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Summer Application of Auxinic Herbicides Improves Late-Season Weed Control in Tall Fescue Hayfields

Abstract

Summer weed pressure in tall fescue (*Schedonorus arundinaceus* Schreb.) hayfields can limit forage production and reduce nutritive value, especially during summer dormancy. Auxinic herbicides are commonly used for broadleaf weed control in forage systems; however, products with limited soil residual activity may fail to control weeds emerging throughout the summer while tall fescue is dormant. This study evaluated the effects of summer-applied herbicides on weed control, forage mass, and nutritive value at the second hay harvest in a “Kentucky 31” tall fescue hayfield in Greeneville, TN. Treatments included a non-treated control, Grassmaster at 24 oz ac^{-1} and 32 oz ac^{-1} (2,4-D + dicamba), Gunslinger at 24 oz ac^{-1} and 32 oz ac^{-1} (2,4-D + aminopyralid), and Prescott at 32 oz ac^{-1} (clopyralid + triclopyr), arranged in a randomized complete block design with four replicates. Visual weed control ratings were assessed at 14, 28, and 84 days after treatment (DAT), and forage and weed mass were quantified at the second hay harvest (84 DAT). Weed control was similar among herbicides through 28 DAT; however, Gunslinger maintained higher control at 84 DAT. All herbicide treatments increased forage mass and reduced weed mass relative to the non-treated control;

however, Gunslinger, at both application rates, resulted in the lowest weed mass and the highest forage crude protein concentration. The extended soil residual activity of aminopyralid in Gunslinger contributed to sustained summer weed control during tall fescue's summer dormancy, improving late-season weed control and hay nutritive value.

Abbreviations: CP – Crude Protein, ADF – Acid Detergent Fiber, NDF – Neutral Detergent Fiber, IVTDMD – *in-vitro* True Dry Matter Digestibility, TDN – Total Digestible Nutrients, NIRS – Near-Infrared Spectroscopy, LSMEANS – Least Square Means, DAT – days after treatment, FM – Forage Mass, WM – Weed Mass

Keywords: forage weed control, summer weeds, nutritive value, hay production

Introduction

Tall fescue (S*chedonorus arundinaceus* Schreb.) is a forage grass native to Europe and grown on almost 35 million acres in the United States, especially in the humid Mid-South, where "Kentucky 31" is the predominant cultivar (Ball et al., 2014). Tall fescue is often infected by an endophyte (*Epichloë coenophiala*), improving its tolerance to close grazing, drought, insect pests, and diseases (Malinowski and Belesky, 2000), resulting in consistently high forage production and widespread use of 'Kentucky 31' as a benchmark cultivar (Aiken and Strickland, 2013; Yasuoka et al., 2023).

In the mid-south, tall fescue produces about two-thirds of its annual growth in the spring and about one-third in the fall (Casler et al., 2020). Forage accumulation is limited during the summer, when tall fescue is dormant due to drought and high temperatures, conditions that can favor weed competition (Oakes and Hancock, 2020). In this context, auxinic herbicides are still the primary tool for controlling broadleaf weeds in tall fescue. Active ingredients such as dicamba and 2,4-D are preferred for rapid control of annual broadleaf weeds in spring and fall, including buttercups (*Ranunculus* spp.), henbit

(*Lamium amplexicaule* L.), and purple deadnettle (*Lamium purpureum* L.). However, the short residual capabilities, along with the long pasture-growing season, require repeated applications to prevent reinfestation. Still, these molecules provide inconsistent suppression of perennial and brushy species (Foster et al., 2024).

Over the years, as tall fescue stands thin, opportunistic weeds can take advantage, establish, and compete with the forage crop for limited light, moisture, and nutrient resources, ultimately contributing to stand deterioration (Ball et al., 2014). Strong weed presence during the summer will negatively impact fall forage accumulation, the second (and last) hay harvest in the region, along with its nutritive value, because, besides competing with the forage crop for limited nutrients, weeds can also restrict forage intake and present potential toxicity issues.

After the first harvest in late May or early June, rainfall typically declines while temperatures increase and persist until late September, when cooler temperatures stimulate the fall growth of tall fescue. This extended period of challenging weather for a cool-season grass creates an opportunity for various weeds to germinate and compete with tall fescue (Kiniry et al., 2018). Late cool-season weeds, such as buckhorn plantain (*Plantago lanceolata* L.) and musk thistle (*Carduus nutans* L.), will germinate in June, succeeded by early warm-season weeds such as horsenettle (*Solanum carolinense* L.) and milkweed (*Asclepias syriaca* L.), and later followed by rough cocklebur (*Xanthium* L.) and pigweeds (*Amaranthus* spp.). Therefore, applying post-emergent herbicides with residual soil activity in early summer is recommended, as these provide sustained weed suppression throughout the dormancy period. This approach limits late-season weed emergence and enhances both forage accumulation and quality for the second hay harvest.

Clopyralid and aminopyralid are auxinic herbicides, like 2,4-D and dicamba, but they belong to the pyridine-carboxylic acid family. They are primarily used for post-emergence control of broadleaf weeds in grass-based systems, although aminopyralid also provides extended soil residual activity that suppresses later-emerging weeds

(Reimer, 2013). Clopyralid is applied almost exclusively post-emergence, with strong activity on composite and legume species, and provides moderate soil residual that persists for weeks to a few months, depending on soil and climate conditions (Tandon and Singh, 2022). Aminopyralid is also used post-emergence but exhibits longer, more consistent soil residual activity, often providing season-long suppression of deep-rooted perennials in pastures and hayfields because of its low sorption to clay particles and organic matter, persistence in the soil solution, and comparatively slow degradation (Miller et al., 2020). The appropriate use of these molecules to control broadleaf weeds, when combined with adequate management, can reduce light, water, and nutrient competition with the desirable grass, thereby enhancing forage nutritive value and ensuring faster regrowth (Furlan and Pedreira, 2024). Thus, our objective was to evaluate the effectiveness of summer-applied auxinic herbicides with differing residual activity on weed control, forage mass, and nutritive value at the second hay harvest in a 'Kentucky 31' tall fescue hay production system.

Methods

The experiment was conducted at the Northeast Tennessee AgResearch and Education Center in Greeneville, TN, between May and October 2025. The 'Kentucky 31' tall fescue hayfield was established approximately ten years before the beginning of the study and was not sprayed for broadleaf weed control in the preceding five years. The hayfield was sprayed to control johnsongrass (*Sorghum halepense* L.) with 0.58 oz ai ac^{-1} of sulfosulfuron on May 2nd. Soil is classified as a Nolichucky loam (fine-loamy, siliceous, semiactive, mesic Typic Paleudults) (Bryant, 2007). Soil pH was 6.4, and Mehlich-1 extractable P, K, and Mg were 94, 120, and 1,120 lb ac^{-1}, respectively, rated high, low, and very high.

Six treatments were evaluated: (1) non-treated; (2) Grassmaster at 24 oz ac^{-1} {2,4-D (0.538 lb ae ac^{-1}) + dicamba (0.188 lb ae ac^{-1})}; (3) Grassmaster at 32 oz ac^{-1} {2,4-D (0.717 lb ae ac^{-1}) + dicamba (0.250 lb ae ac^{-1})}; (4) Gunslinger at 24 oz ac^{-1}

{aminopyralid (0.078 lb ae ac^{-1}) + 2,4-D (0.626 lb ae ac^{-1})}; (5) Gunslinger at 32 oz ac^{-1} {aminopyralid (0.104 lb ae ac^{-1}) + 2,4-D (0.833 lb ae ac^{-1})}; and (6) Prescott at 32 oz ac^{-1} {triclopyr (0.564 lb ae ac^{-1}) + clopyralid (0.188 lb ae ac^{-1})}. All treatments included a non-ionic surfactant (NIS) at 0.25% v/v. The herbicides utilized, Grassmaster®, Gunslinger AMP®, and Prescott® are registered under Alligare LLC, Opelika, AL.

Each experimental unit was 10 by 30 ft and arranged as a randomized complete block design with four replicates. The hayfield was mowed on June 4th, the forage was baled and removed on June 6th, and the treatments were applied on June 23rd, 2025, with a four-nozzle sprayer boom, which covered an area of 6.3 by 30 ft in each plot, allowing 1.5 ft on each side of the treated area as a border. Applications were conducted mid-morning, after the dew in the hayfield had dried, in a single pass using a handheld CO_2-pressurized backpack sprayer calibrated to deliver 20 GPA at 40 psi with AIXR 8002 (TeeJet Technologies, Springfield, Illinois, USA) nozzles.

Visual weed control was estimated at 14, 28, and 84 DAT, with 84 being the day before harvest, on a scale of 0 to 100, where 0 is no weed control, and 100 is total weed control. Forage mass (FM) and weed mass (WM) were obtained by harvesting two 2.7 ft^2 quadrats with 3" of stubble height per plot on September 17, as the second hay harvest in the region. The material was separated into tall fescue and weeds, then dried at 130°F until constant weight was achieved. After drying, the material was combined and ground to pass through a 1-mm screen in a Wiley Mill Grinder (Thomas Scientific, Swedesboro, NJ) in preparation for nutritive value analysis. The samples were scanned using near-infrared spectroscopy (NIRS; Unity Spectrastar XL-R instrument, Unity Scientific, Milford, MA) to estimate crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), in vitro true dry matter digestibility in 48h (IVTDMD), and total digestible nutrients (TDN).

The FM, WM, and nutritive value data were analyzed using a mixed model with a parametric covariance matrix structure, via the MIXED procedure in SAS (Littell et al., 2006), with repeated measurements and the maximum likelihood restricted method.

Replication (block) was treated as a random effect, and herbicide was a fixed effect. Linear predictors and quantile-quantile plots of the residuals were used to verify homogeneity of variance and normality of the errors. Treatment means were estimated by least square means (LSMEANS), and comparisons were performed using the Student's *t*-test ($p < .05$). Weed mass data were log-transformed [ln (x + 5)] before analysis; back-transformed means are presented with 95% confidence intervals, as standard error of the mean is not appropriate for retransformed data.

Visual weed control data were square-root transformed to meet model assumptions. Data were analyzed using the GLIMMIX procedure in SAS (SAS Institute, Cary, NC), with herbicide, days after treatment (DAT), and their interaction as fixed effects, and block as a random effect. A Gaussian distribution with an identity link function was specified, and degrees of freedom were adjusted using the Satterthwaite method. Model fit was evaluated using Akaike Information Criterion (AIC), and the Gaussian distribution provided the best fit. LSMEANS were estimated, and pairwise comparisons were conducted using the Tukey–Kramer adjustment ($\alpha = 0.05$). Means are presented as back-transformed values, whereas letters and statistical tests are based on the transformed values.

Results

Visual weed control rating was affected by the herbicide × DAT interaction ($P = 0.0060$; Table 1). At 14 and 28 DAT, all herbicides provided similar and greater weed control than untreated plots. At 84 DAT, Gunslinger provided the greatest weed control, averaging 86%, whereas Grassmaster and Prescott had intermediate levels of control, averaging 46%.

Table 1. Visual weed control as affected by the interaction of herbicide × days after treatment (DAT).

DAT	14 DAT	28 DAT	84 DAT
Herbicide treatment and rate	**Weed control (%)**		
Non-treated	**0 Ba**	**0 Ba**	**0 Ca**
Grassmaster 24 oz/A	**68 Aa**	**70 Aa**	**50 Ba**
Grassmaster 32 oz/A	**72 Aa**	**67 Aa**	**50 Ba**
Gunslinger 24 oz/A	**80 Aa**	**89 Aa**	**88 Aa**
Gunslinger 32 oz/A	**75 Aa**	**87 Aa**	**84 Aa**
Prescott 32 oz/A	**70 Aa**	**69 Aa**	**40 Bb**

Means followed by common lowercase letters in the row and uppercase letters in the column are not significantly different by Tukey's test ($p<.05$).

Forage mass (FM) was affected by herbicide ($P = 0.0001$; Table 2). The lowest FM was observed in the non-treated plots, with values approximately 10-fold lower than those in all herbicide-treated plots. Weed mass (WM) was also affected by herbicide ($P < 0.0001$; Table 2), with herbicides reducing WM. The highest WM was observed in the non-treated plots; intermediate values were recorded for Grassmaster and Prescott, and the lowest WM was observed with Gunslinger, regardless of rate.

Crude protein (CP) was affected by herbicide ($P = 0.0036$; Table 2), with the lowest values recorded in the non-treated and the highest values in the Gunslinger plots. Grassmaster and Prescott treatments resulted in intermediate values. Neutral detergent fiber (NDF) was also affected by herbicide ($P = 0.0104$; Table 2). NDF was lowest in the non-treated control and higher in the herbicide-treated plots. TDN, IVTDMD, and ADF were not affected by herbicide treatment, with averages of 60.2%, 70.8%, and 36.7%, respectively.

Table 2. Forage mass (FM), weed mass (WM), crude protein (CP), and neutral detergent fiber (NDF) as affected by herbicide.

	FM	WM	CP	NDF
Herbicide	**(lb acre^{-1})**		**(%)**	
Non-treated	**210 B**	**3570 (±2300) A**	**12.9 D**	**50.1 B**
Grassmaster 24 oz/A	**2170 A**	**230 (±155) B**	**13.9 CD**	**61.2 A**
Grassmaster 32 oz/A	**1590 A**	**440 (±290) B**	**13.7 CD**	**58.4 A**
Gunslinger 24 oz/A	**2030 A**	**7 (±7) C**	**15.9 AB**	**65.5 A**
Gunslinger 32 oz/A	**2270 A**	**20 (±15) C**	**16.5 A**	**62.3 A**
Prescott 32 oz/A	**1820 A**	**400 (±260) B**	**14.7 BC**	**59.5 A**
SEM	**220**	**-**	**0.6**	**2.5**

WM presents individuals' 95% confidence intervals due to data transformation for statistical analysis.

Means followed by common uppercase letters in the column are not significantly different by Tukey's test ($p<.05$).

Discussion

The differences in visual weed control among herbicides observed on the day of harvest (84 DAT) can be attributed to aminopyralid's residual activity in the Gunslinger treatments (Table 1). In contrast, warm-season weed emergence was observed in the other herbicide treatments, lowering the visual control ratings, mostly due to the presence of horsenettle. Additionally, when milkweed was present in both Grassmaster and Gunslinger plots, only Gunslinger maintained effective control of it. These results align with previous work, which demonstrates the extended residual activity of aminopyralid-containing formulations compared with other auxinic mixtures lacking this active ingredient, particularly against targeted weeds, such as rhizomatous weeds, such as milkweeds (Ferrell et al., 2006).

The use of herbicides at the beginning of regrowth for the second hay cutting allowed tall fescue to grow with less weed competition, resulting in higher FM values when compared to the non-treated plots (Table 2). In line with the visual weed control ratings, Gunslinger plots also had lower WM than the other herbicides, mainly due to aminopyralid's residual activity. Although clopyralid, one of the active ingredients in Prescott, has some residual activity, it has shorter soil activity and is less efficient than aminopyralid (Enloe et al., 2007). Higher WM is associated with reduced forage nutritive value, particularly lower crude protein levels, as observed in weedier treatments compared with Gunslinger (Furlan and Pedreira, 2024). Higher fiber quantities, NDF fraction, were observed in the herbicide-treated plots than in the non-treated plots, reflecting the higher proportion of grass in the FM (which is higher in fiber) relative to broadleaf weeds (Blaix et al., 2023; Van Soest, 1994).

Regardless of the herbicide, all herbicide treatments increased FM and reduced WM. However, the best weed control, with virtually no weed presence, and the highest crude protein were observed in the Gunslinger plots, regardless of the application rate. Although all herbicides provided high weed control at 28 DAT (Table 1), the longer soil residual activity of aminopyralid maintained weed suppression during the summer period when tall fescue growth is weather-limited (Furlan and Pedreira, 2025; Oakes and Hancock, 2020). The longer soil residual activity prolongs weed control, minimizing late-season weed emergence and maintaining a cleaner stand entering fall, resulting in higher forage nutritive value and a weed-free hay harvest. It is also important to note that this study was conducted at one location and year; thus, results could vary across different settings

Conclusion

The application of Prescott, Grassmaster, and Gunslinger increased FM and CP while reducing WM. Gunslinger provided higher visual weed control and higher CP than the other herbicides, regardless of application rate. These findings demonstrate that herbicides with extended residual activity, especially aminopyralid-based formulations, are effective tools for enhancing summer weed control during tall fescue dormancy and improving fall hay production and quality.

Literature Cited

Aiken, G., and Strickland, J. (2013). Forages and pastures symposium: managing the tall fescue–fungal endophyte symbiosis for optimum forage-animal production. *Journal of Animal Science*, *91*, 2369-2378.

Ball, D. M., Hoveland, C. S., and Lacefield, G. D. (2014). *Southern Forages: Modern Concepts for Forage Crop Management*. International Plant Nutrition Institute (IPNI). https://books.google.com/books?id=S47IsgEACAAJ

Blaix, C., Chabrerie, O., Alard, D., Catterou, M., Diquelou, S., Dutoit, T., Lacoux, J., Loucougaray, G., Michelot-Antalik, A., Pacé, M., Tardif, A., Lemauviel-Lavenant, S., and Bonis, A. (2023). Forage nutritive value shows synergies with plant diversity in a wide range of semi-natural grassland habitats. *Agriculture, Ecosystems and Environment*, *347*, 108369. https://doi.org/https://doi.org/10.1016/j.agee.2023.108369

Bryant, J. L. (2007). Ground Cover Management for Conservation Tillage Burley Tobacco.

Casler, M. D., Kallenbach, R. L., and Brink, G. E. (2020). Cool-Season Grasses for Humid Areas. In *Forages* (pp. 297-311). https://doi.org/https://doi.org/10.1002/9781119436669.ch16

Enloe, S. F., Lym, R. G., Wilson, R., Westra, P., Nissen, S., Beck, G., Moechnig, M., Peterson, V., Masters, R. A., and Halstvedt, M. (2007). Canada thistle (Cirsium arvense) control with aminopyralid in range, pasture, and noncrop areas. *Weed Technology*, *21*, 890-894.

Ferrell, J. A., Mullahey, J. J., Langeland, K. A., and Kline, W. N. (2006). Control of Tropical Soda Apple (Solanum viarum) with Aminopyralid. *Weed Technology*, *20*, 453-457. https://doi.org/10.1614/WT-05-120R.1

Foster, D. C., Mueller, T. C., and Steckel, L. E. (2024). Spray interval, application order, and plant height influences control of dicamba-resistant Palmer amaranth. *Weed Technology*, *38*.

Furlan, R., and Pedreira, B. C. (2024). Weed Control Strategies to Maximize Cool-Season Pasture Productivity In E. University of Tennessee (Ed.), (pp. 4).

Furlan, R., and Pedreira, B. C. (2025). Maximizing Grazing Days with Seasonal Forage Planning In. Knoxville, TN: University of Tennessee Institute of Agriculture.

Kiniry, J., Kim, S., Williams, A., Lock, T., and Kallenbach, R. (2018). Simulating bimodal tall fescue growth with a degree-day-based process-oriented plant model. *Grass and Forage Science*, *73*, 432-439.

Littell, R. C., Milliken, G. A., Stroup, W. W., Wolfinger, R. D., and Schabenberger, O. (2006). *SAS for mixed models*. SAS Institute.

Malinowski, D. P., and Belesky, D. P. (2000). Adaptations of endophyte-infected cool-season grasses to environmental stresses: mechanisms of drought and mineral stress tolerance. *Crop Science*, *40*, 923-940.

Miller, A. J., Leite, V. M., Hall, L. M., and Bork, E. W. (2020). Forage legume establishment under exposure to progressive declines in aminocyclopyrachlor and aminopyralid in temperate pastures. *Agronomy*, *10*(3), 392.

Oakes, R. N., and Hancock, D. W. (2020). Systems for Humid Transition Areas. In *Forages* (pp. 419-432). https://doi.org/https://doi.org/10.1002/9781119436669.ch23

Reimer, J. (2013). Complicated composting: persistent pyridine carboxylic acid herbicides.

Tandon, S., and Singh, A. (2022). Residue Behavior of Clopyralid Herbicide in Soil and Sugar Beet Crop under Subtropical Field Conditions. *Journal of Food Protection*, *85*(5), 735-739. https://doi.org/https://doi.org/10.4315/JFP-21-355

Van Soest, P. (1994). Nutritional ecology of the ruminant., 2nd edn.(Cornell University Press: New York).

Yasuoka, J. I., Pedreira, B. C., Helwig, D., Farney, J., and Sassenrath, G. (2023). Impact of N, P, and K rates on stockpiled tall fescue in claypan soils. *Crop, Forage and Turfgrass Management*, *9*(2), e20255. https://doi.org/https://doi.org/10.1002/cft2.20255