GENETIC PARAMETERS OF BAHIAGRASS HALF-SIB FAMILIES

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Introduction

Turfgrass Industry

- Florida's most important turf species (St. Augustinegrass, Zoysiagrass, Bermudagrass, and **Bahiagrass**).
- Around 4.4 million acres in Florida of maintained turf (1991-1992). (Hodges et al, 1994)
- Turfgrass occupies more area than any other crop in the US. (Milesi et al, 2005)
- Increase in revenue from $6.26 billion in 2007 to $14.3 billion in 2019.

Introduction

Need for Low Input Turf

- St. Augustinegrass preferred (higher aesthetic value).
- Eutrophication has led to the enforcement of ordinances regarding fertilization.
- Need of low maintenance turf species and cultivars.

Current low input turf options

Bahiagrass (*Paspalum notatum* Flügge)

- Perennial, warm-season grass.
- Sexual diploid (2n=2x=20) and apomictic tetraploid (2n=4x=40).
- Comprises 30% of the sod production in Florida, only surpassed by St. Augustinegrass.
- Low nutrient and water requirements.

Bahiagrass

- Pensacola – Most widely grown cultivar (Diploid).

- Argentine – Preferred cultivar for turfgrass (tetraploid).

Genetic Parameters

Bahiagrass:

- Dominant low-input species in Florida.
- However, existing cultivars were developed as forages.
- Desire for improved turf-type bahiagrass.
- The extent of genetic variation for turfgrass is unknown.
- Determining the range of variation and level of genetic effect is important when considering a breeding program.

Objective

- Determine the extent of variability, and to obtain variance components and estimates of heritability for leaf morphological and flowering attributes in diploid half-sib families of *P. notatum.*

Materials and Methods

- Half-sib family produced from diploid population selected for turfgrass characteristics.

- The trial was established at the Agronomy Forage Research Unit, Hague, FL.

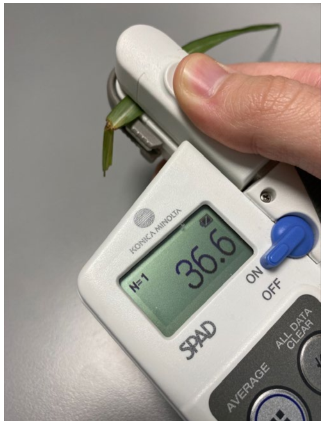
- Randomized complete block design (RCBD) with two repetitions.

- Experimental unit is a row with 20 individual plants from the same half-sib family (treatment).

Genetic Parameters of Morphological Traits in Bahiagrass

Response variables

- Leaf length and width
- Chlorophyll level
- Seed head height
- Stem diameter
- Raceme length
- Spikelet number
- Raceme number per seed head
- Seed head number per plot area
- Days of flowering



Genetic Parameters of Morphological Traits in Bahiagrass

Statistical analysis

•Linear-mixed model leaf variables:

$$y = X\beta + Zg + \epsilon$$

y - vector for the response variable

β - vector for the fixed effects (blocks, date, and number of plants as covariate)

g - vector of the random genotypic effect and genotypic effect x date interaction with g ~ N(0, $I\sigma_g^2$).

•The restricted maximum likelihood-ratio test (REMLRT) was used to tests for significance of the random parameters

Genetic Parameters of Morphological Traits in Bahiagrass

- Linear-mixed model seed head variables:

$$y = X\beta + Zg + \epsilon$$

y - vector for the response variable

β - vector for the fixed effects (blocks and number of plants as covariate)

g - vector of the random genotypic effect with g ~ N(0, $I\sigma_g^2$).

- The restricted maximum likelihood-ratio test (REMLRT) was used to tests for significance of the random parameters

Genetic Parameters of Morphological Traits in Bahiagrass

- Broad-sense heritability estimated for leaf variable as follows:

$$H^2 = \frac{\sigma_G^2}{\sigma_G^2 + \frac{\sigma_{GD}^2}{GD} + \frac{\sigma_E^2}{RD}}$$

σ_G^2 is the genotypic variance

σ_{GD}^2 is the genotypic × date interaction variance

σ_E^2 is the error variance

R corresponds to replication

Genetic Parameters of Morphological Traits in Bahiagrass

- Broad-sense heritability estimated for seed head variable as follows:

$$H^2 = \frac{\sigma_G^2}{\sigma_G^2 + \frac{\sigma 2_E}{R}}$$

σ_G^2 is the genotypic variance

σ_E^2 is the error variance

R corresponds to replication

Genetic Parameters of Morphological Traits in Bahiagrass

- Broad-sense heritability was alternatively estimated as proposed by Cullis et al, (2006):

$$H_c^2 = 1 - \frac{PEV}{2*\sigma_c^2}$$

PEV is the mean of the prediction error variance, from the difference between the BLUP's of two families.

σ_c^2 is the genetic variance of the families

Genetic Parameters of Morphological Traits in Bahiagrass

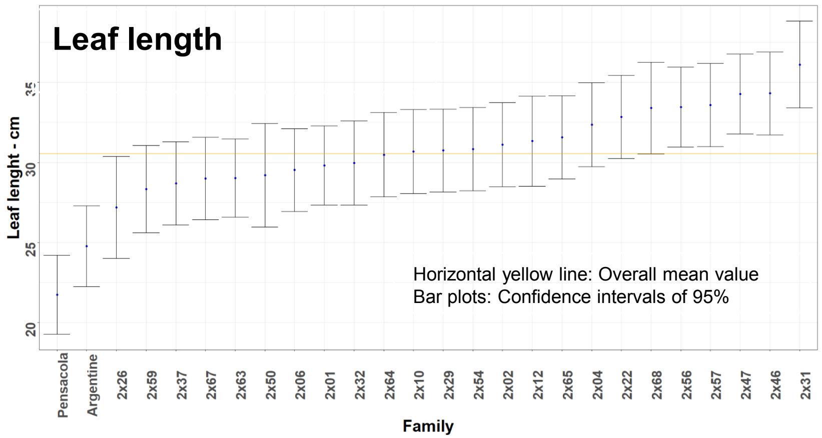
Significance level for random genetic effect on leaf and seed head variables.

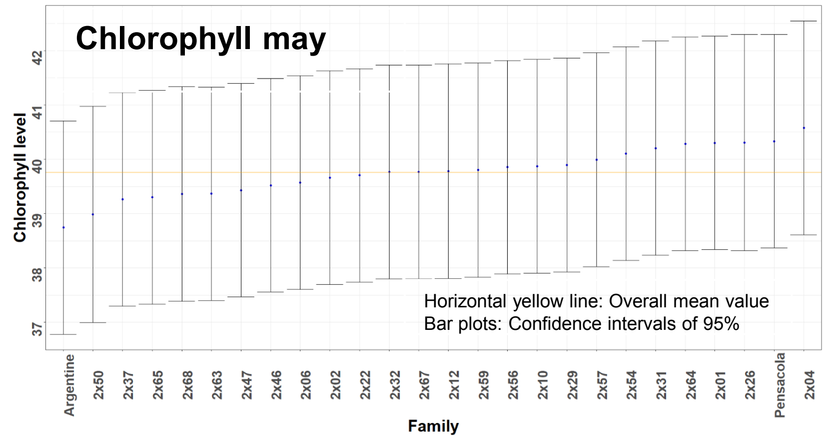
Variable	Maximum Likelihood-ratio test P-value ($P \leq 0.05$)
Leaf length	***
Leaf width	***
Chlorophyll content May	NS
Chlorophyll content Sep	***
Seed head height	***
Stem diameter	NS
Raceme length	**
Spikelet number	***
Number of racemes per seed head	***
Number of seed head per plot area	NS
Flowering window	*

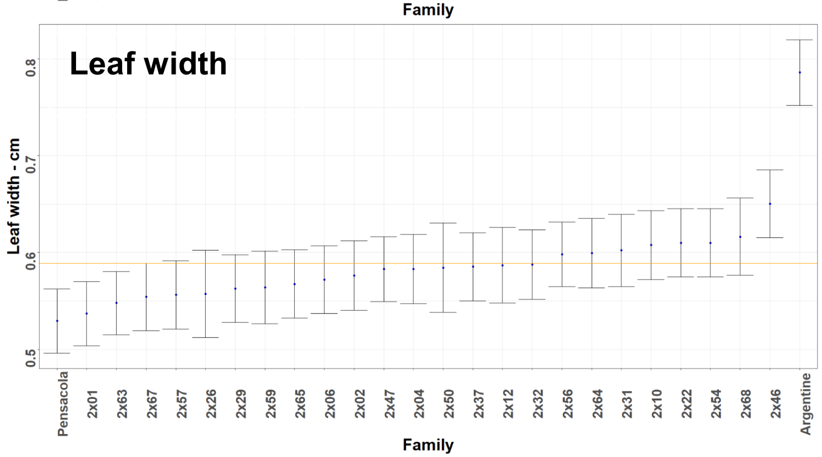
Significance (Sig.) Level: '***' < 0.001, '**' < 0.01, '*' < 0.05, ‘NS’ Non-significant

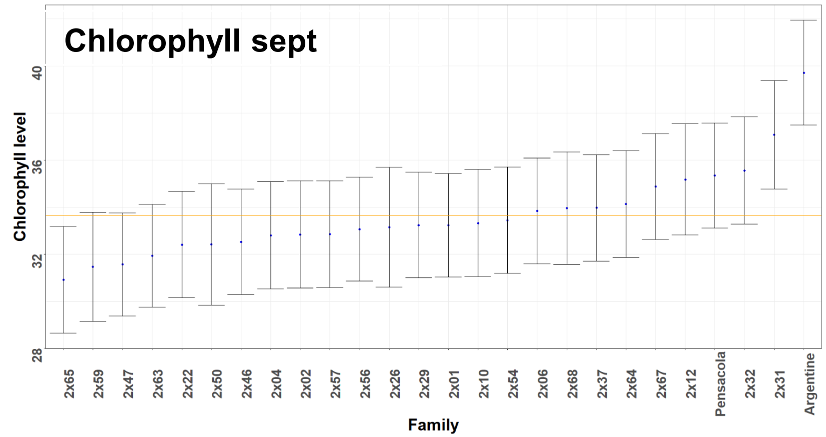
Results

Leaf variables





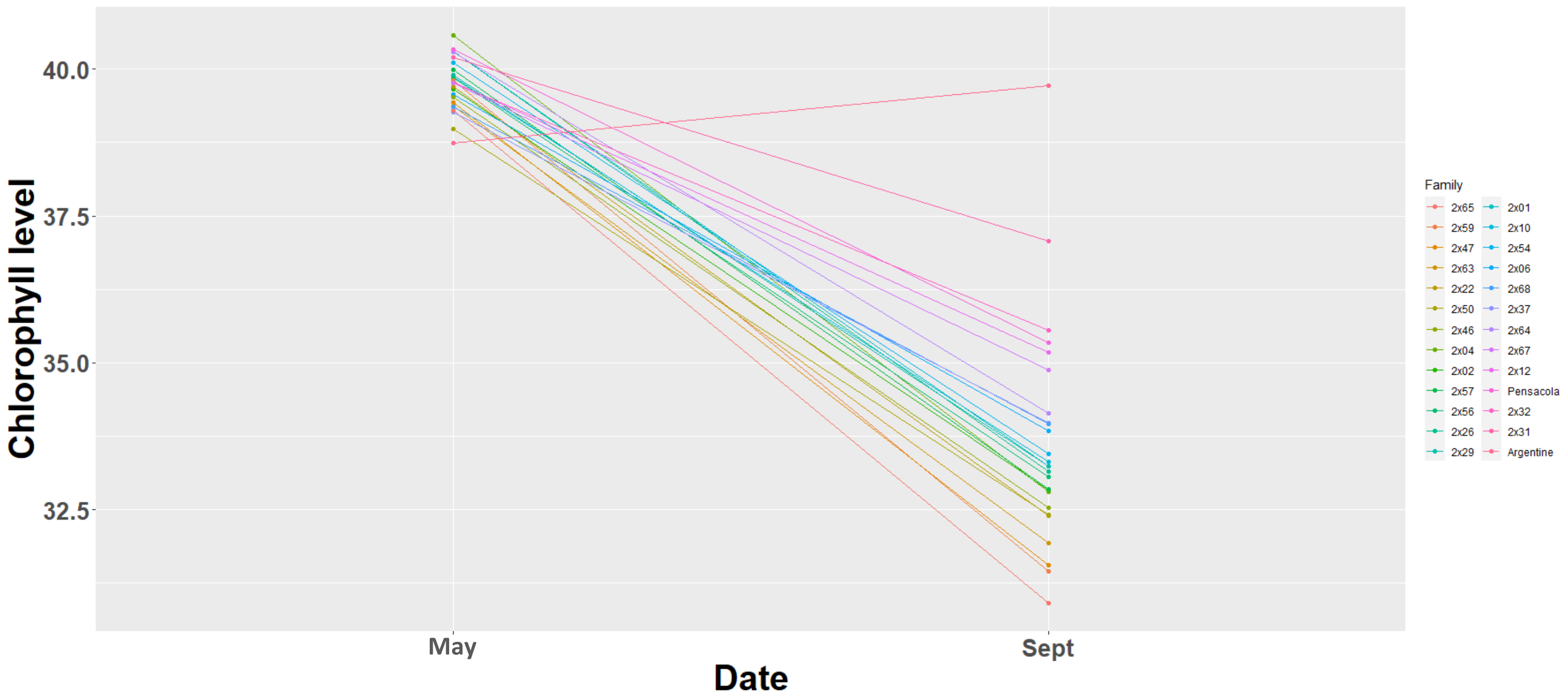




Results

Genetic Parameters of Morphological Traits in Bahiagrass

Differences in Chlorophyll content between Dates.



Results

Genetic Parameters of Morphological Traits in Bahiagrass

Estimate of variance components, broad-sense heritability (H^2), and heritability according to Cullis et al. (2006) ($H^2 c$) for leaf measurements.

Source	Variance estimates			
	Leaf length	Leaf width	Chlorophyll level	
			May	Sept
Genetic	10.36	0.0022	1.07	4.81
Genetic : Date	1.72	0.0009	-	-
Error	7.14	0.0012	9.11	3.28
H^2	0.80	0.75	0.19	0.75
H^2c	0.82	0.85	0.19	0.72

Results

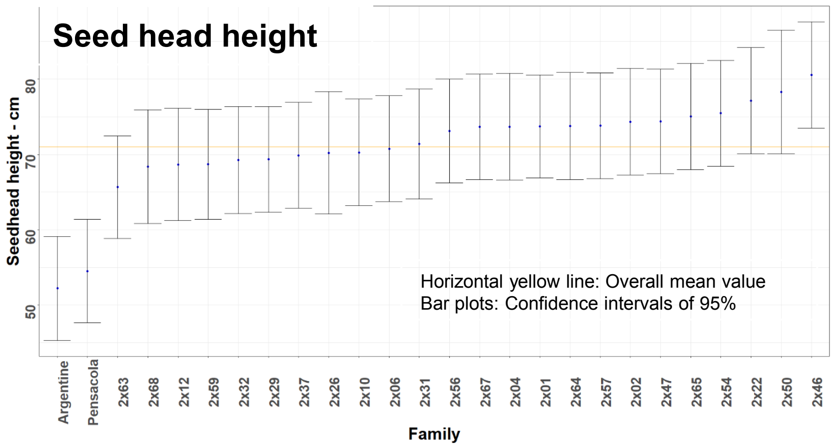
Genetic Parameters of Morphological Traits in Bahiagrass

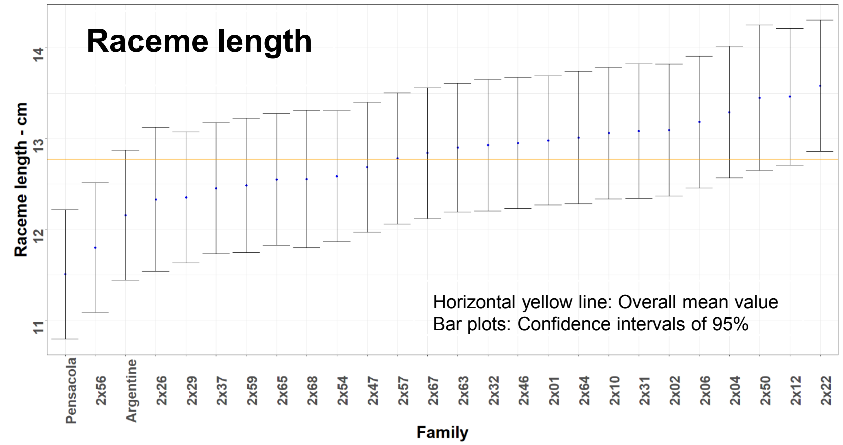
Means and standard errors of half-sib families of bahiagrass for leaf width, leaf length, and chlorophyl content.

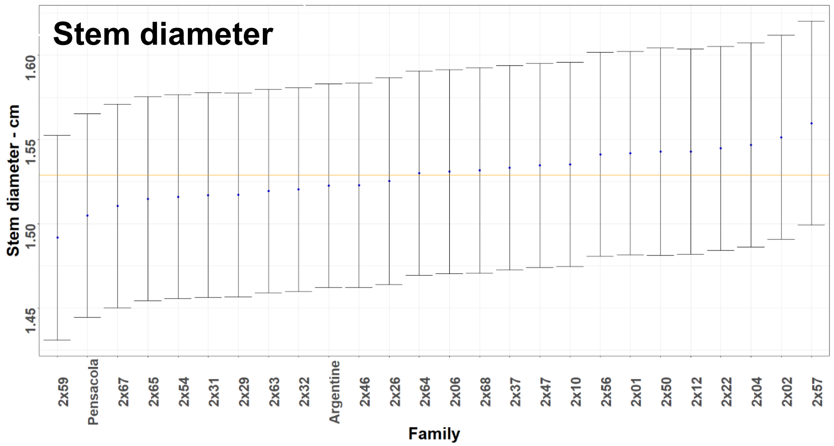
Family	Leaf length (cm)	Leaf width (cm)	Chlorophyll content (May)	Chlorophyll content (Sept)
2x31	36.1 (1.38)	0.60 (0.019)	40.2 (1.01)	37.1 (1.17)
2x46	34.3 (1.32)	0.65 (0.018)	39.5 (1.00)	32.5 (1.15)
2x47	34.3 (1.27)	0.58 (0.017)	39.4 (1.00)	31.6 (1.12)
2x57	33.6 (1.32)	0.56 (0.017)	40.0 (1.00)	32.9 (1.15)
2x56	33.5 (1.27)	0.60 (0.017)	39.9 (1.00)	33.1 (1.13)
2x68	33.4 (1.46)	0.62 (0.020)	39.4 (1.01)	34.0 (1.22)
2x22	32.8 (1.32)	0.61 (0.018)	39.7 (1.00)	32.4 (1.15)
2x04	32.4 (1.34)	0.58 (0.018)	40.6 (1.00)	32.8 (1.16)
2x65	31.6 (1.32)	0.57 (0.018)	39.3 (1.00)	30.9 (1.15)
2x12	31.3 (1.44)	0.59 (0.019)	39.8 (1.01)	35.2 (1.21)
2x02	31.1 (1.34)	0.58 (0.018)	39.7 (1.00)	32.8 (1.16)
2x54	30.8 (1.32)	0.61 (0.018)	40.1 (1.00)	33.4 (1.15)
2x29	30.7 (1.32)	0.56 (0.018)	39.9 (1.00)	33.2 (1.15)
2x10	30.7 (1.34)	0.61 (0.018)	39.9 (1.00)	33.3 (1.16)
2x64	30.5 (1.34)	0.60 (0.018)	40.1 (1.00)	34.1 (1.16)
2x32	30.0 (1.34)	0.59 (0.018)	39.8 (1.00)	35.6 (1.16)
2x01	29.8 (1.26)	0.54 (0.017)	40.3 (1.00)	33.2 (1.12)
2x06	29.5 (1.32)	0.57 (0.018)	39.6 (1.00)	33.8 (1.15)
2x50	29.2 (1.65)	0.58 (0.024)	39.0 (1.02)	32.4 (1.31)
2x63	29.0 (1.25)	0.55 (0.018)	39.4 (1.00)	31.9 (1.11)
2x67	29.0 (1.31)	0.55 (0.017)	39.8 (1.00)	34.9 (1.15)
2x37	28.7 (1.32)	0.59 (0.018)	39.3 (1.00)	34.0 (1.15)
2x59	28.3 (1.40)	0.56 (0.019)	39.8 (1.01)	31.5 (1.19)
2x26	27.2 (1.62)	0.56 (0.023)	40.3 (1.01)	33.1 (1.30)
Argentine	24.8 (1.26)	0.78 (0.017)	38.7 (1.00)	39.7 (1.13)
Pensacola	21.7 (1.26)	0.53 (0.017)	40.3 (1.00)	35.3 (1.14)
Average	30.6 (0.86)	0.59 (0.008)	39.8 (0.43)	33.6 (0.39)

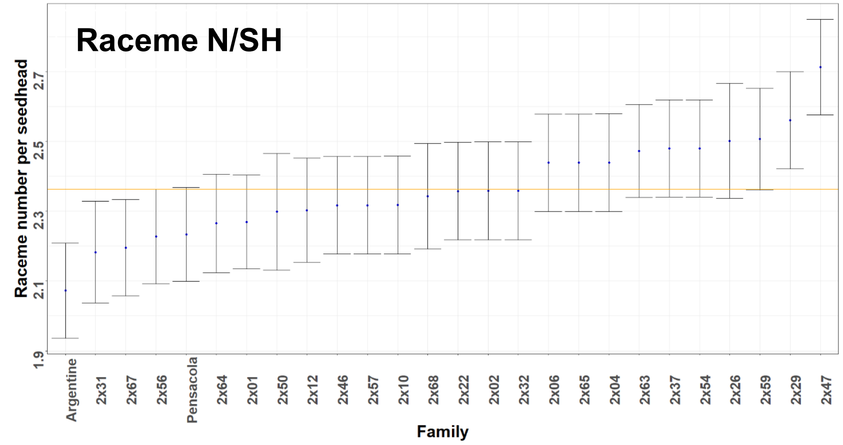
Results

Seed head variables

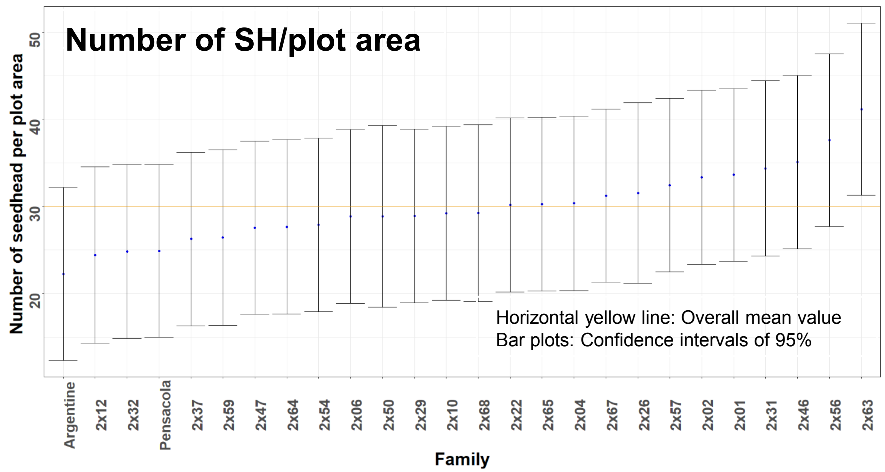


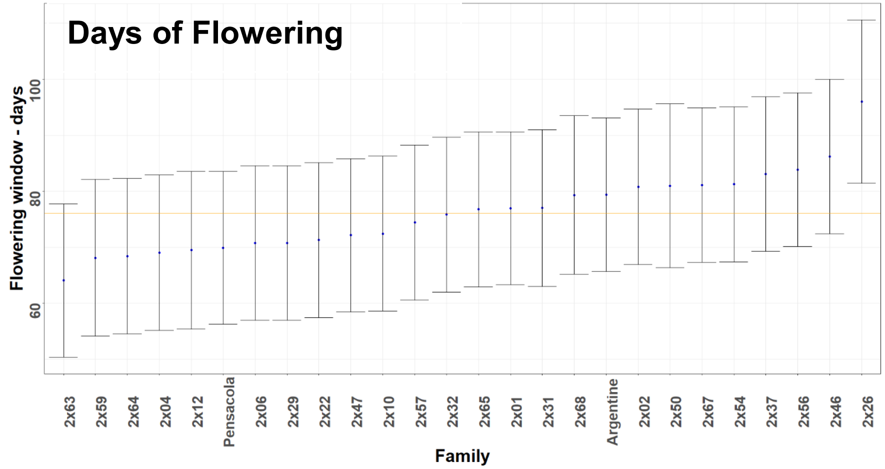






Results


Number of SH/plot area
Number of seedhead per plot area
50
40
30
20
Horizontal yellow line: Overall mean value
Bar plots: Confidence intervals of 95%
Argentine
2x12
2x32
Pensacola
2x37
2x59
2x47
2x64
2x54
2x06
2x50
2x29
2x10
2x68
2x22
2x65
2x04
2x67
2x26
2x57
2x02
2x01
2x31
2x46
2x56
2x63
Family


Days of Flowering
Flowering window - days
100
80
60
2x63
2x59
2x64
2x04
2x12
Pensacola
2x06
2x29
2x22
2x47
2x10
2x57
2x32
2x65
2x01
2x31
2x68
Argentine
2x02
2x50
2x67
2x54
2x37
2x56
2x46
2x26
Family

Results

Genetic Parameters of Morphological Traits in Bahiagrass

Estimate of variance components, broad-sense heritability (H^2), and heritability according to Cullis et al. (2006) ($H^2 c$) for seed head measurements.

	Variance estimates						
Source	Seed Head height	Stem diameter	Raceme length	Spikelet number	Raceme num/SH	Num. SH/ plot area	Flowering window
Genetic	51.8	0.001	0.38	27.8	0.02	85.8	98.2
Error	30.8	0.007	0.38	15.6	0.01	339.0	178.8
H^2	0.77	0.23	0.64	0.78	0.81	0.44	0.52
H^2c	0.74	0.22	0.64	0.75	0.78	0.32	0.50

Results

Genetic Parameters of Morphological Traits in Bahiagrass

Means and standard errors for seed head heights, stem diameters, and raceme length in bahiagrass.

Family	Seed head height (cm)	Stem diameter (cm)	Raceme length (cm)
2x46	81 (3.59)	1.52 (0.03)	13.0 (0.37)
2x50	78 (4.19)	1.54 (0.03)	13.5 (0.41)
2x22	77 (3.59)	1.54 (0.03)	13.6 (0.37)
2x54	76 (3.59)	1.52 (0.03)	12.6 (0.37)
2x65	75 (3.59)	1.51 (0.03)	12.6 (0.37)
2x47	74 (3.53)	1.53 (0.03)	12.7 (0.37)
2x02	74 (3.62)	1.55 (0.03)	13.1 (0.37)
2x64	74 (3.63)	1.53 (0.03)	13.0 (0.37)
2x57	74 (3.59)	1.56 (0.03)	12.8 (0.37)
2x04	74 (3.62)	1.55 (0.03)	13.3 (0.37)
2x67	74 (3.57)	1.51 (0.03)	12.8 (0.37)
2x01	74 (3.49)	1.54 (0.03)	13.0 (0.36)
2x56	73 (3.52)	1.54 (0.03)	11.8 (0.37)
2x31	71 (3.71)	1.52 (0.03)	13.1 (0.38)
2x06	71 (3.59)	1.53 (0.03)	13.2 (0.37)
2x10	70 (3.62)	1.54 (0.03)	13.1 (0.37)
2x26	70 (4.13)	1.53 (0.03)	12.3 (0.41)
2x37	70 (3.59)	1.53 (0.03)	12.5 (0.37)
2x32	69 (3.62)	1.52 (0.03)	12.9 (0.37)
2x29	69 (3.59)	1.52 (0.03)	12.4 (0.37)
2x12	69 (3.81)	1.54 (0.03)	13.5 (0.38)
2x59	69 (3.73)	1.49 (0.03)	12.5 (0.38)
2x68	68 (3.85)	1.53 (0.03)	12.6 (0.39)
2x63	66 (3.47)	1.52 (0.03)	12.9 (0.36)
Pensacola	55 (3.49)	1.50 (0.03)	11.5 (0.36)
Argentine	52 (3.52)	1.52 (0.03)	12.2 (0.37)
Average	71 (1.23)	1.53 (0.02)	12.8 (0.13)

Results

Genetic Parameters of Morphological Traits in Bahiagrass

Means and standard errors of spikelet number, raceme number, number of seed heads, and days of flowering in bahiagrass.

Family	Spikelet number	Raceme Number	Seed Head Number	Days of Flowering	Spikelet potential
2x01	100 (2.50)	2.3 (0.07)	34 (5.06)	77 (6.98)	7411 (1141)
2x12	98 (2.74)	2.3 (0.08)	24 (5.17)	70 (7.19)	5344 (1164)
2x22	96 (2.58)	2.4 (0.07)	30 (5.09)	71 (7.05)	6670 (1148)
2x06	95 (2.58)	2.4 (0.07)	29 (5.09)	71 (7.05)	6446 (1148)
2x10	95 (2.60)	2.3 (0.07)	29 (5.10)	72 (7.07)	6361 (1150)
2x47	94 (2.58)	2.7 (0.07)	28 (5.07)	72 (6.98)	6419 (1144)
2x31	94 (2.69)	2.2 (0.07)	34 (5.14)	77 (7.14)	7238 (1158)
2x02	93 (2.60)	2.4 (0.07)	33 (5.10)	81 (7.07)	7217 (1150)
2x46	92 (2.58)	2.3 (0.07)	35 (5.09)	86 (7.03)	7418 (1148)
2x04	92 (2.60)	2.4 (0.07)	30 (5.10)	69 (7.07)	6686 (1150)
2x64	91 (2.61)	2.3 (0.07)	28 (5.11)	68 (7.07)	5931 (1151)
2x68	91 (2.77)	2.3 (0.08)	29 (5.19)	79 (7.22)	6247 (1167)
2x50	90 (3.01)	2.3 (0.09)	29 (5.32)	81 (7.45)	6124 (1194)
2x57	90 (2.58)	2.3 (0.07)	33 (5.09)	74 (7.05)	6813 (1148)
2x67	90 (2.56)	2.2 (0.07)	31 (5.08)	81 (7.03)	6409 (1146)
2x32	90 (2.60)	2.4 (0.07)	25 (5.10)	76 (7.07)	5397 (1150)
2x56	89 (2.56)	2.2 (0.07)	38 (5.06)	84 (6.99)	7755 (1143)
2x63	89 (2.49)	2.5 (0.07)	41 (5.05)	64 (6.96)	8851 (1140)
2x29	88 (2.58)	2.6 (0.07)	29 (5.09)	71 (7.05)	6342 (1148)
2x59	88 (2.68)	2.5 (0.07)	26 (5.14)	68 (7.14)	5727 (1158)
2x65	85 (2.58)	2.4 (0.07)	30 (5.09)	77 (7.05)	6378 (1148)
2x37	85 (2.58)	2.5 (0.07)	26 (5.09)	83 (7.05)	5652 (1148)
Pensacola	85 (2.50)	2.2 (0.07)	25 (5.06)	70 (6.96)	5088 (1141)
2x54	84 (2.58)	2.5 (0.07)	28 (5.09)	81 (7.05)	5890 (1148)
2x26	84 (2.99)	2.5 (0.08)	32 (5.30)	96 (7.43)	6701 (1190)
Argentine	82 (2.53)	2.1 (0.07)	22 (5.07)	79 (7.00)	4589 (1143)
Average	90 (0.94)	2.4 (0.03)	30 (1.73)	76.1 (2.32)	6427 (394)

Conclusions

- The difference among families was significant ($P \leq 0.05$) in leaf length and width, chlorophyll level, seed head height, raceme length, spikelet number, raceme number per seed head, and flowering window.

- Broad-sense heritabilities ranged from low to high depending on the trait and showed that selection can be used to genetically improve bahiagrass.

- Potential exist for breeding turf-type sexual diploid bahiagrass.

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Thank you!