

UNDERSTANDING THE TALL FESCUE ENDOPHYTE

PRACTICAL SOLUTIONS TO THE FESCUE TOXICITY PROBLEM



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UNDERSTANDING THE TALL FESCUE ENDOPHYTE

Tall fescue (*Lolium arundinaceum* Schreb. Darbysh; formerly *Festuca arundinacea* Schreb.) is a versatile perennial grass used for livestock feed, turf and erosion control. Commonly referred to simply as “fescue,” it is easy to establish, tolerant of a wide range of management regimens and a good forage yielder. Laboratory nutritive analyses of fescue compare favorably to those of other cool-season perennial grasses.

Fescue was first planted on a widespread basis in the USA in the 1940s and now is estimated to occupy over 35 million acres. However, in the late 1970s it was discovered that in most of this acreage a high percentage of fescue plants were infected with an endophyte (*Acremonium coenophialum*). “Endophyte” means internal fungus; it grows *inside* fescue plants. Soon thereafter it was learned that this endophyte can produce toxins (specifically, ergot alkaloids) that can have profound negative effects on grazing animals. However, the endophyte has positive effects on the grass itself.

Anyone who uses tall fescue to provide nutrition for grazing animals needs to know about the fescue endophyte. This story constitutes one of the most important developments in the history of agricultural research, and is of great economic importance to livestock producers.

ENDOPHYTE TERMS

To set the stage for this discussion, three terms pertaining to the tall fescue endophyte that will be used throughout this publication need to be defined. Abbreviations of these terms (TE, EF and NE fescue) will be used throughout the remainder of the publication.

TE (Toxic “Wild” Endophyte) Fescue

This refers to tall fescue that contains the wild type of endophyte that infects most of the millions of acres of this grass established in the United States beginning in the 1940s. TE fescue produces toxic alkaloids that cause animal disorders.

EF (Endophyte-Free) Fescue

This term refers to tall fescue that does not contain an endophyte. If there is no endophyte, then there will be no endophyte-related toxic alkaloid production, and thus endophyte-free fescue is non-toxic. However, endophytes also produce compounds that favor pest resistance and stress tolerance of fescue plants, with the result being that endophyte-free types have generally not been as persistent as endophyte-containing types in stressful environments (i.e. roughly the southern half of the area in which tall fescue is adapted in the United States).



NE (Novel Endophyte) Fescue

In the late 1990s, scientists identified strains of the tall fescue endophyte that do not produce the alkaloids that cause the animal disorders described in the following section of this publication. However, novel endophytes *do* produce compounds that favor pest resistance, grazing tolerance and persistence in stressful environments. NE strains have been inserted into some fescue varieties and several are commercially available. Either EF fescue or NE fescue can be referred to as being non-toxic.

A description of the livestock disorders associated with certain alkaloids produced by TE fescue are as follows.

LIVESTOCK DISORDERS

Fescue Foot

Fescue foot is a dry, gangrenous condition of the body extremities of cattle consuming TE fescue. Usually it causes lameness and/or loss of the tips of tails or ears, but may result in sloughing of hooves or feet. Animal gains also are reduced. Fescue foot is generally associated with cold weather.

Bovine Fat Necrosis

This condition of cattle is characterized by the presence of masses of hard fat in the abdominal cavities that can cause digestive or calving problems. It usually occurs only where essentially pure TE fescue pastures have been heavily fertilized with poultry litter or nitrogen fertilizer. Fat necrosis is normally an issue only in older cows that have grazed TE for an extended period of time (usually their entire lifetime).

Fescue Toxicity

Signs of fescue toxicity in many species of grazing animals can include: (1) reduced feed intake; (2) decreased weight gain; (3) lower milk production; (4) increased respiration rate; (5) elevated body temperature; (6) rough hair coat; (7) more time spent in water and/or shade; (8) less time spent grazing; (9) low blood serum prolactin concentration; (10) excessive salivation; and (11) lower reproductive performance. Some or all of these responses have been observed with beef cattle, dairy cattle, sheep and deer consuming TE fescue

pasture, greenchop, hay and/or seed. (In an attempt to minimize confusion, it should be stated that the term fescue toxicity is sometimes used to refer to all fescue endophyte-related disorders, but that is not the case in this publication.)

The term “summer slump” (used by many as a synonym for fescue toxicity) refers to a drop off in weight gain of animals grazing fescue during warm weather. High temperatures, high levels of ergot alkaloids (especially common in late spring) and increased fiber in the diets of animals all play a role in decreased performance of grazing animals on fescue during warm weather. As a result, animals are in a general malaise (due mainly to elevated body temperatures) that results in less grazing time and lower forage intake.

Horse Disorders

Reproductive difficulties of mares grazing toxic endophyte fescue have been widely recognized and are often severe or in some cases lethal. They include: abortions, prolonged pregnancy, foaling problems that can result in foal and/or mare deaths, thick or retained placentas and agalactia (little or no milk production).

Fescue foot and bovine fat necrosis can be important to individual producers, but are of relatively little consequence on a nationwide basis. However, fescue toxicity is of widespread occurrence and of great economic importance to cattle producers. Also, reproductive difficulties of mares can be devastating for a horse producer.

ANIMAL SYMPTOMS OF FESCUE TOXICITY

Grazing Time

Several studies have shown that as toxic endophyte infection level (the percentage of fescue plants in a stand that are infected) increases, animals spend less time grazing during the day and more time grazing at night. In Maryland, grazing time was reduced by about 20% as compared to steers grazing EF fescue (Table 1). In a Georgia study, steers grazing EF (<1% Infected) spent about 60% of the time between noon and 6:00 p.m. grazing as compared to only about 5% of the time for steers grazing TE (95% infected) fescue. Steers switched to TE fescue showed a reduction in grazing time within two days, and forage intake for this group was depressed within one week. Forage intake for the group switched to EF fescue remained

lower for at least 10 days following the switch, but was normal after 28 days.

Table 1. Percentage of the time steers grazed during daylight or dark hours.

| | Endophyte Level | |
|----------|-----------------|--------|
| | Low % | High % |
| Daylight | 52 | 34 |
| Dark | 14 | 22 |

Bond, J., J.B. Powell and B.T. Weinland. 1984. Behavior of steers grazing several varieties of tall fescue during summer conditions. *Agron. J.* 76:707.

Intake and Digestibility

On-farm observations and research have provided evidence that cattle prefer EF and NE fescue over TE fescue. In Tennessee, steers had a preference for clover in TE pastures, but there were indications that they preferred fescue to clover in EF pastures. When heifers in Missouri were offered diets containing 60% fescue

seed, either EF or 75% TE, 11 of 12 heifers avoided the TE diets. Much, but not all, of the reduction in livestock average daily gain (ADG) or gain per unit area of land on TE fescue is due to reduced feed intake. Forage digestibility and crude protein levels are similar in TE, EF and NE fescue.

Table 2. Daily gains of steers as affected by low or high incidence of endophyte infection.

| Location | Endophyte ¹ | | Daily gain | | Feed | Reference |
|-------------|------------------------|-------------|-----------------|------------------|---------|-----------------------|
| | Low E % | High E % | Low E lb/day | High E lb/day | | |
| Alabama | 2 | >90 | 1.83 | 0.99 | Pasture | Hoveland et al., 1983 |
| Alabama | 0 | >90 | 1.46 | 0.62 | Hay | Schmidt et al., 1982 |
| Alabama | 0 | 100 | 2.12 | 0.44 | Seed | Schmidt et al., 1982 |
| Arkansas | 0 | 81 | 1.57 | 1.21 | Pasture | Goetsch et al., 1988 |
| Georgia | 0 | 89 | 2.27 | 0.81 | Pasture | Hoveland et al., 1997 |
| Kentucky | <1 | 61 | 1.54 | 0.99 | Pasture | Boling, 1985 |
| Mississippi | NR ² | NR | 1.50 | 1.01 | Pasture | Evans et al., 1989 |
| Missouri | 3 | 83 | 1.37 | 0.46 | Pasture | Crawford et al., 1989 |
| Oklahoma | <1 | 76 | 1.87 | 1.37 | Pasture | McMurphy et al., 1990 |
| Tennessee | 2 | 71 | 1.48 | 1.06 | Pasture | Chestnut et al., 1991 |
| Texas | 8 | 91 | 2.14 | 1.01 | Pasture | Read and Camp, 1986 |
| Virginia | 0 | 77 | 1.43 | 0.90 | Pasture | Tulley et al., 1989 |

¹Number of infected tillers per 100 tillers.

²Not reported.

Boling, J.A. 1985. Endophytic fungus and tall fescue utilization by ruminants. Prof. Anim. Sci. 1:29.

Chestnut, A.B., H.A. Fribourg, J.B. McClaren, D.G. Keitner, B.B. Reddick, R.J. Carlisle and M.C. Smith. 1991. Effects of *Acremonium coenophialum* infestation, bermudagrass and nitrogen or clover on steers grazing tall fescue pastures. J. Prod. Agric. 4:208.

Crawford, R.J., J.R. Forwood, R.L. Belyea and G.B. Garner. 1989. Relationship between level of endophyte infection and cattle gains on tall fescue. J. Prod. Agric. 2:147.

Evans, R.R., R.L. Ivy, A.W. Groce and W. Cox. 1989. Selenium supplementation for steers on fungus free and fungus infected fescue pastures. (Preliminary report) Proc. Tall Fescue Toxicosis Workshop. Nov. 13-14, Atlanta, GA.

Goetsch, A.L., K.L. Landis, G.E. Murphy, B.L. Morrison, Z.B. Johnson, E.L. Piper, A.C. Hardin and K.L. Hall. 1988. Supplements, parasite treatments and growth implants for Brahman or English crossbred steers grazing endophyte-infected or noninfected fescue in the spring and fall. Prod. Anim. Sci. 4:32.

Hoveland, C.S., M.A. McCann, and J.H. Bouton. 1997. Influence of endophyte, alfalfa and grazing pressure on steer performance and plant persistence of Jesup tall fescue. J.Prod. Agric. 10:546-550.

Hoveland, C.S., S.P. Schmidt, C.C. King, Jr., J.W. Odom, E.M. Clark, J.A. McGuire, L.A. Smith, H.W. Grimes and J.L.Holliman. 1983. Steer performance and association of *Acremonium coenophialum* fungal endophyte on tall fescue pasture. Agron. J. 75:821.

McMurphy, W.E., K.S. Lusby, S.C. Smith, S.H. Muntz and C.A. Strasia. 1990. Steer performance on tall fescue pasture. J.Prod. Agric. 3:100.

Read, J.C. and B.J. Camp. 1986. The effect of the fungal endophyte *Acremonium coenophialum* tall fescue and animal performance, toxicity and stand maintenance. Agron. J. 78:848.

Schmidt, S.P., C.S. Hoveland, E.M. Clark, N.D. Davis, L.A. Smith, H.W. Grimes and J.L. Holliman. 1982. Association of an endophytic fungus with fescue toxicity in steers fed Kentucky 31 tall fescue seed or hay. J. Anim. Sci. 55:1259.

Stuedemann, J.A., S.R. Wilkinson, D.P. Belesky, C.S. Hoveland, O.J. Devine, F.W. Thompson, H.S. Campbell, W.E. Townsend and H. Ciordia. 1986. Effect of level of fungus and nitrogen fertilization rate of KY-31 tall fescue on steer performance. J.Anim. Sci. 63 (Suppl.1):290 (Abstr.).

Tulley, J.K., J.P. Fontenot and V.G. Allen. 1989. Influence of endophyte infection in performance of steers grazing tall fescue with and without clover. (Preliminary report) Tall Fescue Toxicosis Workshop. Nov. 13-14, Atlanta, GA.

Effects on Beef Yearling Gains

Many grazing and feeding trials comparing TE and non-toxic fescue have been conducted. A summary of data (Table 2) illustrates that as compared to non-toxic fescue, decreased gains of steers grazing TE forage are widespread, quite uniform and not limited to certain geographic areas or management conditions.

Fescue toxicity symptoms are most pronounced during hot weather, but poor weight gains on TE pastures can occur throughout the grazing season. In an Alabama study (Table 3), during November, December and March there was a 50% decrease in ADG of steers grazing TE fescue, as compared to EF fescue. During the warmer months of April, May and June, the decrease was 59%. However, in some studies the decrease in gain of stocker cattle on TE fescue as compared to non-toxic fescue has been about twice as severe in late spring as in autumn.

Factors affecting animal reaction to fungal toxins include air temperature, humidity, presence of other forages in the diet, animal management, and time of year (toxin levels are usually higher in late spring and autumn than at other times during the year). Though several factors affect reaction to the toxins, steer ADG typically

Table 3. Seasonal daily gains (lb) of steers grazing infected and non-infected fescue (3 yr average).

| Months | Endophyte | | ADG Decrease |
|------------------|-----------|------|--------------|
| | <5% | >94% | |
| Nov., Dec., Mar. | 1.59 | .79 | 50% |
| Apr., May, June | 1.72 | .71 | 59% |

Hoveland, C.S., S.P. Schmidt, C.C. King, Jr. and E.M. Clark.1984. Association of fungal endophyte with seasonal gains of beef steers grazing tall fescue pasture. In: H. Riley and A.D. Skelvag (Ed.) Proc. Eur. Grassl. Fed. p. 382-386.

decreases about 0.1 lb for each 10% increase in infection rate. Work done in Missouri and Georgia showed that TE fescue hay (especially ammoniated hay) contains lower levels of toxic alkaloids (usually half or less) than greenchop or silage.

In Georgia, grazing behavior of steers on TE and EF fescue pastures was similar in March. However, higher temperatures during April and June (and probably higher levels of ergot alkaloids present in pasture forage) resulted in steers on TE fescue spending less time

Table 4. Effect of endophyte-infected fescue on the performance of cows and nursing cows.

| Cows | | Pregnancy rate | | Daily gain | | Calves | | Reference |
|--------|--------|-----------------|--------|------------|--------|--------|--------|----------------------|
| Low E | High E | Low E | High E | Low E | High E | Low E | High E | |
| lb/day | | % | % | lb/day | lb | lb | | |
| 1.01 | -0.51 | -- ¹ | -- | 2.56 | 1.87 | 520 | 434 | Schmidt et al., 1983 |
| 0.46 | -0.11 | 95 | 55 | 1.72 | 1.37 | 474 | 410 | Gay et al., 1988 |
| 0.44 | -0.15 | 87 | 58 | 1.63 | 1.30 | 489 | 419 | Essig et al, 1989 |
| 0.09 | -0.24 | 89 | 74 | 1.61 | 1.28 | -- | -- | Tucker et al, 1986b |
| 0.79 | -0.46 | 78 | 49 | 2.25 | 1.90 | 529 | 461 | McDonald, 1989 |

¹Not determined or not reported

²Low E fescue was 21% INF vs. 77% for High E.

Essig, H.W., C.E. Cantrell, F.T. Withers, Jr., D.J. Lang, D.H. Laughlin and M.E. Boyd. 1989. Performance and profitability of cow-calf systems grazing on EF and EI KY-31 fescue. (Preliminary report) Proc. Tall Fescue Toxicosis Workshop, Nov. 13-14, Atlanta, GA.

Gay, N., J.A. Boling, R. Dew and E.D. Miksch. 1988. Effects of endophyte infected tall fescue on beef cow-calf performance. Appl. Agric. Res. 3:182.

McDonald, W.T. 1989. Performance of cows and calves grazing endophyte-infested pasture. M.S. Thesis. University of Tennessee, Knoxville.

Schmidt, S.P., C.C. King, Jr., C.S. Hoveland, E.M. Clark, L.A. Smith, H.W. Grimes and J.L. Holliman.1983. Cow-calf performance as affected by fungus infestation of Kentucky-31 tall fescue pastures. J. Anim. Sci. 57 (Suppl.1):295 (Abstr.).

Tucker, C.A., R.E. Morrow, J.R. Gerrish, C.J. Nelson, G.B. Garner, V.E. Jacobs, W.G. Hires, J.J. Schinkel and J.R. Forwood. 1989. Forage systems for beef cattle: Effect of winter supplementation and forage system on reproductive performance of cows. J. Prod. Agric. 2:217.

grazing, more time standing in the shade (heat stressed animals normally stand to maximize evaporative cooling) and consuming more water than steers on EF fescue. If forced to exert themselves physically during hot weather, animals suffering from severe fescue toxicity are at risk for heat overload that can result in death.

Increased nitrogen (N) fertilization increases the incidence of bovine fat necrosis, but investigations have revealed that N fertilization does not affect steer ADG on TE fescue (except indirectly by increasing the competitiveness and percentage of fescue plants in a pasture, thus increasing the amount of toxic fescue in an animal's diet). However, N fertilization of TE fescue can increase gain per acre because of higher stocking rates.

Effects on Beef Cows and Calves

Most fescue pastures in the United States are used in commercial beef cow-calf operations. In several studies (Table 4), cows grazing TE fescue lost weight and had lower pregnancy rates, and their nursing calves had slower gains and reduced weaning weights, compared to those grazing EF pastures.

A decline in body condition can affect reproduction, and cows that are thin before and at calving may have a long interval between calving and first estrus. Therefore, cows entering the breeding season in a poor or negative gaining condition because of TE fescue probably will have a prolonged post-partum interval regardless of later endophyte effects.

In Kentucky and Missouri, supplementary feed (in the form of either clover or grain) for cattle on TE fescue improved pregnancy rates, but not up to economically acceptable levels. Thus, it appears that factors other than

nutrition are involved in the reduced pregnancy rates associated with TE fescue. Research done in Arkansas and South Carolina indicates that if cattle are switched from TE fescue to NE fescue for at least 28 days prior to breeding, many of the TE impacts on reproduction can be eliminated.

Reproduction Effects on Bulls

Recent work done by scientists at the University of Tennessee and at Clemson University indicates that the reproductive efficiency of bulls is negatively affected by TE tall fescue. This research shows that a higher proportion of bulls grazing TE fescue fail breeding soundness exams than bulls grazing non-toxic tall fescue. In addition, semen morphology and motility are also negatively impacted by TE fescue. The result has been decreased rates of *in vitro* fertilization. Preliminary work from Clemson University indicates that actual conception rates can be depressed by 10-18% when semen from bulls grazing toxic tall fescue is used to inseminate cows that have not grazed fescue.

Effects on Beef Heifers

In an Alabama study, weaned beef heifers were assigned to pastures having low, medium or high levels of infection (Table 5), and received hay of similar infection levels during winter. Heifer ADG decreased as infection level increased. All heifers were observed in estrus prior to their first breeding, but pregnancy rates decreased as infection level increased. Following first calf births, pregnancy rates were further reduced in heifers grazing pastures with medium and high infection levels, but not in those grazing pastures containing a low percentage of plants infected with toxic endophyte.

Table 5. Effect of endophyte-infected fescue on gains, pregnancy rates and milk yield of heifers.

| Endophyte level % | Initial weight lb | Daily gains | | Post-calving milk | | |
|-------------------|-------------------|----------------|---------------|-------------------|------------|------------------|
| | | Grazing lb/day | Winter lb/day | Pregnant % | Pregnant % | Produced lb/12hr |
| 0-5 | 562 | 1.65 | 0.18 | 0.96 | 0.93 | 8.16 |
| 25-60 | 560 | 1.26 | 0.35 | 0.82 | 0.45 | 7.05 |
| 80-99 | 591 | 0.75 | 1.19 | 0.55 | 0.33 | 3.97 |

Danielson, C.A., S.P., Schmidt, C.C. King, L.A. Smith and W.B. Webster. 1986. Fescue toxicity and reproduction in beef heifers. J. Anim. Sci. 63 (Suppl.1): 296 (Abstr.).

Schmidt, S.P., D.A. Danielson, J.A. Holliman, H.W. Grimes and W.B. Webster. 1986. Fescue fungus suppresses growth and reproduction in replacement beef heifers. Alabama Agric. Exp. Stn. Highlights Agric. Res. 33 (4):15.

Initiation of the estrous cycle in heifers grazing TE fescue was not delayed, and cessation of the estrous cycle in animals already cycling did not occur. Reduced calving percentages of cattle on TE fescue appears to be due to some combination of early embryonic death, semen quality issues and perhaps other factors.

Brahman vs British Breeds of Cattle

Brahman cattle are known for their heat tolerance, and may be better adapted to resist or tolerate the hyperthermia (high body temperature) observed during hot weather. In breed comparisons, both Angus and Brahman-Angus cross steers have exhibited decreased gains when grazing TE fescue, but the magnitude of the decrease is less for the Brahman-cross steers. Brahman-cross animals frequently gain better due to greater heterosis, so reduced endophyte effects, if any, are difficult to detect.

Feedlot Gains of Steers that Previously Grazed Fescue

Because of their unthrifty appearance, steers that have grazed TE fescue often sell for less, making it important to determine whether there are carryover effects on feedlot performance. Studies in Georgia, Arkansas, Oklahoma,

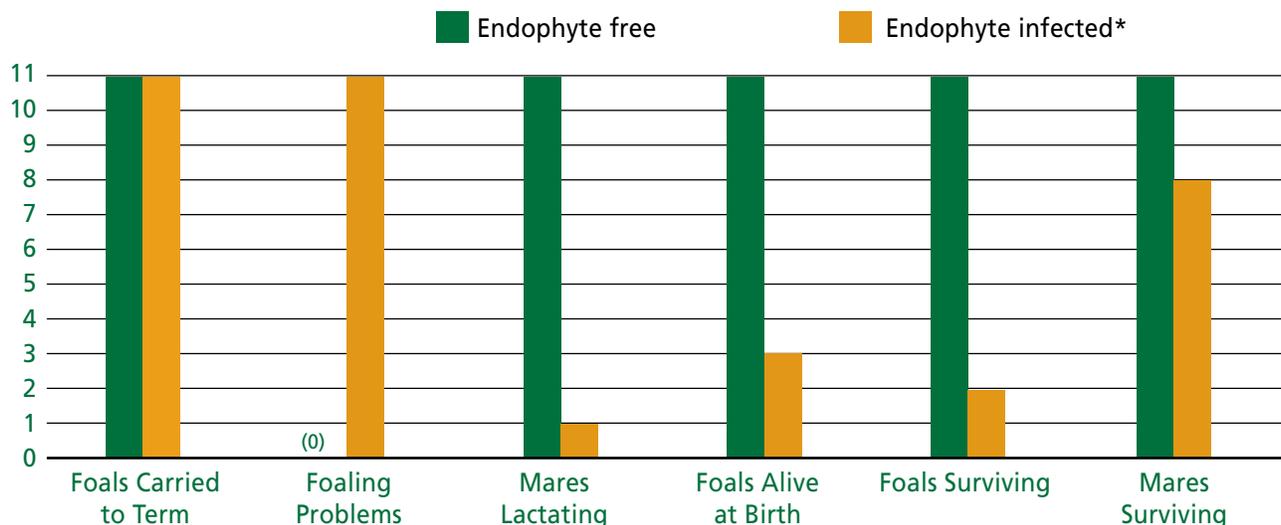
and Tennessee indicate that when steers grazed on TE fescue arrived at a feedlot during cooler weather, they gained faster than steers that had grazed EF fescue, especially during the first 28 days.

Steers arriving at a feedlot during hot weather did not show increased gains. However, in a Georgia experiment, steers grazing EF fescue continued to show the same gain advantage over TE fescue in the feedlot as they had shown on pasture.

Effects on Milk Production

Consumption of TE fescue reduced milk production by as much as 45% in beef cows and 50% in beef heifers in Alabama, and by 60% in dairy cows in Kentucky. Milk production of lactating dairy cows can be sharply reduced even when fescue has low TE infection levels. Milk production by dairy cows consuming EF fescue was similar to those grazing alfalfa-orchardgrass in Kentucky, and annual ryegrass in Alabama. Differences in milk production caused by consumption of TE fescue appear to be primarily due to differences in forage intake and blood levels of prolactin, a hormone that is required for milk production and which is consistently low in cattle that graze TE fescue. It is also possible that vasoconstriction from toxins reduce blood flow (and therefore energy flow) to mammary glands.

Figure 1. Effect of the fungal endophyte on pregnant mares and foals grazing tall fescue.



* Greater than 80% of plants testing positive for *A. coenophialum* analyses conducted at the Auburn University Fescue Diagnostic Laboratory. Source: Putnam, et al., 1990. The effects of the fungal endophyte, *Acremonium coenophialum* fescue on pregnant mares and foal viability. Am. J. Vet. Res. 52: 2071.

On average, the gestation period for mares grazing infected fescue was 20 days longer than for those grazing non-infected fescue (Figure 2). Evidence in foals of this longer gestation period was provided by overgrown hooves, poor and irregular incisor eruption, a long hair coat, poor muscling, large skeletal development and heavier birth weights.

Effects on Horses

TE fescue can reduce the growth rate of young horses, but the main problem associated with toxic fescue in horses pertains to reproduction. Clemson University scientists found that mares grazing EF pastures produced more live foals and had lower incidence of agalactia, fewer retained placentas and greater conception rates than mares on TE fescue. In Kentucky, 40% of the mares grazing TE fescue had reproductive abnormalities. In Georgia, prolactin concentrations in the blood (associated with milk production) were depressed when mares grazed TE, but not EF, fescue.

In a classic study at Auburn University, pregnant mares of various breeds were placed on adjacent TE and EF pastures, where they remained until foaling. The dramatic increase in foaling problems, foal deaths, gestation lengths, decreased foal weights and the reduction in numbers of mares lactating, foals surviving and mares surviving (Figures 1 and 2) provide convincing evidence of the dangers associated with grazing pregnant mares on TE fescue.

A striking difference between horses and cattle is the lack of carryover effects when mares are removed from TE pastures. Test results show that horses respond quickly to EF fescue and have a rapid turnover of toxins, allowing them to promptly overcome the negative effects. Conversely, lactating mares moved onto TE fescue will cease lactation within a few days.

Mares removed from TE fescue one month before foaling usually recover and have normal foals. The prevalent recommendation is that mares be removed from TE fescue at least 60 to 90 days before anticipated foaling. Grain supplementation to mares grazing TE fescue has no benefit in alleviating endophyte effects.

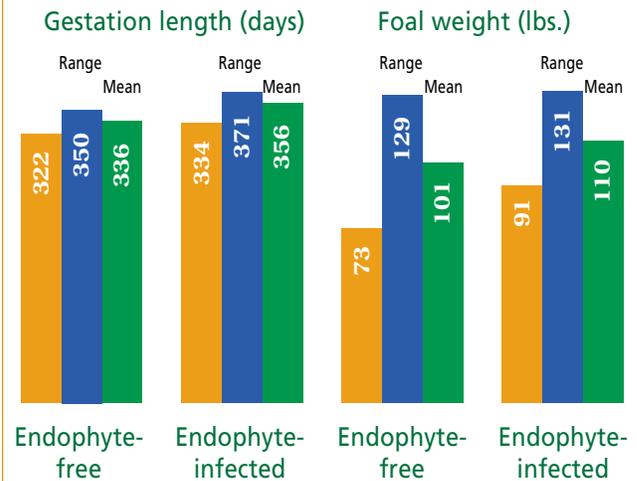
In Mississippi, NE fescue was compared to TE fescue and EF fescue in a grazing trial with pregnant brood mares. Only mares grazing TE fescue showed signs associated with endophyte toxins.

Effects on Thermoregulation

Cattle consuming TE fescue typically exhibit hyperthermia (abnormally high body temperature) during warm weather as shown by increased rectal temperature. Studies in Kentucky have shown that TE fescue has the most detrimental effect on cattle when the ambient temperature exceeds 88° F.

In Alabama, steers were fed EF or TE hay and seed in controlled environments at 70° F (cool) and 90° F (hot). Feed intake was reduced 36% by steers fed TE

Figure 2. Effect of the fungal endophyte on length of gestation and foal weight when mares grazed tall fescues.



Source: Putnam, et al., 1990. The effects of the fungal endophyte, *Acremonium coenophialum* fescue on pregnant mares and foal viability. Am. J. Vet. Res. 52: 2071.

diets in the cool environment, but rectal temperatures and respiration rates were not affected. In the hot environment, feed intake was reduced 60% in steers fed the TE diet and rectal temperatures and respiration rates increased.

In the cool environment, steers fed the TE diet had reduced temperatures at the body extremities (ear tips, tail tips, and hooves). This hypothermia (reduced body temperature) in animals consuming TE fescue is most likely a result of vasoconstriction (constriction of the blood vessels) caused by the fungus toxins and the reduced blood flow results in the fescue foot syndrome. In a Georgia study, body temperatures of steers grazing TE fescue was higher in summer and colder in winter than those of animals grazing either EF or NE fescue.

Thus, it is clear that the toxins in TE fescue result in abnormal function of the thermoregulatory center in many animals. In warm weather animals have difficulty eliminating heat from their bodies (evidenced by standing in shade or water, panting, etc.). Cold temperature results in natural restriction of blood flow in body extremities to minimize heat loss, but additional restriction caused by the fungus toxins can reduce blood flow too much and thus may cause gangrene. Furthermore, when an animal's body temperature is such that it makes it uncomfortable (hot or cold), it spends less time grazing, so forage intake is reduced.

ENDOPHYTE EFFECTS ON PLANTS

Greenhouse and environmental chamber work at multiple locations has shown that several insect species prefer and/or develop more rapidly on EF fescue. Kentucky studies provided evidence that alkaloids in TE fescue are associated with increased resistance to insect feeding. Also, a greenhouse study in Alabama revealed over three times as many spiral nematodes associated with the roots and soil of EF, as compared to TE, plants.

TE fescue also is more stress tolerant than EF fescue, at least in some environments. This is partially because it is more drought-tolerant, a trait that seems to be associated with TE plants exhibiting improved osmotic adjustment, greater sugar accumulation, better root growth and more leaf rolling, which conserves water.

Many research studies as well as producer experience have shown that if overgrazing, severe drought or other highly stressful conditions occur, EF fescue will not persist as well as TE fescue, especially on sites or soils that are marginal for growing fescue. It is now known that the increased pest resistance and stress tolerance of TE, as compared to EF, fescue is associated with alkaloids produced by the fescue endophyte, but not the same alkaloids that cause animal disorders.

Despite persistence problems in stressful situations, at many locations stands of EF fescue have persisted

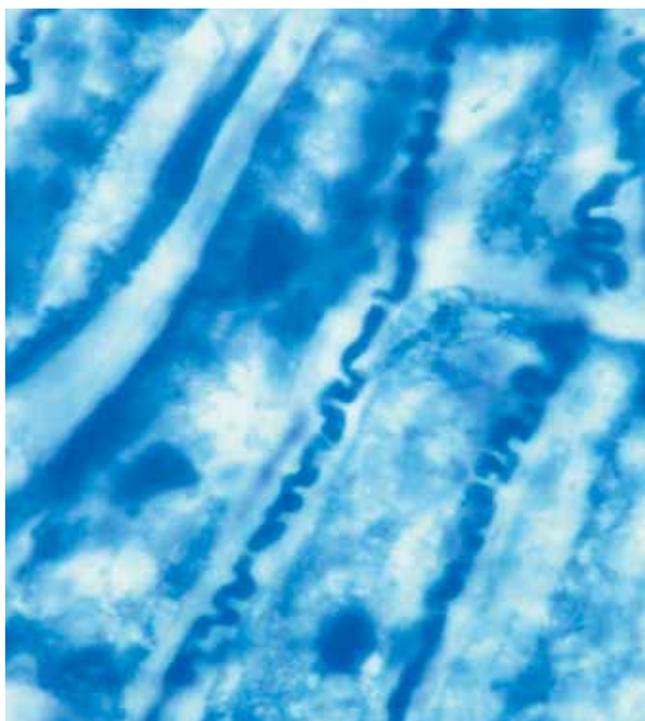
and remained non-infected for 10 to over 20 years when frequently rested and/or only lightly grazed in summer. It is easier to get EF fescue to persist in cool climates and sites having good moisture availability; the more stressful the situation, the more difficult it is to get good stand persistence of EF fescue.

These findings have important implications. Overgrazing of EF fescue should be avoided, especially during the establishment year, and always during summer. Fields to which TE fescue is only marginally adapted should not be planted to EF fescue. Also, as compared to TE fescue, EF fescue requires better grazing management, but the reward is much improved animal performance.

Grazing trials with lambs, beef steers, beef cows and horses have shown excellent performance on NE fescue pastures similar to that on EF fescue. When inserted into plants that previously contained no endophyte, NE strains can also result in tall fescue plants having vigor, pest resistance and tolerance to drought and grazing similar to that of toxic TE fescue. Under severe overgrazing and drought conditions for four years in Georgia, NE fescue planted in bermudagrass sod showed excellent stand persistence as compared to EF fescue. However, overgrazing is never recommended. In fact, producers need to be more careful to avoid overgrazing NE fescue than with TE fescue. The reason is that livestock are less likely to graze TE fescue as closely as non-toxic fescue because the latter is more palatable. However, when good grazing management is exercised, the persistence of NE fescue is similar to that of TE fescue.

Thus, in relatively stressful climates, novel endophyte fescue is the best choice for long-lasting pastures and high animal productivity. However, endophyte strains have varying characteristics, just as do different varieties of fescue. Also, not all fungus strains and varieties are equally compatible. Therefore, field-testing is needed to determine the suitability of any particular fungus/variety combination for a given geographical area.

NOTE: The endophyte status of a plant never changes. Infected plants come from infected seed, and non-infected plants come from non-infected seed. However, an EF stand can be outcompeted and thus replaced by TE plants that came from infected seed (either present in the field before EF fescue was planted, or introduced later). This is especially likely to occur in stressful climates or when EF fescue is overgrazed.



Endophyte mycelium present in tall fescue tissue

PRACTICAL SOLUTIONS TO THE FESCUE TOXICITY PROBLEM

Fescue toxicity is a widespread problem that has negative impacts on numerous species of forage-consuming animals. It is estimated that it costs the U.S. beef industry alone over one billion dollars annually. Obviously, this is a problem that needs to be addressed. Fortunately, there are a number of approaches that can be used to reduce the impact of the toxic tall fescue endophyte, ranging from inexpensive to expensive. However, they differ in effectiveness in mitigating the negative effects, depending on the extent to which they reduce intake of toxic alkaloids.

- Management of fescue pastures to favor other grasses such as Kentucky bluegrass, orchardgrass or bermudagrass can dilute the fescue toxins in animal diets. For example, grazing fairly closely during spring will reduce shade competition by fescue for lower-growing plants. Also, summer application of nitrogen will encourage warm season species such as bermudagrass and crabgrass.

- Grazing or mowing of seedheads in TE fescue pastures during spring and early summer may reduce subsequent toxin intake by grazing animals. This is because it reduces the ability of animals to selectively graze seedheads in which endophyte fungus growth (and associated toxin levels) tends to be greater than in other plant parts.

- Planting of legumes such as clovers, alfalfa or annual lespedeza in TE fescue pastures is a relatively inexpensive way to improve animal performance. This can be highly beneficial for many beef cow-calf producers, but it is usually not a dependable long term solution, as legume stands may disappear, and legume growth is often poor during summer, especially in the lower South.

- Feeding of hay other than TE fescue during winter can reduce the toxicity problem. Grain feeding can reduce toxicity in beef cattle, but is of little benefit to pregnant mares.

- Domperidone is a commercial product that can be administered to pregnant mares grazing toxic fescue to prevent loss of foals. However, this product has thus far been too expensive for use with cattle, as the effects are short-lived.

- Numerous other products have shown some benefit in certain situations, but have not been proven to be significantly or consistently effective or economically feasible across environments.

- The most effective way to eliminate fescue toxicity is to eliminate all toxic alkaloids from the animal's diet.



In warm weather animals eliminate heat from their bodies by standing in the shade or water.

Thus, on farms where fescue toxicity has been a problem, replanting pastures with EF or NE fescue seed is an attractive option. However, due to the cost of eliminating existing toxic pastures and replanting them, it is a major decision. In less stressful environments, EF fescue can be used, but in stressful environments the superior stress tolerance and long stand life of novel endophyte fescue offer extra benefits and will pay off over time.

- When establishing a new fescue pasture, the importance of knowing the level of endophyte infection in fescue seed used and whether any endophyte present is a wild, toxic type or a non-toxic NE can hardly be overemphasized. If a field planted will be used to produce hay or to provide grazing for livestock, it makes no sense to plant fescue seed containing toxic endophyte.

Replanting with EF or NE fescue is a highly logical choice for producers who have dairy cattle, beef stockers, horses, deer and purebred cattle where high animal performance is essential. Growing clover or other legumes as a companion species with either NE or EF fescue will further increase gains, but the increase is less than when legumes are grown with TE fescue.

Considerations Associated With Replacing TE Tall Fescue

The major cost in replanting infected pastures is completely eliminating the TE fescue stand. In addition, use of the pasture may be lost for nearly a year. The benefits of planting non-toxic fescue (EF or NE) are not fully achieved without using better grazing management. However, the dramatically increased beef production on EF or NE fescue (as compared to TE fescue) can be expected every year for the life of the stand.

- On land suitable for crops, spring tillage followed by cropping in summer is generally effective in eliminating the old TE fescue for autumn planting.
- If tillage creates a soil erosion hazard, the best alternative is killing TE fescue with a herbicide and drilling EF or NE seed with a sod-seeder.

When converting a TE fescue field to non-toxic fescue, it is important to ensure that any seed in the field that was produced by TE plants are more than one year old (the endophyte typically dies in unrefrigerated seed after about one year, so year-old seed present in a field will not result in volunteer TE plants in the newly-established stand.) To eliminate seed containing viable endophyte, tillage or use of herbicide to kill existing TE plants should be done either in the calendar year before the field is replanted or in the same calendar year but before seedheads emerge. While more precarious in terms of the probability of eliminating the presence of all less-than-one-year-old seed from a field, prompt mowing whenever seedheads begin to appear can also be used to combat seed production during the year of establishment.

- In a TE fescue stand that has been killed in spring, a good approach is to plant a summer annual grass such as pearl millet or sorghum-sudangrass into the dead sod. This serves as a “smother crop” to eliminate TE fescue escapes, and can be grazed or cut for hay in summer.
- The field to be replanted should be mowed or grazed closely in early autumn and an herbicide applied to kill any remaining fescue or other grass. Then EF or NE fescue can be drilled into the dead sod or a seedbed can be prepared. Rye, wheat, oats, or (especially) annual ryegrass should not be planted with fescue as these are quite competitive and may result in weak fescue stands. Even white clover can sometimes out-compete seedling fescue and should not be planted at the same time that a new stand of fescue is planted.
- A new fescue stand should not be grazed or cut for hay until it is well established and has a good root system. This is normally late spring for autumn-planted fescue. However, if there is thick, heavy growth accumulated, the forage needs to be removed by cutting or grazing to



Quality seed production means that pasture purity is in your hands.

around a 4-inch stubble height to prevent self-shading and stand thinning.

- To prevent introduction of toxic seed through feces, animals should never be moved from toxic fescue pastures to a new non-toxic pasture without a three-day wait on a pasture that contains no toxic fescue. Likewise, toxic fescue hay should never be fed on EF or NE fescue pastures as this will likely result in introduction of TE seed that may result in volunteer TE plants.

Fall and Winter Pasture Management

Stored feed is usually the single biggest cost item associated with producing livestock. In several studies the amount (cost) of hay fed during winter was the single best indication of profitability in beef cattle production. In many areas tall fescue can play an important role in reducing the amount of hay required by providing pasture over a long grazing season.

In order to reduce the amount of stored feed needed, it is important to start grazing early in spring and graze as late as possible in autumn-early winter. The long growing season of tall fescue permits grazing earlier, and provides feed later, in the year than other cool season perennial grasses. Nitrogen and moisture play a key role in determining just how long a grazing season tall fescue will provide.

Growing a legume such as white clover, red clover or annual lespedeza with tall fescue will increase animal performance regardless of the endophyte status of the grass. Tall fescue (whether TE, EF or NE), with or without legumes, should not be grazed or cut closer than 3-1/2 to 4 inches and should be grazed rotationally for best results.

Early spring grazing - Adding a light application of nitrogen when tall fescue begins growth in spring usually will permit grazing several weeks earlier than fescue that does not receive such a fertilizer application. This practice should be evaluated with reference to pasture needs, hay supply, nitrogen cost and other management decisions.

Fall & Winter (Stockpiled) - Many livestock producers can take advantage of late summer-fall growing conditions to obtain high quality fescue pasture for fall and winter. Tall fescue is an excellent grass for stockpiling because it grows at lower temperatures than many grasses, retains its forage quality well and is a good sod-forming grass

Stockpiling procedure - Geographic location impacts on the appropriate timing for initiating stockpiling. However, late summer or early autumn is a good time to begin the process in many areas.

Stockpiling involves removing cattle from a pasture, applying 40-80 pounds of nitrogen per acre and allowing grass to accumulate growth until November-December. Kentucky research has shown that when moisture is adequate, each pound (unit) of nitrogen applied in mid-August usually results in production of about 25 pounds of dry matter by December 1.

To make most efficient use of stockpiled grass, a temporary electric fence can be used to restrict animals to a small area in which they will consume the accumulated forage in a few days. Then the fence can be moved to provide access to a new section of the field. In a Missouri study, stockpiled tall fescue reduced hay feeding from 120 to 60 days.

Endophyte toxins in stockpiled fescue decline over time, so feeding hay or utilizing other feed sources early in the feeding season followed by use of stockpiled fescue will decrease total toxin intake. Animal reaction to toxin intake is less during cool weather, but fescue foot can sometimes be a problem. Stockpiled forage of EF or NE fescue contains no fungal toxins.

Seed Production

Cool-season grasses are well adapted to the mild winters and dry harvest season found in valleys of the Pacific Northwest. Oregon has established a reputation as a dependable supplier of high-quality forage grass seed,

including tall fescue, which it supplies for much of the forage production in the U.S. and other parts of the world.

National and international laws provide a basis for seed marketing by requiring that specific information be provided on the labels on seed bags including the name of the crop, percentage of pure seed, inert matter, other crop seed, weed seed and germination. Genetic identity is also an important seed quality factor. Seed certification programs have been established to monitor the seed multiplication process to assure that genetic purity has been maintained.

Plant breeders, seed producers and seed companies have great concern about the endophyte status of tall fescue varieties they develop, grow or market. Those who target forage producers have developed many EF varieties, and several varieties that contain a NE are being marketed. Conversely, those who supply turf producers usually want a high percentage of endophyte infection to ensure endophyte-induced stress tolerance and pest resistance.

Approaches taken to provide labeling information regarding the endophyte status of tall fescue seed vary among companies. Some obtain such labeling through the Oregon Department of Agriculture, while others provide their own labels based on their knowledge of their varieties, or simply do not provide such information. Only a few states require endophyte labeling on tall fescue seed, but if seed is labeled, it is incumbent on seed marketers to be certain it is accurate.



Good tall fescue grass seed production is an art and a science as well as a way of life.

Tall fescue seed containing a NE must be protected to ensure survival of the fungus. Therefore, special packaging and handling procedures are taken with NE-containing seed to minimize the effects of high temperatures and humidity that are common in areas outside the Pacific Northwest. Carryover seed from the previous planting season should not be retained as NE seed. It is likely that the novel endophyte in the seed has died, resulting in an EF seed source.

Straw Production and Use

Grass straw is a by-product of grass seed production, with over one million tons being produced in Oregon annually. In recent years, much of this has been exported to Japan, Korea and Taiwan for use as livestock feed products, various fiber products such as paper, particle board and composted fertilizer, and to produce chemical products including gasoline and plastics.

Though grass straw has low forage quality, a substantial quantity is used as a supplemental livestock feed. However, the toxins produced by TE fescue (either forage or turf varieties) persist in straw and can cause fescue toxicity or fescue foot. Thus, livestock producers who use TE grass straw as a feed source need to observe their animals carefully and be prepared to reduce the quantity in animal diets or even cease using it if necessary.



Tall fescue has earned a reputation as a widely adapted, drought and shade tolerant grass which is more and more in demand for pastures where water, manpower costs and ecological concerns are factors.

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The authors gratefully acknowledge reviews of this publication provided by:

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Citation: Ball, D.M., G.D. Lacefield, S.P. Schmidt, C.S. Hoveland and W.C. Young III, 2015. Understanding The Tall Fescue Endophyte. Oregon Tall Fescue Commission, Salem, OR





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