# DEVELOPMENT OF NOVEL PERENNIAL SORGHUM GEMPLASM: INDUCED POLYPLOIDIZATION AND HYBRIDIZATION OF *S. BICOLOR* X *S. PROPINQUUM*

A Thesis

by

TYLER L. FOSTER

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

| | |
|---|---|
| Chair of Committee, | Russell W. Jessup |
| Committee Members, | Byron L. Burson |
| | Seth C. Murray |
| Head of Department, | David D. Baltensperger |

August 2019

Major Subject: Plant Breeding

ABSTRACT

Plant polyploidization can provide valuable, novel phenotypes. In *Sorghum*, induced polyploidization is possible and relatively inexpensive. However, efficiency remains low and a consensus "best" method has yet to be determined. Some *Sorghum* species provide a unique opportunity to develop perennial cropping systems due to their interspecific hybridization compatibility and phenotypic plasticity from annual to perennial life cycle. Due to their relatively close taxonomic relationship, *Sorghum bicolor* (L.) Moench x *S. propinquum* (Kunth) Hitchc. offer both valuable insights between annuals and perennials, as well as hybridization opportunities for the introgression of perenniality into a major cereal crop. Hybridization between these species also has potential to introgress other desirable alleles that have been lost through the domestication of *S. bicolor*.

Our research identified transgressive segregation for height in a *Sorghum bicolor* x *S. propinquum* $F_2$ population. Perennial *Sorghum* hybrids (PSH) were also intermediate for days to maturity and tillering capacity; when compared to both parents. Experimental units overwintered through harsh winter conditions which allowed a stronger selection criterion for overwintering capacity than previous studies.

Unfortunately, our novel method for inducing ploidy levels in *Sorghum* were unsuccessful. Thus, more research is still needed to improve this methodology. This thesis addresses induced polyploidy, wide hybridization, and perenniality in the genus

*Sorghum* with the purpose of developing novel germplasm suitable for perennial cropping systems.

# DEDICATION

This study is wholeheartedly dedicated to my beloved parents, Steven and Echo Foster, who have been the source of my inspiration, provided strength when I thought of giving up, and continually encouraged me to strive for my aspirations. I hope that this work has provided a good example of the young man that you have raised.

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to my committee chair, Dr. Russell Jessup, for his excellent mentorship and support during the course of my M.S. degree program. Without his guidance and persistent help, this thesis would not have been possible.

In addition, I would like to acknowledge my appreciation to my committee members, Dr. Byron Burson and Dr. Seth Murray, for serving as excellent examples of scientists and mentors. I would also like to thank Dr. William Rooney for providing seed that helped make this research possible.

Finally, I want to thank my friends, colleagues, and the department faculty for making my time at Texas A&M University a memorable experience.

# CONTRIBUTORS AND FUNDING SOURCES

## Contributors

This work was supervised by a thesis committee consisting of (Chair) Dr. Russell Jessup and Dr. Seth Murray of the Department of Soil and Crop Sciences and Dr. Byron Burson of the Department of Molecular and Environmental Plant Sciences.

I would like to recognize Drs. Russell Jessup and Byron Burson for helping me develop the skills necessary to work in the flow cytometry lab. I would also like to thank Dr. Russell Jessup for aiding me in advancing my analytical writing and statistical analysis skills. I am also appreciative for having worked alongside my fellow graduate students: Heather Baldi, Nick Porter, Sylvia Shen, Runshi Xie, and Yifeng Xu. I am grateful for their help in this project, particularly Nick Porter and Sylvia Shen, who provided invaluable help in acquiring field data.

## Funding Sources

The following research was supported by: 1) the Roy J. Quinby Fellowship distributed by the Department of Soil & Crop Sciences at Texas A&M University, and 2) unrestricted gift research funding within the Perennial Grass Breeding Program in the Department of Soil & Crop Sciences at Texas A&M University.

## NOMENCLATURE

| | |
|---|---|
| APM | Amiprophos-methyl |
| DMSO | Dimethyl sulfoxide |
| PSH | Perennial *Sorghum* hybrid |
| SOPR | *Sorghum propinquum* |
| QTL | Quantitative trait loci |

TABLE OF CONTENTS

Page

ABSTRACT ....................................................................................................ii

DEDICATION ...............................................................................................iv

ACKNOWLEDGEMENTS ..............................................................................v

CONTRIBUTORS AND FUNDING SOURCES ......................................................vi

NOMENCLATURE .........................................................................................vii

TABLE OF CONTENTS ..................................................................................viii

LIST OF FIGURES ..........................................................................................x

LIST OF TABLES ...........................................................................................xi

CHAPTER I INTRODUCTION ............................................................................1

CHAPTER II FIELD EVALUATION AND CHARACTERIZATION OF *SORGHUM BICOLOR* X *SORGHUM PROPINQUUM* HYBRIDS ................................3

Literature Review ..........................................................................................3
Sorghum bicolor ............................................................................................3
Sorghum propinquum ....................................................................................4
Sorghum spp. Hybridization ...........................................................................5
Objective and Expected Outcome ....................................................................6
Materials and Methods ...................................................................................7
Field Evaluation .............................................................................................7
Data Analysis and Statistics ............................................................................8
Results and Discussion ...................................................................................9
Field Evaluation .............................................................................................11
$F_2$ Hybrid Selection ....................................................................................37

CHAPTER III SEED PRIMING AS A TOOL TO INDUCE POLYPLOIDIZATION OF *SORGHUM BICOLOR* AND *SORGHUM PROPINQUUM* ......................................41

Literature Review ..........................................................................................41
Induced Polyploidy ........................................................................................41

Seed Priming ........ 43
Objective and Expected Outcome ........ 44
Materials and Methods ........ 45
Utilizing Calcined Clay as a Primer ........ 45
Parafilm Encapsulation Priming ........ 47
Flow Cytometry ........ 49
Results and Discussion ........ 49
Sorghum bicolor ........ 49
Sorghum propinquum ........ 50

CHAPTER IV SUMMARY AND CONCLUSIONS ........ 56

REFERENCES ........ 58

APPENDIX A SUBSAMPLING ANALYSIS OF VARIANCE TABLES ........ 64

APPENDIX B  SUPPLEMENTAL DATA ........ 71

LIST OF FIGURES

Page

Figure 1. The generated model explained the amount of variation due to the dependent variable, height$^{Z}$, for data gathered on the 30-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). .......14

Figure 2. The generated model explained the amount of variation due to the dependent variable, height$^{Z}$, for data gathered on the 60-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). .......17

Figure 3. The generated model explained the amount of variation due to the dependent height$^{Z}$, for data gathered on the 90-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)........................21

Figure 4. The generated model explained the amount of variation due to the dependent variable, tillering capacity, for data gathered on the 30-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)..........................................................................................................25

Figure 5. The generated model explained the amount of variation due to the dependent variable, tillering capacity, for data gathered on the 60-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)..........................................................................................................28

Figure 6. The generated model explained the amount of variation due to the dependent variable, tillering capacity, for data gathered on the 90-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)..........................................................................................................31

Figure 7. The generated model explained the amount of variation due to the dependent variable, primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ......................................34

LIST OF TABLES

Page

Table 1. Minimum, mean, and maximum value table of each entry of the dependent variable, height[Z], for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 9

Table 2. Minimum, mean, and maximum value table of each entry of the dependent variable, tillering capacity, for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 10

Table 3. Minimum, mean, and maximum value table of each entry of the dependent variable, primary culm days to midbloom, for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 10

Table 4. Summary variance component percentage table for block, entry, and block*entry of the dependent variable, height[Y], for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 11

Table 5. Analysis of variance for significance of block, entry, and block*entry on 30-day height[Y] for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 12

Table 6. All pairs, Tukey HSD block means comparison for 30-day height for ATx623, perennial *Sorghum* species hybrid (PSH), and *S. propinquum* (SOPR). ........ 13

Table 7. All pairs, Tukey HSD entry means comparison for 30-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 13

Table 8. All pairs, Tukey HSD block x entry means comparison for 30-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 13

Table 9. Analysis of variance for significance of block, entry, and block x entry on 60-day height[Y] for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 16

Table 10. All pairs, Tukey HSD block means comparison for 60-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 16

Table 11. All pairs, Tukey HSD entry means comparison for 60-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ........ 16

Table 12. All pairs, Tukey HSD block x entry means comparison for 60-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)...17

Table 13. Analysis of variance for significance of block, entry, and block x entry on 90-day height[Y] for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ...........................................................................19

Table 14. All pairs, Tukey HSD block means comparison for 90-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). .......19

Table 15. All pairs, Tukey HSD entry means comparison for 90-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). .......20

Table 16. All pairs, Tukey HSD block x entry means comparison for 90-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)...20

Table 17. Summary variance component percentage table for block, entry, and block*entry of the dependent variable, tillering capacity, for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)........................22

Table 18. Analysis of variance for significance of block, entry, and block x entry on 30-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ......................................................................24

Table 19. All pairs, Tukey HSD block means comparison for 30-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)...24

Table 20. All pairs, Tukey HSD entry means comparison for 30-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)...24

Table 21. All pairs, Tukey HSD block x entry means comparison for 30-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)..........................................................................................25

Table 22. Analysis of variance for significance of block, entry, and block x entry on 60-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ......................................................................27

Table 23. All pairs, Tukey HSD block means comparison for 60-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)...27

Table 24. All pairs, Tukey HSD entry means comparison for 60-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)...27

Table 25. All pairs, Tukey HSD block x entry means comparison for 60-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)....28

Table 26. Analysis of variance for significance of block, entry, and block x entry on 90-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ....30

Table 27. All pairs, Tukey HSD block means comparison for 90-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)...30

Table 28. All pairs, Tukey HSD entry means comparison for 90-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)...30

Table 29. All pairs, Tukey HSD block x entry means comparison for 90-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR)....31

Table 30. Analysis of variance for significance of block, entry, and block x entry for primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ....33

Table 31. All pairs, Tukey HSD block means comparison for primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ....33

Table 32. All pairs, Tukey HSD entry means comparison for primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ....33

Table 33. All pairs, Tukey HSD block x entry means comparison for primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR). ....34

Table 34. Summary table of overwintering capacity for all entries ATx623, perennial *Sorghum* hybrid (PSH), PSH subset and *S. propinquum* (SOPR) across all time effects....36

Table 35. Repeated measures analysis of variance for overwintering basal tillering capacity for the perennial *Sorghum* hybrid experimental units. ....36

Table 36. Repeated measures analysis of variance for overwintering rhizome derived shoot capacity for the perennial *Sorghum* hybrid experimental units. ....37

Table 37. Wilcoxon rank sum data table for the perennial *Sorghum* hybrid experimental units that showed the capacity to overwinter. ............................39

Table 38. *Sorghum bicolor* polyploidization treatments utilizing calcined clay as a primer.............................................................................................52

Table 39. *Sorghum propinquum* polyploidization treatments utilizing calcined clay as a primer. ..........................................................................................53

Table 40. *Sorghum propinquum* polyploidization treatments using parafilm encapsulation as a primer....................................................................54

Table 41. *Sorghum propinquum* polyploidization treatments using parafilm encapsulation as a primer. Table compares the number of normal seedlings, abnormal seedlings, and dead seedlings across treatments. ............................55

Table 42. Analysis of variance for significance of block, entry, and block x entry on 30-day height$^{Y}$ for subsampling perennial *Sorghum* hybrid............................64

Table 43. Analysis of variance for significance of block, entry, and block x entry on 60-day height$^{Y}$ for subsampling perennial *Sorghum* hybrid............................65

Table 44. Analysis of variance for significance of block, entry, and block x entry on 90-day height$^{Y}$ for subsampling perennial *Sorghum* hybrid............................66

Table 45. Analysis of variance for significance of block, entry, and block x entry on 30-day tillering capacity for subsampling perennial *Sorghum* hybrid.............67

Table 46. Analysis of variance for significance of block, entry, and block x entry on 60-day tillering capacity for subsampling perennial *Sorghum* hybrid.............68

Table 47. Analysis of variance for significance of block, entry, and block x entry on 90-day tillering capacity for subsampling perennial *Sorghum* hybrid.............69

Table 48. Analysis of variance for significance of block, entry, and block x entry for primary culm days to mid-bloom for subsampling perennial *Sorghum* hybrid. .........................................................................................70

Table 49. Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids". ....................72

# CHAPTER I

# INTRODUCTION

When compared to perennials, the shorter growing season of annuals results in less solar energy being captured (Boehmel et al., 2008; Washburn et al., 2013a). Annual cropping systems are furthermore prone to result in more soil erosion due to transient living root systems (Cox et al., 2002). When managed correctly, perennial cropping systems can require less fertilizer and are able to repartition resources for the next growing season (Boehmel et al., 2008; Jessup, 2009). Studies of perennial bioenergy crops growing on relatively fertile soils have demonstrated that these species have the capacity to sequester significant amounts of carbon (C) because of greater root biomass through rhizome development (Zan et al., 2001; Bosco et al., 2016; Christensen et al., 2016).

Perennial cereal crops require resources to be allocated to belowground growth for the next season; the same resources that are normally allocated to seed. Furthermore, in an environment with the same amount of finite resources available, developing perennial grain crops may create obstacles based on physiological trade-offs (Glover et al., 2010). The high yields of modern cereal crops are the product of intense selection for increased allocation of photosynthate to seed. Wild, perennial ancestors of cereal grain crops have considerably lower seed yield as a result of being undomesticated and undergoing natural selection in highly competitive environments (Cox et al., 2006). For this reason, perennial crops are sometimes considered less desirable to improve than grain crops. However, this does not necessarily prevent perennial grain crops from being high-yielding and economically viable given commensurate investments in genetic improvement (Glover et al., 2010). Some *Sorghum* species provide an unique opportunity for developing perennial cropping systems because they are interfertile with the domesticated species and have the ability to behave as either annuals or perennials (Washburn et al., 2013a).

CHAPTER II

# FIELD EVALUATION AND CHARACTERIZATION OF *SORGHUM BICOLOR* X *SORGHUM PROPINQUUM* HYBRIDS

## Literature Review

### *Sorghum bicolor*

Sorghum is the third-largest cereal grain crop grown in the United States, primarily due to its drought tolerance and adaptability across different climatic conditions (USGC, 2018). In addition to grain, sorghum also is grown for biofuel, forage/silage, and syrup production. Sweet sorghum or “sorgo” varieties in particular are grown for syrup production (Mask and Morris, 1991). Sorghum production in the United States is primarily concentrated in areas extending from southern Nebraska to the southern tip of Texas (USGC, 2018). In 2017, 5,045,000 acres of grain sorghum and 284,000 acres of sorghum silage were harvested in the United States (USDA 2018).

*Sorghum bicolor* is a diploid (2n=2x=20), (Hoang-Tang and Liang, 1988), summer annual species that belongs to the section *Sorghum*, and does not produce rhizomes. The other sections of the genus *Sorghum* include: *Chaeotosorghum, Heterosorghum, Parasorghum*, and *Stiposorghum* (de Wet, 1978). Even though *S. bicolor* is a summer annual that is typically harvested only once, it has the ability to produce basal tillers (Nabukalu and Cox, 2016). Because of tillering, sorghum has the ability to be used as a ratoon crop as described by Mourtzinis et al. (2016). The basal tillering capacity, if combined with rhizome formation in other *Sorghum* species, indicate the potential for developing perennial sorghum.

### *Sorghum propinquum*

*Sorghum propinquum* is a diploid (2n=2x=20) perennial, rhizomatous species native to Asia and is a wild relative of *S. bicolor* (Zhang et al., 2013). Rhizomes of grasses are developmentally related to tillers, and both are initiated from basal nodes (Kong et al., 2015). The primary initiating difference is due to gravitropism. Shoots exhibiting positive gravitropism from a basal node are referred to as tillers and those derived from negative gravitropism from a basal node are rhizomes. Rhizomes serve as propagules in spreading the species and are usually affiliated with weediness; an excellent example of this is johnsongrass, *Sorghum halepense* (L.) Pers. However, in many perennial forage crops and turf grasses such as bermudagrass, *Cynodon dactylon (L.) Pers.* (Zhou et al., 2014), rhizomes provide nutrients for sustainable growth (Kong et al., 2015). *Sorghum propinquum* is unique in that of all species of sorghum, it is the only diploid rhizomatous species. The other rhizomatous species are tetraploids with 40 chromosomes. In contrast, *S. propinquum* has the same number of chromosomes as *S. bicolor* (2n=2x=20) (Endrizzi, 1957; Hoang-Tang and Liang, 1988). The reason for this may be because *S. propinquum* could be a derivative of *S. halepense* (Endrizzi, 1957). A more recent and likely theory for this phenomenon proposes the opposite; *S. halepense* is a derivative from an interspecific hybrid between *S. bicolor* and *S. propinquum* (Paterson, 1995; Paterson et. al., 2008). To confound these theories, a small number of

RFLPs revealed that only a few alleles are common between *S. propinquum* and *S. halapense* (Chittenden et al., 1994).

Like *S. bicolor*, *S. propinquum* belongs to the *Sorghum* section (de Wet, 1978). *Sorghum propinquum* possesses many characteristics common to both wild and cultivated grasses, notably small seed, abundant tillering, narrow leaves, and rhizomes (Chittenden et al., 1994).

### *Sorghum* spp. *Hybridization*

Hybrids between *S. propinquum* and *S. bicolor* are fertile, and these two taxa may actually belong to a single biological species (de Wet, 1978). However, it is important to note these taxa have been classified as different taxonomic species based their differential morphology and natural distribution (de Wet, 1978). With such a close relationship, *S. bicolor* and *S. propinquum* provide a valuable insight into biological differences between annuals and perennials. This relationship also provides an unique opportunity in developing perennial cereal crops through interspecific hybridization. Hybridization also has potential of introgressing other desirable alleles that have been lost from the domestication of *S. bicolor* (Vandenbrink et al., 2013). In addition, *S. propinquum*'s less extensive rhizome capacity in comparison to *S. halapense* indicates a perennial sorghum with a reduced risk of invasiveness could be developed (Jessup et al., 2017).

In *Sorghum*, growth immediately following the winter season is directly linked with both rhizomatousness and tillering. Paterson et al. (1995) reported that 92% of the

*S. bicolor x S. propinquum* $F_2$ progeny survived the winter at College Station, TX while only 46.3% of the $BC_1$ progeny had regrowth the following spring. All *S. propinquum* plants overwintered, but no *S. bicolor* plants survived. This clearly demonstrated the impact of the genes expressing perennialism provided in *S. propinquum.* In another study, *S. bicolor* x *S. propinquum* hybrids experienced harsher winter conditions and only 25.2% of the $F_{3:4}$ lines survived and only 8.2% of all plants in these families overwintered (Washburn et al., 2013a). The climatic conditions under which this study was grown provided greater pressure for selecting individuals with more over-wintering potential. QTLs conferring this trait also were identified and mapped (Washburn et al., 2013a).

## Objective and Expected Outcome

The objective of this study was to characterize a novel *S. bicolor* x *S. propinquum* $F_2$ population for height, tillering capacity, maturity, and overwintering capacity.

The expected outcome of this study was a notable amount of segregation among individuals for perennialism, height, maturity, and other desirable agronomic traits would be identifiable. Such segregation would allow selections to be made based upon individuals with the desired phenotypes for a wide range of *Sorghum* ideotypes.

## Materials and Methods

*Field Evaluation*

### Field Planting

All seed were planted into professional growing mix medium (Sun Gro Horticulture Agawam, MA) in pots within a greenhouse. After the seed had germinated and grown to approximately 10 cm in height, all seedlings were transplanted into individual tray cells containing the above mentioned growing medium. Four hundred and eighty $F_2$ seedlings derived from a single cross between diploid *S. bicolor* (ATx623) and *S. propinquum* (unnamed accession) were transplanted into a field plot on June 14, 2018. In addition, 40 seedlings of each parental line were planted in a randomized complete block design (RCBD) at College Station, Texas. The plot was managed by applying herbicides “Prowl $H_2O$” and “Bayer Advanced Weed Killer” and insecticide “Bioadvanced 3-in-1 Insect Disease & Mite Control” using a backpack sprayer when needed. The plot was also watered via drip irrigation at a minimum of once a week during the dry summer months. The soil series for the plot was a Chazos loamy fine sand with 1 to 5 percent slope.

### Data Collection

Primary culm growth (cm) and the number of tillers produced were recorded every 30-days from the date of transplanting until 90-days after transplanting. Primary culm mid-bloom date was also observed and noted once a week until a strong storm occurred on October 15, 2018 where the wind caused the plants to severely lodge. Plants were allowed to overwinter and phenotypically scored for basal tillering and rhizome derived shoot regrowth the following spring. This was accomplished by hand-counting each individual basal tiller and rhizome derived shoot for each plant individually. This process required meticulous manipulation of plant shoots, as to not cause damage, while carefully classifying each shoot correctly. Because of a late-season frost in March of 2019, phenotypic scores were not taken until the beginning of April 2019. Following this initial scoring, the plants were scored in 14-day intervals.

### *Data Analysis and Statistics*

The experimental design of the field trial was a randomized complete block design (RCBD) with four blocks. A single plant composed a single experimental unit where the experimental unit size for each entry replicate was 10 individual plants. Each individual block was comprised of a single replicate of ATx623 and *S. propinquum*, as well as 11 replicates of the $F_2$ interspecific hybrids. For analysis, a single replicate, composed of 10 successive individual plants, of the $F_2$ interspecific hybrids was randomly selected as a subsample to represent the entire entry of the block. Dependent variables included 30-day height (cm), 60-day height (cm), 90-day height (cm), 30-day tillering number, 60-day tillering number, 90-day tillering number, and days to midbloom maturity. Data collected was submitted to analysis of variance and, where appropriate, multiple means separated using all pair, Tukey HSD with JMP software (JMP Pro14, Statistical Analysis System, USA). Differences were considered significant at $P \leq 0.05$ but values above this were reported for each analysis.

For overwintering basal tillering capacity and rhizome derived shoots capacity, only the $F_2$ interspecific hybrid entries were analyzed. Data was collected on April 1, 15, and 29 of 2019 and then submitted to a repeated measures analysis of variance. This phenotypic data, along with the other dependent variables, were later analyzed utilizing a Wilcoxon Ranked Sum Test to identify and select superior plants to advance to the $F_3$ generation.

## Results and Discussion

Using JMP software, the minimum, maximum and means of entries across all time intervals for height (Table 1), tillering capacity (Table 2), and primary culm days to midbloom (Table 3) were determined.

Table 1. Minimum, mean, and maximum value table of each entry of the dependent variable, height[Z], for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Time Interval | Entry | Minimum | Mean | Maximum |
|---|---|---|---|---|
| 30 Days | ATx623 | 25.40 | 53.20 | 104.14 |
| | PSH | 17.78 | 65.19 | 134.62 |
| | SOPR | 10.16 | 34.42 | 63.50 |
| 60 Days | ATx623 | 60.96 | 80.39 | 104.14 |
| | PSH | 68.58 | 121.55 | 200.66 |
| | SOPR | 30.48 | 68.58 | 101.60 |
| 90 Days | ATx623 | 66.04 | 87.48 | 121.92 |
| | PSH | 66.04 | 176.68 | 243.84 |
| | SOPR | 50.80 | 114.45 | 152.40 |

[Z] Height measurements recorded in cm.

Table 2. Minimum, mean, and maximum value table of each entry of the dependent variable, tillering capacity, for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Time Interval | Entry | Minimum | Mean | Maximum |
|---|---|---|---|---|
| 30 Days | ATx623 | 0 | 1.11 | 4 |
| | PSH | 0 | 0.44 | 4 |
| | SOPR | 0 | 1.05 | 5 |
| 60 Days | ATx623 | 0 | 1.21 | 4 |
| | PSH | 0 | 4.00 | 14 |
| | SOPR | 0 | 6.21 | 15 |
| 90 Days | ATx623 | 0 | 1.21 | 2 |
| | PSH | 0 | 4.52 | 13 |
| | SOPR | 2 | 9.24 | 22 |

Table 3. Minimum, mean, and maximum value table of each entry of the dependent variable, primary culm days to midbloom, for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry | Minimum | Mean | Maximum |
|---|---|---|---|
| ATx623 | 33 | 52.63 | 67 |
| PSH | 32 | 67.93 | 112 |
| SOPR | 118 | 118.00 | 118 |

*Field Evaluation*

**Height Segregation Analysis**

Summary variance component percentages along with ANOVA significances (Table 4) revealed there was a significant difference P≤ 0.001 for entry at every time interval. Blocking effect was significant at the P≤ 0.05 level for 30-day and 90-day height, but not at the 60-day height time interval. The variance component with the largest variance, across all time effects, was entry. Each individual time effect is analyzed below.

Table 4. Summary variance component percentage table for block, entry, and block*entry of the dependent variable, height[Y], for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| | 30-Day height[Y] | 60-Day height | 90-Day height |
|---|---|---|---|
| Block | 0.37*[Z] | 5.20[NS] | 4.10* |
| Entry | 31.55*** | 33.10*** | 41.80*** |
| Block x Entry | 14.45** | 30.90*** | 16.13*** |

[Z] Analysis of variance was NS (nonsignificant) or significant at P≤ 0.05 (*), 0.01 (**), or 0.001 (***).

[Y] Height measurements recorded in cm.

*30 Day-Height (cm) of the Initial Transplanting*

The ANOVA table (Table 5) showed there was a significant blocking effect at the P≤ 0.05 level for 30-day height. Using Tukey's HSD (Table 6), only blocks 4 and 2 were significantly different than one another. Using variance component percentages (Table 4) the largest amount of variation for this test was attributed from entry; where significance was detected at the P≤ 0.001 level.

Using Tukey's HSD (Table 7), the performance of entries were compared. At the 30-day interval, the tallest entry was the perennial *Sorghum* hybrid (PSH). Along with this, the shortest entry was the *S. propinquum* (SOPR) parent. Using Tukey's HSD (Table 8), the performance of block x entry was also analyzed; although with much less importance due to the lower variance. The $R^2$ to explain the variability for this test was 0.46 (Figure 1).

Table 5. Analysis of variance for significance of block, entry, and block*entry on 30-day height[Y] for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Source | Df[X] | SS[W] | MS[V] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3 | 3865.47 | 1288.49 | 3.70 | 0.0143[Z] |
| Entry | 2 | 17170.64 | 8585.32 | 24.64 | <.0001 |
| Block x Entry | 6 | 7397.09 | 1232.85 | 3.54 | <.0032 |
| Residual | 100 | 34846.31 | 348.46 | | |
| Total | 111 | 63279.51 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y]Height measurements recorded in cm.
[X]Degrees of freedom
[W]Sum of squares
[V]Mean squares

Table 6. All pairs, Tukey HSD block means comparison for 30-day height for ATx623, perennial *Sorghum* species hybrid (PSH), and *S. propinquum* (SOPR).

| Block | Letter | Least Sq. Mean[Y] |
|---|---|---|
| 4.00 | A[Z] | 57.41 |
| 3.00 | AB | 54.06 |
| 1.00 | AB | 49.68 |
| 2.00 | B | 41.96 |

[Z] Block means followed by the same letter are not significantly different according to all pairs, Tukey HSD.
[Y] Height means recorded in cm.

Table 7. All pairs, Tukey HSD entry means comparison for 30-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry | Letter | Least Sq. Mean[Y] |
|---|---|---|
| PSH | A[Z] | 65.11 |
| ATx623 | B | 52.70 |
| SOPR | C | 34.52 |

[Z] Block means followed by the same letter are not significantly different according to all pairs, Tukey HSD.
[Y] Height means recorded in cm.

Table 8. All pairs, Tukey HSD block x entry means comparison for 30-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry, Block | Letter | Least Sq. Mean[Y] |
|---|---|---|
| ATx623,4 | A[Z] | 77.47 |
| PSH,3 | AB | 70.61 |
| PSH,4 | ABC | 66.55 |
| PSH,1 | ABC | 64.35 |
| PSH,2 | ABC | 58.93 |
| ATx623,3 | BCD | 46.99 |
| SOPR,3 | BCD | 44.59 |
| ATx623,1 | BCD | 44.31 |
| ATx623,2 | BCD | 42.05 |
| SOPR,1 | CD | 40.39 |
| SOPR,4 | D | 28.22 |
| SOPR,2 | D | 24.89 |

[Z] Block x entry means followed by the same letter are not significantly different according to all pairs, Tukey HSD.
[Y] Height means recorded in cm.

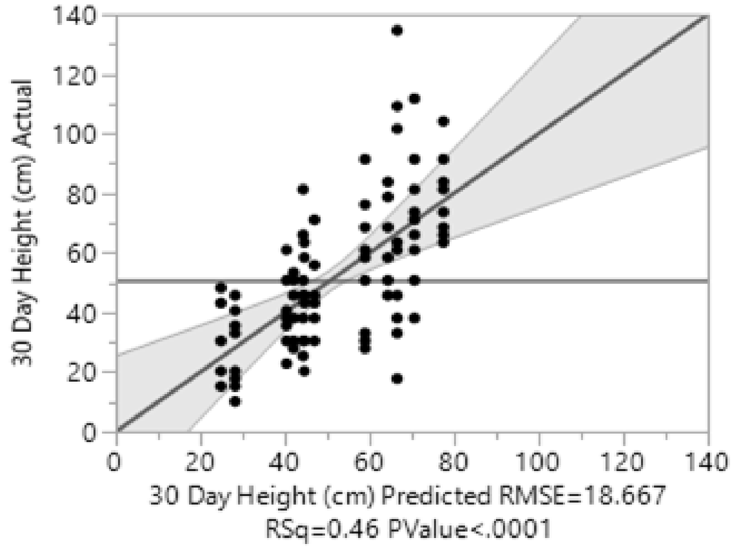


Figure 1. The generated model explained the amount of variation due to the dependent variable, height[Z], for data gathered on the 30-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).
[Z] Height measurements recorded in cm.

*60-Day Height (cm) of the Initial Transplanting*

The ANOVA table (Table 9) showed there was not a significant blocking effect at any alpha level. Using Tukey's HSD (Table 10), we were unable to detect differences between blocks. Due to these findings, the source of variance of importance was entry; where the variance component percentage was 33.10 (Table 4).

Using Tukey's HSD (Table 11), the performance of entries were compared. At the 60-day interval, the best performing entry, for height, was the PSH. To add, the shortest entry was the SOPR. The data clearly shows transgressive segregation for height in the PSH for this time effect and beyond.

A considerable amount of variance was also detected in the block by entry source of variation (Table 4). Using Tukey's HSD (Table 12), the performance of entries within blocks were compared. At the 60-day interval, the tallest entries were the PSH found within the third and fourth blocks. Furthermore, the shortest entries were the SOPR found within the second, third and forth blocks; as well as the ATx623 found in the first block. The $R^2$ to explain the variability for this test was 0.76 (Figure 2).

Table 9. Analysis of variance for significance of block, entry, and block x entry on 60-day height[Y] for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Source | Df | SS | MS | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3 | 1529.46 | 509.82 | 1.86 | 0.14 |
| Entry | 2 | 48608.36 | 24304.18 | 88.71 | <.0001[Z] |
| Block x Entry | 6 | 26912.73 | 4485.46 | 16.37 | <.0001 |
| Residual | 93 | 25480.67 | 273.99 | | |
| Total | 104 | 102531.22 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y] Height measurements recorded in cm.
[X] Degrees of freedom
[W] Sum of squares
[V] Mean squares

Table 10. All pairs, Tukey HSD block means comparison for 60-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Block | Letter | Least Sq. Mean[Y] |
|---|---|---|
| 3.00 | A[Z] | 92.46 |
| 4.00 | A | 90.51 |
| 1.00 | A | 86.47 |
| 2.00 | A | 82.73 |

[Z] Block means followed by the same letter are not significantly different according to all pairs, Tukey HSD.
[Y] Height means recorded in cm.

Table 11. All pairs, Tukey HSD entry means comparison for 60-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry | Letter | Least Sq. Mean[Y] |
|---|---|---|
| PSH | A[Z] | 118.40 |
| ATx623 | B | 79.85 |
| SOPR | C | 65.87 |

[Z] Entry means followed by the same letter are not significantly different according to all pairs, Tukey HSD.
[Y] Height means recorded in cm.

Table 12. All pairs, Tukey HSD block x entry means comparison for 60-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry, Block | Letter | Least Sq. Mean[Y] |
|---|---|---|
| PSH,3 | A[Z] | 143.26 |
| PSH,4 | AB | 131.23 |
| PSH,2 | BC | 108.09 |
| SOPR,1 | CD | 98.55 |
| ATx623,4 | CDE | 93.73 |
| PSH,1 | CDE | 91.02 |
| ATx623,2 | DEF | 80.15 |
| ATx623,3 | DEF | 75.69 |
| ATx623,1 | EFG | 69.85 |
| SOPR,2 | FG | 59.94 |
| SOPR,3 | FG | 58.42 |
| SOPR,4 | G | 46.57 |

[Z] Block x entry means followed by the same letter are not significantly different according to All pairs, Tukey HSD.
[Y] Height means recorded in cm.

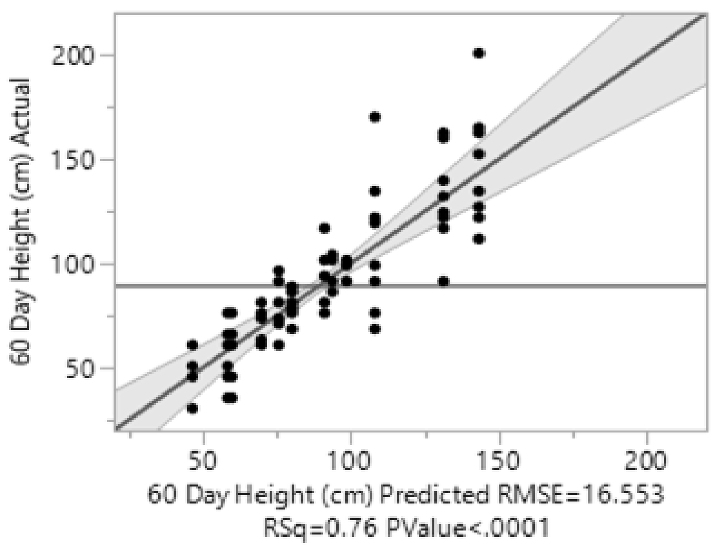


Figure 2. The generated model explained the amount of variation due to the dependent variable, height[Z], for data gathered on the 60-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).
[Z] Height measurements recorded in cm.

*90-Day Height (cm) of the Initial Transplanting*

The ANOVA table (Table 13) showed there was a significant blocking effect at the $P \leq 0.05$ level. However, using Tukey's HSD (Table 14), a significance for blocking effect could not be determined. Using variance component percentages (Table 4), source of variance with the largest percentage was entry; where ANOVA significance was detected at the $P \leq 0.0001$ level.

Using Tukey's HSD (Table 15), the performance of entries was compared. At the final interval, the tallest entry was the PSH. Along with this, the shortest entry was ATx623. Lastly, Tukey's HSD (Table 16) was used to analyze the performance of entries within blocks. The variance component was lower than the entry effect and may not be as important of a test. The $R^2$ to explain the variability for this test was 0.73 (Figure 3).

These findings conflict with those of Lin et al. (1995) who found that *S. propinquum* populations were significantly taller than both *S. bicolor* and $F_2$ hybrids between the two species. There are several ways to explain these differences. First, our plots were planted noticeably later than their study; June 14 compared to April 30. Secondly, our research focused on measuring height from the base of the plant to the flag leaf of the main culm. They measured height from the base of the plant to the tip of the inflorescence of the main culm. Our measurements for height make more logical sense as plants, especially the $F_2$ hybrid experimental units, had noticeable phenotypic differences in panicle architecture and length. Unfortunately, this trait was not of major importance for us to track in this population and as a result, we have no data to explain the observed phenotypes. Lastly, they were able to obtain height data for all experimental units until November 28, compared to October 10 for our experiment. It should also be stated that latitude did not play an effect as both trials were conducted in the College Station, Texas area. Most importantly, they identified six QTLs that accounted for 71% of the phenotypic variance for height; which may explain the height variation of the two studies.

Table 13. Analysis of variance for significance of block, entry, and block x entry on 90-day height[Y] for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Source | Df[X] | SS[W] | MS[V] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3 | 6643.87 | 2214.62 | 2.83 | 0.0427[Z] |
| Entry | 2 | 127556.29 | 63778.15 | 81.56 | <.0001 |
| Block x Entry | 6 | 34601.15 | 5766.86 | 7.37 | <.0001 |
| Residual | 90 | 70370.67 | 781.90 | | |
| Total | 101 | 239171.98 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y]Height measurements recorded in cm.
[X]Degrees of freedom
[W]Sum of squares
[V]Mean squares

Table 14. All pairs, Tukey HSD block means comparison for 90-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Block | Letters | Least Sq. Mean[Y] |
|---|---|---|
| 3.00 | A[Z] | 135.26 |
| 1.00 | A | 130.18 |
| 2.00 | A | 117.30 |
| 4.00 | A | 116.44 |

[Z] Block means followed by the same letter are not significantly different according to All pairs, Tukey HSD.
[Y] Height means recorded in cm.

Table 15. All pairs, Tukey HSD entry means comparison for 90-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry | Letters | Least Sq. Mean$^{Y}$ |
|---|---|---|
| PSH | A$^{Z}$ | 173.36 |
| SOPR | B | 113.19 |
| ATx623 | C | 87.84 |

$^{Z}$ Entry means followed by the same letter are not significantly different according to All pairs, Tukey HSD.
$^{Y}$ Height means recorded in cm.

Table 16. All pairs, Tukey HSD block x entry means comparison for 90-day height for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry, Block | Letter | Least Sq. Mean$^{Y}$ |
|---|---|---|
| PSH,3 | A$^{Z}$ | 215.90 |
| PSH,2 | B | 169.33 |
| PSH,4 | BC | 158.33 |
| SOPR,1 | BC | 152.40 |
| PSH,1 | BCD | 149.86 |
| SOPR,4 | CDE | 109.22 |
| SOPR,3 | DE | 99.70 |
| SOPR,2 | E | 91.44 |
| ATx623,2 | E | 91.12 |
| ATx623,3 | E | 90.17 |
| ATx623,1 | E | 88.27 |
| ATx623,4 | E | 81.79 |

$^{Z}$ Block x entry means followed by the same letter are not significantly different according to All pairs, Tukey HSD.
$^{Y}$ Height means recorded in cm.

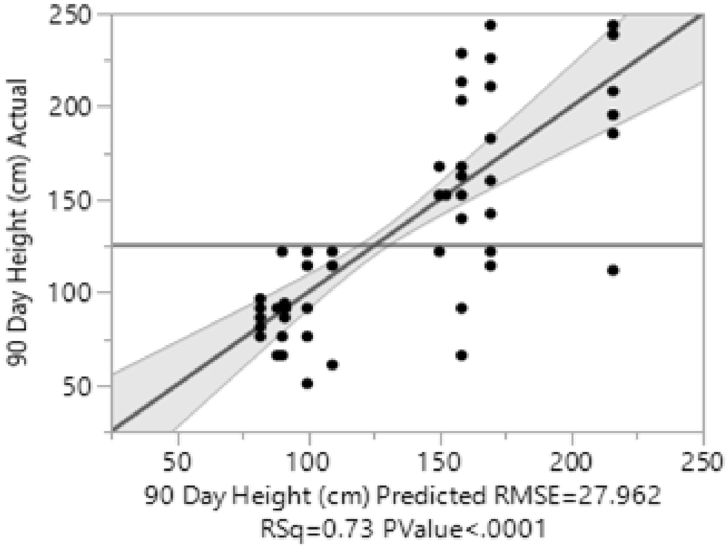


Figure 3. The generated model explained the amount of variation due to the dependent height$^{Z}$, for data gathered on the 90-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

$^{Z}$ Height measurements recorded in cm.

**Tillering Capacity Analysis**

Summary variance component percentages, along with ANOVA significances, (Table 17) indicate there were significant differences P≤ 0.01 for the 30-day time interval and P≤ 0.001 for the 60-day and 90-day intervals. Although time was a critical factor in entry performance, the overall means indicated that the perennial *Sorghum* hybrids (PSH) had a stronger tillering capacity than the *S. bicolor* parent (ATx623) but had a weaker tillering capacity than the *S. propinquum* parent (SOPR). Paterson et al. (1995) identified a *S. propinquum* allele in the region near pSB195-pSB062 that increases the number of tillers and rhizomes. This information helped explain the phenotypic variation that was recorded for tillering capacity, not only amongst entries but also within PSH experimental units. Each individual time effect are analyzed below.

Table 17. Summary variance component percentage table for block, entry, and block*entry of the dependent variable, tillering capacity, for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| | 30-Day Tillering | 60-Day Tillering | 90-Day Tillering |
|---|---|---|---|
| Block | $4.82^{NS}$ | $2.98^{**Z}$ | $3.22^{*}$ |
| Entry | $5.63^{**}$ | $29.66^{***}$ | $54.4^{***}$ |
| Block x Entry | $23.62^{***}$ | $18.08^{***}$ | $1.92^{NS}$ |

$^{Z}$ Analysis of variance was NS (nonsignificant) or significant at P≤ 0.05 (*), 0.01 (**), or 0.001 (***)

*30-Day Tillering Capacity of the Initial Transplanting*

The ANOVA table (Table 18) indicated there was not a significant blocking effect at any alpha level. Using Tukey's HSD (Table 19), we were unable to identify blocks that performed significantly different from one another.

Using Tukey's HSD (Table 20), entry performance was compared. For this test, the means showed that both parents, ATx623 and SOPR, out-performed the hybrid, PSH, for early-tillering capacity. However, means for this analysis only ranged from 0.45-1.09 tillers. Due to this finding, the comparison of the tillering capacity between entries at this time interval was fairly insignificant. It is also important to note that ATx623 individuals were ratoon cropped which could contribute to the higher than expected early tillering capacity. Although no blocking effect was identified, the largest source of variation component percentage (Table 17) was block by entry; where significance was detected at the $P \leq 0.001$ level. This large variance can be attributed to the first block of SOPR and the second of ATx623 that performed well-above the mean of the respective entry (Table 21). The $R^2$ to explain the variability for this test was 0.41 (Figure 4).

Table 18. Analysis of variance for significance of block, entry, and block x entry on 30-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Source | Df[Y] | SS[X] | MS[W] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3 | 4.22 | 1.41 | 1.79 | 0.15 |
| Entry | 2 | 8.90 | 4.45 | 5.67 | 0.0047[Z] |
| Block x Entry | 6 | 38.08 | 6.35 | 8.08 | <.0001 |
| Residual | 100 | 78.53 | 0.79 | | |
| Total | 111 | 129.73 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y]Degrees of freedom
[X]Sum of squares
[W]Mean squares

Table 19. All pairs, Tukey HSD block means comparison for 30-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Block | Letters | Least Sq. Mean |
|---|---|---|
| 1.00 | A[Z] | 1.19 |
| 3.00 | A | 0.83 |
| 4.00 | A | 0.77 |
| 2.00 | A | 0.64 |

[Z] Block means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

Table 20. All pairs, Tukey HSD entry means comparison for 30-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry | Letters | Least Sq. Mean |
|---|---|---|
| ATx623 | A[Z] | 1.09 |
| SOPR | A | 1.03 |
| PSH | B | 0.45 |

[Z] Entry means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

Table 21. All pairs, Tukey HSD block x entry means comparison for 30-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry, Block | Letter | Least Sq. Mean |
|---|---|---|
| SOPR,1 | A | 2.40 |
| ATx623,4 | AB | 2.00 |
| ATx623,2 | ABC | 1.11 |
| PSH,3 | BC | 1.00 |
| SOPR,3 | BC | 0.89 |
| ATx623,1 | BC | 0.67 |
| ATx623,3 | C | 0.60 |
| SOPR,2 | C | 0.60 |
| PSH,1 | BC | 0.50 |
| SOPR,4 | C | 0.22 |
| PSH,2 | C | 0.20 |
| PSH,4 | C | 0.10 |

[Z] Block x entry means followed by the same letter are not significantly different according to All pairs, Tukey HSD.

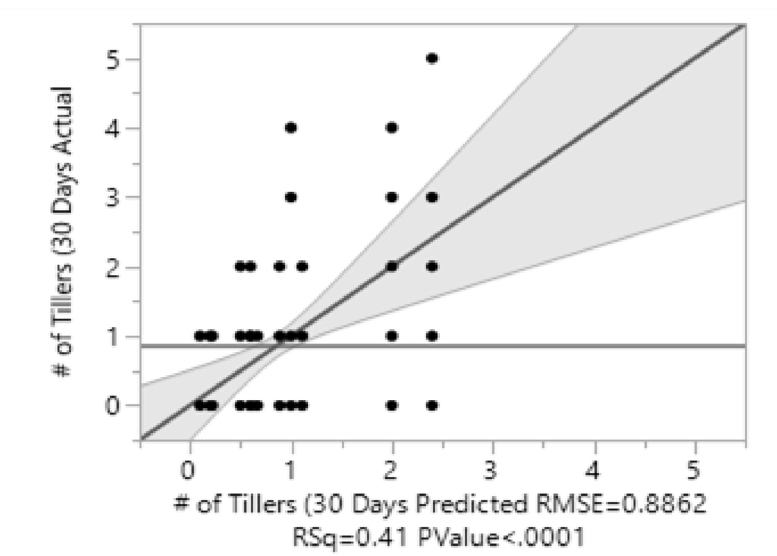


Figure 4. The generated model explained the amount of variation due to the dependent variable, tillering capacity, for data gathered on the 30-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

*60-Day Tillering Capacity of the Initial Transplanting*

The ANOVA table (Table 22) revealed there was a significant blocking effect at the $P \leq 0.01$ level. Using Tukey's HSD (Table 23), we identified that block 1 performed differently than both blocks 2 and 4. Although there was the presence of a blocking effect, the largest source of variance was still entry (Table 17); and significance was detected at the $P \leq 0.001$ level. With Tukey's HSD (Table 24) entry means were compared and SOPR was identified with having the greatest amount of tillering capacity, at the 60-day time interval.

Using Tukey's HSD (Table 25), block by entry performance was also compared. For this test, the means indicated that the SOPR entry in the first block performed the greatest. The means also indicated that the PSH did not perform differently than all block entries of ATx623 and the fourth block SOPR entry. There was a noticeable trend for tillering capacity at this time effect. Overall, it was evident there were higher levels of tillering capacity in SOPR, intermediate levels of tillering capacity in PSH, and lower levels of tillering in ATx623. The $R^2$ to explain the variability for this test was 0.52 (Figure 5).

Table 22. Analysis of variance for significance of block, entry, and block x entry on 60-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Source | Df[Y] | SS[X] | MS[W] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3 | 123.34 | 41.11 | 5.36 | 0.0019[Z] |
| Entry | 2 | 372.00 | 186.00 | 24.23 | <.0001 |
| Block x Entry | 6 | 190.00 | 31.67 | 4.13 | 0.001 |
| Residual | 93 | 713.84 | 7.68 | | |
| Total | 104 | 1399.18 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y]Degrees of freedom
[X]Sum of squares
[W]Mean squares

Table 23. All pairs, Tukey HSD block means comparison for 60-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Block | Letters | Least Sq. Mean |
|---|---|---|
| 1.00 | A[Z] | 5.44 |
| 3.00 | AB | 3.69 |
| 2.00 | B | 3.36 |
| 4.00 | B | 2.24 |

[Z] Block means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

Table 24. All pairs, Tukey HSD entry means comparison for 60-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry | Letters | Least Sq. Mean |
|---|---|---|
| SOPR | A[Z] | 5.76 |
| PSH | B | 4.09 |
| ATx623 | C | 1.19 |

[Z] Entry means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

Table 25. All pairs, Tukey HSD block x entry means comparison for 60-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry, Block | Letters | Least Sq. Mean |
|---|---|---|
| SOPR,1 | A[Z] | 10.10 |
| SOPR,2 | B | 5.40 |
| SOPR,3 | BC | 5.38 |
| PSH,1 | ABCD | 5.33 |
| PSH,3 | BCD | 4.90 |
| PSH,2 | BCD | 3.67 |
| PSH,4 | BCD | 2.44 |
| SOPR,4 | BCD | 2.17 |
| ATx623,4 | BCD | 2.10 |
| ATx623,2 | CD | 1.00 |
| ATx623,1 | CD | 0.88 |
| ATx623,3 | D | 0.80 |

[Z] Block x entry means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

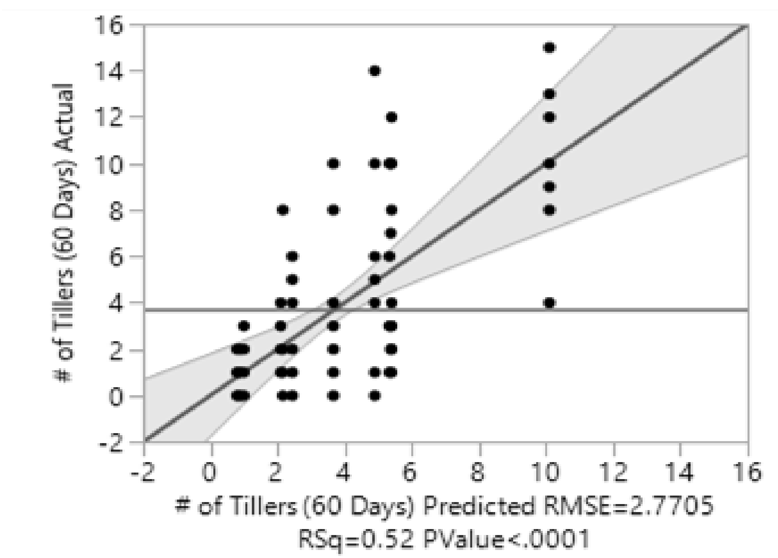


Figure 5. The generated model explained the amount of variation due to the dependent variable, tillering capacity, for data gathered on the 60-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

*90-Day Tillering Capacity of the Initial Transplanting*

The ANOVA table (Table 26) revealed there was a significant blocking effect at the $P \leq 0.05$ level. Using Tukey's HSD (Table 27), we were unable to confirm the blocking difference detected. The source of variance with the largest variance component was entry (Table 17); where significance was detected at the $P \leq 0.001$ level.

Using Tukey's HSD (Table 28), entry performance was compared. For this test, the means indicated that the SOPR had the greatest tillering capacity. The means also indicated that the PSH has a higher tillering capacity than the ATx623 parent. These late-period results suggest that the PSH entries have the capability to overwinter; similar to that of the SOPR species. Lastly, Tukey's HSD was used (Table 29) to study block by entry performance. As in some of the previous time effect, the variance component percentage was low, 1.92%, and most likely is not the most significant test. Previous studies have reached similar conclusions. The $R^2$ to explain the variability for our test was 0.56 (Figure 6).

Cox et al. (2018) reported that annual x perennial *Sorghum* $F_1$ hybrids and the $F_2$ populations had more profuse tillering and branching, this was more similar to the perennial parent than the annual parent. However, they also reported anomalous diploid hybrid plants that were closer in phenotype to *S. bicolor*. Because our results show that hybrids were more intermediate than either parent, we cannot refute their conclusions.

Paterson et al. (1995) concluded that spring regrowth was positively correlated with tillering and rhizomatousness. They identified six QTLs, three of which were for tillering, which accounted for 29.9% of the phenotypic variation in regrowth. They also identified four genomic regions that controlled the overall number of tillers in *S. halepense.*

Table 26. Analysis of variance for significance of block, entry, and block x entry on 90-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Source | Df$^{Y}$ | SS$^{X}$ | MS$^{W}$ | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3 | 113.84 | 37.95 | 3.23 | 0.0261$^{Z}$ |
| Entry | 2 | 1082.75 | 541.37 | 46.09 | <.0001 |
| Block x Entry | 6 | 94.38 | 15.73 | 1.34 | 0.25 |
| Residual | 90 | 1057.23 | 11.75 | | |
| Total | 101 | 2348.20 | | | |

$^{Z}$ NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
$^{Y}$Degrees of freedom
$^{X}$Sum of squares
$^{W}$Mean squares

Table 27. All pairs, Tukey HSD block means comparison for 90-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Block | Letters | Least Sq. Mean |
|---|---|---|
| 1.00 | A$^{Z}$ | 6.20 |
| 3.00 | A | 5.94 |
| 4.00 | A | 4.29 |
| 2.00 | A | 3.69 |

$^{Z}$ Block means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

Table 28**.** All pairs, Tukey HSD entry means comparison for 90-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry | Letters | Least Sq. Mean |
|---|---|---|
| SOPR | A$^{Z}$ | 9.25 |
| PSH | B | 4.66 |
| ATx623 | C | 1.18 |

$^{Z}$ Entry means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

Table 29. All pairs, Tukey HSD block x entry means comparison for 90-day tillering capacity for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry, Block | Letters | Least Sq. Mean |
|---|---|---|
| SOPR,1 | A[Z] | 11.10 |
| SOPR,3 | AB | 11.00 |
| SOPR,4 | ABC | 8.50 |
| PSH,1 | ABCD | 6.50 |
| SOPR,2 | ABCD | 6.40 |
| PSH,3 | BCD | 5.70 |
| PSH,2 | CD | 3.67 |
| PSH,4 | CD | 2.78 |
| ATx623,4 | D | 1.60 |
| ATx623,3 | D | 1.13 |
| ATx623,2 | D | 1.00 |
| ATx623,1 | D | 1.00 |

[Z]Block x entry means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

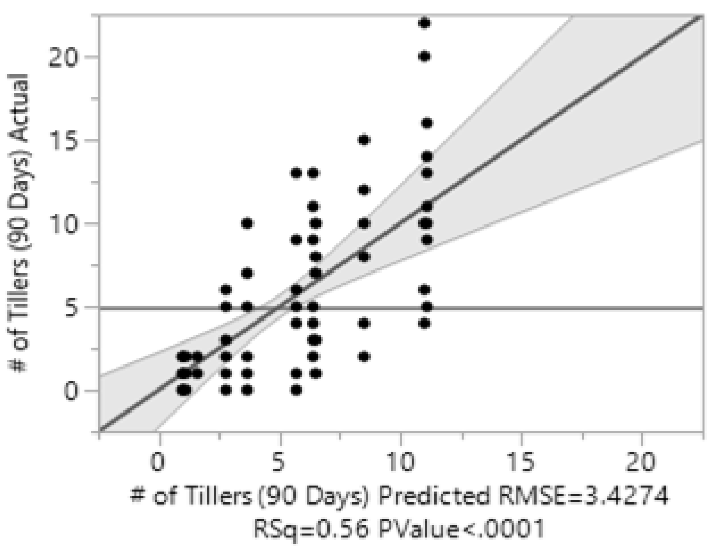


Figure 6. The generated model explained the amount of variation due to the dependent variable, tillering capacity, for data gathered on the 90-day interval for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

**Maturity Analysis**

The ANOVA table (Table 30) indicated there was a significant blocking effect at the P≤ 0.001 level. Using Tukey's HSD (Table 31), we were able to identify a blocking effect. The source of variance with the largest variance component was entry; where significance was detected at the P≤ 0.001 level.

Using Tukey's HSD (Table 32), entry performance was compared. For this test, the means indicated that the SOPR, flowered the latest and ATx623 flowered the earliest. An important aspect of this research (maturity) is a considerable amount of data was biased for this test. The last day primary culm mid-bloom date was recorded was on October 10, 2018, 5 days prior to the storm that resulted in plant lodging. Until this time, 7 PSH experimental units from the subset population had not flowered, and they were assigned values of the last date when the data was recorded. This caused the means of the PSH entries to be slightly lower than how they phenotypically performed. Lin et al. (1995) also reported the same biased results in favor of early maturity in their $F_2$ population. Using Tukey's HSD (Table 33), we were also able to study the interaction between blocks and entries. The $R^2$ to explain the variability for this test was 0.72 (Figure 7).

Table 30. Analysis of variance for significance of block, entry, and block x entry for primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Source | Df[Y] | SS[X] | MS[W] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3 | 3630.90 | 1210.30 | 3.43 | 0.02[Z] |
| Entry | 2 | 71841.37 | 35920.69 | 101.78 | <.0001 |
| Block x Entry | 6 | 3667.25 | 611.21 | 1.73 | 0.12 |
| Residual | 91 | 32116.58 | 352.93 | | |
| Total | 102 | 111256.10 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y] Degrees of freedom
[X] Sum of squares
[W] Mean squares

Table 31. All pairs, Tukey HSD block means comparison for primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Block | Letters | Least Sq. Mean |
|---|---|---|
| 3.00 | A[Z] | 88.65 |
| 2.00 | A | 87.39 |
| 1.00 | AB | 81.89 |
| 4.00 | B | 73.32 |

[Z] Block means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

Table 32. All pairs, Tukey HSD entry means comparison for primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry | Letters | Least Sq. Mean |
|---|---|---|
| SOPR | A[Z] | 118.00 |
| PSH | B | 64.94 |
| ATx623 | C | 53.11 |

[Z] Entry means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

Table 33. All pairs, Tukey HSD block x entry means comparison for primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

| Entry, Block | Letters | Least Sq. Mean |
|---|---|---|
| SOPR,4 | A[Z] | 118.00 |
| SOPR,3 | A | 118.00 |
| SOPR,1 | A | 118.00 |
| SOPR,2 | A | 118.00 |
| PSH,3 | AB | 94.40 |
| PSH,2 | BC | 84.67 |
| PSH,1 | BCD | 72.67 |
| ATx623,2 | CD | 59.50 |
| PSH,4 | CD | 57.56 |
| ATx623,1 | CD | 55.00 |
| ATx623,3 | D | 53.56 |
| ATx623,4 | D | 44.40 |

[Z] Entry means followed by the same letter are not significantly different according to all pairs, Tukey HSD.

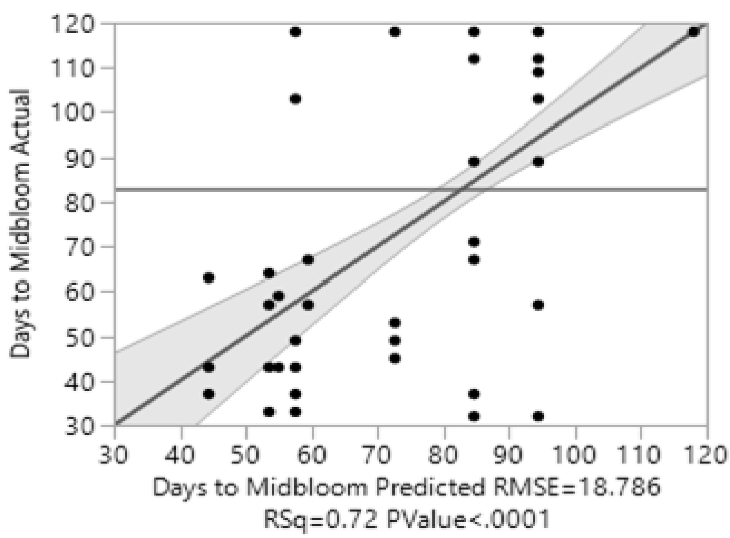


Figure 7. The generated model explained the amount of variation due to the dependent variable, primary culm days to mid-bloom for ATx623, perennial *Sorghum* hybrid (PSH), and *S. propinquum* (SOPR).

### Overwintering Capacity Analysis

Table 34 shows the number of basal tillers and rhizome derived shoots counted in the field. A total of 63 PSH, 3 SOPR, and 0 ATx623 plants successfully overwintered. Habyarimana et al. (2018) reported that rhizome overwintering capacity in interspecific hybrids greatly depended on an increase in proportion of perennial *Sorghum* genome. Our experiment resulted with a higher proportion of hybrids overwintering than the perennial parent which is questionable and counterintuitive. One explanation for this effect was the multiple warm thaw periods, which were followed by a hard freeze, on the *S. propinquum*.

The repeated measures ANOVA for basal tillering capacity (Table 35) revealed that the number of basal tillers significantly changed over time at the $P \leq 0.001$ level. Whereas, the repeated ANOVA for rhizome derived shoots (Table 36) indicated that the number of rhizome derived shoots did not significantly change over time at the $P \leq 0.05$ level. These results are logical as perennial crops initially invest more resources into developing tillers as they require less energy to develop when compared to rhizomes. This process is beneficial to the plant as basal tillers can replenish resources with photosynthate. Once established, perennial plants differ in rhizome quality. Some perennial species develop long, well-branched rhizomes which require a long duration of elongation; whereas, some develop numerous, short rhizomes that are useful for penetrating the soil surface rather quickly (Brejda et al., 1989). In the case with *Sorghum*, the longer, branching rhizomes are more prevalent. Washburn et al. (2013b) tracked rhizome composition and showed that nutrients are being assimilated from rhizomes into above ground tissue, such as basal tillers. This could also help explain why we did not have as many rhizome derived shoots as compared with basal tillers for overwintering analysis.

Table 34. Summary table of overwintering capacity for all entries ATx623, perennial *Sorghum* hybrid (PSH), PSH subset and *S. propinquum* (SOPR) across all time effects.

| Date | Entry | No. Overwintering Plants | No. BT[Z] | No. RDS[Y] |
|---|---|---|---|---|
| April 1, 2019 | ATx623 | 0 | 0 | 0 |
| | SOPR | 2 | 2 | 3 |
| | PSH | 58 | 231 | 75 |
| | PSH subset | 4 | 29 | 2 |
| April 15, 2019 | ATx623 | 0 | 0 | 0 |
| | SOPR | 5 | 5 | 6 |
| | PSH | 65 | 317 | 83 |
| | PSH subset | 4 | 33 | 2 |
| April 29, 2019 | ATx623 | 0 | 0 | 0 |
| | SOPR | 3 | 4 | 3 |
| | PSH | 63 | 348 | 86 |
| | PSH subset | 5 | 36 | 3 |

[Z] Basal Tiller
[Y] Rhizome Derived Shoot

*Basal Tillering Capacity*

Table 35. Repeated measures analysis of variance for overwintering basal tillering capacity for the perennial *Sorghum* hybrid experimental units.

| | Value | Exact F | NumDF | DenDF | Pro>F |
|---|---|---|---|---|---|
| F Test | 0.55 | 14.48 | 2 | 52 | <.0001[Z] |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.

*Rhizome Derived Shoot Capacity*

Table 36. Repeated measures analysis of variance for overwintering rhizome derived shoot capacity for the perennial *Sorghum* hybrid experimental units.

| | Value | Exact F | NumDF | DenDF | Pro>F |
|---|---|---|---|---|---|
| F Test | 0.04 | 1.09 | 2 | 52 | $0.35^{Z}$ |

$^{Z}$ NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.

*$F_2$ Hybrid Selection*

For our selection purposes, the primary trait of interest was overwintering capacity, as selecting on grain only results in an annual sorghum with low grain yield. Thus, selecting from the experimental units that successfully demonstrated the ability to re-grow either basal tillers or rhizome derived shoots during April was prioritized.

With this criterion, we created a Wilcoxon Rank Sum table (Table 37) to use as a selection tool. The dependent variables of primary interest for our selection process were: 90-day height (cm), the number of tillers at 90 days, primary culm days to mid-bloom, the number of basal tillers present on April 29, 2019, and the number of rhizome derived shoots present on April 29, 2019.

Only 63 plants, or roughly 14.3%, of the $F_2$ hybrids overwintered. This is slightly lower than the *S. bicolor* x *S. propinquum* hybrids reported by Washburn et al. (2013a) where 25.2% of the $F_{3:4}$ lines survived and were significantly lower than the 92.2% survival rate reported by Paterson et al. (1995). However, in both cases it was likely due to a more mild winter because in 2019 every warm thaw period was followed by a hard freeze.

Using the Wilcoxon Rank Sum, we were able to select the top 5% by progressing with the individuals that scored over an average of 50 and higher. We also could select the top 10% by progressing with the individuals that scored an average of 47 and higher. The problem with this approach is that every dependent variable is given equal weight. Although this may be a helpful selection tool, developing an equation that assigns a higher value to dependent variables could be more beneficial and/or more difficult. This work is still ongoing.

Table 37. Wilcoxon rank sum data table for the perennial *Sorghum* hybrid experimental units that showed the capacity to overwinter.

| Plant ID | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/29/2019 BT[Z] | 4/29/2019 RDS[Y] | Average |
|---|---|---|---|---|---|---|
| 1 | 11.0 | 5.5 | 9.0 | 5.5 | 40.0 | 14.2 |
| 2 | 25.5 | 55.0 | 52.0 | 43.5 | 15.5 | 38.3 |
| 3 | 54.5 | 23.5 | 52.0 | 43.5 | 15.5 | 37.8 |
| 4 | 31.0 | 30.5 | 20.5 | 62.0 | 15.5 | 31.9 |
| 5 | 13.0 | 61.0 | 52.0 | 59.0 | 51.0 | 47.2 |
| 6 | 31.0 | 34.5 | 20.5 | 5.5 | 40.0 | 26.3 |
| 7 | 54.5 | 57.5 | 20.5 | 47.5 | 40.0 | 44.0 |
| 8 | 41.0 | 45.5 | 32.5 | 23.0 | 15.5 | 31.5 |
| 9 | 16.0 | 63.0 | 32.5 | 38.0 | 40.0 | 37.9 |
| 10 | 41.0 | 45.5 | 32.5 | 5.5 | 40.0 | 32.9 |
| 11 | 1.5 | 15.0 | 10.0 | 5.5 | 40.0 | 14.4 |
| 12 | 13.0 | 45.5 | 52.0 | 31.0 | 15.5 | 31.4 |
| 13 | 16.0 | 9.5. | 52.0 | 38.0 | 58.0 | 34.7 |
| 14 | 23.5 | 34.5 | 52.0 | 23.0 | 15.5 | 29.7 |
| 15 | 7.5 | 30.5 | 32.5 | 13.5 | 15.5 | 19.9 |
| 16 | 21.0 | 15.0 | 32.5 | 38.0 | 40.0 | 29.3 |
| 17 | 41.0 | 23.5 | 32.5 | 54.0 | 40.0 | 38.2 |
| 18 | 54.5 | 9.5 | 20.5 | 43.5 | 54.5 | 36.5 |
| 19 | 54.5 | 39.5 | 32.5 | 13.5 | 15.5 | 31.1 |
| 20 | 45.0 | 49.5 | 52.0 | 60.5 | 40.0 | 49.4 |
| 21 | 44.0 | 57.5 | 52.0 | 57.5 | 15.5 | 45.3 |
| 22 | 54.5 | 59.5 | 32.5 | 63.0 | 62.5 | 54.4 |
| 23 | 34.0 | 2.5 | 15.0 | 23.0 | 40.0 | 22.9 |
| 24 | 54.5 | 55.0 | 32.5 | 57.5 | 15.5 | 43.0 |
| 25 | 54.5 | 23.5 | 20.5 | 60.5 | 15.5 | 34.9 |
| 26 | 54.5 | 34.5 | 32.5 | 38.0 | 15.5 | 35.0 |
| 27 | 1.5 | 15.0 | 3.0 | 5.5 | 51.0 | 15.2 |
| 28 | 54.5 | 34.5 | 32.5 | 51.0 | 15.5 | 37.6 |
| 29 | 13.0 | 30.5 | 7.5 | 13.5 | 15.5 | 16.0 |
| 30 | 18.5 | 23.5 | 52.0 | 23.0 | 15.5 | 26.5 |
| 31 | 54.5 | 39.5 | 52.0 | 43.5 | 61.0 | 50.1 |
| 32 | 16.0 | 23.5 | 52.0 | 23.0 | 15.5 | 26.0 |
| 33 | 54.5 | 59.5 | 20.5 | 55.5 | 62.5 | 50.5 |

[Z] Basal Tiller
[Y] Rhizome Derived Shoot

Table 37 (Continued). Wilcoxon rank sum data table for the perennial *Sorghum* hybrid experimental units that showed the capacity to overwinter.

| Plant ID | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/29/2019 BT$^Z$ | 4/29/2019 RDS$^Y$ | Average |
|---|---|---|---|---|---|---|
| 34 | 54.5 | 15.0 | 32.5 | 5.5 | 54.5 | 32.4 |
| 35 | 7.5 | 1.0 | 32.5 | 5.5 | 54.5 | 20.2 |
| 36 | 54.5 | 9.5 | 11.0 | 43.5 | 40.0 | 31.7 |
| 37 | 21.0 | 5.5 | 2.0 | 5.5 | 51.0 | 17.0 |
| 38 | 54.5 | 9.5 | 12.0 | 23.0 | 15.5 | 22.9 |
| 39 | 3.0 | 5.5 | 52.0 | 34.0 | 40.0 | 26.9 |
| 40 | 36.5 | 23.5 | 52.0 | 23.0 | 40.0 | 35.0 |
| 41 | 36.5 | 23.5 | 20.5 | 13.5 | 15.5 | 21.9 |
| 42 | 28.0 | 15.0 | 32.5 | 5.5 | 40.0 | 24.2 |
| 43 | 54.5 | 45.5 | 20.5 | 34.0 | 15.5 | 34.0 |
| 44 | 7.5 | 2.5 | 52.0 | 31.0 | 15.5 | 21.7 |
| 45 | 54.5 | 45.5 | 52.0 | 23.0 | 15.5 | 38.1 |
| 46 | 41.0 | 62.0 | 52.0 | 5.5 | 40.0 | 40.1 |
| 47 | 7.5 | 39.5 | 52.0 | 23.0 | 15.5 | 27.5 |
| 48 | 4.0 | 55.0 | 1.0 | 43.5 | 54.5 | 31.6 |
| 49 | 23.5 | 39.5 | 52.0 | 23.0 | 15.5 | 30.7 |
| 50 | 7.5 | 45.5 | 7.5 | 50.0 | 40.0 | 30.1 |
| 51 | 21.0 | 5.5 | 13.5 | 13.5 | 15.5 | 13.8 |
| 52 | 34.0 | 23.5 | 5.5 | 38.0 | 40.0 | 28.2 |
| 53 | 34.0 | 51.5 | 52 | 55.5 | 60.0 | 50.6 |
| 54 | 41.0 | 15.0 | 13.5 | 52.5 | 15.5 | 27.5 |
| 55 | 31.0 | 39.5 | 32.5 | 13.5 | 15.5 | 26.4 |
| 56 | 25.5 | 53.0 | 52.0 | 23.0 | 40.0 | 38.7 |
| 57 | 28.0 | 30.5 | 4.0 | 52.5 | 15.5 | 26.1 |
| 58 | 28.0 | 39.5 | 52.0 | 23.0 | 15.5 | 31.6 |
| 59 | 38.0 | 49.5 | 52.0 | 47.5 | 40.0 | 45.4 |
| 60 | 54.5 | 23.5 | 32.5 | 31.0 | 15.5 | 31.4 |
| 61 | 54.5 | 23.5 | 16.0 | 49.0 | 58.0 | 40.2 |
| 62 | 18.5 | 51.5 | 5.5 | 34.0 | 58.0 | 33.5 |
| 63 | 7.5 | 15.0 | 52.0 | 23.0 | 15.5 | 22.6 |

$^Z$ Basal Tiller

$^Y$ Rhizome Derived Shoot

CHAPTER III

# SEED PRIMING AS A TOOL TO INDUCE POLYPLOIDIZATION OF *SORGHUM BICOLOR* AND *SORGHUM PROPINQUUM*

## Literature Review

### *Induced Polyploidy*

Polyploidization of plants has value as polyploid plants can express novel phenotypes. Polyploids possess more than two sets of chromosomes, which increases genome sizes over related diploids (Otto, 2007). Polyploidization can occur either through natural means, as in some species of the genera *Gossypium* (Fang et al., 2017), *Saccharum* (da Silva, 2017), and *Triticum* (Matsuoka, 2011), or it can be artificially induced (*cf.* Sattler et al., 2015). In *Sorghum*, the primary interest revolves around the latter, because the technology is available to induce chromosome doubling relatively inexpensively. Novel phenotypes in polyploid plants can express higher levels of antioxidant enzymes, protein, soluble carbohydrates, and chlorophyll (Ardabili et al., 2015). In addition to biochemical changes, polyploids express differences in morphological characteristics including: cell sizes, leaf thickness, presence of pubescence, and cuticular thickness (Madlung 2013). Unfortunately, induced polyploidy has been shown to decrease fertility due to meiotic chromosome irregularities (Schertz, 1962).

Several different methods have been used to induce polyploidy in plants. Colchicine has been used since the late 1930’s to double the chromosomes in plants

(Eigsti, 1938). This was apparent in a study using sudangrass, *Sorghum bicolor* (L.) Moench ssp. *drummondii* (Nees ex Steud.) de Wet & Harlan, where the ploidy level was increased to cross the grass with johnsongrass (Casady and Anderson, 1952). Colchicine duplicates the number of chromosomes by disrupting spindle formation during mitosis and the chromosomes are not able to move to the poles at anaphase. Thus, the resulting cell has twice the number of chromosomes. Colchicine is therefore considered a mutagenic agent (Murali et al., 2013). Two other commonly used chemicals are oryzalin and trifluralin. With oryzalin, the chemical binds to plant tubulin and inhibits microtubule polymerization (Morejohn et al., 1987). Trifluralin primarily interrupts the mitotic division in root tips (Nag et. al., 2011). These chemicals, oryzalin and trifluralin, are often mixed with dimethyl sulfoxide (DMSO) which increases cell permeability (Dhooghe et al., 2011). However, with an increase in permeability, mortality rates also increase. Fortunately, the number of induced polyploids produced also increases (Hamill et al., 1992). Oryzalin and triflualin have been used to double the chromosomes of some fruit crops, such as bananas, pears, and oranges, and ornamental crops, such as roses (Allum et al., 2007; Dhooghe et al., 2011). Amiprophos-methyl (APM) is often used with chemicals, such as colchicine and trifluralin, to increase the chance of producing a polyploid (Dhooghe et al., 2011). APM is a germination inhibitor that interferes with the microtubular system of the plant (Kiermayer and Fedtke, 1977). Nitrous oxide has been used for induced polyploidization by retention of bivalent homologous chromosomes at the equatorial plane during meiosis followed by asymmetrical cell plate formation (Kitamura et al., 2009). In red clover, *Trlfolium pratense L.*, Taylor et al. (1976) used nitrous oxide instead of colchicine to avoid sectoral chimeras. They found that the frequency of mixoploids was lower. However, when other *Trifolium* species, such as *T. hirtum* All. and *T. heldreichianum* (Gibelli & Belli) Hausskn,. were treated with nitrous oxide, the treated plants did not survive because of the toxicity of the chemical. Each of these chemicals, excluding nitrous oxide, are limited in exposure time because of the lethality of the agents (Allum et al., 2007; Dhooghe et al., 2011; Murali et al., 2013).

Considerable research has been conducted in developing a protocol that will successfully double the chromosomes of different *Sorghum* spp. (Schertz, 1962; Sun et al., 1994; Murali et al., 2013; Ardabili et al., 2015) with success ranging from less than 1 to as high as 10 percent. However, a consensus "best" method based on concentration rate, duration of exposure, and mode of action has not yet been established.

### *Seed Priming*

Seed priming using solid carriers, such as calcined clay, is known as solid matrix priming (SMP) (Ermiş, 2016). It is a method that is primarily used to synchronize germination while also optimizing seed germination and seedling establishment (Heydecker and Coolbear, 1977; Ermiş, 2016). To combat chemical lethality of antimitotic agents, seed priming is an approach that can be used to slow the uptake of the chemical and afford longer exposure times (Khan et al., 1992). Germination begins with the uptake of water by the seed, referred to as imbibition, and is finalized when the radicle emerges from the seed pericarp (Bewley, 1997). Imbibition is further separated into three phases (Bewley, 1997). During phase I, a rapid initial uptake of water occurs which initiates protein synthesis, respiration, and mitochondrial repair. Phase II is known as the "plateau" stage where very little, if any, water is absorbed. However, mitochondrial repair continues, and the synthesis of new mitochondria begins. Most importantly for seed priming, cell division begins during this stage. Phase III is later initiated with radicle protrusion followed by a second rapid uptake of water. At this time, stored reserves begin to be mobilized for cell division and elongation (Bewley, 1997; Nonogaki et al., 2010). As the result of seed priming, seed are able to absorb sufficient moisture for pre-germinative metabolic activity (phases I and II) but prevents radicle emergence (Heydecker and Coolbear, 1977; Gurushinghe, 1999). A seed priming approach theoretically allows exposure to the doubling agent across multiple cell division cycles.

## Objective and Expected Outcome

The objective of this study was to develop a novel method to improve chromosome doubling efficiency for *S. bicolor* and *S. propinquum*.

This study is expected to provide a more efficient and novel method for doubling the chromosomes in different species in the genus *Sorghum* with the possibility that the technique will become the accepted practice across multiple genera.

## Materials and Methods

### *Utilizing Calcined Clay as a Primer*

Multiple colchicine treatments as described below, were conducted by placing 25 seed of a given species into a resealable, quart-sized, polypropylene bag along with a primer, calcined clay, (Agsorb® 40/100 LVM, Oil-Dri Corporation, Chicago, IL, USA) at a ratio of 10:1 (media:seed weight), and this was replicated four times for each treatment. Each treatment contained a specific concentration and mixture of the following: colchicine, DMSO, and APM. In addition, treatments were applied to each bag in the quantity of 3.5mL or 10mL depending on the treatment. Once the solution was added to each bag, the media was shaken and/or ribboned, as one would do to test for soil texture, to create a homogeneous mixture. During the five to 20 days of the various treatments, individual seeds were examined for cracked pericarps and radicle emergence. Upon completion of priming, the seed were separated from the clay medium using a 6x28 cm wire mesh (*S. propinquum*) and a 2 mm aluminum sieve (*S. bicolor*). The seed were then immediately rinsed in water for 3 to 5 minutes. Following rinsing, the seed were planted into a professional growing mix media (Sun Gro Horticulture Agawam, MA) in 2.5 cm x 2.5 cm trays and maintained in different controlled environments. Four weeks after planting, final germination numbers were recorded and the surviving plants from each replication were transplanted into individual pots. Seed from two species, *S. bicolor* and *S. propinquum*, were used for this described methodology.

***Sorghum bicolor***

For *S. bicolor*, there were a total of (9) treatments.

(1) 0.1% colchicine, 5% DMSO, 0 µM APM, 3.5mL of solution, and 5 days in solution.

(2) 0.2% colchicine, 5% DMSO, 0 µM APM, 3.5mL of solution, and 5 days in solution.

(3) 0.4% colchicine, 10% DMSO, 0 µM APM, 3.5mL of solution, and 5 days in solution.

(4) 0.4% colchicine, 20% DMSO, 0 µM APM, 10mL of solution, and 5 days in solution.

(5) 0.4% colchicine, 20% DMSO, 0 µM APM, 10mL of solution, and 10 days in solution.

(6) 0.4% colchicine, 20% DMSO, 0 µM APM, 10mL of solution, and 15 days in solution.

(7) 0.4% colchicine, 20% DMSO, 0 µM APM, 10mL of solution, and 20 days in solution.

(8) 0.4% colchicine, 20% DMSO, 100 µM APM, 10mL of solution, and 5 days in solution.

(9) 0.4% colchicine, 20% DMSO, 100 µM APM 10mL of solution, and 10 days in solution.

**_Sorghum propinquum_**

For *S. propinquum*, there were a total of (5) treatments, because seed was a more limiting factor.

(1) 0.1% colchicine, 5% DMSO, 0 µM APM, 3.5mL of solution, and 5 days in solution.

(2) 0.2% colchicine, 5% DMSO, 0 µM APM, 3.5mL of solution, and 5 days in solution.

(3) 0.4% colchicine, 10% DMSO, 0 µM APM, 3.5mL of solution, and 5 days in solution.

(4) 0.4% colchicine, 20% DMSO, 100 µM APM, 10mL of solution, and 5 days in solution.

(5) 0.4% colchicine, 20% DMSO, 100 0 µM, 10mL of solution, and 10 days in solution.

*Parafilm Encapsulation Priming*

The second protocol to induce chromosome duplication required controlling seed moisture content on a single-seed basis. This was accomplished by initially treating each individual seed with 0.5µmL of solution, specific for each treatment, enclosed between two strips of parafilm (Parafilm M, Bemis Company, Inc, USA). Seed were quickly sealed in a dome with 2.5 cm diameter between parafilm strips to prevent evaporation of the solution and created a micro-environment for each seed. Treatments not only varied in chemical composition, but also for exposure length to the seed. The only species used for this experiment was *S. propinquum*.

Treatments applied directly to the seed were as followed:

(1) 0.1% colchicine, 20% DMSO, 0 µM APM, and 5 days in solution,

(2) 0.1% colchicine, 20% DMSO, 100 µM APM, and 5 days in solution,

(3) 0.2% colchicine, 20% DMSO, 0 µM APM, and 5 days in solution,

(4) 0.1% colchicine, 20% DMSO, 0 µM APM, and 10 days in solution,

(5) 0.1% colchicine, 20% DMSO, 100 µM APM, and 10 days in solution

(6) 0.2% colchicine, 20% DMSO, 0 µM APM, and 10 days in solution.

(7) 0.2% colchicine, 20% DMSO, 0 µM APM, and 10 days in solution.

Treatment (7) was identical in chemical composition as treatment (6). However, instead of treating 40 seed, as was done for treatments 1-6, a bulk experiment was conducted which resulted in 300 seed being treated. Once the desired time for a treatment duration had elapsed, seed were taken out of the laboratory and individually planted in autoclaved (121 $^{o}$C at 16 PSI. for 1 hour), professional soil mix media-filled Styrofoam cups. Four weeks after planting, final germination numbers were recorded and the surviving plants from each replication were transplanted into individual pots.

### *Flow Cytometry*

Approximately 10 weeks after transplanting into pots, the DNA content of all plants were determined using a flow cytometer and the ploidy level of each plant was estimated. Approximately 1 $cm^3$ of leaf tissue was collected from each seedling and chopped with a razor blade in 1.5 mL of Galbraith's buffer in a Petri dish. The buffer solution consisted of: 8.8 g $L^{-1}$ sodium citrate dihydrate, 4.2 g $L^{-1}$ MOPS, 4.26 mL $L^{-1}$ $MgCl_2$, 1.0 mL $L^{-1}$ Triton X-100, and 100 µL $L^{-1}$ RNase A (Galbraith, 1989). The buffer solution containing the chopped leaf tissue was then filtered through a 30 µM mesh into a sample tube. Subsequently, 5 µL of propidium iodide were added to each sample and the sample tubes were placed on ice for a minimum of 30 minutes in the dark. Each sample was analyzed using a CyFlow® flow cytometer (Partec GmbH, Münster, Germany), and a minimum of 1,000 nuclei were analyzed for each sample. Known diploid samples, BTx623 for *S. bicolor* and unnamed accession for *S. propinquum*, were used to establish the position of the 2C and 4C peaks for each species of plant tested. The protocol outlined is the default procedure unless stated otherwise.

## Results and Discussion

### *Sorghum bicolor*

Across all treatments, a total of 1,100 *S. bicolor* seed were treated. Of the 1,100 seed, a total of 343 seedlings were analyzed through flow cytometry. Across all treatments, no tetraploid or mixoploid plants were identified (Table 38).

*Sorghum propinquum*

**Calcined Clay Priming**

Across all treatments, a total of 500 *S. propinquum* seed were treated. Of the 500 seed, a total of 64 seedlings were analyzed using flow cytometry. Of the 64 seedlings, none were classified as being either tetraploid or mixoploid (Table 39).

**Parafilm Encapsulation Priming**

Across all treatments, a total of 540 seed was treated. Of the 540 seed, 179 seedlings were analyzed using flow cytometry. Of these 179 seedlings, none were determined to be tetraploid. However, one individual from treatment 1 was identified as a mixoploid (Table 40).

Some very interesting seedling results were observed when comparing treatments (Table 41). The number of abnormal seedlings produced with treatment 6 was noticeably higher when compared with the other concurring treatments. Because of this, we replicated treatment 6 in a bulk treatment, treatment 7. Abnormal seedlings had stunted growth and necrotic tissue. Unfortunately, only 70 seedlings survived the treatment and none were tetraploids.

To speculate why our procedure failed, I contribute it to the inability to incorporate the exact quantity of antimitotic agents necessary to induce polyploidization. Our methods either lead to lethality or failed to incorporate the agents to prevent mitotic division. To achieve the levels of success of typical *Sorghum* polyploidization research, treatments could focus on shoot and root exposure (Sun et al. 1994). Another practice could call for treating seed with chemical agents multiple times before allowing the seed to germinate.

Table 38. *Sorghum bicolor* polyploidization treatments utilizing calcined clay as a primer.

| Treatment | Colchicine % | DMSO % | APM Concentration | Amount of Solution[Z] | Days in Solution | Seed Treated | Seedlings Tested by Flow Cytometry | Mixoploids/ Tetraploids Produced |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1% | 5% | 0 µM | 3.5mL | 5 | 300 | 249 | 0 |
| 2 | 0.2% | 5% | 0 µM | 3.5mL | 5 | 100 | 16 | 0 |
| 3 | 0.4% | 10% | 0 µM | 3.5mL | 5 | 100 | 0 | 0 |
| 4 | 0.4% | 20% | 0 µM | 10mL | 5 | 100 | 16 | 0 |
| 5 | 0.4% | 20% | 0 µM | 10mL | 10 | 100 | 36 | 0 |
| 6 | 0.4% | 20% | 0 µM | 10mL | 15 | 100 | 0 | 0 |
| 7 | 0.4% | 20% | 0 µM | 10mL | 20 | 100 | 0 | 0 |
| 8 | 0.4% | 20% | 100 µM | 10mL | 5 | 100 | 16 | 0 |
| 9 | 0.4% | 20% | 100 µM | 10mL | 10 | 100 | 10 | 0 |

[Z] Amount of solution per 10 grams of calcined clay.

Table 39. *Sorghum propinquum* polyploidization treatments utilizing calcined clay as a primer.

| Treatment | Colchicine % | DMSO % | APM Concentration | Amount of Solution | Days in Solution | Seed Treated | Seedlings Tested by Flow Cytometry | Mixoploids/ Tetraploids Produced |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1% | 5% | 0 µM | 3.5mL | 5 | 100 | 21 | 0 |
| 2 | 0.2% | 5% | 0 µM | 3.5mL | 5 | 100 | 23 | 0 |
| 3 | 0.4% | 10% | 0 µM | 3.5mL | 5 | 100 | 13 | 0 |
| 4 | 0.4% | 20% | 100 µM | 10mL | 5 | 100 | 4 | 0 |
| 5 | 0.4% | 20% | 100 µM | 10mL | 10 | 100 | 3 | 0 |

[Z] Amount of solution per 10 grams of calcined clay.

Table 40. *Sorghum propinquum* polyploidization treatments using parafilm encapsulation as a primer.

| Treatment | Colchicine % | DMSO % | APM Concentration | Amount of Solution[Z] | Days in Solution | Seed Treated | Seedlings Tested in Flow Cytometry | Mixoploids/Tetraploids Produced |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1% | 20% | 0 µM | 0.5 µmL | 5 | 40 | 26 | 1 |
| 2 | 0.1% | 20% | 100µM | 0.5 µmL | 5 | 40 | 22 | 0 |
| 3 | 0.2% | 20% | 0 µM | 0.5 µmL | 5 | 40 | 19 | 0 |
| 4 | 0.1% | 20% | 0 µM | 0.5 µmL | 10 | 40 | 17 | 0 |
| 5 | 0.1% | 20% | 100 µM | 0.5 µmL | 10 | 40 | 19 | 0 |
| 6 | 0.2% | 20% | 0 µM | 0.5 µmL | 10 | 40 | 6 | 0 |
| 7 | 0.2% | 20% | 0 µM | 0.5 µmL | 10 | 300 | 70 | 0 |

[Z] Amount of solution per seed.

Table 41. *Sorghum propinquum* polyploidization treatments using parafilm encapsulation as a primer. Table compares the number of normal seedlings, abnormal seedlings, and dead seedlings across treatments.

| Treatment | Number of Seed Treated | Number of Normal Seedlings | Number of Abnormal Seedlings | Number of Dead Seedlings | Number Screened by Flow Cytometry | Number of Polyploids/Mixoploids |
|---|---|---|---|---|---|---|
| 1 | 40 | 27 | 11 | 2 | 26 | 1 |
| 2 | 40 | 21 | 12 | 7 | 22 | 0 |
| 3 | 40 | 21 | 16 | 3 | 19 | 0 |
| 4 | 40 | 18 | 14 | 8 | 17 | 0 |
| 5 | 40 | 19 | 17 | 4 | 19 | 0 |
| 6 | 40 | 6 | 29 | 5 | 6 | 0 |

# CHAPTER IV

# SUMMARY AND CONCLUSIONS

Contrary to previous findings, plant height showed transgressive segregation in an interspecific hybridization between *Sorghum bicolor* and *S. propinquum*. $F_2$ hybrids exhibited the ability to produce more basal tillers than the *S. bicolor* parent, ATx623, but did not produce more than the *S. propinquum* parent. $F_2$ hybrids also matured later than the *S. bicolor* parent but matured earlier than the *S. propinquum* parent. Overwintering potential was only analyzed for the $F_2$ hybrids where 63 of 440 experimental units successfully overwintered. Although lower than reported by previous researchers, this may be contributed to an unexpectedly early frost in October 2018 followed by multiple late frosts in March 2019 in College Station, Texas. A selection tool was created for those plants that successfully overwintered to move forward to the $F_3$ generation. However, we believe an equation that is more predictive for the desired dependent variables is achievable and desirable.

Induced plant polyploidization was more difficult than expected. Using both calcined clay and parafilm encapsulation as seed primers, no tetraploid *Sorghum* plants were recorded. However, one mixoploid plant was recovered from the following treatment: 0.1% colchicine, 20% DMSO, 0 µM APM, and 5 days in solution. Although no tetraploid plants were recovered, we believe that we have made good headway in producing a more efficient protocol. As our research progressed, we were identifying an increased rate of abnormal seedlings that makes us believe that we are on the cusp of something innovating. The next step to achieve success, we believe, would be to identify a protocol that would allow seed to be exposed to multiple treatments before germinating. To add, most success in *Sorghum* polyploidization has been in root-tip exposure and this may prove to be the future area of focus. Additional research is needed to improve the success of induced polyploidization in *Sorghum*.

## REFERENCES

Allum, J. F., D. H. Bringloe, and A.V. Roberts. 2007. Chromosome doubling in a *Rosa rugosa* Thunb. hybrid by exposure of in vitro nodes to oryzalin: the effects of node length, oryzalin concentration and exposure time. Plant Cell Rep. 26:1977-1984. doi:10.1007/s00299-007-0411-y.

Ardabili, G. S., R. A. Zakaria, and N. Zare. 2015. In vitro induction of polyploidy in *Sorghum bicolor* L. Cytologia 80:495-503. Doi:10.1508/cytologia.80.495.

Bewley, J. D. 1997. Seed germination and dormancy. Plant Cell 9:1055. doi:10.1105/tpc.9.7.1055.

Bhatti, A. G., J. E. Endrizzi, and R. G. Reeves. 1960. Origin of johnson grass. J. Hered. 51:107-110. Doi:10.1093/oxfordjournals.jhered.a106962.

Bhuiyan, S. A., V. J. Galea, M. J. Ryley, and D. Tay. 2000. In vitro screening and evaluation of fungicides for the control of *Claviceps africana* on sorghum seed. Australas. Plant Pathol. 29:178-183. doi:10.1071/ap00031.

Boehmel, C., I. Lewandowski, and W. Claupein. 2008. Comparing annual and perennial energy cropping systems with different management intensities. Agri. Syst. 96:224-236. doi:10.1016/j.agsy.2007.08.004.

Bosco, S., N. N. o Di Nasso, N. Roncucci, M. Mazzoncini, and E. Bonari. 2016. Environmental performances of giant reed *Arundo donax* L. cultivated in fertile and marginal lands: a case study in the Mediterranean. Eur. J. Agron. 78:20-31. doi: 10.1016/j.eja.2016.04.006.

Brejda, J. J., Moser, L. E., and Waller, S. S. (1989). Rhizome and tiller development of three Nebraska Sandhills warm-season grasses. p. 211-215. *In* Proc. 11th North Am. Prairie Conf.

Casady, A. J., and K. L. Anderson. 1952. Hybridization, cytological, and inheritance studies of a *Sorghum* cross-autotetraploid sudangrass × (johnsongrass × 4n sudangrass). Agron. J. 44:189-194. doi:10.2134/agronj1952.00021962004400040007x.

Chittenden, L. M., K. F. Schertz, Y. R. Lin, R. A. Wing, and A. H. Paterson. 1994. A detailed RFLP map of *Sorghum bicolor* x *S. propinquum*, suitable for high-density mapping, suggests ancestral duplication of Sorghum chromosomes or chromosomal segments. Theor. Appl. Genet. 87:925-933. doi:10.1007/bf00225786.

Christensen, B. T., P. E. Lærke, U. Jørgensen, T. P. Kandel, and I. K. Thomsen. 2016. Storage of Miscanthus-derived carbon in rhizomes, roots, and soil. Can. J. Soil Sci. 96:354-360. doi: 10.1139/cjss-2015-0135.

Cox, S., P. Nabukalu, A. Paterson, W. Kong, and S. Nakasagga. 2018. Development of perennial grain sorghum. Sustainability 10:172.

Cox, T. S., J. D. Glover, D. L. Van Tassel, C. M. Cox, and L. R. DeHaan. 2006. Prospects for developing perennial grain crops. BioScience 56:649-659. doi:10.1641/0006-3568(2006)56[649:pfdpgc]2.0.co;2.

Cox, T. S., M. Bender, C. Picone, D. L. Van Tassel, J. B. Holland, E. C. Brummer, B. E. Zoeller, A. H. Paterson, and W. Jackson. 2002. Breeding perennial grain crops. Crit. Rev. Plant Sci. 21:59-91. doi:10.1080/0735-260291044188.

da Silva, J. A. 2017. The Importance of the wild cane *Saccharum spontaneum* for bioenergy genetic breeding. Sugar Tech. 19:229-240. doi:10.1007/s12355-017-0510-1.

de Wet, J. M. J. 1978. Systematics and evolution of *Sorghum* sect. (Gramineae). Am. J. Bot. 65:477-484. doi:10.2307/2442706.

Dhooghe, E., K. Van Laere, T. Eeckhaut, L. Leus, and J. Van Huylenbroeck. 2011. Mitotic chromosome doubling of plant tissues in vitro. Plant Cell Tissue Organ Cult. 104:359-373. doi:10.1007/s11240-010-9786-5.

Eigsti, O. J. 1938. A cytological study of colchicine effects in the induction of polyploidy in plants. Proc. Natl. Acad. Sci. 24:56-63. doi:10.1073/pnas.24.2.56.

Endrizzi, J. E. 1957. Cytological studies of some species and hybrids in the Eu-sorghums. Bot. Gaz. 119:1-10. doi:10.1086/335954.

Ermiş, S., F. Kara, E. Özden, and I. Demir. 2016. Solid matrix priming of cabbage seed lots: repair of ageing and increasing seed quality. Tarım Bilim. Derg. 22:588-595. doi:10.1501/tarimbil_0000001417.

Fang, L., X. Guan, and T. Zhang. 2017. Asymmetric evolution and domestication in allotetraploid cotton (*Gossypium hirsutum* L.). Crop J. 5:159-165. doi:10.1016/j.cj.2016.07.001.

Frederiksen, R. A., and F. Miller. 1972. Proposal for release and increase ATx622, BTx622, ATx623, BTx623, ATx624, BTx624. TAES Form 96-72.

Galbraith, D. W. 1989. Analysis of higher plants by flow cytometry and cell sorting. Int. Rev. Cytol. 116:165-228.

Glover, J. D., J. P. Reganold, L. W. Bell, J. Borevitz, E. C. Brummer, E. S. Buckler, C.M. Cox, T. S. Cox, T. E. Crews, S. W. Culman, and L. R. DeHaan. 2010. Increased food and ecosystem security via perennial grains. Science 328:1638-1639. doi:10.1126/science.1188761.

Gurusinghe, S. H., Z. Cheng, and K. J. Bradford. 1999. Cell cycle activity during seed priming is not essential for germination advancement in tomato. J. Exp. Bot. 50:101-106. doi:10.1093/jexbot/50.330.101.

Habyarimana, E., C. Lorenzoni, R. Redaelli, M. Alfieri, S. Amaducci, and S. Cox. 2018. Towards a perennial biomass sorghum crop: A comparative investigation of biomass yields and overwintering of *Sorghum bicolor* x *S. halepense* lines relative to long term *S. bicolor* trials in northern Italy. Biomass Bioenergy 111:187-195.

Hamill, S. D., M. K. Smith, and W. A. Dodd. 1992. In vitro induction of banana autotetraploids by colchicine treatment of micropropagated diploids. Aust. J. Bot. 40:887-896. doi:10.1071/bt9920887.

Heydecker, W., and P. Coolbear. 1977. Seed treatments for improved performance survey and attempted prognosis. Seed Sci. Technol. 5:353-425.

Hoang-Tang, and G. H. Liang. 1988. The genomic relationship between cultivated sorghum [*Sorghum bicolor* (L.) Moench] and johnsongrass [*S. halepense* (L.) Pers.]: a re-evaluation. Theor. Appl. Genet. 76:277-284. doi:10.1007/bf00257856.

Jessup, R. W., R. R. Klein, B. L. Burson, S. C. Murray, J. D. Washburn, J. J. Heitholt, and J. L. Foster. 2017. Registration of Perennial *Sorghum bicolor* x *S. propinquum* Line PSH12TX09. J. Plant Reg. 11:76-79. doi:10.3198/jpr2015.09.0054crgs.

Jessup, R. W. 2009. Development and status of dedicated energy crops in the United States. In Vitro Cell. Devel. Biol.-Plant 45:282-290. doi:10.1007/s11627-009-9221-y.

Khan, A. A., G.S Abawi, and J. D. Maguire. 1992. Integrating matriconditioning and fungicidal treatment of table beet seed to improve stand establishment and yield. Crop Sci. 32:231-237. doi:10.2135/cropsci1992.0011183x003200010047x.

Kiermayer, O., and C. Fedtke. 1977. Strong anti-microtubule action of amiprophos-methyl (APM) in Micrasterias. Protoplasma 92:163-166.

Kitamura, S., M. Akutsu, and K. Okazaki. 2009. Mechanism of action of nitrous oxide gas applied as a polyploidizing agent during meiosis in lilies. Sexual Plant Reprod. 22:9-14.

Kong, W., C. Kim, V. H. Goff, D. Zhang, and A. H. Paterson. 2015. Genetic analysis of rhizomatousness and its relationship with vegetative branching of recombinant inbred lines of *Sorghum bicolor x S. propinquum.* Am. J. Bot. 102:718-724. doi:10.3732/ajb.1500035.

Lin, Y. R., K. F. Schertz, and A. H. Paterson. 1995. Comparative analysis of QTLs affecting plant height and maturity across the Poaceae, in reference to an interspecific sorghum population. Genetics 141:391-411.

Madlung, A. 2013. Polyploidy and its effect on evolutionary success: old questions revisited with new tools. Heredity 110:99-104.

Mask, P. L., and W. C. Morris. 1991. Sweet sorghum culture and syrup production. Circular ANR-Alabama Cooperative Extension Service, Auburn University (USA). https://store.aces.edu/ItemDetail.aspx?ProductID=15629. Accessed Aug 3, 2018.

Matsuoka, Y. 2011. Evolution of polyploid *Triticum* wheats under cultivation: the role of domestication, natural hybridization and allopolyploid speciation in their diversification. Plant Cell Physiol. 52:750-764. doi:10.1093/pcp/pcr018.

Morejohn, L. C., T. E. Bureau, J. Mole-Bajer, A. S. Bajer, and D. E. Fosket. 1987. Oryzalin, a dinitroaniline herbicide, binds to plant tubulin and inhibits microtubule polymerization in vitro. Planta 172:252-264.

Mourtzinis, S., W. J. Wiebold, and S. P. Conley. 2016. Feasibility of a grain sorghum ratoon cropping system in Southeastern Missouri. Crop, Forage Turfgrass Manage. 1-7. doi:10.2134/cftm2015.0215.

Murali, K. M., J. Vanitha, S. Jiang, and S. Ramachandran. 2013. Impact of colchicine treatment on *Sorghum bicolor* BTx623. Mol. Plant Breed. 4:128-135. doi:10.5376/mpb.2013.04.0015.

Nabukalu, P., and T.S Cox. 2016. Response to selection in the initial stages of a perennial sorghum breeding program. Euphytica 209:103-111. doi:10.1007/s10681-016-1639-9.

Nag, S. K., R. Kookana, L. Smith, E. Krull, L. M. Macdonald, and G. Gill. 2011. Poor efficacy of herbicides in biochar-amended soils as affected by their chemistry and mode of action. Chemosphere 84:1572-1577.

Nonogaki, H., G. W. Bassel, and J. D. Bewley. 2010. Germination—still a mystery. Plant Sci. 179:574-581. doi:10.1016/j.plantsci.2010.02.010.

Otto, S. P. 2007. The evolutionary consequences of polyploidy. Cell 131:452-462. doi:10.1016/j.cell.2007.10.022.

Paterson, A. H., K. F. Schertz, Y. R. Lin, S. C. Liu, and Y. L. Chang. 1995. The weediness of wild plants: molecular analysis of genes influencing dispersal and persistence of johnsongrass, *Sorghum halepense* (L.) Pers. Proc. Natl. Acad. Sci. 92:6127-6131. doi:10.1073/pnas.92.13.6127.

Paterson, A. H. 2008. Genomics of sorghum. Int. J. Plant Genomics 2008:1-6. doi:10.1155/2008/362451.

Sattler, M. C., C. R. Carvalho, and W. R. Clarindo. 2016. The polyploidy and its key role in plant breeding. Planta 243:281-296. doi:10.1007/s00425-015-2450-x.

Schertz, K. F. 1962. Cytology, fertility, and gross morphology of induced polyploids of *Sorghum vulgare*. Can. J. Genet. Cytol. 4:179-186. doi:10.1139/g62-023.

Sun, Y., S. Q. Cheng, and G. H. Liang. 1994. Induction of autotetraploid plants of *Sorghum versicolor.* Cytologia 59:109-114.

Taylor, N. L., M. K. Anderson, K. H. Quesenberry, and L. Watson. 1976. Doubling the chromosome number of *Trifolium* Species using nitrous oxide. Crop Sci. 16:516-518. doi:10.2135/cropsci1976.0011183x001600040019x.

USGC. 2018. Sorghum, grains.org/buying-selling/sorghum/. Accessed Jul 20, 2018.

USDA. 2018. National Statistics for Sorghum. www.nass.usda.gov/Statistics_by_Subject/result.php?52EC9945-AD57-3463-933E-3297EBB43382. Accessed Jul 20, 2018.

Vandenbrink, J. P., V. Goff, H. Jin, W. Kong, A. H. Paterson, and F. A. Feltus. 2013. Identification of bioconversion quantitative trait loci in the interspecific cross *Sorghum bicolor x Sorghum propinquum*. Theor. Appl. Genet. 126:2367-2380. doi:10.1007/s00122-013-2141-6.

Washburn, J. D., S. C. Murray, B. L. Burson, R. R. Klein, and R. W. Jessup. 2013a. Targeted mapping of quantitative trait locus regions for rhizomatousness in chromosome SBI-01 and analysis of overwintering in a *Sorghum bicolor x S. propinquum* population. Mol. Breed. 31:153-162. doi:10.1007/s11032-012-9778-8.

Washburn, J. D., D. K. Whitmire, S. C. Murray, B. L. Burson, T. A. Wickersham, J. J. Heitholt, and R. W. Jessup. 2013b. Estimation of rhizome composition and overwintering ability in perennial Sorghum spp. using Near-Infrared Spectroscopy (NIRS). BioEnergy Res. 6:822-829.

Zan, C. S., J. W. Fyles, P. Girouard, and R. A. Samson. 2001. Carbon sequestration in perennial bioenergy, annual corn and uncultivated systems in southern Quebec. Agri. Ecosyst. Environ. 86:135-144. doi:10.1016/s0167-8809(00)00273-5.

Zhang, T., X. Zhao, L. Huang, X. Liu, Y. Zong, L. Zhu, D. Yang, and B. Fu. 2013. Tissue-specific transcriptomic profiling of sorghum propinquum using a rice genome array. PloS One 8:e60202. doi:10.1371/journal.pone.0060202.

Zhou, Y., C. J. Lambrides, and S. Fukai. 2014. Drought resistance and soil water extraction of a perennial C4 grass: contributions of root and rhizome traits. Funct. Plant Biol. 41:505-519. doi:10.1071/fp13249.

# APPENDIX A

## SUBSAMPLING ANALYSIS OF VARIANCE TABLES

Table 42. Analysis of variance for significance of block, entry, and block x entry on 30-day height[Y] for subsampling perennial *Sorghum* hybrid.

| Source | Df[Y] | SS[X] | MS[W] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3.00 | 635.99 | 212.00 | 0.27 | 0.84[Z] |
| Sample | 1.00 | 139.86 | 139.86 | 0.18 | 0.67 |
| Block x Sample | 3.00 | 884.13 | 294.71 | 0.38 | 0.77 |
| Residual | 440.00 | 339987.84 | 772.70 | | |
| Total | 447.00 | 341647.83 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y]Height measurements recorded in cm.
[X]Degrees of freedom
[W]Sum of squares
[V]Mean squares

Table 43. Analysis of variance for significance of block, entry, and block x entry on 60-day height[Y] for subsampling perennial *Sorghum* hybrid.

| Source | Df[X] | SS[W] | MS[V] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3.00 | 12443.79 | 4147.93 | 3.85 | 0.0097[Z] |
| Sample | 1.00 | 44.66 | 44.66 | 0.04 | 0.84 |
| Block x Sample | 3.00 | 11497.96 | 3832.65 | 3.56 | 0.0144 |
| Residual | 412.00 | 443479.55 | 1076.41 | | |
| Total | 419.00 | 467465.96 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y]Height measurements recorded in cm.
[X]Degrees of freedom
[W]Sum of squares
[V]Mean squares

Table 44. Analysis of variance for significance of block, entry, and block x entry on 90-day height[Y] for subsampling perennial *Sorghum* hybrid.

| Source | Df[X] | SS[W] | MS[V] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3.00 | 31194.96 | 10398.32 | 4.77 | 0.0028[Z] |
| Sample | 1.00 | 56.63 | 56.63 | 0.03 | 0.87 |
| Block x Sample | 3.00 | 13314.09 | 4438.03 | 2.04 | 0.11 |
| Residual | 405.00 | 882837.68 | 2179.85 | | |
| Total | 412.00 | 927403.35 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y]Height measurements recorded in cm.
[X]Degrees of freedom
[W]Sum of squares
[V]Mean squares

Table 45. Analysis of variance for significance of block, entry, and block x entry on 30-day tillering capacity for subsampling perennial *Sorghum* hybrid**.**

| Source | Df[Y] | SS[X] | MS[W] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3.00 | 5.59 | 1.86 | 1.06 | 0.36[Z] |
| Sample | 1.00 | 4.72 | 4.72 | 2.69 | 0.10 |
| Block x Sample | 3.00 | 4.96 | 1.65 | 0.94 | 0.42 |
| Residual | 440.00 | 771.46 | 1.75 | | |
| Total | 447.00 | 786.73 | | | |

[Z] NS (nonsignificant) or significant at $P \leq 0.05$, 0.01, or 0.001.
[Y]Degrees of freedom
[X]Sum of squares
[W]Mean squares

Table 46. Analysis of variance for significance of block, entry, and block x entry on 60-day tillering capacity for subsampling perennial *Sorghum* hybrid.

| Source | $Df^{Y}$ | $SS^{X}$ | $MS^{W}$ | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3.00 | 54.02 | 18.01 | 1.71 | $0.16^{Z}$ |
| Sample | 1.00 | 0.49 | 0.49 | 0.05 | 0.83 |
| Block x Sample | 3.00 | 31.12 | 10.37 | 0.99 | 0.40 |
| Residual | 412.00 | 4325.70 | 10.50 | | |
| Total | 419.00 | 4411.32 | | | |

$^{Z}$ NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.

$^{Y}$Degrees of freedom

$^{X}$Sum of squares

$^{W}$Mean squares

Table 47. Analysis of variance for significance of block, entry, and block x entry on 90-day tillering capacity for subsampling perennial *Sorghum* hybrid.

| Source | Df[Y] | SS[X] | MS[W] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3.00 | 96.31 | 32.10 | 1.75 | 0.16[Z] |
| Sample | 1.00 | 1.78 | 1.78 | 0.10 | 0.76 |
| Block x Sample | 3.00 | 46.51 | 15.50 | 0.84 | 0.47 |
| Residual | 405.00 | 7437.77 | 18.36 | | |
| Total | 412.00 | 7582.37 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y]Degrees of freedom
[X]Sum of squares
[W]Mean squares

Table 48. Analysis of variance for significance of block, entry, and block x entry for primary culm days to mid-bloom for subsampling perennial *Sorghum* hybrid.

| Source | Df[Y] | SS[X] | MS[W] | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Block | 3.00 | 10480.08 | 3493.36 | 4.10 | 0.0072[Z] |
| Sample | 1.00 | 2041.42 | 2041.42 | 2.40 | 0.12 |
| Block x Sample | 3.00 | 6200.19 | 2066.73 | 2.43 | 0.07 |
| Residual | 279.00 | 237668.39 | 851.86 | | |
| Total | 286.00 | 256390.08 | | | |

[Z] NS (nonsignificant) or significant at P≤ 0.05, 0.01, or 0.001.
[Y]Degrees of freedom
[X]Sum of squares
[W]Mean squares

# APPENDIX B

## SUPPLEMENTAL DATA

Raw supplemental data collected for “Field Evaluation and Characterization of *Sorghum bicolor* x *Sorghum propinquum* Hybrids” from June 2018 – April 2019 and discussed in Chapter I is provided below. Additionally, a hyperlink can be followed: Raw Supplemental Data Google Doc.

Table 49. Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1 | 1 | 1 | PSSH: 2n | 28 | 71.12 | 3 | 36 | 91.44 | 3 | 43 | 109.2 | 2 | | | | | | | | 1 |
| 2 | 1 | 2 | 1 | PSSH: 2n | 60 | 152.4 | 2 | 66 | 167.6 | 5 | 68 | 172.7 | 13 | 32.00 | | | | | | | 1 |
| 2 | 1 | 3 | 1 | PSSH: 2n | 32 | 81.28 | 1 | 54 | 137.2 | 2 | 60 | 152.4 | 2 | 67.00 | | | | | | | 1 |
| 2 | 1 | 4 | 1 | PSSH: 2n | 18 | 45.72 | 1 | 48 | 121.9 | 5 | 48 | 121.9 | 7 | 109.00 | | | | | | | 1 |
| 2 | 1 | 5 | 1 | PSSH: 2n | 25 | 63.5 | 3 | 60 | 152.4 | 4 | 72 | 182.9 | 6 | 107.00 | | | | | | | 1 |
| 2 | 1 | 6 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 1 |
| 2 | 1 | 7 | 1 | PSSH: 2n | 16 | 40.64 | 3 | 41 | 104.1 | 5 | 62 | 157.5 | 5 | 112.00 | | | | | | | 1 |
| 2 | 1 | 8 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 36 | 91.44 | 0 | 28 | 71.12 | 0 | 59.00 | | | | | | | 1 |
| 2 | 1 | 9 | 1 | PSSH: 2n | 27 | 68.58 | 1 | 42 | 106.7 | 2 | 48 | 121.9 | 4 | 53.00 | | | | | | | 1 |
| 2 | 1 | 10 | 1 | PSSH: 2n | 38 | 96.52 | 3 | 60 | 152.4 | 7 | 96 | 243.8 | 14 | 120.00 | | | | | | | 1 |
| 2 | 1 | 11 | 1 | PSSH: 2n | 29 | 73.66 | 1 | 72 | 182.9 | 2 | 62 | 157.5 | 2 | 59.00 | 0 | 2 | 1 | 2 | 0 | 1 | 1 |
| 2 | 1 | 12 | 1 | PSSH: 2n | 26 | 66.04 | 3 | 46 | 116.8 | 4 | 96 | 243.8 | 10 | 109.00 | | | | | | | 1 |
| 2 | 1 | 13 | 1 | PSSH: 2n | 28 | 71.12 | 2 | 63 | 160 | 8 | 72 | 182.9 | 13 | | 3 | 0 | 5 | 0 | 6 | 0 | 1 |
| 2 | 1 | 14 | 1 | PSSH: 2n | 17 | 43.18 | 1 | | | | | | | | | | | | | | 1 |
| 2 | 1 | 15 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 50 | 127 | 6 | 50 | 127 | 7 | 51.00 | | | | | | | 1 |
| 2 | 1 | 16 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 42 | 106.7 | 6 | 60 | 152.4 | 6 | | | | | | | | 1 |
| 2 | 1 | 17 | 1 | PSSH: 2n | 17 | 43.18 | 0 | 40 | 101.6 | 3 | 72 | 182.9 | 4 | 109.00 | | | | | | | 1 |
| 2 | 1 | 18 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 1 |
| 2 | 1 | 19 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 44 | 111.8 | 7 | 50 | 127 | 5 | 103.00 | | | | | | | 1 |
| 2 | 1 | 20 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 26 | 66.04 | 0 | | | | 78.00 | | | | | | | 1 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1 | 21 | 1 | PSSH: 2n | 29 | 73.66 | 0 | 48 | 121.9 | 0 | 24 | 60.96 | 0 | 43.00 | | | | | | | 2 |
| 2 | 1 | 22 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 40 | 101.6 | 7 | 61 | 154.9 | 6 | | | | | | | | 2 |
| 2 | 1 | 23 | 1 | PSSH: 2n | 27 | 68.58 | 3 | 68 | 172.7 | 7 | 64 | 162.6 | 9 | 43.00 | | | | | | | 2 |
| 2 | 1 | 24 | 1 | PSSH: 2n | 26 | 66.04 | 4 | 65 | 165.1 | 8 | 96 | 243.8 | 13 | | | | | | | | 2 |
| 2 | 1 | 25 | 1 | PSSH: 2n | 36 | 91.44 | 2 | 69 | 175.3 | 9 | 63 | 160 | 9 | 53.00 | | | | | | | 2 |
| 2 | 1 | 26 | 1 | PSSH: 2n | 26 | 66.04 | 4 | 51 | 129.5 | 4 | 96 | 243.8 | 5 | | 5 | 0 | 6 | 0 | 6 | 0 | 2 |
| 2 | 1 | 27 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 2 |
| 2 | 1 | 28 | 1 | PSSH: 2n | 17 | 43.18 | 1 | 47 | 119.4 | 5 | 76 | 193 | 6 | 109.00 | 20 | 0 | 23 | 0 | 23 | 0 | 2 |
| 2 | 1 | 29 | 1 | PSSH: 2n | 24 | 60.96 | 4 | 60 | 152.4 | 10 | 63 | 160 | 18 | | 10 | 2 | 15 | 2 | 16 | 2 | 2 |
| 2 | 1 | 30 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 34 | 86.36 | 0 | 51 | 129.5 | 0 | 109.00 | | | | | | | 2 |
| 2 | 1 | 31 | 1 | PSSH: 2n | 17 | 43.18 | 0 | | | | | | | | | | | | | | 2 |
| 2 | 1 | 32 | 1 | PSSH: 2n | 5 | 12.7 | 0 | 37 | 93.98 | 5 | 72 | 182.9 | 5 | 76.00 | | | | | | | 2 |
| 2 | 1 | 33 | 1 | PSSH: 2n | 28 | 71.12 | 3 | 59 | 149.9 | 8 | 96 | 243.8 | 16 | 107.00 | | | | | | | 2 |
| 2 | 1 | 34 | 1 | PSSH: 2n | 34 | 86.36 | 1 | 52 | 132.1 | 2 | 63 | 160 | 2 | | | | | | | | 2 |
| 2 | 1 | 35 | 1 | PSSH: 2n | 12 | 30.48 | 1 | 29 | 73.66 | 2 | 73 | 185.4 | 1 | 103.00 | | | | | | | 2 |
| 2 | 1 | 36 | 1 | PSSH: 2n | 9 | 22.86 | 0 | | | | | | | | | | | | | | 2 |
| 2 | 1 | 37 | 1 | PSSH: 2n | 32 | 81.28 | 1 | 60 | 152.4 | 8 | 60 | 152.4 | 11 | 45.00 | | | | | | | 2 |
| 2 | 1 | 38 | 1 | PSSH: 2n | 17 | 43.18 | 0 | | | | | | | | | | | | | | 2 |
| 2 | 1 | 39 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 24 | 60.96 | 2 | 48 | 121.9 | 2 | 76.00 | | | | | | | 2 |
| 2 | 1 | 40 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 30 | 76.2 | 0 | | | | | | | | | | | 2 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 41 | 4 | SOPR | 17 | 43.18 | 1 | 24 | 60.96 | 3 | 30 | 76.2 | 6 | 118.00 | | | 0 | 1 | | | 3 |
| 1 | 1 | 42 | 4 | SOPR | 25 | 63.5 | 1 | 26 | 66.04 | 7 | 45 | 114.3 | 10 | 118.00 | 0 | 1 | 0 | 2 | 0 | 1 | 3 |
| 1 | 1 | 43 | 4 | SOPR | 18 | 45.72 | 2 | 26 | 66.04 | 7 | 45 | 114.3 | 10 | 118.00 | | | | | | | 3 |
| 1 | 1 | 44 | 4 | SOPR | 25 | 63.5 | 1 | 26 | 66.04 | 10 | 48 | 121.9 | 10 | 118.00 | | | | | | | 3 |
| 1 | 1 | 45 | 4 | SOPR | | | | | | | | | | | | | | | | | 3 |
| 1 | 1 | 46 | 4 | SOPR | 12 | 30.48 | 0 | 18 | 45.72 | 2 | 20 | 50.8 | 20 | 118.00 | | | | | | | 3 |
| 1 | 1 | 47 | 4 | SOPR | 12 | 30.48 | 0 | 20 | 50.8 | 2 | 45 | 114.3 | 4 | 118.00 | | | | | | | 3 |
| 1 | 1 | 48 | 4 | SOPR | 23 | 58.42 | 2 | 30 | 76.2 | 10 | 45 | 114.3 | 22 | 118.00 | | | | | | | 3 |
| 1 | 1 | 49 | 4 | SOPR | 8 | 20.32 | 0 | | | | | | | | | | | | | | 3 |
| 1 | 1 | 50 | 4 | SOPR | 18 | 45.72 | 1 | 14 | 35.56 | 2 | 36 | 91.44 | 6 | 118.00 | | | | | | | 3 |
| 2 | 1 | 51 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 48 | 121.9 | 5 | 78 | 198.1 | 8 | 95.00 | | | | | | | 3 |
| 2 | 1 | 52 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 3 |
| 2 | 1 | 53 | 1 | PSSH: 2n | 14 | 35.56 | 1 | 14 | 35.56 | 0 | | | | | | | | | | | 3 |
| 2 | 1 | 54 | 1 | PSSH: 2n | 16 | 40.64 | 0 | 36 | 91.44 | 3 | 56 | 142.2 | 6 | 45.00 | | | | | | | 3 |
| 2 | 1 | 55 | 1 | PSSH: 2n | 26 | 66.04 | 0 | 45 | 114.3 | 2 | 60 | 152.4 | 1 | 43.00 | | | | | | | 3 |
| 2 | 1 | 56 | 1 | PSSH: 2n | 37 | 93.98 | 0 | 54 | 137.2 | 1 | 48 | 121.9 | 1 | 48.00 | | | | | | | 3 |
| 2 | 1 | 57 | 1 | PSSH: 2n | 29 | 73.66 | 2 | 57 | 144.8 | 5 | 76 | 193 | 7 | 109.00 | 0 | 1 | 0 | 1 | 0 | 1 | 3 |
| 2 | 1 | 58 | 1 | PSSH: 2n | 42 | 106.7 | 2 | 70 | 177.8 | 14 | 96 | 243.8 | 14 | 109.00 | 4 | 1 | 7 | 1 | 7 | 1 | 3 |
| 2 | 1 | 59 | 1 | PSSH: 2n | 14 | 35.56 | 0 | 36 | 91.44 | 5 | 52 | 132.1 | 5 | | | | | | | | 3 |
| 2 | 1 | 60 | 1 | PSSH: 2n | 29 | 73.66 | 2 | 34 | 86.36 | 0 | | | | 32.00 | | | | | | | 3 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1 | 61 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 4 |
| 2 | 1 | 62 | 1 | PSSH: 2n | 34 | 86.36 | 4 | 60 | 152.4 | 6 | 84 | 213.4 | 9 | 112.00 | | | 1 | 0 | 2 | 0 | 4 |
| 2 | 1 | 63 | 1 | PSSH: 2n | 17 | 43.18 | 0 | 50 | 127 | 6 | 65 | 165.1 | 7 | 63.00 | | | | | | | 4 |
| 2 | 1 | 64 | 1 | PSSH: 2n | 38 | 96.52 | 3 | 46 | 116.8 | 10 | 65 | 165.1 | 15 | 37.00 | | | | | | | 4 |
| 2 | 1 | 65 | 1 | PSSH: 2n | 15 | 38.1 | 1 | 50 | 127 | 0 | 96 | 243.8 | 0 | 112.00 | | | | | | | 4 |
| 2 | 1 | 66 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 57 | 144.8 | 4 | 90 | 228.6 | 3 | | | | 1 | 0 | | | 4 |
| 2 | 1 | 67 | 1 | PSSH: 2n | 19 | 48.26 | 3 | 62 | 157.5 | 4 | 96 | 243.8 | 4 | 71.00 | | | | | | | 4 |
| 2 | 1 | 68 | 1 | PSSH: 2n | 29 | 73.66 | 1 | 47 | 119.4 | 2 | 76 | 193 | 2 | 109.00 | | | | | | | 4 |
| 2 | 1 | 69 | 1 | PSSH: 2n | 46 | 116.8 | 0 | 75 | 190.5 | 3 | 86 | 218.4 | 3 | 112.00 | | | | | | | 4 |
| 2 | 1 | 70 | 1 | PSSH: 2n | 37 | 93.98 | 3 | 57 | 144.8 | 9 | 64 | 162.6 | 23 | 112.00 | 3 | 1 | 4 | 1 | 5 | 1 | 4 |
| 1 | 1 | 71 | 3 | ATx623 | 32 | 81.28 | 2 | 34 | 86.36 | 1 | 36 | 91.44 | 1 | 43.00 | | | | | | | 4 |
| 1 | 1 | 72 | 3 | ATx623 | 29 | 73.66 | 2 | 34 | 86.36 | 2 | 38 | 96.52 | 2 | 43.00 | | | | | | | 4 |
| 1 | 1 | 73 | 3 | ATx623 | 27 | 68.58 | 3 | 34 | 86.36 | 2 | 30 | 76.2 | 1 | 43.00 | | | | | | | 4 |
| 1 | 1 | 74 | 3 | ATx623 | 25 | 63.5 | 3 | 34 | 86.36 | 2 | 30 | 76.2 | 2 | 43.00 | | | | | | | 4 |
| 1 | 1 | 75 | 3 | ATx623 | 41 | 104.1 | 4 | 41 | 104.1 | 4 | 30 | 76.2 | 1 | 37.00 | | | | | | | 4 |
| 1 | 1 | 76 | 3 | ATx623 | 27 | 68.58 | 1 | 40 | 101.6 | 1 | 30 | 76.2 | 1 | 43.00 | | | | | | | 4 |
| 1 | 1 | 77 | 3 | ATx623 | 36 | 91.44 | 2 | 40 | 101.6 | 2 | 32 | 81.28 | 2 | 43.00 | | | | | | | 4 |
| 1 | 1 | 78 | 3 | ATx623 | 33 | 83.82 | 2 | 40 | 101.6 | 3 | 32 | 81.28 | 2 | 43.00 | | | | | | | 4 |
| 1 | 1 | 79 | 3 | ATx623 | 26 | 66.04 | 0 | 36 | 91.44 | 3 | 34 | 86.36 | 2 | 43.00 | | | | | | | 4 |
| 1 | 1 | 80 | 3 | ATx623 | 29 | 73.66 | 1 | 36 | 91.44 | 1 | 30 | 76.2 | 2 | 63.00 | | | | | | | 4 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 1 | 1 | PSSH: 2n | 66 | 167.6 | 3 | 73 | 185.4 | 9 | 73 | 185.4 | 9 | 37.00 | | | | | | | 1 |
| 2 | 2 | 2 | 1 | PSSH: 2n | 27 | 68.58 | 8 | 51 | 129.5 | 10 | 74 | 188 | 13 | | | | | | | | 1 |
| 2 | 2 | 3 | 1 | PSSH: 2n | 84 | 213.4 | 2 | 61 | 154.9 | 2 | 48 | 121.9 | 3 | 32.00 | | | | | | | 1 |
| 2 | 2 | 4 | 1 | PSSH: 2n | 48 | 121.9 | 2 | 44 | 111.8 | 2 | 48 | 121.9 | 4 | 37.00 | | | | | | | 1 |
| 2 | 2 | 5 | 1 | PSSH: 2n | 55 | 139.7 | 4 | 65 | 165.1 | 20 | 55 | 139.7 | 24 | 32.00 | | | | | | | 1 |
| 2 | 2 | 6 | 1 | PSSH: 2n | 43 | 109.2 | 2 | 48 | 121.9 | 2 | 48 | 121.9 | 1 | 32.00 | | | | | | | 1 |
| 2 | 2 | 7 | 1 | PSSH: 2n | 30 | 76.2 | 1 | 64 | 162.6 | 3 | 64 | 162.6 | 2 | 37.00 | | | | | | | 1 |
| 2 | 2 | 8 | 1 | PSSH: 2n | 34 | 86.36 | 5 | | | | | | | 37.00 | | | | | | | 1 |
| 2 | 2 | 9 | 1 | PSSH: 2n | 36 | 91.44 | 9 | 60 | 152.4 | 9 | 86 | 218.4 | 15 | 107.00 | | | | | | | 1 |
| 2 | 2 | 10 | 1 | PSSH: 2n | 46 | 116.8 | 3 | 58 | 147.3 | 3 | 67 | 170.2 | 3 | 59.00 | | | | | | | 1 |
| 2 | 2 | 11 | 1 | PSSH: 2n | 15 | 38.1 | 2 | 70 | 177.8 | 10 | 84 | 213.4 | 9 | 112.00 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| 2 | 2 | 12 | 1 | PSSH: 2n | 36 | 91.44 | 0 | 60 | 152.4 | 5 | 96 | 243.8 | 5 | 84.00 | | | | | | | 1 |
| 2 | 2 | 13 | 1 | PSSH: 2n | 29 | 73.66 | 0 | 38 | 96.52 | 0 | 38 | 96.52 | 0 | 59.00 | | | | | | | 1 |
| 2 | 2 | 14 | 1 | PSSH: 2n | 16 | 40.64 | 0 | 46 | 116.8 | 4 | 65 | 165.1 | 4 | 112.00 | | | | | | | 1 |
| 2 | 2 | 15 | 1 | PSSH: 2n | 7 | 17.78 | 0 | 42 | 106.7 | 4 | 50 | 127 | 4 | 57.00 | | | | | | | 1 |
| 2 | 2 | 16 | 1 | PSSH: 2n | 16 | 40.64 | 0 | | | | | | | | | | | | | | 1 |
| 2 | 2 | 17 | 1 | PSSH: 2n | 24 | 60.96 | 1 | 46 | 116.8 | 13 | 84 | 213.4 | 13 | 103.00 | | | | | | | 1 |
| 2 | 2 | 18 | 1 | PSSH: 2n | 39 | 99.06 | 3 | 63 | 160 | 6 | 72 | 182.9 | 7 | 32.00 | | | | | | | 1 |
| 2 | 2 | 19 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 1 |
| 2 | 2 | 20 | 1 | PSSH: 2n | 34 | 86.36 | 2 | 49 | 124.5 | 3 | 48 | 121.9 | 4 | 67.00 | | | 0 | 1 | 0 | 1 | 1 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 2 | 21 | 2 | PSSH: 4n | 20 | 50.8 | 0 | 47 | 119.4 | 0 | 72 | 182.9 | 0 | | | | | | | | 2 |
| 3 | 2 | 22 | 2 | PSSH: 4n | 15 | 38.1 | 0 | 47 | 119.4 | 1 | 72 | 182.9 | 1 | | | | | | | | 2 |
| 3 | 2 | 23 | 2 | PSSH: 4n | 30 | 76.2 | 1 | 70 | 177.8 | 4 | 96 | 243.8 | 3 | | | | | | | | 2 |
| 3 | 2 | 24 | 2 | PSSH: 4n | 18 | 45.72 | 0 | 36 | 91.44 | 0 | 63 | 160 | 0 | | | | | | | | 2 |
| 3 | 2 | 25 | 2 | PSSH: 4n | 19 | 48.26 | 0 | 48 | 121.9 | 5 | 72 | 182.9 | 5 | | | | 2 | 0 | 2 | 0 | 2 |
| 3 | 2 | 26 | 2 | PSSH: 4n | 19 | 48.26 | 0 | 42 | 106.7 | 1 | 72 | 182.9 | 1 | | | | | | | | 2 |
| 3 | 2 | 27 | 2 | PSSH: 4n | 18 | 45.72 | 0 | 42 | 106.7 | 6 | 64 | 162.6 | 4 | | | | | | | | 2 |
| 3 | 2 | 28 | 2 | PSSH: 4n | | | | | | | | | | | | | | | | | 2 |
| 3 | 2 | 29 | 2 | PSSH: 4n | 19 | 48.26 | 0 | 36 | 91.44 | 6 | 57 | 144.8 | 5 | | | | | | | | 2 |
| 3 | 2 | 30 | 2 | PSSH: 4n | 39 | 99.06 | 0 | 51 | 129.5 | 4 | 90 | 228.6 | 4 | | 3 | 0 | 4 | 0 | 4 | 0 | 2 |
| 2 | 2 | 31 | 1 | PSSH: 2n | 36 | 91.44 | 0 | 51 | 129.5 | 0 | 51 | 129.5 | 0 | 57.00 | | | | | | | 2 |
| 2 | 2 | 32 | 1 | PSSH: 2n | 29 | 73.66 | 4 | 68 | 172.7 | 7 | 96 | 243.8 | 6 | | | | | | | | 2 |
| 2 | 2 | 33 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 2 |
| 2 | 2 | 34 | 1 | PSSH: 2n | 78 | 198.1 | 2 | 74 | 188 | 3 | 62 | 157.5 | 5 | 32.00 | | | | | | | 2 |
| 2 | 2 | 35 | 1 | PSSH: 2n | 27 | 68.58 | 3 | 48 | 121.9 | 6 | 76 | 193 | 6 | | | | | | | | 2 |
| 2 | 2 | 36 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 36 | 91.44 | 2 | 62 | 157.5 | 2 | | | | | | | | 2 |
| 2 | 2 | 37 | 1 | PSSH: 2n | 48 | 121.9 | 1 | 52 | 132.1 | 1 | 50 | 127 | 1 | 64.00 | | | | | | | 2 |
| 2 | 2 | 38 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 40 | 101.6 | 1 | 84 | 213.4 | 1 | 112.00 | | | | | | | 2 |
| 2 | 2 | 39 | 1 | PSSH: 2n | 32 | 81.28 | 2 | 53 | 134.6 | 15 | 96 | 243.8 | 16 | 98.00 | | | | | | | 2 |
| 2 | 2 | 40 | 1 | PSSH: 2n | 34 | 86.36 | 0 | 42 | 106.7 | 0 | 42 | 106.7 | 0 | 32.00 | | | | | | | 2 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 41 | 1 | PSSH: 2n | 29 | 73.66 | 1 | 60 | 152.4 | 8 | 84 | 213.4 | 8 | 112.00 | | | | | | | 3 |
| 2 | 2 | 42 | 1 | PSSH: 2n | 36 | 91.44 | 0 | 65 | 165.1 | 4 | 96 | 243.8 | 5 | 109.00 | | | | | | | 3 |
| 2 | 2 | 43 | 1 | PSSH: 2n | 42 | 106.7 | 1 | 77 | 195.6 | 6 | 74 | 188 | 6 | 51.00 | 2 | 0 | 2 | 0 | | | 3 |
| 2 | 2 | 44 | 1 | PSSH: 2n | 18 | 45.72 | 2 | 32 | 81.28 | 4 | 40 | 101.6 | 8 | | | | | | | | 3 |
| 2 | 2 | 45 | 1 | PSSH: 2n | 24 | 60.96 | 3 | 40 | 101.6 | 5 | 63 | 160 | 9 | | 3 | 0 | 4 | 0 | 3 | 0 | 3 |
| 2 | 2 | 46 | 1 | PSSH: 2n | 34 | 86.36 | 1 | 40 | 101.6 | 4 | 57 | 144.8 | 7 | 35.00 | | | | | | | 3 |
| 2 | 2 | 47 | 1 | PSSH: 2n | 26 | 66.04 | 0 | 12 | 30.48 | 0 | 12 | 30.48 | 0 | | | | | | | | 3 |
| 2 | 2 | 48 | 1 | PSSH: 2n | 21 | 53.34 | 0 | 42 | 106.7 | 3 | 64 | 162.6 | 3 | | 4 | 0 | 5 | 4 | 5 | 4 | 3 |
| 2 | 2 | 49 | 1 | PSSH: 2n | 34 | 86.36 | 1 | 42 | 106.7 | 4 | 67 | 170.2 | 7 | | 1 | 0 | 1 | 0 | 2 | 0 | 3 |
| 2 | 2 | 50 | 1 | PSSH: 2n | 33 | 83.82 | 1 | 50 | 127 | 6 | 60 | 152.4 | 6 | 112.00 | 1 | 0 | 1 | 0 | 1 | 0 | 3 |
| 2 | 2 | 51 | 1 | PSSH: 2n | 35 | 88.9 | 0 | 54 | 137.2 | 0 | | | | 64.00 | | | | | | | 3 |
| 2 | 2 | 52 | 1 | PSSH: 2n | 18 | 45.72 | 4 | 36 | 91.44 | 13 | 63 | 160 | 13 | | | | | | | | 3 |
| 2 | 2 | 53 | 1 | PSSH: 2n | 34 | 86.36 | 0 | 52 | 132.1 | 4 | 66 | 167.6 | 4 | 112.00 | 1 | 1 | 6 | 1 | 5 | 1 | 3 |
| 2 | 2 | 54 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 3 |
| 2 | 2 | 55 | 1 | PSSH: 2n | 21 | 53.34 | 2 | 59 | 149.9 | 5 | 96 | 243.8 | 10 | 112.00 | | | | | | | 3 |
| 2 | 2 | 56 | 1 | PSSH: 2n | 36 | 91.44 | 2 | 36 | 91.44 | 1 | 36 | 91.44 | 1 | 32.00 | | | | | | | 3 |
| 2 | 2 | 57 | 1 | PSSH: 2n | 34 | 86.36 | 1 | 74 | 188 | 1 | 96 | 243.8 | 6 | 76.00 | | | | | | | 3 |
| 2 | 2 | 58 | 1 | PSSH: 2n | 40 | 101.6 | 1 | 65 | 165.1 | 2 | 84 | 213.4 | 5 | 112.00 | 11 | 1 | 14 | 1 | 12 | 1 | 3 |
| 2 | 2 | 59 | 1 | PSSH: 2n | 30 | 76.2 | 2 | 66 | 167.6 | 3 | 96 | 243.8 | 3 | 109.00 | 5 | 3 | 6 | 3 | 6 | 3 | 3 |
| 2 | 2 | 60 | 1 | PSSH: 2n | 35 | 88.9 | 2 | 63 | 160 | 5 | 63 | 160 | 5 | 37.00 | | | | | | | 3 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| 0 | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 61 | 1 | PSSH: 2n | 48 | 121.9 | 0 | 38 | 96.52 | 3 | 38 | 96.52 | 3 | 32.00 | | | | | | | 4 |
| 2 | 2 | 62 | 1 | PSSH: 2n | 36 | 91.44 | 2 | 48 | 121.9 | 2 | 85 | 215.9 | 2 | | | | | | | | 4 |
| 2 | 2 | 63 | 1 | PSSH: 2n | 25 | 63.5 | 1 | 53 | 134.6 | 7 | 96 | 243.8 | 8 | 112.00 | | | | | 1 | 0 | 4 |
| 2 | 2 | 64 | 1 | PSSH: 2n | 12 | 30.48 | 1 | 36 | 91.44 | 4 | 63 | 160 | 3 | | | | | | | | 4 |
| 2 | 2 | 65 | 1 | PSSH: 2n | 32 | 81.28 | 0 | 43 | 109.2 | 7 | 43 | 109.2 | 7 | 43.00 | | | | | | | 4 |
| 2 | 2 | 66 | 1 | PSSH: 2n | 64 | 162.6 | 0 | 48 | 121.9 | 4 | 48 | 121.9 | 4 | 32.00 | | | | | | | 4 |
| 2 | 2 | 67 | 1 | PSSH: 2n | 34 | 86.36 | 1 | 44 | 111.8 | 4 | 87 | 221 | 5 | | | | | | | | 4 |
| 2 | 2 | 68 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 36 | 91.44 | 1 | 57 | 144.8 | 0 | 107.00 | | | | | | | 4 |
| 2 | 2 | 69 | 1 | PSSH: 2n | 38 | 96.52 | 1 | 69 | 175.3 | 13 | 72 | 182.9 | 13 | 53.00 | | | | | | | 4 |
| 2 | 2 | 70 | 1 | PSSH: 2n | 27 | 68.58 | 0 | 57 | 144.8 | 3 | 86 | 218.4 | 6 | 91.00 | | | | | | | 4 |
| 2 | 2 | 71 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 67 | 170.2 | 3 | 82 | 208.3 | 4 | 85.00 | 0 | 1 | | | | | 4 |
| 2 | 2 | 72 | 1 | PSSH: 2n | 17 | 43.18 | 7 | 33 | 83.82 | 3 | 40 | 101.6 | 10 | | | | | | | | 4 |
| 2 | 2 | 73 | 1 | PSSH: 2n | 24 | 60.96 | 4 | 62 | 157.5 | 10 | 92 | 233.7 | 10 | | 8 | 1 | 12 | 1 | 18 | 1 | 4 |
| 2 | 2 | 74 | 1 | PSSH: 2n | 14 | 35.56 | 0 | 34 | 86.36 | 0 | 57 | 144.8 | 0 | 98.00 | | | | | | | 4 |
| 2 | 2 | 75 | 1 | PSSH: 2n | 33 | 83.82 | 0 | 64 | 162.6 | 2 | 57 | 144.8 | 2 | 91.00 | | | | | | | 4 |
| 2 | 2 | 76 | 1 | PSSH: 2n | 34 | 86.36 | 3 | 65 | 165.1 | 12 | 65 | 165.1 | 12 | 49.00 | | | | | | | 4 |
| 2 | 2 | 77 | 1 | PSSH: 2n | 10 | 25.4 | 1 | | | | | | | | | | | | | | 4 |
| 2 | 2 | 78 | 1 | PSSH: 2n | 23 | 58.42 | 3 | 50 | 127 | 13 | 85 | 215.9 | 14 | | 11 | 0 | 12 | 0 | 14 | 0 | 4 |
| 2 | 2 | 79 | 1 | PSSH: 2n | 33 | 83.82 | 0 | 51 | 129.5 | 1 | 86 | 218.4 | 1 | | | | | | | | 4 |
| 2 | 2 | 80 | 1 | PSSH: 2n | 32 | 81.28 | 0 | 39 | 99.06 | 4 | 72 | 182.9 | 5 | | | | | | | | 4 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 1 | 4 | SOPR | 9 | 22.86 | 3 | 39 | 99.06 | 8 | 60 | 152.4 | 9 | 118.00 | | | | | | | 1 |
| 1 | 3 | 2 | 4 | SOPR | 20 | 50.8 | 3 | 39 | 99.06 | 8 | 60 | 152.4 | 9 | 118.00 | | | | | | | 1 |
| 1 | 3 | 3 | 4 | SOPR | 20 | 50.8 | 3 | 40 | 101.6 | 10 | 60 | 152.4 | 11 | 118.00 | | | | | | | 1 |
| 1 | 3 | 4 | 4 | SOPR | 24 | 60.96 | 3 | 40 | 101.6 | 15 | 60 | 152.4 | 16 | 118.00 | | | | | | | 1 |
| 1 | 3 | 5 | 4 | SOPR | 20 | 50.8 | 1 | 40 | 101.6 | 13 | 60 | 152.4 | 14 | 118.00 | | | | | | | 1 |
| 1 | 3 | 6 | 4 | SOPR | 15 | 38.1 | 5 | 39 | 99.06 | 12 | 60 | 152.4 | 13 | 118.00 | | | | | | | 1 |
| 1 | 3 | 7 | 4 | SOPR | 12 | 30.48 | 2 | 40 | 101.6 | 9 | 60 | 152.4 | 10 | 118.00 | | | | | | | 1 |
| 1 | 3 | 8 | 4 | SOPR | 14 | 35.56 | 3 | 39 | 99.06 | 10 | 60 | 152.4 | 11 | 118.00 | | | 2 | 0 | | | 1 |
| 1 | 3 | 9 | 4 | SOPR | 16 | 40.64 | 1 | 36 | 91.44 | 12 | 60 | 152.4 | 13 | 118.00 | | | 0 | 1 | 0 | 1 | 1 |
| 1 | 3 | 10 | 4 | SOPR | 9 | 22.86 | 0 | 36 | 91.44 | 4 | 60 | 152.4 | 5 | 118.00 | | | | | | | 1 |
| 2 | 3 | 11 | 1 | PSSH: 2n | 40 | 101.6 | 0 | 60 | 152.4 | 5 | 60 | 152.4 | 5 | 32.00 | | | | | | | 1 |
| 2 | 3 | 12 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 58 | 147.3 | 3 | 70 | 177.8 | 3 | 49.00 | | | | | | | 1 |
| 2 | 3 | 13 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 42 | 106.7 | 6 | 56 | 142.2 | 6 | | | | | | | | 1 |
| 2 | 3 | 14 | 1 | PSSH: 2n | 36 | 91.44 | 0 | 48 | 121.9 | 3 | 52 | 132.1 | 3 | 53.00 | | | | | | | 1 |
| 2 | 3 | 15 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 48 | 121.9 | 3 | 80 | 203.2 | 3 | 109.00 | | | | | | | 1 |
| 2 | 3 | 16 | 1 | PSSH: 2n | 30 | 76.2 | 4 | 48 | 121.9 | 12 | 96 | 243.8 | 15 | | | | | | | | 1 |
| 2 | 3 | 17 | 1 | PSSH: 2n | 42 | 106.7 | 0 | 42 | 106.7 | 0 | 66 | 167.6 | 2 | 43.00 | | | | | | | 1 |
| 2 | 3 | 18 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 38 | 96.52 | 5 | 72 | 182.9 | 6 | | | | | | | | 1 |
| 2 | 3 | 19 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 36 | 91.44 | 3 | 66 | 167.6 | 3 | | | | | | | | 1 |
| 2 | 3 | 20 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 32 | 81.28 | 1 | 48 | 121.9 | 0 | | | | | | | | 1 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 21 | 1 | PSSH: 2n | | | | 12 | 30.48 | 0 | | | | | | | | | | | 2 |
| 2 | 3 | 22 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 24 | 60.96 | 0 | 32 | 81.28 | 0 | | | | | | | | 2 |
| 2 | 3 | 23 | 1 | PSSH: 2n | 21 | 53.34 | 3 | 50 | 127 | 10 | 74 | 188 | 10 | | | | | | | | 2 |
| 2 | 3 | 24 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 40 | 101.6 | 3 | 60 | 152.4 | 3 | 49.00 | | | | | | | 2 |
| 2 | 3 | 25 | 1 | PSSH: 2n | 26 | 66.04 | 0 | 48 | 121.9 | 5 | 74 | 188 | 5 | | | | | | | | 2 |
| 2 | 3 | 26 | 1 | PSSH: 2n | 13 | 33.02 | 1 | 39 | 99.06 | 5 | 65 | 165.1 | 5 | 43.00 | | | | | | | 2 |
| 2 | 3 | 27 | 1 | PSSH: 2n | 42 | 106.7 | 0 | 65 | 165.1 | 0 | 71 | 180.3 | 0 | 49.00 | | | | | | | 2 |
| 2 | 3 | 28 | 1 | PSSH: 2n | 42 | 106.7 | 0 | 68 | 172.7 | 13 | 96 | 243.8 | 15 | 112.00 | 23 | 11 | 28 | 12 | 30 | 13 | 2 |
| 2 | 3 | 29 | 1 | PSSH: 2n | 50 | 127 | 0 | 45 | 114.3 | 4 | 60 | 152.4 | 4 | 43.00 | | | | | | | 2 |
| 2 | 3 | 30 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 38 | 96.52 | 4 | 70 | 177.8 | 6 | | | | | | | | 2 |
| 2 | 3 | 31 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 2 |
| 2 | 3 | 32 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 2 |
| 2 | 3 | 33 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 42 | 106.7 | 2 | 84 | 213.4 | 4 | 112.00 | | | | | | | 2 |
| 2 | 3 | 34 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 2 |
| 2 | 3 | 35 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 51 | 129.5 | 0 | 72 | 182.9 | 0 | | | | | | | | 2 |
| 2 | 3 | 36 | 1 | PSSH: 2n | 32 | 81.28 | 0 | 48 | 121.9 | 2 | 72 | 182.9 | 2 | 49.00 | | | | | | | 2 |
| 2 | 3 | 37 | 1 | PSSH: 2n | 26 | 66.04 | 1 | 42 | 106.7 | 9 | 79 | 200.7 | 7 | | | | | | | | 2 |
| 2 | 3 | 38 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 64 | 162.6 | 10 | 96 | 243.8 | 12 | 73.00 | | | | | | | 2 |
| 2 | 3 | 39 | 1 | PSSH: 2n | 14 | 35.56 | 0 | 32 | 81.28 | 3 | 64 | 162.6 | 2 | | | | | | | | 2 |
| 2 | 3 | 40 | 1 | PSSH: 2n | 11 | 27.94 | | | | | | | | | | | | | | | 2 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 41 | 3 | ATx623 | 15 | 38.1 | 0 | 24 | 60.96 | 0 | | | | | | | | | | | 3 |
| 1 | 3 | 42 | 3 | ATx623 | 18 | 45.72 | 1 | 32 | 81.28 | 1 | 36 | 91.44 | 1 | 64.00 | | | | | | | 3 |
| 1 | 3 | 43 | 3 | ATx623 | 22 | 55.88 | 1 | 29 | 73.66 | 1 | 36 | 91.44 | 2 | 57.00 | | | | | | | 3 |
| 1 | 3 | 44 | 3 | ATx623 | 22 | 55.88 | 1 | 29 | 73.66 | 1 | 36 | 91.44 | 2 | 57.00 | | | | | | | 3 |
| 1 | 3 | 45 | 3 | ATx623 | 28 | 71.12 | 0 | 28 | 71.12 | 0 | | | | 33.00 | | | | | | | 3 |
| 1 | 3 | 46 | 3 | ATx623 | 17 | 43.18 | 0 | 24 | 60.96 | 2 | 26 | 66.04 | 2 | 57.00 | | | | | | | 3 |
| 1 | 3 | 47 | 3 | ATx623 | 12 | 30.48 | 0 | 38 | 96.52 | 0 | 48 | 121.9 | 0 | 57.00 | | | | | | | 3 |
| 1 | 3 | 48 | 3 | ATx623 | 17 | 43.18 | 1 | 36 | 91.44 | 1 | 36 | 91.44 | 0 | 57.00 | | | | | | | 3 |
| 1 | 3 | 49 | 3 | ATx623 | 17 | 43.18 | 1 | 29 | 73.66 | 1 | 30 | 76.2 | 2 | 57.00 | | | | | | | 3 |
| 1 | 3 | 50 | 3 | ATx623 | 17 | 43.18 | 1 | 29 | 73.66 | 1 | 36 | 91.44 | 0 | 43.00 | | | | | | | 3 |
| 1 | 3 | 51 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 48 | 121.9 | 0 | 73 | 185.4 | 0 | 103.00 | | | | | | | 3 |
| 1 | 3 | 52 | 1 | PSSH: 2n | 24 | 60.96 | 1 | 48 | 121.9 | 14 | 82 | 208.3 | 13 | | | | | | | | 3 |
| 1 | 3 | 53 | 1 | PSSH: 2n | 28 | 71.12 | 0 | 53 | 134.6 | 1 | 77 | 195.6 | 1 | 89.00 | 4 | 1 | 2 | 1 | 2 | 1 | 3 |
| 1 | 3 | 54 | 1 | PSSH: 2n | 26 | 66.04 | 1 | 60 | 152.4 | 6 | 96 | 243.8 | 9 | 57.00 | | | | | | | 3 |
| 1 | 3 | 55 | 1 | PSSH: 2n | 20 | 50.8 | 4 | 65 | 165.1 | 5 | 96 | 243.8 | 6 | 103.00 | | | | | | | 3 |
| 1 | 3 | 56 | 1 | PSSH: 2n | 44 | 111.8 | 1 | 44 | 111.8 | 4 | 44 | 111.8 | 4 | 32.00 | | | | | | | 3 |
| 1 | 3 | 57 | 1 | PSSH: 2n | 32 | 81.28 | 3 | 64 | 162.6 | 10 | 96 | 243.8 | 13 | 112.00 | 8 | 0 | 13 | 0 | 14 | 0 | 3 |
| 1 | 3 | 58 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 50 | 127 | 1 | 96 | 243.8 | 1 | 109.00 | | | | | | | 3 |
| 1 | 3 | 59 | 1 | PSSH: 2n | 29 | 73.66 | 0 | 53 | 134.6 | 4 | 94 | 238.8 | 5 | 112.00 | | | | | | | 3 |
| 1 | 3 | 60 | 1 | PSSH: 2n | 36 | 91.44 | 0 | 79 | 200.7 | 4 | 96 | 243.8 | 5 | 109.00 | 17 | 0 | 18 | 0 | 18 | 0 | 3 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 61 | 1 | PSSH: 2n | 27 | 68.58 | 0 | 27 | 68.58 | 3 | 27 | 68.58 | 3 | 49.00 | | | | | | | 4 |
| 2 | 3 | 62 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 4 |
| 2 | 3 | 63 | 1 | PSSH: 2n | 14 | 35.56 | 0 | 48 | 121.9 | 6 | 96 | 243.8 | 7 | 112.00 | 3 | 0 | 5 | 0 | 5 | 0 | 4 |
| 2 | 3 | 64 | 1 | PSSH: 2n | 18 | 45.72 | 3 | 40 | 101.6 | 4 | 48 | 121.9 | 4 | 49.00 | 0 | 2 | 0 | 2 | 0 | 2 | 4 |
| 2 | 3 | 65 | 1 | PSSH: 2n | 16 | 40.64 | 0 | | | | | | | | | | | | | | 4 |
| 2 | 3 | 66 | 1 | PSSH: 2n | 24 | 60.96 | 2 | 50 | 127 | 7 | 96 | 243.8 | 7 | 112.00 | 6 | 0 | 11 | 0 | 10 | 0 | 4 |
| 2 | 3 | 67 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 60 | 152.4 | 6 | 63 | 160 | 6 | 57.00 | | | 1 | 0 | 1 | 0 | 4 |
| 2 | 3 | 68 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 35 | 88.9 | 5 | 65 | 165.1 | 5 | | 1 | 0 | 1 | 0 | 2 | 0 | 4 |
| 2 | 3 | 69 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 54 | 137.2 | 8 | 96 | 243.8 | 8 | | 2 | 5 | 5 | 5 | 6 | 6 | 4 |
| 2 | 3 | 70 | 1 | PSSH: 2n | 52 | 132.1 | 1 | 54 | 137.2 | 1 | 48 | 121.9 | 3 | 32.00 | | | | | | | 4 |
| 2 | 3 | 71 | 1 | PSSH: 2n | 18 | 45.72 | 1 | 43 | 109.2 | 8 | 92 | 233.7 | 10 | 109.00 | | | | | | | 4 |
| 2 | 3 | 72 | 1 | PSSH: 2n | 15 | 38.1 | 1 | 36 | 91.44 | 0 | 92 | 233.7 | 0 | 103.00 | | | | | | | 4 |
| 2 | 3 | 73 | 1 | PSSH: 2n | 18 | 45.72 | 1 | 36 | 91.44 | 4 | 48 | 121.9 | 4 | 59.00 | | | | | | | 4 |
| 2 | 3 | 74 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 28 | 71.12 | 0 | 39 | 99.06 | 0 | | | | | | | | 4 |
| 2 | 3 | 75 | 1 | PSSH: 2n | 26 | 66.04 | 0 | 34 | 86.36 | 3 | 34 | 86.36 | 3 | 43.00 | | | | | | | 4 |
| 2 | 3 | 76 | 1 | PSSH: 2n | 36 | 91.44 | 1 | 60 | 152.4 | 7 | 65 | 165.1 | 7 | 49.00 | | | | | | | 4 |
| 2 | 3 | 77 | 1 | PSSH: 2n | 34 | 86.36 | 1 | 60 | 152.4 | 0 | 60 | 152.4 | 0 | 71.00 | | | | | | | 4 |
| 2 | 3 | 78 | 1 | PSSH: 2n | 21 | 53.34 | 0 | 38 | 96.52 | 4 | 60 | 152.4 | 4 | | | | | | | | 4 |
| 2 | 3 | 79 | 1 | PSSH: 2n | 26 | 66.04 | 0 | 47 | 119.4 | 3 | 72 | 182.9 | 3 | 103.00 | | | | | | | 4 |
| 2 | 3 | 80 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 41 | 104.1 | 3 | 64 | 162.6 | 5 | | 6 | 0 | 6 | 0 | 2 | 0 | 4 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 4 | 1 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 24 | 60.96 | 0 | 34 | 86.36 | 0 | | | | | | | | 1 |
| 2 | 4 | 2 | 1 | PSSH: 2n | 29 | 73.66 | 0 | 46 | 116.8 | 6 | 64 | 162.6 | 7 | 112.00 | | | | | | | 1 |
| 2 | 4 | 3 | 1 | PSSH: 2n | 41 | 104.1 | 1 | 53 | 134.6 | 0 | 44 | 111.8 | 0 | 35.00 | | | | | | | 1 |
| 2 | 4 | 4 | 1 | PSSH: 2n | 30 | 76.2 | 2 | 60 | 152.4 | 6 | 84 | 213.4 | 5 | 112.00 | | | | | | | 1 |
| 2 | 4 | 5 | 1 | PSSH: 2n | 30 | 76.2 | 6 | 62 | 157.5 | 9 | 96 | 243.8 | 9 | | | | | | | | 1 |
| 2 | 4 | 6 | 1 | PSSH: 2n | 27 | 68.58 | 0 | 55 | 139.7 | 3 | 60 | 152.4 | 3 | 74.00 | | | | | | | 1 |
| 2 | 4 | 7 | 1 | PSSH: 2n | 22 | 55.88 | 3 | 61 | 154.9 | 6 | 90 | 228.6 | 10 | 112.00 | | | | | | | 1 |
| 2 | 4 | 8 | 1 | PSSH: 2n | 12 | 30.48 | 0 | | | | | | | | | | | | | | 1 |
| 2 | 4 | 9 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 38 | 96.52 | 3 | 60 | 152.4 | 3 | 57.00 | | | | | | | 1 |
| 2 | 4 | 10 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 40 | 101.6 | 4 | 93 | 236.2 | 33 | 103.00 | | | | | | | 1 |
| 2 | 4 | 11 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 51 | 129.5 | 2 | 96 | 243.8 | 3 | 91.00 | | | | | | | 1 |
| 2 | 4 | 12 | 1 | PSSH: 2n | 33 | 83.82 | 3 | 48 | 121.9 | 8 | 60 | 152.4 | 8 | 49.00 | | | | | | | 1 |
| 2 | 4 | 13 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 51 | 129.5 | 3 | 96 | 243.8 | 4 | 109.00 | | | | | | | 1 |
| 2 | 4 | 14 | 1 | PSSH: 2n | 13 | 33.02 | 1 | 40 | 101.6 | 8 | 60 | 152.4 | 6 | | | | | | | | 1 |
| 2 | 4 | 15 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 34 | 86.36 | 0 | 44 | 111.8 | 0 | 74.00 | | | | | | | 1 |
| 2 | 4 | 16 | 1 | PSSH: 2n | 22 | 55.88 | 4 | 58 | 147.3 | 8 | 96 | 243.8 | 11 | | | | | | | | 1 |
| 2 | 4 | 17 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 48 | 121.9 | 3 | 65 | 165.1 | 3 | | | | | | | | 1 |
| 2 | 4 | 18 | 1 | PSSH: 2n | 18 | 45.72 | 2 | 47 | 119.4 | 2 | 86 | 218.4 | 2 | | | | | | | | 1 |
| 2 | 4 | 19 | 1 | PSSH: 2n | 12 | 30.48 | 0 | 34 | 86.36 | 3 | 51 | 129.5 | 3 | | | | | | | | 1 |
| 2 | 4 | 20 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 40 | 101.6 | 2 | 72 | 182.9 | 3 | 49.00 | | | | | | | 1 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 21 | 4 | SOPR | 6 | 15.24 | 0 | 14 | 35.56 | 3 | 36 | 91.44 | 4 | 118.00 | | | | | | | 2 |
| 1 | 4 | 22 | 4 | SOPR | 17 | 43.18 | 2 | 24 | 60.96 | 12 | 36 | 91.44 | 13 | 118.00 | | | | | | | 2 |
| 1 | 4 | 23 | 4 | SOPR | 19 | 48.26 | 2 | 24 | 60.96 | 10 | 36 | 91.44 | 11 | 118.00 | | | | | | | 2 |
| 1 | 4 | 24 | 4 | SOPR | 8 | 20.32 | 0 | 24 | 60.96 | 8 | 36 | 91.44 | 9 | 118.00 | | | | | | | 2 |
| 1 | 4 | 25 | 4 | SOPR | 12 | 30.48 | 0 | 24 | 60.96 | 8 | 36 | 91.44 | 9 | 118.00 | | | | | | | 2 |
| 1 | 4 | 26 | 4 | SOPR | 6 | 15.24 | 0 | 18 | 45.72 | 1 | 36 | 91.44 | 2 | 118.00 | | | | | | | 2 |
| 1 | 4 | 27 | 4 | SOPR | 6 | 15.24 | 0 | 26 | 66.04 | 3 | 36 | 91.44 | 4 | 118.00 | | | | | | | 2 |
| 1 | 4 | 28 | 4 | SOPR | 8 | 20.32 | 0 | 26 | 66.04 | 2 | 36 | 91.44 | 3 | 118.00 | | | | | | | 2 |
| 1 | 4 | 29 | 4 | SOPR | 8 | 20.32 | 1 | 26 | 66.04 | 4 | 36 | 91.44 | 5 | 118.00 | | | | | | | 2 |
| 1 | 4 | 30 | 4 | SOPR | 8 | 20.32 | 1 | 30 | 76.2 | 3 | 36 | 91.44 | 4 | 118.00 | | | | | | | 2 |
| 2 | 4 | 31 | 1 | PSSH: 2n | 36 | 91.44 | 3 | 59 | 149.9 | 5 | 59 | 149.9 | 5 | 43.00 | | | | | | | 2 |
| 2 | 4 | 32 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 43 | 109.2 | 0 | 43 | 109.2 | 0 | 41.00 | | | | | | | 2 |
| 2 | 4 | 33 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 48 | 121.9 | 0 | 48 | 121.9 | 0 | 46.00 | | | | | | | 2 |
| 2 | 4 | 34 | 1 | PSSH: 2n | 17 | 43.18 | 0 | 12 | 30.48 | 0 | | | | | | | | | | | 2 |
| 2 | 4 | 35 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 35 | 88.9 | 0 | 35 | 88.9 | 0 | 41.00 | | | | | | | 2 |
| 2 | 4 | 36 | 1 | PSSH: 2n | 19 | 48.26 | 2 | 40 | 101.6 | 8 | 64 | 162.6 | 4 | 112.00 | | | | | | | 2 |
| 2 | 4 | 37 | 1 | PSSH: 2n | 24 | 60.96 | 2 | 60 | 152.4 | 6 | 90 | 228.6 | 10 | | | | | | | | 2 |
| 2 | 4 | 38 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 42 | 106.7 | 1 | 42 | 106.7 | 1 | 57.00 | | | | | | | 2 |
| 2 | 4 | 39 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 42 | 106.7 | 3 | 96 | 243.8 | 2 | 91.00 | | | | | | | 2 |
| 2 | 4 | 40 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 56 | 142.2 | 2 | 96 | 243.8 | 4 | 109.00 | | | | | | | 2 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 4 | 41 | 1 | PSSH: 2n | 48 | 121.9 | 4 | 60 | 152.4 | 8 | 72 | 182.9 | 10 | 29.00 | | | | | | | 3 |
| 2 | 4 | 42 | 1 | PSSH: 2n | 30 | 76.2 | 3 | 63 | 160 | 8 | 90 | 228.6 | 6 | 74.00 | | | | | | | 3 |
| 2 | 4 | 43 | 1 | PSSH: 2n | 28 | 71.12 | 3 | 41 | 104.1 | 9 | 54 | 137.2 | 10 | | | | | | | | 3 |
| 2 | 4 | 44 | 1 | PSSH: 2n | 8 | 20.32 | 0 | 18 | 45.72 | 1 | 38 | 96.52 | 1 | | | | | | | | 3 |
| 2 | 4 | 45 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 51 | 129.5 | 2 | 84 | 213.4 | 2 | 59.00 | | | | | | | 3 |
| 2 | 4 | 46 | 1 | PSSH: 2n | 18 | 45.72 | 1 | 51 | 129.5 | 4 | 96 | 243.8 | 6 | 98.00 | | | | | | | 3 |
| 2 | 4 | 47 | 1 | PSSH: 2n | 14 | 35.56 | 0 | 36 | 91.44 | 3 | 84 | 213.4 | 3 | | | | | | | | 3 |
| 2 | 4 | 48 | 1 | PSSH: 2n | 50 | 127 | 0 | 48 | 121.9 | 3 | 48 | 121.9 | 3 | 35.00 | | | | | | | 3 |
| 2 | 4 | 49 | 1 | PSSH: 2n | 15 | 38.1 | 0 | | | | | | | | | | | | | | 3 |
| 2 | 4 | 50 | 1 | PSSH: 2n | 24 | 60.96 | 3 | 46 | 116.8 | 5 | 46 | 116.8 | 5 | 49.00 | | | | | | | 3 |
| 2 | 4 | 51 | 1 | PSSH: 2n | 32 | 81.28 | 4 | 61 | 154.9 | 11 | 96 | 243.8 | 15 | 109.00 | 11 | 10 | 13 | 13 | 13 | 13 | 3 |
| 2 | 4 | 52 | 1 | PSSH: 2n | 14 | 35.56 | 0 | 35 | 88.9 | 0 | 67 | 170.2 | 0 | 103.00 | | | | | | | 3 |
| 2 | 4 | 53 | 1 | PSSH: 2n | 21 | 53.34 | 0 | 47 | 119.4 | 4 | 96 | 243.8 | 4 | 112.00 | 0 | 2 | 0 | 2 | 0 | 3 | 3 |
| 2 | 4 | 54 | 1 | PSSH: 2n | 38 | 96.52 | 1 | 60 | 152.4 | 5 | 72 | 182.9 | 6 | 71.00 | | | | | | | 3 |
| 2 | 4 | 55 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 45 | 114.3 | 3 | 45 | 114.3 | 2 | 37.00 | | | | | | | 3 |
| 2 | 4 | 56 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 43 | 109.2 | 0 | 60 | 152.4 | 0 | 112.00 | | | 0 | 1 | 0 | 3 | 3 |
| 2 | 4 | 57 | 1 | PSSH: 2n | 16 | 40.64 | 0 | 40 | 101.6 | 0 | 40 | 101.6 | 0 | 43.00 | | | | | | | 3 |
| 2 | 4 | 58 | 1 | PSSH: 2n | 43 | 109.2 | 1 | 62 | 157.5 | 3 | 60 | 152.4 | 7 | 43.00 | | | | | | | 3 |
| 2 | 4 | 59 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 37 | 93.98 | 3 | 73 | 185.4 | 5 | | | | | | | | 3 |
| 2 | 4 | 60 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 79 | 200.7 | 4 | 96 | 243.8 | 3 | 71.00 | 5 | 1 | 6 | 1 | 6 | 1 | 3 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 61 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 64 | 162.6 | 4 | 64 | 162.6 | 5 | 49.00 | | | | | | | 4 |
| 1 | 4 | 62 | 1 | PSSH: 2n | 53 | 134.6 | 0 | 55 | 139.7 | 0 | 55 | 139.7 | 0 | 37.00 | | | | | | | 4 |
| 1 | 4 | 63 | 1 | PSSH: 2n | 18 | 45.72 | 1 | 48 | 121.9 | 1 | 80 | 203.2 | 1 | 49.00 | | | | | | | 4 |
| 1 | 4 | 64 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 46 | 116.8 | 2 | 26 | 66.04 | 3 | 43.00 | | | | | | | 4 |
| 1 | 4 | 65 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 36 | 91.44 | 0 | 36 | 91.44 | 0 | 43.00 | | | | | | | 4 |
| 1 | 4 | 66 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 49 | 124.5 | 5 | 90 | 228.6 | 6 | | | | | | | | 4 |
| 1 | 4 | 67 | 1 | PSSH: 2n | 25 | 63.5 | 0 | 52 | 132.1 | 6 | 84 | 213.4 | 6 | 103.00 | | | | | | | 4 |
| 1 | 4 | 68 | 1 | PSSH: 2n | 43 | 109.2 | 0 | 63 | 160 | 2 | 66 | 167.6 | 2 | 43.00 | 0 | 1 | 0 | 1 | 0 | 2 | 4 |
| 1 | 4 | 69 | 1 | PSSH: 2n | 40 | 101.6 | 0 | 52 | 132.1 | 2 | 60 | 152.4 | 2 | 33.00 | | | | | | | 4 |
| 1 | 4 | 70 | 1 | PSSH: 2n | 7 | 17.78 | 0 | | | | | | | | | | | | | | 4 |
| 3 | 4 | 71 | 2 | PSSH: 4n | 7 | 17.78 | 0 | | | | | | | | | | | | | | 4 |
| 3 | 4 | 72 | 2 | PSSH: 4n | 22 | 55.88 | 0 | 42 | 106.7 | 0 | 60 | | 0 | | | | | | | | 4 |
| 3 | 4 | 73 | 2 | PSSH: 4n | 25 | 63.5 | 0 | 38 | 96.52 | 3 | 63 | | 3 | | | | | | 1 | 1 | 4 |
| 3 | 4 | 74 | 2 | PSSH: 4n | 22 | 55.88 | 0 | 42 | 106.7 | 1 | 84 | | 1 | | | | | | | | 4 |
| 3 | 4 | 75 | 2 | PSSH: 4n | 20 | 50.8 | 0 | 48 | 121.9 | 4 | 84 | | 4 | | 0 | 1 | 0 | 2 | 0 | 2 | 4 |
| 3 | 4 | 76 | 2 | PSSH: 4n | 18 | 45.72 | 4 | 48 | 121.9 | 4 | 84 | | 6 | | 5 | 2 | 5 | 0 | 5 | 0 | 4 |
| 3 | 4 | 77 | 2 | PSSH: 4n | | | | | | | | | | | | | | | | | 4 |
| 3 | 4 | 78 | 2 | PSSH: 4n | 14 | 35.56 | 0 | 14 | 35.56 | 0 | 24 | | 0 | | | | | | | | 4 |
| 3 | 4 | 79 | 2 | PSSH: 4n | 24 | 60.96 | 0 | 42 | 106.7 | 1 | 78 | | 1 | | 2 | 0 | 2 | 0 | 2 | 0 | 4 |
| 3 | 4 | 80 | 2 | PSSH: 4n | 24 | 60.96 | 0 | 42 | 106.7 | 1 | 61 | | 1 | | | | | | | | 4 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 5 | 1 | 2 | PSSH: 4n | 26 | 66.04 | 0 | 28 | 71.12 | 2 | 51 | 129.5 | 2 | | | | | | | | 1 |
| 3 | 5 | 2 | 2 | PSSH: 4n | 20 | 50.8 | 0 | 32 | 81.28 | 3 | 51 | 129.5 | 3 | | | | | | | | 1 |
| 3 | 5 | 3 | 2 | PSSH: 4n | 18 | 45.72 | 0 | 32 | 81.28 | 3 | 60 | 152.4 | 2 | | | | | | | | 1 |
| 3 | 5 | 4 | 2 | PSSH: 4n | 18 | 45.72 | 0 | 40 | 101.6 | 3 | 67 | 170.2 | 2 | | | | | | 5 | 0 | 1 |
| 3 | 5 | 5 | 2 | PSSH: 4n | 24 | 60.96 | 0 | 48 | 121.9 | 2 | 67 | 170.2 | 2 | | | | | | | | 1 |
| 3 | 5 | 6 | 2 | PSSH: 4n | | 0 | | | | | | | | | | | | | | | 1 |
| 3 | 5 | 7 | 2 | PSSH: 4n | 25 | 63.5 | 0 | 48 | 121.9 | 3 | 75 | 190.5 | 3 | | | | | | | | 1 |
| 3 | 5 | 8 | 2 | PSSH: 4n | 11 | 27.94 | 0 | | | | | | | | | | | | | | 1 |
| 3 | 5 | 9 | 2 | PSSH: 4n | 24 | 60.96 | 0 | 48 | 121.9 | 3 | 77 | 195.6 | 4 | | | | | | | | 1 |
| 3 | 5 | 10 | 2 | PSSH: 4n | 10 | 25.4 | 0 | 20 | 50.8 | 0 | 36 | 91.44 | 0 | | | | | | | | 1 |
| 2 | 5 | 11 | 1 | PSSH: 2n | 11 | 27.94 | 1 | 37 | 93.98 | 2 | 65 | 165.1 | 2 | 112.00 | | | | | | | 1 |
| 2 | 5 | 12 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 42 | 106.7 | 2 | 74 | 188 | 2 | 73.00 | | | | | | | 1 |
| 2 | 5 | 13 | 1 | PSSH: 2n | 26 | 66.04 | 0 | 45 | 114.3 | 4 | 67 | 170.2 | 1 | 73.00 | | | | | | | 1 |
| 2 | 5 | 14 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 49 | 124.5 | 3 | 70 | 177.8 | 2 | 45.00 | | | | | | | 1 |
| 2 | 5 | 15 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 38 | 96.52 | 3 | 66 | 167.6 | 3 | | | | | | | | 1 |
| 2 | 5 | 16 | 1 | PSSH: 2n | 25 | 63.5 | 0 | 49 | 124.5 | 3 | 96 | 243.8 | 2 | | | | | | | | 1 |
| 2 | 5 | 17 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 39 | 99.06 | 1 | 72 | 182.9 | 1 | | | | | | | | 1 |
| 2 | 5 | 18 | 1 | PSSH: 2n | 21 | 53.34 | 0 | 37 | 93.98 | 5 | 72 | 182.9 | 5 | 112.00 | | | | | | | 1 |
| 2 | 5 | 19 | 1 | PSSH: 2n | 32 | 81.28 | 0 | 37 | 93.98 | 5 | 48 | 121.9 | 4 | 73.00 | | | | | | | 1 |
| 2 | 5 | 20 | 1 | PSSH: 2n | 15 | 38.1 | 0 | | | | | | | | | | | | | | 1 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 21 | 3 | ATx623 | 18 | 45.72 | 0 | 34 | 86.36 | 3 | 36 | 91.44 | 2 | 57.00 | | | | | | | 2 |
| 1 | 5 | 22 | 3 | ATx623 | | | | | | | | | | | | | | | | | 2 |
| 1 | 5 | 23 | 3 | ATx623 | 15 | 38.1 | 2 | 35 | 88.9 | 1 | 37 | 93.98 | 1 | 67.00 | | | | | | | 2 |
| 1 | 5 | 24 | 3 | ATx623 | 12 | 30.48 | 1 | 27 | 68.58 | 1 | 34 | 86.36 | 1 | 57.00 | | | | | | | 2 |
| 1 | 5 | 25 | 3 | ATx623 | 12 | 30.48 | 1 | 30 | 76.2 | 0 | 36 | 91.44 | 0 | 57.00 | | | | | | | 2 |
| 1 | 5 | 26 | 3 | ATx623 | 20 | 50.8 | 2 | 30 | 76.2 | 2 | 36 | 91.44 | 1 | 57.00 | | | | | | | 2 |
| 1 | 5 | 27 | 3 | ATx623 | 11 | 27.94 | 0 | 30 | 76.2 | 0 | 36 | 91.44 | 0 | 57.00 | | | | | | | 2 |
| 1 | 5 | 28 | 3 | ATx623 | 20 | 50.8 | 2 | 32 | 81.28 | 1 | 36 | 91.44 | 1 | 67.00 | | | | | | | 2 |
| 1 | 5 | 29 | 3 | ATx623 | 20 | 50.8 | 0 | 31 | 78.74 | 0 | | | | | | | | | | | 2 |
| 1 | 5 | 30 | 3 | ATx623 | 21 | 53.34 | 2 | 35 | 88.9 | 1 | 36 | 91.44 | 2 | 57.00 | | | | | | | 2 |
| 2 | 5 | 31 | 1 | PSSH: 2n | 8 | 20.32 | 0 | 25 | 63.5 | 2 | 39 | 99.06 | 2 | 112.00 | | | | | | | 2 |
| 2 | 5 | 32 | 1 | PSSH: 2n | 25 | 63.5 | 2 | 84 | 213.4 | 5 | 84 | 213.4 | 7 | 59.00 | | | | | | | 2 |
| 2 | 5 | 33 | 1 | PSSH: 2n | 29 | 73.66 | 0 | 61 | 154.9 | 3 | 68 | 172.7 | 3 | 59.00 | | | | | | | 2 |
| 2 | 5 | 34 | 1 | PSSH: 2n | 36 | 91.44 | 0 | 61 | 154.9 | 4 | 96 | 243.8 | 4 | 112.00 | | | | | | | 2 |
| 2 | 5 | 35 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 36 | 91.44 | 4 | 74 | 188 | 4 | | | | | | | | 2 |
| 2 | 5 | 36 | 1 | PSSH: 2n | 20 | 50.8 | 3 | 38 | 96.52 | 1 | 61 | 154.9 | 1 | 112.00 | | | | | | | 2 |
| 2 | 5 | 37 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 25 | 63.5 | 0 | 45 | 114.3 | 0 | | | | | | | | 2 |
| 2 | 5 | 38 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 35 | 88.9 | 4 | 72 | 182.9 | 4 | | | | | | | | 2 |
| 2 | 5 | 39 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 34 | 86.36 | 0 | 48 | 121.9 | 0 | | | | | | | | 2 |
| 2 | 5 | 40 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 36 | 91.44 | 1 | 76 | 193 | 2 | 112.00 | | | | | | | 2 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 5 | 41 | 1 | PSSH: 2n | 38 | 96.52 | 0 | 60 | 152.4 | 2 | 84 | 213.4 | 2 | 67.00 | | | | | | | 3 |
| 2 | 5 | 42 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 40 | 101.6 | 0 | 44 | 111.8 | 0 | 59.00 | | | | | | | 3 |
| 2 | 5 | 43 | 1 | PSSH: 2n | 26 | 66.04 | 0 | | | | | | | | | | | | | | 3 |
| 2 | 5 | 44 | 1 | PSSH: 2n | 26 | 66.04 | 0 | 64 | 162.6 | 2 | 96 | 243.8 | 3 | 78.00 | 3 | 0 | 1 | 0 | 2 | 0 | 3 |
| 2 | 5 | 45 | 1 | PSSH: 2n | 43 | 109.2 | 0 | 48 | 121.9 | 4 | 48 | 121.9 | 4 | 37.00 | | | | | | | 3 |
| 2 | 5 | 46 | 1 | PSSH: 2n | 20 | 50.8 | 1 | | | | | | | | | | | | | | 3 |
| 2 | 5 | 47 | 1 | PSSH: 2n | 15 | 38.1 | 0 | | | | | | | | | | | | | | 3 |
| 2 | 5 | 48 | 1 | PSSH: 2n | 8 | 20.32 | 0 | 26 | 66.04 | 0 | 36 | 91.44 | 0 | | | | | | | | 3 |
| 2 | 5 | 49 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 38 | 96.52 | 3 | 58 | 147.3 | 3 | 112.00 | | | | | | | 3 |
| 2 | 5 | 50 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 48 | 121.9 | 6 | 94 | 238.8 | 6 | 85.00 | | | | | | | 3 |
| 2 | 5 | 51 | 1 | PSSH: 2n | 9 | 22.86 | 0 | 37 | 93.98 | 5 | 74 | 188 | 6 | | | | | | | | 3 |
| 2 | 5 | 52 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 57 | 144.8 | 3 | 76 | 193 | 3 | 76.00 | | | | | | | 3 |
| 2 | 5 | 53 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 85 | 215.9 | 2 | 60 | 152.4 | 3 | 69.00 | | | | | | | 3 |
| 2 | 5 | 54 | 1 | PSSH: 2n | 27 | 68.58 | 0 | 39 | 99.06 | 5 | 40 | 101.6 | 5 | 59.00 | | | | | | | 3 |
| 2 | 5 | 55 | 1 | PSSH: 2n | 4 | 10.16 | 0 | | | | | | | | | | | | | | 3 |
| 2 | 5 | 56 | 1 | PSSH: 2n | 16 | 40.64 | 0 | 38 | 96.52 | 3 | 72 | 182.9 | 4 | 112.00 | | | | | | | 3 |
| 2 | 5 | 57 | 1 | PSSH: 2n | 8 | 20.32 | 0 | 34 | 86.36 | 0 | 55 | 139.7 | 1 | | | | | | | | 3 |
| 2 | 5 | 58 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 39 | 99.06 | 4 | 84 | 213.4 | 4 | | | | | | | | 3 |
| 2 | 5 | 59 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 48 | 121.9 | 0 | 96 | 243.8 | 0 | | | | | | | | 3 |
| 2 | 5 | 60 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 33 | 83.82 | 2 | 51 | 129.5 | 2 | | 3 | 1 | 4 | 1 | 4 | 1 | 3 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 5 | 61 | 1 | PSSH: 2n | 17 | 43.18 | 0 | 40 | 101.6 | 2 | 72 | 182.9 | 1 | 67.00 | | | | | | | 4 |
| 2 | 5 | 62 | 1 | PSSH: 2n | 12 | 30.48 | 2 | 36 | 91.44 | 4 | 78 | 198.1 | 5 | | 0 | 1 | 2 | 1 | 2 | 1 | 4 |
| 2 | 5 | 63 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 42 | 106.7 | 4 | 78 | 198.1 | 5 | 109.00 | 1 | 0 | 1 | 0 | 1 | 0 | 4 |
| 2 | 5 | 64 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 36 | 91.44 | 4 | 75 | 190.5 | 4 | 112.00 | 0 | 3 | 0 | 2 | 0 | 1 | 4 |
| 2 | 5 | 65 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 37 | 93.98 | 0 | 37 | 93.98 | 0 | 53.00 | | | | | | | 4 |
| 2 | 5 | 66 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 46 | 116.8 | 3 | 72 | 182.9 | 4 | 53.00 | | | | | | | 4 |
| 2 | 5 | 67 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 29 | 73.66 | 0 | 52 | 132.1 | 0 | | | | | | | | 4 |
| 2 | 5 | 68 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 34 | 86.36 | 0 | 75 | 190.5 | 0 | | | | | | | | 4 |
| 2 | 5 | 69 | 1 | PSSH: 2n | 21 | 53.34 | 1 | 36 | 91.44 | 4 | 70 | 177.8 | 3 | 117.00 | | | | | | | 4 |
| 2 | 5 | 70 | 1 | PSSH: 2n | 24 | 60.96 | 2 | 48 | 121.9 | 6 | 96 | 243.8 | 9 | 109.00 | 3 | 0 | 2 | 0 | 4 | 0 | 4 |
| 2 | 5 | 71 | 1 | PSSH: 2n | 27 | 68.58 | 1 | 59 | 149.9 | 5 | 96 | 243.8 | 6 | | | | | | | | 4 |
| 2 | 5 | 72 | 1 | PSSH: 2n | 16 | 40.64 | 2 | 36 | 91.44 | 1 | 60 | 152.4 | 1 | | | | 1 | 0 | 3 | 0 | 4 |
| 2 | 5 | 73 | 1 | PSSH: 2n | 21 | 53.34 | 0 | 45 | 114.3 | 0 | 62 | 157.5 | 0 | 85.00 | | | | | | | 4 |
| 2 | 5 | 74 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 4 |
| 2 | 5 | 75 | 1 | PSSH: 2n | 27 | 68.58 | 0 | 38 | 96.52 | 3 | 65 | 165.1 | 3 | | 1 | 1 | 2 | 0 | | | 4 |
| 2 | 5 | 76 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 48 | 121.9 | 6 | 96 | 243.8 | 9 | | 0 | 1 | 1 | 0 | 2 | 0 | 4 |
| 2 | 5 | 77 | 1 | PSSH: 2n | 7 | 17.78 | 0 | 20 | 50.8 | 1 | 36 | 91.44 | 0 | | | | | | | | 4 |
| 2 | 5 | 78 | 1 | PSSH: 2n | 11 | 27.94 | 1 | 26 | 66.04 | 2 | 88 | 223.5 | 2 | 98.00 | | | | | | | 4 |
| 2 | 5 | 79 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 36 | 91.44 | 2 | 36 | 91.44 | 2 | 59.00 | | | | | | | 4 |
| 2 | 5 | 80 | 1 | PSSH: 2n | 33 | 83.82 | 3 | 58 | 147.3 | 9 | 84 | 213.4 | 20 | | 0 | 1 | 0 | 1 | 0 | 1 | 4 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 6 | 1 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 34 | 86.36 | 4 | 34 | 86.36 | 4 | 53.00 | | | | | | | 1 |
| 2 | 6 | 2 | 1 | PSSH: 2n | 15 | 38.1 | 2 | | | | | | | | | | | | | | 1 |
| 2 | 6 | 3 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 35 | 88.9 | 2 | 60 | 152.4 | 3 | | | | | | | | 1 |
| 2 | 6 | 4 | 1 | PSSH: 2n | 31 | 78.74 | 0 | 45 | 114.3 | 5 | 52 | 132.1 | 5 | 33.00 | | | | | | | 1 |
| 2 | 6 | 5 | 1 | PSSH: 2n | 21 | 53.34 | 0 | 35 | 88.9 | 5 | 60 | 152.4 | 5 | | | | | | | | 1 |
| 2 | 6 | 6 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 37 | 93.98 | 7 | 55 | 139.7 | 6 | 109.00 | | | | | | | 1 |
| 2 | 6 | 7 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 29 | 73.66 | 3 | 44 | 111.8 | 2 | | | | | | | | 1 |
| 2 | 6 | 8 | 1 | PSSH: 2n | 52 | 132.1 | 1 | 51 | 129.5 | 9 | 72 | 182.9 | 9 | 37.00 | | | | | | | 1 |
| 2 | 6 | 9 | 1 | PSSH: 2n | 46 | 116.8 | 0 | 36 | 91.44 | 2 | 52 | 132.1 | 6 | 32.00 | | | | | | | 1 |
| 2 | 6 | 10 | 1 | PSSH: 2n | 24 | 60.96 | 2 | 48 | 121.9 | 7 | 48 | 121.9 | 7 | 59.00 | | | | | | | 1 |
| 1 | 6 | 11 | 1 | PSSH: 2n | 33 | 83.82 | 2 | 46 | 116.8 | 6 | 60 | 152.4 | 8 | | | | | | 2 | 0 | 1 |
| 1 | 6 | 12 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 1 |
| 1 | 6 | 13 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 37 | 93.98 | 10 | 66 | 167.6 | 10 | 45.00 | | | | | | | 1 |
| 1 | 6 | 14 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 1 |
| 1 | 6 | 15 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 1 |
| 1 | 6 | 16 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 40 | 101.6 | 6 | 60 | 152.4 | 10 | 53.00 | | | | | | | 1 |
| 1 | 6 | 17 | 1 | PSSH: 2n | 20 | 50.8 | 1 | 30 | 76.2 | 6 | 60 | 152.4 | 7 | | | | | | | | 1 |
| 1 | 6 | 18 | 1 | PSSH: 2n | 31 | 78.74 | 0 | 30 | 76.2 | 1 | 48 | 121.9 | 1 | 53.00 | | | | | | | 1 |
| 1 | 6 | 19 | 1 | PSSH: 2n | 27 | 68.58 | 0 | 32 | 81.28 | 3 | 60 | 152.4 | 3 | 49.00 | | | | | | | 1 |
| 1 | 6 | 20 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 1 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 6 | 21 | 1 | PSSH: 2n | 26 | 66.04 | 2 | 36 | 91.44 | 5 | 48 | 121.9 | 6 | | | | | | | | 2 |
| 2 | 6 | 22 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 2 |
| 2 | 6 | 23 | 1 | PSSH: 2n | 14 | 35.56 | 0 | 64 | 162.6 | 1 | 60 | 152.4 | 2 | 64.00 | | | | | | | 2 |
| 2 | 6 | 24 | 1 | PSSH: 2n | 30 | 76.2 | 1 | 54 | 137.2 | 5 | 60 | 152.4 | 5 | 49.00 | | | | | | | 2 |
| 2 | 6 | 25 | 1 | PSSH: 2n | 41 | 104.1 | 2 | 65 | 165.1 | 5 | 96 | 243.8 | 8 | 109.00 | | | | | | | 2 |
| 2 | 6 | 26 | 1 | PSSH: 2n | 30 | 76.2 | 1 | 46 | 116.8 | 7 | 76 | 193 | 10 | | | | | | | | 2 |
| 2 | 6 | 27 | 1 | PSSH: 2n | 36 | 91.44 | 4 | 47 | 119.4 | 1 | 47 | 119.4 | 1 | 59.00 | | | | | | | 2 |
| 2 | 6 | 28 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 34 | 86.36 | 4 | 48 | 121.9 | 4 | 112.00 | | | | | | | 2 |
| 2 | 6 | 29 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 2 |
| 2 | 6 | 30 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 34 | 86.36 | 0 | 52 | 132.1 | 0 | | | | | | | | 2 |
| 2 | 6 | 31 | 1 | PSSH: 2n | 7 | 17.78 | 0 | 27 | 68.58 | 1 | 52 | 132.1 | 1 | | | | | | | | 2 |
| 2 | 6 | 32 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 39 | 99.06 | 3 | 65 | 165.1 | 3 | | | | | | | | 2 |
| 2 | 6 | 33 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 42 | 106.7 | 4 | 65 | 165.1 | 5 | | | | | | | | 2 |
| 2 | 6 | 34 | 1 | PSSH: 2n | 27 | 68.58 | 0 | | | | | | | 32.00 | | | | | | | 2 |
| 2 | 6 | 35 | 1 | PSSH: 2n | 18 | 45.72 | 1 | 46 | 116.8 | 1 | 48 | 121.9 | 0 | 57.00 | | | | | | | 2 |
| 2 | 6 | 36 | 1 | PSSH: 2n | 32 | 81.28 | 0 | | | | | | | | | | | | | | 2 |
| 2 | 6 | 37 | 1 | PSSH: 2n | 43 | 109.2 | 0 | 60 | 152.4 | 0 | 60 | 152.4 | 0 | 57.00 | | | | | | | 2 |
| 2 | 6 | 38 | 1 | PSSH: 2n | 34 | 86.36 | 0 | 45 | 114.3 | 4 | 60 | 152.4 | 6 | 32.00 | | | | | | | 2 |
| 2 | 6 | 39 | 1 | PSSH: 2n | 39 | 99.06 | 0 | 53 | 134.6 | 0 | 53 | 134.6 | 0 | 37.00 | | | | | | | 2 |
| 2 | 6 | 40 | 1 | PSSH: 2n | 34 | 86.36 | 0 | | | | | | | | | | | | | | 2 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 6 | 41 | 2 | PSSH: 4n | 21 | 53.34 | 0 | 39 | 99.06 | 1 | 81 | 205.7 | 1 | 98.00 | 2 | 0 | 1 | 0 | | | 3 |
| 3 | 6 | 42 | 2 | PSSH: 4n | 23 | 58.42 | 2 | 61 | 154.9 | 14 | 96 | 243.8 | 16 | 83.00 | 0 | 8 | 4 | 9 | 12 | 7 | 3 |
| 3 | 6 | 43 | 2 | PSSH: 4n | 8 | 20.32 | 2 | 14 | 35.56 | 1 | 22 | 55.88 | 0 | 75.00 | | | | | | | 3 |
| 3 | 6 | 44 | 2 | PSSH: 4n | 29 | 73.66 | 0 | 48 | 121.9 | 2 | 72 | 182.9 | 2 | | | | | | | | 3 |
| 3 | 6 | 45 | 2 | PSSH: 4n | 20 | 50.8 | 1 | 48 | 121.9 | 3 | 84 | 213.4 | 3 | | | | | | | | 3 |
| 3 | 6 | 46 | 2 | PSSH: 4n | | | | | | | | | | | | | | | | | 3 |
| 3 | 6 | 47 | 2 | PSSH: 4n | 9 | 22.86 | 0 | | | | | | | | | | | | | | 3 |
| 3 | 6 | 48 | 2 | PSSH: 4n | 14 | 35.56 | 0 | 27 | 68.58 | 0 | 49 | 124.5 | 0 | | | | | | | | 3 |
| 3 | 6 | 49 | 2 | PSSH: 4n | 21 | 53.34 | 0 | 37 | 93.98 | 4 | 60 | 152.4 | 1 | | | | | | | | 3 |
| 3 | 6 | 50 | 2 | PSSH: 4n | 33 | 83.82 | 0 | 27 | 68.58 | 2 | 60 | 152.4 | 2 | | | | | | | | 3 |
| 2 | 6 | 51 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 46 | 116.8 | 6 | 74 | 188 | 7 | | | | | | | | 3 |
| 2 | 6 | 52 | 1 | PSSH: 2n | 29 | 73.66 | 0 | 54 | 137.2 | 3 | 79 | 200.7 | 4 | 83.00 | | | | | | | 3 |
| 2 | 6 | 53 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 3 |
| 2 | 6 | 54 | 1 | PSSH: 2n | 34 | 86.36 | 3 | 55 | 139.7 | 5 | 55 | 139.7 | 13 | 39.00 | 3 | 4 | 6 | 4 | 6 | 3 | 3 |
| 2 | 6 | 55 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 37 | 93.98 | 0 | 63 | 160 | 0 | | | | | | | | 3 |
| 2 | 6 | 56 | 1 | PSSH: 2n | 24 | 60.96 | 2 | 45 | 114.3 | 5 | 69 | 175.3 | 5 | 112.00 | | | | | | | 3 |
| 2 | 6 | 57 | 1 | PSSH: 2n | 27 | 68.58 | 1 | 39 | 99.06 | 5 | 67 | 170.2 | 8 | | 1 | 0 | 2 | 0 | 2 | 0 | 3 |
| 2 | 6 | 58 | 1 | PSSH: 2n | 9 | 22.86 | 3 | 12 | 30.48 | 0 | 24 | 60.96 | 2 | | | | | | | | 3 |
| 2 | 6 | 59 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 20 | 50.8 | 2 | 59 | 149.9 | 2 | | | | | | | | 3 |
| 2 | 6 | 60 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 3 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 6 | 61 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 47 | 119.4 | 7 | 74 | 188 | 9 | | | | | | | | 4 |
| 2 | 6 | 62 | 1 | PSSH: 2n | 16 | 40.64 | 0 | 24 | 60.96 | 0 | 62 | 157.5 | 0 | 112.00 | | | | | | | 4 |
| 2 | 6 | 63 | 1 | PSSH: 2n | 26 | 66.04 | 2 | 45 | 114.3 | 9 | 74 | 188 | 10 | | | | | | | | 4 |
| 2 | 6 | 64 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 4 |
| 2 | 6 | 65 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 24 | 60.96 | 6 | 60 | 152.4 | 5 | | | | | | | | 4 |
| 2 | 6 | 66 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 38 | 96.52 | 3 | 72 | 182.9 | 4 | 89.00 | | | | | | | 4 |
| 2 | 6 | 67 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 60 | 152.4 | 6 | 60 | 152.4 | 9 | 57.00 | 9 | 1 | 9 | 1 | 9 | 1 | 4 |
| 2 | 6 | 68 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 25 | 63.5 | 0 | 36 | 91.44 | 3 | 64.00 | | | | | | | 4 |
| 2 | 6 | 69 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 31 | 78.74 | 2 | 60 | 152.4 | 2 | | | | | | | | 4 |
| 2 | 6 | 70 | 1 | PSSH: 2n | 11 | 27.94 | 2 | 12 | 30.48 | 0 | 29 | 73.66 | 0 | | | | | | | | 4 |
| 2 | 6 | 71 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 39 | 99.06 | 2 | 66 | 167.6 | 2 | 85.00 | 1 | 0 | 1 | 0 | 1 | 0 | 4 |
| 2 | 6 | 72 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 45 | 114.3 | 5 | 80 | 203.2 | 6 | 109.00 | | | | | | | 4 |
| 2 | 6 | 73 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 54 | 137.2 | 5 | 77 | 195.6 | 5 | 53.00 | 6 | 0 | 6 | 1 | 5 | 1 | 4 |
| 2 | 6 | 74 | 1 | PSSH: 2n | 22 | 55.88 | 3 | 48 | 121.9 | 8 | 77 | 195.6 | 11 | | 2 | 4 | 8 | 5 | 13 | 5 | 4 |
| 2 | 6 | 75 | 1 | PSSH: 2n | 22 | 55.88 | 0 | 60 | 152.4 | 5 | 84 | 213.4 | 4 | 85.00 | 5 | 0 | 8 | 0 | 11 | 0 | 4 |
| 2 | 6 | 76 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 47 | 119.4 | 8 | 76 | 193 | 8 | 112.00 | 1 | 0 | 1 | 0 | 1 | 0 | 4 |
| 2 | 6 | 77 | 1 | PSSH: 2n | 41 | 104.1 | 0 | 57 | 144.8 | 2 | 46 | 116.8 | 4 | 39.00 | | | | | | | 4 |
| 2 | 6 | 78 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 4 |
| 2 | 6 | 79 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 4 |
| 2 | 6 | 80 | 1 | PSSH: 2n | 8 | 20.32 | 0 | | | | | | | | | | | | | | 4 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 1 | 3 | ATx623 | 12 | 30.48 | 0 | 32 | 81.28 | 1 | 36 | 91.44 | 2 | 59.00 | | | | | | | 1 |
| 1 | 7 | 2 | 3 | ATx623 | 15 | 38.1 | 1 | 32 | 81.28 | 2 | 36 | 91.44 | 2 | 59.00 | | | | | | | 1 |
| 1 | 7 | 3 | 3 | ATx623 | 20 | 50.8 | 1 | 24 | 60.96 | 0 | 26 | 66.04 | 1 | 59.00 | | | | | | | 1 |
| 1 | 7 | 4 | 3 | ATx623 | 18 | 45.72 | 1 | 29 | 73.66 | 2 | 36 | 91.44 | 1 | 59.00 | | | | | | | 1 |
| 1 | 7 | 5 | 3 | ATx623 | 32 | 81.28 | 1 | 24 | 60.96 | 1 | 36 | 91.44 | 1 | 43.00 | | | | | | | 1 |
| 1 | 7 | 6 | 3 | ATx623 | 26 | 66.04 | 1 | 30 | 76.2 | 1 | 36 | 91.44 | 1 | 43.00 | | | | | | | 1 |
| 1 | 7 | 7 | 3 | ATx623 | 12 | 30.48 | 1 | | | | | | | | | | | | | | 1 |
| 1 | 7 | 8 | 3 | ATx623 | | | | | | | | | | | | | | | | | 1 |
| 1 | 7 | 9 | 3 | ATx623 | 10 | 25.4 | 0 | 25 | 63.5 | 0 | 36 | 91.44 | 0 | 59.00 | | | | | | | 1 |
| 1 | 7 | 10 | 3 | ATx623 | 12 | 30.48 | 0 | 24 | 60.96 | 0 | 36 | 91.44 | 0 | 59.00 | | | | | | | 1 |
| 2 | 7 | 11 | 1 | PSSH: 2n | 12 | 30.48 | 0 | 26 | 66.04 | 5 | 48 | 121.9 | 4 | | | | | | | | 1 |
| 2 | 7 | 12 | 1 | PSSH: 2n | 12 | 30.48 | 1 | 30 | 76.2 | 3 | 48 | 121.9 | 2 | 83.00 | | | | | | | 1 |
| 2 | 7 | 13 | 1 | PSSH: 2n | 23 | 58.42 | 3 | 48 | 121.9 | 7 | 84 | 213.4 | 7 | | | | | | | | 1 |
| 2 | 7 | 14 | 1 | PSSH: 2n | 25 | 63.5 | 5 | 49 | 124.5 | 12 | 70 | 177.8 | 13 | | | | | | | | 1 |
| 2 | 7 | 15 | 1 | PSSH: 2n | 27 | 68.58 | 0 | | | | | | | | | | | | | | 1 |
| 2 | 7 | 16 | 1 | PSSH: 2n | 14 | 35.56 | 0 | 46 | 116.8 | 1 | 84 | 213.4 | 1 | 90.00 | | | | | | | 1 |
| 2 | 7 | 17 | 1 | PSSH: 2n | 22 | 55.88 | 2 | 47 | 119.4 | 12 | 72 | 182.9 | 12 | | 1 | 1 | 2 | 1 | 2 | 1 | 1 |
| 2 | 7 | 18 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 1 |
| 2 | 7 | 19 | 1 | PSSH: 2n | 11 | 27.94 | 0 | | | | | | | | | | | | | | 1 |
| 2 | 7 | 20 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 36 | 91.44 | 4 | 79 | 200.7 | 4 | 98.00 | | | | | | | 1 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 21 | 1 | PSSH: 2n | 36 | 91.44 | 0 | 36 | 91.44 | 8 | 45 | 114.3 | 7 | 37.00 | | | | | | | 2 |
| 1 | 7 | 22 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 27 | 68.58 | 0 | 48 | 121.9 | 0 | | | | | | | | 2 |
| 1 | 7 | 23 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 47 | 119.4 | 2 | 89 | 226.1 | 2 | 89.00 | | | | | | | 2 |
| 1 | 7 | 24 | 1 | PSSH: 2n | 12 | 30.48 | 1 | 30 | 76.2 | 1 | 48 | 121.9 | 1 | | | | | | | | 2 |
| 1 | 7 | 25 | 1 | PSSH: 2n | 11 | 27.94 | 0 | | | | | | | | | | | | | | 2 |
| 1 | 7 | 26 | 1 | PSSH: 2n | 27 | 68.58 | 1 | 53 | 134.6 | 10 | 83 | 210.8 | 10 | 67.00 | | | | | | | 2 |
| 1 | 7 | 27 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 36 | 91.44 | 1 | 63 | 160 | 1 | 112.00 | | | | | | | 2 |
| 1 | 7 | 28 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 48 | 121.9 | 3 | 72 | 182.9 | 2 | 32.00 | | | | | | | 2 |
| 1 | 7 | 29 | 1 | PSSH: 2n | 36 | 91.44 | 0 | 39 | 99.06 | 4 | 56 | 142.2 | 5 | | | | | | | | 2 |
| 1 | 7 | 30 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 67 | 170.2 | 4 | 96 | 243.8 | 5 | 71.00 | | | | | | | 2 |
| 2 | 7 | 31 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 60 | 152.4 | 2 | 65 | 165.1 | 4 | 83.00 | | | | | | | 2 |
| 2 | 7 | 32 | 1 | PSSH: 2n | 16 | 40.64 | 0 | 52 | 132.1 | 7 | 83 | 210.8 | 7 | 83.00 | | | | | | | 2 |
| 2 | 7 | 33 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 49 | 124.5 | 6 | 90 | 228.6 | 6 | 109.00 | | | | | | | 2 |
| 2 | 7 | 34 | 1 | PSSH: 2n | 28 | 71.12 | 3 | 63 | 160 | 3 | 96 | 243.8 | 4 | | | | | | | | 2 |
| 2 | 7 | 35 | 1 | PSSH: 2n | 34 | 86.36 | 4 | 74 | 188 | 8 | 96 | 243.8 | 16 | | | | | | | | 2 |
| 2 | 7 | 36 | 1 | PSSH: 2n | 13 | 33.02 | 0 | 58 | 147.3 | 0 | 96 | 243.8 | 0 | 83.00 | | | | | | | 2 |
| 2 | 7 | 37 | 1 | PSSH: 2n | 30 | 76.2 | 1 | 58 | 147.3 | 5 | 63 | 160 | 5 | 55.00 | | | | | | | 2 |
| 2 | 7 | 38 | 1 | PSSH: 2n | 35 | 88.9 | 3 | 72 | 182.9 | 9 | 82 | 208.3 | 8 | 83.00 | | | | | | | 2 |
| 2 | 7 | 39 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 13 | 33.02 | 0 | 13 | 33.02 | 0 | | | | | | | | 2 |
| 2 | 7 | 40 | 1 | PSSH: 2n | 31 | 78.74 | 0 | 24 | 60.96 | 0 | 48 | 121.9 | 5 | 43.00 | | | | | | | 2 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for "Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids".

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 7 | 41 | 1 | PSSH: 2n | 29 | 73.66 | 1 | 47 | 119.4 | 6 | 75 | 190.5 | 6 | 51.00 | | | 7 | 0 | 11 | 0 | 3 |
| 2 | 7 | 42 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 40 | 101.6 | 5 | 77 | 195.6 | 4 | | | | | | | | 3 |
| 2 | 7 | 43 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 3 |
| 2 | 7 | 44 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 37 | 93.98 | 3 | 78 | 198.1 | 5 | 112.00 | | | | | | | 3 |
| 2 | 7 | 45 | 1 | PSSH: 2n | 28 | 71.12 | 0 | 62 | 157.5 | 2 | 55 | 139.7 | 3 | 64.00 | | | | | | | 3 |
| 2 | 7 | 46 | 1 | PSSH: 2n | 35 | 88.9 | 0 | 38 | 96.52 | 2 | 77 | 195.6 | 5 | | | | | | | | 3 |
| 2 | 7 | 47 | 1 | PSSH: 2n | 19 | 48.26 | 0 | 63 | 160 | 0 | 63 | 160 | 3 | 57.00 | | | | | | | 3 |
| 2 | 7 | 48 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 39 | 99.06 | 1 | 81 | 205.7 | 2 | 112.00 | | | | | | | 3 |
| 2 | 7 | 49 | 1 | PSSH: 2n | 30 | 76.2 | 0 | 46 | 116.8 | 7 | 75 | 190.5 | 8 | | 1 | 0 | 1 | 0 | 2 | 0 | 3 |
| 2 | 7 | 50 | 1 | PSSH: 2n | 24 | 60.96 | 0 | 41 | 104.1 | 0 | 90 | 228.6 | 0 | 112.00 | | | | | | | 3 |
| 2 | 7 | 51 | 1 | PSSH: 2n | 32 | 81.28 | 2 | 46 | 116.8 | 9 | 81 | 205.7 | 10 | | 1 | 1 | 5 | 1 | 7 | 1 | 3 |
| 2 | 7 | 52 | 1 | PSSH: 2n | 33 | 83.82 | 0 | 48 | 121.9 | 2 | 96 | 243.8 | 2 | | | | | | | | 3 |
| 2 | 7 | 53 | 1 | PSSH: 2n | 26 | 66.04 | 0 | 46 | 116.8 | 2 | 96 | 243.8 | 2 | 112.00 | | | | | | | 3 |
| 2 | 7 | 54 | 1 | PSSH: 2n | 27 | 68.58 | 2 | 48 | 121.9 | 5 | 96 | 243.8 | 5 | 112.00 | 1 | 0 | 2 | 0 | 3 | 0 | 3 |
| 2 | 7 | 55 | 1 | PSSH: 2n | 20 | 50.8 | 0 | 35 | 88.9 | 5 | 70 | 177.8 | 5 | | | | | | | | 3 |
| 2 | 7 | 56 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 36 | 91.44 | 0 | 76 | 193 | 0 | | | | | | | | 3 |
| 2 | 7 | 57 | 1 | PSSH: 2n | 25 | 63.5 | 0 | 47 | 119.4 | 6 | 79 | 200.7 | 8 | | | | | | | | 3 |
| 2 | 7 | 58 | 1 | PSSH: 2n | 22 | 55.88 | 1 | 39 | 99.06 | 1 | 78 | 198.1 | 1 | 109.00 | | | | | | | 3 |
| 2 | 7 | 59 | 1 | PSSH: 2n | 11 | 27.94 | 0 | 40 | 101.6 | 4 | 96 | 243.8 | 5 | 94.00 | 6 | 4 | 6 | 4 | 8 | 4 | 3 |
| 2 | 7 | 60 | 1 | PSSH: 2n | 12 | 30.48 | 0 | 37 | 93.98 | 5 | 72 | 182.9 | 5 | | | | | | | | 3 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.

Table 49 (Continued). Raw supplemental data used for analyzation for “Field Evaluation and Characterization of *Sorghum bicolor* x *S. propinquum* hybrids”.

| Grouping[Z] | Row[Y] | Entry[X] | Field Number[W] | Plant Species | 30 Day Height (In) | 30 Day Height (cm) | # of Tillers (30 Days | 60 Day Height (In) | 60 Day Height (cm) | # of Tillers (60 Days) | 90 Day Height (In) | 90 Day Height (cm) | # of Tillers (90 Days) | Days to Midbloom | 4/1/2019 BT[V] | 4/1/2019 RDS[U] | 4/15/2019 BT | 4/15/2019 RDS | 4/29/2019 BT | 4/29/2019 RDS | Blcok[T] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 7 | 61 | 1 | PSSH: 2n | 7 | 17.78 | 0 | | | | | | | | | | | | | | 4 |
| 2 | 7 | 62 | 1 | PSSH: 2n | 23 | 58.42 | 0 | 31 | 78.74 | 0 | 71 | 180.3 | 0 | 86.00 | | | | | | | 4 |
| 2 | 7 | 63 | 1 | PSSH: 2n | 10 | 25.4 | 1 | 24 | 60.96 | 2 | 61 | 154.9 | 3 | | | | | | | | 4 |
| 2 | 7 | 64 | 1 | PSSH: 2n | 14 | 35.56 | 0 | 27 | 68.58 | 0 | 54 | 137.2 | 0 | 107.00 | | | | | | | 4 |
| 2 | 7 | 65 | 1 | PSSH: 2n | 7 | 17.78 | 2 | | | | | | | | | | | | | | 4 |
| 2 | 7 | 66 | 1 | PSSH: 2n | 32 | 81.28 | 0 | 60 | 152.4 | 7 | 65 | 165.1 | 11 | 53.00 | 2 | 4 | 2 | 4 | 4 | 4 | 4 |
| 2 | 7 | 67 | 1 | PSSH: 2n | 15 | 38.1 | 0 | 38 | 96.52 | 3 | 60 | 152.4 | 4 | | 2 | 0 | 2 | 0 | 2 | 0 | 4 |
| 2 | 7 | 68 | 1 | PSSH: 2n | 17 | 43.18 | 0 | 34 | 86.36 | 0 | 77 | 195.6 | 4 | 112.00 | | | | | | | 4 |
| 2 | 7 | 69 | 1 | PSSH: 2n | | | | | | | | | | | | | | | | | 4 |
| 2 | 7 | 70 | 1 | PSSH: 2n | 18 | 45.72 | 0 | 30 | 76.2 | 2 | 48 | 121.9 | 5 | 43.00 | | | | | | | 4 |
| 1 | 7 | 71 | 4 | SOPR | 14 | 35.56 | 0 | 18 | 45.72 | 8 | 48 | 121.9 | 15 | 118.00 | 2 | 2 | 3 | 2 | 4 | 1 | 4 |
| 1 | 7 | 72 | 4 | SOPR | 8 | 20.32 | 0 | | | | | | | | | | | | | | 4 |
| 1 | 7 | 73 | 4 | SOPR | 4 | 10.16 | 0 | | | | | | | | | | | | | | 4 |
| 1 | 7 | 74 | 4 | SOPR | 13 | 33.02 | 0 | 20 | 50.8 | 2 | 48 | 121.9 | 10 | 118.00 | | | | | | | 4 |
| 1 | 7 | 75 | 4 | SOPR | 7 | 17.78 | 0 | 18 | 45.72 | 0 | 48 | 121.9 | 4 | 118.00 | | | | | | | 4 |
| 1 | 7 | 76 | 4 | SOPR | 16 | 40.64 | 1 | 24 | 60.96 | 0 | 45 | 114.3 | 8 | 118.00 | | | | | | | 4 |
| 1 | 7 | 77 | 4 | SOPR | 14 | 35.56 | 1 | 12 | 30.48 | 1 | 24 | 60.96 | 2 | 118.00 | | | | | | | 4 |
| 1 | 7 | 78 | 4 | SOPR | 6 | 15.24 | 0 | | | | | | | | | | | | | | 4 |
| 1 | 7 | 79 | 4 | SOPR | 18 | 45.72 | 0 | 18 | 45.72 | 2 | 45 | 114.3 | 12 | 118.00 | | | | | | | 4 |
| 1 | 7 | 80 | 4 | SOPR | | | | | | | | | | | | | | | | | 4 |

[Z]Grouping: Group 1 was directly used for analysis of variance, groups 1 and 2 were used for subsampling and hybrid comparisons, group 3 was not directly used for this study.
[Y]Row: A single, linear column where plants were transplanted into; between row spacing of 106 cm.
[X]Entry: Individual plant within a row.
[W]Field Number: Assigned number to each plant species.
[V]BT: Basal tiller.
[U]RDS: Rhizome derived shoot.
[T]Block: Used to control field variation.