Virginia Cooperative Extension
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Publication SPES-163P

Strategies for Managing Endophyte-Infected Tall Fescue – A Whole-Farm Approach

Authored by John Fike, Associate Professor and Extension Forage Specialist, School of Plant and Environmental Sciences, Virginia Tech; and Gabriel Pent, Superintendent, Shenandoah Valley Agricultural Research and Extension Center, Virginia Tech

Introduction

Toxicosis caused by alkaloids in tall fescue presents serious challenges and financial losses for livestock producers in Virginia and across the Southeast (see VCE publication SPES-114P, "Tall Fescue, Endophytes and Alkaloids, and Fescue Toxicosis"). Increasing temperatures are likely to exacerbate this problem. In many cases, replacing fescue stands with varieties containing a nontoxic endophyte strain is warranted and will pay for itself in two to five years, but replacement is not always feasible given factors such as steep terrain and short-term land leases. This publication considers management approaches that can help mitigate fescue toxicosis where replacement is not an option.

Tall Fescue Toxicosis

Tall fescue toxicosis is caused by the consumption of ergot alkaloids found in plant tissues. The alkaloids are not produced by tall fescue but rather by wild fungal strains that live within the plants (see VCE publication SPES-114P). Dietary levels of alkaloids that cause problems for livestock are not well defined. Although 400 parts per billion of ergovaline is often considered a threshold level for toxicosis symptoms in cattle, this likely depends on the sensitivity of the individual animal and levels of environmental stress, among other factors.

While small ruminants often display no outward symptoms of fescue toxicosis, cattle often have visible symptoms which typically are more pronounced during times of environmental stress. Alkaloids consumed in toxic fescue constrict blood flow. This increases heat stress in summer and reduces heat flow to the extremities in winter. Thus, animals suffering from toxicosis and related environmental stresses may have lower intake, along with lower milk and meat production. Other physical signs of toxicosis include long, rough, faded hair coats and missing ear tips and tail switches (due to frostbite). In fall and winter, especially after sudden drops in temperature, cattle may display a limp. In severe cases of "fescue foot," cattle will experience damage to the coronary band above the hoof. Behavioral manifestations of fescue toxicosis most typically are noticed in summer, when cattle seek shade, form wallows, or stand in surface waters (figure 1). Thus, fescue toxicosis has accompanying negative environmental impacts.

Figure 1: Cattle on toxic fescue routinely seek shade or surface waters for cooling. (Photo by John Fike.)

Endophytes, Alkaloids, and the Limits of Dilution

Most producers in Virginia have pastures of infected fescue. Testing pastures to determine levels of endophyte presence, alkaloid concentrations, or both, can be helpful in making a whole farm plan. Those interested in testing should read VCE Publication SPES-21P, "Sampling Tall Fescue for Endophyte Infection and Ergot Alkaloid Concentration." Understanding alkaloid production within fields may be useful for identifying when and how to utilize fields using the principles outlined below to minimize livestock exposure to alkaloids.

Knowing percent infection rate or alkaloid concentrations in pastures is of secondary interest for some producers who recognize that they have a problem they need to address. For many, however, it can be difficult to determine how much toxicosis is really costing the livestock operation. An understanding of the toxicity potential of a farm can be helpful in identifying the opportunity costs of toxic tall fescue. Some producers may think historical management recommendations are sufficient to address the problem. For example, the phrase, "Dilution is the solution to pollution" has long been used to encourage producers to grow legumes or feed supplements to animals on infected tall fescue. This is an important management strategy but is unlikely to completely eliminate toxicosis issues. While it may be theoretically possible to dilute the toxins to an extent that would prevent toxicosis symptoms, this might be impractical or unreachable with some forages. The added intake supported by white clover (or supplements) improves animal performance, but it does not eliminate the toxin effects (figure 2).

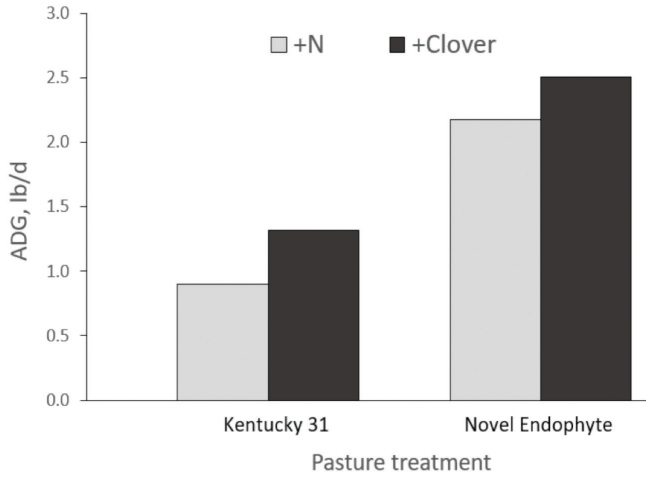

Figure 2: Research from Arkansas compared animals' average daily gain (pounds per day) on pastures fertilized with nitrogen (N) or overseeded with clover. Similar increases in gain occurred when clover was added to fescue pastures containing toxic (Kentucky 31) and nontoxic endophytes (Jesup MaxQ and Texoma MaxQII). However, the average daily gain was more than twice as great for animals grazing fescue with nontoxic endophytes compared with toxic KY31. Thus, clover boosted gain with all pastures, but it didn't overcome the toxicosis. (Adapted from from Beck et al. 2012.)

Managing Fescue Pastures to Mitigate Alkaloids

Converting toxic, endophyte-infected tall fescue pastures to other forages should be an option for many producers. Economic estimates indicate that replacement will pay for itself in two to five years on many farm operations, depending on the type of operation and the portion of farm acres converted. Converting even a limited portion of toxic fescue acres, perhaps 25%, coupled with their timely use, can improve calving rates, weaning weights, and returns per acre (Caldwell et al. 2013).

However, factors such as uncertain land leases, highly erodible land, and the loss of production during conversion can make replacement infeasible. Thus, some portion of land under management is likely to remain in toxic fescue and will need appropriate management. Producers who use good forage management practices to reduce the negative impact of ergot alkaloids on their livestock will see improved animal production and farm economic performance. Thus, the rest of this publication discusses alkaloid levels in fescue and provides management practices to mitigate fescue toxicosis.

Alkaloid Levels as a Function of Season, Fertility, and Plant Part

Fescue alkaloid concentrations vary based on several factors, including plant part and plant maturity, season, weather, fertility, and harvest management. The endophyte receives nutrients from its plant host, and alkaloid concentrations are tied to the plant's productivity. Thus, alkaloid concentrations typically are highest during spring and fall growing seasons, when fescue is growing actively. This can

be compounded by adding nitrogen fertilizer. Thus, for grazed pastures, apply only moderate levels of nitrogen. The endophyte primarily grows in the stem base, and alkaloid concentrations are correspondingly higher in stems than in leaves (figures 3 and 4). Close grazing will likely force livestock to consume more stems, which have much higher concentrations of alkaloids. Timely grazing, clipping, or application of growth regulators can be used to minimize seed head development. The endophyte cannot reproduce apart from the grass and spreads by entering the seeds of the host plant. In spring, the fungus grows up into the plant's reproductive tillers, and alkaloid concentrations will be highest in the seed heads (figure 4). However, in vegetative tissues, total ergot alkaloid concentrations may be greatest in fall (figure 5). Seasonal variation is likely location-dependent, with summer depressions in alkaloid concentrations apparently greater at warmer sites that have more challenging growing environments (Rogers et al. 2011). Regardless, as days grow shorter and cooler in early fall, growing conditions support the accumulation of soluble sugars and proteins, and these mounting resources allow for greater alkaloid synthesis. Following their peak concentrations around mid-fall, total ergot alkaloid levels will begin to decline.

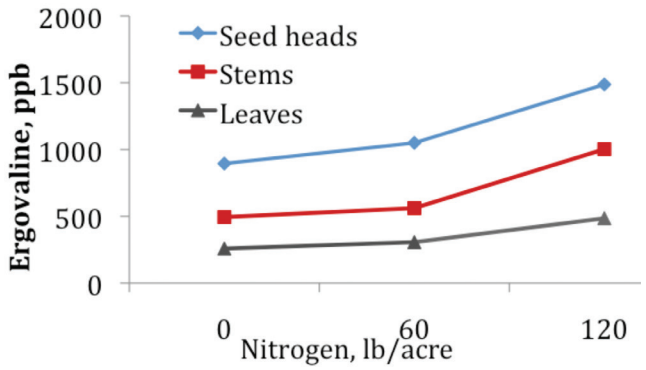

Figure 3: Alkaloid concentrations are lowest in leaf tissues and greatest in seed heads, and generally increase with added nitrogen fertility. (Figure adapted from Rottinghaus et al. 1991.)

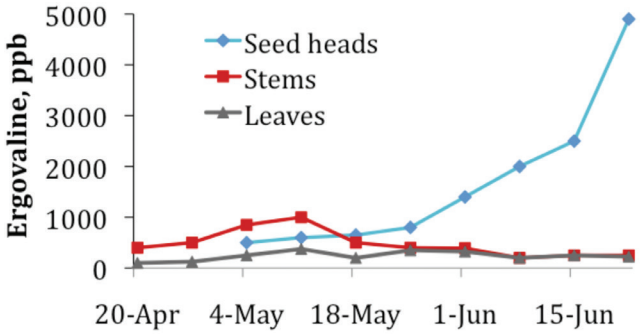

Figure 4: Development and maturation of seed heads speak to the need for good grazing and harvest management. Making a late first cutting of fescue hay both increases plant alkaloid concentrations and also substantially reduces forage nutritive value. Tall fescue in this figure was fertilized with 60 pounds of nitrogen per acre. (Figure adapted from Rottinghaus et al. 1991.)

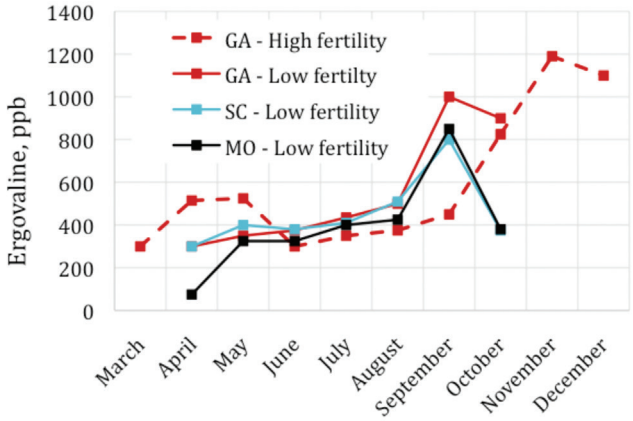

Figure 5: Fescue alkaloid (ergovaline) concentrations presented in this figure are informative about seasonal variation and management. Fescue alkaloids typically rise and fall with plant productivity, and the response is affected by fertility and plant part. Seed heads were controlled in the low fertility studies; otherwise, alkaloid concentrations have a peak in spring, followed by summer depression and another peak in fall. After reaching a peak, ergot alkaloids dropped at all sites in fall following a series of hard freezes. (Figure adapted from Belesky et al. 1988 and Rogers et al. 2011. GA – Georgia, SC – South Carolina, MO – Missouri.)

Hay, Stockpiling, and Implications for Grazing and Harvest Management

Among methods of forage conservation used in Virginia, dry hay seems best suited to mitigating fescue toxicosis because fescue alkaloids degrade

during the curing process (figure 6). While it can be challenging to make hay in spring due to poor weather for curing, alkaloid concentrations are lower and the forage itself is more nutritious. Producers who have moved to baleage systems to avoid the challenges of drying hay in spring weather may instead be maintaining high levels of total ergot alkaloids in their conserved forage, because the acids in baleage likely help preserve alkaloids.

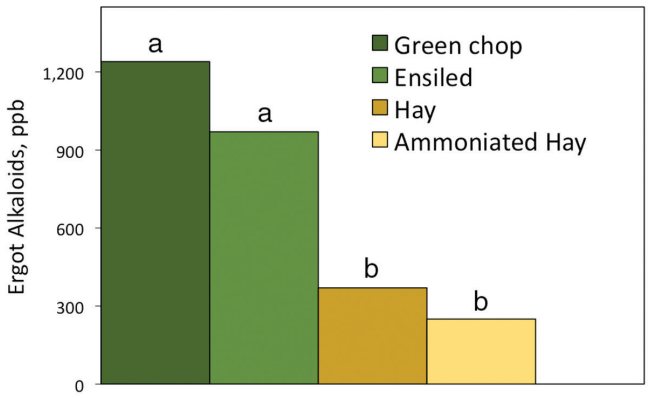

Figure 6: Total ergot alkaloid concentrations can vary by conservation method. Fescue in this study (Roberts, Kallenbach, and Hill 2002) was cut and analyzed after freeze-drying, ensiling, sun curing for hay, and ammoniating (after curing). Alkaloid levels decline substantially during the curing process but may be maintained with ensiling.

Forage conservation and feeding is a critical aspect of forage-livestock systems, but often the costs are not critically evaluated. Many Virginia producers feed hay more than 120 days per season, with profound negative economic and fescue toxicosis implications. Most of this hay is fed during the winter when little grazable forage is available. Shifting hay feeding to late summer during late gestation can allow time for pastures to grow the stockpile. Because cows are not eating as much fresh fescue, this can reduce exposure to alkaloids during a season of high temperatures. Feeding some hay in early fall can reduce exposure to alkaloids as the concentration begin to increase in fescue. Alkaloids decline in stockpiled fescue from around mid- to late fall and into the winter (figure 7) after significant hard freezing events, and the forage itself is far better than hay from a nutritional sense. The freeze and thaw cycles of late winter will have small impacts on forage nutritive value, but will cause a more dramatic decline in ergot alkaloid levels. Thus, stockpiled fescue can be a nutritious and safe feed for livestock in the middle of the winter.

Fertility Management

As noted above, conditions that support abundant plant growth also support alkaloid production. Thus, moderate fertility inputs are recommended to avoid high alkaloid concentrations in tall fescue. Lower nitrogen inputs will also support greater abundance and growth of legumes in fescue pastures, further benefitting pasture diversity and animal performance. Some research suggests nitrate-based fertilizers (as opposed to ammonium-based fertilizers) as well as synthetic fertility sources are more likely to increase alkaloid levels (e.g., figure 8).

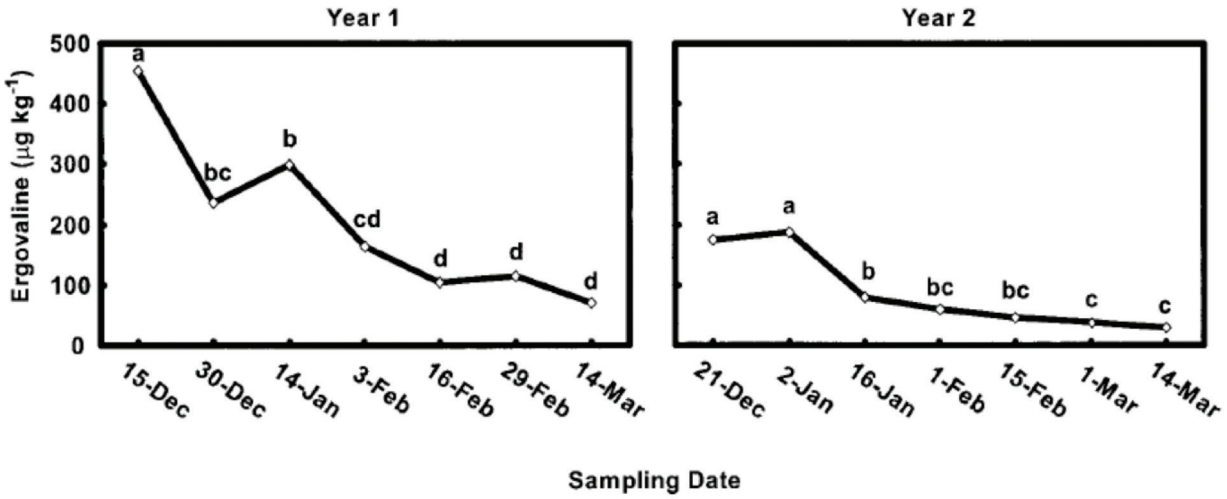

Figure 7: Alkaloid concentrations in stockpiled fescue decline over winter, particularly with hard freeze events. In this graph from Kallenbach et al. (2003), ergovaline, the alkaloid associated with toxicosis, declined about five-fold over each winter of this Missouri study.

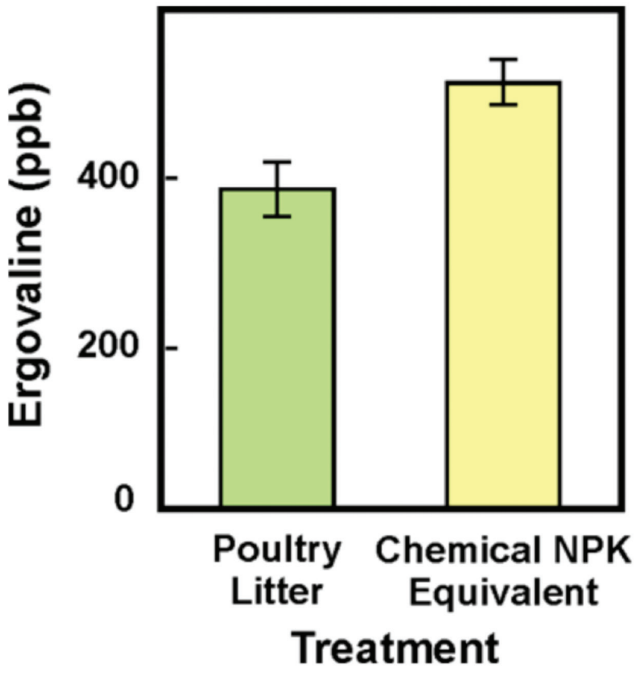

Figure 8: Nutrient source can affect the concentration of alkaloids. In this case, ergovaline – the primary alkaloid associated with toxicosis – was about 25% higher in forage treated with chemical fertilizer. (Figure from Rogers et al. 2010.)

Incorporating Legumes to Improve Intake and Counteract Toxins

Numerous studies have shown that legumes increase animal performance when incorporated into fescue-based pastures. Where this occurs independent of endophyte infection level (e.g., figure 2), it likely reflects greater levels of intake that often occur when legumes are provided to livestock. Some legume species also contain bioactive compounds that may directly offset the effects of alkaloids. For example, biochanin A, an estrogenic isoflavone found in red clover, dilates blood vessels, reducing the vasoconstrictive effects of fescue toxins. Legumes with tannins (e.g., birdsfoot trefoil, crown vetch, annual and sericea lespedezas, and black locust) or saponins (alfalfa, milkvetch, and beans) also may alleviate intake of fescue toxins because these compounds can bind alkaloids in the digestive tract.

Increasing Within-pasture and Within-farm Species Diversity with Greater Grazing Management

On many farms throughout the North-South transition zone, tall fescue has become the predominant forage because it tolerates stressors such as overgrazing, limited fertility, drought, and insect and disease pressures. Fescue's persistence in the face of these stressors – which largely occurs due to the presence of the endophyte – has allowed for lax management. This, in turn, has driven many producers' unwitting selection for predominantly endophyte-infected tall fescue stands.

Greater pasture diversity can help reduce alkaloid intake but requires greater management than commonly occurs with simple, continuously stocked pasture systems. Rotational stocking is fundamental to improved pasture diversity, because it allows the manager to choose the timing and intensity of forage defoliation. Residual grazing heights and rest periods can be targeted to meet the needs of forage species more sensitive to frequent, intense defoliation than tall fescue.

Rotational stocking also allows pasture diversity across the farm through the addition of alternative forages that can be grazed strategically to reduce toxin intake (and consequent stress) during critical periods such as the breeding season. For spring calving cows, evidence suggests that grazing nontoxic forage several weeks prior to and after breeding can result in substantial improvements in reproductive success. Animals need five to six weeks to eliminate from their bodies all of the alkaloids that they have consumed, but signs of toxicosis in stocker calves may begin to improve within a couple of weeks following removal from a toxic pasture (Williamson and Aiken 2017).

Alternative forages may include other cool-season perennial grass species such as novel endophyte tall fescue, endophyte-free tall fescue, or orchardgrass. Other forages to consider include summer annuals, such as millet, sorghums, or crabgrass, or winter annuals, such as cereal grains and annual ryegrass. For summer and fall, consider native warm-season grasses, such as switchgrass and big bluestem, or non-native warm-season grasses, such as bermudagrass. Ensuring that toxic seed does not enter novel endophyte pastures

will be a primary concern in such rotations. Seed is often transferred from field to field by equipment (such as mowers) and livestock. If livestock have been grazing pastures with mature toxic tall fescue seed heads, first move them to a site where contamination is not an issue and feed them a diet free of fescue seed for at least two days before moving them to pastures where contamination is a concern.

Seed Head Suppression

As noted above, pasture management that reduces seed head development can reduce alkaloid exposure and improve gains for grazing livestock. This can be achieved with grazing management, clipping, or with chemical seed head suppression. Timing grazing and clipping events to reduce seed heads can sometimes be a challenge, however. Often, grazing pressure suitable to suppress seed head development may have negative effects on the forage stand. Clipping, typically by mowing seed heads above the vegetative portion of the stand, frequently will not get many slower-developing or lower-growing reproductive tillers that grow out later. Chemical suppression with a metsulfuron such as Chaparral[1] (Dow AgroSciences) offers a third way of reducing fescue seed heads. Along with reduced alkaloids, this treatment can increase forage nutritive value and may support greater species diversity among grasses, although it can kill clover and stunt grass growth. Thus, application timing and frequency as well as stocking rate adjustments are important factors that should be considered before deciding to use this product.

Managing Livestock to Mitigate Toxicosis

Although the focus of this publication is on pasture and forage management, other strategies can be used to reduce toxicosis in livestock.

Supplemental Feeding

Supplemental feeds increase animal performance through greater intake, and perhaps through alkaloid dilution to some degree. Feeding high levels of supplement may defeat the purpose of pasture systems, however, if the added cost of feeding is not justified by greater gain. Recent research indicates some supplements have more than simple nutritional effects. For example, pelleted soybean hulls have been of particular interest because they also contain bioactive isoflavones (see "Incorporating Legumes," above). Initial studies indicate that supplementing with pelleted soy hulls both increases animal performance and improves markers of fescue toxicosis, such as hair coat quality and amount of serum prolactin.

Ensure that dietary copper is adequate. The symptoms of copper deficiency in cattle closely resemble symptoms of fescue toxicosis. Infected fescue has lower copper concentrations, and feeding supplemental copper will ensure that poor animal performance is not due to a deficiency of this mineral nutrient. At the same time, remember that sheep are very susceptible to copper toxicity: Levels over 40 parts per million are toxic to sheep.

Feed additives or dietary treatments may help reduce fescue toxicosis, but caution is warranted. New products are entering the market to combat the effects of toxic fescue, particularly vasoconstriction. Some show promise, but they have not been clearly proven to date. More effective products include yeast cell wall components that bind alkaloids and red pepper derivatives that dilate blood vessels.

Animal Reproductive Management

Several animal management strategies have been used to address fescue toxicosis issues – whether intentional as a fescue management strategy or simply a response to poor performance. For example, many Virginia beef producers have moved to fall calving to improve reproductive success rates. Despite the higher alkaloid levels, cows bred in late fall have less challenge breeding back because they are not subject to the heat stress commonly faced by spring calving herds. Producers also select for resistant livestock by keeping and breeding those animals that remain fertile, grow good offspring, and keep birthing intervals to about a year. Cattle producers also can use genetic tests such as the T-Snip[1] to identify animals that are resistant (or sensitive) to fescue alkaloids. Currently, expected progeny differences (EPDs) for fescue-tolerant bulls

[1] Mention of specific product and company names does not imply endorsement. Chaparral currently is the only product labeled for chemical seed head suppression.

are not available. However, when using artificial insemination or purchasing bulls and cows from off farm, it may be beneficial to avoid using animals with no history of exposure to tall fescue.

As noted above (in "Managing Fescue Pastures to Mitigate Alkaloids"), keeping animals off of toxic pasture just before and during breeding season has been a useful strategy for improving reprodutive performance. This is particularly useful for spring-calving herds, which can be moved to novel fescue about four weeks before breeding season begins. An Arkansas study (Caldwell et al. 2013) found that for spring-calving herds, replacing 25% of toxic pastures with novel fescue was sufficient to achieve reproductive rates comparable to rates on 100% novel fescue.

Tips for Mitigating Alkaloids

A whole-farm management approach that considers needs and options for the entire farming operation – including production system, markets, soils, climate, and year-round forage production – is likely to be the most successful. The following tips offer specific actions that can be beneficial as you work to mitigate fescue toxicosis issues:

- Keep tall fescue in a vegetative stage. Timely grazing and clipping as well as appropriate stocking rates help keep plant tissues young and vegetative. Heavier grazing pressure in spring or chemical seed head suppression can help control seed head development and alkaloid production.

- Don't overgraze. Graze cool-season pastures with a "take-half, leave-half" approach during the growing season. Grazing only leaf tissue reduces intake of the more toxic stem bases and allows orchardgrass and other forages to be more competitive with fescue.

- Manage pastures and farm for greater diversity. For example, adding paddocks of warm-season forages to the grazing system reduces animal exposure to toxins and gives fescue an opportunity to rest during the heat of summer.

- Incorporate legumes into pastures. Clovers in general will improve animal performance. Red clover contains chemical compounds that counter the effects of fescue alkaloids and should be used for frost seeding.

- Fields dominated by toxic fescue should be used for haymaking and stockpiling. Strip graze the stockpiled forage in late winter for greater utilization efficiency and to decrease forage residues. This will also improve the effectiveness of frost seeding with red and white clover.

- Fertilize sparingly with nitrogen. In healthy pastures with abundant legumes, nitrogen fertilization may not be warranted economically.

- Harvest tall fescue in the boot stage and conserve as hay. Timely harvest reduces seed head development, resulting in a more nutrient-dense hay crop with higher energy values and lower alkaloid concentrations. Conserving fescue as hay degrades alkaloids to a greater degree than conserving as baleage.

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Produced by Virginia Cooperative Extension, Virginia Tech, 2019

VT/1119/SPES-163P