

## **Dedication**

To the soul of my mother Saadia Bit  
Mohammed Ahmed.

To my father who lights me the candles of  
love and support.

To my really mother Salowa who beat of her  
heart provides generosity and warmth.

To my faithful brother Basheer for his  
patience and constant encouragement during the  
study period.

To my family members Temeara, AAbody,  
Alofa, AAlam and friends and to every one who  
contributed to the success of this study.

With love and respect.

**Zeinab**

## **ACKNOWLEDGEMENT**

I am first thankful to the Almighty Allah who had given me the strength and patience till completing this study.

I feel very happy to express my all great feeling to Dr. Maarouf Ibrahim Mohammed for his keen supervision and guidance during the course of this study.

I also thank Dr. Ahmed Ali Mohamed Osman for his great help during this study.

I would like to express my sincere thanks to the technical staff of Seed Quality Control of the Seed Production Administration – Ministry of Agriculture – Sennar State for their unlimited help. Special thanks goes to Mariam Abdelhaleem.

Deep thanks to the technical staff of Sennar Research Station particularly Masaad Bakhiet.

## CONTENTS

	Page
Dedication	i
Acknowledgement	ii
Contents	iii
List of Tables	vi
List of Appendices	x
Abstract	xi
Arabic Abstract	xiii
<b>CHAPTER ONE: INTRODUCTION</b>	<b>1</b>
<b>CHAPTER TWO: LITERATURE REVIEW</b>	<b>5</b>
2.1. General background	5
2.1.1. Adaptability and uses	6
2.1.2. The genetic resource	7
2.2. Variability in forage sorghum	8
2.3. Forage sorghum research in the Sudan	12
2.3.1. Forage Improvement Program at Shambat	14
2.4. Approximate analysis of forage quality traits	16
2.4.1. Crude protein (CP)	16
2.4.2. Acid detergent fiber (ADF)	16
2.4.3. Neutral Detergent Fiber (NDF)	16
2.5. Research in quality traits of forage sorghum	17
2.6. Brown mid-rib (bmr) trait	21
<b>CHAPTER THREE: MATERIALS AND METHODS</b>	<b>24</b>
3.1. The experimental site	24

3.2. Plant materials	24
3.3. Management	24
3.4. Treatments and experimental design	25
3.5. Data collection	25
3.6. Proximate analysis for forage quality traits	26
3.7. Statistical Analysis	26
<b>CHAPTER FOUR: RESULTS</b>	29
4.1. Agronomic performance	29
4.2. Forage yield in single environments	30
4.3. Yield related traits in single environments	30
4.4. Agronomic performance combined over the two environments	31
4.5. Proximate analysis for forage quality traits	32
4.6. Performance of quality traits in single environments	33
4.6.1. Crude protein (CP)	33
4.6.2. Neutral detergent fiber (NDF)	34
4.6.3. Acid detergent fiber (ADF)	34
4.6.4. Ether extract (EE)	34
4.6.5. ASH	34
4.7. Quality performance combined over the two environments	34
4.8. Contrast and Correlation study	36
<b>CHAPTER FIVE: DISCUSSIONS</b>	66
<b>CONCLUSION</b>	70
<b>REFERENCES</b>	72
<b>APPENDICES</b>	82

## LIST OF TABLES

Table		Page
1.	Table 1. Forage sorghum germplasm used in the study	27
2.	Source of variations and partition of degrees of freedom used in the analysis	28
3.	Mean squares from single ANOVA for some characters in forage sorghum based on data taken from 12 genotypes evaluated at two growth stages (Shambat, 2005)	38
4.	Mean squares from single ANOVA for two characters in forage sorghum based on data taken from 10 genotypes evaluated at two growth stages (Sennar, 2006)	39
5.	Mean squares from single ANOVA for days to flowering obtained from different forage sorghum genotypes grown at two environments	40
6.	Mean squares from combined ANOVA for two characters in forage sorghum based on data of 10 genotypes evaluated at two environments and two growth stage (Shambat 2005, Sennar 2006)	41
7.	Mean squares from combined ANOVA for days to flower based on data obtained form 10 genotypes evaluated at two environments (Shambat 2005, Sennar 2006)	42
8.	Agronomic performance of different forage sorghum genotypes for green (GMY) dry (DMY) matter yield and two yield related traits (Shambat,2005)	43
9.	Green matter yield (GMY) and related traits obtained by different forage sorghum genotypes grown at Sennar (2006)	44
10.	Effect of growth stage on green (GMY) and dry (DMY) forage yield of 12 forage sorghum genotypes grown at Shambat (2005) and Sennar (2006)	45
11.	Green matter yield (GMY) and Plant height obtained from combined data of different forage sorghum genotypes (Shambat 2005, Sennar 2006)	46
12.	Effect of interaction of genotype with environment on green matter yield (t/ha) of 10 forage sorghum genotypes	47

13.	Effect of interaction of genotype with environment on plant height of 10 forage sorghum genotypes grown at two environments	48
14.	Effect of interaction of genotype with growth stage on green matter yield (t/ha) of 10 forage sorghum genotypes grown at environments (Shambat 2005, Sennar 2006)	49
15.	Mean squares from single ANOVA for acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), Ash and ether extract (EE) of 12 forage sorghum genotypes grown at Shambat (2005)	50
16.	Mean squares from single ANOVA for acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), Ash and ether extract (EE) of 12 forage sorghum genotypes grown at Sennar (2006)	51
17.	Mean squares from combined ANOVA for acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), Ash and ether extract (EE) of 10 forage sorghum genotypes grown at two environments (Shambat 2005, Sennar 2006)	52
18.	Performance of different forage sorghum genotypes for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE) and Ash (Shambat, 2005)	53
19.	Performance of different forage sorghum genotypes for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE) and Ash (Sennar, 2005)	54
20.	Performance of different forage sorghum genotypes for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE) obtained from data combined over two environments (Shambat 2005, Sennar 2006)	55
21.	Effect of growth stage on some quality attributes of forage sorghum based on data combined over two environments	56

	(Shambat 2005, Sennar 2006)	
22.	Effect of plant part on some quality attributes of forage sorghum based on data combined over two environments	
	(Shambat 2005, Sennar 2006)	57
23.	Effect of interaction of plant part with growth stage on some quality traits of forage sorghum based on data combined over two environments (Shambat 2005, Sennar 2006)	58
24.	Effect of interaction of genotype with plant part on Ash in forage sorghum based on data combined over two environments (Shambat 2005, Sennar 2006)	59
25.	Effect of interaction of environment with plant part and growth stage on crude protein (CP) in forage sorghum based on data combined over two environments (Shambat 2005, Sennar 2006)	60
26.	Effect of interaction of environment with plant part and growth stage on percentage of neutral detergent fiber (NDF) based on data of 10 forage sorghum genotypes combined over two environments (Shambat 2005, Sennar 2006)	61
27.	Effect of interaction of environment with plant part and growth stage on percentage of ether extract (EE) based on data of 10 forage sorghum genotypes combined over two environments (Shambat 2005, Sennar 2006)	62
28.	Effect of interaction of environment with plant part and growth stage on percentages of Ash based on data of 10 forage sorghum genotypes combined over two environments (Shambat 2005, Sennar 2006)	63
29.	Performance of selected forage sorghum genotypes in contrast to their parental populations for green matter yield (GMY) and some quality traits based on data combined over two environments (Shambat 2005, Sennar 2006)	64
30.	Correlation of some quality traits with forage yield in forage	65

sorghum



## **List of Appendices**

<b>Appendix</b>		<b>Page</b>
(I)	Monthly mean of temperature (0C), rainfall (mm) and relative humidity (R.H%) during the growing season at Shambat (2005 – 2006)	82
(II)	Monthly mean of temperature (0C), rainfall (mm) and relative humidity (R.H%) during the growing season at Sennar (2006 – 2007)	83
(III)	Physical and chemical properties of the experimental sites	84

## ABSTRACT

An experiment was conducted at two environments (Shambat 2005 and Sennar 2006) to investigate the agronomic and quality performance at different growth stages and plant parts using 12 forage sorghum genotypes representing the major local stocks of forage sorghum in the Sudan. The treatments were arranged in RCBD with the growth stage imposed on genotype as split in time and the plant part was further split on growth stage. Agronomic and quality traits studied included: Green and dry matter yields, days to flowering, plant height, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), ash and ether extract (EE).

Significant differences were detected among genotypes in forage yield and plant height. Interaction of genotype with environment was significant for both characters pointing to the differential performance of genotypes across environment.

The recommended cultivar (Kambal) ranked first in GMY; however, it was not significantly different from that of the check Abu Sab'in. The genotypes ANK43 from Ankolib and SG32-2A from Sudan Grass significantly outyielded their respective parental populations.

Significant differences among genotypes were detected for NDF but not for CP, ADF, EE, and ASH. Differences between growth stages were significant for ADF, NDF and CP. Differences between plant parts were significant for ADF, CP and ASH. The interaction of growth stage with plant part was significant for all traits other than ADF.

The CP at boot stage was significantly higher than that obtained at dough stage. The NDF and ADF percentages were significantly lower at boot than dough stage. CP and Ash in the leaf were significantly higher than those in the stem. ADF percentage in the leaf was

.significantly lower than that in the stem

The association study revealed that correlation of forage yield with crude protein was significantly negative, with ADF was significantly positive and with NDF was also positive but insignificant. Correlation of crude protein with NDF was significantly negative and .with ADF, EE Ash was also negative but insignificant

The forage yield, but not quality attributes of the selected lines has been improved over their parental population; this has been .attributed to the adverse association between forage yield and CP

The results obtained in this study suggest that harvesting at boot .stage will maximize the benefits gained from forage sorghum

## المستخلص

تم إجراء التجربة في مو قعين (شمبات 2005، سنار 2006) لدراسة الأداء الد قلّي والمحتوى الغذائي لمراحل نمو مختلفة (الحملة، العجينة) ودراسة أجزاء النبات (الساق، الأوراق). استعملت 12 سلالة من الأصول المحلية للذرة العلفية الرفيعة في السودان، تم وضع المعاملات في تصميم كامل العشوائية باعتبار مراحل النمو قطع منشقة زمانياً على الأصناف وأجزاء النبات منشقة على مراحل النمو. تضمنت الدراسة الأداء الد قلّي وصفات النوعية (الإنتاجية الخضراء والجافة، عدد أيام الإزهار، طول النبات، البروتين الخام CP، الألياف الذائبة في وسط متعادل (NDF)، الألياف الذائبة في وسط حامض (ADF)، الرماد (Ash)، ومستخلص الايثر (EE). تم العثور على فروق معنوية بين السلالات في الإنتاجية وطول النبات. التفاعل بين السلالات والبيئة كان معنوياً لصفتي الطول والإنتاجية مشيراً إلى عدم ثبات أداء السلالات عبر المواقع. الصنف المحسن كمبال كان أعلى في الإنتاجية الخضراء غير أن إنتاجيته لا تختلف معنوياً عن الصنف التقليدي أبو سبعين. السلالات ANK 43 من العنكوليب و 2A-32 من حشيشة السودان تفوقت في الإنتاجية على العشائر الأم لكل منهما. تم العثور على فروق معنوية بين السلالات بالنسبة NDF بينما لم يعثر على فروق معنوية بالنسبة Ash, EE, ADF, CP. الاختلاف بين مراحل النمو (طور الحملة، طور العجينة) كان معنوياً بالنسبة CP, NDF, ADF. التفاعل بين مراحل النمو وأجزاء النبات كان معنوياً لكل الصفات عدا ADF. النسب المئوية لـ ADF, NDF أقل معنوياً في طور الحملة عنها في طور العجينة. البروتين الخام والرماد في الأوراق أعلى من الساق. نسبة الـ ADF في الأوراق أقل من الساق. أوضحت الدراسة تلازم معنوي سالب بين إنتاجية العلف والبروتين الخام وتلازم معنوي إيجابي بين الإنتاجية و ADF، التلازم بين الإنتاجية و NDF كان إيجابياً من غير فروق معنوية. التلازم بين البروتين الخام و NDF كان سالباً معنوياً ومع ADF, EE, Ash كان سالباً أيضاً ولكن من غير فرق معنوي.

إنتاجية العلف بالنسبة للسلا لات وليست الصفات المرتبطة بالقيمة التغذوية قد تحسنت مقارنة بالعشائر الأم ويعزى ذلك إلى العلاقة المتعاكسة بين صفتي الإنتاجية والبروتين الخام. الحصاد في طور الحملة يعمل على معظمة المكتسبات الكمية والنوعية لأعلاف الذرة الرفيعة.