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Effect of Variety and Sowing Date on Performance of Rain-fed Sorghum (*Sorghum bicolor* L. Moench) Grown at Zalingei Locality in Darfur, Sudan

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Abstract

A field experiment was conducted at the University of Zalingei demonstration farm. (Zalingei, Central Darfur State, Sudan), during 2013/ 2014 rainy season, to investigate the effect of sowing date and variety each separately and in interaction on growth and yield of sorghum (*Sorghum bicolour* L. Moench) cultivars under rain fed condition .Treatments were consisted of three sowing dates (7thof July, 10thof July and 15thof July), four sorghum varieties and genotypes (Tabat, Wad-Ahmed, Abu-ragaba and Abu-Kunjara). Treatments were arranged in split plot design replicated four times with sowing dates in the main plots and varieties in the subplots. The size of the main plots and subplots were 12 ×3 and 3×3 m respectively. Numbers of germinated seeds and plant heights (cm) were read three times. At harvest number of thousand grain weights (g) and yield (kg/feddan) were determined. All collected data were statistically analyzed. Analysis of variance and test of significance were done according to standard procedure of split plot design (Gomez and Gomez 1984) using MSTAT-C program. Results of germinated seeds counts showed significant differences ($p \leq 0.05$) for the both three counts. Locally well known sorghum variety Wad-Ahmed and the genotype Abu-Ragaba showed the highest counts of germinated seeds (372.1, 368.3), whereas Tabat and Aba-Kunjara showed the lowest counts of germinated seeds (323.3; 321.3).Results showed no significant differences for both three readings of plant heights in different varieties. The results of the three counts of number of germinated seeds under different sowing dates revealed no significant differences between sowing dates both in first and third counts of number of germinated seeds (NGS), whereas significant differences ($p \leq 0.05$) were found in second count of NGS (360.0 was the highest NGS in first sowing date, followed by 351.6 NGS for the second sowing date, then 338.3 NGS for the third sowing date the lowest. Results also showed no significant differences between sowing dates both in three readings of plant heights. The effect of interaction of sowing dates and variety on growth performance and yield components of sorghum showed significant differences ($p \leq 0.05$). For yield results revealed that no significant differences were found through all interactions. Yield for all interactions varied from 667.1 kg/feddanto 362.5 kg/feddan.

Keywords

Sorghum, Sowing Dates, Varieties, Growth, Yield, Rain-Fed

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1. Introduction

Sorghum (*Sorghum bicolour* L .Moench) is an indigenous crop to Africa [11] .Commercial sorghum refers to the cultivation and commercial exploitation of species of grasses within the genus *Sorghum* (often *Sorghum bicolor*). The plants are cultivated in warmer climates worldwide. Commercial *Sorghum* species are originated in north-eastern Africa with domestication having taken place there around 5000 - 8000 years ago. The largest diversity of cultivated and wild sorghum is also found in this part of Africa. The secondary centre of origin of sorghum is the Indian Subcontinent, with evidence

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for early cereal cultivation dating back about 4500 years[1, 9, and 19].Sorghum is an important crop worldwide used for food (as grain and in sorghum syrup or "sorghum molasses"), fodder, the production of alcoholic beverages and bio-fuels. Most varieties are drought and heat-tolerant especially important in arid regions where the grain is one of the staple food for poor and rural people. These varieties form important components of pastures in many tropical regions. *Sorghum bicolor* is an important food crop in Africa, Central America, and South Asia, and is the fifth-most important cereal crop grown in the world[2, 3, 4, 5, 6, 7, 8, and20].Traditional foods made from sorghum include unfermented and fermented breads, porridges, couscous and snacks, as well as alcoholic beverages. Sorghum blended with wheat flour has been used over the last two decades to produce baked products, including yeast-leavened pan, hearth and flatbreads, cakes, cookies, and flour tortillas [9, 12, and 13].Sorghum grain is one of the major ingredients in swine, poultry and cattle feed in the western hemisphere, China and Australia. Sorghum is also grown for forage; in northern India it is very common and fed to animals fresh or as silage or hay. Sweet sorghum is used to a limited extent in producing sorghum syrup and 'jiggery' (raw sugar) in India and has recently gained importance in ethanol production. Sorghum has been, for centuries, one of the most important staple foods for millions of poor rural people in the semiarid tropics of Asia and Africa [8, 12, 13, and 14]. For some impoverished regions of the world, sorghum remains a principal source of energy, protein, vitamins and minerals. Sorghum grain contains 11.3% protein, 3.3% fat and 56–73% starch. It is relatively rich in iron, zinc, phosphorus and B-complex vitamins. Tannins, found particularly in red-grained types, contain antioxidants that protect against cell damage, a major cause of diseases and agents [9, 10, 11, and 18].The protein and starch in sorghum grain are more slowly digested than those from other cereals, and slower rates of digestibility are particularly beneficial for people with diabetes. Sorghum starch is gluten-free, making sorghum a good alternative to wheat flour for individuals suffering from celiac disease. Sorghum grows in harsh environments where other crops do not grow well, just like other staple foods, such as cassava, that are common in impoverished regions of the world. It is usually grown without application of any fertilizers or other inputs by a multitude of small-holder farmers in many countries. An international effort is under way to improve sorghum farming. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has improved sorghum using traditional genetic improvement and integrated genetic and natural resources management practices [12, 13, and 14]. A new variety of sorghum from ICRISAT has now resulted in India producing 7 tons per hectare. Some 194 improved cultivars are now planted worldwide. In India, increases in sorghum productivity resulting from improved cultivars have freed up six million hectares of land, enabling farmers to diversify into high-income cash crops as cattle feed and in brewing applications [14, 15, and 16]. For Sudan sorghum is one of the most important crops widely used for food and animal feeding. The cultivations of sorghum cover the most of the irrigated and rain-fed areas of the country. Little research has been done to improve sorghum cultivars because of the vast majority of sorghum production is done by subsistence farmer .The crop is therefore mostly limited by insects, disease and weeds, rather than by the plant's inherent ability. To improve the plant's viability in sustaining populations in drought-prone areas, just like Darfur region, a larger capital investment would be necessary to control plant pests and ensure optimum planting and harvesting practices. This study was conducted in Zalingei locality (Central Darfur state, Sudan) , during 2013/ 2014 rainy season, to investigate the effect of sowing date and variety on growth and yield of sorghum (*Sorghum bicolor* L.) cultivars under rain- fed conditions.

2. Materials and Methods

A field experiment was conducted at the University of Zalingei demonstration farm, Zalingei (Latitude 120° 54´N; longitude 230° 29´ E and altitude 900 m above mean sea level) Central Darfur State Sudan during 2013/ 2014 rainy season, to investigate the effect of sowing date and variety on growth and yield of sorghum (*Sorghum bicolor* L.) cultivars under rain fed condition. Treatments consisted of three sowing dates (7thof July, 10thof July and 15thof July). Four sorghum varieties (Abu-ragaba and Abu-Kunjara) genotype locally named (Barbarei) obtained from South Darfur local farmers, Tabat and Wad-Ahmed which are locally improved varieties from ministry of agriculture Central Darfur State (Photos 1-4).

Photo 1. Tabat

Tabat is locally improved variety grown in many parts of the Sudan, grown under irrigation and rain-fed conditions with compact heads, seed color is white, it play important role (economic and nutrition).

Photo 2. Wad-Ahmed

Wad-Ahmed is locally improved variety grown in many parts of the Sudan, under irrigation and rain-fed conditions, heads seems to be compact, it play important role (economic and nutrition).

Photo 3. Abu-Ragaba

Local name Abu-ragaba, position of the head on the main stem is erect, the seed color is white. It is widely grown in South and West Darfur States and it play important role (economic and nutrition).

Photo 4. Abu-Kunjara

Local name Abu-kunjara position of the head on the main stem is bending 180°. Seed color is Yellow. It is widely grown in South and West Darfur States and it play important role (economic and nutrition).

Treatments were arranged in split plot design replicated four times with sowing dates in the main plots and varieties in the subplots. The size of the main plots and subplots were 9×3 and 3×3 m respectively. Numbers of germinated seeds were counted three times. Measurements of vegetative growth attributes were carried on plant samples from the three central rows of each plot. Five plants were selected randomly from each plot and tagged for vegetative growth attributes. Plants were left in the field for 25-30 days after maturity; this was meant to allow for complete maturity and minimum grain moisture content to prevent rotting later on. The crop was manually harvested by using traditional implement and stored in paper bags at room temperature for a month to complete drying. Thereafter, heads harvested from each plot were threshed and the weight of grain was determined, this was used in the calculation of grain yield. Random sample of 1000- grains was taken from each plot and then weighed to obtain 1000-grain weight. All collected data were statistically analyzed. Analysis of variance and test of significance were done according to the standard procedure of split plot design (Gomez and Gomez 1984) using MSTAT-C software program.

3. Results and Discussion

3.1. Effect of Variety and Sowing Date on Plant Growth Attributes

Results of counts of germinated seeds, as shown in fig.1, showed significant differences ($p \leq 0.05$) for the both three counts. In first count locally well known sorghum variety Wad-Ahmed and the genotype Abu-Ragaba showed the highest counts of germinated seeds (372.1; 368.3), whereas Tabat and Aba-Kunjara showed the lowest counts of germinated seeds (323.3; 321.3).In the second and third counts figures revealed the similar results (dominance of Wad-Ahmed and the genotype Abu-Ragaba with NGS 378.9, 374.7 and lowest NGS for Tabat and Aba-Kunjara respectively). This could be attributed to genetic factors.

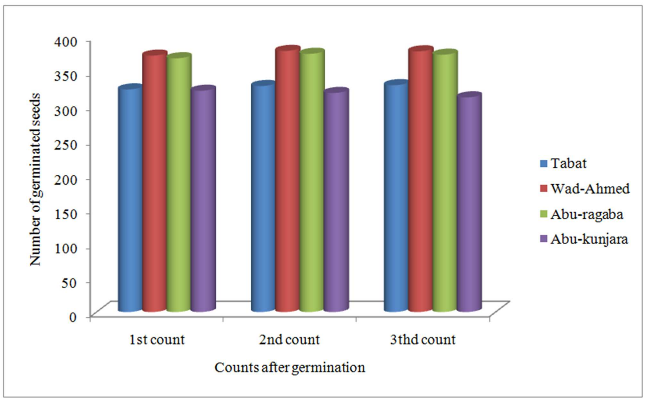

Fig. 1. Effect of variety on number of germinated seeds

As illustrated in Fig.2 results showed no significant differences for both three readings of plant heights. In first reading height varied from 22.58 cm for Wad-Ahmed to 19.90 cm for Tabat. In second reading height varied from 100.9 cm for Tabat to 80.95 cm for Wad Ahmed. In third reading height varied from 171.7 cm for Abu-Kunjara to 135.4 cm for Wad-Ahmed. These results also could be due genetic factors.

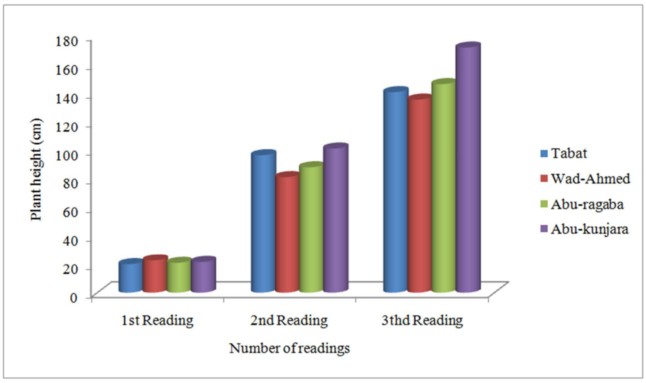

Fig. 2. Effect of variety on plant height (cm)

As shown in Fig.3, the results of the three counts of number of germinated seeds under different sowing dates of plants (7thof July, 10thof July and 15thof July) revealed no significant differences between sowing dates both in first and third counts of NGS, whereas significant differences ($p \leq 0.05$) were found in second count of NGS(360.0 was the highest NGS in first sowing date followed by 351.6 NGS for the second sowing date then 338.3 NGS for the third sowing date. This may be influenced by better rainfall conditions of the second sowing date.

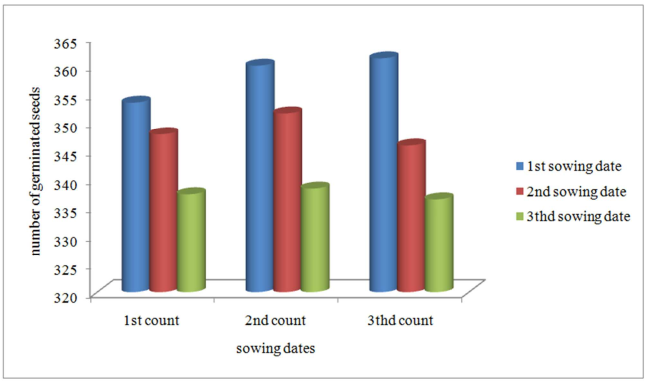

Fig. 3. Effect of sowing date on number of germinated seeds

As illustrated in Fig.4 results showed no significant differences between sowing dates both in three readings of plant heights. In first reading plant heights varied from24.14 cm to 18.96 cm, in second reading heights varied from 104.3 cm to 84.39 cm, while in third reading heights varied from 184.1 cm to 121.1 cm.

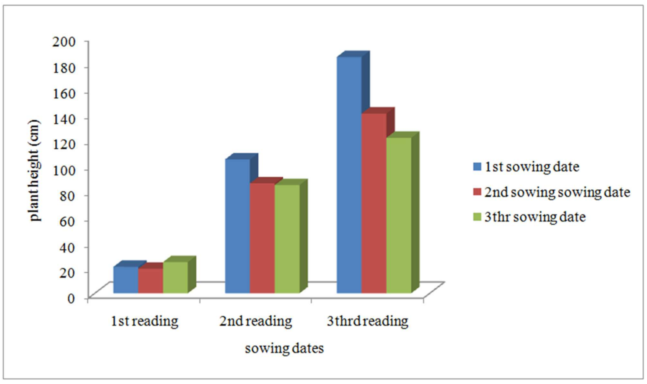

Fig. 4. Effect of sowing date on plant height (cm)

3.2. Effect of Variety and Sowing Date on Yield Components and Yield

As shown in Table 1, results revealed that no significant differences on yield components between varieties and genotypes.1000 grain weight varied from 29.25 g for Wad-Ahmed as highest level to 22.17 g for Abu-ragaba as lowest level. For the yield, Abu-Kunjara showed the highest result (226.2 kg/feddan), while Wad-Ahmed gave the lowest result (47.6 kg/feddan).

Table 1. Effect of variety on yield component

Varieties	1000 grain weight(g)	Yield kg/fed
Abu-ragaba	22.17a	201.3a
Abu-kujara	23.67a	226.2a
Tabat	27.33a	208.9a
Wad-Ahmed	29.25a	47.6a
LSD	16.13 ns	263.8 ns
S.E	5.042	82.5

Note: ns=not significant.

Table 2. Effect of sowing date on yield component

Sowing dates	1000 grain weight(g)	Yield kg/fed
7^{th} of July	27.82a	201.3a
10^{th} of July	25.44a	226.2a
15^{th} of July	23.56a	208.9a
LSD	18.63ns	304.7ns
S.E	5.82	95.2

Note: ns=not significant.

Results in Table 2 showed that no significant differences on yield components were registered both in three different sowing dates (7th of July, 10th of July and 15th of July). These results are in line with results obtained by many researchers [21] reported that Grain yield and yield components were influenced by planting date, the effects of planting dates on growth, development, and yield of grain sorghum hybrids were found to be variable among hybrid maturity groups and locations, whereas [22] found that planting dates had significant effects on plant height, head weight and final grain yield. Results obtained by [23] indicated that yield component of corn such as 300 kernel weight, Kernel no. per row, kernel depth and ear length were adversely affected in delay planting date.

The results in Table 3 showed the effect of interaction of sowing dates and variety on growth performance (NGS, PH cm in third reading) and yield components (SGW and yield) of sorghum. Both results of growth performance and yield components showed significant differences ($p \leq 0.05$). Concerning NGS, the interaction (4) revealed the highest counts (385.3) while the interaction (12)showed the lowest NGS. For plant height the interaction (1,7,10) gave the tallest plants(193.8,187.4 and 187.1 cm),whereas interaction (2,9,3,6) gave the shortest plants (119.3,109.3,108.9,108.3 cm).Results also revealed that the heavy SGW was found in interaction (11 showed 32.00 g) followed by interaction(8,10 showed 30.25 g and 29.50 g respectively) while interaction (2) showed the lightest SGW (18.50 g). For yield results revealed that no significant differences were found through all interactions. Yield for all interactions varied from 667.1 kg/feddan (Interaction 7) to 362.5 kg/feddan (Interaction11). Significant variety-by-planting date existed for plant height, head weight, and final grain yield was reported by [21].It was found that effect of (variety × sowing date) interaction was highly significant on number of tillers per square meter and grain yield of wheat [24].

Table 3. Effect of interaction of sowing date and variety on growth and yield parameters

Variety×Sowing date	Number of germinated seeds	plant height (cm)	1000grain weight(g)	Yield (kg/feddan)
1Tabat×7th July	343.0d	193.8a	25.50abc	230.9a
2Tabat× 10thJuly	330.3d	119.3d	18.50c	201.3ab
3Tabat × 15thJuly	315.0e	108.9d	22.50abc	226.2a
4Wad-Ahmed ×7th July	385.3a	168.1abc	28.00abc	208.9ab
5Wad-Ahmed× 10th July	379.5abc	129.9cd	21.00bc	47.6bc
6 Wad-Ahmed ×15th July	370.0bc	108.3d	22.00abc	263.5a
7Abu-Ragaba×7th July	381.0ab	187.4a	28.25abc	231.7a
8Abu-Ragaba ×10th July	374.3abc	142.0bcd	30.25ab	181.3abc
9Abu-Ragaba ×15th July	365.0c	109.3d	23.50abc	47.6bc
10 Abu-Kunjara×7th July	336.0d	187.1a	29.50ab	200.2ab
11Abu-Kunjara×10th July	303.8ef	170.1ab	32.00a	192.1abc
12Abu-Kunjara×15th July	295.5f	157.9abc	26.25abc	27.4c
LSD	13.77*	77.35*	9.313*	152.3*
S.E	4.305	11.18	2.911	47.6

4. Conclusion

Sorghum bicolor species locally named (barbarei) includes wide diversity of phenotypes (Abu- ragaba and Abu- kunjara) both with different seeds color. The babarei phenotypes seems to have different behavior in comparison with other cultivated species or varieties of sorghum in Darfur that the plants produces flowers and grain only when weather gets cooler (October-November), although the plant heads continue to form normally. It could be concluded that the vegetative growth parameters of sorghum as NGS and plant height are mostly determined by genetic factors rather than be influenced by environmental factors. On the other hand, interaction of variety ×sowing dates showed significant differences both for vegetative parameters (NGS, PH cm) and yield components (SGW g, yield kg/feddan).Therefore further studies are recommended.

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