

Comparison of Commercially Available Novel-Endophyte Tall Fescue Forage Varieties

NC STATE

EXTENSION

History and Importance of Tall Fescue as a Forage Crop

Tall fescue is one of the most common forage species in the eastern United States (Figure 1). First recognized on a Kentucky farm owned by William Suiter, it was initially known as “Suiter’s grass.” In 1931, E.N. Fergus, a professor and plant breeder at the University of Kentucky, visited Suiter to look at the grass. He recognized the potential of this grass to contribute to grassland agriculture, so he took seeds to the University of Kentucky, where he began growing it in test plots. William Johnstone, a fellow professor, encouraged Fergus to release this variety of tall fescue, Kentucky-31 (KY-31), to the public in 1943. Kentucky-31 tall fescue quickly became the forage of choice across the mid-South due to its superior drought tolerance, ability to withstand heavy grazing, and high yield capacity.

The improved agronomic performance of KY-31 is the result of a fungal endophyte living between the cells of the plant. The endophyte found in KY-31 (sometimes called the “wild type” endophyte) produces toxins called ergot alkaloids and other groups of alkaloids that are beneficial to the plant. However, these alkaloids can cause detrimental effects that lead to loss of production when animals consume infected plants. Health and reproductive effects include decreased intake, decreased weight gains and milk production, abortion, rough hair coat (Figure 2A), increased heat sensitivity, and severe lameness. These symptoms are collectively called “fescue toxicosis syndrome,” and they result in a loss of about \$1 billion in the U.S. cattle industry each year. Decreased performance also reduces income produced by other farm animal species, including small ruminants and equines, which also forage on KY-31.

In the 1980s and 1990s, endophyte-free (EF) varieties of tall fescue were released as a solution to fescue toxicosis. However, absence of the endophyte negatively impacted seedling vigor and plant persistence, greatly reducing the agronomic performance of EF varieties of tall fescue compared to KY-31.



Figure 1. Heifers grazing novel-endophyte (NE) tall fescue stockpiled for winter grazing. Photo by Charlotte Talbott.



Figure 2A. Heifer, suffering from fescue toxicosis, grazing toxic tall fescue. Note mud stains, created when the animal makes wallows to attempt to alleviate heat stress. Photo by Matt Poore.

Naturally occurring, nontoxic “novel” endophytes had been previously identified in perennial ryegrass, which led to identification of novel endophytes in tall fescue. These novel endophytes were isolated and transferred into improved tall fescue varieties, creating what is

now commercially available as novel-endophyte (NE) tall fescue (Phillips 2012). Novel-endophyte tall fescue is NOT the same as EF tall fescue, as NE tall fescue has increased persistence due to endophyte presence. Novel-endophyte tall fescue retains the agronomic benefits of KY-31 fescue without the toxicity to animals (Roberts et al. 2002; Nihsen et al. 2004). Though these breakthroughs have been available to producers for more than 20 years, their adoption has remained low. The cost of renovating pastures, uncertainty concerning NE tall fescue stand persistence, and confusion surrounding the available varieties may be reasons why farmer implementation has been slow. To provide streamlined information about available NE tall fescue varieties, North Carolina State University, the Alliance for Grassland Renewal, and cooperating seed companies have created this publication to help farmers identify the best NE tall fescue variety for each unique production situation.

Planning for Renovation

Renovation should begin by controlling seedheads of existing cool-season perennials, such as KY-31, during the spring prior to renovation. This reduces viable seed on the land, preventing development of new KY-31 seedlings along with the newly established NE tall fescue seedlings. Implementing either a spray-smother-spray or spray-wait-spray land management plan will further ensure that competition is eliminated—by eliminating seedlings and missed places (skips in spray pattern) twice before establishment. Achieving a successful renovation requires planning and attention to detail, but it is generally more successful than establishment of many other forage types.

Choosing and Purchasing Seed

Before shopping for seed, understand that there are three distinct types of tall fescue available: endophyte-infected KY-31, EF (contains no endophyte), and NE-infected (tall fescue variety matched with a proven NE). For the best combination of agronomic and animal performance attributes, NE tall fescue will usually be the best choice across the entire Fescue Belt, which stretches from Kansas to North Carolina and from Pennsylvania to Georgia. In this region, KY-31 tall fescue has established itself as the primary forage plant present in pastures. Endophyte infection is critical for plant survival across most of the Fescue Belt. Endophyte-free tall fescue is recommended only for situations not requiring a long-lasting pure stand of tall fescue, such as in multispecies forage mixtures; in short crop rotations; or in the most temperate parts of the Fescue Belt. Alternatively, KY-31 is generally not recommended except in situations in which a very stress-tolerant stand is needed and high

animal performance is not an important goal. Endophyte-free varieties generally will not tolerate conditions such as drought, constant overgrazing, or insect infestation because they do not contain an endophyte. Alternatively, NE varieties perform better than EF varieties under such conditions, but are more expensive to establish than KY-31, therefore making it counterintuitive to plant them where these issues are expected and will not be mitigated.

Novel-endophyte tall fescue seed is significantly more expensive than the other varieties of forage-type tall fescue; however, economic calculations have shown that the initial input cost can be offset by increased revenue resulting from improved animal performance (Figure 2B), as compared to that of KY-31. Choosing the best variety of NE tall fescue involves consideration of many factors, such as region and management style. The two soft-leaf types, BarOptima® PLUS E34® and Tower^{Protek}®, can be expected to support slightly higher intake and animal performance (important for dairy and stocker cattle), but these varieties require increased attention to management, and preferential grazing may lead to overgrazing. Traditional-leaf NE tall fescue varieties still support high levels of performance and are generally less likely to be overgrazed than soft-leaf counterparts.

It is critical to begin planning early for conversion to NE tall fescue varieties for many reasons. You must consider that NE tall fescue seed is not stocked early in the season in quantities comparable to KY-31. Novel-endophyte tall fescue seed is generally not harvested until July of the establishment year. After commercial seed is harvested, it is sampled and submitted for testing under the quality-control standards of the Alliance for Grassland Renewal. To qualify for an Alliance for Grassland Renewal quality-



Figure 2B. Healthy heifers grazing Jesup MaxQ II®, a novel-endophyte tall fescue. Minus stressors caused by toxicosis, the animals display good body condition and clean coats. Photo by Matt Poore.

assurance label (Figure 3), seed lots must contain at least 70% viable endophyte and no more than 5% “off type/wild type endophytes” (KY-31 or turf-type varieties containing high ergot alkaloids). The timing of seed harvest and the subsequent quality-control process mean seed becomes available very close to establishment season. Because of this, planning for and placing seed orders ahead of time are recommended. Upon receiving a shipment, store seed in a cool, dry place until planting. It may be difficult or impossible to obtain NE tall fescue seed without pre-ordering, as many dealers do not generally stock large quantities; however, seed supply stores commonly have some EF varieties (for example, KY-32) and KY-31 in stock. To purchase the correct seed, it is important to be aware of the differences between EF, NE, and wild-type endophyte-infected tall fescue varieties. The Alliance for Grassland Renewal quality-assurance label will always be present on proven NE forage-type tall fescue seed.

recommended seeding rate ranges from 13 to 25 lb/acre (consult state-specific planting guides). Seed should be planted at a depth of ¼” to ½” using a no-till drill or broadcast onto a prepared seedbed and followed with a cultipacker. Seeding too deeply is the most common cause of establishment failure. It is best to consult specific state planting guides for recommended planting dates; within the Fescue Belt, early autumn is the usual planting time. Before planting, amend soil pH to a value between 6.0 and 6.5 and apply phosphorus and potassium according to soil tests. Starter nitrogen should be applied at a rate of 25 to 35 lb/acre.

General management recommendations for new novel fescue stands are applicable to all varieties. Do not graze or hay new stands until they are 6” to 8” tall, being sure to leave 3” to 4” of residual after grazing or haying. Rest newly established pastures during the summer season.

Comparison of Tall Fescue Products and Traits

Table 1 compares available NE products, a common EF variety, and KY-31. Traits for comparison include time to maturity and leaf type. Time to maturity is presented relative to KY-31 and is adapted from the University of Kentucky’s variety trial results (Spitaleri et al. 2002). Leaf type is classified as either traditional or soft, with most tall fescue varieties being classified as having a traditional leaf type, which is how the blades of KY-31 are classified. Tower^{Protek}® and BarOptima® PLUS E34® are considered to have a soft leaf type. Currently, there is no accepted standard method among agronomists of assessing and assigning a leaf type, but there are specific visual and tactile differences, although these are subjective. In general, a traditional leaf feels somewhat coarse and has a sharp serrated leaf edge. A soft leaf feels softer and the leaf edge is not as sharp. Livestock find the soft leaf varieties more palatable, so they will tend to eat more, and this means they are more likely to overgraze. While soft leaf types may lead to better animal performance, the importance of management to prevent overgrazing cannot be overemphasized. Seedling vigor, which is the ability of seedlings to survive during the plant’s early development, is also a very important trait considered during variety development.

Seedling vigor, forage yield, and animal performance have not been different among varieties during most variety trials, other than the obvious KY-31, so these categories are not included in the table. Stand life and persistence are also not included in the table because there is not enough long-term data to provide an estimate, although available data indicates that EF varieties are less

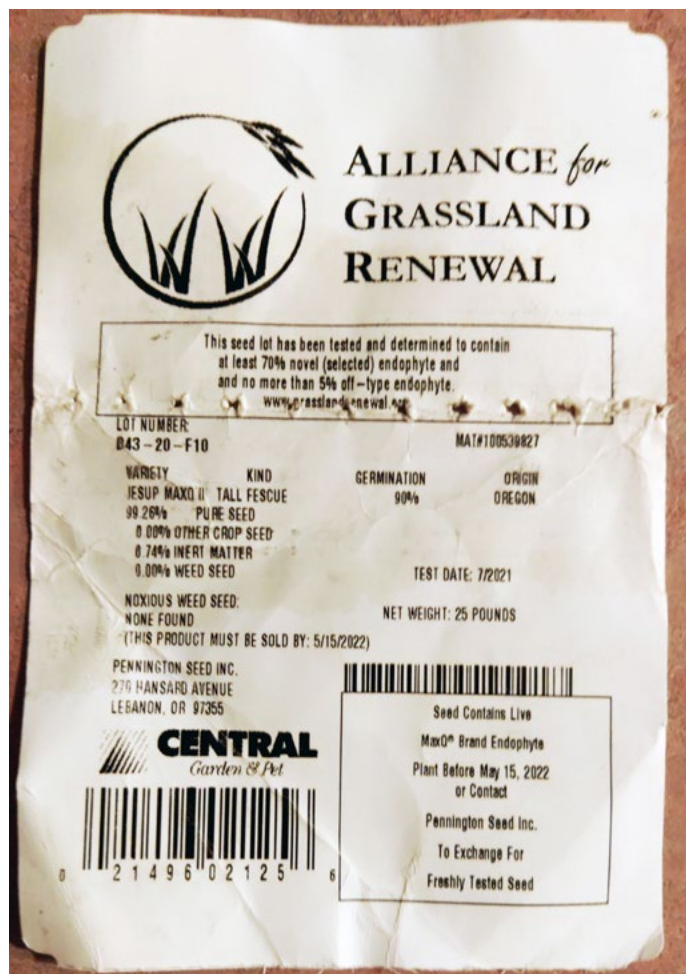


Figure 3. The Alliance for Grassland Renewal quality-assurance label documents that the seed has been tested and meets the standards for infection rate with viable novel endophyte. Photo by Matt Poore.

Establishment and Management

Establishment and management recommendations are essentially the same for all NE varieties. The

Table 1. Comparison of Tall Fescue Products and Traits

Product	Company	Endophyte Technology	Endophyte Type	Leaf Type	Time to Maturity	Target Market Area
Lacefield MaxQ II®	Pennington	MaxQ II®	Novel	Traditional	Medium	Northern Fescue Belt
Texoma MaxQ II®	Pennington	MaxQ II®	Novel	Traditional	Early	Western Fescue Belt
Jesup MaxQ II®	Pennington	MaxQ II®	Novel	Traditional	Early	Eastern Fescue Belt
Jesup MaxQ®	Pennington	MaxQ®	Novel	Traditional	Early	Eastern Fescue Belt
Tower ^{Protek} ®	DLF Pickseed	Protek®	Novel	Soft	Late	Northern Fescue Belt
BarOptima® PLUS E34®	Barenbrug	E34®	Novel	Soft	Late	Fescue Belt
Martin 2 ^{Protek} ®	DLF Pickseed	Protek®	Novel	Traditional	Early/ Medium	Fescue Belt
Estancia with ArkShield®	Mountain View Seeds	ArkShield®	Novel	Traditional	Medium	Fescue Belt
Cajun II ¹	Smith Seed Services	None	None (Endophyte Free)	Traditional	Early	Fescue Belt
Kentucky-31 (KY-31) ²	None	Wild Type (Toxic)	Wild Type (Toxic)	Traditional	Medium	Fescue Belt

(Spitaleri et al. 2002; Olson et al. 2019)

1 Cajun II is included as an example of a popular endophyte-free (EF) variety for comparison.

2 Kentucky-31 (KY-31) is included as an example of tall fescue varieties usually infected with toxic endophyte.

persistent and have shorter stand life than KY-31 and NE varieties. Ergot alkaloid concentrations among NE and EF varieties are generally negligible, with the exception of BarOptima® PLUS E34®. Typically, the ergot alkaloid concentrations produced by BarOptima® PLUS E34® are well below what is considered toxic; however, toxin levels vary between years and within seasons. Although these levels are highly variable, they are typically negligible in relation to animal performance; however, special caution should be taken for pregnant mares (Dillard, Smith, and Hancock 2019).

History and Description of Current Novel-Endophyte (NE) Tall Fescue Varieties

Pennington

Pennington offers four varieties of NE tall fescue. None of these varieties are commercially available as endophyte-free. All are traditional-leaf varieties, with the latest three utilizing the same endophyte technology (AR584). AR584 is sold under the trade name MaxQ II®. The largest difference between varieties is the specified regions for which they are adapted. All are adapted to the Fescue Belt, with Texoma MaxQ II® having capabilities in the drier western regions and even outside of the Fescue Belt, and Lacefield MaxQ II® being well suited

for Kentucky and the surrounding area. Lacefield MaxQ II® is also a later maturing variety. Jesup MaxQ II® is the current recommendation for the eastern Fescue Belt.

Jesup MaxQ® and Jesup MaxQ II®

Jesup MaxQ® was the first NE fescue product made commercially available, and it was marketed simply as MaxQ®. The story of its development begins with Joe Bouton, a forage breeder at the University of Georgia in 1977. Around this time, work was being done to identify the cause of fescue toxicosis syndrome, and the staff at the United States Department of Agriculture's Richard B. Russell Research Center in Athens, Georgia, proposed that fungal endophytes living in KY-31 were the cause. Researchers at Auburn University began fescue grazing studies and noticed that on some pastures, animal weight gains were nearly double that of others. These pastures had been planted with fescue seed from a previous year, and a combination of time and storage in warm conditions had killed the endophyte in this seed. Bouton created populations of fescue and selected for persistence, but his selections proved to be highly infected with the toxic endophyte. Endophyte-free populations were created from these varieties, but stands of these EF varieties did not persist in trials, further proving that the endophyte was connected to the exceptional agronomic performance of KY-31 tall

fescue. Bouton began to search for a way to maintain the agronomic performance of the toxic populations while eliminating the negative effects on animal performance.

Research was being done in New Zealand at that time to isolate strains of endophyte from around the world in both perennial ryegrass and tall fescue. The research was led by Garry Latch of AgResearch. Bouton met Latch at the International Grassland Congress in France in 1989 and began a collaborative effort to create a nontoxic fescue that contained an NE. Using both of his developed fescue populations, Jesup and Georgia 5, Bouton conducted research to identify which variety would respond best to several different NEs, and he chose Jesup with AR542 endophyte. Grazing trials were conducted across several animal species, including cattle, sheep, and horses, to ensure that this NE did not have toxic effects. The trials proved that this NE allowed for the best of both worlds: agronomic persistence and no negative impacts on animal health and well-being. MaxQ® Tall Fescue, as it would come to be marketed, was rigorously tested across several different environments to prove the plant's ability to perform in many regions of the Fescue Belt. Because it was the first NE tall fescue variety, more is known about MaxQ® than many varieties on the market now. Recently, Pennington has begun to replace Jesup MaxQ® with Jesup MaxQ II®. Jesup MaxQ II® utilizes the same variety of fescue as Jesup MaxQ® but contains an improved, more resilient NE, AR584, known commercially as MaxQ II®.

Lacefield MaxQ II®

Tim Phillips began his career as a forage breeder at the University of Kentucky in 1992, where he inherited an old tall fescue variety trial. In the spring of 1993, he selected plants from several EF KY-31 genetic lines and began crossing these plants, selecting for excellent seedling vigor and later-maturing plants than KY-31. At the time, tobacco was a large agricultural crop in Kentucky. Most farmers growing forage there also produced tobacco, which often delayed hay harvest until after setting tobacco. This delay resulted in lower-quality hay, leading Phillips to select plants that matured later, allowing the forage to maintain its quality later in spring. In 2002, Phillips was beginning the process for releasing this EF variety, known at the time as KYFA9301, when he was approached by the New Zealand-based company AgResearch about using one of its NEs in the variety. The research process proceeded for 13 years after the addition of the NE and nearly 22 years after KYFA9301 was released as Lacefield MaxQ II® in 2015. Lacefield MaxQ II®, named for forage pioneer Garry Lacefield, became widely available in 2018.

Texoma MaxQ II®

Researcher Andy Hopkins began work at the Noble Research Institute in April 1997 and immediately began developing a cool-season perennial forage well-suited for the southern Great Plains. The institute had extremely old tall fescue pastures in southern Oklahoma. Hopkins began collecting seed from tall fescue plants in high and dry areas of these pastures, which gave this tall fescue the characteristic of being selected from an existing population, rather than being bred. It was evaluated for several years for grazing tolerance during periods of drought. The institute partnered with AgResearch to infect the plant with an NE, AR584, making extensive efforts to ensure that there was no toxic endophyte infection. Using lambs, cattle, and horses, several grazing trials were performed at the institute and at collaborating universities during periods of drought, and the variety proved persistent. The name Texoma MaxQ II® was chosen for this Product because of its origin and target market in Texoma—an interstate region containing parts of Texas and Oklahoma.

Mountain View Seeds

Estancia with ArkShield®

The development of Estancia with ArkShield® began as a fescue variety called HiMag being studied at the University of Missouri and the United States Department of Agriculture's Agricultural Research Service (USDA-ARS) in Idaho. The original goal was to produce a variety with low grass-tetany potential (because it contains higher magnesium than most tall fescue). The University of Arkansas, in cooperation with the University of Missouri, furthered research on HiMag to create ArkPlus NE tall fescue. It was not marketed to reduce the risk of grass tetany but rather as a variety well-adapted to the transition zone of the eastern half of the United States with an endophyte proven to aid plant persistence while lacking livestock toxins. ArkPlus was pulled from the market due to a patent dispute. Eventually, Peak Plant Genetics and Mountain View Seeds in Oregon obtained the rights to produce and market this variety. It is sold under the brand name Estancia with ArkShield®. Estancia with ArkShield® is marketed as a medium-maturing, high-yielding tall fescue with high seedling vigor and very good persistence if properly managed. No EF version of this variety is available. Much of the research data was produced in Arkansas and Missouri, but Estancia with ArkShield® has also done well in many other locations in the eastern and southeastern United States.

DLF Pickseed

Protek® Endophyte Program

The company DLF Trifolium began in 1906 when a group of Danish seed growers formed a grass seed cooperative in Denmark. The cooperative later expanded into other countries. When DLF's expansion reached Australia and New Zealand, the company noticed the value of NEs, which led to a group collaboration and the isolation of the endophyte (referred to as *Protek®*). This endophyte naturally existed in the wild and was found and brought back to be analyzed. The endophyte *Protek®* was first developed in the United States with the isolations ISO 207 and ISO 647. These isolations were able to move forward in trials and research and were both introduced to a potential host: Martin 2. After many trials and research studies, it was decided that ISO 647 would be renamed *Protek®* due to its performance and stable relationship with its host, while ISO 207 did not move forward in development. One of the most notable moments in the research on *Protek®* was the discovery that it was safe, had a stable relationship with its host plant, and did not produce any ergot alkaloids.

Martin 2^{Protek®}

Protek® was inoculated into the Martin 2 variety because of its genetics and compatibility. Research with Martin 2^{Protek®} spread to the United States with animal safety trials beginning in 2009 and ending in 2012. These trials, conducted with sheep, demonstrated no negative impacts on the animals' weight gain or health. The Martin 2 variety was developed from Mozark, Martin, Cajun and KY-31 genetics. It is traditional in terms of leaf type and growth and has an early to medium maturity relative to other varieties. Martin 2^{Protek®} produces a high quantity of forage, but compared to Tower^{Protek®}, the quality ranks lower. Martin 2^{Protek®} also has good fiber digestibility and is relatively preferred or well-selected to be grazed by livestock. DLF Pickseed also sells an EF variety simply named Martin 2, which does not contain *Protek®* or an endophyte of any kind, so farmers wishing to establish NE tall fescue need to make sure they are using Martin 2^{Protek®}.

Tower^{Protek®}

The variety Tower originated in France. Tower is considered to have a later maturity and a softer leaf than many other tall fescue varieties, although a method to test leaf type has not been established. This soft-leaf variety has improved quality and digestibility, but it must be more closely managed than some other varieties because animal preference for softer leaves can lead to overgrazing. In the United States, *Protek* endophyte technology was added to Tower for regions where endophyte is needed. Tower^{Protek®} is more focused on

quality rather than total weight of forage production, and is best suited to situations that need high performance. Tower^{Protek®} is commonly found in the northern Fescue Belt, but may perform well farther south if soil, environment, and management conditions are suitable.

Barenbrug USA

BarOptima® PLUS E34®

The development of BarOptima® PLUS E34® began in the 1990s in France as the demand for an NE tall fescue increased in the United States. The first successful line, created from an NE and a selection from Barenbrug breeding lines, was named BE9301. As development progressed, trials of what is now known as BarOptima® PLUS E34® began in the United States in the early 2000s. After many years of trials and research, BarOptima® PLUS E34® was finally patented in January 2010. The name was created by Devesh Singh, a Barenbrug agronomist, who wanted to portray the superiority for germplasm and the endophyte to consumers. He wanted a name that would identify the company and describe the multiple optimum traits of the variety, hence BarOptima® PLUS E34®. Although the early stages of the development process began in France, the credit for this variety of fescue must also be shared with a group of scientists in the Netherlands who performed the initial endophyte inoculation. While testing leaf type is subjective and there is not an established method to do so, BarOptima® PLUS E34® is considered to have a softer leaf than other fescue varieties. European breeders selected a softer leaf germplasm to increase both the palatability and the digestibility of the grass. Because a softer leaf may lead to better digestibility, livestock may prefer it over other grasses, making it more prone to overgrazing in the absence of proper management. The target market for BarOptima® PLUS E34® is the southern two-thirds of the Fescue Belt.

Smith Seed Services

Cajun II*

Cajun II is a popular example of many EF tall fescue varieties that perform well in the northernmost areas of tall fescue adaptation. These varieties also are sometimes useful in multispecies mixtures or for short-term rotations (especially for hay production) within the entire Fescue Belt. Early research on the development of Cajun II began in the late 1980s to produce a nontoxic variety of fescue that was well-adapted to the southern half of the Fescue Belt (including North Carolina, Kentucky, Tennessee, and South Carolina). Wayne County in North Carolina was the original testing site for Cajun II, with supporting research taking place in Pennsylvania and Kentucky. The development was a decade-long process that selected

traits for regional adaptation, winter hardiness, and pest resistance. Breeders started by looking at varieties that excelled in these traits, including Cajun, Martin, Mozark, and other hardy varieties like KY-31. Two types of tall fescue germplasm, Mediterranean and Continental, were crossed to make Cajun II. Mediterranean plants are summer dormant, and Continental varieties are summer active, making Cajun II suited to spring and summer performance.

Cajun II is generally recommended for hay production in mid-Atlantic states due to its hardiness, persistence, and low management input. During the time of development, there was a growing need for a variety other than the toxic KY-31, and other available varieties had limited survivability in harsher climates. Early reports of other EF varieties showed limited survivability (although there was often no yield difference), meaning they should not be recommended for continuous grazing. Cajun II showed equal survivability performance to NE varieties in three-year clipping trials, making it an affordable option for rotational grazing conditions or hay production. However, Cajun II is not recommended for situations in which a very long-lived monoculture stand is desired, or where overgrazing may occasionally occur. Cajun II is also recommended for hay production because it is earlier to mature, yielding more cuts of hay. While Cajun II is targeted primarily for the mid-Atlantic states, it is also popular in Missouri, Oklahoma, North Carolina, South Carolina, Tennessee, Virginia, Kentucky, Arkansas, northern Texas, northern Mississippi, northern Alabama, northern Georgia, and Canada. Establishment recommendations include terminating all KY-31 before planting or diluting KY-31 without completely killing it. Cajun II can be seeded into KY-31 with a stress/shock approach by withholding fertilization in the spring, grazing heavily during the summer, broadcasting Cajun II when KY-31 is grazed short, and then “hoofing-in” with cattle. Cajun II and orchardgrass work very well when planted together.

** It is generally recommended that farmers plant NE varieties, but in some cases an EF variety may fit the need of a specific farm. Cajun II is described here for purposes of comparison. Its inclusion does not imply that other EF varieties would not also occasionally be appropriate.*

Summary

Novel-endophyte (NE) tall fescue is a productive, persistent grass plant for the Fescue Belt of the United States, where the soils and climate support tall fescue. Novel-endophyte tall fescue supports a high level of animal performance comparable to endophyte-free (EF) tall fescue, while delivering the agronomic performance expected from toxic KY-31 tall fescue. The NE tall fescue varieties described here are subjected to quality control through the Alliance for Grassland Renewal, which has set standards for marketing this technology. When creating a pasture renovation plan, select an appropriate variety carrying the Alliance for Grassland Renewal label, which confirms that the specific lot of seed passed stringent quality-control tests.

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