Cool-Season Perennials and Stability in Year-Round Forage Production Systems

Teutsch, C.D.*
*University of Kentucky

Keywords: Cool-season; grasses; perennials; persistence; yield; climate change; year-round grazing.

Abstract. Changes in long-term climate normals have resulted in warmer and wetter summers and milder winters in the humid eastern United States. This will likely impact regional forage species adaptation in the long-term and varietal adaptation in the short term. Variety evaluation has been occurring at the University of Kentucky for almost 100 years. There are several considerations for selecting forage species and varieties including regional and local adaptation, productivity, distribution of growth, palatability, nutritive value, anti-quality factors, tolerance to stress, and persistence. Two of the most important criteria are long-term productivity and persistence under grazing, both of which are currently being evaluated in Kentucky. One potential way to use long-term data to aid in the selection of resilient cool-season perennial grass varieties for year-round grazing systems may be to graph yield (x-axis) against persistence (y-axis) where '100' represents the average for the trials. This allows varieties to be ranked either above or below average for yield and persistence. Varieties in the upper right-hand quadrant are varieties that have above-average yield and persistence and would be good candidates to include in year-round grazing systems. In contrast, varieties in the lower left-hand quadrant are varieties that are below average in both yield and persistence and probably are not good candidates to include in a year-round grazing system. This approach may require adapting current variety testing strategies to better assess yield potential and persistence under grazing.

Introduction

Changes in long-term climate normals have been observed across the United States (Dixon, 2021). Most regions of the country have seen increases in annual mean temperatures (Fig. 1). Precipitation has generally increased in the eastern U.S. and decreased in the west (Figure 1). USDA Plant Hardiness Zones are projected to move northward (Fig. 2) resulting in milder winters and more intense summers. These changes in long-term climate normals and absolute minimum temperatures during the winter months will likely impact regional forage species adaptation in the long-term and varietal adaptation in the short-term. The objective of this paper is to explore strategies for identifying perennial cool-season forage varieties that will be adapted to the pressures that shifting weather patterns are imposing.

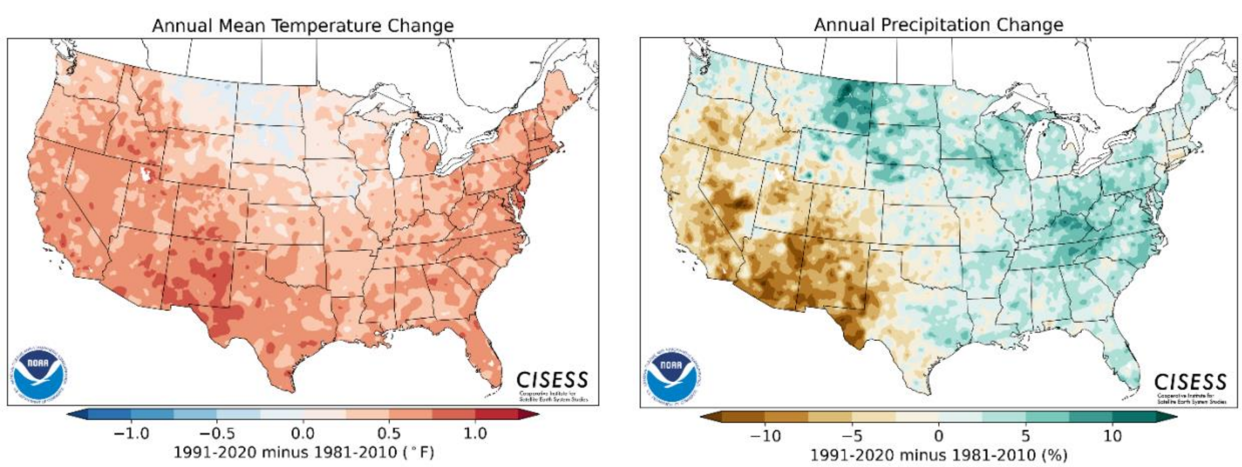

Figure 1. Annual mean temperature and precipitation change between 1991-2020 and 1981-2020 climate normal (NCEI-NOAA, 2021).

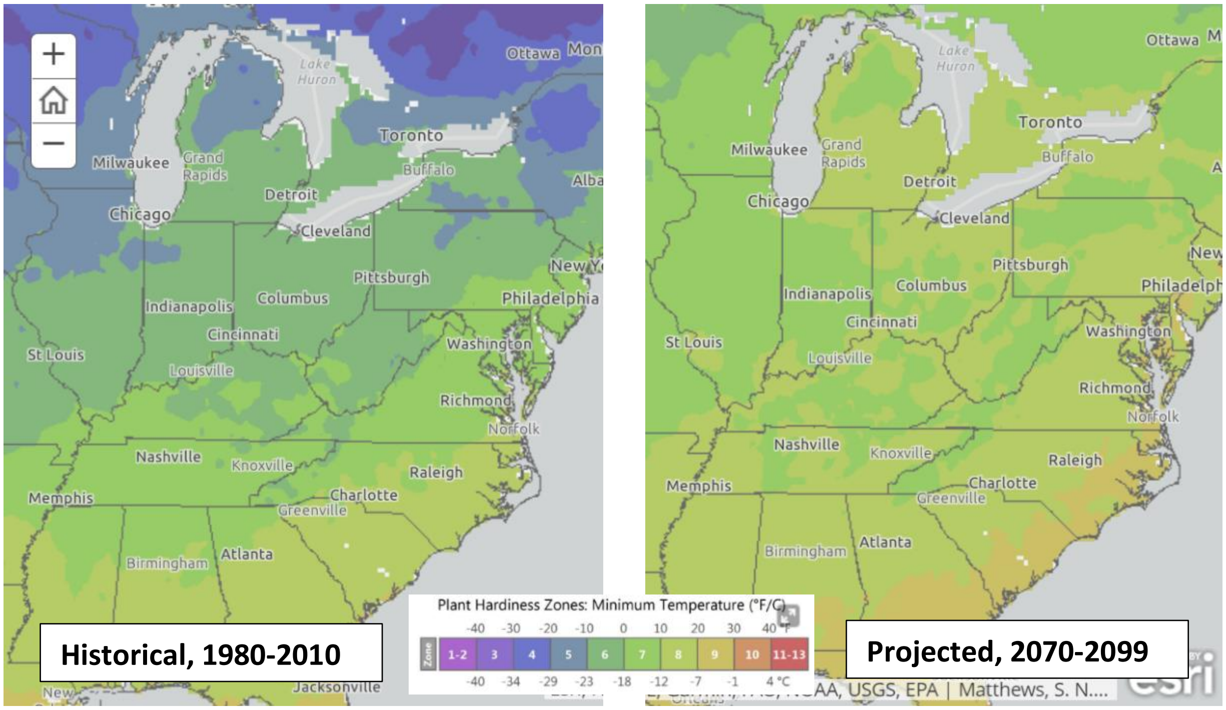

Figure 2. Projected shifts in USDA Plant Hardiness Zones (USDA Office of Sustainability and Climate, 2018).

Methods and Background

University of Kentucky Forage Variety Testing

Variety testing at the University of Kentucky (UKY) has been occurring for almost 100 years (J. Henning, Personal Communication, 13-Nov-22). In 1990, the UKY Forage Variety Testing Program was formally established and has grown to be one of the most extensive variety testing programs in the country. Prior to 1990, variety evaluations occurred as part of the very successful grass and legume breeding programs at UKY. In 1994, a grazing tolerance component was added to the variety testing program. The initial grazing evaluations were conducted with cattle and later horse trials were added.

Forage species evaluated include cool-season perennial grasses and legumes such as tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort., nom. cons.), orchardgrass (*Dactylis glomerata* L.), Kentucky bluegrass (*Poa pratensis* L.), red and white clover (*Trifolium pratense* L. and *repens* L.), and alfalfa (*Medicago sativa* L.), cool-season annual grasses such as wheat (*Triticum aestivum* L.), triticale (*X Triticosecale* Wittmack), cereal rye (*Secale cereale* L.), oats (*Avena sativa* L.), and annuals ryegrass (*Lolium multiflorum* Lam.), and warm-season annuals grasses such as the sorghum species (*Sorghum bicolor* L.), teff (*Eragrostis tef* (Zuccagni) Trotter), pearl millet (*Pennisetum glaucum* (L.) R. Br.), and crabgrass (*Digitaria ciliaris* (Retz.) Koeler). In 2022, data were collected on more than 5,000 plots (S.R. Smith, Personal Communication, 13-Nov-22). Variety testing reports are archived on UKY Forage Extension Webpage under the 'variety trial' icon.

Results and Discussion

Selecting Forage Species and Varieties

There are several considerations for selecting forage species and varieties to be included a year-round forage production system. These include:

- ✓ *Regional adaptation*. Forage species and varieties must be adapted to where they are being grown. Regional adaptation is critical to long-term productivity and persistence.
- ✓ *Local adaptation*. A forage species or variety can be regionally adapted, but not adapted to local conditions such as soil type or drainage class.
- ✓ *Productivity*. The yield potential of species and varieties is an important consideration when assembling an extended grazing system.
- ✓ *Distribution of growth*. The seasonal distribution of forage is an important consideration when selecting species and varieties for a year-round grazing system.
- ✓ *Palatability*. Species and varieties must be readily consumed to be part of a successful forage-livestock system.
- ✓ *Nutritive value*. Improved digestibility and high concentrations of non-structural carbohydrates increase the value of species and varieties when included in grazing systems.
- ✓ *Anti-quality factors*. Factors that decrease palatability, utilization in the rumen, or cause psychological distress in the animal should be considered.
- ✓ *Tolerance to abiotic and biotic stresses*. Tolerance to stresses such as temperature, drought, disease, and insects is becoming increasingly important as long-term climate normals change.
- ✓ *Persistence*. In low input and extensive forage systems that are utilizing marginal land not suited for row crop production, long-term persistence is critical.

The question becomes how do we use the above-listed criteria for selecting cool-season perennial forage species for extended grazing systems? Two of the most important criteria are long-term productivity and persistence under grazing, both of which are currently being evaluated in the UKY Forage Testing Program. In the 'Long-Term Summary of Kentucky Forage Variety Trials' (Olson, 2021) that is compiled annually, yield and persistence under grazing being expressed as a percent of the mean of the commercial varieties in the trial, except for tall fescue persistence which is expressed as a percent of stand rating for KY-31+. A 100 on this scale would be average for the trial. Varieties above 100 would be above-average performers and varieties below 100 would be below-average performers (Olson et al., 2021).

One potential way to use the data from the 'Long-Term Summary of Kentucky Forage Variety Trials' to aid in the selection of varieties that have both above average yield and persistence, maybe to graph yield (x-axis) against persistence (y-axis) where '100' represents the average for the trials. This allows varieties to be ranked either above or below average for yield and persistence (Figure 3). Varieties in the upper right-hand quadrant are varieties that have above-average yield and persistence and would be good candidates to include in year-round grazing systems. In contrast, varieties in the lower left-hand quadrant are varieties that are below average in both yield and persistence and probably are not good candidates to include in a year-round grazing system.

This approach requires varietal separation for yield and especially for persistence. In Figure 3, there is a reasonable separation for yield and persistence for orchardgrass, but not for tall fescue. The range for both yield and persistence was less than 4% for the tall varieties in these trials (Fig. 3). This indicates that even though tall fescue varieties had been grazed, grazing had not imposed enough stress to result in significant stand loss and ultimately varietal differences in persistence.

One potential solution may be to implement a grazing protocol that is designed to accelerate stand loss. This was done by Bouton and coworkers (2002) in the development of novel endophyte tall fescue varieties. In their protocol, they planted tall fescue cultivars into established bermudagrass sods and implemented continuous stocking. The bermudagrass competed aggressively for soil and water resources during the summer months when tall cool-season grass growth was limited by high temperatures (Nelson, 1996). A similar to protocol could be implemented in Kentucky where bermudagrass is adapted, especially in the western portion of the state. Additional stress could be imposed on tall fescue cultivars by conducting grazing tolerance trials on marginal soils that are low in fertility. This would more closely approximate the conditions found on most livestock farms in the mid-South.

Conclusions

Improving the yield stability of cool-season perennials in the mid-south will require selecting more resilient varieties that are better adapted to climatic conditions imposed shifting weather patterns. This may require adapting current variety testing strategies to better assess yield potential and persistence under grazing. To accomplish this varieties will need to be concurrently evaluated for yield potential in traditional clipping trials and persistence under grazing using some type of an accelerated stand loss protocol.

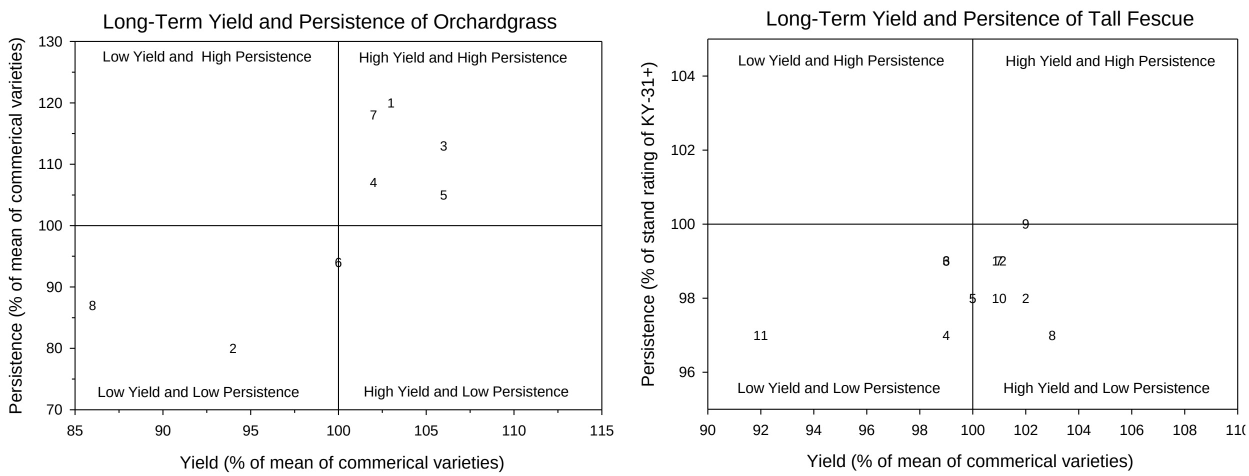

Figure 3. The relationship between yield and persistence for orchardgrass (left) and tall fescue (right). A value of '100' represents the average for the trials.

References

Bouton, J.H., G. Latch, N.S. Hill, C.S. Hoveland, M.A. McCann, R.H. Watson, J.A. Parish, L.L. Hawkins, F.N. Thompson. 2002. Reinfection of tall fescue cultivars with non-Ergot alkaloid–producing endophytes. Agron. J. 94:567–574.

Dixon, M. 2021. Long-term weather trends and implications for grazing operations in the mid-south. In the 2021 Kentucky Fall Grazing Conference Proceedings. Available at https://uknowledge.uky.edu/ky_grazing/2021/session/3/.

Nelson, J. 1996. Physiology and developmental morphology. p. 87-126. *In* L.E. Moser et al., (eds.) Cool-Season Forage Grasses. Agron. Mongr. No. 31, ASA-CSSA-SSSA, Madison, WI.

Olson, G.L., S.R. Smith, J.C. Henning, and C.D. Teutsch. 2021. Long-Term Summary of Kentucky Forage Variety Trials, PR-810. Agricultural Experiment Station, UK College of Agriculture, Food and Environment, Lexington.

NCEI-NOAA. 2021. Decadal update from NCEI gives forecasters and public latest averages for 1991–2020. Available at https://www.ncei.noaa.gov/news/noaa-delivers-new-us-climate-normals.

USDA Office of Sustainability and Climate. 2018. Climate Change Pressures in the 21st Century. Retrieved from https://usfs.maps.arcgis.com/apps/MapSeries/index.html?appid=96088b1c086a4b39b3a75d0fd97a4c40.