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Evaluation of Some Local Sorghum Genotypes in North Kordofan of Sudan Semi-Arid Agro-Ecological Environment

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Abstract A field experiment was conducted during seasons (2011/2012) in semi-arid zone at North Kordofan, Sudan to evaluate local sorghum (*Sorghum bicolor* L. Moench) genotypes for early flowering and yielding. 19 early flowered and high yielding ability genotypes were selected from the previous experiment. Randomized complete block design (RCBD) with four replications was used. Selection was done visually based on early flowering and bigger panicle size plants. Morphological, yield and yield component traits were estimated. Statistical analyses revealed significant differences among all the studied traits. Duncan Multiple Range Test organized and ranked the significances among the trait means. Results of the experiment disclosed that the highest amount of grain yield per area produced by the following genotypes: Tagat 4 (2.3), Tagat 7B (1.9), Tagat 10 (2.2), Tagat 14 (2.7) and Tagat 19 (1.9 ton h^{-1}).

Keywords Sorghum, Cereals, Seed yield, Sudan

1. Introduction

Sorghum (*Sorghum bicolor* L. Moench) is one of the most important staple food and fodder crops in the semi–arid regions of the world [1], [2]. It is considered more tolerant to many stresses, drought, salinity, heat and flooding [3], [4]. The crop grown in rain fed areas is highly effected by drought stress [5]. Because of its tolerance to drought and heat stress, sorghum is cultivated in areas considered to be too dry and hot for other cereals [6]. Sorghum is fourth important cereal crops of the world after wheat, rice and maize [7]. It is widely grown in Africa, China, USA, Mexico and India. Sorghum (Sorghum bicolor) is a multipurpose crop grown for food, animal feed and industrial purposes [11].

Grain sorghum has so many local names among these: Durra, Egyptian millet, Feterita, Daza, Sorgo, Gonia corn, Jowar, Kaffir corn, Milo, Shallo and Sudan grass [8].

Sorghum in Sudan is the main staple food crop that grown in both traditional and semi-mechanized rain-fed areas [9]. However, Sudan's sorghum productivity is low compared with other sorghum producing countries. Sorghum productivity in Sudan ranged between 104- 200 kg/ feddan [8], [20]. It represents about 14%, 15% and 16% of that of Argentina, USA and China, respectively [10].

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The rain-fed sorghum areas exceed 90% of the total cultivated sorghum areas [20]. Therefore, some reasons behind low productivity could be attributed to fluctuation in rain-fall, short rainy season and low amount of precipitation per season. For these, selection for moisture stress resistant among genotypes could be of great importance for sustainability of sorghum production. The objective of this study are to: Studying the yield components and estimating of yielding ability of selected local genotypes of grain sorghum in semi-arid environment in North Kordofan of Sudan.

2. Materials and Methods

A field experiment was conducted in rainy seasons (2011/2012) at the Farm of Crop Sciences Department, Faculty of Natural Resources and Environmental Studies, University of Kordofan, Sudan. Latitude (11-15°N) and longitude (27-32°E). The climate of the area is arid and semi arid. The soil is sandy, annual rain fall ranges between 350-450 mm (Ahmed, 2009). Average maximum daily temperature ranges between 30-50°C throughout the year.

2.1. Field Experiment

Nineteen sorghum genotypes were selected from the 39 genotypes (tested in season 2010/2011) based on early flowering and high yielding-ability for further investigation in second field experiment conducted in 2011/2012. Randomized Complete Block Design (RCBD) with four replicates was used. The experimental unit area was 3m X

10m. Inter and intra row spacing was 50cm apart. Sowing was done in 25th July, 2011. Five seeds were placed in each hole. The re-sowing was done after two weeks from sowing. The first weeding after a week from re-sowing. The second one after a month from the first weeding, all the seedlings were thinned to two per hole, prior flowering all sorghum plants in the experiment were labeled by tags. Genotypes̓ names, flowering and maturity date were written on these tags. All plants were covered by clothes bags to protect heads from crossing and bird attack. Observations were taken from sowing up to maturity.

2.2. Phenological Attributes

1. Days to 50% flowering: were recorded as the number of days from the effective sowing date to the day on which 50% of the plants in a plot reached anthesis at least halfway down the panicle.
2. Days to physiological maturity: the number of days from effective sowing date to the day on which 95% of the panicles in a plot reached physiological maturity as monitored by the appearance of black glumes.
3. Grain filling period

2.3. Vegetative Growth Parameters

In each plot, four plants were selected at random from the middle row to measure the following characters:

1. Plant height (cm): measured from soil surface to the tip of the main head, just before harvesting.
2. Stem diameter (cm): measured by using a vernier (caliper) at the third node.
3. Number of leaves per plant

2.4. Yield Attributes

1. Grain yield per plant (g)
2. 100 grains weight (g): 100 seeds will be weighted (four times) from each sample and weighed.
3. Grain yield (ton ha^{-1}): panicles from each plot were harvested, sun dried, threshed, weighed and converted to ton/ha
4. Number of grains per panicle
5. Harvest index: Harvest index was determined by using the fallowing formula:-

$$Harvesting\ index = \frac{\text{Economical yield (seed yield/plant)}}{\text{Biological yield (shoot dry weight)}} \times 100$$

3. Results and Discussion

Table1. Shows the results of morphological and yield components of 19 selected Sorghum genotypes.

3.1. Growth Attributes

With regard to plant height, Tagat 4 and Tagat 9A were the shortest genotypes in the field experiment (51.25 and 43.25 cm, respectively). Therefore, they could be early. On the other hand, Tagat 14, Tagat 15 and Yourwasha were the tallest genotypes in the experiment (117.05, 117.08 and 122.55, respectively). Late in maturity most probably associated with high grain yield. Similar results were reported by El Naim et al. [11].

With respect to days to 50% flowering, Tagat 7B, Tagat 10 and Tagat 14 were the earliest flowering genotypes (74.75, 78.00 and 72.25, respectively). Therefore, they might be classified as drought escaper. Similar observations were reported by Seetharama [12]. On the other hand, the latest flowering genotypes in the field experiment were Arose-Elremal (89.17), Tagat 4 (89.17), Gadamballea (89.13), Geshaish (89.03) and Tagat 7A (89.05). Late flowering genotypes always produce high grain yield per plant, but they may require long rainy season. So, they are not suitable for cultivation in areas with low rain fall. The significant differences among sorghum genotypes in days to 50% flowering were reported by many Workers: Abdel-Rahman, [13], Abduli, [14], Emendwack, [15] and Ahmed, [8].

Yourwasha and Tagat 13 scored the highest estimates for stem diameter in field experiment (1.71 and 2.1 cm, respectively). These genotypes could be less susceptible to wind lodging. On the other hand, Tagat 9A recorded low estimates for stem diameter (0.91 cm). Therefore, it could be susceptible to lodging.

The highest number of leaves per plant in was shown by Tagat 10 and Tagat 5B (12.25). These genotypes also recorded high estimates of grain filling period. Thus, high metabolites deposition in long grain filling period would be expected from this genotype and consequently high grain yield. In contrast, Tagat 9A recorded the lowest number of leaves per plant (6.6) and showed low estimates of grain filling period. Therefore, low photosynthates in short grain filling period would be expected for developing grains and consequently low grain yield per plant. Ahmed [8] and Ismail [16] reported similar results. The earliest maturating genotypes Tagat 7A, it matured in 98.25 days. The early maturing genotype has a high potentiality to escape drought. Therefore, it is suitable to be grown in drought prone areas. The latest maturing genotypes was Tagat 10, it matured in 108.75 days. Hence, its maturity is dependent on moisture availability.

In grain filling period, Arose, Tagat 4, Gadamballia, Tagat 9A, Geshesh and Tagat 7A genotypes showed a short grain filling period in the field experiment (less than 17 days). These genotypes might escape drought via reducing their grain filling period. On the other hand, Tagat 20 and Tagat 7B recorded long grain filling period (25.00 and 24.25 days, respectively). Consequently, high100 grain weight would be expected.

Table 1. Means of some Morphological and yield components of 19 selected Sorghum genotypes (*Sorghum bicolor* (L.) Moench) grown during season (2011/ 2012)

Genotype	Plant height (cm)	Days to 50% flowering	Stem diameter (cm)	Number of Leaves per plant	Days to maturity	Grain filling period (days)	Grain yield per p plant (g)	100 grain weight (g)	Number of grains per panicle	Grain yield (t/ha)	Harvest index %
Tagat5B	88.7^{bcd}	87.5^{abc}	1.5^{b}	12.3^{a}	103.5^{abcd}	16.5^{ef}	12.8^{de}	3.9^{de}	342.5^{g}	1.58^{e}	10.7^{d}
Aros	69.1^{h}	89.2^{a}	1.5^{b}	8.4^{d}	104.3^{abcd}	14.9^{f}	6.5^{hi}	4.4^{abcd}	175.1^{kl}	0.79^{h}	7.2^{ef}
Tagat 4	51.3^{i}	89.1^{a}	1.2^{bc}	10.6^{bc}	104.3^{abcd}	15.0^{f}	17.5^{b}	2.9^{f}	718.5^{b}	2.30^{b}	15.5^{c}
Gadambalea	70.2^{gh}	89.1^{a}	1.2^{bc}	8.0^{d}	104.3^{abcd}	15.0^{f}	6.7^{hi}	3.9^{df}	174.9^{kl}	$0.78.3^{h}$	7.7^{e}
Tagat 9A	43.3^{i}	85.0^{abcd}	0.9^{c}	6.6^{e}	99.2^{cd}	15.0^{f}	14.8^{c}	1.8^{g}	799.7^{a}	1.68^{de}	84.6^{a}
Tagat 20	69.9^{gh}	73.3^{g}	1.3^{bc}	9.7^{c}	100.2^{cd}	25.0^{a}	8.1^{gh}	3.8^{de}	211.2^{ikl}	0.98^{gh}	4.5^{efgh}
Tagat 15	117.1^{a}	77.8^{ef}	1.2^{bc}	10.5^{bc}	98.7^{d}	21.5^{abcd}	5.1^{i}	4.4^{abcd}	116.7^{m}	0.55^{i}	$3.8f^{gh}$
Tagat 7B	73.8^{fgh}	74.8^{fg}	1.4^{bc}	12.0^{ab}	100.7^{cd}	24.2^{a}	15.3^{c}	3.5^{e}	453.5^{d}	1.86^{cd}	2.8^{gh}
Tagat 9C	79.2^{defg}	83.0^{cd}	1.3^{bc}	11.5^{ab}	105.7^{abc}	21.0^{abcd}	9.7^{fg}	4.7^{ab}	215.7^{ij}	1.18^{fg}	5.4^{efgh}
Tagat 14	117.0^{a}	72.2^{g}	1.4^{bc}	12.0^{ab}	107.5^{ab}	22.8^{abc}	22.8a	3.9^{de}	503.7^{c}	2.72^{a}	2.9^{gh}
Tagat 10	85.1^{cde}	78.0^{ef}	1.4^{bc}	12.2^{a}	108.7^{a}	21.5^{abcd}	21.5a	4.1^{bcde}	426.7^{de}	2.25^{b}	7.0^{ef}
Nabig	97.3^{b}	84.0^{acd}	1.2^{bc}	11.0^{abc}	101.3^{bcd}	19.7^{bcde}	10.2^{f}	3.8^{de}	239.2^{hi}	1.22^{f}	6.2^{efg}
Tagat 5A	87.2^{cde}	85.2^{abcd}	1.4^{b}	11.5^{ab}	103.5^{abcd}	19.2^{cde}	13.1^{d}	4.1^{cde}	396.0^{ef}	1.54^{e}	25.0^{b}
Tagat 6A	89.9^{bc}	80.4^{de}	1.4^{b}	11.0^{abc}	103.7^{abcd}	23.5^{ab}	10.5f	4.7^{abc}	155.0	$1.05f^{g}$	4.8^{efgh}
Tagat 19	81.4^{cdef}	$81.2d^{e}$	1.5^{b}	12.5^{a}	101.5^{bcd}	17.5^{def}	17.1^{b}	3.9^{de}	370.0^{fg}	1.94^{c}	5.6^{efgh}
Yourwasha	$122.^{5a}$	83.0^{cd}	1.7^{ab}	10.5^{bc}	101.2^{bcd}	23.7^{ab}	11.2^{ef}	4.1^{bcde}	270.2^{h}	1.25^{f}	2.5^{h}
Tagat 13	77.7^{efgh}	88.0^{ab}	2.1^{a}	12.0^{ab}	100.0^{cd}	7.2^{g}	17.8^{b}	4.2^{abcde}	199.2^{jl}	2.17^{b}	4.5^{efgh}
Geshash	68.7^{h}	89.0^{a}	1.5^{b}	8.3^{d}	104.2^{abcd}	15.1^{f}	7.1^{h}	3.9^{de}	175.3^{kl}	0.77^{h}	12.3^{d}
Tagat 7A	77.8^{efgh}	89.0^{a}	1.5^{b}	12.0^{ab}	98.2^{d}	15.1^{g}	17.7^{b}	4.8^{a}	207.2^{ikl}	2.15^{b}	4.7^{efgh}
CV%	7.5%	3.6%	23.4%	8.8%	3.7%	12.6%	9.2%	8.6%	7.4%	9.0%	18.6%
SE±	3.09	1.49	1.65	0.46	1.92	1.30	0.60	0.17	11.98	6.83	1.07

N.B: Similar letters in column are not significantly different at the 0.05 level of probability according to Duncan Multiple Range Test

3.2. Yield Attributes

Tagat 10, Tagat 14, Tagat 13, Tagat 19 and Tagat 7A genotypes showed the highest grain yield per plant (range between 17.0 and 23.0 g). While, the Aroselremal, Gadambalea and Tagat 15 were recorded the lowest estimate (5.0 -7.0 g).

7A genotypes scored the highest 100-grain weight (4.89 g). On the other hand, Tagat 9A scored the lowest estimate (1.81 g). This could be attributed to low grain filling period.

Tagat 9A Tagat 4 genotypes produced high estimates for number of grains per panicle in the field experiment. On the other hand, Tagat 10, Tagat 6A, Geshesh, Gadambalea, and Arose produced low estimates (between 155 and 176). The wide variation in the estimates of this trait among genotypes in field experiment could be attributed to the time of moisture stress onset since the genotypes differ in their flowering time [17].

The highest yields per square meter in the experiment were Tagat 13, Tagat 14. Tagat 4 and Tagat 7A (varied between 2.15 and 2.72 ton ha^{-1}). In contrast, Tagat 15, Arose and Gadambalea were the lowest yield in the experiment (between 56 and 79 ton ha^{-1}). Different genotypes under condition of severe drought decrease their yield in varying degree [18].

Tagat 9A genotype scored the highest harvest index in the field experiment. This genotype although it took only 71 days to reach 50% flowering date it produced the highest harvest index. High estimates of harvest index mean efficient metabolites conversion to the developing grains. This could be attributed to the nature of the genotype. On the other hand, the lowest estimates were recorded by Yourwasha in season field experiment. This findings was similar to that obtain by Blum et al. [19] who stated that late maturing genotypes of cereals have lower harvest index compared with early maturing ones.

4. Conclusions

The results revealed the presence of broad intra-specific variation among sorghum (*Sorghum bicolor* L. Moench) genotypes. This study proved that genotypes: Tagat 7B, Tagat 10, Tagat 13, Tagat 14 and Tagat 19 were the most high yielding over all genotypes studied. However these genotypes need further investigations in north kordofan environment.

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