

TALL FESCUE ENDOPHYTE CONCEPTS



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Tall fescue (*Festuca arundinacea* Schreb.) is a versatile perennial grass used for livestock feed, various turf purposes 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 grasses.

Fescue was first planted on a widespread basis in the USA in the 1940s, and now occupies over 35 million acres. Since the discovery in the late 1970s that an endophyte (fungus) within this grass can produce compounds called alkaloids that may have profound effects on both grazing animals and the grass itself, attitudes toward fescue have changed greatly. This publication provides a review of current knowledge of the impacts of this endophyte and explains options livestock producers have for increasing profitability when using this important grass.

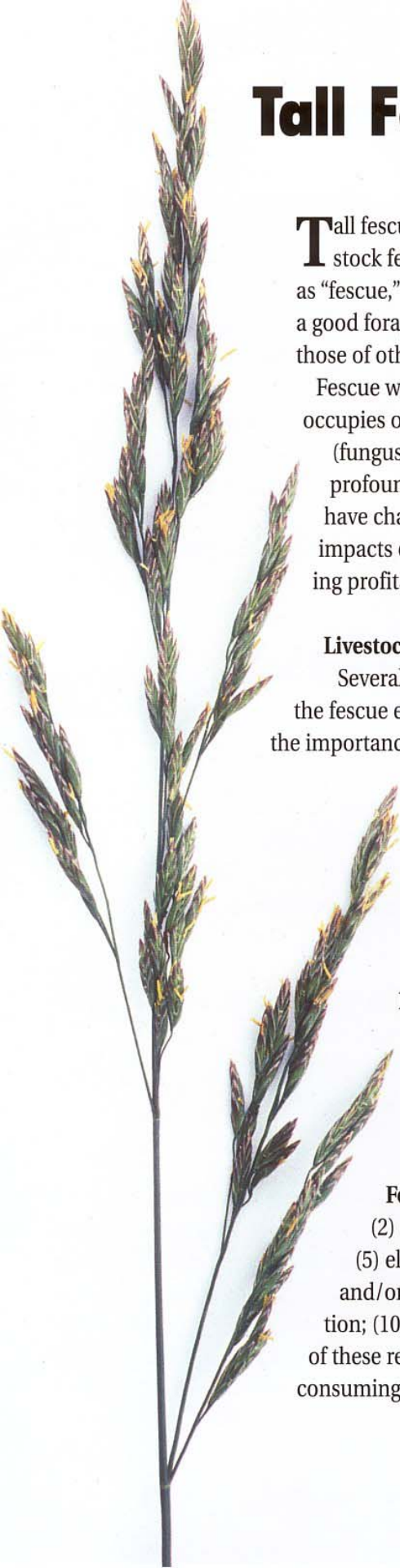
Livestock Disorders

Several livestock disorders have been associated with certain alkaloids produced by the fescue endophyte. A brief description of these disorders facilitates understanding of the importance of research findings discussed in this publication.

Fescue Foot - Fescue foot is a dry, gangrenous condition of the body extremities of cattle consuming “wild” endophyte fescue. Usually it causes lameness and/or the 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 caused 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 wild endophyte fescue pastures have been heavily fertilized with poultry litter or nitrogen fertilizer.

Fescue Toxicity - Signs of fescue toxicity can include: (1) reduced feed intake; (2) decreased weight gain; (3) lower milk production; (4) higher 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 pasture, greenchop, hay, and/or seed.



Horse Disorders - Reproductive difficulties of mares grazing fescue have also been widely recognized. 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, and reproductive difficulties of mares can be devastating to a horse producer.

Endophyte Discovery

It is remarkable that such a highly detrimental agent could have been undetected for so long in such a widely-grown forage species, but the fungal endophyte *Neotyphodium coenophialum* (originally classified as *Acremonium coenophialum*) was not associated with animal disorders until the late 1970s. Since then our understanding of tall fescue/endophyte/animal relationships has greatly increased.

Two characteristics of the endophyte are of great practical importance. First, the fungus lives within fescue plants and does not affect the appearance of the grass. A laboratory analysis is required to detect its presence. Secondly, it is transmitted only by seed. Thus, once an endophyte-free (EF) stand is established, it will remain non-infected unless infected seed (either present before EF fescue was seeded or introduced later) germinate and become established. Likewise, an endophyte infected (EI) stand will remain infected as long as the plants are alive. This is true both for "wild" or toxic endophyte strains that produce livestock disorders, as well as for non-toxic "novel" endophytes (to be discussed later in this publication) that do not produce livestock disorders.

NOTE: The acronym EI (for endophyte infected) is used in this publication to refer only to wild, toxic endophyte strains; it does not encompass novel endo-

Table 1. Percentage of 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.

phyte strains. However, the term "non-toxic" can apply to EF and/or novel endophyte fescue.

ENDOPHYTE EFFECTS ON ANIMALS

Grazing Time - Several studies have shown that as 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 in which steers were switched from EI (95% infected) to EF (<1% infected) fescue, steers on EF fescue spent about 60% of the time between noon and 6:00 p.m. grazing, as compared to only about 5% by steers on EI fescue. Steers switched to EI 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. However, grazing time for those switched to EF fescue was still reduced one month later.

Intake and Digestibility - On-farm observations and research have provided evidence that cattle prefer EF and novel endophyte fescue. In Tennessee, steers had a preference for clover in EI pastures, but there were indications that they preferred fescue to clover in EF

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

¹ Number of infected tillers per 100 tillers.

² Not 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* in 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.

pastures. When heifers in Missouri were offered diets containing 60% fescue seed, either EF or 75% EI, 11 of 12 heifers avoided the EI diets. Much, but not all, of the reduction in livestock average daily gain (ADG) or gain per unit area of land on EI fescue is due to reduced feed intake.

Normally, physical factors such as high fiber content of forage are associated with poor intake, but they do not explain intake differences between EI and EF fescue. Further, the toxins do not appear to have a major effect on microbial digestion in the rumens of grazing animals. Forage digestibility and crude protein levels are similar in EI and EF fescue.

Effects on Beef Yearling Gains

Since the early reports of the association of the endophyte with fescue toxicity, many grazing and feeding trials with EI and EF fescue have been conducted. A summary of data (Table 2, prior page), illustrates that decreased gains of steers grazing EI forage are widespread, quite uniform, and not limited to certain geographic areas or management conditions.

Fescue toxicity is sometimes referred to as "summer syndrome" or "summer slump" because visible signs are most pronounced during hot weather. However, poor weight gains on EI 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 EI fescue, as compared to EF fescue. During the warmer months of April, May and June, the decrease was 59%.

Factors affecting animal reaction to fungus toxins include air temperature, humidity, presence of other forages, animal management, and time of year (toxin levels are higher in spring and summer than at other times during the year). Though several factors affect reaction to the toxins, steer ADG typically decreases about 0.1 lb for each 10% increase in infection rate.

In Georgia, grazing behavior of steers on EI and EF fescue pastures was similar in March. However, high temperatures during April and June resulted in

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.

steers on EI fescue spending less time 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 EI fescue (except indirectly by increasing the competitiveness of fescue, thus increasing the amount of toxic fescue in an animal's diet). However, N fertilization of EI fescue can increase gain per acre because of higher stocking rates.

Effects on Beef Cows and Calves

Most fescue pasture in the United States is used in commercial beef cow-calf operations. In several studies (Table 4), cows grazing EI 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.

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

Cows				Calves				
Daily gain		Pregnancy rate		Daily gain		205-day wean wt		
Low E	High E	Low E	High E	Low E	High E	Low E	High E	Reference
lb/day		%		lb/day		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	892	74	1.61	1.28	--	--	Tucker et al, 1986b
0.79	-0.46	78	49	2.25	1.90	529	461	McDonald, 1989

¹ Not determined or not reported

² Low 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. Shinkel 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.

Therefore, cows entering the breeding season in a poor or negative gaining condition because of EI 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 EI 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 EI 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 low-endophyte pastures.

Initiation of the estrous cycle in heifers grazing EI fescue is not delayed, and cessation of the estrous cycle in animals already cycling does not occur. Research in Alabama indicates that conception in cattle is not affected by the endophyte. Reduced calving

Feedlot Gains of Steers that Previously Grazed Fescue

Because of their unthrifty appearance, steers that have grazed EI fescue often bring reduced prices, 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 EI 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 during hot weather did not show increased gains, but their gains were not reduced as a result of previous exposure to EI fescue. However, in a Georgia experiment, steers grazing endophyte-free fescue continued to show the same gain advantage over EI fescue in the feedlot as they did on pasture.

Effects on Milk Production

Consumption of EI 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 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 toxic fescue appear to be primarily due to differences in forage intake.

Effects on Horses

Toxic 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 pas-

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/12 hr
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, D.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.

percentages of cattle on EI fescue appears to be due to early embryonic death.

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, Angus and Brahman-Angus cross steers have exhibited decreased gains when grazing EI 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.

tures produced more live foals, and had less agalactia, fewer retained placentas, and greater conception rates than mares on EI fescue. In Kentucky, 40% of the mares grazing EI fescue had reproductive abnormalities. In Georgia, prolactin concentrations in the blood (associated with milk production) were depressed when mares grazed toxic EI, but not EF, fescue.

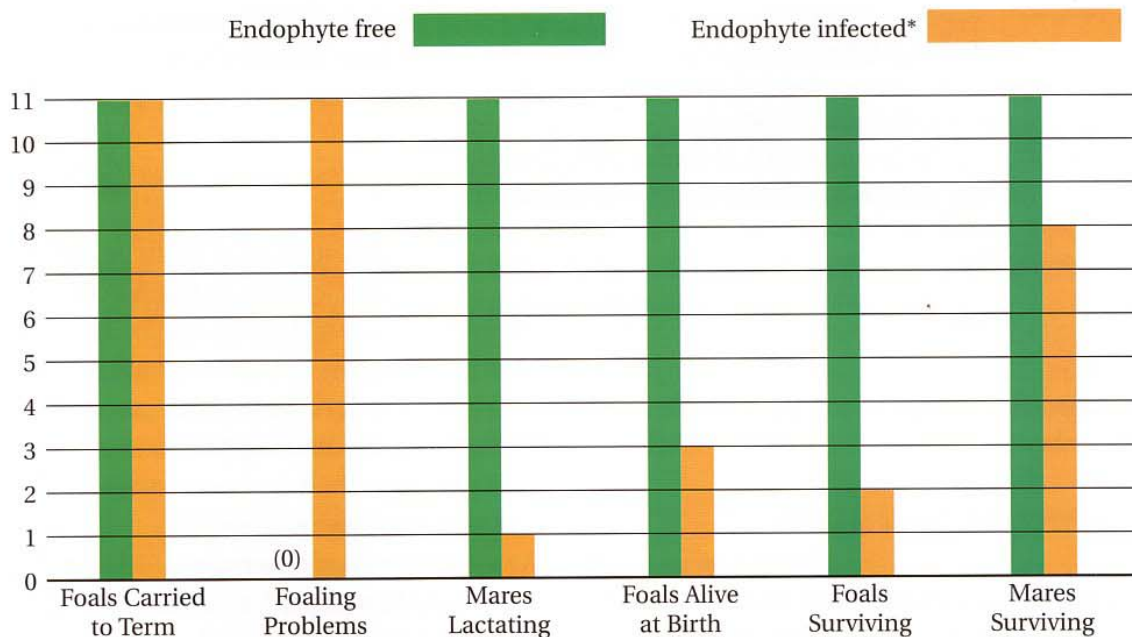
In a classic study at Auburn University, pregnant mares of various breeds were placed on adjacent EI and EF pastures, where they remained until foaling. The dramatic increase in foaling problems, foal deaths, gestation lengths, and foal weights; and the reduction in numbers of mares lactating, foals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

convincing evidence of the dangers associated with grazing pregnant mares on EI fescue.

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

Mares removed from EI fescue one month before foaling usually recover from fescue toxicosis and have normal foals. The prevalent recommendation is that mares be removed from EI fescue 60 to 90 days before

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

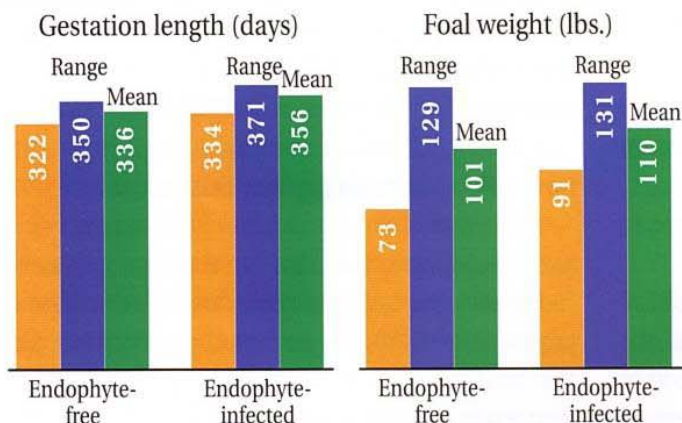


* Greater than 80% of plants testing positive for *A. coenophialum* in analyses conducted at the Auburn University Fescue Diagnostic Laboratory.

Source: Putnam, et al., 1990. The effects of the fungal endophyte, *Acremonium coenophialum* in 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.

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* in fescue on pregnant mares and foal viability. Am. J. Vet. Res. 52: 2071.

anticipated foaling. Grain supplementation to mares grazing EI fescue has no benefit in alleviating endophyte effects.

In Mississippi, novel endophyte fescue was compared to wild type endophyte fescue and EF fescue in a grazing trial with pregnant brood mares. Only mares grazing wild endophyte fescue showed signs consistent with fescue toxicity.

Effects on Thermoregulation

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

In Alabama, steers were fed non-infected or infected hay and seed in controlled environments at 70° F (cool) and 90° F (hot). Feed intake was reduced 36% by steers fed the EI 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 EI diet, and rectal temperatures and respiration rates increased.

In the cool environment, steers fed the EI diet had reduced temperatures at the body extremities (ear tips, tail tips, hooves). This hypothermia (reduced temperatures) in animals consuming EI 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 study in Georgia, body temperatures of steers grazing EI fescue was higher in summer and colder in winter than those of animals grazing either EF or novel endophyte fescue.

Thus, it is clear that the toxins in EI 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 reduces blood flow too much and 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 and forage intake is reduced.

ENDOPHYTE EFFECTS ON PLANTS

Scientists in New Zealand found that the Argentine stem weevil would devastate EF, but not EI, perennial ryegrass. This insect is not a pest in the United States, but this knowledge is of concern because the endophytes in the two grasses, as well as the grass species, are closely related.

Greenhouse and environmental chamber work at several locations has shown that several insect species

prefer and/or develop more rapidly on EF fescue. Kentucky studies provided evidence that alkaloids in EI 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, than of EI, plants.

EI fescue is also 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 EI plants having improved osmotic adjustment, greater sugar accumulation, better root growth, and more leaf rolling to conserve 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 EI 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 EI, as compared to EF, fescue is associated with alkaloids produced by the fescue endophyte. However, these are not the same alkaloids that cause animal disorders.

Despite persistence problems in stressful situations, stands of EF fescue at many locations have persisted and remained non-infected for 10 to over 20 years when rested 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. Fields to which EI fescue is only marginally adapted should not be planted to EF fescue. Also, as compared to EI, EF fescue requires better grazing management, but the reward is much improved animal performance.

NOTE: It is important to understand that the endophyte status of a plant never changes. Infected plants

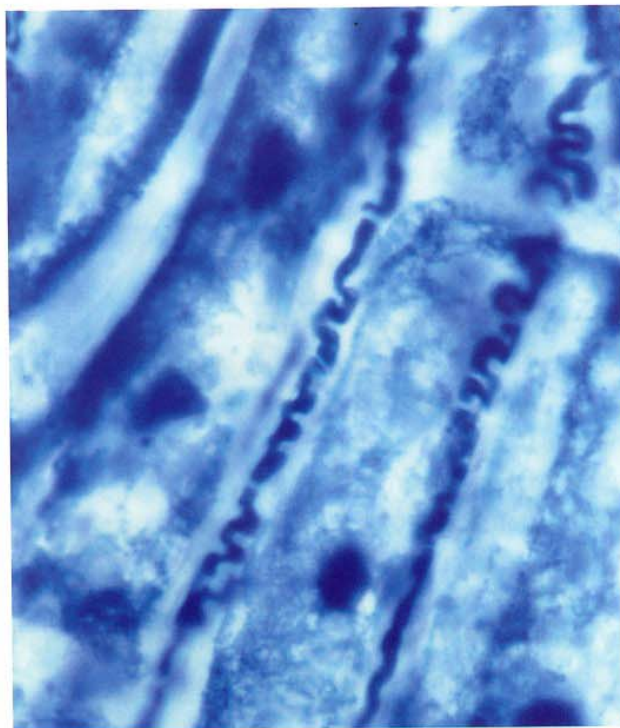
come from infected seed, and vice-versa for non-infected plants. However, an EF stand can be largely or completely outcompeted and thus replaced by EI plants that came from infected seed (either present in the field before EF fescue was planted or introduced later). This is especially likely to occur in stressful climates or when EF fescue is overgrazed.

Novel (Non-Toxic) Endophyte Tall Fescue

Some endophyte strains (referred to by scientists as “novel endophytes”) have been identified that do not produce the toxins that cause animal disorders, but that do impart pest resistance and stress tolerance to fescue plants (i.e., they produce the desirable alkaloids but not the undesirable ones). Novel or non-toxic endophyte strains have been inserted into some fescue varieties and some are now commercially available.

Grazing trials with lambs, beef steers, beef cows, and horses have shown excellent performance on novel endophyte fescue pastures similar to that on EF

Endophyte mycelium present in tall fescue tissue



fescue. Novel endophytes can also give the tall fescue plant vigor, pest resistance, and tolerance to drought and grazing similar to that of toxic EI fescue. Under severe overgrazing in bermudagrass sod under drought conditions for four years in Georgia, novel endophyte fescue showed excellent stand persistence as compared to EF fescue.

Thus, novel endophyte fescue offers the potential for long-lasting pastures and high animal productivity. However, different endophyte strains have different characteristics just as do different varieties of fescue. Also, not all fungus strains and varieties are equally compatible. Therefore, lengthy field-testing will be required to determine the suitability of any particular fungus/variety combination for a given geographical area.

Practical Solutions to the Toxicity Problem

There are a number of solutions to the fescue toxicity problem, ranging from inexpensive to expensive. However, they differ in effectiveness in alleviating the problem.

- 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, close grazing during spring will reduce shade competition by fescue for lower-growing plants, and summer application of nitrogen will encourage bermudagrass and crabgrass.

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

- Planting of legumes such as clovers, alfalfa, or annual lespedeza in toxic fescue pastures is a cheap

way to dilute the toxicity. This may be adequate for many beef cow-calf producers, but it is not a dependable solution, as legume stands may disappear and growth is often poor during summer, especially in the lower South.

- Feeding of hay other than toxic 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 is too expensive for cattle as the effects are short-lived.

- On farms where fescue toxicity has been a problem, replanting pastures with EF or novel endophyte fescue seed may be an attractive option, but 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 on stressful sites (especially in the lower South) the superior stress tolerance and long stand life of novel endophyte fescue offers extra benefits and will pay off over time.

Replanting with novel endophyte fescue is a particularly 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 novel endophyte or EF fescue will further increase gains, but the increase is much less than when legumes are grown with EI fescue.

Replanting Infected Tall Fescue

The major cost in replanting infected pastures is completely eliminating the toxic fescue stand. In addition, use of the pasture may be lost for nearly a year. The benefits of planting non-toxic fescue (EF or novel endophyte) are not fully achieved without using better grazing management.

The importance of knowing the level of endophyte infection in fescue seed and whether any endophyte present is a wild, toxic type or a non-toxic novel endophyte can hardly be overemphasized. The dramatically increased beef production on EF or novel endophyte 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 fescue for autumn planting.

■ If tillage creates a soil erosion hazard, the best alternative is killing toxic infected fescue with a herbicide and drilling EF or novel endophyte seed with a sod-seeder. However, it is important to prevent toxic fescue seed from maturing during the calendar year during which non-toxic fescue is being established.

Thus, if a herbicide is applied to kill toxic fescue, it should be done before seed head emergence.

■ In a toxic 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 toxic fescue escapes, and can be grazed or cut for hay in summer.

■ The field to be replanted should be mowed closely in early autumn and a herbicide applied to kill any remaining fescue or other grass. Then EF or novel endophyte 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 competitive and may result in weak fescue stands.

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



■ In order to allow good root establishment, the new stand should not be grazed or cut for hay until late spring.

■ 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 another forage crop. Likewise, toxic fescue hay should never be fed on EF or novel endophyte fescue pastures.

Fall and Winter Pasture Management

Stored feed is usually the single biggest cost item associated with producing livestock. In several studies 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, it is important to start grazing early in spring and graze as late as possible in fall-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.

Grazing stockpiled tall fescue pasture



Early spring grazing- Adding a light application of nitrogen when tall fescue begins growth in spring will usually permit grazing several weeks earlier than non-nitrated fescue. This practice should be evaluated with reference to pasture needs, hay supply, nitrogen cost, and 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- Though location impacts on the appropriate timing for initiating stockpiling, late summer or early autumn is a good time to begin the process in many areas.

Remove cattle, apply 40-80 pounds of nitrogen per acre and allow 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 results in 25 pounds of dry matter by December 1.

To make most efficient use of stockpiled grass, use a temporary electric fence restricting animals to a small area that they will consume in a few days, then move the fence 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. Cost per cow was \$1.23/day for feeding tall fescue hay and 43 cents/day for feeding stockpiled tall fescue. Wintering cost per cow was reduced \$117 by grazing stockpiled tall fescue.

Some toxins are present in stockpiled EI forage, but the levels are lower in autumn than spring, thus the toxicity is less severe during cool weather, though fescue foot can sometimes be a problem. Stockpiled forage of EF or novel endophyte fescue contains no fungal toxins.

Seed Production

The 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 fescue, which it supplies for much of the forage production of the U.S.A. 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. Information on these labels include 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.

The Oregon State University Seed Laboratory is responsible for testing Oregon certified seed. The laboratory has a highly skilled staff and performs many special tests important to certification and proper

seed labeling. Seed samples collected under the direction of Extension agents are examined in the laboratory. Reports are reviewed by certification staff and eligibility checked against field records. Seed lots meeting quality standards are approved, after which tags are attached under the supervision of county Extension staff.

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 endophyte-free varieties, and some varieties that contain a non-toxic novel endophyte are now being marketed. Conversely, those who supply turf producers usually want a high percentage of 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

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



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.

Tall fescue seed containing a novel or non-toxic endophyte must be protected to ensure survival of the fungus. Therefore, special packaging and handling procedures are taken with novel endophyte-containing seed to minimize the effects of high temperatures and humidity that are common in areas outside the Pacific Northwest.

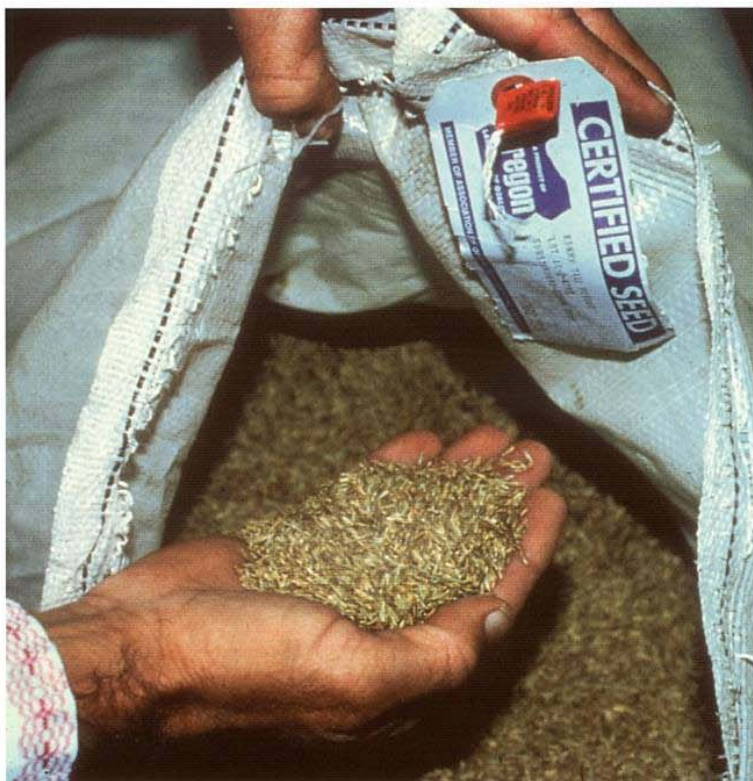
Straw Production And Use

In recent years, over 150,000 acres of tall fescue have been devoted to seed production in Oregon each year. Most of this grass contains a high percentage of infection with toxic endophyte strains due to the fact that the majority of it is used to produce seed for turf purposes.

Grass straw is a by-product of grass seed production, with over one million tons being produced in Oregon annually. Limits on field burning, which was once widely practiced, have resulted in over 500,000 tons of grass straw being exported to Japan, Korea, and Taiwan in recent years for use as livestock feed products. Other uses for grass straw include 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 wild endophytes persist in straw and can cause fescue toxicity or fescue foot. Thus, livestock producers who use toxic endophyte 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. ■

Quality seed production means that pasture purity is in your hands



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TALL FESCUE ENDOPHYTE CONCEPTS



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