Bahiagrass Breeding at the University of Florida

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Background

Bahiagrass breeding is a multi-disciplinary and multi-state effort between faculty at the University of Florida and USDA-ARS scientists in Georgia and Florida. Bahiagrass is a perennial grass species, and improvements through plant breeding have been multi-disciplinary. Faculty involved in breeding bahiagrass includes forage breeders, animal nutritionists, forage management specialists, soil scientists, and crop physiologists.

Bahiagrass is one of the predominant pasture grasses utilized by the beef cattle industry in southern Georgia, southern Alabama, and throughout Florida. Its popularity is attributed to its tolerance of low soil fertility, establishment by seed, persistence under grazing, long-lived stands, disease and nematode suppressing ability in crop rotations, and use as a pasture, hay, or sod crop. Although bahiagrass is native to South America, it has proved to be remarkably adapted to the southern Coastal Plain and, particularly, to our Florida environment. This species is estimated to cover at least 6.0 million acres throughout the southeastern United States (Burton et al., 1997). Strong support from the beef industry sector in the southeast has prompted a multi-state emphasis on bahiagrass variety development. The focus of the breeding program has emphasized plant improvement in seedling vigor and establishment, cold tolerance, photoperiod response, seasonal distribution of forage production, forage quality, rooting, and insect, nematode and disease resistance.

'Pensacola' bahiagrass dominates the bahiagrass acreage in the southeastern U.S. In Florida, an estimated 60% of the bahiagrass acreage is planted in Pensacola, about 25% in 'Argentine', 10% in 'Tifton 9', and 5% in 'Paraguay 22' (Carrol Chambliss, University of Florida State Extension Forage Specialist, 2002). The bahiagrass cultivar 'AU Sand Mountain' was recently released from Auburn University. In the northern parts of Alabama and Georgia, this new variety has out-yielded Tifton 9. AU Sand Mountain is not expected to greatly impact bahiagrass acreage in southern Alabama, southern Georgia, or Florida, however it may be very successful further north.

Dr. Glenn Burton, at the USDA-ARS Crop Genetics and Breeding Research Unit at Tifton, GA, began a bahiagrass breeding program there in the early 1960s (Burton, 1982). He used a selected procedure called Recurrent Restricted Phenotypic Selection (RRPS). Applying this procedure to Pensacola bahiagrass, he selected for increased above-ground yield for nine cycles, which led to the development of Tifton 9. Twenty-three cycles of RRPS selection were eventually conducted at Tifton, and seed has been maintained from each population. Efforts at Tifton, Ona, Brooksville and Marianna utilize this existing germplasm to select for such attributes as increased forage production, improved digestibility and rapid stand establishment.

Bahiagrass, as is typical of most warm-season grasses, has lower forage quality (protein and digestibility) than cool-season grasses such as ryegrass and tall fescue. Bahiagrass forage quality is particularly low in late summer. Frequent cutting does not increase digestibility appreciably (Gates et al., 1999). Selections have recently been made at Tifton for individual plants with superior forage quality. Eight cycles of selection for higher digestibility have resulted in small, but significant progress in improved digestibility that will hopefully be incorporated into the breeding program. Also, low seedling germination and poor stand has been a common problem with pasture establishment. As part of the breeding selection, seed from each new cycle are germinated in the greenhouse and plants are selected based on rapid emergence and early seedling vigor, in an effort to improve seedling establishment.

Ploidy and Diploid Cultivar Development

Many bahiagrass cultivars are tetraploid (2n=40) and apomictic; however Pensacola bahiagrass is diploid (2n=20) and sexual. Individual plants within this heterogeneous population vary for many agronomic traits, like crown growth, plant height and foliage yield. A system of recurrent restricted phenotypic selection (RRPS) was used to increase forage yields in Pensacola bahiagrass, which is heterogeneous for forage production (Werner and Burton, 1991). Selections cycles were developed at the Coastal Plain Experiment Station based on selection for a single trait, forage yield, in spaced-plant bahiagrass tests for a number of years, beginning in 1960.
Burton selected for a single trait, above-ground forage yield using the RRPS procedure (G.W. Burton, personal communication, 1999). While each annual cycle improved forage yield, the morphology of the plants comprising each cycle was altered toward a more upright growth habit with a smaller basal diameter (Werner and Burton, 1991).

The release of Tifton 9 bahiagrass resulted from the ninth cycle of breeding for forage improvement in Pensacola, and is the only cultivar that has made a significant impact on newly established acreage in the southeastern US (Burton, 1989).

Bahiagrass growth essentially ceases during the fall and winter months, which has a negative impact on livestock production (Blount, 2000). Cessation of growth may be a response to several environmental limitations, including solar radiation, temperature and rainfall. In Florida, simulated forage yields with bahiagrass resulted in winter harvests yielding slightly more than half the peak yield harvested in early summer (Sinclair et al., 1997). This was attributed to reduced solar radiation in the fall and winter months. Observed winter yields, however, are only a very small fraction of summer yields (Mislevy and Everett, 1981). One possible explanation for this dramatic decrease during the winter is plant response to the short daylength. While shortening daylength has been shown to be associated with induced dormancy in floral initiation and vegetative growth behavior in many plants (Aamlid, 1992; Damann and Lyons, 1993; Ellis, et al., 1997; Marousky, et al., 1991; Wallace, et al., 1993), its affect on vegetative growth of tropical and subtropical grasses has not been well documented.

A recent study, conducted at the Range Cattle Research and Education Center (RCREC) at Ona, FL, determined that daylength in the winter months influenced the vegetative behavior of bahiagrass and bermudagrass (Sinclair et al., 2001). A field study was designed to compare the winter growth of these two subtropical genera under a light regime mimicking summer daylength (15 h) and normal (shortening) daylength. The study resulted in a greater than 6-fold increase for bahiagrass exposed to the supplemental light under the shortest daylength, compared to the growth of the same grass under normal (short-day) conditions. This finding may be significant for bahiagrass improvement, if genetic diversity for photoperiod response was found in diploid bahiagrass. Genotypes identified for insensitivity to shortening daylength could provide the genetic base in developing bahiagrass with improved fall/winter growth.

Based on the RCREC-Ona findings with bahiagrass, another experiment, conducted at the North Florida Research and Education Center (NFREC) at Quincy, FL from 1999-2001, looked at genetic differences for photoperiod among bahiagrass selection cycles (Blount et al., 2001). Photoperiod response influenced the growth and development of ‘Pensacola' derived bahiagrass in four selection cycles [C0 (Pensacola), C4, C9 (Tifton 9) and C23. Field grown plants representing these four cycles were exposed to two daylength treatments. One treatment used natural light and the other imposed a 15 h extended daylength using quartz-halogen lamps. Foliage growth of individual plants was harvested and plant height was recorded from 1999 through 2001. Crown area was measured in mid February 2000 and 2001. Increasing daylength exposure to 15 h after August on all bahiagrass cycles was found to dramatically increase the foliage and height of bahiagrass, while reducing crown area, at nearly all dates where foliage harvests or plant heights were recorded. By October 1999, extended light significantly ($P < 0.05$) increased foliage yield by 69%, 76%, 47%, and 9% for C0, C4, C9, and C23, respectively, compared to yields of those under natural light (Fig. 1). Similar differences were reported at other harvest dates. Plant height was also greatly increased under the extended light treatment for nearly all cycles, at all dates. For example, October 1999 plant heights are shown in Fig. 2. Extended daylength reduced crown area by nearly half that of the plants grown under normal daylength conditions in winter 2000 (Fig. 3). While not as dramatic, similar behavior was observed in 2001. Overall, C9 and C23 appeared to be somewhat less sensitive to daylength, than C0 and C4. Results from that experiment demonstrated a high sensitivity in growth and development of Pensacola-derived bahiagrass to daylength, and implicated photoperiod as a major influence on plant development. The study also identified plants that exhibited a day-neutral (no or little influence from the daily duration of sunlight exposure) response, which should be valuable in cultivar development.

Diploid Breeding

As we develop late season forage types, cold tolerance in the population will allow the forage to withstand cold fronts that often occur in Florida in the late fall, winter, and early spring seasons. The current status of bahiagrass cultivar development is based on recurrent selection for cold tolerance, late-season forage growth, and ample stolon development within the original Pensacola germplasm. Utilizing plants selected from the NFREC-Quincy photoperiod study, and the breeding nursery at Quincy, selections were made in winter 1999 for high levels of cold tolerance and excellent crown and top growth. Vegetative cuttings from these selections were crossed in the greenhouse at NFREC-Quincy and seed from this cycle (FL PCA Cycle 1) was then germinated in the greenhouse at Quincy in late spring. Seedlings were selected for rapid seedling emergence and vigor in the greenhouse, and inferior seedlings were eliminated from the program. Selected seedlings were then planted at the NFREC-Marianna Beef Unit in late summer 1999. Plant selections for fall forage growth and cold tolerance were made in late fall 1999 and winter 1999-2000. Vegetative cuttings from these selections were crossed in early spring in the greenhouse at NFREC- Quincy. The seed (FL PCA Cycle 2) was germinated in the greenhouse and resulting seedlings were transplanted at the Range Cattle Research and Education Center (RCREC) at Ona, FL in summer 2000. After rigorous culling of the selections in March 2001 at RCREC-Ona, vegetative cuttings were taken from superior plants selected for better photoperiod insensitivity, cold tolerance and general appearance. These cuttings were brought back to NFREC-Marianna and were crossed in the greenhouse at NFREC-Marianna in late spring and early summer 2001. Seed (FL PCA Cycle 3) from this cross was tested for rapid seedling emergence and seedling vigor at Tifton, GA. Plants selected from that cycle were planted at the RCREC-Ona in fall 2001. Again, superior plants in the population at the RCREC-Ona were selected in spring 2002. Selected plants were crossed at the NFREC-Marianna in summer 2002 and seed (FL PCA Cycle 4) resulting from that cross was germinated. The resulting seedlings were selected for rapid seedling emergence and seedling vigor at Quincy-NFREC in late Summer 2002. The seedlings or Cycle 4 plants are now presently growing at the RCREC Ona in a spaced-plant nursery and a breeder's seed increase was established at Marianna in 2005. While cultivar development is a long term project, we have accomplished four selection cycles in rapid succession, as a result of an integrated team effort.

FL PCA Cycle 5 is the next cycle of selection that was developed from FL PCA Cycle 4 through an elite polycross of selected genotypes that had deep rooting characteristics along with improved dollar spot resistance, forage yield and improved digestibility. A breeder's seed increase of FL PCA Cycle 5 was established at Marianna in 2006.

One other population of diploid bahiagrass was developed from advanced cycles of selection form Dr. Burton's RRPS breeding program and was designated as FL Hay. This experimental line was designed for sod-based rotation systems where less dense sod would be desirable along with improvements in forage yield and quality, plant persistence and pest resistance. At present we are testing FL Hay in sod systems for short-term rotation with peanuts and cotton.

Preliminary variety trials indicate excellent seedling vigor and early-season forage production on FL PCA 4, FL PCA 5 and FL Hay. Variety trials that include these lines are a multi-location and multi-year efforts. This is necessary to adequately test these experimental diploid lines prior to releasing of a commercial cultivar.

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Fig. 1. Mean foliage yield of bahiagrass cycles grown under natural light (MN) and extended light (ME) treatments on 22 Oct. 1999.

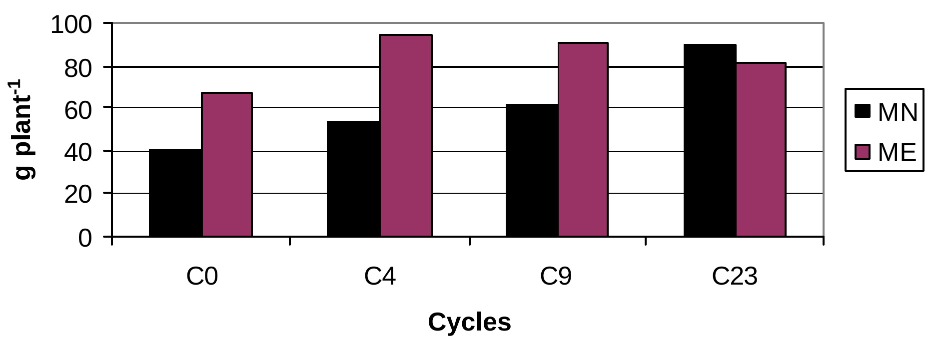

Fig. 2. Mean foliage height of bahiagrass cycles grown under natural light (MN) and extended light (ME) treatments on 20 Oct. 1999.

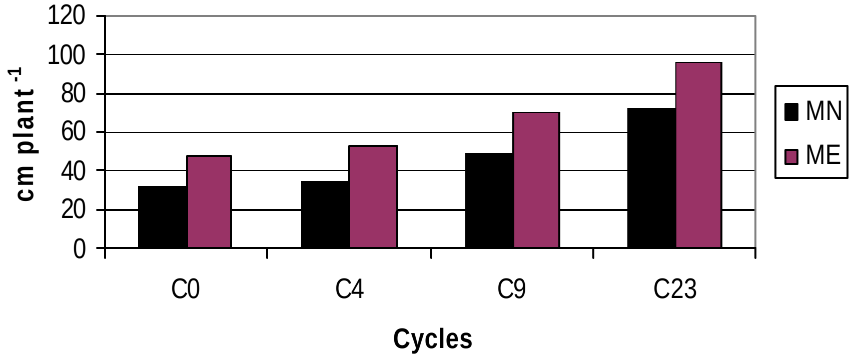

Fig. 3. Mean crown area of bahiagrass plants grown under natural light (MN) and extended light (ME) treatments recorded on 15 Feb. 2000.