Breeding small grains as a forage, silage and cover crop for the southern Coastal Plain (USA) in a changing climatic environment

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Abstract

Forage breeding of small grains in the southern Coastal Plains region of the U.S. mimic many other countries experiencing climate changes and breeding strategies should be similar for improving small grains grown for forage, silage or as cover crops. Significant focus on improvements in stress-adaptation has encouraged members of the SunGrains cooperative to cross, evaluate and develop experimental lines with inherent adaptation to climatic conditions including heat stress, drought tolerance, short-day and long-day forage production periods, and flooded conditions for events with storm-related, short-term durations. Many new cultivars, grown throughout the southeastern U.S. have resulted from breeding selection under abiotic and biotic stresses, adapted to climate change and related concerns, such as disease and insect pests.

Introduction

On a global scale, temperatures are warming and will likely affect future crop production (Kimball, et al. 2018). These global changes are significant to impact our approach to breeding food and forage crops for the future, keeping an eye on strategies to combat climate change (Cammarano and Tian, 2018). In the southern Coastal Plain and the peninsular of Florida of the U.S. (a geographic area delineating part of the southeastern United States, comprised of southern Georgia, southern Alabama, and Florida) we are addressing climate change through breeding small grains for abiotic and biotic stresses. The southern Coastal Plain typically experiences a mild, temperate climate and can support many tropical and semi-tropical forage plant species. This region is located at the extreme limits for both tropical and temperate forage species. However, in recent years, the landscape in this region has been fraught with drought and coupled with high heat extremes during summer and warm winter weather. Recent flood events have also imposed significant crop production losses. These extremes in weather have led to an escalation in disease and insect pressure with many of our row crops, particularly with small grains, often grown as winter forage for grazing, silage, or wildlife forage, as well as for cover cropping.

Livestock producers in this region do not typically treat forage plantings of small grains, like wheat, rye, oat or triticale, with fungicides or insecticides because of the lack of legal crop application labeling or the cost or equipment associated with chemical control on forage crops. To combat the low-input systems often associated with growing small grains as forages in the southern Coastal Plain, plant breeders formed the SunGrains consortium (Southeastern UNiversity GRAINS), a cooperative university-based research program initially established in 2005 among five land grant universities, and later expanded to six institutions in 2011 (www.sungrains.lsu.edu). This collaborative effort has led to the development of a many small grain varieties that are dual purpose for grain and forage and these dominate winter forage plantings in the southern Coastal Plain as grazed forage and/or silage grown for the livestock industry (dairy and beef) in that region. Additionally, these small grain forages are used as wildlife forage or as conventional cover crops. Working together to breed and screen advanced germplasm, rapid advancement of new varieties has been accomplished to address the changing environment.

Breeding strategy

Small grains breeding in this region has produced varieties that are able to tolerate the heat and drought stress typically found in the variable southern environment. With recent shifting weather extremes, including long-term drought or storm-related flooded conditions, our plant breeding criteria now focuses on environmental stress-condition selection when developing new varieties for the southern Coastal Plain of the United States. Similar to issues of climate change threats to Australian wheat production (Simmons, et al. 2020), we must alter our approach from breeding small grains under optimum conditions that maximize productivity, to developing germplasm that is still productive, but better adapted to sub-optimal environments.

As we select under sub-optimal conditions, we take into mind evaluating advanced plant lines under lower fertilizer inputs, selecting for production on acid soils and in water-limited environments. Strategies involving crop rotation or mixed plantings that include legumes in small grains production systems is a key step in the effort to reduce inorganic N fertilization needs and to improve the soil microbiome. We have initiated root studies with advanced selections in small grains to examine their mycorrhizal associations concurrently with plant breeding improvement. By improving the soil microbiome, and ultimately soil health, we should increase the productivity of the crops grown, especially when growing in a stress environment. We have seen this with growth of small grains following a legume crop rotation or grown in blends with clovers, vetch, or winter pea.

Many new cultivars developed for the southern Coastal Plain of the U.S. are also grown world-wide in areas where similar climatic conditions occur. At present, SunGrains cooperators at the University of Florida, jointly breed and develop small grains forages through a collaborative agreement in Australia and Argentina. Our breeding strategy addresses climate change and selection based on broad environmental adaption. These new small grain cultivars have resistances to many disease and insect pressures that occur world-wide, and have improved adaptation to the climatic shifts in temperatures and rainfall. Small grains, typically oat, triticale and rye, are planted for forage generally earlier than when planted for grain. Because of this, disease resistance is a major breeding strategy. Many fungal diseases of small grains, such as head scab (*Fusarium graminerum*), crown rust (*Puccinia graminis*) and *Bipolaris* leafspot, may begin earlier in the season with infection if weather patterns support warmer fall planting periods.

We also find, in the southern Coastal Plain, that insect pest problems are increasing due to these warmer fall seasons and mild winters, which allow insect pests to more easily overwinter in crop residues or on alternative host plants. Aphid feeding on small grains in the early fall is not only problematic, but may transmit viral diseases to small grains, like Barley Yellow Dwarf Virus (BYVD), a grass virus of world-wide importance. Many southern-adapted small grain cultivars are prone to BYDV infection (transmitted by infected aphids), which often move from summer corn or other grasses onto susceptible varieties, particularly in oat. Variety development in the southern Coastal Plain includes screening for high levels of field resistance to BYDV. By altering the photoperiod and vernalization responses in small grains, our breeding strategy has helped us to develop cultivars that avoid infection because of earlier growth response and maturation.

While critical criteria for small grains breeding includes the selection for productivity under low-fertilizer inputs, growth under drought or high heat temperatures, freeze and multiple pest resistances (disease and insect), SunGrains breeders recently realized that flood tolerance should be another factor in the selection process, in part due to the recent catastrophic hurricanes that have plagued the region.

Breeding for biotic and abiotic stresses in small grains for the southern Coastal Plain has focused on developing earlier, as well as later maturing variety releases of oat, cereal rye, and triticale. Photoperiod responses have been altered to accommodate short-season rapid growth and early forage yield production under low fertility and dryland conditions. Concurrently, cultivars are developed for later season growth and maturity to fill the forage deficit in early through late spring. The University of Florida Forage Breeding Program, located at the North Florida Research and Education Center and the Food Crop Breeding Program at Gainesville along with other members of the SunGrains consortium, have successfully released widely popular small grains cultivars, such a Legend (FL0567) and Horizon 720 (FL0720) oat (*Avena sativa* L.) and has been testing advanced lines of black oat (*A. strigosa*). Successful releases of triticale, a man-made cross between wheat and rye, have included TriCal 342 (FL 342) and TriCal 1143 (FL 01143) triticale (*X Triticosecale cereale*), and just newly released FL 08128 bronze-chaffed triticale. By altering the photoperiod of cereal rye (*Secale cereale*), new cultivars, such as FL 405 and FL 406, will grow rapidly under short winter days, producing available forage for early winter grazing. Their early growth and early maturity often allow these cultivars to evade disease and insect pressures that build up over time. Early maturity is also advantageous from a cover crop prospective, to allow for quick cover and maturity prior to the following cropping season.

Summary:

As we develop small grains cultivars for southern Coastal Plain region of the U.S., we emphasize photoperiod and vernalization manipulation to develop short-season forage productivity under low fertilization, drought or flood tolerance, and resistance to fungal, bacterial, viral and insect pests. With climate change, these selection criteria are of global concern. We, as forage breeders, understand that many small grains, such as wheat, are important food crops on a global basis. Global food security related to climatic changes are a concern (Leng and Hall, 2019). However, small grains remain multi-purpose in their usage in the southern Coastal Plain, nationally in the U.S. and internationally. While we strive to breed small grains as grain crops, we simultaneously breed for improved forage types. The SunGrains consortium has made significant advances in developing improved forages through selection under abiotic and biotic-related stresses for livestock and wildlife enterprises in an ever-changing edaphoclimatic environment.

References:

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