ASSESSMENT OF BOTANICAL FEATURES AND CROP FIELD POTENTIALITIES OF (*Sorghum bicolor* L. (MOENCH) SPECIFIC PHENOTYPE (BARBAREI) IN SOUTH DARFUR STATE, SUDAN

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ABSTRACT

Two field experiments were conducted in South Darfur State during 2006/2007 growing season to investigate the morphological, physiological features and crop potentialities of [*Sorghum bicolor* (L.) Moench], (Phenotype barbarei). Field observations, soil physical and chemical analysis, plant growth and yield parameters were used for data collection, which were presented after statistical analysis. The results showed that barbarei crop was considered as a unique phenotype in comparison with other sorghum varieties that the crop produces flowers and grain only during the cool season (October - November). The barbarei plants seem to have intensive growth of the main stem, leaves, tillers and green heads while rains continue to fall and the temperature and the relative humidity are keeping high (20 -35ºc and 60 -70% respectively), while grain starts filling when the temperature decreases to 10-15ºC on October and the weather gets cooler. Results showed that the soil moisture was affected by the number of seedling/hole at different depths one month after transplanting and at grain filling stage. Four seedling/hole one month after transplanting showed the highest soil moisture content (29.77%, 20.06%) at 0-20 cm depth and (25.58%, 24.19%) at 20-40 cm depth for both barbarei phenotypes locally named (Abu-ragaba and Abu-kunjara), respectively. Two seedling/hole one month after transplanting showed the highest soil moisture content (40.48%) at 40-60 cm depth while it was the lowest (16.53%, 20.85%) at 0-20 and 20-40 cm depth respectively. Results of the field experiments revealed that some local sorghum varieties (Tabat and Wad Ahmed) showed good agronomic performance, when transplanted and treated with the same agro-techniques as practiced for barbarei but the differences were not significant except the main difference that the barbarei remains keeping vegetative growth till the weather get cooler as in October -November before flowering and grain filling, while the mentioned two varieties produces flowers and grains even if planted in early July. More attention should be drawn to barbarei cultivation in the present production areas (West and South Darfur States), in addition to other promoting areas in the country with similar environmental conditions (Kassala State), so as to make use of the wide potentialities of the crop such as vigor growth and high grain yield.

Keywords: *Sorghum bicolor* (L.) Moench, botanical features, specific phenotype (barbarei) Sudan.

INTRODUCTION

Sorghum bicolor L. (Moench) is a widely grown cereal crop in the world, particularly in Africa, Sorghum ranks 5th in global cereal production. Determining when and where sorghum was first domesticated has been a quandary for historian. Whether it was domesticated in Africa, or transported from Africa and domesticated in India then returned to Africa is not certain [1, 2, 3, and 4]. Sorghum, like many grains has different uses, including human consumption and animal feed. Sorghum is used for human nutrition all over the world. Globally, over half of all sorghum is used for human consumption [5]. It is a major crop for many poor farmers, especially in Africa, Central America, and South Asia. Grain sorghum is used for flours, porridges and side dishes, malted and distilled beverages, and specialty foods such as popped grain. Sorghum is also considered to be a significant crop for animal feeds, and in the US this is the major use of the grain. [6]. Grain sorghum is also used for silage, but it is not as commonly used as the sweet sorghum for this purpose. Sweet sorghums have higher silage yield, but grain sorghums have higher nutrition due to the grains, therefore sweet sorghum farmers may plant soybeans along with sorghum to raise the nutritional value of the silage Sorghum fibers are used in wallboard, fences, biodegradable packaging materials, and solvents. Dried stalks are used for cooking fuel, and dye can be extracted from the plant to color leather. A more recent use of sorghum is for ethanol production. Sorghum's range of genetic diversity is truly amazing. Some types look so abnormal that until recently they were classified as separate species. However, all of them cross readily with one another, all have a chromosome complement of 2n = 20, and all are recognized today as variants of the same plant, *Sorghum bicolor* [7]. Many of the unusual types are promising resources in their own right. Some have properties and uses quite unexpected of a cereal. A few hold out the possibility of producing far better grains than those of today's major sorghums. Others could provide entirely new types of sorghum foods. Yet others can yield feed, forage, fertilizer, fiber, fuel, sugar, and raw materials for factories of many kinds. The genus (*Sorghum* Moench) contains (4) species and (6) accepted taxa overall classified as following: Species- *Sorghum almum* Parodi - Columbus grass. Species- *Sorghum bicolor* (L.) Moench - sorghum. Subspecies- *Sorghum bicolor* (L.) Moench ssp. *arundinaceous* (Desv.) de Wet and Harlan - common wild sorghum. Subspecies- *Sorghum bicolor* (L.) Moench ssp.

bicolor - grain sorghum Subspecies - *Sorghum bicolor* (L.) Moench ssp. *drummondii* (Nees ex Steud.) de Wet and Harlan - Sudangrass. Species *Sorghum halepense* (L.) Pers. - Johnsongrass. Species- *Sorghum propinquum* (Kunth) Hitchc. - Sorghum [8, 9, and 10]. Grain sorghum is dominant summer crop in Sudan; many varieties are grown under rain-fed areas and under irrigation in some central states. Although barbarei is widely grown in South and West Darfur States and it play important role (economic and nutrition) but no studies or research were done about it. This study was conducted in South Darfur State (Sudan) in 2006/2007 growing season, to investigate morphological, physiological characteristics and field crop potentialities of unique Phenotype (or may be unique genotype) of sorghum bicolor species locally named (barbarei). This species 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. The study also aims to compare growth and yield components of Barbarei with other sorghum varieties usually cultivated in South Darfur in rainy season (Tabat and Wad-ahmad).

MATERIALS AND METHODS

Two field experiments were conducted in Wadi Shakhara, Tolous, South Darfur State (Sudan) in 2006/2007 growing season. This area is located within the zone of rich savannah about 90 miles south Nyala city. The warm rainy season starts on July and extends to the end of October with annual rainfall 500-600mm, 60% of which falls in the period of July -August. The dry cool season starts on November and extends to the end of February the time of Barbarei plants maturity and harvest. The soil in the study area is sandy clay loam with increasing of sand percentage, while clay and loam percentages decline. It is slightly acid with high moisture holding capacity at root system zone, pH is 6.2-6.8, and dry bulk density is 1.25-1.43g/cm^3 at of 0-60 cm depth. The first experiment aimed to study the effect of plant density on growth and yield of two sorghum (barbarei) phenotypes Abu-ragaba and Abu-kunjara and also the effect of plant density on soil moisture at root system zone. Split plot design (phenotypes in main plots and plant density in subplots) with three replicates. The plot size was (6m × 7m). Seedlings were prepared by direct seeds spreading in well protected small plots on third week of September, on the first week of November 2006; seedlings were transplanted to the main field then allowed to grow without using any extra irrigation or fertilizers. Seedlings planted in rows with 70cm in between and 30cm between holes. 2, 4, 5, 6 plants / hole were used to investigate the effect of plant density in the hole on the growth parameters and yield components of the selected varieties. One month after transplanting five plants of each plot were selected for growth and yield parameters measurements as follows: plant height (cm), number of leaves/plant, number of tillers/plant, main stem diameter (cm), the 1000- grains weight (g), grain weight/plant (g) and soil moisture content at different depths was determined as described by [10, 11]. Analysis of variance and test of significance were done according to the standard procedure of split plot design as described by [12]. Means was differentiated according to Duncan's Multiple Range Test (DMRT). The aim of the second experiment was to evaluate the performance of two sorghum (barbarei) phenotypes (Abu-ragaba and Abu-kunjara) in comparison with other two locally improved varieties (Tabat and Wad-ahmad) grown under the same conditions using the same methods and agro-techniques as described in the first experiment. Completely randomized block design (CRBD) with four replications was used. Data collected were statistically analyzed as described by [12].

RESULTS AND DISCUSSIONS

Results in Table-1 showed that the soil moisture was affected by the number of seedling/hole in different depth one month after transplanting and at grain filling stage. Four seedling/hole one month after transplanting showed the highest soil moisture content (29.77%, 20.06%) at 0-20 cm depth, and (25.58%, 24.19%) at 20-40 cm depth for both barbarei phenotypes (Abu-ragaba and Abu-kunjara respectively). Two seedling/hole one month after transplanting showed the highest soil moisture content (40.48%) at 40-60 cm depth while it was the lowest (16.53%, 20.85%) at 0-20, 20.40 cm depth respectively. This may be due to evaporation increase from soil surface. On the other hand, six seedling / hole showed the lowest soil moisture content throughout the vegetative period of the two varieties. This may be attributed to the highest consumption of soil moisture by intensive growth of plants root system. Results revealed also that soil moisture content decreases by time to the grain filling stage compared with early time after transplantation. It could be concluded that four seedling/hole is more positively effecting vegetative growth and then yield of the two barbarei phenotypes.

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Table-1. Effect of seedling/hole density of two sorghum (barbarei) phenotypes on volumetric soil moisture content (%).

Local name	Number of seedlings/hole	Volumetric soil moisture content (%)					
		One month after seedlings transplanting			At grain filling stage		
		0-20	20-40	40-60	0-20	20-40	40-60
Abu-ragaba	2	16.53	20.85	40.48	4.79	10.80	16.94
	4	29.77	25.58	33.68	6.17	11.64	17.48
	5	26.39	24.79	30.45	8.10	10.02	14.07
	6	18.18	21.13	28.79	7.18	8.86	12.76
Abu-kunjara	2	19.29	22.98	32.65	5.73	9.13	19.29
	4	21.06	24.19	24.35	8.33	12.01	18.70
	5	16.23	24.50	29.67	7.03	7.55	11.33
	6	18.08	21.37	25.75	9.37	7.70	10.82

Results in Table-2 revealed that the plant height at 30, 60 days after transplanting and also the main stem diameter at maturity showed no significant difference between both Abu-ragaba and Abu-kunjara barbarei phenotypes and even the number of seedling/hole. Whereas, number of leaves at 30, 60 days after transplanting and the number of tillers/plant at maturity showed significant differences ($p \leq 0.05$). Abu-ragaba showed the highest number of leaves at 30 days after transplanting (7.2) when the number of seedling/hole was two while Abu-kunjara showed the lowest number of leaves (6.5) at the same time when the number of seedling/hole was five, this could be reasoned to the higher plant competition in the same hole according to the number of seedling/hole. Abu-ragaba showed also higher number of leaves (10.0) at 60 days after transplanting when the number of seedling/hole was five while Abu-kunjara showed only (9.4) leaves when number of seedlings/hole was four at the same time. This could be due other factors affecting vegetative growth-in addition to plant competition- like soil type, pests. Concerning the number of tillers/plant at maturity results revealed that Abu-ragaba showed the biggest number (12.1) when seedling/hole was four while Abu-kunjara showed the smallest number (5.2) when five seedling/hole was used.

Table-2. Effect of seedling/hole density on vegetative growth parameters of two sorghum (babarei) phenotypes.

Local names	Seedling/hole	Vegetative growth parameters (3 replications)					
		Plant height (30) days after sowing (cm)	Plant height (60) days after sowing (cm)	No. of leaves (30) days after sowing	No. of leaves (60) days after sowing	No. of tillers at maturity	Stem diameter at maturity
Abu-ragaba (white)	2	38.60	133.67	7.20 a	8.23ab	6.97 bc	1.87
	4	38.63	120.00	6.47 ab	8.00ab	12.13 a	1.80
	5	36.80	127.00	5.33 ab	10.03a	6.43 bc	1.77
	6	33.67	116.67	5.77 ab	8.70 ab	10.77ab	2.00
Abu-kunjara (red)	2	29.03	139.80	5.53 ab	9.10ab	8.40abc	1.93
	4	30.53	125.77	5.77ab	9.43 b	6.07 c	1.87
	5	27.33	119.87	5.00 b	8.20ab	5.23 c	1.77
	6	32.53	127.33	5.00 b	8.13ab	8.30abc	1.90
C. v %		23.48	17.89	19.10	17.96	31.84	18.79
LSD		13.95ns	40.17ns	1.96	2.67	4.68	0.62ns

a-c: means with similar letters in columns are not significantly different at 5% level of LSD test.

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Table-3. Some morphological features of two sorghum bicolor specific phenotype – barbarei.

Local name	Position of head on the main stem	Seed color	1000-grain weight (g)
Abu-ragaba	Erect	White	34.1
		Yellow	37.5
Abu-kunjara	Bending 90˚	White	42.5
	Bending 180˚	Yellow	42.1
		Brown	44.7
Mean			40.18

Abu-ragaba and Abu-kunjara barbarei phenotypes are plants of sorghum bicolor genus, up to5-6m tall with large branched clusters of grains. The head is erect standing or bending with an angle of 90 or 180 degree (photos 1 and 2). The individual grains are small- about 3-4 mm in diameter. 1000-grain weight varies from 34.1 to 44.7(g). Grains vary in color from white to pale yellow through reddish brown to dark brown depending on the cultivar. Cultivars are annuals or perennials when soil moisture is sufficient enough for the root system to keep viable. Results in Table-4 showed that there was no significant differences between vegetative growth parameters (plant height, number of leaves, number of tillers at maturity, stem diameter at maturity) for both barbarei phenotypes(Abu-ragaba with white colored seeds and Abu-kunjara with brown colored seeds) compared with two locally improved varieties (Tabat and Wad-ahmad). That may lead to the conclusion that both Tabat and Wad-ahmad could be successfully cultivated in South Darfur practicing the same agro-techniques as used for barbarei cultivation (seedling preparation by the middle of September, transplanting on October, harvest on February without using any extra irrigation or fertilizers), whereas barbarei plants are completely failure to produce flowers and then grains when grown earlier at the beginning of the rainy season on July. Tabat and Wad-ahmad were always very successful in vegetative growth and yield when grown in early rainy season (July). This may be attributed to the variation of genetic or physiological factors affecting growth and yielding ability.

Table-4. Performance of four local sorghum bicolor varieties and phenotypes when treated with the same agro-technical packages.

Vegetative growth parameters						Local names
Stem diameter at maturity	**No. of tillers at maturity**	**No. of leaves (60) days after sowing**	**No. of leaves (30) days after sowing**	**Plant height (60) days after sowing** (cm)	**Plant height (30) days after sowing** (cm)	
2.33	7.35	9.83	3.85	113.40	23.32	Abu-ragaba(white)
2.30	6.60	9.15	3.83	127.60	20.32	Abu-kunjara(red)
2.10	7.68	9.95	3.93	109.80	21.70	Tabat
1.98	5.85	9.00	3.33	102.3	24.65	Wad-ahmad
17.63	30.77	17.95	18.65	18.76	30.54	Cv%
0.62	3.43	2.75	1.12	34.17	11.27	Lsd (0.05)

Figure-1. A field of Abu-ragaba barbarei plants (Erect) at maturity (South Darfur).

Figure-2. A field of Abu-kunjara barbarei plants (Bending 180^0) at grain filling (South Darfur).

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