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Journal of Agricultural and Veterinary Sciences
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Effect of Sowing Date and Nitrogen Fertilizer Rate on Yield of Sorghum (*Sorghum bicolor* L.) and Nitrogen Use Efficiency

Azrag, A.A.D [1*], Dagash, Y.M .I [2] and Yagoub, S.O.[2]

1.Department of Agronomy, Agricultural Science, University of Dalang
2.Department of Agronomy, Sudan University of Science and Technology, Shambat
*Corresponding author: E- mail: adoma_d@yahoo.com
Article history: Recieved: 25.01.2015
Accepted: 21.06.2015

Abstract
A field experiment was conducted at the College of Agricultural Studies, Sudan University of Science and Technology in Khartoum (Shambat), during two summer seasons 2011/2012 and 2012/2013, to study the effect of Sowing date and Fertilizer rate on growth of Sorghum (*Sorghum bicolor* L.). The cultivar used was Wad Ahmed. The experimental design used was split- plot arrangement (a randomized complete block design (CRBD) with three replications. The main plots were four Fertilizer rate control (No), 45kg/ha (N_1), 90kg/ha (N_2) and 135kg/ha (N_3), subplots were four sowing date on 1 st July (s_1), 15 th July (s_2), 1 st August (s_3) and 15 th August (s_4). Yield components which studied were length of head, seed weight /plant, 100. Seed weight, grain yield, harvest index and nitrogen use efficiency. The general trend was that sowing date had significant effect on harvest index in both seasons, grain yield in season one, length of head and 100. Seed weight in season two .Generally application of fertilizer resulted in significant effect on grain yield and nitrogen use efficiency in both seasons.

Key words: Fertilizer, Nitrogen use efficiency, Sorghum, Sowing date, Yield.

Introduction
Grain sorghum (S*orghum bicolor* L.) is an important cereal crop. It ranks fifth among the world's cereals. It is grown mainly in semi arid areas of the tropics and subtropics. Grain sorghum is a basic human food crop in many developing African and Asian countries. It is also used as an animal feed. The sorghum stalks are used as construction material and fire Fuel (Taha, 1998).

The total area under sorghum production in the world is more than 52 million hectares with an average grain yield of about 1.09 metric tons per hectare.
In Africa sorghum is important in the region from Ethiopia and south wards through east and central to South Africa. Africa produces less than 1/4 of the world total production with average yield less than 1/3 of the world average. Sorghum is a basic food crop in many developing African countries. It is

also used as animal feed and for industrial purposes (Abdalla, 1987).

Sorghum production in Sudan takes place in all three production systems. The irrigated sub-sector, the mechanized rain fed sector and the traditional rain fed sector (Taha, 1998).

Grain is easy to store and will not spoil when properly stored. It is easy to convert into food. Grains are excellent sources of necessary nutrients, particularly the carbohydrates which provide energy.

They are also easy to grow in different parts of the world (Douglas, et al, 1983). There are many verities of *sorghum bicolor*, ranging in grain color from white through red to brown and mixed classes in the grain standards (Baidab, 2012). Sorghum is broadly adapted and grown in a great range of environments. One of its strongest traits is its great adaptability to tropical and subtropical areas of the world where water availability and soil conditions are considered marginal for other grain crops. Under optimal conditions, sorghum has a high yields potential comparable to other cereals such as rice, maize or wheat (Mohamed, 2011).

Faddal (1963) found that sowing on August 25 led to low grain yield (662 kg/ha) compared with (1042 kg/ha) obtained on July 27 sowing. Fadlel Mula. (2009) reported that the grain yield was high (498-689 kg/fed), when the sowing date of sorghum starts early from the first to the 3rd week of July.

Fertilizer nitrogen has contributed more than any other fertilizer towards increasing yield of grain crops, including sorghum studies in the U.S.A and other parts or the world in the past 30 years, showed that nitrogen fertilizer increases yield of crops more than any other single factor(Olson et al 1986). Consequently, nitrogen has become the foremost input in relation to cost and energy requirement in advanced agricultural production systems (Yousif, 1993).

The objectives of this study were:

1- To study the effect of sowing time on yield of sorghum cultivar.

2- To determine the best nitrogen dose.

3- To calculate the nitrogen use efficiency.

Materials and Methods

This study was carried out during July – December for two consecutive seasons (2011/2012 and 2012/2013) in the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat. Latitude 1540N, Longistude 32 32E and 375 meters above sea level.The climate of the site is described as tropical semi arid with only three months of rainfall during July, August and September. Maximum temperature is above 40^{o}C in the summer and the minimum is around 20^{o}C in the winter season. The relative humidity ranges between 14-27% during dry season and 31-51% during the wet season.

The soil is typical clay soil, it is deep cracking, Moderately alkaline clays, low permeability, low nitrogen content and pH ranging between 7.5 – 8. Its low permeability is related to both high pH content and high exchangeable sodium percentage (ESP), in sub soils (Azrag, 2010).

Hybrid Sorghum (Wad Ahmed) seeds which were used in the experiment were obtained from the Gezira Research Station. A split plot arrangement in a randomized complete block design (R.C.B.D), with three replications was be used. The treatments components were as follows:

a. Variety Faterita wad Ahmed (FWA). This is a local commercial name for the new release (Osman and Mahmoud, 1992) pedigree A/239: 1/2/3 X Gadam ElHamam. Its grain hardness is medium (70-80%) it

ISSN (Print): 1858 6775 eISSN (Online): 1858-8775

stays green even after grain harvesting.

b. Sowing dates:
S_1 = 1st July, S_2 = 15th July, S_3 = 1 st August and S_4 = 15th August.

c. Nitrogen Rates.
Four nitrogen rates were applied, namely:
ON (control), 1N (45 Kg N/ha), 2N (90 kg N/ha and 3N (135 Kg N/ha).

Sowing was done by hand where five seeds per holes were sown on top of the ridge at 4-5 cm depth. The spacing between ridges and hole were 70 and 20 cm respectively. The plot size was 3x3 meters and each plot consisted of four ridges.

The fertilizer was side-dressed in the form of urea (46% N) 4 weeks after effective sowing i.e. at till ring.

The watering interval was 7-10 days in both seasons and the plants were thinned to two plants per hole after two weeks from sowing. Three manual weedings in each season were carried out. Stem borer was observed when the crop was 50 days old at the first sowing date (1th July) in first season and when the crop was 27, 75 days old in the first sowing date in the second sedson. The crop was sprayed with pychovex 480 EC and Delta plan 250 EC in first season and Zork a.i. Carbosulfan 25% EC and Fastac 100 EC in second season (Sudan university crop protection).

Head length (cm): The heads of four selected plants in each plot were measured and the average head length was recorded.

100- Seeds weight (g): 100-seeds were counted randomly then weighed for each plot of the four selected plants.The harvested plants from each plot were threshed and seed yields for each plot were recorded, yield per hectare was then estimated yield (t/ha).

$$\frac{\text{Wt. of seeds per plot}}{\text{Area of the plot}} \times \frac{10000\ m^2}{1000\ kg}$$

Harvest index: It was calculated as the radio of grain to total biological yields as follows:

$$\frac{\text{grain yield (t/ha)}}{\text{Biological yield (t/ha)}} \times 100$$

Nitrogen use efficiency (NUE): This was determined by dividing the grain yield by the N fertilizer applied, i.e., grain yield obtained per Kg N applied:

$$\frac{\text{grain yield (kg/ha)}}{\text{kg N/ha}}$$

The data were analyzed by computer, using the M STAT. C program.

The treatment means were compared using Duncan multiple range test (DMRT)

Results and Discussion

From the analysis of variance it was clear that sowing date had significant effect of (P=0.05) on length of head in the 2nd season. S_4 gave the longest heads in 1st season.On the other hand, the effect of fertilizer and interaction between sowing date and fertilizer were not significantly on length of head in both seasons. But there were significant differences (P = 0.05) in interaction between four levels of sowing date and four levels of fertilizer in both seasons. The longest heads were recorded for the treatment S4 with fertilizer dose 90 KgN/ha in 1st season and S1 with fertilizer dose 135 KgN/ha in 2nd season (Table 1) . Sowing date had highly significant effect on 100. Seeds weight in 2nd season and also there were significant differences a among the four levels of sowing date in 1st season, when S_2 recorded highest 100. Seeds weight. On the other hand, the fertilizer had no significant effect on 100. Seeds weight in both seasons.

The analysis showed that the interaction between sowing date and fertilizer had a significant effect on 100 seeds weight in 1st season. Also there were significant

differences in interaction between four levels of sowing date and four levels of nitrogen fertilizer. The highest weight of 100 seeds was recorded for the treatment S_4 with N_2 in 1st season and S_1 with N_3 in 2nd season (Table2). From the analysis of variance , it was clear that the sowing date had significant effect on grain yield in 1st season. Also there were significant differences between four levels of sowing date, when S_3 gaved highest grain yield (4.18 t/ha) 2nd season. The influence of fertilizer on grain yield had significantly effect in both seasons , also there were significant differences among the four levels of nitrogen fertilizer in both seasons, when fertilizer dose 135 KgN/ha gaved highest grain yield in both seasons . The interaction between sowing date and fertilizer had effected significantly grain yield in 2nd season. On the other hand, there were significant differences in interaction between levels of sowing date and levels of nitrogen fertilizer. The highest grain yield was recorded for the treatment sowing date (S_4) with fertilizer dose 90 kg N/ha in both seasons (Table 3). Statistical analysis showed that the sowing date had significantly effected harvest index in both seasons. Also there were significant differences between the levels of sowing date. The S_4 and S_3 gave the higher significant Harvest index in 1st season and 2nd season respectively.

The analysis showed that fertilizer and interaction between swing date and fertilizer had not significantly affected the Harvest index in both seasons but there were significant differences in interaction between four levels of sowing date and four level of nitrogen fertilizer.

The highest Harvest index was recorded for the treatment S_3 with fertilizer dose 90 Kg N/ha and sowing date (S_2) with fertilizer dose 135 KgN/ha in 1st season and 2nd season respectively (Table 4).

From the analysis of variance. It was evident that; sowing date had no significant effect on Nitrogen use efficiency in both seasons. The fertilizer had highly significant effect on Nitrogen use efficiency in both seasons. The application of 45 Kg N/ha gave the higher significant Nitrogen use efficiency in both seasons . The statistical analysis showed that the interaction between sowing date and fertilizer had significant effect on Nitrogen use efficiency in 2nd seasons. Also, there were significant differences in interaction between levels of sowing date and levels of nitrogen fertilizer. The highest nitrogen use efficiency was recorded for the interaction sowing date (S_2) with fertilizer dose 90 Kg N/ha in 1st season and sowing date (S_2) with fertilizer dose 45 KgN/ha in 2nd seasons (Table 5).

ISSN (Print): 1858 6775 eISSN (Online): 1858-8775

Table 1: Effect of sowing date and nitrogen rate on length of head (cm) of sorghum

	1st season					2nd season				
	Sowing-date									
Fertilizer	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
No	14.63 bc	15.07 bc	15.07 bc	14.37 c	14.79 a	15.40 cde	16.53 abcd	16.57 abc	16.87 abc	16.34 a
N_1	15.80 abc	15.23 bc	15.00 bc	14.97 bc	15.25 a	14.83 e	16.43 abcd	15.97 bcde	16.07 bcde	15.83 a
N_2	15.77 abc	16.20 ab	15.30 bc	17.37 a	16.16 a	15.03 de	16.33 abcde	16.53 abcd	16.20 abcde	16.02 a
N_3	15.90 abc	15.97 abc	15.67 abc	15.73 abc	15.82 a	17.63 a	17.23 ab	16.93 ab	17.40 ab	17.3 a
Mean	15.53a	15.62 a	15.26 a	15.61 a		15.72 a	16.63 a	16.5 a	16.64 a	
C.V					7.64					7.05
C.FS					0.99					1.47
C.FN					0.97					1.00
C.FSN					1.81					1.52

Means followed by different letters are significantlydifferent at $p < 0.05$ (Duncant test).Key S_1 = sowing date at 1^{tst} July , S_2 = 15^{th} July , S_3 = 1^{tst} August , S_4 =15^{th} August,Fertilizer NO, N_1 , N_2 and N_3 control , 45 , 90 and 35 KgN/ha (uria) respectively , C.V = Coefficient of Variation and C.F= critical factor .

ISSN (Print): 1858 6775 eISSN (Online): 1858-8775

Table 2: Effect of sowing date and nitrogen rate on weight of 100 seed (cm) of sorghum

	1st season					2nd season				
	Sowing-date									
Fertilizer	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
No	3.87abc	3.90abc	3.83bc	3.87abc	3.87a	4.53cde	4.17de	4.27de	4.27de	4.31b
N_1	3.93abc	4.03abc	3.67c	4.17abc	3.95a	4.93abc	4.93abc	5.13ab	5.33a	5.08a
N_2	4.03abc	4.23abc	3.60c	4.00abc	3.97a	4.07e	4.13de	4.17de	4.43cde	4.2b
N_3	4.43abc	3.87abc	4.77a	4.60ab	4.42a	4.90abc	4.63bcd	4.60cd	4.60cd	4.68a
Mean	4.07a	4.01a	3.97a	4.16a		4.61a	4.47a	4.54a	4.66a	
C.V					7.84					10.05
C.FS					0.36					0.73
C.FN					0.30					0.27
C.FSN					0.91					0.53

Means followed by different letters are significantlydifferent at $p < 0.05$ (Duncant test).Key S_1 = sowing date at 1st July , S_2 = 15th July , S_3 = 1st August , S_4 =15th August, Fertilizer NO, N_1 , N_2 and N_3 control , 45 , 90 and 35 KgN/ha (uria) respectively , C.V = Coefficient of Variation and C.F = critical factor .

ISSN (Print): 1858 6775 eISSN (Online): 1858-8775

Table 3: Effect of sowing date and nitrogen rate on grain yield (t/ha) of sorghum.

	1st season					2nd season				
	Sowing-date									
Fertilizer	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
No	2.10 e	3.37 abcde	3.40 abcde	2.27 de	2.79 a	4.33 ab	3.70 ab	4.50 ab	5.73 ab	4.57 a
N_1	2.83 bcde	3.20 bcde	3.00 bcde	3.63 abcde	3.17 a	3.67 b	5.70 ab	5.00 ab	5.50 ab	4.97 a
N_2	2.60 cde	4.33 abc	4.63 ab	5.17 a	4.18 a	4.23 ab	4.30 ab	5.80 ab	5.87 a	5.05 a
N_3	3.50 abcde	3.50 abcde	3.60 abcde	4.03 abcd	3.66 a	5.47 ab	5.17 ab	5.27 ab	5.17 ab	5.27 a
Mean	2.76 a	3.6 a	3.66 a	3.78 a		4.43 a	4.72 a	5.14 a	5.57 a	
C.V					26.73					15.77
C.FS					1.64					1.09
C.FN					0.66					0.78
C.FSN					1.83					2.19

Means followed by different letters are significantly different at $p < 0.05$ (Duncant test).Key S_1 = sowing date at 1st July , S_2 = 15th July , S_3 = 1st August , S_4 =15th August, Fertilizer NO, N_1 , N_2 and N_3 control , 45 , 90 and 35 KgN/ha (uria) respectively , C.V = Coefficient of Variation and C.F = critical factor .

ISSN (Print): 1858 6775 eISSN (Online): 1858-8775

Table 4: Effect of sowing date and nitrogen rate on Harvest index (%) of sorghum.

	1st season					2nd season				
	Sowing-date									
Fertilizer	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
No	24.53 bcde	27.93 abcd	25.43abcde	21.23 de	24.78 a	29.40 def	26.73 f	30.33 cdef	30.67 cdef	29.28 b
N_1	24.60 bcde	21.43 cde	18.23 e	24.80 bcde	22.27 b	32.30 cdef	32.97 cdef	33.77 bcdef	28.83 ef	31.97 a
N_2	30.73 abc	32.60 ab	34.60 a	34.33 a	33.07 a	30.63 cdef	38.07 abcde	34.10 bcdef	39.90 abc	35.68 a
N_3	30.33 abcd	33.90 ab	33.20 ab	27.50 abcde	31.23 a	37.53 abcde	36.77 a	39.33 abcd	43.30 ab	41.73 a
Mean	27.55 a	28.97 a	27.87 a	26.97 a		32.47 a	36.14 a	34.38 a	35.68 a	
C.V					21.53					25.19
C.FS					6.18					8.76
C.FN					5.36					5.05
C.FSN					9.46					10.34

Means followed by different letters are significantly different at $p < 0.05$ (Duncant test).Key S_1 = sowing date at 1st July , S_2 = 15th July , S_3 = 1st August , S_4 =15th August,

Fertilizer NO, N_1 , N_2 and N_3 control , 45 , 90 and 35 KgN/ha (uria) respectively , C.V = Coefficient of Variation and C.F = critical factor .

ISSN (Print): 1858 6775 eISSN (Online): 1858-8775

Table 5: Effect of sowing date and nitrogen rate on Nitrogen use efficiency of sorghum

	1st season					2nd season				
	Sowing-date									
Fertilizer	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
No	0.00 f	74.83 b	37.80 cd	17.53 e	32.54 a	0.00 F	50.00 BCD	50.00 DE	42.47 E	43.67 a
N_1	0.00 f	71.10 b	33.33 de	26.93 de	32.84 a	0.00 F	126.70 A	55.57 DE	40.77E	55.76 a
N_2	0.00 f	96.33 a	51.50 c	38.30 cd	46.53 a	0.00 F	95.57 ABC	64.47 CDE	43.47 E	50.88 a
N_3	0.00 f	77.77 b	40.00 cd	29.83 de	36.9 a	0.00 F	114.80 AB	58.53 DE	38.27 E	52.90 a
Mean	0.00 f	80.01 a	40.66 b	28.15 b		0.00 f	104.82 a	57.14 b	41.25 b	
C.V					33.28					20.82
C.FS					18.38					14.32
C.FN					8.91					10.44
C.FSN					17.39					33.38

Means followed by different letters are significantly different at $p < 0.05$ (Duncant test).Key S_1 = sowing date at 1st July , S_2 = 15th July , S_3 = 1st August , S_4 =15th August,

Fertilizer NO, N_1 , N_2 and N_3 control , 45 , 90 and 35 KgN/ha (uria) respectively , C.V = Coefficient of Variation and C.F = critical factor .

ISSN (Print): 1858 6775 eISSN (Online): 1858-8775

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ISSN (Print): 1858 6775 eISSN (Online): 1858-8775

تأثير تاريخ الزراعة ومستويات النيتروجين على إنتاجية الذرة الرفيعة وكفاءة السماد النتروجينى

ادم عبدالقادر ضوالبيت ازرق [1] ويس محمد ابراهيم دقش [2] وسامية عثمان يعقوب [2]

1 - كلية العلوم الزراعية ' جامعة الد لنج

2 - كلية الدراسات الزراعية ' جامعة السودان للعلوم والتكنولوجيا

المستخلص

أجريت تجربة حقلية بكلية الدراسات الزراعية –جامعة السودان للعلوم والتكنولوجيا في خلال العروة الصيفية فى خلال موسمى 2011–2012م و 2012–2013م– الخرطوم (شمبات) لدراسة تأثير ميعاد الزراعة و مستويات النتروجين على إنتاجية الذرة الرفيعة و كفاءة السماد النيتروجينى واستخدم الصنف ود أحمد و نفذت التجربة فى القطع المنشقة . التصميم العشوائى ذ ى القطاعات العشوائية الكاملة و ثلاثة مكررات وأحتوت القطع الرئيسية على أربعة تواريخ زراعة هى أول يوليو و 15 يوليو وأول أغسطس و 15 أغسطس ، والقطع الفرعية على أربعة مستويات من سماد النيتروجين وهى الشاهد و 45 كيلوجرام للهكتار و 95 كيلوجرام للهكتار و 135 كيلوجرام للهكتار . معايير الإنتاجية التى تمت دراستها كانت طول القندول ، وزن الـــــ .. 1 حبة ، إنتاج الغلة للهكتار ، دليل الحصاد وحساب كفاءة السماد النيتروجينى . الملامح العامة أشارت إلى أن تاريخ الزراعة له أثر معنوى على دليل الحصاد فى الموسمين ، وإنتاجية البذور في الموسم الأول ، طول القندول ووزن ..1 حبة في الموسم الثانى . عموماً إضافة السماد نتجت عنه اختلافات معنوية على إنتاجية البذور وحساب كفاءة النيتروجين في الموسمين .

ISSN (Print): 1858 6775
eISSN (Online): 1858-8775