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Pasture and cattle responses to fertilization and endophyte association in the southern Piedmont, USA

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Abstract

A 3-year experiment was conducted to determine pasture and cattle responses to tall fescue–endophyte association (free, novel, and wild endophyte associated with 'Jesup' cultivar) and fertilization source (inorganic and broiler litter). Fertilization source had only minor or no effects on botanical composition, forage mass, cattle stocking rate, and yearly cattle performance and productivity. However, cattle performance and production were greater with broiler litter than with inorganic fertilization during summer, but lower in autumn and winter, suggesting a difference in timing of nutrient availability to forage due to mineralization of organic nutrients in broiler litter. Pastures with wild endophyte association either had higher forage mass during some periods or were able to carry more cattle than other endophyte associations. Cattle performance was lower with wild than with other endophyte associations at all times of the year, except in summer. Cattle gain in winter was not different among endophyte associations (64 kg ha^{-1}; $p = 0.43$), was lower in spring with wild endophyte than with other endophyte associations (244 kg ha^{-1} versus 302 kg ha^{-1}; $p = 0.04$), was higher in summer with wild endophyte (147 kg ha^{-1} versus 117 kg ha^{-1}; $p < 0.001$), and was lower in autumn with wild endophyte (97 kg ha^{-1} versus 129 kg ha^{-1}; $p = 0.10$). Seasonal differences in pasture responses to fertilization and endophyte association suggested that management options could be developed to avoid or limit toxic cattle responses to wild endophyte.

Keywords: Botanical composition; Broiler litter; Cattle gain; Endophyte free; Novel endophyte; Wild endophyte

1. Introduction

Tall fescue (*Festuca arundinacea* Schreb.) is a widely disseminated, perennial, cool-season grass grown around the world. In the USA alone (mostly in the eastern half of the USA), it is grown on ca. 14 Mha of land (Buckner et al., 1979). Its geographical distribution surpasses many other cool-season grasses available to producers in this country. Therefore, it is considered the most important perennial, cool-season grass in the southeastern USA. It withstands grazing pressure by foraging cattle and persists better than other cool-season perennial forages, making it an excellent choice for keeping pastures productive for years. In addition to its desirable cool-season attributes, it is productive when moisture is available during the summer, but more importantly, survives the hot, drought-prone conditions common during the summer.

One reason for the superior persistence of tall fescue is likely related to a mutualistic association with a fungal endophyte (*Neotyphodium coenophialum* Glenn, Bacon & Hanlin) first reported by Bacon et al. (1977). The fungus resides in the above-ground portions of susceptible grasses, where it produces various alkaloids that have been shown to be toxic when consumed in large quantities by grazing cattle, sheep, and horses (Stuedemann and Hoveland, 1988). In addition to the negative effects on grazing cattle, toxic alkaloids produced in leaf tissue of endophyte-infected forage can deter herbivorous insects (Prestidge et al., 1982; Latch, 1993; Rowan and Latch, 1994) and other pests such as pathogenic fungi, viruses, and root-feeding nematodes (Latch, 1997), leading to greater persistence of endophyte-infected

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forage. Endophyte infection can also enhance drought resistance of forage (Bouton et al., 1993; West et al., 1993), which could affect water utilization from the soil profile.

Recently, research into endophyte associations has led to the development of a novel strain of fungal endophyte that does not induce the production of toxic ergot alkaloids in leaf tissue, but retains the endophyte to help maintain persistence (Bouton et al., 2002). A distinction can now be made between wild endophyte association (occurring naturally with high ergot alkaloid production) and novel endophyhte association (selected fungus with little or no ergot alkaloid production). Long-term data on the persistence of tall fescue stands with novel endophyte are not yet available, but short-term evaluations have suggested greater persistence than endophyte-free stands (Bouton et al., 2002). Making a choice among high wild-type endophyte infection with poor animal performance (Stuedemann and Hoveland, 1988; Schmidt and Osborn, 1993), endophyte-free tall fescue with poor plant persistence (Read and Camp, 1986; Bouton et al., 1993; Franzluebbers and Stuedemann, 2005), or novel-endophyte-infected tall fescue that has relatively high current seed cost and uncertain persistence is not easy for animal producers, because of the lack of data to quantify long-term production, ecological, and economic impacts of these choices.

In tall fescue pastures, there are a few key management factors that producers can control, which can significantly affect the balance between productivity and environmental quality. These factors include:

- type of tall fescue cultivar and/or endophyte association;
- interseeded crop to increase productivity;
- fertilizer quantity, timing, and source;
- grazing pressure and harvest management.

The objective of this study was to determine the effect of the factorial arrangement of fertilization source and tall fescue–endophyte association on pasture and cattle responses during the first 3 years of an intended long-term study. Botanical composition of pastures is an important variable that controls forage productivity and quality and cattle production. Nutrients derived from inorganic or organic sources could affect forage and cattle productivity in many ways, including seasonal and total availability of macronutrients and secondary nutrients, and potential interaction with endophyte-produced metabolites of forage that could alter cattle responses (Malinowski and Belesky, 2000). Although information is abundant on cattle performance and production in wild-type and endophyte-free associations, little current information is available to assess the effect of novel endophyte association on forage and cattle production.

2. Materials and methods

The field experiment was located on a 20 ha tract of typical southern Piedmont landscape operated by the J. Phil Campbell Sr. Natural Resource Conservation Center near Watkinsville, GA (33°52′N, 83°25′W). Slope varied from 0 to 10%. Long-term mean annual precipitation was 1250 mm and temperature was 16.5 °C. Soils were sandy loam to sandy clay loam (clayey, kaolinitic, thermic Typic Kanhapludults) composed of 80% Cecil, 12% Pacolet, and 8% Appling.

The site was developed for this experiment during 1998–2001 by establishing a set of 14 experimental paddocks (1.00 ± 0.05 ha each) with ≈0.4 m high and 1 m wide soil berms along the edge of each experimental unit. Good stands of all tall fescue ('Jesup')–endophyte associations were obtained by spring of 2002 following attempts to seed pastures with no-tillage planting during several previous autumns (precipitation during 1999–2001 was only $76 \pm 8\%$ of yearly normal). Land was sprayed with glyphosate (1.0–1.9 L a.i. ha^{-1}) and/or paraquat (1.3 L a.i. ha^{-1}) prior to seeding. Tall fescue was drilled in 20-cm-wide rows at a rate of 20–30 kg ha^{-1} in autumn of each year. Graze-on [2,4-D (0.9–1.4 L a.i. ha^{-1}) + picloram (0.2–0.4 L a.i. ha^{-1})] was sprayed onto pastures in spring of 2001 to control broadleaves with no further chemical weed control after successful stand establishment. Dolomitic limestone at 2.2 Mg ha^{-1} was spread on all paddocks in March 2002.

The experimental design was a randomized arrangement of seven treatments in two blocks. Six of the seven treatments were grazed by yearling Angus heifers whenever sufficient forage was available and the remaining treatment was cut for hay. The six grazed treatments were a factorial combination of three tall fescue–endophyte associations and two fertilization strategies. Tall fescue–endophyte associations were: (1) endophyte-free Jesup tall fescue (Free), (2) Jesup tall fescue infected with a novel endophyte that produces low levels of ergot alkaloids, marketed as Max-Q by Pennington Seed[1] (Novel), and (3) Jesup tall fescue infected with a naturalized wild strain of fungus that produces high levels of ergot alkaloids (Wild). Fertilization strategies were: (1) inorganic fertilizer applied at 180–45–90 kg $N–P_2O_5–K_2O$ ha^{-1} $year^{-1}$ split during early spring and early autumn and (2) broiler litter applied twice yearly in spring and autumn to supply similar available N as with inorganic fertilizer (we assumed 67% of applied N would be available during the first year). Actual nutrient application varied (Table 1) due to spreading with commercial equipment and variability of nutrient concentration in broiler-house floor litter. All broiler litter was purchased from the same chicken grower, who spread litter onto paddocks with a truck-type spreader.

Each paddock contained a 2 m × 4 m corrugated-metal shade, a non-freezing water tank, and a mineral feeder positioned in a 20 m line to accommodate two criteria: (1)

[1] Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA.