Effect of nitrogen fertilization on growth, yield and ethanol production of sweet sorghum (*Sorghum bicolor* (L. Moench)

أثر التسميد النيتروجيني على النمو والإنتاجية وإنتاج الايثانول للذرة الحلوة
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المستخلص:

أجريت هذه التجارب لمعرفة أثر التسميد النيتروجيني علي نمو وإنتاجية السيفان والعصير ومحتوى السكر وإنتاجية الايثانول من الذرة الحلوة. تم إجراء التجارب في شهر أكتوبر 2013 في المزرعة التجريبية لكلية الزراعة - جامعة الخرطوم - شمبات. والمزرعة التجريبية لمحطة أبحاث سوبا لاستصلاح الأراضي الملحية والصودية - هيئة البحوث الزراعية. اشتملت المعاملات على ثلاثة معدلات من سماد النيتروجين (اليوريا) هي صفر، 43 و 86 كيلو جرام نيتروجين للهكتار، واثنين من الطرز الوراثية هما بلدية ومنتخبة RSSS.11. صممت التجارب على نظام التجارب كاملة العشوائية بأربعة مكررات. أظهرت النتائج أن هنالك فروقات معنوية ($P \geq 0.05$) بين الطرز الوراثية في سمك الساق في موقع سوبا وفي طول النبات ومساحة الأوراق في موقع شمبات وفي عدد الأوراق الخضراء في النبات الواحد وإنتاجية السيقان والعصير والايثانول في الموقعين. وان العينة RSSS.11 كانت في الغالب أحسن في نتائجها من العينة البلدية. وان التسميد النيتروجيني أد إلى زيادة معنوية ($P \geq 0.05$) في عدد الأوراق الخضراء في النبات الواحد ومساحة الأوراق في موقع شمبات وفي طول النبات وإنتاجية العصير والايثانول في الموقعين وسجل موقع سوبا نتائجاً أعلى من موقع شمبات كما أعطت

المعاملة 86 كيلو جرام نيتروجين للهكتار أعلى كمية (255.61 لتر للهكتار)
ايتانول.

الكلمات المدخلية: الوقود الحيوي، الذرة الحلوة، النيتروجين، العصير، السكريات،
الايتانول

Abstract

Field trials were carried out to test the effect of nitrogen fertilization on the growth, stalks and juice yield, sugar content and ethanol production of sweet sorghum. The experiments were carried out on winter 2013 in the Domonstration Farm of the Faculty of Agriculture, University of Khartoum, Shambat and Experimental Farm of the Soba Research Station for Reclamation of Saline and Sodic soils. The treatments comprised the addition of nitrogen fertilizer (urea) at three levels (0, 43 and 86 Kg N ha⁻¹) and two sweet sorghum genotypes (Baladi and RSSS.11), arranged in randomized complete block design replicated 4 times. Results indicated that there were significant ($P \geq 0.05$) differences between genotypes in stem diameter at Soba location, stalk height and leaves area at Shambat location, number of green leaves per plant, stalk juice and ethanol yield in both locations. With the genotype RSSS.11 generally superior over genotype Baladi. Nitrogen fertilization increased significantly ($P \geq 0.05$) number of green leaves per plant and leaves area at Shambat location and plant height and juice and ethanol yield in both locations. With the Soba location recorded the highest values over Shambat location and 86 kg N ha⁻¹ recorded the highest ethanol yield (255.6l h⁻¹).

Keywords: bio fuel, sweet sorghum, nitrogen, juice, sugar, ethanol.

Introduction

The world depends heavily on crude oil for its energy fuels, which is limited natural resources and contributes to global warming. Therefore, there is a need for exploration of clean and renewable energy sources which are cost effective and eco-friendly such as bio fuels(e. g. bioethanol and biodiesel) (Cifuentes et al.,2014).

Bioethanol is a fuel that can be produced from biomass by action of micro – organisms and enzymes through the fermentation of sugars, starches or

cellulose. It's the most common biofuel worldwide particularly in Brazil. Moreover, it's a colorless liquid, clean burning fuel with high octane rating and it can be blended with petrol to the extent of 15-20% (Shinde et al., 2013). It increasingly being used as a substitute fuel for root transport application. Plants, used for production of bioethanol include maize, corn, potato, sugar beet, sugarcane, sweet sorghum and cassava (Mutepe, 2012). One the other hand, pure ethanol is used in medicine, beverage, as a solvent, cosmetic, detergents and disinfectants, food and drug processing, surface coating, pharmaceutical and in combustion engines as a stand alone fuel, fuel extender in petroleum blends and as an additive.

Sweet sorghum received considerable attention in recent years for use as a biofuel crop. It's a C4 crop in the grass family, capable of producing high biomass and sugar yield and the only crop which produces grain and sweet stalk that can be used as a

substrate for the production of sugar, ethanol, syrup, fodder, fuel, bedding, roofing, fencing and paper (Laopaiboon et al., 2006). It possesses characteristics such as short growth cycle(4 months), low fertilizer requirement, high water use efficiency, ability to adopt well to diverse climatic and soil conditions and accumulate sugars in the stalks (Almodares et al., 2007). The juice which extracted from the fresh stalks composes of sucrose, glucose and fructose that can be readily fermented to bioethanol. Therefore, it was considered as an attractive feedstock for ethanol production (Wu et al., 2008).

Biofuels are widely blamed for driving food prices higher and causing food riots in many countries. With Sweet sorghum however, only the plant's stalks which contains readily fermentable sugars at high concentration are used for biofuel production while the grains can be utilized for food or livestock feed. Sweet sorghum in Sudan locally called ankolib. It grown mainly in the areas south of Gedarif, kosti, Eldeweim, Sennar , El souki, Darfur and Gezira for its sweet stalks. Which mainly used for chewing and syrup was produced from condensed juice. The vegetative part is used as forage and the grains are used as feed for livestock and birds (Sir ElKhatim, 2003). On the other hand, currently sugarcane molasses are the main raw materials used for bioethanol production in Sudan (Kenana Sugar Company). Ahmed,(2014) stated that molasses – based ethanol distillery at Kenana operates only for 180 – 200 days year⁻¹ and this is due to lack of supply of feedstock. Thus, they are in need of other sugar rich crops to be a supplementary feedstock to molasses. Therefore, the use of sweet sorghum In Sudan could be extended to produce more useful products.

There are many factors affecting growth and yield of sweet sorghum among them, nutrient supply is the primary factor. Reports on nitrogen requirement of sweet sorghum revealed that inadequate supply of nitrogen result in lower yield and sugar per unit area, while excessive application result in poor juice quality (Reddi, 2006). Regarding this Gardner et al. (1994) showed that sweet sorghum has good nitrogen use efficiency and Johnston (2000) reported that application of nitrogen fertilizer increase sweet sorghum stalks yield, sucrose content, protein% and growth rate .

The main objective of this study was to evaluate the effect of nitrogen fertilization on the production of ethanol from two genotypes of sudanese sweet sorghum. While specific objectives were to evaluate the effect of nitrogen fertilization on growth, biomass and juice yield, Sugar content and ethanol production.

Materials and methods

Field experiments were conducted at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum, Shambat and Experimental Farm of the Soba Research Station for Reclamation of Saline and Sodic soil –Agricultural Research Corporation on October 2013. The two experimental sites were disc ploughed, finely harrowed, leveled, ridged at 0.7 meter apart and divided into plots (4x5 meter) with five rows and arranged in a randomized complete block design with 4 replications. Two sweet sorghum genotypes were used in this study. One of them was Baladi obtained from the local market and the other one RSS.11 was Sudanese Selection from local sweet sorghum

provided by Dr. Abdelwahab Hassan Abdalla at the Department of Agronomy Faculty of Agriculture, University of Khartoum. 5 seeds per hole at spacing of 0.2 meter between holes were sown on side of ridge. A basal dressing of triple superphosphate was applied to all plots at rate of 43 Kg P₂O₅ ha⁻¹ as bands near to the plant at the time of sowing. A light irrigation was applied immediately after planting with subsequent irrigation intervals of 7-10 days. After 15 days the plants were thinned to two plants per hole. Nitrogen fertilizer as urea was applied at 3 levels (0, 43 and 86 Kg Nha⁻¹) designated as N0, N1, and N2 respectively in bands at the side of the furrow before the third irrigation. Pesticide (folemat) was used to control stem borers. At the hard dough stage 10 stalks were selected randomly from the three Inner rows in each plot for measurement of Stalk height, stem diameter, total number of green leaves and leaf area which was calculated as follows:

Leaf area plant⁻¹(cm²) = leaf length x leaf width x0.75 x number of green leaves (Stickler et al., 1961).

The trials were harvested at the hard dough stage; ten random plants were selected from each plot from the two Inner rows and were cut about 4.5 cm above ground level. Leaves and ear heads were removed from the stalks and the stripped stalks yield was recorded as fallows.

$$\text{Cane yield (Ton ha}^{-1}\text{)} = \frac{\text{Weight of stripped stalk (kg)} \times 10000}{\text{Harvested area (m}^2\text{)} \times 1000}$$

The stripped stalks were crushed with three roller crusher and juice yield was expressed as:

Juice yield ($l\ ha^{-1}$) = volume of juice extracted (ml) x millable stalks yield ($Ton\ ha^{-1}$) / weight of stripped stalks (Kg)

The total sugar and reducing sugar content of the juice was determined according to the method described by (AOAC, 2000). Sucrose was determined by calculation from the total and reducing sugar as reported by AOAC (2000). Ethanol was determined by high performance liquid Chromatograph (HPLC) as described by Mancilha et al. (1984).

Statistical Analysis

Analysis of variance for the individual experiments was performed following the standard procedure of analyzing the randomized complete block design (Steel and Torrie, 1960). The means were separated using the least significant differences procedure (LSD).

Results and discussion

The recorded values of stalk height of sweet sorghum in Table 1 showed that it generally increases with the increase of nitrogen dose with significant ($P \geq 0.05$) difference of N2 from control and without significant difference of N1 from control and N2 in Shambat location while in Soba location application of N1 increased stalk height significantly ($P \geq 0.05$) compared to control without further increase with N2. These findings were in line with that of Johnston (2000) and Nour (2010). The possible explanation of this could be due to the positive effect of added nitrogen on plant growth parameters that lead to progressive increase in internodes length and consequently plant height. On

the other hand, the difference in stalk height between genotypes in shambat location was significant ($P \geq 0.05$) and this suggest varietal differences in response to nitrogen application. While in Soba location the difference was minor. Significant difference between genotypes in stalk height had been reported by many research workers (ElSharief, 1993; Alkhalifa, 2009; Nour, 2010).

Table 1: Mean plant height (cm) of sweet sorghum genotypes as affected by nitrogen

Genotype	Shambat location			Main genotype effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	123.79	143.91	152.54	140.08	149.58	149.58	141.33	146.83
RSSS.11	113.81	130.79	143.37	129.32	138.71	149.37	157.33	148.47
Main N effect	118.80	137.35	147.16		144.15	149.48	149.33	

LSD 5% (N) = 27.3

LSD 5% (N) = 4.0945

LSD 5% (G) = 5.831

LSD 5% (G) = 10.275

C.V. (N) = 9.85

C.V. (N) = 1.73 %

C.V (V) = 3.7 %

C.V (G) = 6.03%

Mean stem diameters of sweet sorghum were presented in Table 2. Genotype RSSS.11 has higher stem diameter than genotype Baladi in both locations and the difference between them was only significant ($P \geq 0.05$) at Soba location. These results agreed with the finding of Elsharief, (1993); Alkhalifa,(2009); Nour,(2010). Regarding the effect of nitrogen fertilizer on stem diameter, it was observed that the stem diameter increases with

increasing of nitrogen level without significant difference between them in both locations. This increase might be due to the positive effect of nitrogen on plant growth similar findings were reported by Gasim (2002) and Ibrahim(2004).

As shown in Table 3 the applied nitrogen fertilizer increased the number of green leaves per plant except for N2 at Soba location compared to the control

Table 2: Mean stem diameter (mm) of sweet sorghum genotypes as affected by nitrogen

Genotype	Shambat location			Main genotype effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	9.86	11.64	13.20	11.57	12.92	15.27	14.35	14.18
RSSS.11	11.07	11.72	13.07	11.95	15.82	14.71	15,68	15.40
Main N effect	10.47	11.68	13.14		14.37	14.99	15.01	

LSD 5% (N) = 3.80

LSD 5% (N) = 1.52

LSD 5% (G) = 1.7

LSD 5% (G) = 0.86

C.V. (N) = 13.19%

C.V. (N)= 5.05%

C.V. (G) = 15.70 %

C.V. (G) = 6.40%

in both location with significant ($P \geq 0.05$) difference only at shambat location .This was found before by Hegde and Relwani(1974) who reported an increase in number of leaves per plant with every increase in nitrogen and confirmed later by Nour (2010).The results also revealed that genotype RSSS.11 has

higher number of green leaves per plant with significant difference ($P \geq 0.05$) from genotype Baladi in both locations. In this context early workers (Mehra et al., 1970 and Sudewad 1976) showed that the number of leaves per plant varied from 5 to 25 among 526 genetic stalks and from 6 to 12 in a few genotypes respectively.

The attained results of leaf area of sweet sorghum revealed that it was increased with increasing of the level of the added nitrogen fertilizer in both locations with significant differences ($P \geq 0.05$) between them only at Shambat location (Table 4). It was also observed from the data that genotype RSSS.11 has more leaf area than genotype Baladi in the two locations with significant ($P \geq 0.05$) difference between them only at Shambat location. Considering this Lakkana et al. (2009) reported that various sweet sorghum genotypes differ widely in their adaptation to various soil and climatic conditions.

Results of stalks yield (ton ha^{-1}) were presented in Table 5. Genotype RSSS.11 significantly ($P \geq 0.05$) out yielded genotype Baladi in the two

Table 3: Mean number of green leaves /plant of sweet sorghum genotypes as affected by nitrogen

Genotype	Shambat location			Main genotype effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	5.46	5.56	6.48	5.83	6.25	6.66	6.25	6.39
RSSS.11	5.99	6.42	7.16	6.52	6.59	7.46	7.75	7.27
Main N effect	5.72	5.99	6.82		6.42	7.06	6.99	

LSD 5% (N) = 0.82

LSD 5% (N) = 1.22

LSD 5% (G) = 0.61

LSD 5% (G) = 0, 42

C.V. % (N) = 6.42%

C.V. % (N) = 11.13%

C.V. % (G) = 8.61%

C.V. % (G) = 5.28%

Table 4: Mean leaf area (cm² plant⁻¹) of sweet sorghum genotypes as affected by nitrogen

Genotype	Shambat location			Main genotype effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	829.8	1004.6	1708.6	1181.0	1668.0	1665.8	1703.9	1679.2
RSSS.11	981.5	1203.0	1668.3	1284.3	1587.1	1798.5	2147.6	1844.4
Main N effect	905.6	1103.8	1668.4		1627.5	1732.1	1925.8	

LSD 5% (N) = 467.02

LSD 5% (N) = 410.68

LSD 5% (G) = 66.63

LSD 5% (G) = 196.60

C.V. (N) = 18.40%

C.V. % (N) = 14.54%

C.V. (G)= 4.69%

C.V. % (G) = 2.01%

locations .This was in agreement with the findings of Miri and Rana (2014). It worth mentioning that genotype RSSS.11 except for plant height at shambat location recorded the highest growth parameters(number of green leaves per plant, stalk diameter and leaf area)compared to genotype Baladi which has been reflected in higher stalk yield of genotype RSSS.11 over genotype Baladi . Regarding, stem diameter Makanda et al, (2009) and Mutkule (2010) reported that there was positive and highly significant correlation of stalk diameter with biomass. The data in Table 5 also showed that the addition of nitrogen fertilizer increased yield by 30.93% and 34.44% for the nitrogen level N1 and N2 respectively compared to control at Shambat location while in Soba location only N2 increased yield by 7.43 % compared to control without significant differences due to added nitrogen fertilizer in both location. Similar findings were recorded by Almodares et al (2007) who reported that the effect of nitrogen fertilization on stalk yield was non significant .In contrast to this Chittapur et al .(1994) ; Kurbanov (2001) ; Singh et al 2014) found reverse results and showed that nitrogen fertilization had significant effect on stalk yield.

Table 5: Mean stalk yield (ton ha⁻¹) of sweet sorghum genotypes as affected by nitrogen

Genotype	Shambat location			Main genotype effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	4.93	6.87	6.38	6.06	8.65	8.33	8.41	8.46
RSSS.11	6.47	8.03	8.91	7.80	9.36	9.52	10.95	9.95
Main N effect	5.69	7.45	7.64		9.01	8.93	9.68	

LSD 5% (N) = 2.97

LSD 5% (N) = 2.56

LSD 5% (G) = 1.18

LSD 5% (G) = 0.94

C.V. (N) = 26.71 %

C.V. (N) = 17.32%

C.V. (G) = 14.78%

C.V. (G) = 8.84%

The obtained results showed that, addition of nitrogen fertilizer increased the juice yield significantly ($P \geq 0.05$) compared to control in the two locations (Table 6). Similar findings were reported by Dhadeech et al. (2000) and confirmed by Singh et al. (2014). This increase in juice yield might be attributed to the effect of nitrogen on the development of growth parameters (leaves, roots and stems) which are pre-requisite for utilization of input resources, nutrients uptake and photosynthesis that play an important role in increasing productivity of juice. However, In Shambat location addition of N1 (43kg Nha⁻¹) gave the highest juice yield (2504.8 t ha⁻¹) which is significantly ($P \geq 0.05$) different from N0 (control), and N2 (86kg Nha⁻¹). While in Soba

location the juice yield increased with increasing of nitrogen level with N2 gave the highest juice yield (3729.9 l ha^{-1}) which significantly ($P \geq 0.05$) different from the other 2 levels (N0 and N1) of nitrogen .On the other hand, genotype RSSS.11 out yielded genotype Baladi significantly($P \geq 0.05$) in the two locations. These significant ($P \geq 0.05$) differences among genotypes in juice yield (l ha^{-1}) suggested genotypic differences in response to nitrogen. The differences between sweet sorghum genotypes in juice yield were well documented in literature (Miri and Rana, 2014).

Table 6: Mean juice yield (l ha^{-1}) of sweet sorghum genotypes as affected by nitrogen

Genotype	Shambat location			Main genotype effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	1149.1	1973.8	1481.5	1534.8	2601.9	2754.0	2776.9	2710.9
RSSS.11	1916.4	3035.8	3061.0	2671.1	3499.5	3515.6	4682.9	3899.3
Main N effect	1532.8	2504.8	2271.2		3050.7	3134.8	3729.9	

LSD 5% (N) =195 .89

LSD 5% (N) =1238.2

LSD 5 % (G) = 258.25

LSD 5 % (G) =346.79

C.V. % (N) = 5.81%

C.V. % (N) = 23.37 %

C.V % (NxG) =10.65

C.V. % (NxG) = 9.

Application of nitrogen fertilizer increased The Total sugar, reducing sugar and sucrose percentage of the sweet sorghum

genotypes compared to control without significant differences between different levels as shown in Table 7,8 and 9 respectively . The results of the effect of nitrogen in sucrose content were on line with finding of Almodres et al. (2007). While sumantri and lestari, (1997), Tsialtas and Maslaris (2005) reported that application of nitrogen increased sucrose content and growth rate. Moreover, There is no significant difference between the two genotypes in the percentage of the sugar although genotype RSSS.11 out yield genotype Baladi in the 3 kind of the sugars in Soba location and Genotype Balabi out yielded genotype RSSS.11 in total sugar and sucrose in Shambat location .The variation among genotypes in sugar % has been reported in literature before by Cifuentes et al. (2014)Teetor et al .(2011).

Table 7: Effect of nitrogen fertilizer on Total sugar (%) of sweet sorghum genotypes

Genotype	Shambat location			Main genotype effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	11.78	12.72	12.40	12.30	10.23	11.02	11.69	10.98
RSSS.11	11.29	12.09	11.67	11.68	11.19	10.29	12.43	11.31
Main N effect	11.54	12.10	12.04		10.71	10.66	12.02	

LSD 5% (N) = 2.75

LSD 5% (N) = 2.38

LSD5% (G) = 1.27

LSD 5 % (G) =1.65

C.V. (N) = 14.32%

C.V. (N) =13.32%

C.V. (G)= 9.21%

C.V. (G) =12.87%

Table 8: Effect of nitrogen fertilizer on reducing sugars (%) of sweet sorghum genotypes

Genotype	Shambat location			Main genotype effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	0.71	1.03	0.84	0.86	1.17	1.00	1.68	1.29
RSSS.11	1.15	1.4	0.94	1.17	1.34	1.23	1.94	1.50
Main N effect	0.93	1.22	0.89		1.26	1.12	1.81	

LSD 5% (N) = 0.39

LSD 5 % (N) = 0.73

LSD 5% (G) = 0.67

LSD5 % (G) = 0.78

C.V. % (N) = 23.74

C.V. % (N) = 23.70

C.V. % (G) = 58.60

C.V % (G) = 48.65

As shown in Table 10 genotype RSSS.1 was significantly ($P \geq 0.05$) superior over genotype Baladi in ethanol production in both locations. This result was in harmony with that attained by Miri and Rana (2014). The difference in ethanol productivity among sweet sorghum genotypes might have originated either by biological unavailability of the sugar and/ or presence of inhibitor

Table 9: Effect of nitrogen fertilizer on Sucrose (%) of sweet sorghum genotypes

Genotype	Shambat location			Main genotype effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	11.07	11.68	11.56	11.44	9.05	10.02	10.00	9.69
RSSS.11	10.14	11.36	10.73	10.75	9.85	9.73	10.49	10.02
Main N effect	10.61	11.52	11.15		9.45	9.88	10.25	

LSD 5% (N) = 2.34

LSD 5% (N) = 2.06

LSD 5% (G) = 0.78

LSD 5% (G) = 1.07

C.V. % (N) = 13.14

C.V % (N) = 13.06

C.V. % (G) = 6.12

C.V % (G) = 9.4

in certain sweet sorghum genotypes as suggested by Ratnavathi et al. (2010). Regarding the effect of nitrogen application on ethanol production, the result showed that addition of nitrogen generally increased ethanol production with 43kg N ha⁻¹ gave the highest ethanol yield (202. 69 l ha⁻¹) with significant ($P \geq 0.05$) difference from control and 86 Kg N ha⁻¹ at Shambat location while at Soba location 86 kg N ha⁻¹ gave the highest ethanol yield (255.6 l ha⁻¹) with significant ($P \geq 0.05$) difference from control and 43 kg N ha⁻¹. The obtained results were in line with the finding of Ratnavathi et al.(2010) and in controversy with that of Lueschen et al. (1991) who stated that the ethanol yield was not affected by application of nitrogen fertilizer.

Conclusions

The present investigation revealed that the genotypes differ in their response to nitrogen fertilization and that genotype RSSS.11 which is a selection from the local genotype performs better than the baladi genotype. Also soils differ in their response to nitrogen fertilization. Thus, in Shambat and Soba locations the highest yield of juice and ethanol were obtained by addition of nitrogen fertilizer at a rate 43 kg N ha^{-1} and 86 kg N ha^{-1} respectively. According to the results of this study it's clear that sweet sorghum can be considered as a promising feedstock for ethanol production in Sudan beside ethanol production from molasses. But this needs first to increase the juice

Table 10: Effect of nitrogen fertilizer on ethanol production (l ha^{-1}) of sweet sorghum genotypes

Genotype	Shambat location			Main genotyp effect	Soba location			Main genotype effect
	Nitrogen Rates				Nitrogen rates			
	N0	N1	N2		N0	N1	N2	
Baladi	81.48	165.11	117.39	121.32	159.32	173.08	212.18	181.52
RSSS.11	148.19	240.26	244.43	210.96	270.58	236.77	299.01	268.79
Main N effect	114.84	202.69	180.91		214.95	204.92	255.60	

LSD 5% (N) = 8.17

LSD 5% (N) = 18.35

LSD 5% (G) = 16.45

LSD 5% (G) = 13.09

C.V. % (N) = 3.07

C.V. % (N) = 5.09

C.V. % (G) = 5.09

C.V.% (G) =5.04

production and sugar content of the stalks so as to increase ethanol production through the improvement of cultural practices, physiological manipulation and breeding. Hence Breeder approach should target improvement of both ethanol and grain production and quality so that the produced sweet sorghum variety could be a dual purpose variety that can give food, fuel and feed and consequently increase its economical value.

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