think that a plant breeder would have been inclined to attempt to improve a plant population, he may not have done so. His primary responsibilities were to teach students and do research on clovers. He probably had plenty of work to keep him busy before he even heard about the Menifee County grass.

However, between 1931 and 1943, a few other farmers obtained and planted seed of "Suiter's grass." A major reason that interest in the grass increased was because of the activities of another University of Kentucky employee, widely known and respected by farmers, county agents, and others throughout the state of Kentucky.

CHAPTER 5

A Passionate Promoter

William Johnstone served as extension agent in McCracken County (of which Paducah is the county seat), in western Kentucky, for 13 years prior to becoming Field Agent in Agronomy at the University of Kentucky in 1937 (essentially an extension specialist working statewide). He was dedicated to helping farmers, and was interested in grassland agriculture, but as an extension agent he had been frustrated by the difficulty of getting good results from the forage crops that were commercially available. He also recognized that soil erosion was a serious problem, and he worked closely with Soil Conservation Service personnel.

Photo Credit: University of Kentucky

William Clarkson Johnstone

Mr. Johnstone had no knowledge of Suiter's Grass until February, 1938. One afternoon he drove past a green pasture on a steep slope near Frenchburg, Kentucky. It was quite impressive compared to the brown, dormant or dead vegetation that dominated the landscape at that time of year, so he drove to the nearby local county Extension office to inquire as to what was growing there. The county agent knew about the grass, and explained the situation.

Mr. Johnstone's immediate enthusiasm regarding this grass was demonstrated by the fact that the next day he visited Dr. Fergus and explained how impressed he was with what he had observed in Menifee County. Dr. Fergus then revealed that he had visited that mountain pasture in 1931 when he had judged a sorghum syrup show. Furthermore, he stated that during that trip he had obtained seed that he had planted on a nearby University of Kentucky experiment station. Dr. Fergus had initially believed the grass was meadow fescue, but eventually, samples were sent to expert botanists who determined it was tall fescue.[60]

As Field Agent in Agronomy at the University of Kentucky, William Johnstone had insight into the forage situation throughout the state, and was in a position to influence farmers. Because he was intrigued with the Menifee County grass, he soon made the acquaintance of Mr. Suiter, talked to him about the great potential he felt the grass had, and encouraged him to save and sell more seed.[50]

During the next few years, Mr. Johnstone often mentioned Suiter's Grass at Extension meetings around the state. He was instrumental in getting a few farmers in addition to William Suiter to produce seed of the grass, and facilitated sale of seed to individuals in various areas of Kentucky.

Mr. Johnstone and Dr. Fergus were friends as well as colleagues. They worked closely on numerous forage-related projects, and saw each other frequently. Mr. Johnstone's enthusiasm for the grass, together with encouragement he likely provided, may have helped inspire Dr. Fergus to eventually release a variety.

William Johnstone worked in Extension in Kentucky for 29 years, and was widely known and highly respected. As a result, he was named Man of the Year in Service to Southern Agriculture by *Progressive Farmer* magazine in 1949. Also, in 1983 the University of Kentucky released a tall fescue variety named 'Johnstone' in his honor. He was posthumously inducted into the University of Kentucky College of Agriculture Hall of Distinguished Alumni in 2015.[4]

CHAPTER 6

The Wonder Grass

The attributes of Kentucky 31 tall fescue as a forage crop are numerous. It is a *long-lived* perennial that tolerates a wide range of management regimens and environmental conditions. It can withstand considerable heat and drought stress, which is especially valuable in warmer climate areas where other cool-season perennial grasses fail.

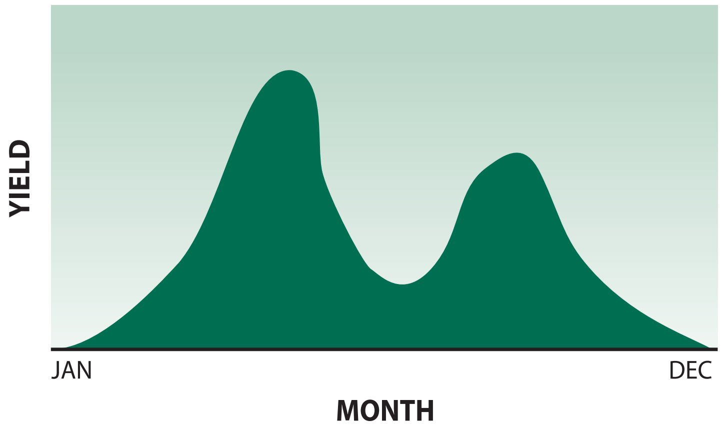
Before Kentucky 31 was released, erosion control was desperately needed on many farms over a large portion of the United States. This included most of what eventually became The Fescue Belt, but tall fescue was adapted in numerous other places, including parts of the Upper Midwest, Northeast, and Pacific Northwest.[102]

Tall fescue is a bunch grass (individual plants grow in bunches or tufts), but it has a vigorous root system, so a thick stand will provide ground cover that protects the soil. However, it is generally easier to grow a legume with it than is the case with true sod-forming warm-season grasses such as bermudagrass and bahiagrass.

The long growing season of tall fescue is especially impressive. Being a cool-season perennial grass, it greens up in late winter or early spring, is highly productive in mid-to-late spring, stays green during summer, and makes a substantial amount of growth in autumn. It comes closer to being a year-round forage grass than any native or introduced forage plant available (**Figure 2**).

In addition, tall fescue is particularly well suited for stockpiling. This term refers to the technique of producing what is essentially "standing hay." If a tall fescue pasture is clipped or grazed closely in late summer, fertilized with nitrogen (and other nutrients if needed), and livestock are excluded, the accumulated autumn forage growth can be grazed when hay or other stored feed would otherwise need to be provided. This technique is most efficient with "strip grazing," in which moveable fence is used to allow animals access to only enough grass for a few days of grazing at a time, thus minimizing forage waste.

Figure 2. Approximate Seasonal Growth Distribution Of Tall Fescue



Stockpiling can be done to some extent with most forage crops, but tall fescue is especially well suited for use of this management technique. This is because leaves and stems of this grass have a waxy coating that resist deterioration from exposure to the elements in late autumn and early winter.

Providing hay or other stored feed when pasture forage is not available is typically the main cost associated with owning grazing animals. Thus, the long growing season of tall fescue, which can be extended by two to three months or more by stockpiling forage, is of great importance. Autumn stockpiled tall fescue forage also offers the advantage of being available for use at the time a producer would otherwise need to begin feeding hay or other stored feed (late autumn and winter).

It became clear to William Johnstone that tall fescue offered just what farmers needed: wide adaptation, easy establishment, dependability, a long growing season, grazing tolerance, suitability for use as either a pasture or hay crop, as well as suitability for stockpiling. Because of these many advantages, it eventually came to be widely referred to as, "The Wonder Grass." This term was widely used in conversations, conferences, and other meetings, seed advertisements, and in farm magazines.

CHAPTER 7

The Fescue War

Between 1938 and 1943, an increasing number of farmers, county agents, and others learned about Suiter's Grass, mainly because of the efforts of William Johnstone. Predictably, the more its attributes were discussed, and as more people observed plantings of it, interest in the grass began to grow.

Eventually, a substantial number of agriculturalists, including scientists on the University of Kentucky faculty, became aware that the release of a new variety of tall fescue was, in all likelihood, imminent. While many were enthusiastic about that prospect, some people were *opposed* to such a release.

It is not unusual for university faculty members to disagree. In fact, discussion and debate in an academic setting is generally viewed as desirable, and in many situations is *encouraged* because it facilitates consideration of all aspects of an issue. Strong and heartfelt arguments were made both in favor of, and in opposition to, release of a tall fescue variety.

However, in this case, the disagreement was eventually viewed as *undesirable*, and the conflict of opinions was not limited to university colleagues. The intensity and length of the period of this discourse was such that it has sometimes been referred to as "The Fescue War."

The dispute apparently began in earnest in 1939 when William Johnstone approached George Roberts, Head of the Department of Agronomy, and explained the potential he felt Suiter's grass had for helping the Kentucky farmers. He told Roberts that he felt there was a need for the university to help "get the grass out" around Kentucky to further evaluate it.

Dr. Roberts agreed, and assigned the task to Johnstone. An argument could be made that a more appropriate choice of persons to do this would have been a man named Ralph Kenney, who was an Agronomy Crops Specialist, as opposed to Johnstone, who was an Agronomy Field Agent. Roberts almost certainly made that decision because Johnstone displayed great enthusiasm for the grass, while Kenney showed little interest in it.[93]

Mr. Johnstone took the assignment seriously. He discussed the grass at many farmer meetings and with agronomy committees in numerous Kentucky counties. Dr. E.N. Fergus later stated, "Johnstone's vision of what the grass would do quickly sold the grass to the farmers of Kentucky. This was particularly true in the western part of the state, where farmers couldn't grow grass well. They had redtop," (another cool-season grass) "but they didn't have anything really to cover the land and prevent erosion, and to last indefinitely - and this did."

Opposition to the grass continued. Interestingly, although the center of the opposition to the grass was within Kentucky, some people in other states were likewise antagonistic regarding use of the grass.[53] There were claims that it was invasive and hard to get rid of once established. In addition, cattle and sheep grazing tall fescue sometimes had lameness or lost portions of their tails. It also was not as palatable as other cool-season grasses.

It was a difficult and politically sensitive issue. Many influential farmers and some seedsmen were firmly in support of the grass. However, some highly respected faculty members and others felt that tall fescue was a detriment to farmers and to the state. It is likely that some seedsmen who produced and/or marketed seed of other grasses were opposed to release of a tall fescue variety because it would constitute business competition.

As will be discussed in the next chapter, arguments against the grass did not prevent release of Kentucky 31, but eventual release of the variety also did not silence the arguments. The "pro-fescue" camp was, of course, headed by William Johnstone, while the "anti-fescue" camp was spearheaded by the aforementioned Ralph Kenney. The animosity, perhaps partially fueled by professional competitiveness and/or personality conflicts, continued throughout the 1940s.

As it happened, Dr. H.L. Donovan, President of the University of Kentucky during this period of time was one of the early users of Kentucky 31 tall fescue. Before becoming President of the University, he had planted it on his farm in Madison County. Thus, he had some personal experience with the attributes of the grass.[50]

The conflict eventually became so acrimonious and publicly visible that in the early 1950s the Dean of the College of Agriculture and the President of the University of Kentucky got involved. Ultimately, the Department Head in Agronomy at this time, Martin Weeks, was required to step down from that position. Ralph Kenny was forced into early retirement. William Johnstone also retired (perhaps with encouragement from the administration) after 29 years of service in Extension. Only then did the Fescue War subside.[93]

By all accounts, Dr. Fergus was a meek and humble man who attempted to maintain harmony in relationships with others. Undoubtedly, he never intended for Kentucky 31 to create a controversy. After he had retired, it was reported that he stated he had tried to stay out of the conflict and had largely been able to do so.[100] However, the controversy regarding the grass may have been partly why it took him so long to release a tall fescue variety.

CHAPTER 8

Variety Status

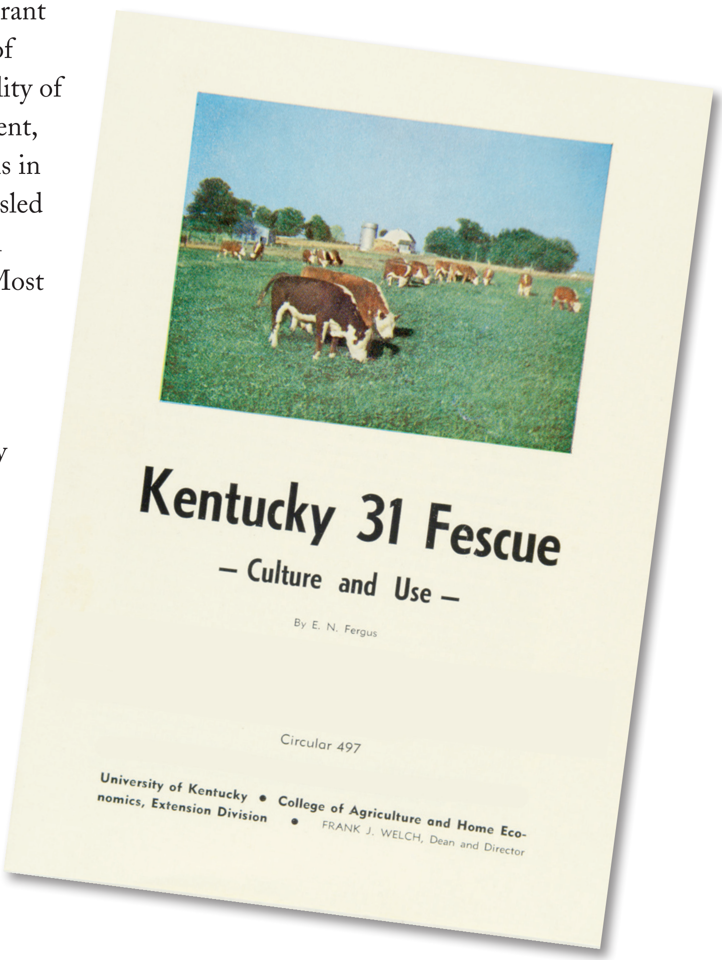
The planting of Suiter's Grass by an increasing number of farmers must have eventually been somewhat of a concern for University of Kentucky personnel as well as for Kentucky seedsmen and forage/livestock enthusiasts. The reason is that when seed (or vegetative material) of an unregistered plant population is being propagated and marketed, farmers cannot be certain they are getting the product they desire. A person selling such seed can claim that it is a particular population or variety, but cannot offer proof.

When a variety is released, it can be entered into a Seed Certification Program. As a result, by virtue of oversight by expert personnel, seed that are genetically consistent with that named variety can be produced and certified. Certification provides a guarantee regarding the genetic makeup of seed sold under a particular varietal name.

Part of the mission of a Land Grant Institution such as the University of Kentucky, as well as the responsibility of states and the US federal government, is to protect farmers from situations in which they could potentially be misled or cheated due to seed having been labeled with an inaccurate name. Most states, and the federal government, have seed laws that are in essence "truth in labeling laws."

Concern about the genetic purity of seed being sold as Suiter's Grass was probably at least part of the reason that, in 1943, Dr. E.N. Fergus released the variety 'Kentucky 31' tall fescue.[32] The "31" stands for 1931, the year Dr. Fergus made that historic trip to Menifee County and obtained seed produced on the William Suiter farm.

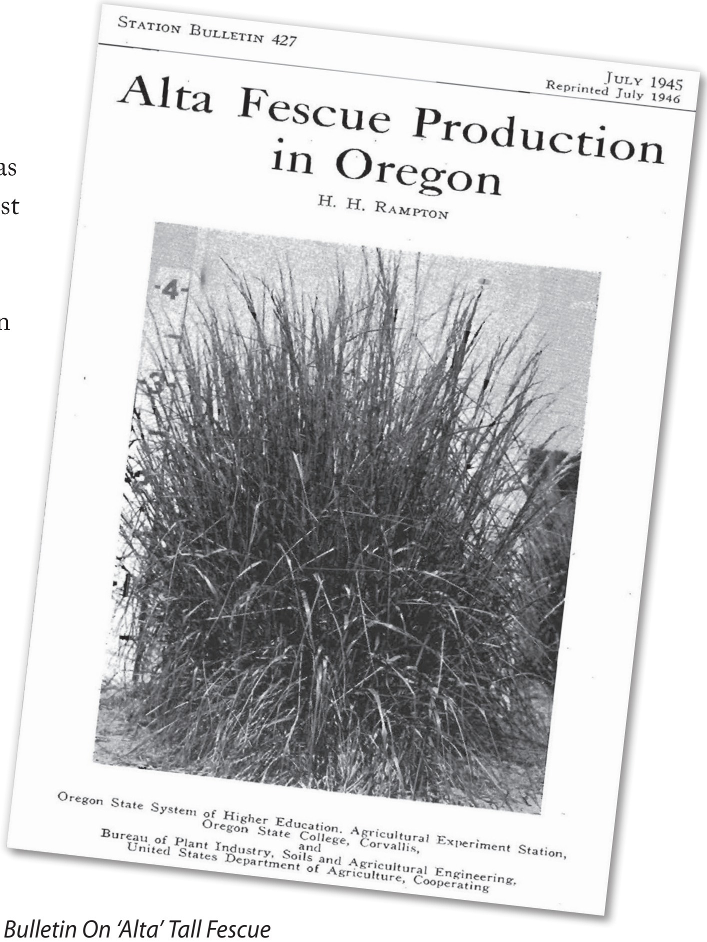
Another tall fescue variety named 'Alta' (meaning tall) was cooperatively developed by the Oregon Agricultural



Kentucky 31 Fescue Circular Published By Dr. E.N. Fergus In 1952

Experiment Station and the USDA, and released in 1945.[22] It was selected for winter hardiness, persistence, and ability to remain green during the dry summers of western Oregon.[22] Alta was widely planted in the Pacific Northwest and in the inter-mountain regions of the western United States, and was marketed to some extent in the eastern United States as well.

Therefore, in the mid-1940s, *two* tall fescue varieties became commercially available to livestock producers in the United States; one having originated in the east and the other in the west. Both were marketed in what has come to be known as The Fescue Belt (the area in which the most tall fescue would be planted), but Kentucky 31 became the variety of choice. Another variety named ‘Goar’ was released in 1946 by Dr. L.G. Goar with the California Crop Improvement Association, but was eclipsed by the other two tall fescue varieties, primarily because of extreme susceptibility to a disease called crown rust.



Bulletin On ‘Alta’ Tall Fescue

Mr. Johnstone’s assessment was, “Alta was a pretty good grass, but showed no superiority to the Kentucky 31 fescue, and in some cases it didn’t seem to resist the adverse conditions that 31 fescue was able to undergo in Kentucky. So we felt that there was some superiority of the 31 strain, and that was borne out by a good many tests in the state.”[50]

E.N. Fergus stated, “Kentucky 31 has occasionally been noticeably more disease resistant than Alta in field plots at Lexington. Kentucky 31 also has produced slightly larger average yields of herbage and withstood close mowing better.” [30] Actually, a number of other factors may have favored domination of Kentucky 31 in the eastern United States, including proximity of farmers in The Fescue Belt to early seed production of this variety, greater promotion, and its extreme hardiness.

PART TWO

REMARKABLE DEVELOPMENTS

CHAPTER 9

Publicity, Promotion, and Transformation

It has often been said that a key to success in marketing is, "Find a need and fill it." When Kentucky 31 was released in 1943, there was a serious need for a well-adapted, productive cool-season perennial grass in Kentucky, as well as in many surrounding states.

There was ever-increasing interest in the grass, but widespread change usually doesn't occur rapidly in agriculture. Farmers tend to be quite independent, and often resist change. Initial reluctance to plant tall fescue was alluded to in an article by W.G. Duncan, III, in which he stated, "One would have thought that Mr. Suiter's neighbors would have followed his example," (by propagating Suiter's Grass after having seen it on the Suiter farm) "but they didn't."[28] Despite increasing interest in the grass, someone needed to champion the new variety Kentucky 31 and convince the public of its value.

William Johnstone, the conservation-minded, widely known, and well-respected University Agronomy Field Agent happily assumed this role. He had promoted the grass even before a variety was released, his department head had designated him to perform this service, and he eagerly complied. He was passionate about Kentucky forage-livestock agriculture, and was a master salesman who promoted the grass with enthusiasm, especially once it attained variety status. Given the many desirable characteristics Kentucky 31 tall fescue exhibited, he had plenty of selling points to use.

He promoted the variety in many ways. But perhaps the most effective approach he took was to encourage farmers around the state to obtain a small quantity of seed (even as little as one pound), plant it, and then evaluate the results on their own farm.

This was a brilliant approach, because farmers learned that tall fescue was easy to establish and widely adapted. In contrast to other forage grasses available at the time, its impressive growth during the cool season, long growing season, and persistence were compelling attributes. Providing enough seed to plant a few acres (or even a small patch) of Kentucky 31 proved to be a highly effective promotional strategy. The success of this approach is consistent with a famous statement made earlier by Seaman Knapp, a Professor of Agriculture at Iowa State Agricultural College: "What a man hears, he may doubt; what he sees he may possibly doubt; but what he does himself, he cannot doubt."

William Johnstone gave much credit to the Soil Conservation Service. This organization was keenly interested in tall fescue because of its ability to stabilize the soil. They established a nursery near Spartanburg, South Carolina, where they produced seed, much of which was used to establish five-acre plantings in various southeastern states during the late 1940s.[50]

A "Kentucky 31 Fescue Association" was organized by about 50 farmers in the vicinity of Hopkinsville, Kentucky in 1947. The purpose of the organization, which was chartered statewide and eventually had over 500 members, was "to tell the story of Kentucky 31 fescue in the most efficient and effective manner." The group was instrumental in placing articles in farm magazines and distributing thousands of article reprints, plus printing and distributing some 100,000 three-color leaflets.[25]

In addition, a famous agricultural newspaper columnist in Atlanta named Channing Cope made an important contribution. In 1949, he published a book titled, "Front Porch Farmer," in which he praised the attributes of Kentucky 31 and highly recommended it.[21] He believed that keeping a cover on the land improved the soil, and he made the case that Kentucky 31 fescue could help accomplish that, even on poor land. A statement he featured was, "It is a wonderful thing to make land live again." The book was widely sold, and no doubt had a substantial influence.

Among many agriculturists, expectations regarding what the grass would mean for Kentucky were high. Campbell Wade, President of the Kentucky 31 Fescue Association, stated in 1949: "Little has been said about the effect Kentucky 31 fescue is having on the general appearance of our beloved Southland. As more and more acres now producing only wild grasses and other scrub growth are properly prepared and seeded to this permanent grass, the more beautiful and more prosperous our part of the world will become. This means that many more tourists will be attracted our way, and tourists do spend money." He also stated that an agronomist (who he failed to identify) recently made the statement, "Kentucky 31 fescue is the greatest discovery since Columbus discovered America."[98]

When William Johnstone was named "Man of the Year" by *Progressive Farmer* magazine in 1949, the editor, W.C. Lassitter said, "Such is the history of Kentucky 31 fescue, the grass the South has been waiting for, the grass it has needed so badly. Such is the contribution of Wm. C. Johnstone, who saw the grass, appraised its value, recognized its merit, felt the need of millions of acres of it, and then fought the battle to make the people who needed it most, accept, and use it."[60]

All the necessary factors came together for Kentucky 31 tall fescue to become highly successful. There had been a great need for a cool-season perennial grass in much of the nation, and thanks to Dr. E.N. Fergus, a tough, persistent variety was released. William Johnstone masterfully took the lead in introducing the variety to Kentucky farmers. The Soil Conservation Service, county agents, Channing Cope, and others provided additional publicity and promotion.

The ultimate result was a transformation, both visually and economically, in a large geographical area within the United States. During the late 1940s, 1950s, and 1960s, millions of acres of Kentucky 31 tall fescue were planted. Subsequently, in many areas, the formerly brown winter landscapes were green during the cool season, the numbers of grazing livestock were greatly expanded, and the incomes on tens of thousands of farms were increased, although some problems with the grass were observed.

CHAPTER 10

Seed Production Thrives In Alabama

As news of Kentucky 31 tall fescue (The Wonder Grass) quickly spread, by the late 1940s it became apparent that there was broad interest in the grass. Some people referred to this as "grass fever." In an effort to favor Kentucky farmers, a law passed by the Kentucky legislature prevented sales of seed to farmers outside of the state. (This law may have further heightened interest in the new variety; people tend to want things to which access is limited.) However, two enterprising brothers who were businessmen and farmers in northern Alabama developed a clever strategy to obtain some seed.

In 1938, brothers Carl and Ed Jones purchased a 2,500-acre farm located just south of Huntsville, Alabama, which at that time was a little known town with fewer than 15,000 residents. Carl and Ed were Colonel and Brigadier General, respectively, in the Alabama National Guard, and served on active duty during World War II. Sarah Elizabeth Jones, Carl Jones's wife, along with help from tenant farm families who lived on the property, ran the farm during the five years her husband and brother-in-law were involved in the war effort. In 1945, the brothers returned to the farm, eager to get on with their lives.

Cotton was the primary crop on the farm, but even with good management, it was difficult to make a profit growing it at that time. They decided to diversify their operation by increasing the number of beef cattle on the farm, which would require establishing good pastures.

Ed Jones heard about the new wonder grass named Kentucky 31, and decided to investigate. He made contact with farmers near Pembroke, a town in western Kentucky, after which both Ed and Carl visited the area. Both were impressed with the fine fields of the grass that existed there.

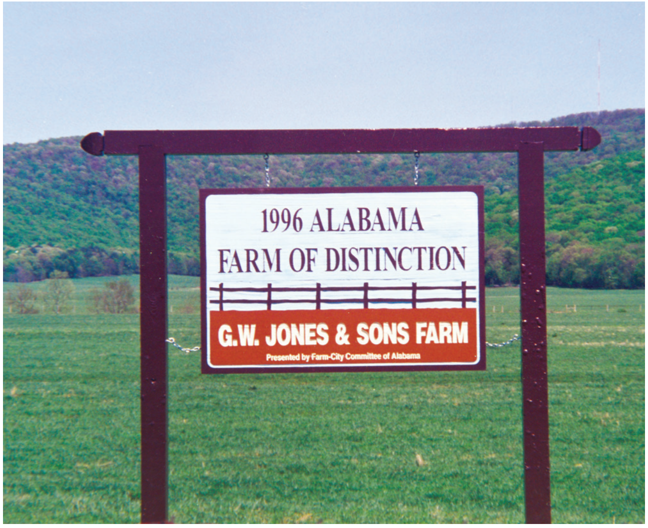
They owned four combines that they used to harvest clover seed, and they knew that with adjustments, they could use this equipment to harvest tall fescue seed. They developed a plan few people would have attempted. They made a deal with some farmers near Pembroke to harvest their tall fescue seed for them if they would allow them to re-thresh the straw after harvest in order to obtain some seed they could keep. The primary challenge associated with this arrangement was that they lived two states away.

Undaunted, in 1948 they assembled a crew of ten farm workers who rode on tractors, combines, and trucks from their farm south of Huntsville to Pembroke, a distance of some 170 miles, which was quite a feat at that time. By re-threshing the straw, they were able to obtain some 2,000 pounds of Kentucky 31 seed without violating the Kentucky seed law that prohibited the selling of seed outside of Kentucky. The farm workers, some of whom had never previously been outside of Madison County, Alabama, reportedly considered the experience a great adventure.[52]

The Jones brothers already had a small seed cleaning facility on their farm that they used for cleaning clover seed. After bringing tall fescue seed back to Alabama in autumn of 1948, they cleaned it and planted about 80 acres, which they used for seed production in subsequent years. The G.W. Jones and Sons Farm owners later increased the size of their beef cattle herd and purchased additional farmland. Eventually they had about 5,000 acres of tall fescue.

Ray Jones, Son Of Carl Jones, In A Kentucky 31 Tall Fescue Pasture Established In Madison County, Alabama In 1948

One of the challenges associated with cleaning the seed was drying it adequately without overheating. Initially, they spread seed on concrete in a thin layer and turned it daily for a week or more. This was necessary because there were no seed dryers at that time, although Carl eventually developed a prototype seed dryer. During the 1950s they built a modern seed cleaning facility to clean tall fescue seed. These developments permitted them to efficiently and economically process substantial quantities of tall fescue seed, and by the mid-1970s they were producing in excess of a million pounds of certified Kentucky 31 tall fescue seed annually.



Sign On G.W. Jones & Sons Farm

At first there was so much interest in Kentucky 31 that selling the seed required little advertising or marketing other than word of mouth. In later years, various seed companies bought large quantities of the seed and marketed it through farm seed outlets. Eventually, G.W. Jones and Sons farm became the world's leading producer of Kentucky 31 tall fescue seed. They were a major supplier of seed of this variety for some forty years.[53]

The farm, now inside the city limits of Huntsville, is probably the largest urban farm in the United States. It is widely known, and has been recognized as an outstanding farm on many occasions. In 1996 it was chosen as Alabama Farm of Distinction, and Ray Jones (son of Carl Jones) was named the Lancaster/Sunbelt Farmer of the year. Many farm groups, school children, and others visit or tour the farm each year.

CHAPTER 11

Puzzling Animal Disorders

Unfortunately, poor animal performance on Kentucky 31 on some farms tarnished the reputation of the new variety.[77] Farmers and sale barn owners sometimes used the term "fescue cattle" in a derogatory manner to refer to animals that were intolerant of heat, failed to shed winter hair coats in early spring, made poor gains, and had calving problems. Horses on tall fescue pastures often had reproductive problems.

It was a puzzle to scientists, as the grass looked good, and there was no evidence of disease on the leaves. Laboratory chemical tests showed the forage contained good levels of protein and digestible energy, thus indicating an unknown "anti-quality" component might be involved.

Over time, scientists found three syndromes associated with tall fescue.[20, 90] **(Note:** The term "*fescue toxicosis*" is an umbrella term commonly used to encompass all tall fescue-related animal disorders.) One syndrome was given the term *bovine fat necrosis.* This condition, caused by the accumulation of fat along the intestinal tract of a cow, results in digestive difficulties and difficult births.[20] This usually occurs where heavy rates of poultry litter are applied to tall fescue pastures. Bovine fat necrosis is observed so rarely that it will not be mentioned again in this publication.

Fescue Toxicity Signs In Cattle Include A Rough Hair Coat And Lack Of Tolerance To Heat

A second syndrome, known as *fescue foot*, was first described in New Zealand.[20, 26] Observed signs in cattle included elevated respiration rate, and a dry, gangrenous condition of body extremities. Usually it caused lameness and/or the loss of the tips of tails or ears, but sometimes resulted in sloughing of hooves or feet. Titles of scientific journal articles are typically subtle, but a 1949 article that discussed fescue foot was downright blunt: Tall fescue grass is poison for cattle.[27]

The third syndrome, *fescue toxicity* or *summer slump*, causes a number of general signs in animals. These include failure to shed the winter hair coat, intolerance to heat, low calf birth weights, poor animal gains, reduced milk production, and low pregnancy rates.[45, 88, 89, 94] These signs are most severe in warm weather.

Fescue foot can be of great economic consequence on some farms. This syndrome is generally associated with cold weather, and thus is most common in northern areas. However, fescue toxicity was (and as of the date of this writing, *is*) of widespread occurrence and of great economic importance for beef cattle producers.

Milk production of dairy cattle is typically greatly reduced when lactating animals consume even relatively small quantities of Kentucky 31 tall fescue. Fescue toxicity can also be a problem with sheep and goats, although goats prefer forbs and browse over grass, and are thus less likely to be affected.

Fescue toxicity can be devastating on a horse farm, but signs in horses are different from cattle. Weight gains of horses can be adversely affected[3], but more importantly, mares consuming tall fescue may have serious reproduction problems. These include abortions, prolonged gestations, difficult births, thick placentas, retained placentas, foal deaths, little or no milk production (agalactia), and sometimes death of mares during foaling.[24] Total annual losses to the horse industry due to fescue toxicity are not known, but in some cases (race horses in particular) the value of a single foal can be tens of thousands of dollars.

In 1993, beef cattle losses in the USA were estimated at well over $600 million annually from reduced calf births and lighter weaning weights.[45] Adjustment to account for higher animal values and other factors led to later loss estimates of $800 million[2] and $1 billion.[56]

By the mid-1950s, millions of acres of tall fescue, primarily Kentucky 31, had been planted on farms in the United States, and a large number of animals were consuming forage of this grass. Despite its many benefits, research was needed to find the cause of the tall fescue toxicosis syndromes.

CHAPTER 12

Pasture Renovation

The worst cases of toxicity often occurred in tall fescue pastures in which there was little or no clover or other companion plants present, and where nitrogen fertilizer had been applied. In contrast, animals on pastures with good legume stands performed well, and fewer toxicity signs were observed. It became clear that the presence of other plant species (including forbs or grasses, but especially clover or other legumes) improved animal performance on tall fescue pastures.

The idea of "pasture renovation," which simply means pasture renewal, was developed. The main focus when renovating tall fescue pastures was primarily the introduction of legumes, usually red and/or white clover. Soil testing followed by application of needed lime, phosphorus, and potassium helped ensure success of planted legume seed. Successful establishment of legumes with tall fescue provided several benefits.

Nitrogen Fixation- A unique and valuable characteristic of most legumes, including clovers, is the ability to obtain nitrogen from the air and 'fix' it in nodules (knots) on legume roots. This process occurs with the help of *Rhizobium* bacteria (specific strains for various legume species) and is symbiotic; i.e. the plant provides food to the bacteria, and the bacteria capture atmospheric nitrogen that can be metabolized into protein, then used by the plant.

Legumes must be infected by inoculating the seed with the proper *Rhizobium* bacterium strain by a process called "inoculation." Early inoculation practices included spreading soil from areas where the legume had previously grown, thus spreading the bacteria. Later, inoculation meant placement at planting time of live, effective strains of the proper bacteria on the surface of legume seed after applying a "sticker" to the seed. Now, most commercially available legume seed is "pre-inoculated" by seed processors just before seed is placed in bags.

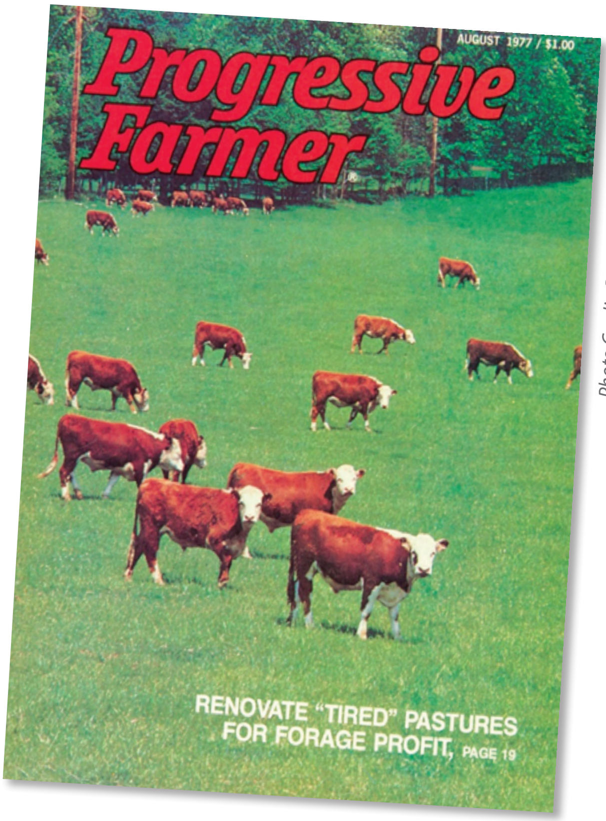


Photo Credit: Progressive Farmer Magazine.

August, 1977 Progressive Farmer Magazine Cover Photo Of Cattle On G.W. Jones and Sons Farm

The amount of nitrogen fixed per year varies depending on a number of factors, but is often in the range of 100 to 150 pounds per acre from a good stand of white clover and 150 to 200 pounds per acre from a good stand of red clover. Initially, most of this nitrogen is used by the legume plant for its own growth, but nitrogen also eventually becomes available to companion grasses or other plants growing with or after legumes. Also, when grazing animals eat legume forage, some of the nitrogen is recycled via deposits of dung and urine.

Nitrogen fixation by legumes is a significant cost reduction benefit as compared to a producer applying a similar amount of nitrogen fertilizer. Furthermore, nitrogen entering surface or ground water via runoff or leaching is less with nitrogen produced from legumes as compared to surface-applied fertilizer.

Improved Nutritive Value - Legume forage, especially from clovers, is generally less fibrous and higher in protein, energy, vitamins, and minerals than forage of grasses and other broadleaf plants. As a result, digestion occurs more rapidly, and animal gains and reproduction are usually improved when legumes make up a substantial portion of a pasture stand; having legumes comprise 25% to 30% of the ground cover is generally considered ideal.

Better Distribution Of Growth - Extending the grazing season minimizes the amount of time animals need to be fed hay or other stored feed. Supplemental feed is expensive, so this should be a major objective in most livestock operations. In many cases, growing clovers or other legumes with a cool-season perennial grass such as tall fescue can help accomplish this objective.

Increased Forage Yield - The total amount of forage produced in a pasture is often greater in a legume/grass mixture than is the case in a pasture containing only grass. This is especially true when grass alone receives little or no nitrogen fertilizer. For example, in a three-year study done at the University of Kentucky, a red clover/tall fescue mixture produced more forage dry matter than tall fescue fertilized with 180 pounds of nitrogen per acre.

Reduced Tall Fescue Disorders - In addition to these attributes, the benefit generally considered most important was that the occurrence of the "puzzling animal disorders" (fescue toxicosis) discussed in Chapter 11 were greatly reduced or eliminated when pasture renovation included introduction of legumes. As a result, pasture renovation came to be a widely recommended practice.

Photo Credit: Steve Thompson

Warren C. Thompson

Numerous Extension personnel disseminated information about renovation of tall fescue to include legumes. This included numerous state Extension Forage Crop Specialists, two of whom deserve special mention.

Warren Thompson, originally a county agent and later state Extension Forage Crop Agronomist in Kentucky (and whose major professor as a Masters degree student was E.N. Fergus), developed an outstanding promotional program pertaining to planting clover in tall fescue pastures. The results were spectacular, with greatly increased livestock performance and few or no fescue toxicity problems in these pastures as long as there was a substantial presence of clover. Tennessee Extension Forage Specialist Joe Burns also had a strong extension program promoting planting clover in tall fescue pastures, with similar positive results.

Like Warren Thompson, Joe Burns tirelessly promoted the planting of clover into tall fescue. He also often used the phrase, "Two, Four, Eight, Let's Renovate." This referred to planting of two pounds of white clover, four pounds of red clover, and eight pounds of annual lespedeza per acre, which he believed was a good mixture to use when renovating tall fescue pastures in Tennessee. Different seeding rates and even different legumes were used in other areas.

Photo Credit: Ben Burns

Joe D. Burns

Research in numerous states documented the value of growing clover or other legumes with tall fescue. In a northern Alabama grazing experiment, daily gain of beef steers was increased 50% when white clover or birdsfoot trefoil was planted in Kentucky 31 tall fescue.[48] In another study in Arkansas, planting red clover in Kentucky 31 tall fescue likewise significantly increased steer gains.[68] Not all studies showed such spectacular animal performance benefits from growing clover with tall fescue, but the benefits of the practice were nonetheless widely recognized.

Thus, even before the reasons for improved animal performance were known, on-farm experience as well as university research showed that growing legumes with tall fescue was an excellent practice. But additional ways to minimize or eliminate animal disorders and improve performance on tall fescue were needed, especially in areas where clovers were not dependable.

CHAPTER 13

Frustrating Research Efforts

The widespread and costly animal disorders associated with tall fescue resulted in significant funding for research. Many scientists worked to find the cause of (and solution to) these serious problems, especially fescue toxicity. Faculty at several universities, as well as USDA Agricultural Research Service scientists, were involved in these efforts.

J.K. Underwood and colleagues at the University of Tennessee noted with great insight that the animal signs associated with fescue toxicity were similar to ergotism. This malady is caused by a fungus (*Claviceps purpurea*) that often affects the seedheads of some grasses, notably small grains such as wheat, oats, barley, and rye. When this happens, the fungus produces structures that contain ergopeptine alkaloids that are toxic to animals. However, they eliminated this as a focus for additional research because there was no visible ergot on tall fescue seed heads.

It seems surprising that there was not more follow up on this clue, as it might have revealed the cause of the problem. Perhaps the reason it was not pursued is that there was reportedly some evidence of pressure having been put on scientists to not work on this because such unfavorable news might hinder sales of tall fescue seed grown by some influential Tennessee producers.

Instead, research was mainly concentrated on external plant fungi, plant alkaloids (there are many types of these nitrogen-containing compounds produced within plants), toxins produced in the rumen, and anions.[20] The USDA Northern Utilization Laboratory in Illinois devoted large sums of money over many years to finding a harmful chemical in tall fescue that was responsible for the toxicity.

Finally, it was suspected that an alkaloid named perloline might be the cause of the problems, which led to development of low-perloline lines of tall fescue in a breeding program in Kentucky. Perloline proved to be effective in deterring feeding by insects, and so it seemed logical that it might also be detrimental to grazing animals.

However, perloline was eventually effectively and dramatically dismissed as a main cause of fescue toxicity by a research report from J.B. Powell and J. Bond at the annual meeting of the Southern Pasture and Forage Crop Improvement Conference in Beltsville, MD in 1979. They had conducted a three-year grazing study that included Kentucky 31, Kenhy, a low perloline experimental designated “K-307,” and a high perloline line, K-306.

In their report they stated, “By measuring animal performance and observing animal behavior, it became apparent that the low perloline line gave a very different animal response than the other lines. The animals gained less, they stood in the shade approximately 40% more, laid in water 35% more, stood in the field 12% less, and grazed 36% less. In addition, they showed signs of emaciation, rough hair coat, elevated respiration, and excessive salivation." [76]

In other words, lowering perloline levels not only did not *reduce* fescue animal disorders, it actually *increased* them! This result is consistent with a profound quote by Thomas Huxley: "Many a beautiful theory has been destroyed by an ugly fact!"

It was even proposed that the toxic agent might not be *inside* tall fescue plants. Perhaps it was produced within the rumens of animals, due to stimulation by some unknown factor or factors.[20] However, no one was able to provide any evidence that this was the case.

Despite the substantial funding and efforts devoted to attempting to understand the animal disorders associated with tall fescue, for a long while it seemed that the grass was reluctant to divulge its secrets. However, after years of research that failed to reveal the cause of the animal problems associated with tall fescue, a ray of hope appeared due to efforts of USDA scientists in Georgia.

Beef Cattle Grazing A White Clover/Tall Fescue Mixture In Central Georgia

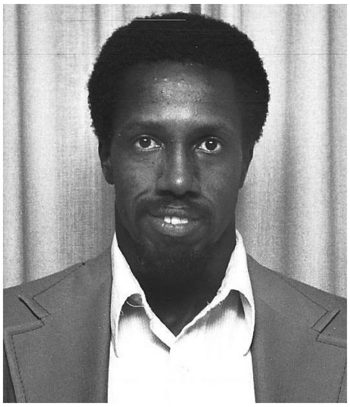
CHAPTER 14

A Suspect Is Identified

Many scientists found it puzzling that occasionally a field of clover-free tall fescue was discovered on which no animal disorders were observed, and on which animal performance was exceptional. For a long while, no one had an explanation for this. Finally, three scientists at the USDA Agricultural Research Service (ARS) at the Russell Research Center in Athens, Georgia made a breakthrough. They were C.W. Bacon (a plant pathologist/mycologist), J.K. Porter (a natural product chemist), and J.D. Robbins (an animal toxicologist).

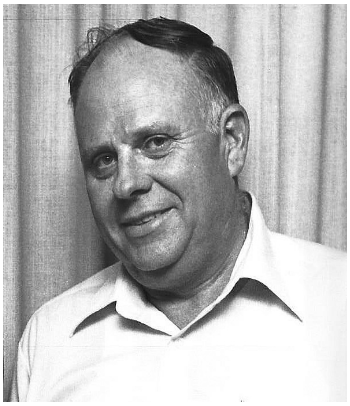
The three-scientist research group of which Joe Robbins was Lead Scientist and Bacon and Porter were members was one component of the research effort at the Athens ARS location. As an animal toxicologist, Robbins was interested in the fescue toxicity problem. Consequently, he brought it to the attention of the ARS National Program Staff in Beltsville, Maryland and also to the ARS Area Administrator, Dr. Bob Barnes, who was located in New Orleans. As a result, permission was given to conduct research on the problem.

Robbins contacted Dr. Bill Flatt, the Director of the University of Georgia Experiment Station, to seek assistance of University of Georgia (UGA) veterinarians. He was especially interested in finding a farm location that might shed some light on the situation. Soon thereafter, a veterinary student who was a grandson of a cattleman named A.E. Hays revealed that on his grandfather's farm some animals were exhibiting signs of fescue toxicity, while other animals on the same farm were not, depending on which pastures they were grazing.



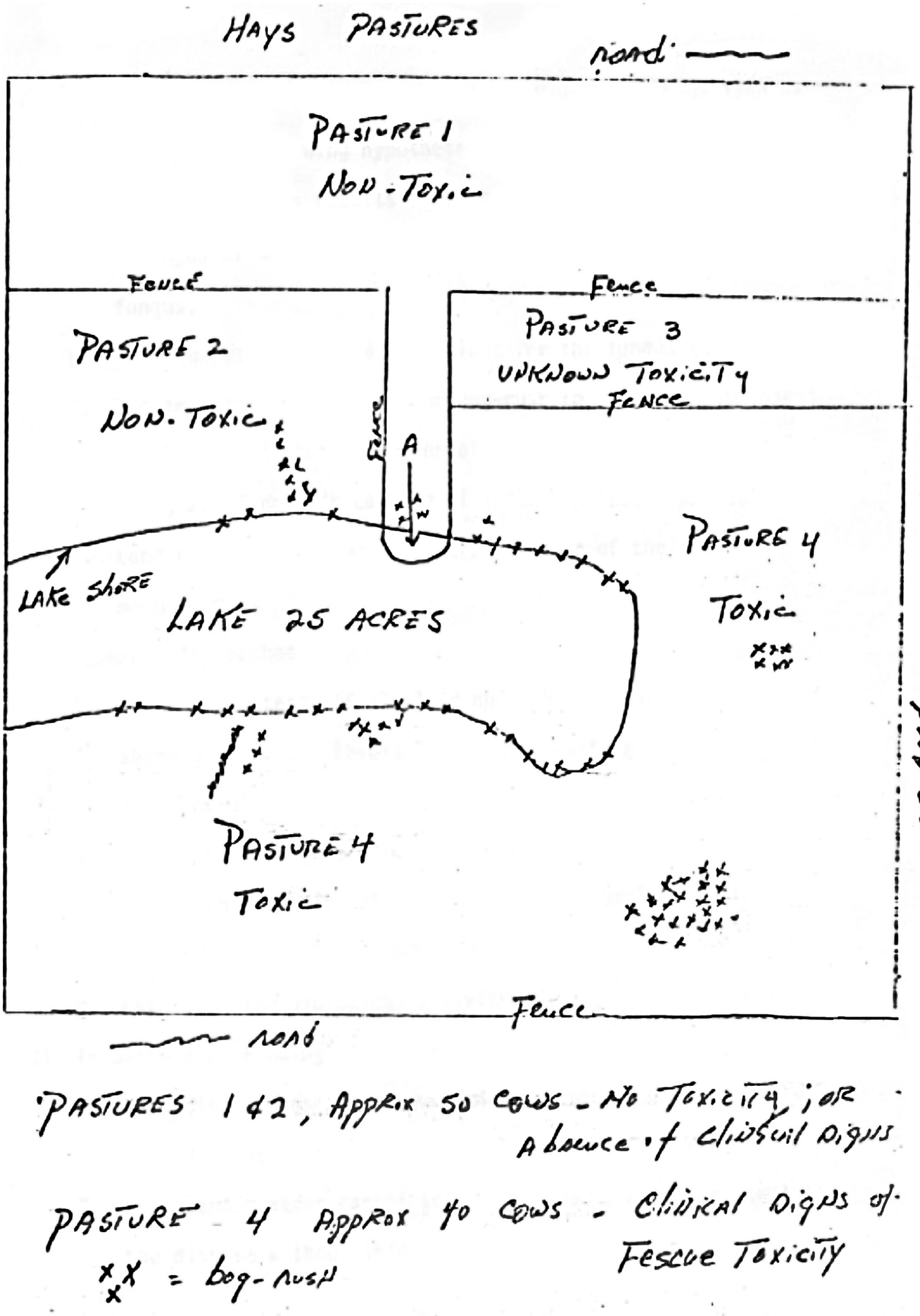
C.W. Bacon

On June 5, 1973, Robbins (accompanied by Mr. Hays' grandson) visited the A.E. Hays farm near the town of Mansfield in north central Georgia, about a one-hour drive southwest of Athens. On that farm, he observed severe fescue toxicity symptoms of beef cattle grazing in two tall fescue pastures, but none in adjacent pastures on the same farm.[80]



J.D. Robbins

Robbins had become convinced that fescue toxicity involved a fungus, because of symptoms being similar to those from ergot toxicity. His thinking regarding this had been influenced by conversations with Bacon, who knew that ergot could be caused by fungi other than *Claviceps*. He reported his exciting finding on the Hays farm to



Sketch of the A.E. Hays Farm Layout Made By J.D. Robbins In 1973 his laboratory chief in the Russell Research Center, and requested permission to return to the farm and sample the pastures to allow close scientific scrutiny of the forage from the pastures.

The attitude of the federal bureaucracy toward innovation (in this case) adds an interesting touch to this story. Amazingly, Robbins was denied permission to travel at ARS expense, and was told to hold off on this effort as it apparently was not considered a worthwhile pursuit.* However, the next day he departed in his own vehicle without official leave, and sampled the pastures on the Hays farm.

J.K. Porter

When C.W. Bacon microscopically examined plant tissue samples from pastures in which cattle showed toxicity symptoms, he found 100% of them were infected with a fungal endophyte. The term arises from "endo" (inside) and "phyte" (plant). The fungus lives inside of fescue plants and is not visible on the exterior of plants. Pastures where cattle were in good condition had a much lower infection rate. This strongly implicated the fungal endophyte as the probable cause of fescue toxicity.

The fungus was initially identified as *Epichloe* typhina,[69] but subsequently had a series of important taxonomic name changes. As a result, various scientific papers referred to the fungus by different scientific names. It was initially popularized as *Acremonium coenophialum,* but as of this writing, the name is *Epichloe coenophiala*.[64]

In reviewing the literature, Bacon learned that much earlier research in New Zealand had revealed that presence of an endophyte in tall fescue and one in perennial ryegrass might produce a toxic compound.[70] An even earlier report from Wales[87] showed that the endophyte depended on seed transmission for dispersal.

J.K. Porter conducted toxicological studies that were of great importance. He isolated and identified ergot alkaloids produced by the isolated tall fescue fungus cultured in media that had the potential to be toxic with regard to their impact on livestock.[6,7,75] Ultimately, the isolation and occurrence of ergot toxins from tall fescue was documented in the scientific literature.[65]

The work done by Bacon, Porter, and Robbins proved to be truly historic. Tall fescue had been commercially available for 30 years and had been planted on millions of acres in the USA, so discovery of a fungus growing inside most tall fescue plants was amazing. Association of presence of the fungus with fescue toxicosis was stunning.

**Correspondence from J.A. Robertson to D. Burdick with copy to J.D. Robbins, 1973.*

CHAPTER 15

Scientific Proof

The apparent association of an endophyte with fescue toxicity on the Hays farm in Georgia was fascinating, but did not constitute scientific proof. As viewed by scientists, it was circumstantial evidence. A controlled, replicated grazing experiment would be required to provide confirmation.

Information regarding the observations on the Hays farm in Georgia came to the notice of scientists at Auburn University. A grazing experiment involving Kentucky 31 tall fescue was initiated by Auburn University Professor Carl Hoveland and co-workers. The experiment was on the Black Belt Substation in central Alabama, which was under the direction of the Station Superintendent, Aubrey Smith. It was not long before steers on some of the tall fescue paddocks were performing much differently than steers on other paddocks.

Superintendent Aubrey Smith

Some animals showed typical fescue toxicity signs: elevated body temperature, rough hair coats that did not shed in spring, excessive salivation, nervousness, and they rarely grazed during the heat of the day. In contrast, steers on other paddocks were in excellent condition. They had slick hair coats, were tolerant of heat, grazed during the day, and did not exhibit nervousness.

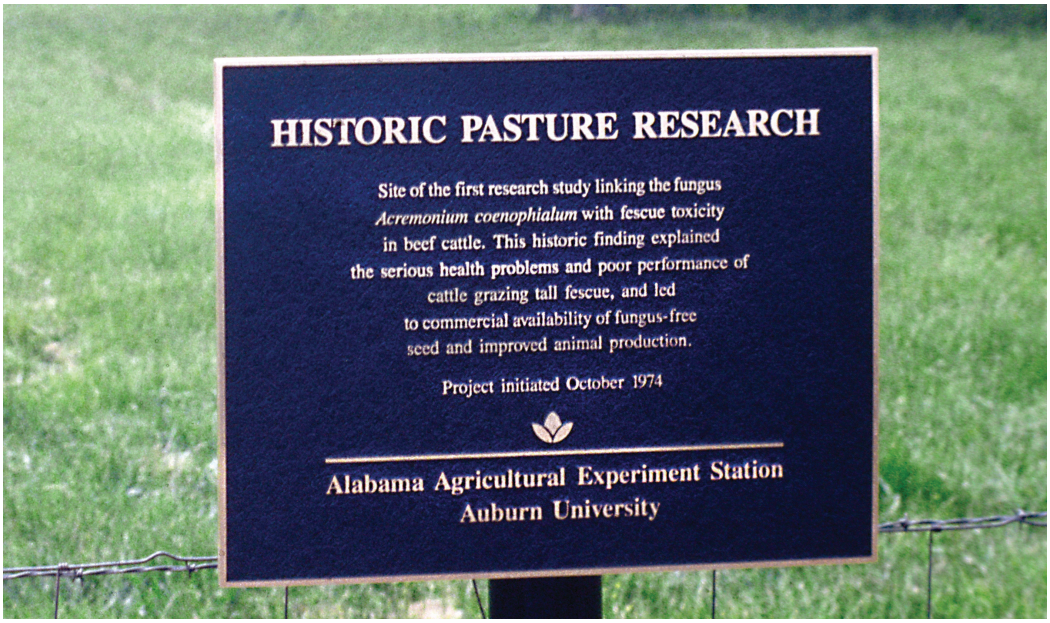
Carl Hoveland By Historic Paddocks

Hoveland and Smith were initially puzzled as to why animals reacted differently on the different paddocks in these studies. When endophyte levels in tall fescue plants in the various paddocks were determined, the infection level was low (about 5% of the plants) in paddocks on which animals were doing well, and high (about 94% of the plants) in paddocks on which fescue toxicity symptoms were evident. Steers on heavily-infected tall fescue displayed typical fescue toxicity signs. While this strongly implicated the endophyte, Mr. Smith didn't understand why the infection level would be different in various paddocks.

After years of widespread research efforts that had turned out to be fruitless, scientists were elated to finally know for certain the cause of the tall fescue toxicosis problem. Contributions by countless people had led to this momentous point in the history of tall fescue in the United States. It was widely recognized that a milestone had been reached. Auburn University administrators hosted an event at the site of the historic paddocks on the Black Belt Substation where they dedicated an Historic Pasture Research sign.

But in reviewing his records he discovered a clue. He found that while all of the tall fescue seed used was of the variety Kentucky 31, the paddocks on which animals were doing well had been established using seed held over from the previous year. New crop seed had been used to plant paddocks on which animals were doing poorly. Why this made a difference would later become clear.

Steer average daily gains were 66% greater, and gain per acre 28% higher, on paddocks where the steers exhibited no fescue toxicity symptoms. This was a *spectacular* difference in performance! Furthermore, these data from three replications had been collected over a three-year period. This study provided scientific confirmation that the fungal endophyte was associated with fescue toxicity.[49] *The cause of the problem had been verified!*



Historic Pasture Research Sign At The Black Belt Substation

CHAPTER 16

Endophyte Traits

Once there was proof that the endophyte in tall fescue was responsible for the disorders often observed in animals consuming forage of the grass, the implications for potentially improving animal performance on a broad basis were apparent and astounding. There were *millions* of acres of tall fescue pasture in the United States. It was astonishing to realize that a grass that had been in use on a widespread basis for decades, and that was already quite useful in livestock production, had the potential to be far *more* valuable. This realization raised numerous important questions related to science, economics, and agricultural practice.[12]

Scientists were eager to learn as much about the fungus as possible, and many important findings quickly ensued. It was determined that the fungus produces toxins, so the terms "toxic-endophyte" and "endophyte toxins" began to come into use. Despite having adverse effects on animals, the fungus appeared to have no negative effects on tall fescue plants.

A particularly important and unusual characteristic of the endophyte was soon determined. Most fungi reproduce via spores (termed "perfect" reproduction by scientists). However, the tall fescue endophyte *does not* produce spores, and therefore exhibits "imperfect" reproduction. There is no sexual reproduction.

The endophyte spreads exclusively via seed. It does not move in the air; it is not harbored in the soil; a plant does not become infected from touching another plant, even if their leaves and/or root systems are intertwined. In nature, the endophyte status of a plant depends *solely* on whether or not viable endophyte was present in the seed from which the plant arose.

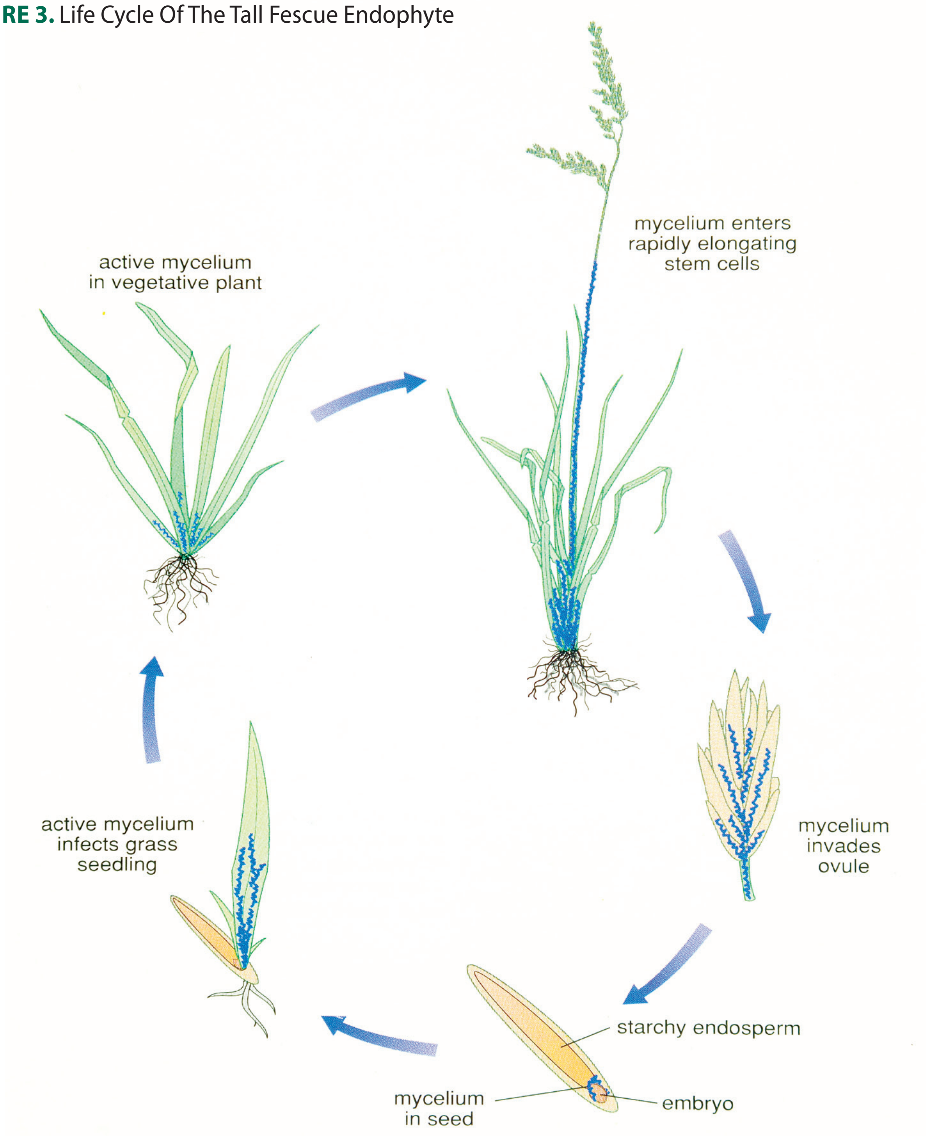
A question that often arises is, "Why is it that this fungus is only transmitted by seed?" Geneticists have shown that the tall fescue endophyte is a hybrid of three closely related fungal species. Inter-species hybridization (crossing of species) is rare in nature, but when it happens, normal reproduction of offspring is generally not possible. This is one of the reasons why the tall fescue endophyte can only be transmitted via seed.

The life cycle is relatively simple.[8, 12, 101] Endophyte presence in a seed results in an infected seedling. The fungus is present in plant crowns, then grows in intercellular spaces within the plant and eventually into seed heads and seed (**Figure 3**), but is not present in leaf blades. Unlike other fungi that produce spores outside a plant and are visible, fungal endophytes are not visible other than with microscopic examination.

Furthermore, the endophyte status of a given plant will not change throughout its life. Seed produced by a tall fescue plant that does not contain an endophyte will always be endophyte-free. A plant that contains an endophyte will remain infected throughout its life, and will produce endophyte-infected seed.

The tall fescue endophyte is surprisingly fragile. Recently harvested endophyte-infected seed will contain viable endophyte fungus that, if promptly planted, will result in endophyte-

FIGURE 3. Life Cycle Of The Tall Fescue Endophyte



Credit: American Scientist[12]

infected plants. However, when seed are stored, the endophyte will eventually die, (although low temperature and low humidity delay this result). After about a year of unrefrigerated storage, the endophyte level in seed will usually decline to near zero.

This knowledge provided an explanation as to why the majority of Kentucky 31 fields produced fescue toxicity symptoms in cattle, but a few did not. During the early years of commercial availability of tall fescue seed, there was a mad rush to obtain and plant it. Most seed was planted within a few months of having been harvested, with the endophyte remaining intact. However, when tall fescue seed was stored for a year or more, most or all of the endophyte in the seed died, resulting in a pasture or hay field in which the endophyte infection was low or zero, as was the case with the experiment at the Black Belt Substation discussed in chapter 15.

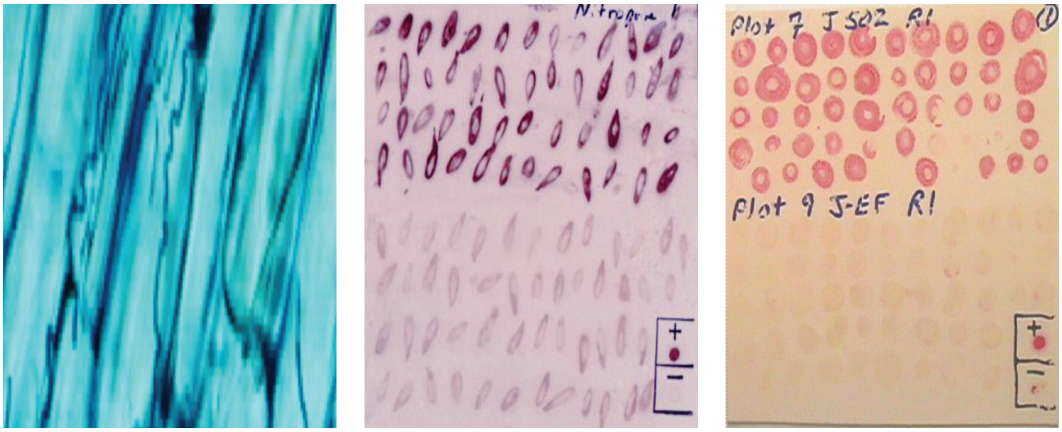


Photo Credit: Nick Hill

Left: Microscopic Image Of Endophyte (Dark Lines) In A Leaf Sheath; Center: Immunoblots Revealing Presence Of Endophytes In Seed (Dark Purple Outlines); Right: Immunoblots Revealing Presence Of Endophytes In Stem Cross Sections (Pink Circles).

It is amazing that the tall fescue endophyte escaped detection for several decades during which the grass was planted on a widespread basis, despite much research effort and a considerable amount of funds having been devoted to trying to understand the cause of associated animal disorders. This occurred because, unlike most fungi, endophyte presence cannot be detected by simply looking at the external portions of a plant.

A number of laboratories, mainly at Land Grant Universities, soon began offering a service to forage producers, university scientists, agency workers, and seedsmen, of determining the level of endophyte infection in tall fescue. This could be accomplished by microscopically examining either seed or pieces of tillers collected from the bases of tall fescue plants, but was a tedious and slow process.

This diagnostic approach was helpful, but the ability to microscopically detect the fungus was initially variable among laboratories, and required extensive training to differentiate the endophyte from other fungi found in plants. Fortunately, an immunological method was eventually developed by Dr. N.S. Hill at the University of Georgia, and was commercialized by a company in Georgia named Agronostics, Ltd.[42,43] This approach proved to be quicker, easier, and more reliable. It also provided the benefit of having a permanent visual record of the results.

Surveys of tall fescue pastures confirmed that most fields of tall fescue were highly infected (had a high percentage of tall fescue plants that contained the endophyte). Typically, at least 70% (and often a much higher percentage) of tall fescue plants in a given field of Kentucky 31 tall fescue contained the endophyte.[57,92]

Ready availability of testing of tall fescue for endophyte presence further solidly confirmed the magnitude of the opportunity that existed. It was clear that there was great potential for increasing animal performance on the millions of acres of tall fescue present on thousands of farms in the United States. The way to achieve this result would be to reduce or eliminate the amount of endophyte toxin-containing forage in animal diets. It was an exciting prospect!

CHAPTER 17

Another Fescue Furor

Improvements in agricultural production that result from agricultural research typically come in small increments. Often the value of a variety, practice, or product cannot be clearly and dependably observed on farms, but rather must be measured and documented in carefully conducted research efforts.

However, in this situation, the appearance and behavior of animals grazing tall fescue infected with the toxic-endophyte typically differed *substantially* from animals grazing endophyte-free fescue. Weight gains and reproductive performance of animals grazing on such pastures were often strikingly different as well.

Livestock producers were interested in the prospect of growing a type of tall fescue that would result in stunningly better animal performance than they had been accustomed to obtaining with Kentucky 31. Seed companies and seed dealers saw potential for greatly increased sales of tall fescue seed.

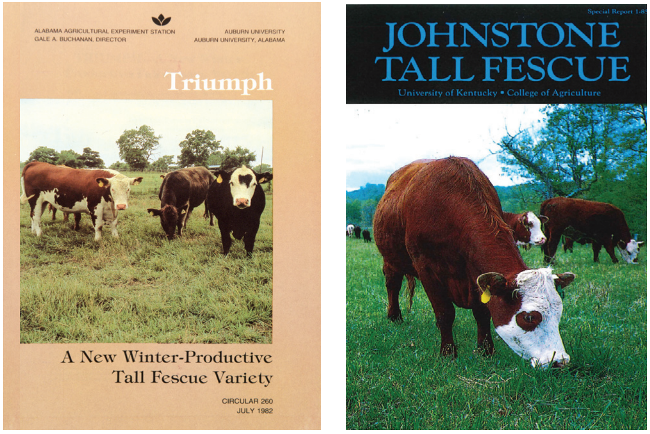
By the time the endophyte in tall fescue had been identified as the causal agent in several animal disorders, there were many millions of acres of the grass in the United States. The ideal solution would have been to find a way to kill the fungus within the grass without killing the grass. Unfortunately, while fungicide application to tall fescue pastures temporarily suppressed the endophyte, this approach did not prove to be a feasible strategy for livestock producers seeking to lessen the economic impact of the endophyte.[104, 105]

However, because the endophyte is transmitted only through seed, there was a straightforward solution. If seed could be provided that did not contain the endophyte, new endophyte-free seed fields, and subsequently non-toxic pastures, could be established. Thus, existing toxic-endophyte-infected pastures could be terminated, followed by replanting with endophyte-free seed.

Removal of the endophyte from tall fescue seed proved to be a simple matter. The endophyte could be killed by moderately heating seed or by treatment of seed with application of certain fungicides or other chemical compounds. As long as the treatment was not harsh enough to have a seriously negative effect on seed germination, endophyte-free plants could be established from treated seed.

Another way to obtain endophyte-free seed was to store it long enough that the endophyte died. This led to many producers “aging” Kentucky 31 seed for a year. However, scientists did not recommend this practice, because germination of holdover seed declined substantially. In addition, sometimes the endophyte infection would not drop to zero, so a newly-planted pasture established by using the seed would not be totally endophyte-free. Also, seedlings established from stored seed are likely to be less vigorous than plants from new crop seed.

In 1982, Auburn University released a tall fescue variety named AU Triumph[47, 73] and in 1983 the University of Kentucky released a variety named Johnstone.[17] Care was taken to ensure these varieties were endophyte-free, and other endophyte-free varieties became commercially available soon thereafter. Expectations were high.



Brochures Describing Two Early Endophyte-Free Varieties

University scientists, Extension personnel, agricultural media workers, and others gave much exposure to the amazing revelation regarding the tall fescue endophyte. Consequently, many livestock producers bought and planted endophyte-free seed in eager anticipation of experiencing the greatly improved animal performance that university tests indicated was possible.

A few years later, many farmers, especially in the southernmost portions of The Fescue Belt, reported that their endophyte-free fescue stands had declined. In some cases, this may have been associated with poor management, but the number of complaints was high, and increased in subsequent years. A grazing experiment in Texas provided scientific proof that there was a problem with persistence of endophyte-free tall fescue.[78]

Lessons learned during the early years of availability of endophyte-free tall fescue seed included the following:

- A toxic-endophyte-infected tall fescue stand should not be allowed to produce seed during the year endophyte-free seed will be replanted. The reason is that recently produced

A Thinning Stand Of Endophyte-Free Tall Fescue

Photo Credit: Joe Bouton

Endophyte Infection Favors Persistence. Both Plots Are The Variety 'Jesup,' But The Grass On The Left Is Infected And The Grass On The Right Is Endophyte-Free.

seed present in the field probably contain viable endophyte, and may result in volunteer toxic-endophyte-infected plants.

• Prior to planting endophyte-free seed, one must make certain to *kill* toxic-endophyte tall fescue plants present in the field. Tillage alone is not effective. One or two applications of a non-selective herbicide is/are typically needed. Planting a "smother crop" (an annual such as pearl millet) between herbicide applications helps ensure that toxic-endophyte-infected fescue plants have been killed.

• In the lower South, endophyte-free fescue often does not persist well due to harsher climatic conditions as compared to areas farther north.

• It is easier to overgraze endophyte-free fescue than toxic-endophyte-infected fescue. Animals like it better, and their grazing behavior is not affected by toxic alkaloids. Thus, they are more inclined to graze it closely. Because they graze it more readily, they eat a larger amount of forage. Therefore, the stocking rate on an endophyte-free pasture needs to be lower than on a toxic-endophyte-infected pasture, and a higher level of grazing management is required in order to prevent overgrazing.

Livestock producers faced a quandary. Research had established that endophyte-free tall fescue offered potential for much better animal performance. However, it was less stress tolerant and persistent, and required different management than endophyte-infected tall fescue.[57] In the lower South, the planting of endophyte-free tall fescue varieties mostly proved to be disappointing, and did not result in the widespread benefit that had generally been expected. This was because the research focus to this point had been on endophyte effects on animals, not on endophyte effects on tall fescue plants, which eventually proved to be numerous and consequential.

CHAPTER 18

Endophyte Effects On Tall Fescue Plants

Research by scientists at various locations revealed that while the endophyte has negative effects on grazing animals, it provides significant *benefits* to tall fescue plants. This is due to a mutually beneficial relationship that exists between the endophyte and the host plant.[8, 92]

These include increased drought tolerance, [14, 79, 103] partially a result of deeper root development. It was also learned that endophytes increase plant tillering and water use efficiency,[66] improve utilization of soil nitrogen,[5] and resistance to certain insects and nematodes.[62] Collectively, in endophyte-free tall fescue plants these factors can result in what is sometimes referred to as "accumulated stress," and have a negative effect on persistence.[82] Also, endophyte toxins cause tall fescue forage to be somewhat less palatable, which, from an evolutionary standpoint, provides some protection to tall fescue plants from grazing animals.

The endophyte obtains nutrients from tall fescue plants, as well as a mechanism for reproduction. Thus, while the plant receives benefits from the endophyte, the endophyte also receives benefits from the plant. Scientists refer to such a relationship between organisms as symbiotic or mutualistic.

Turf production is not the focus of this publication, but tall fescue is widely used on golf courses, lawns, and many other sites to which grazing animals do not have access. Once it had been recognized that the endophyte conferred pest resistance and drought tolerance to tall fescue, it became of much interest to people who work with turf tall fescue.[36] From their perspective, having an endophyte in tall fescue is a benefit.

In nature as well as in on-farm situations, a seemingly minor disadvantage can often be important with regard to plant productivity and survival. A good example is when a producer attempts to establish a totally endophyte-free pasture, but ends up having some endophyte-infected plants in the stand. This could occur if some endophyte-infected seed were present in what was supposed to be endophyte-free seed, from viable endophyte-infected seed being present in the field at planting time, or from infected plants that were not killed during preparation for planting.

As compared to endophyte-free tall fescue plants, endophyte-infected plants are more competitive, tend to make more seed, and seedlings are more vigorous and likely to survive under adverse conditions. Consequently, if a pasture contains a mixture of infected and non-infected plants, infected plants may eventually dominate. This is especially likely to occur in stressful situations such as drought, extreme heat, and/or overgrazing.

In fields planted to endophyte-free fescue, it sometimes appeared that the plants became infected over time. Actually, since the endophyte does not move from plant to plant, this was not the case. It was a matter of endophyte-free plants being outcompeted and replaced by endophyte-infected plants. Endophyte-free plants do not become infected with the endophyte.

Dominance and persistence of endophyte-infected versus non-infected tall fescue plants is strongly influenced by climatic conditions. In the upper portion of The Fescue Belt, the Pacific Northwest, and other parts of the world with a mild climate, endophyte-free fescue persists well because of less environmental stress.

However, the farther south it is planted in The Fescue Belt (with greater likelihood of prolonged periods of severe heat and/or drought), and the greater extent to which overgrazing is allowed to occur, the less likely it is that endophyte-free tall fescue will persist. The situation is confounded by some endophyte-free varieties being significantly more stress tolerant and persistent than others.

CHAPTER 19

A Novel Solution

Taxonomically, tall fescue is closely related to perennial ryegrass, which is the single most important forage grass in New Zealand. In a 1981 paper, L.R. Fletcher and co-workers reported that perennial ryegrass infected with a fungal endophyte caused a toxicity syndrome in sheep called ryegrass staggers.[33] This was similar to the tall fescue endophyte situation in the United States.

Both tall fescue and perennial ryegrass are widely grown and of immense importance in world pastoral agriculture. Because of their impact economically, ecologically, and on animal health, the realization that fungal endophytes are responsible for animal disorders spurred a great deal of research and farmer educational outreach programs into all facets of grass-endophyte interaction.

Two highly important findings soon proved to be quite consequential. In 1985, G.C.M. Latch and M.J. Christensen, fungal mycologists at the Department of Scientific and Industrial Research Plant Protection (later named AgResearch) in New Zealand, reported that endophyte metabolism varies greatly, and various endophyte strains have different effects on perennial ryegrass host plants.[61] Another advancement of critical importance was their development of laboratory techniques that allowed insertion of various endophyte strains into perennial ryegrass plants.[63]

In 1988, C.W. Bacon (USDA Agricultural Research Service in Athens, Georgia) and M.R. Siegel (University of Kentucky)) proposed that some fungal endophyte strains might potentially produce beneficial influences on tall fescue plants without causing animal toxicities.[8] If such an endophyte strain could be

Novel Endophyte Tall Fescue - The word "novel" is often used as a synonym for the word "new." However, in this case it is a synonym for "unique." It refers to a situation in which a specific endophyte (i.e. a desired endophyte strain) has been inserted into a grass.

In many ways, non-toxic-endophytes would mimic biotech traits that are so important to row crops, such as plant resistance to a certain herbicide or resistance to a particular insect. Like biotech traits, novel endophyte tall fescues would be "engineered" (i.e. a specific strain of non-toxic-endophyte inserted into the plant and, once there, confer desirable traits and outcomes).

However, a crucial difference from biotech traits is that in this scenario the endophyte is naturally-occurring, involving no genetic manipulation by humans. This fact would eliminate the need to place them under the regulatory authorities. This would be no small matter for their eventual deployment into the commercial seed market.

identified and then inserted into endophyte-free tall fescue, it could result in a superior forage grass that caused no toxicity problems. The concept of identifying such an endophyte strain that could be used with tall fescue captivated the imaginations of many scientists. The term “novel endophyte tall fescue” began to be used to refer to such a situation.

The stage was set for another remarkable development that had the potential of radically changing the status of tall fescue in the United States. First, the cause of fescue toxicosis (i.e., tall fescue-related animal disorders) had been identified; namely, a toxic-endophyte strain or strains that produce(s) powerful toxins. Second, other tall fescue endophyte strains had been identified that *did not* produce the toxins. Third, it was known that it was possible for a non-toxic-endophyte strain to be inserted into an endophyte-free grass. Fourth, the fact that endophytes are transmitted exclusively via seed, would ensure propagation of the beneficial endophyte.

CHAPTER 20

A Scientific Triumph

A "tipping point event" underlying the development of the first commercially-available novel endophyte tall fescue variety occurred at the 1989 International Grassland Congress in Nice, France. It was a chance and serendipitous meeting at that Congress that led to ensuing discussion between two scientists from normally disparate disciplines and even different parts of the world. These scientists were G.C.M. Latch, who worked with AgResearch in New Zealand, and J.H. Bouton, a forage breeder with the University of Georgia UGA).

Dr. Latch was reporting at the Congress on his research with deploying non-toxic-endophytes into perennial ryegrass varieties. During their discussion, Dr. Bouton told Latch of his research that had revealed the tall fescue varieties Jesup, Georgia 5, and Kentucky 31 were *only* persistent when infected with an endophyte (which in Bouton's experience to that point had always been a toxic-endophyte).

Drs. G.C.M. Latch And J.H. Bouton

When Latch indicated he had non-toxic tall fescue endophyte strains, they agreed that Bouton's varieties, which relied on endophytes for persistence, could potentially be excellent hosts for Latch's non-toxic strains. An urban legend reported in a 2016 CSA News article was that Bouton "grabbed hold of Latch and didn't let him go!"[44]

In 1994, Dr. Bouton arranged for a sabbatical leave in New Zealand to allow him to work with Dr. Latch and his colleagues to insert several of the AgResearch non-toxic-endophyte strains into two UGA tall fescue varieties, Georgia 5 and Jesup. Formal research collaboration was then set up between the University of Georgia and AgResearch (and their commercial partners Agricom and Wrightson's Seeds) with a goal to identify the best UGA cultivar-AgResearch non-toxic-endophyte combination for possible commercialization.

Pennington Seed was already the licensee for both Georgia 5 and Jesup, and promptly agreed to act as the commercial producers of any novel endophyte tall fescue variety. Therefore, all pieces of the puzzle for commercialization were readily and fairly easily put in place.

New Zealand Scientists Who Collaborated With Bouton During His Sabbatical. From Left: Mike Christensen, Brian Tapper, Ollie Ball, David Hume, Sid Easton, John Hay, Geoff Lane, and Garry Latch.

The initial proof-of-concept studies between UGA and AgResearch were conducted on several variety-strain combinations, and were quite successful.[1, 15, 16, 71, 72, 99] One particular combination, the variety Jesup and a non-toxic-endophyte strain named AR542 (later renamed "Max Q" for marketing purposes), best mimicked the agronomic persistence and performance of Jesup with its endemic toxic-endophyte strain. It also simultaneously provided the absence of toxicity and good animal performance of endophyte-free Jesup.

Immunoblot assays developed by Nick Hill and colleagues (mentioned in Chapter 16) allowed for the rapid and accurate appraisal of the many samples generated from the scores of variety-endophyte strain combinations generated by Latch and Bouton. This approach was quicker and more accurate than standard microscopic and chromatography analyses.[41] Without these assays, it is doubtful that progress would have occurred as quickly as it did. This evaluation approach subsequently aided other tall fescue plant breeding programs that focused on developing novel endophyte varieties.

Other research on this non-toxic-endophyte/tall fescue combination further demonstrated the excellent host plant benefits from the endophyte, and furnished high performance and animal safety traits for lambs as well as beef cows and calves that grazed novel tall fescue. Final confirmation of animal safety was accomplished by a trial conducted at Mississippi State University with pregnant horses, the animal species most sensitive to fescue toxicity.

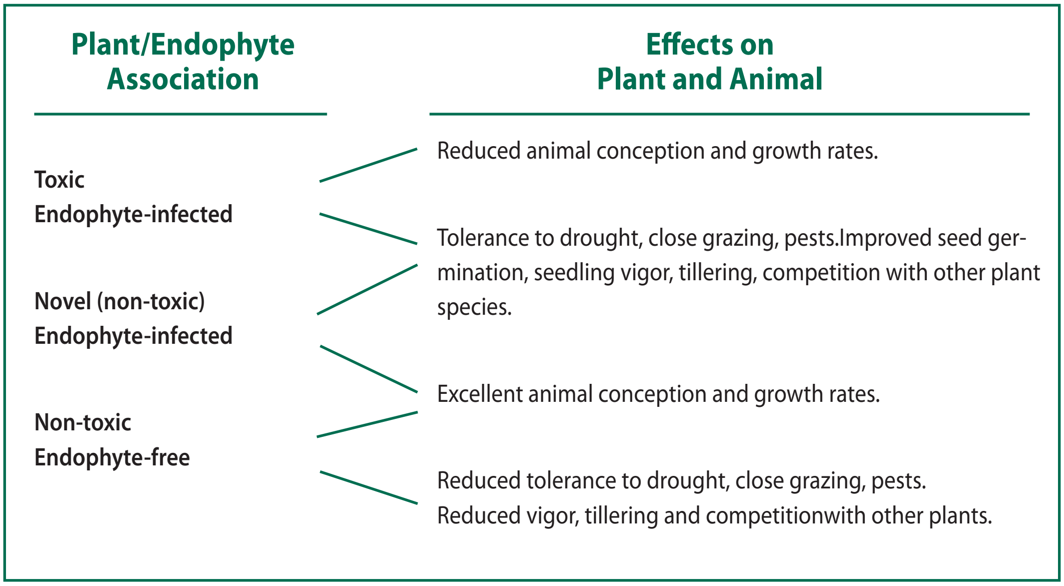
At the University of Georgia, the early experimental non-toxic-endophyte/tall fescue combination deemed as the best choice of novel endophytes inserted into Bouton's tall fescue varieties provided excellent host plant benefits from the endophyte,[16] and also furnished high performance of lambs,[71] steers,[72] and beef cows and calves.[99] This led to the commercial availability in 2000 of the first novel endophyte tall fescue variety, Jesup MaxQ ("Jesup" is the variety name; "MaxQ" is the commercial name of the endophyte inserted into the variety).

A number of other novel endophyte tall fescue varieties were subsequently developed and marketed by various universities and commercial companies. The success of several of these products demonstrates two noteworthy facts. First, the concept of replacing toxic-endophytes with non-toxic-endophytes in novel combinations with tall fescue varieties was valid. In addition, the fact that seed companies made a large investment in research and development, production, and sales provided evidence of their belief in the importance of novel endophyte varieties to the future of the forage seed market.

Endophyte-free tall fescue proved to be of much value in mild-summer climates where it persisted well. However, in the more southern portions of The Fescue Belt, and even under stressful conditions in northern areas, novel endophyte tall fescue varieties quickly became the most dependable method of eliminating animal losses from fescue toxicosis.

Most of the lessons learned with regard to establishing endophyte-free tall fescue (Chapter 18) applied to novel endophyte tall fescue as well. The one exception was that novel endophyte tall fescue persists much better under stressful conditions, assuming it is not overgrazed or cut too low during summer. Novel endophyte tall fescue is more palatable than toxic tall fescue, so it may be grazed more closely. Nonetheless, it is always better to leave some residue going into, and throughout, summer.

FIGURE 4. Effect of endophyte infection on tall fescue characteristics



Courtesy Of The International Plant Nutrition Institute[10]

The advent of novel endophyte tall fescue further changed the options livestock producers had with regard to growing the grass. Tall fescue varieties could be placed into three endophyte status categories. The effects on animals and on tall fescue plants vary greatly (**Figure 4**).

Ergot alkaloids produced by the toxic-endophyte present in a high percentage of most Kentucky 31 tall fescue populations were identified as being closely associated with fescue toxicosis. A particular alkaloid named ergovaline was associated closely enough with animal disorders that it could be used as a plant marker for toxicity. A method of measuring the quantity of this alkaloid was developed and widely used, and an approach developed later is used to analyze for total ergot alkaloids

Note: To date, most novel endophyte varieties produce *no* ergot alkaloids; however, the term encompasses a variety that produces a negligible quantity that provides some insect resistance. It should also be noted that the endophyte of tall fescue can produce other types of alkaloids, primarily lolines and peramines, some of which reduce insect damage to plants, but certain ones may also have some negative impact on grazing animals.

PART THREE

IMPACTS, INSIGHTS, AND IMPLICATIONS

CHAPTER 21

Fescue Foot Disorder Is Understood

Fescue foot is a relatively rare disorder in the southern portion of The Fescue Belt, but more common in the northern portion. When it occurs it can cause serious economic losses. It is manifested by a dry, gangrenous condition of the extremities of the bodies of cattle grazing fescue, most commonly rear feet.[38] Affected animals are sometimes only lame, but in other cases, sloughing of feet and hooves or even an entire limb can occur. In addition, an animal may lose part of its tail (especially the switch) and sometimes the tips of its ears.

Once it was proven that the endophyte was the causal agent of fescue toxicity, scientists suspected that it might be involved in causing fescue foot as well. However, fescue foot does not occur with regularity, so it was more difficult to prove its involvement. Furthermore, it was puzzling to scientists that warm temperatures aggravated fescue toxicity, while fescue foot seemed to be associated with cold weather and cooler climates.

It was eventually learned that the toxins (ergot alkaloids) produced by the fungus cause fescue toxicity signs in animals at least partially by interfering with the ability of the animals to dissipate body heat. As a result, during warm weather the animals breathe heavily, run a low-grade fever, and try to keep cool by staying in the shade or by staying in or near water. At least part of the reason they gain poorly is because they spend less time grazing than would otherwise be the case.

Fescue Foot Disorder Resulted In Loss Of This Animal's Tail

These alkaloids also act as vasoconstrictors (cause narrowing of the blood vessels), particularly in the body extremities of animals. Cold weather also causes vasoconstriction. This response to cold weather is a natural reaction of the animals' bodies, because it helps conserve heat.

Thus, fescue foot symptoms usually develop in winter. If an animal already has a substantial amount of narrowing of blood vessels due to cold weather, the addition of a powerful chemical vasoconstrictor can result in enough additional reduction of blood flow to cause gangrene. This explains why in warm climates such as in the southeastern United States there is a much lower incidence of fescue foot than occurs farther north. Conversely, fescue toxicity is more evident in warmer areas.

To date, no breed or line of livestock has been identified or developed that is immune or resistant to fescue toxicity or fescue foot. However, some animals are more tolerant of endophyte toxins than others. In 2015, a genetic test (T-snip™)[81] became commercially available that measures "tolerance" of individual beef animals to endophyte toxins.

Photo Credit: Matt Booher

Cow Hoof Bleeding Due To Fescue Foot

Photo Credit: Dr. William S. Swecker, Jr.

Left: Internal Scan Of A Normal Cow Hoof; Right: Internal Scan Showing Vasoconstriction Of Blood Vessels

CHAPTER 22

Strategies For Reducing Or Eliminating Toxin Intake

Beginning in the early 1980s, research on tall fescue and its endophyte became a major focus of scientists throughout the area in which the grass is grown. Most of this research was aimed at developing strategies to reduce the monetary losses livestock producers experienced that were caused by endophyte-produced toxins in tall fescue. Several approaches came to be generally recommended.

Avoidance

Reducing or eliminating the access of animals to toxic-endophyte tall fescue at certain times is helpful in some situations. This is predicated on two facts: (1) Endophyte toxins have a greater adverse effect on grazing animals during warm weather than during cool weather; and (2) Toxin levels are typically highest in toxic tall fescue during late spring, with a lesser peak in levels in late summer/autumn.[85]

Consequently, gains and pregnancy rates of animals grazing toxic fescue in late spring are likely to be low. Therefore, preventing animals (especially classes of animals that are particularly toxin-sensitive or are of high value) from grazing toxic tall fescue at certain times can reduce economic losses.

Dilution

More than 50 years after Warren Thompson, Joe Burns, and others vigorously promoted planting legumes with tall fescue, this continues to be a useful strategy for reducing the impact of tall fescue endophyte toxins. While the greatest increase in animal performance results from growing legumes with toxic-endophyte tall fescue, a significant increase occurs even when a legume is grown with non-toxic (endophyte-free or novel endophyte) tall fescue. Thus, this technique is still widely promoted by scientists regardless of tall fescue endophyte status.[58]

Initially, the animal performance benefits of using legumes was attributed exclusively to the excellent nutritive value of clover forage. However, it was later learned that endophyte-produced toxins within tall fescue were being diluted, which was also an important factor. This knowledge prompted Professor Joe Burns, Extension Forage Crop Agronomist at the University of Tennessee, to use the old adage, "The solution to pollution is dilution." This statement was likely quite effective in helping many livestock producers better understand the situation.

In addition, in 2016 it was found that at least some legumes such as red clover, contain biochanin and isoflavones that enhance animal performance.[40] These naturally-occurring compounds accomplish this by having a favorable influence on digestive tract bacteria.[34, 40]

Thus, legumes help improve the performance of animals grazing toxic-endophyte tall fescue in several ways. Planting them is relatively inexpensive, so this management approach is quite feasible, especially for many beef cow-calf producers. However, it is usually not a dependable long-term solution. The reason is that legume stands may decline and eventually disappear. Also, legume growth is often poor during summer, especially in the lower South.

The lower the amount of endophyte toxins consumed, the less negative impact there will be on grazing animals. Therefore, legumes are not the only way to achieve dilution. Management of toxic tall fescue pastures to favor other grasses such as Kentucky bluegrass, orchardgrass, or bermudagrass, or even annuals such as large crabgrass or annual lespedeza, can also dilute fescue toxins in animal diets.

For example, while overgrazing should always be avoided, close grazing during spring will reduce shade competition by tall fescue for lower-growing plants. Also, summer application of nitrogen will encourage warm-season species such as bermudagrass and crabgrass.

Judicious Use Of Nitrogen Fertilizer

Nitrogen is the nutrient element that typically has the most dramatic impact on plant growth, but research has shown that forage-livestock producers who have toxic-endophyte tall fescue need to be prudent about applying high amounts of nitrogen.[86] Nitrogen is a component of alkaloids, including the ones that cause tall fescue-related animal disorders. Higher levels of nitrogen favor increased levels of endophyte toxins. In addition, when tall fescue is highly fertilized with nitrogen, the grass tends to dominate pastures, with the result being that tall fescue comprises a higher percent of the diet of grazing animals, and toxin ingestion is increased

Reduce Seedhead Consumption

Grazing animals often selectively graze tall fescue seedheads. This is undesirable because endophyte fungus growth (and associated toxins) tend to be high in seed and seedheads.[85, 89] Close grazing that reduces seedhead production during spring and early summer may reduce toxin intake by grazing animals. Mowing to remove seedheads can also be effective. In addition, application of a chemical plant growth regulator that suppresses tall fescue seedheads can likewise reduce toxin intake.

Feeding Of Non-Toxic Tall Fescue Hay Or Other Feedstuffs

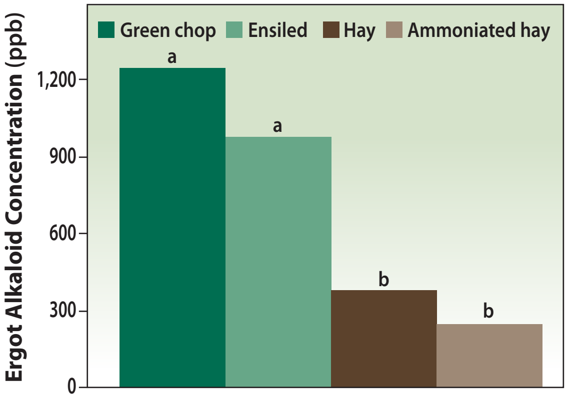
Hay made from toxic tall fescue has less negative impact on animals than green pasture forage for two reasons. First, the level of ergot alkaloids in toxic tall fescue hay is sharply lower than that in green pasture forage[83] (**Figure 5**). Also, most hay is fed during cooler months of the year when the effect of toxins on animals is less severe. Ergot alkaloid levels decline sharply once forage has been cut, but it is advisable to not feed hay until at least one month after cutting.[84]

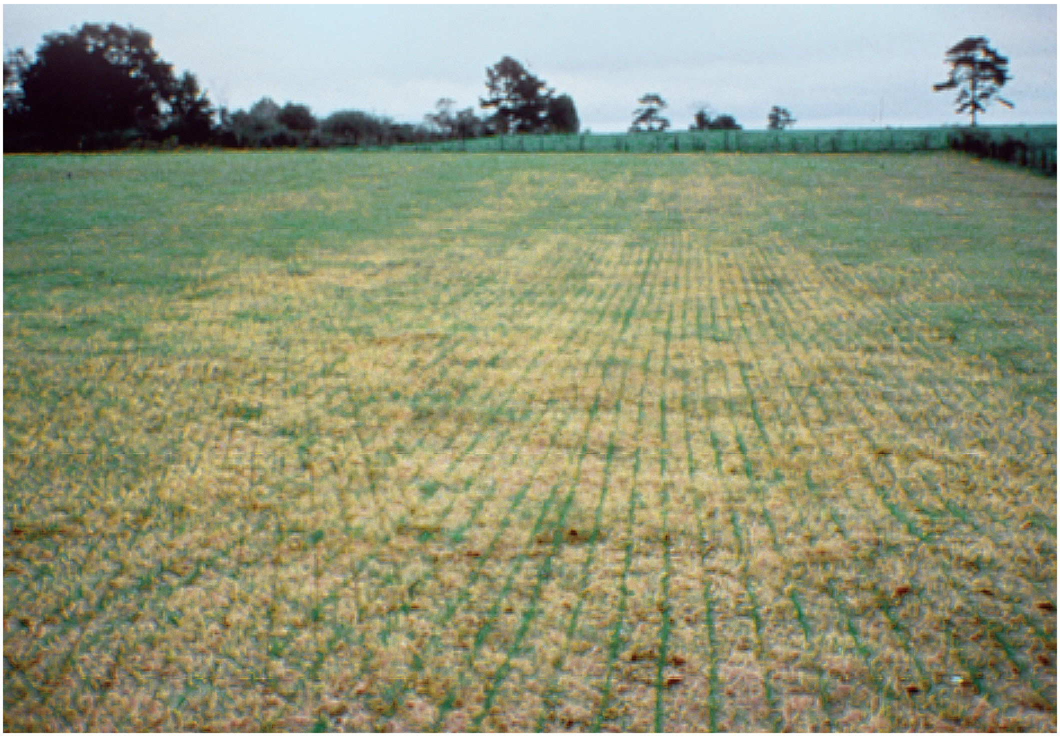
Toxic tall fescue hay usually contains half or less of the amount of endophyte toxins present in green pasture forage, but non-toxic hay of tall fescue or other types of hay contain *no* endophyte toxins. Replacing some of the toxic fescue forage that would otherwise be in an animal's diet with grain or other feedstuffs can therefore be helpful.

Ammoniation of Hay

Putting toxic tall fescue hay in sealed plastic bags, followed by injecting anhydrous ammonia at the rate of about 60 pounds per ton of hay causes ergot alkaloid levels to drop substantially. In addition, this treatment increases digestibility, provides non-protein nitrogen, and increases hay intake. Results vary, but in many trials, total digestible nutrients, crude protein, and intake have been increased by 10% to 20%, 5% to 10%, and 15% to 20%, respectively.

FIGURE 5. Ergot Alkaloid Levels In Toxic Tall Fescue Forage (90% Infection) Treated In Various Ways[83]





New Stand Of Tall Fescue In A Killed Sod

Stockpiling Forage

Stockpiled toxic-endophyte tall fescue forage contains lower levels of toxins than green forage, and the levels also tend to decline over time.[54] Therefore, stockpiling autumn tall fescue growth and then delaying the use of the stockpiled forage helps reduce the amount of toxins consumed. In addition, as is the case with hay, stockpiled tall fescue forage is usually consumed during cool weather, so the impact on the animals is less than during warm weather.

Planting Of Non-Toxic Tall Fescue

Seed of both endophyte-free and novel endophyte tall fescue are commercially available. Thus, the disorders that commonly occur with toxic-endophyte tall fescue are avoided when these products are used to establish tall fescue pastures.

If a stand of a novel endophyte tall fescue variety is to be established, the purchaser needs to obtain seed with a known high level of endophyte viability. Both the seed dealer and the purchaser need to protect the seed (and thus the novel endophyte) from exposure to high temperatures and high humidity, otherwise the percentage of seed containing viable novel endophyte will decline (ultimately to zero). Grazing management is also an important factor. Endophyte-free tall fescue is less stress-tolerant and pest-resistant than either toxic–endophyte or novel endophyte tall fescue.

When endophyte-free tall fescue is grown in a mild climate with minimal heat and drought stress and/or is not overgrazed, it persists well. In stressful environments, a novel endophyte variety is likely to persist much better than endophyte-free fescue, but because animals like it so much, care also needs to be taken to prevent it being overgrazed.

Once a good stand of novel tall fescue has been established and overgrazing and excessively close cutting are prevented, invasion by toxic-endophyte tall fescue is unlikely. However, it is prudent to avoid taking animals directly from a toxic-endophyte tall fescue field where seedheads are present and immediately placing them on a non-toxic-endophyte field. A three-day waiting period is advisable. The reason is that in a study in which toxic-endophyte seed was fed to a steer, it was found that a small percentage of toxic-endophyte seed can pass through an animal's digestive system with the endophyte remaining viable for close to 40 hours.[91] Hay that may contain toxic-endophyte seed should not be fed on a non-toxic tall fescue sod.

Other

Numerous products or other management approaches have shown some benefit in certain situations. However, most of these have either not been proven to be consistently effective across environments or situations, or the extent of benefit has been marginally economical. One exception, though narrow in application, is that a compound named domperidone (marketed under several brand names) can prevent foaling problems of horses grazing toxic-endophyte tall fescue.[23]

CHAPTER 23

Discernible Fescue Toxicity Effects

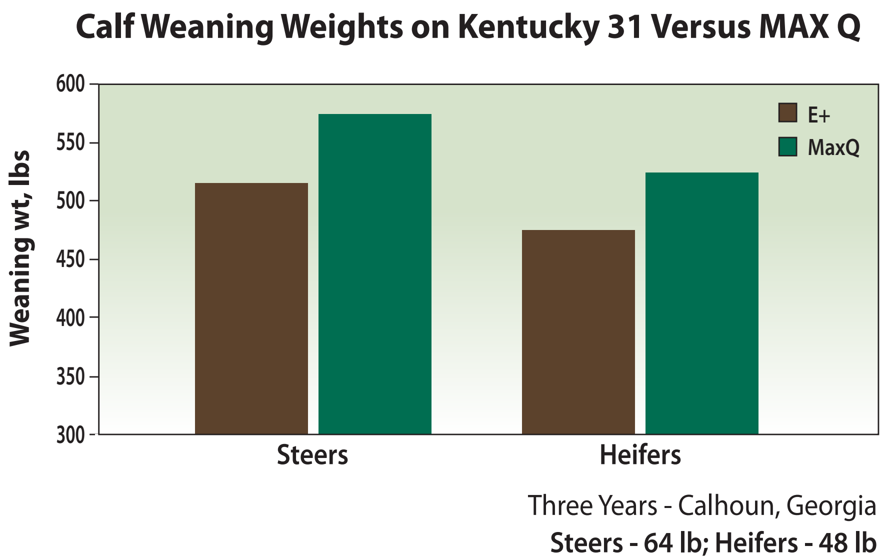
Discovery of the toxic-endophyte in tall fescue, and development of strategies to reduce the impact of endophyte toxins, has had an important impact on the profitability of many livestock operations. However, destroying stands of toxic-endophyte-infected tall fescue and replanting with non-toxic (endophyte-free or novel endophyte) varieties is expensive in the short run, and often causes producers to hesitate to replant. Calculations of the economic impact made at any given point in time are useful, but the costs and returns associated with livestock production vary greatly from year-to-year and sometimes even within a particular year.

Thus, a single economic assessment is of limited value over time. In this publication, a better approach is to provide research-based information that clearly reflects the differing animal production on toxic infected versus non-toxic tall fescue. Such information can then be used to calculate or estimate likely economic impacts. Species and class of animal is a major consideration. This discussion will be limited to beef cattle, as the vast majority of tall fescue is used in beef enterprises.

Cow/Calf Production - Calf Weaning Weights

The weaning weights of calves are heavier when a beef cattle herd is grazed on non-toxic (endophyte-free or novel endophyte) tall fescue rather than toxic-endophyte tall fescue. A good example is a study done near Calhoun, Georgia in which animals were grazed on either toxic-endophyte Kentucky 31 tall fescue or the novel tall fescue variety Jesup MaxQ[15, 99] (**Figure 6**).

FIGURE 6. Calf Weaning Weights On Kentucky 31 (Toxic-endophyte) Versus Jesup MaxQ (Non-Toxic Novel)Tall Fescue In A Three-Year Study Near Calhoun, Georgia.[15, 99]



The average weaning weight of calves in this study (steers and heifers combined) was increased by 56 pounds. *Based on this data, if a beef producer had 100 calves to sell, half of which were steers and half were heifers, using non-toxic fescue rather than toxic-endophyte fescue would result in having 5,600 more pounds of beef to sell.*

Cow/Calf Production - Effect On Reproduction

Studies in several states have shown that pregnancy rates of cows can be reduced by toxic-endophyte tall fescue. Animals under nutritional stress (such as first calf heifers) are particularly likely to fail to reproduce. Some studies have also provided evidence that bulls grazing toxic-endophyte tall fescue are likely to have reduced sperm quality as compared to bulls on non-toxic tall fescue.

In four studies (**Table 1**), the average pregnancy rate for cows on endophyte-free and toxic-endophyte tall fescue was 87% versus 59%, respectively.[29, 39, 67, 96] *In a herd of 100 cows grazing toxic-endophyte tall fescue, that level of reproductive difference could mean a producer would have 28 fewer calves to sell, plus there would be expense associated with feeding and otherwise maintaining dry cows, even if they were sold promptly after it had been learned they were not pregnant.*

Stocker Cattle Weight Gains

Weaned beef calves (stocker cattle) are commonly grazed on high-quality pasture to obtain low-cost gains prior to being placed in a feedlot for finishing prior to slaughter. Small grains and/or annual ryegrass on which daily gains are around 2.0 pounds are often used for this purpose, despite the annual establishment expense and risk.

Gains are much lower on toxic-endophyte tall fescue than on non-toxic tall fescue. Grazing trials with beef steers in nine states over multiple years averaged only 0.99 pound daily gain on toxic-endophyte tall fescue as compared to 1.61 pounds on non-toxic tall fescue.

An additional 0.6 pounds of gain per day on non-toxic tall fescue as compared to toxic-endophyte tall fescue over a 160-day grazing season would result in 96 more pounds of gain per animal. *A stocker cattle producer who sells 100 animals that gained this amount of additional weight would sell 9,600 additional pounds of beef.* However, the stocking rate needed to produce the higher performance is somewhat lower, and a higher level of grazing management is required.

TABLE 1. Pregnancy Rates Of Cows Grazing Endophyte-Free (Non-Toxic Fescue) Versus Toxic-endophyte Infected Tall fescue In Studies In Four States[29,39, 67, 96]

Pregnancy Rates of Cows (percent)

Reference	Endophyte Free (E-)	Endophyte Infected (E+)
Gay et al., 1988 (KY)	95	55
Essig et al., 1989 (MS)	87	58
Tucker et al., 1989 (MO)	89	74
McDonald, 1989 (TN)	78	49

Use Of Non-Toxic Tall Fescue And Good Grazing Management Can Result In A Highly Productive And Profitable Pasture.

Tall fescue is a perennial and, where adapted, does not have to be re-established each year. Thus, the economics of grazing stocker cattle on non-toxic tall fescue compares favorably with grazing them on annual grasses. This is potentially an important development as it may result in a substantial number of stocker cattle enterprises being located in areas suited to growing tall fescue.

Conclusion

Many factors affect animal performance, including forage botanical composition, climatic conditions, stocking rate, grazing management, and animal factors (such as age, weight, breed, and health), therefore performance varies. However, the differences in animal performance between toxic-endophyte tall fescue and non-toxic tall fescue are well-documented and are too great to ignore. The profit potential is far greater on non-toxic tall fescue, once the costs associated with establishment have been offset.

Furthermore, tall fescue is a *long-lived* perennial. Once a non-toxic stand is established on a site and in a situation in which it can persist, it has the potential of providing much greater profits to a producer *year after year for many years* than is the case with toxic-endophyte tall fescue.

CHAPTER 24

Unnoticed Toxin Impacts On Livestock

The data and information presented in Chapter 23 reveal the potential economic importance of the toxic-endophyte of tall fescue to beef cattle producers, who most frequently use the crop as pasture or hay. The differences in the appearance and performance between animals that are primarily consuming toxic-endophyte infected tall fescue forage and animals that are mostly consuming non-toxic tall fescue forage are remarkable. In agricultural production, few factors can make such an impressive difference.

The data presented in Chapter 23 were generated in locations where tall fescue is well adapted and where it typically dominates pasture stands. In such areas it is not uncommon for over 90% of the plants in a pasture to be tall fescue, especially if the pasture is well fertilized. In most Kentucky 31 tall fescue pastures, 70% to 100% of the tall fescue plants are infected with toxic-endophyte.

The endophyte itself is not toxic or harmful to grazing animals; it is the *toxins* produced by the endophyte that are detrimental. In pastures in which most plants are tall fescue and most of the plants are infected with toxin-producing endophyte, grazing animals typically ingest a large quantity of toxins, thus increasing the likelihood, extent, and ease of recognition of disorders.

There is a direct correlation between amount of toxins ingested and impact on animal performance[74] (**Table 2**). Steers grazing pastures having differing infection levels (low, medium, high), had gains that reflected the level of endophyte infection. Obviously, a high toxic-endophyte infection percentage results in much toxin being consumed; a low toxic-endophyte infection percentage results in little toxin being consumed.

When toxic tall fescue is the dominant pasture species, animal signs of fescue toxicity are easy to recognize, if a person knows what to look for. However, a producer may not know the signs, which include a rough hair coat, lack of tolerance to heat, and standing in water or in shade a big part of the time during warm weather. Furthermore, if most cattle in an agricultural community look and behave about the same, the likelihood of suspicion of negative impacts by endophyte toxins is low.

Before a problem can be solved, it is necessary to recognize that the problem

TABLE 2. Effect Of Endophyte Level In Tall Fescue On Steer Gains In Alabama.[74]

Effect of Endophyte Level On Steer Gains

ENTRY	ADG (lbs)	Gain/Acre (lbs)
KY 31 (1 percent)	2.16	462
KY 31 (34 percent)	1.76	397
KY 31 (90 percent)	1.41	370

exists. Loss due to endophyte toxins is often an unrecognized problem for several reasons. In areas where tall fescue *is not* the dominant species in pastures, it is unlikely that the impact of ingestion of low levels of endophyte toxins will be evident, and therefore adverse effects will likely not be observed by a livestock producer. In addition, animal reaction to endophyte toxins are greater when the temperature is high, so the cooler and less drought-prone the climate, the less likely it is that signs in animals will be readily apparent.

Photo Credit: Joe Bouton

Typical Animal Behavior On A Hot Day. Cattle In The Foreground Are Grazing Toxic Tall Fescue; Those In The Background Are Grazing Jesup AR542 Novel Endophyte Tall Fescue

Some effects caused by endophyte toxins are not visible in animals even when they are consuming a substantial amount of endophyte toxins. These include elevated body temperature, vasoconstriction (restriction of blood flow through blood vessels), lower heart rate, and reduced level of lactation. Also, a point of great economic importance is that when a lowered pregnancy rate occurs, a producer may not realize, or even suspect, that this costly problem resulted from ingestion of endophyte toxins.

Furthermore, it is possible that some publications or presentations aimed at helping producers understand the importance of fescue toxicity may have inadvertently been misleading. Often, photographs show animals that had been grazing toxic-endophyte infected tall fescue and non-toxic tall fescue standing side-by-side.

In such instances, an animal that appears to be particularly unthrifty, and a particularly nice-looking animal may have been chosen to provide a vivid contrast. A producer seeing such images may conclude he or she doesn't have a fescue toxicity problem because his or her animals don't look as bad as the one depicted that had been severely affected by fescue toxicity.

Conclusion

The extent of the effects of endophyte toxins on animals are closely correlated with the amount of toxins consumed. While there are major production and economic impacts when animals consume large quantities of endophyte toxins, there undoubtedly are negative impacts on animals on many farms where no symptoms whatsoever are observed. Thus, the overall economic impact of toxic-endophyte tall fescue on livestock production is frequently not recognized, and often underestimated.

CHAPTER 25

Opportunities Remain

Once the toxic-endophyte of tall fescue had been associated with fescue toxicity and other animal disorders encompassed by the term fescue toxicosis, information pertaining to it was widely disseminated. This included articles in scientific journals and farm magazines, internet posts that include a comprehensive monograph on tall fescue,[35] and presentations made at scientific or producer meetings and conferences.

In 1987, the Oregon Tall Fescue Commission funded printing of a producer-oriented publication titled, "The Fescue Endophyte Story."[9] Hundreds of thousands of copies were distributed, and in subsequent years, this organization sponsored publication of additional practical publications pertaining to tall fescue that were likewise widely disseminated.[11] Many other publications and other media forms of various types have also addressed the situation. In addition, countless field days, pasture walks, and farm demonstrations have focused on the topic.

A modern educational approach that shows much promise is the Alliance for Grassland Renewal (grasslandrenewal.org). Active participants include partners from universities, government, industry (producers, seed companies, testing laboratories), and non-profit groups that hold educational schools to assist producers with successfully converting Kentucky 31 tall fescue to non-toxic varieties. This organization also monitors seed quality to help ensure viable endophyte and a pure (desired) strain of novel endophyte in seed.

Without doubt, these educational efforts have significantly reduced economic losses of livestock producers as compared to the situation prior to discovery of the toxic-endophyte. However, opportunities to increase production and profitability by minimizing or eliminating the effects of endophyte toxins continue to exist.

Regardless of the extent of information dissemination, some producers somehow escape being exposed to the message (or, in some cases, don't believe the message or fully appreciate its importance). Others are simply resistant to making changes, especially if it requires a substantial effort. After all, some livestock operations are basically hobby farms on which profit is not a high priority. Another common reason for lack of action is (as discussed in Chapter 24) that many producers do not believe they have a problem, or at least not a problem of much consequence.

The consensus thinking of scientists is that a livestock producer should learn the endophyte status of existing tall fescue pastures. If a pasture is likely Kentucky 31, tissue samples from the bases of tillers should be tested to determine the extent of endophyte infection. This could even include testing of pastures planted to endophyte-free tall fescue, especially if animal performance, appearance, or behavior do not appear to be consistent with expectations for animals grazing non-toxic tall fescue. Private and public labs conduct these analyses for a reasonable fee. It is also possible to have tissue samples analyzed for ergot alkaloid content, although these analyses are more expensive.

If the analyses indicate endophyte infection levels and/or ergot alkaloid levels are high, a management plan should be developed to reduce toxin intake by animals and thus reduce adverse effects. The steps taken could be analogous to a physician making recommendations to a patient who has elevated blood pressure or blood cholesterol levels.[13] If the elevation in these measurements is marginal, the physician's recommendation may simply be to make some changes in diet and exercise. If they are seriously high, the recommendations will be more drastic.

Numerous factors can impact decisions a livestock producer might make. Obviously, one consideration should be the probable annual negative economic impact of the levels of endophyte toxins likely being ingested, as discussed (with regard to beef cattle) in Chapter 23. A much higher priority can be given to replacement of toxic-endophyte tall fescue where pregnant horses, stocker beef cattle, or lactating dairy animals will be pastured.

In addition, the expected number of years a pasture will continue to be used, cash flow of the operation, estimated cost of replacing toxic-endophyte tall fescue, costs and benefits of management options such as planting legumes, and current and anticipated cattle prices may deserve consideration. Also, because animals prefer to graze non-toxic tall fescue as compared to toxic-endophyte tall fescue, it is important to exercise management that will prevent overgrazing. Therefore, the ability and desire to exercise such management should be contemplated.

The potential financial benefits realized from endophyte research vary considerably depending on a producer's knowledge of the endophyte, the extent to which animals are ingesting endophyte toxins, and a producer's willingness to take action as needed to avoid or minimize endophyte toxin ingestion by their animals. Profit-oriented livestock producers who use, or want to use, tall fescue should employ some combination of the strategies for reducing toxin intake by animals outlined in Chapter 22.

Use Of Non-Toxic Tall Fescue And Good Grazing Management Can Result In A Highly Productive And Profitable Pasture

CHAPTER 26

Eventual Seed Industry Development

During the first few decades after tall fescue seed became commercially available, the single most successful seed production operation was in North Alabama, as discussed in Chapter 10. However, there was some tall fescue seed production in most places where the grass was grown to any significant extent. Kentucky, the state in which the variety Kentucky 31 was released, was an important source of seed for many years. In fact, as late as the early 1970s, Kentucky reported 55,000 acres on which tall fescue seed was being produced.

When demand for tall fescue seed was high, it was relatively easy to make a profit producing seed. As demand diminished, the number of people producing seed declined as well. However, several decades after the release of Kentucky 31 in 1943, tall fescue seed production flourished and persisted primarily in two areas.

Missouri has more acres of tall fescue than any other state, most of which is the variety Kentucky 31. Most Missouri cattlemen are not dedicated seed producers; rather they are opportunists. When cattle prices lag, many of these producers allow tall fescue fields to head, which enables them to harvest tall fescue seed to supplement their incomes; otherwise they may not produce seed.

Many harvest seed from standing tall fescue in fields that are generally managed more like pastures than seed fields. Seed yields are relatively low, but the number of farmers who produce seed is often impressively high. The result is that there is more Missouri-produced seed marketed as Kentucky 31 than from anywhere else in the nation. The vast majority of this seed is infected with toxic-endophyte, and much of it is sold for turf or conservation purposes.

Tall Fescue Seed Harvest In Oregon

The other major tall fescue seed production area is Oregon. The Willamette Valley (roughly 30 miles wide and 100 miles long) begins about 50 miles south of Portland in the northern part of the state, and produces about 90% of the cool-season forage and turf seed sold commercially in the United States. Well over half of the tall fescue seed produced there is of turf varieties, but it is the center of production of virtually all forage-type tall fescue other than Kentucky 31.

The Willamette Valley is often referred to as "the grass seed capital of the world," and for good reason. The soils and climate are well suited to this enterprise. Typically, there is frequent, soft rain during the cool season, but low humidity and little rainfall during the seed harvest period in summer. In addition, seed producers, university personnel, consultants and others in this area have developed much seed production expertise. Furthermore, an infrastructure developed by seed, equipment, and chemical companies facilitates every aspect of seed production, harvesting, and handling.

Widespread tall fescue grass seed production developed more slowly in Oregon than in Missouri. Perhaps part of the reason was that Oregon is much farther from the tall fescue seed market, thus complicating the logistics of seed transport. Also, most tall fescue varieties developed after 1960 were bred in the eastern United States, and initially there was concern that plants grown from seed produced in such a distant and climatically different location might not exhibit desired variety traits, but this proved to be groundless.

Over time, the Willamette Valley became recognized as a premier location for cool-season grass production. Yields of tall fescue and other cool-season grasses are often around twice as high in Oregon than in the areas in the eastern United States in which tall fescue is widely used for forage production. Also, seed transportation and marketing channels slowly but surely developed. The result is that Missouri is generally recognized as the center of Kentucky 31 seed production, while most seed of other tall fescue varieties marketed in the United States is produced in Oregon.

Tall Fescue Seed In A Warehouse

EPILOGUE

An Amazing Odyssey

The story of tall fescue in the United States is beyond interesting and impressive; it is amazing. The grass was not even present on the North American continent until European settlement occurred, but became the most widely grown introduced forage species in the nation. Like most Americans and/or their ancestors, it was an immigrant.

Many of the developments pertaining to tall fescue defied probability and logic. A farmer named William Suiter "discovered" and subsequently propagated what he recognized as an impressive grass on his mountain farm in eastern Kentucky. It proved to be an ecotype of tall fescue, but since tall fescue was not a native species and no tall fescue seed was commercially available in the USA, how it got there and how long it had been there are baffling questions.

Two University of Kentucky employees, Professor E.N. Fergus and Agronomy Field Agent William Johnstone, made critically important contributions that revealed their initiative, professional dedication, and determination. Dr. Fergus obtained seed from the Suiter farm for evaluation purposes, and observed plantings for over ten years. Mr. Johnstone enthusiastically promoted the grass, despite the extremely unusual situation of there being much public controversy regarding it. Nonetheless, the variety Kentucky 31 tall fescue was released in 1943.

A virtual "perfect storm" of activities and efforts led to tens of millions of acres of the grass being planted during the next 30 years. Brothers Carl and Ed Jones of G.W. Jones and Sons farm accomplished a remarkable feat by sending a "caravan" of farm workers from Alabama to Kentucky to obtain seed to establish seed fields. Subsequently, they were highly creative in their approach to the tall fescue seed business, and the farm ultimately became the largest producer of Kentucky 31 seed in the world.

The widespread planting of tall fescue transformed a large portion of the United States. Soil erosion was greatly reduced, and the appearance and profitability of thousands of farms was improved. Tall fescue was (and is) also widely grown for turf purposes including highway rights-of-way, parks, lawns, and athletic fields.

However, along with the positive changes resulting from Kentucky 31, animal disorders, collectively referred to as "fescue toxicosis," were observed. The most economically important was "fescue toxicity," also called "summer slump." Animals affected by this syndrome made poor weight gains, and reproductive efficiency was often low. Despite many research efforts aimed at identifying the cause of the problems associated with the grass, it defied solution for many years.

Initially, the only management approach known to mitigate the problem was to plant clover (or other legumes or grasses) with tall fescue. While effective, stand persistence of clover is not highly dependable when weather conditions are unfavorable, especially in the lower South.

In the 1970s a *stunning* observation was made on a beef cattle farm near the town of Mansfield in north central Georgia. Cattle on separate tall fescue pastures differed greatly in appearance, a situation that ultimately provided a strong hint as to the probable cause of fescue toxicity.

C.W. Bacon, J.K. Porter, and J.D. Robbins, who were scientists at the Agricultural Research Service Unit in Athens, Georgia determined that on a farm in Georgia there was an internal fungus (endophyte) present in tall fescue grazed by animals doing poorly, but not present in pastures where animals appeared to be doing well. Subsequent animal grazing experiments conducted by Auburn University personnel confirmed that toxins produced by an endophyte present in most Kentucky 31 tall fescue was, indeed, associated with fescue toxicity.

Amazingly, transmission of the endophyte occurs only via seed, and removal of the endophyte from seed was easy to accomplish. Endophyte-free seed of several varieties soon became commercially available, and there was great optimism regarding the potential for increasing animal performance on tall fescue.

Unfortunately, most endophyte-free varieties did not persist well in the lower South especially when factors such as extreme heat, drought, and/or overgrazing occurred. This was surprising, but the reason it happened was that endophyte effects on tall fescue plants had not been studied. Research subsequently revealed that the endophyte provides numerous *benefits* to plants, including pest resistance, stress tolerance, and persistence.

In the 1990s, an ingenious and innovative strategy for combatting the problems associated with tall fescue was developed. New Zealand scientist G.C.M. Latch identified tall fescue endophyte strains that were persistent and productive when inserted into endophyte-free tall fescue.

Collaboration with Joe Bouton (University of Georgia and later The Samuel Roberts Noble Foundation) resulted in insertion of a novel ("friendly") endophyte strain into two agronomically superior tall fescue varieties Bouton had developed. The result was release of a novel endophyte fescue variety named Jesup Max Q, that became commercially available in 2000. Subsequently, several other novel endophyte varieties were developed and marketed. Eventually, much of the seed production of Kentucky 31 moved to Missouri, while almost all seed production of other cool-season forage and turf varieties occurs in Oregon.

The rich and interesting history of this grass in the United States is unique and multi-faceted, and it explains an important development in American agriculture. Tall fescue is the dominant plant species in a huge portion of the humid grazing lands in the nation. Countless people contributed to our understanding of the characteristics, attributes, and limitations of this grass. Tall fescue has had an astonishing impact on our nation. It is, indeed, a Wonder Grass!

Photo Taken During the 2004 International Grass Endophyte Conference, Fayetteville, AR. Left to right: Don Ball (Auburn University), Gary Latch (AgResearch Grasslands, New Zealand), Carl Hoveland (University of Georgia), Joe Bouton (The Samuel Roberts Noble Foundation), and Garry Lacefield (University of Kentucky).

Timing Of Some Significant Events Related To Tall Fescue In The United States

Date/Time	Activity or Development
1771-	German taxonomist Christian Daniel von Schreber identified a new plant species, *Festuca arundinacea*, which later was given the common name "tall fescue." Previously, meadow fescue and tall fescue had been lumped together as one species (*Festuca elatior*).
Around 1893-	A productive grass was discovered on a mountain pasture by William Suiter, a farmer in Menifee County, KY.
1893-1931-	"Suiter's Grass" (eventually identified as tall fescue) was propagated by William Suiter and planted on his property as well as on a few other farms in Kentucky.
1931-	During a trip to Menifee County, University of Kentucky Professor Dr. E.N. Fergus obtained seed of Suiter's grass in order to plant and study it.
1938-	University of Kentucky Extension Field Agent William Johnstone learned about Suiter's Grass and began to encourage people to plant it.
1943-	The variety Kentucky 31 (derived from Suiter's grass) was released by the University of Kentucky.
1945-	The variety Alta was released by the Oregon Agricultural Experiment Station and the United States Department of Agriculture.
1948-	Seed of Kentucky 31 was obtained in Kentucky, transported to Madison County, Alabama, and then planted on the G.W. Jones and Sons farm near Huntsville. This farm eventually became the world's largest producer of Kentucky 31 seed.
1949-	New Zealand scientist I.J. Cunningham observed a syndrome in cattle grazing tall fescue that mimicked ergot poisoning symptoms, but no ergot was present. The syndrome became known as "fescue foot."
1970-	Fat necrosis, an animal syndrome associated with application of high levels of nitrogen in poultry litter, was also identified as a tall fescue disorder.
1973-	Thanks to efforts of USDA/ARS scientists C.W. Bacon, J.K. Porter, and J.D. Robbins, an endophyte was implicated as being associated with a syndrome commonly referred to as fescue toxicity, based on differing appearance of cattle on the A.E. Hays farm near Mansfield, Georgia.

1977-	Dr. C.W. Bacon and colleagues at the USDA Russell Research Center in Athens, GA identified the fungus as *Epichloe typhina* (classified as of this writing as *Epichloe coenophiala*).
1981-	A fungal endophyte was directly associated with sheep staggers in perennial ryegrass in New Zealand.
1983-	Publication of grazing research done by Auburn University scientists provided *scientific proof* that the endophyte of tall fescue adversely affects beef steer performance.
1985-	Artificial inoculation of endophyte strains with differing metabolic abilities was demonstrated in perennial ryegrass.
1986-	J.C. Read and B.J. Camp confirmed in a Texas grazing trial what many producers had reported; endophyte-free fescue may not persist as well as endophyte-infected fescue.
1986-	P.C. Lyons, R.D. Plattner, and C.W. Bacon reported in an article in *Science* magazine that ergot alkaloids are ubiquitous in tall fescue infected with fungal endophyte.
1988-	C.W. Bacon and M.R. Seigel proposed that it might be possible to insert an endophyte into tall fescue that provided beneficial influences on tall fescue plants without causing animal disorders.
1989-	G.C.M. Latch reported successful deployment of novel endophytes into perennial ryegrass varieties.
1993-	University of Georgia scientists reported that tall fescue varieties Kentucky 31, Jesup, and Georgia 5 were only persistent under stressful field conditions in southern Georgia when infected with an endemic toxic-endophyte.
1994-	Joe Bouton, Professor at the University of Georgia, and G.C.M. Latch, a scientist with AgResearch Grasslands in New Zealand, successfully inserted selected strains of a non-toxic-endophyte identified by Latch into two tall fescue populations bred by Bouton.
1995-2000 -	Proof-of-concept studies with Jesup and Georgia 5 tall fescue varieties infected with different novel endophyte strains were conducted.
2000-	The first novel endophyte tall fescue, Jesup MaxQ became commercially available.
2015-	A genetic test to determine tolerance of individual animals to endophyte toxins became commercially available.
2000-Present -	Several novel endophyte tall fescue varieties were developed and became commercially available, and others are expected. Several endophyte-free varieties that are marketed mainly in the upper portion of The Fescue Belt are also commercially available.

APPENDIX A. 1

Plants Mentioned in This Book

Common Name(s)	Scientific Name(s)
Annual Ryegrass	*Lolium multiflorum*
Bahiagrass	*Paspalum notatum*
Bermudagrass	*Cynodon dactylon*
Big Bluestem	*Andropogon gerardii*
Broomsedge	*Andropogon virginicus*
Crimson Clover	*Trifolium incarnatum*
Little Bluestem	*Schizachyrium scoparium*
Eastern Gamagrass	*Tripsacum dactyloides*
Harding Grass	*Phalaris aquatica*
Indiangrass	*Sorghastrum nutans*
Kentucky Bluegrass	*Poa pratensis*
Korean Annual Lespedeza	*Lespedeza stipulacea*
Large Crabgrass	*Digitaria sanguinalis*
Meadow Fescue	Originally *Festuca elatior;* now *Lolium pratense*
Oats	*Avena sativa*
Orchardgrass	*Dactylis glomerata*
Perennial Ryegrass	*Lolium perenne*
Red Clover	*Trifolium pratense*
Redtop	*Agrostis alba*
Rye	*Secale cereal*
Sassafras	*Sassafras albidum*
Sawbriars	*Smilax* species
Striate Annual Lespedeza	*Lespedeza striata*
Switchgrass	*Panicum virgatum*
Tall Fescue	Originally *Festuca arundinacea;* now *Lolium arundinaceum*
Timothy	*Phleum pretense*
Wheat	*Triticum aestivum*
White Clover	*Trifolium repens*

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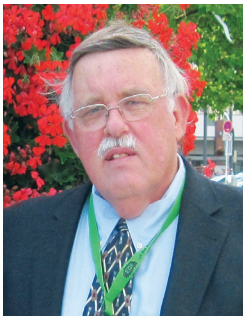

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Dr. Carl Hoveland grew up on a dairy farm near Sand Creek, Wisconsin. He received B.S. and M.S. degrees in soils from the University of Wisconsin and a Ph.D. in agronomy and animal nutrition from the University of Florida. He was at Auburn University from 1959-1981 and the University of Georgia (UGA) from 1981-2006. He also did grassland research in New Zealand at two periods. He is a Fellow of the American Association for the Advancement of Science, and an inductee of the Georgia Cattlemen's Hall of Fame. He was predeceased by two beloved wives, Dorothy and Patricia, and now lives in Athens, Georgia. He is Terrell Distinguished Professor of Crop and Soil Sciences (ret.) at UGA.

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