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Effect of Sowing Date and Nitrogen Rate on Growth, Yield Components of Sorghum (Sorghum Bicolor L.) and Nitrogen Use Efficiency

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Abstract

A field experiment was conducted at the College of Agricultural Studies, Sudan University of Science and Technology in Khartoum (Shambat). During summer season in 2011/2012 and 2012/2013, to study the effect of Sowing date and nitrogen rate on yield and yield components of Sorghum **(Sorghum bicolor L.**) and nitrogen use efficiency . The cultivar used was Wad Ahmed. The experiment designed used was split plot arrangement in a randomized complete block design (CRBD) with three replications. The main plots were four sowing date on 1th July (S1), 15th July (S2), 1th August (S3) and 15th August (S4). Subplots were four Fertilizer rate control (No), 45kg/ha (N1), 90kg/ha (N2) and 135kg/ha (N3).

Growth parameter which studied was plant height, leaves number /plant and leaf area. In addition yield components were length of head, weight of seeds /plant, weight of 100.seeds, grain yield, and harvest index and nitrogen use efficiency.

The general trend was that sowing date had significant effect on leaf area, harvest index in seasons, leaves number and grain yield in season one, length of head and weight of 100.seeds in season two. Generally application of fertilizer resulted in significant affect on grain yield and nitrogen use efficiency in both seasons, leaves number /plant in season two.

Keywords: Fertilizer; Nitrogen Use Efficiency; Productivity; Sorghum; Sowing Date.

Introduction

Grain sorghum (sorghum bicolor-L-M Moench) 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 Africa and Asian countries. It is also used as an animal feed. The sorghum stalks are used as construction material and fire. Fuel (Taha.1998).

Grain sorghum (sorghum bicolor (L) Moench) is a major crop in many parts of Africa that is noted for its versatility and diversity. Grain was the basic food crop for the first farmers more than 10.000 years ago. Today, grain is still the most basic food crop. Grain is important for two reasons. First, it is the major source of food for the world's population. Second, it is used to feed livestock, which provide meat, dairy products, wool, and eggs.

Grain is easy to store and will not spoil properly stored. It is easy to convert into food. Grains are excellent sources of needed nutrients, particularly the carbohydrates which provide energy. They are also easy to grow in many different parts of the world (Douglas, et al, 1983). Sorghum grains are classified as sorghum bicolor (with many cultivars). There are many verities of sorghum bicolor. Ranging in color from white thought red to brown and mixed classes in the grain standards (Baidab, 2012).

Sorghum belongs to the tribe and ropogonae of the grass family gramineae. Sorghum common names are great millet, guinea corn (West Africa), Milo and sorgo (U.S.A), Kaoliang (China), dura (Sudan), Mtama (Fast Africa), Jola, Jawa, Jowar and Cholam (India). (Gibbon and pain, 1985). Sorghum is the fifth most important tropical cereal crop after wheat, rice, maize and Barley. It is the staple food in many of the drier tropic areas of Africa, India and China as it is resistant to drought and can consistently out yield maize under rain fed. Conditions in areas with variable annual rainfall.

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).

In Sudan Ali (2005) reported that the highest grain yield was produced by July first sowing, followed by Mid June sowing. Late planting (August) reduced grain yield of sorghum by 76.7% compared to the recommended sowing date (15 June – 12 July). Ishag and Farah (1963) reported that the optimum planting time for the late maturing varieties (Wad akar and Fahal) was the first half of June, the early (1) Warf White Milo and Medium variety (Dwarf Feterita 7028).

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 (Yousif 1993). Consequently, nitrogen has become the foremost input in relation to cost and energy requirement in advanced agricultural production systems (Yousif, 1993). In Sudan, Ishag and Farah (1963) found that 86 kg N/ ha in form of urea or sulphate of ammonia gave straw yield of 6133kg/ha and 5909 kg/ha, respectively. They also found that broad casting of urea was better side dressing. Application of nitrogen at flowering gave low grain yield, while addition of nitrogen between sowing and flowering increased the grain yield to 2473kg/ha. They also found the best time for increasing grain yield was one month after planting.

Mol et al. (1982) defined NUE as the yield of grain per unit of available N in the soil including the residual N present in the soil and fertilizer. NUE can further be divided into two processes: 1. Nitrogen uptake efficiency and 2. Nitrogen utilization efficiency. Nitrogen uptake efficiency is defined as a quotient of plant nitrogen uptake (Nupt) and total crop nitrogen supply (NSUP) (Fertilizer plus soil mineral nitrogen) (Samborski et al., 2008) nitrogen uptake efficiency is also called nitrogen recovery efficiency.

In order to increase yield of sorghum should be initiated within the national sorghum improvement program of the agricultural research corporation in the Sudan. Also the optimum sowing date and the best nitrogen rate of sorghum in Sudan are one of the key components for a better sorghum grain yields.

The objectives of this study were:

1. To study the effect of sowing time on growth and yield of sorghum cultivar.
2. To determine the best nitrogen dose.

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) at 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 40C in the summer and the minimum is around 20C in the winter season. The relative humidity range between 14-27% during dry season and 31-51% during the wet season.

The soil is typical clay soil it is characterized by beep cracking, moderately alkaline clays, low permeability, low nitrogen content and pH ranging between 7.5 – 8. It's low permeability is related to both high pH content and high exchangeable sodium percentage (ESP), in sub soils (Azrag, 2010).

Hybrid (Wad Ahmed) seeds which were used in the experiment were obtained from the Gezira research station. Asplit plot arrangement in a randomized complete block design (R.C.B.S), with three replications will be used. The treatments components were as follows:

(1) **Variety Faterita wad Ahamed (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 stays green even after grain harvesting.

(2) **Sowing date:**

S_1 = 1th July, S_2 = 15th July, S_3 = 1th August and S_4 = 15th August.

(3) **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 hole 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 tillering.

The watering interval was 7-10 days in both seasons and the plants were thinned to two plants per hole after two weeks from planting. Three manual weddings in each season carried out. Stem borer was observed when the crop was 50 days old in the first sowing date (1^{th} July) in first season and 27, 75 days old in the first sowing date in second. 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).

Measurements of growth attributes were taken after 65 days from sowing from each plot. Four plants were selected randomly after leaving 50 cm at each and of the plot. The selected plants were togged.

Plants height was measurement in (cm) from the soil surface up to the collar of the last leaf on the plant, from four selected plants then the mean plant height was calculated for each plot.

The four plants used for the measurement of plant height were also used for counting of leaves per plant where the average numbers of leaves were recorded.

Leaf area for three leaves per plant of each of the four plants per plot was measured. For each leaf, the maximum length multiplied by the maximum width and then multiplied by 0.75 to obtain the leaf area (Sticker, 1961).

Measurements of yield components were taken when signs of maturity were clear observed on the plants (complete yellowing of leaves and heads and partial shedding of leaves).

The heads of four selected plants in each plot were measurement and the average head length was recorded.

The harvested heads of four plants were air dried and threshed and bulk weight and the average weight of seeds were calculated.

100-seeds were counted randomly then weighed for each plot of the four selected plants.

The harvest plants from each plot were threshed and seed yields for each plot were recorded, yield per hectare was then estimed yield (t/ha).

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

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

$$\frac{\text{grain yield (t/ha)} \quad A = \pi r^2}{\text{Biological yield (t/ha)}} \times 100$$

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:

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

The data were analyzed by computer, using the M state. C program. The treatment means were compared using Duncan multiple range test (DMRT).

Results

From the statistical analysis of variance (table 1,2) it was clear that there were no-significant (P=0.05) effect for sowing date and nitrogen fertilizer on plant height in both seasons, but there was asignificant difference among the four levels of nitrogen fertilizer in 2nd season, when nitrogen fertilizer dose 135 KgN/ha was recorded the tallest plants.

Plant height was no significantly affected by interaction between sowing date and nitrogen fertilizer in both seasons, but there were significant differences in Interaction between levels of sowing date and levels of fertilizer. The tallest plants were recorded for the treatment S4 with fertilizer dose 90 KgN/ha in 2nd season.

Table 1: Summary of the ANOVA table for sowing date and fertilizer of sorghum 2012 season.

Source of variation	D. F	F. Value								
		Plant height (cm)	Level number /plant	Leaf area (cm2)	Length of head(cm)	Weight of seed/plant(g)	100.seeds wt (g)	Grain yield(t/ha)	Harvest index (%)	Nitrogen use efficiency
Replication	2	53.36	2.00	3396.3	0.73	498.23	0.32	0.12	58.71	219.9
Sowing date (s)	3	78.22 NS	1.90*	26413.6 *	4.44 N.S	9232.24NS	0.74 N.S	4.29*	316.95 *	509.3 N.S
Error A	6	39.35	0.49	2925.8	2.18	1411.50	0.54	1.18	76.93	205.4
Fertilizer (F)	3	36.86 NS	0.26 NS	2889.4 N.S	0.34 N.S	734.53 N.S	0.08 N.S	2.67*	8.47 NS	13250.0 * *
Sowing date Fertilizer (SxF)	9	11.19 NS	0.57 N.S	377.6 N.S	0.96 N.S	853.39*	0.24*	0.98 N.S	26.24 N.S	88.5 N.S
Error B	24	16.08	0.78	1790.0	1.40	925.14	0.10	0.85	35.91	153.5
SE ±	-	1.57	0.18	20.27	0.37	9.39	0.18	0.27	2.19	3.58
C.V %	-	4.20 %	6.53%	17.40%	7.64%	24.02%	7.84%	26.73%	21.53 %	33.28%

** = Significant at 1% level (highly significant)

* = significant at 5% level (significant)

NS = Not significant.

Table 2: Summary of the ANOVA table for sowing date and fertilizer of sorghum 2013 season.

Source of variation	D. F	F. Value								
		Plant height (cm)	Level number /plant	Leaf area (cm2)	Length of head(cm)	Weight of seed/plant(g)	100.seeds wt (g)	Grain yield(t/ha)	Harvest index (%)	Nitrogen use efficiency
Replication	2	161.03	0.51	938.2	0.80	43.30	0.26	0.63	13.22	108.0
Sowing date (s)	3	7.54 NS	3.41 NS	70745.5 **	5.13*	66.15 NS	1.93**	1.03 NS	354.64 *	319.4 NS
Error A	6	43.24	1.72	2773.0	0.99	160.49	0.13	2.68	38.31	338.5
Fertilizer (F)	3	15.00NS	2.72*	3150.6 NS	2.27 NS	62.75 NS	0.08 NS	2.99**	38.09 NS	22520.1 **
Sowing date Fertilizer (SxF)	9	17.80 NS	1.16 NS	2545.1 NS	0.67NS	85.78*	0.08 NS	1.41*	37.36 NS	326.7 *
Error B	24	15.01	0.92	3926.0	1.33	34.10	0.13	0.61	40.45	111.8
SE ±	-	1.64	0.33	13.16	0.25	3.16	0.09	0.41	1.49	4.60
C.V %	-	3.89%	6.80%	14.65%	7.05%	14.43%	10.05%	15.77%	25.19 %	20.82%

** = Significant at 1% level (highly significant)

* = significant at 5% level (significant)

NS = Not significant.

Statistical analysis (table 1, 2) showed that sowing date had significant effect on leaves number / plant in first season (P = 0.05) when, S2, sowing date gaved highest leaves number.

Leaves number / plant was significantly affected by nitrogen fertilizer in the 2nd season and also there were significant differences among the four levels of sowing date in 2nd season and significant differences among the four levels of nitrogen fertilizer in first season, when application 135 KgN/ha gave highest leaves number .

There were no-significant effect for the interaction between sowing date and fertilizer on leaves number in both seasons, but there were significant differences in interaction between levels of sowing date and levels of nitrogen fertilizer. The highest leaves number were recorded for the treatment S2 with fertilizer dose 45 Kg N/ha in 1st season and S4 with fertilizer dose 45 Kg N/ha in 2nd season.

According to statistical analysis it was clear that sowing date had significant effect on leaf area in both seasons. 1st season gave the largest area of leaf and in 2nd season S3 was the best.

Leaf area was not significantly affected by fertilizer and interaction between sowing date and fertilizer in both seasons (table 1, 2). But there were significant differences in interaction between levels of sowing date and levels of nitrogen fertilizer. The largest area of leaf was recorded for the treatment S4 with fertilizer dose 135 Kg N/ha in both seasons.

From the analysis of variance it was clear that sowing date had significant effect (P=0.05) on length of heed in 2nd season (table 2). The S4 gave the highest significantly bigger head in 1st season.

On the other hand, the effect of fertilizer and interaction between sowing date and fertilizer were not significant on length of head in both seasons (table 1, 2). 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 tallest length of head was 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.

Statistical analysis (table 1, 2) showed that sowing date and fertilizer had no significant effect on weight of seeds/plant in both seasons. There were significant differences (P=0.05) among the four levels of sowing date in 2nd season and the sowing date (S_3) gave highest significant weight.

The analysis showed that the interaction between sowing date and fertilizer had significantly effect on weight of seeds/plant in both season (table 1, 2). Also there were significant differences for the interaction between levels of sowing date and levels of nitrogen fertilizer. The highest weight of seeds/plant was recorded for the treatment sowing date (S_4) with fertilizer dose 90 KgN/ha in 1st season and sowing date (S_1) with fertilizer dose 135 KgN/ha in 2nd season.

According to statistical analysis it was clear that sowing date had highly significant effect on weight of 100. seeds in 2nd season (table 2) and also there were significant differences among the four levels of sowing date in 1st season, when S_2 recorded highest weight of 100 Seeds. On the other hand, the fertilizer had no significant effect on weight of 100 seeds in both seasons (table 1, 2)

The analysis showed that the interaction between sowing date and fertilizer had a significant effect on weight of 100 seeds in 1st season (table 1). 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_3 with N_3 in 1st season and S_2 with N_1 in 2nd season.

From the analysis of variance (table 1,2), it was clear that the sowing date had significantly effect on grain 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 significant effect in both seasons (Table 1,2), 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 affected significantly grain yield in 2nd season (Table 2). 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_3) with fertilizer dose 90 kg N/ha in both season.

Statistical analysis (Table 1,2) 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 effect significantly the Harvest index in both seasons (table 1,2) 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.

From the analysis of variance (table 1, 2). 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 (Table 2) 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 best nitrogen use efficiency recorded for the treatment 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.

Discussion

The general trend is that sowing date had significant effect on leaf area, harvest index in both seasons, leaves number, grain yield in season one, length of head and 100 seeds weight in season two. However, application of fertilizer resulted in a significant effect on grain yield, nitrogen use efficiency in both seasons, leaves number / plant in season two.

Sowing at mid July and 1th August increased all vegetative growth and yield component, compared to other sowing in both seasons. General temperature was similar in both growing season. Decrease of all assessed morphologic traits, plant height, leaves number, leaf area, length of head, weight of seeds / plant, 100seeds weight, grain yield, harvest index and nitrogen use efficiency at delayed sowing date can be attribute to unfavorable climatic conditions during vegetative growth.

In the first year huge problem with stem borer infestation was occurred which greatly reduce all growth characters and yield components.

Under the conditions of this study in the two environments, the characters which include plant height, leaves number, leaf area, length of head, weight of seed, 100. Seed weight, grain yield and harvest index increased as the amount of nitrogen fertilizer increased from 0Kg N/ ha to 135Kg N/ha. This was attributed to the fact that nitrogen fertilizers will give healthy vigorous plant and the plant will be photo synthetically efficient.

Interaction between sowing date and nitrogen rate had significant effect on weight of seeds / plant in both seasons, 100 seed weight in season one, grain yield, nitrogen use efficiency in season two.

From the statistical analysis of variance it was clear that there were no. significant effect of sowing date and nitrogen fertilizer on plant height in both seasons. These results did not agreed with the results obtained by Ishag (1963) who reported that plant height was more affected by later sowing date than the others. This might be a photo- periodic effect. Abdel Rahman et al (2005) reported that sowing date had significant effect on plant height. Venkates et al (1977) found that July sowing date gave the highest plant height. Ali (2007) reported that sowing date treatments was highly significant for plant height.

In this study there were significant differences among the four levels of nitrogen rate in 2nd season, nitrogen dose 135KgN/ha recorded the tallest plants. This might be attributed to the fact that nitrogen fertilizer will give healthy vigorous plant. These result were in agreement with Yousif (1993) finding who reported that the application of 86 Kg N/ha gave the highest plant height. Mohamed (1990) stated that nitrogen significantly increased plant height. Elasha (2007) stated that, applying no nitrogen resulted in a significantly shorter plants compared to fertilization. Plant height was not significantly effected by interaction between sowing date and nitrogen rate in both seasons. These results did not agree with Ali (2006) WHO reported the significance of interaction effects of sowing date and nitrogen rate for plant height.

The results showed that sowing date had significant effect on leaves number / plant in 1st season. Sowing at 15th July gave highest leaves number. Nitrogen fertilizer had significant effect on leaves number / plant in 2nd season. Application of 135KgN/ha gave highest leaves numbers. This result was in agreement with lowrenco et al (1993) who found that the application of nitrogen up to 100Kg N/ha increased shoot numbers of Sudan grass.

Sowing date had a significant effect on leaf area in both season. August sowing gave the largest area of leaf in both seasons. This might be due to favorable climatic conditions during vegetative growth. However, interaction between sowing dates and nitrogen rates had no significant effect on leaf area. The results in this study showed that there were significant differences in interaction between four levels of sowing dates and four levels of nitrogen rates. The largest area of leaf was recorded for the treatment 15th August with fertilizer dose 135 Kg N/ha in both seasons.

In the present study in the two seasons, if was clear that sowing date had significant effect on length of head in 2nd season. In this connection, Abdel Rahman et al (2005) reported that sowing date had significant effect on length of head. On the other hand, the effect of interaction between sowing date and nitrogen rate were not significantly on length of head in both seasons. There were significant differences in interaction between levels of sowing dates and levels of nitrogen rates. This might be attributed to favorable climatic conditions during vegetative growth with developing growth stages and the good utilization of nitrogen. This result was in agreement with Elasha (2008) who reported that nitrogen levels had significant effect on length of head.

The results obtained in both seasons, showed no significant effect of sowing date and nitrogen fertilizer on weight of seeds / plant. There were significant differences among the four levels of sowing date. 1th August sowing gave the highest weight. Reduction of weight of seeds / plant on early sowing might be attributed to shorten vegetative growth period, lower amounts of carbohydrates and reduce translocation assimilation to grains. On the other hand, the interaction between sowing dates and nitrogen rates had significantly effect on weight of seeds / plant in both seasons. Also there were significant differences between levels of sowing date and levels of nitrogen rate.

Sowing date had highly significant effect on weight of 100.seeds as there were significant differences among the four levels of sowing date in 1st season. Sowing at 15th July recorded highest weight of 100 seed. Similar results were obtained by Abdel Rahman et al (2005). They found that sowing date had significant effect on 100 seed weight. Ali (2007) reported that sowing date treatment was highly significant for 100seed weight. The non –significant effect of nitrogen application on 100seed weight which was obtained in this study was supported by Mohamed et al (1998), and Elhassan (1986). Yousif (1993) obtained the increased 100.seed weight from application of 86 Kg N/ha.

From the analysis of variance, it was clear that the sowing date had significantly effected grain yield in 1st season. Sowing at 1th August gave highest grain yield (4.18t/ha) in 2nd season. Similar results were reported by Ali (2007) who obtained significant effects for sowing date on grain yield. Ishag and Farah (1963) reported that the optimum planting time for the medium varieties which responded better to planting in the second half of June. Elrayah (1977) found that grain yield was high with 15th June and 1th July sowing. Fadda (1963) found that sowing on July 27 gave highest grain yield. Chielle and Chielle (1990) reported that sowing date had greater effect on yield than cultivar. The influence of fertilizer on grain yield was significant in both seasons. Fertilizer dose 135 Kg N/ha gave the highest grain yield in both seasons. This might be due to increase of leaf area, better growth period, length of head, greater head and increase weight of seeds / plant . These were the most important components for high grain yield. This result was in agreement with Atar and Pains (1973) who reported that the application of 120 Kg N/ha gave the highest grain yield. Babiker (1998) found that the highest grain yield was obtained by applying 86 Kg N/ha. Mohamed (1998) reported that grain yield was increased significantly with increasing nitrogen dose. Farah and Faki (1991) obtained the grain yield of HD-1which was significantly effected by application of 86 Kg N/ha. Bebawi and Abdel Aziz (1983) reported the application of 172 Kg N/ha to give the highest grain yield. Shukla et al (1976) found that 120 Kg N/ha increased grain yield. Gono (1990) reported the nitrogen application of 100 Kg N/ha which significantly increased the grain yield. In a similar study Patel et al (1990) reported application of 150 Kg N/ha + 6 irrigation gave the highest grain yield.

Statistical analysis of variance showed that sowing date had a significant effect on Harvest index in both seasons. Sowing at 1th and 15th August gave the highest significant harvest index in 1st and 2nd season respectively. The interaction between sowing date and nitrogen rate had not significantly effected Harvest index in both seasons. But there were significant differences in interaction between levels of sowing date and levels of nitrogen rate. The best Harvest index recorded for the treatment sowing at 15th July with fertilizer dose 135kgN/ha in 2nd season. These results closely resemble the results of Elash (2008) who reported that nitrogen levels had significant on Harvest index.

In this study sowing date had no significant effect on nitrogen use efficiency in both seasons. This result did not agree with Elasha (1997) who found that the early planting of sorghum had significantly larger effects on nitrogen use efficiency, (% IN). The fertilizer had highly significant effect on Nitrogen efficiency in both seasons. The application of 45 Kg N/ha gave the highest significant nitrogen use efficiency in both seasons. This might be due to the efficient use of nitrogen at the growth stages which was then reffected on the grain yield and the extra amount of nitrogen was not utilized by the plant. These results were in agreement with Babiker et al (1999). They reported that nitrogen use efficiency was decreased by increasing the rate of nitrogen and the highest value was obtained within (43 Kg N/ha). Simth et al (2012). Found that improved nitrogen use efficiency can help to enhance yield under low nitrogen and thus improve crop nutritional quality and it will also reduce ground water contamination by excess nitrates. The interaction between sowing date and nitrogen rate had a significant effect on nitrogen use efficiency in 2nd season. On the other hand there were significant differences in interaction between levels of sowing date and levels of nitrogen rate. The best nitrogen use efficiency recorded for the treatment sowing at 15th July with fertilizer dose 45 Kg N/ha in 2nd season . This due to highest grain yield in 2nd season.

Summary and Conclusion

A field experiment was undertaken in 2011/12 and 2o12/2013 Summer seasons at the College of Agricultural Studies, Sudan University of Science and Technology in Khartoum (Shambat) to study the effect of sowing date and nitrogen rate on yield of sorghum (sorghum bicolor L.) and nitrogen use efficiency.

Sowing in mid July to first week of August significantly increased all growth parameter and yield components in both seasons. This was mainly attributed to the optimum sowing date.

The application of fertilizer 135 Kg N/ha resulted in more plant height, more leaves number, more leaf area, more length of head, more weight of seed, more 100. Seed weight and more grain yield in both season than the 90 Kg N/ha, 45 Kg N/ha and 0 Kg N/ha, respectively.

The application of 45 Kg N/ha gave the highest significant nitrogen use efficiency in both season. This was revealed that nitrogen use efficiency was decreased by increasing the rate of nitrogen over 45 Kg N/ha.

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