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Evaluation of Some Pearl Millet (*Pennisetum glaucum* (L) R. Br.) Local Races in North Kordofan of Sudan

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Abstract Pearl millet is an important food and forage crop for Sudan. It has many uses in food products as well as a forage crop. It has become the staple food for millions of people in the Western Sudan (Darfur and North Kordofan) who live on a semi-desert fringes and arid region. It is the cereal crop that has a great potential for ensuring food security and income in marginal areas for its suitability to the extreme limits of agriculture. The study was carried out at the Crop Sciences Experimental Farm, University of Kordofan, Elobeid, Sudan, during 2020-2022 seasons to evaluate the agronomic and yield of some pearl millets local races of different genetic background and origin were collected from Darfur and Kordofan. The treatments consisted of twelve local races designated as P_1, P_2, ..., and P_{12} and Three cultivars (Faris, Ombader and Ashana). The total number of treatments were fifteen. The treatments were arranged in a randomized complete block design with four replications. Characters studied included: the number of productive tillers per plant, panicle length (cm), panicle width (cm), seed weight (g panicle^{-1}), 1000-seed weight (g), number of seeds panicle^{-1}, grain yield (Kg ha^{-1}), straw yield (kg ha^{-1}), threshing % and Harvest index. Data analysis showed that the local races had significant effect ($P \leq 0.05$) on the most of yield attributes. The local race P_3 had the highest panicle width (2.9 cm) and grain yield (540 kg ha^{-1}). The local race P_{12} displayed the highest number of reproductive tillers per plant (7) and a highest harvest index (23%). The local races (P_3 and P_{12}) demonstrated superiority concerning some agronomic characteristics and grain yield. Henceforth the study recommended those local races to be used by millet breeders and growers of North Kordofan to attained highest grain yield.

Keywords: *dukhn, aish barno, grain yield, harvest index, millet*

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1. Introduction

Pearl millet (*Pennisetum glaucum* L. R.Br.) is one of the most extensively cultivated cereals in the world, ranking sixth after rice, wheat, maize, barley and sorghum in terms of area planted to these crops [1]. Pearl Millet was domesticated over 4,000 years ago in the West African Sahel, spreading later to East Africa (Sudan) and India [2,3]. Millet (Dukhn) and sorghum, have been dominant staple crops in Sudan for over a thousand years. Millet more drought resistant than other sorghum crop. It has become the staple food for millions of people in the Western Sudan (Darfur and North Kordofan) who live on a semi-desert fringes and arid regions [4]. Millet now is widely distributed, occurring in parts of the central and Eastern parts of Sudan. Millet is the second most important cereal crop, following sorghum, with about 12.4% share in total annual cereal production in the Sudan [5]. There is a recent renewed interest in Pearl Millet for use in regions facing increased droughts and intensified desertification, as it is more drought tolerant than sorghum. Pearl Millet is adapted to environment too harsh for other crops [6]. It survives and produces seed on poor quality, sandy soils in hot, low-rainfall regions. It thrives under less severe growing condition, not tolerate waterlogged soils.

Pearl millet is both a food grain and a forage crop. Pearl millet is a principal source of energy, protein, vitamins and minerals for millions of poorest people in the regions where it is cultivated [1,7]. It generally has 9 to 13% protein, but large variation among local races ranging from 6 to 21% has been observed. Pearl millet contains more calories than wheat, probably because of its higher oil content of 5%, of which 50% are polyunsaturated fatty acids. It is rich in calcium, potassium, magnesium, iron, zinc, manganese, riboflavin, thiamine, niacin, lysine and tryptophan [1,10]. The sweet raw grains sometimes are consumed whole. Mature grains are ground into flour and used in the preparation of fermented and non-fermented flat breads. Millet in Sudan is mainly used for producing acida and gado gado. Millet is combined with maize or sorghum to produce a traditional beer, known as marisa.

Productivity of pearl millet is very low due to many factors, of which unavailability and very low adoption rate of improved cultivars and other recommended technology is the most important one. The Agricultural Research Corporation has a research programme to develop new improved cultivars of millet characterized by high yields and efforts are directed towards purifying local cultivars (*Eldahbi, ElKordofani, Aish Barno and Bayouda*). The programme is also called "millet genetic sources". Pearl millet is a major climate resilient cereal crop that is cultivated extensively on resource-poor marginal lands of arid and semiarid regions of Asia and sub-Saharan Africa [8]. It forms a source of food and fodder and ensures food and nutritional security to the inhabitants who are practicing low-input agriculture [9]. Being a "Nutri-cereal" and thriving well in any cropping system, it shows a crucial role in defeating malnutrition and improving the socioeconomic status of resource-poor farmers 10]. The main constrained facing millet production in Sudan, uncertain and unevenly distributed rain is one of the most important factors inhibiting productivity, since millet will be subjected to water stress. Local millet cultivars require four months to mature while the duration of the rain is three months. This has reduced crop adaptability. Variable quality of inputs. Traditional millet cultivars got mixed up also –growers started to purchase millet seeds from the market and cultivate them. They do not know the source and quality of these seeds. Thus the objective of these study to evaluate the some land races of Pearl millet (*Pennisetum glaucum* (L) collected from different parts of Kordofan and Darfur, the main regions producing pearl millet crop in Sudan.

2. Materials and Methods

2.1. The Experimental Site and Climate

A field experiment was conducted under rain fed for two successive seasons (2020/2021- 2021/2022) at the Crop Sciences Experimental Farm, Faculty of Natural Resources and Environmental Studies, University of Kordofan, Elobeid, Sudan. To investigate the effect of some local races of pearl millets collected from different parts of Kordofan and Darfur regions (Sudan). The site of the experiment lies between latitude (33º-34´) N and longitude (72º-38´) E.

The climate of area is arid and semiarid. The soil is sandy, annual rain fall ranges between 490.5-506.3 (mm), Average maximum daily temperature ranges between 27.23 Cº - 26.83 Cº and Relative humidity (%) between 42.88 % and 47.07 % throughout the year [12,13]

2.2. Experiment Materials and Layout

The experimental material used in this study consisted of fifteen local races of pearl millet; two Cultivars released for drought tolerance (Faris and Ombader) were provided by Agricultural research Corporation (ARC), Ashana was provided by Arab Sudanese Seed Company (ASSCO.) and twelve local landraces were collected from farmer fields Villages in North Kordofan State and Darfur during rainy season 2019/2020

The experiment was laid out in a randomized complete block design with four replicates. The experimental unit was 4 X 4 meters. The treatments consisted of twelve local races of pearl millet (*Pennisetum glaucum* L. R. Br.) designated as: P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11} and P_{12}, and three cultivars: Faris, Ombader and Ashana. The total number of treatments were fifteen.

Sowing:

Before sowing, seeds were treated with Fernisan-D at 3 g/kg seed to protect seeds against termite.

Sowing was on 6th of July for the first season and on 31th of July for the second season. Seeds were sown at spacing of 60 cm between line and 50 cm within line. Five to six seeds were placed in each hole, which were then thinned to two plants per hole, after two weeks from sowing. The plots were weeded twice, the first one was after two weeks from sowing and the second weeding after a month from the first weeding.

2.3. Characters Studied

Seven plants were randomly selected from the inner rows in all plots. From these the following parameters were measured:

Number of Panicles per plant

Panicle length (cm): Mean length of the panicle measured on a sample of four head measured from the base to the tip of the head.

Panicle width (cm): Mean width of the panicle measured on a sample of four head measured at maximum width of the panicle

Seed Weight (g panicle^{-1})

1000-seed weight (g): 1000 seeds will be weighted (four times) from each sample and weighed.

Number of seeds panicle^{-1}

Grain yield (Kg ha^{-1}): Calculated by using the following formula:

$$\text{Grain yield} = \frac{\text{grain yield}(\text{kg}) \text{of plot}}{\text{harvest plot area}} \times 10000$$

Straw yield (kg ha^{-1})

Threshing %.

Harvest index (H. I): Harvest index was determined by using the following formula:

$$\text{Harvest Index} = \frac{\text{Economical yield}(\text{grain yield})}{\text{Bilogical yield}} \times 100$$

2.4. Statistical Analysis

Data were statistically analyzed using STAR (Statistical Tool for Agricultural Research) software version 2.0.1. For comparison between means, they were separated using Duncan Multiple Range Test (DMRT), at 0.05 level of significance, according to the procedure described by Gomez and Gomez [14].

3. Results and Discussion

In the present study, the fifteen pearl millet local races exhibited significant differences in most of the characters

studied (Table 1, Table 2, and Table 3). Similar findings were obtained by many workers in pearl millet and different cereal crops under different environments [15,16]. Considering the local races studied, there is a noticeable variation, not only among the different local races of the same species, but also within the same local race or cultivar. Such variation may be attributed to the open pollination system of this crop [17] and to independent domestication and emigrational events [18]. In the parameters studied, the different local races showed significant difference for most of the parameters. These variations between the different local races have special value for adaptation to the local agro- climatic conditions. The high tillering (ability to produce tillers) capacity local races can compensate the loss of the main panicle succeeding in preventing a famine and starvation. These results indicate variability among pearl millet local races for grain yield, panicle length, 1000- seed weight and productive tillers. The yield components (panicle length, 1000-seed weight and productive tillers) determine grain in pearl millet. These results increased the probability of isolating superior local race for obtaining higher yielding local race, since direct selection for grain yield alone could be misleading. The obtained results are expressing the different response of studied local races and some of them could be used as promised local races when the seed yield applied as selection criteria. These results are agreed with those reported by Khairwal *et.al*. [1] and Gebre [19] who found significant difference between studied pearl millet local races for grain weight. Similar observations were reported by Abuali *et al*. [20]

General Pearl millet characterized by short and compact panicle, with panicle length and weight being important selections criteria affecting the farmers acceptance to the variety especially in arid and semi-arid environments, in the current study the highest panicle length (cm) showed by local race P_8 (29.0 cm),

The highest number of productive tillers recorded by local race P_9 is 7 tillers showed significant differences, Substantial variations in pearl millet have been relatively by Yadav [21]. This components productive tillers determine grain in millet.

Straw weight (g) showed no significant difference among local race, the local race P3 (2200 kg ha^{-1}) showed the highest weight, this result disagree with The results of Salih , *et.al* [22] as reported the local race were differed highly significantly for straw yield (kg/ha).

Harvest index (HI) indicate the ability of the local race to convert the accumulated dry matter into the economic component (grain). Especially when subject to unfavourable conditions, HI is proposed an important selection criteria indicate the plant to set grain under stress [23]. The analysis of variance for the Harvest index showed no significant difference among local races the highest index is 21.6 detect by Faris, this result similar that reported by Shaalan. et. al. [24] reviled non-significant variation in the HI among the treatment.

Table 1. Effect of local race on number of productive tillers/plant, panicle length (cm) and panicle width (mm) of pear millet grown during season (2020/21 and 2021/22)

Local races	2020/2021			2021/2022		
	Number of Productive tillers/plant	Panicle Length (cm)	Panicle width (cm)	Number of Productive tillers/plant	Panicle Length (cm)	Panicle width (cm)
P1	5.0b	24.2a	2.7a	3.0c	27.1a	2.0b
P2	3.4c	27.0a	2.0c	6.0a	25.3a	2.1b
P3	4.1c	29.8a	2.9[a]	4.0b	26.1a	2.6a
P4	4.3c	29.7a	2.3c	6.0a	26.2a	1.9c
P5	4.1c	24.0a	2.1c	4.0	23.6a	1.9c
P6	5.2b	24.0a	2.4b	6.0a	27.2a	1.9c
P7	6.0b	27.6a	2.6b	5.0b	25.2a	2.0b
P8	4.1c	30.9a	2.1c	5.0b	27.2a	2.1b
P9	7.0a	23.0a	2.4b	3.1c	21.4a	2.3b
P10	6.0b	23.3a	2.3b	5.3b	21.7a	2.1b
P11	5.1b	23.0a	2.5b	5.3b	24.8a	2.3b
P12	7.0a	25.1a	2.8a	6.4a	24.9a	2.5a
Ashana	4.0c	21.9a	2.5b	4.1b	20.8a	1.9c
Ombader	4.3c	25.2a	2.2c	5.2b	22.8a	2.1b
Faris	4.2	22.0	2.2c	5.1	25.7	2.5
Mean	5.0	25.4	2.4	4.0	24.6	2.1
CV%	17.15	16.14	22.37	10.03	13.51	21.94

Similar letters are not significant different at the 0.05 level of probability according to Duncan Multiple Range Test

Table 2. Effect of local race on seed weight (g), 1000-seed weight (g) and seed yield (kg/ha) of pear millet grown during season (2020/2021-2021/2022)

Local races	2020/2021				2021/2022			
	Seed Weight (g $panicle^{-1}$)	1000 Seed Weight(g)	Number of seeds $panicle^{-1}$	Grain yield (Kg ha^{-1})	Seed Weight (g $panicle^{-1}$)	1000 kernels Weight(g)	Number of seeds $panicle^{-1}$	Grain yield (Kg ha^{-1})
P1	14.7	15.5	1670.0	440.1[b]	20.0	13.9	1538.5	220.5
P2	32.0	14.1	2500.0	360.0[c]	31.3	13.3	2353.4	300.9
P3	22.6	14.9	1516.7	540.5[a]	24.9	13.6	1830.9	380.6

Local races	2020/2021				2021/2022			
	Seed Weight (g panicle^{-1})	1000 Seed Weight(g)	Number of seeds panicle^{-1}	Grain yield (Kg ha^{-1})	Seed Weight (g panicle^{-1})	1000 kernels Weight(g)	Number of seeds panicle^{-1}	Grain yield (Kg ha^{-1})
P4	44.0	15.2	2894.7	460.1b	16.6	13.7	1211.7	240.6
P5	28.6	15.2	1881.6	500.4^{b}	33.3	14.5	2296.5	240.8
P6	27.6	16.1	1714.3	440.7^{b}	24.5	15.3	1601.3	260.0
P7	16.6	15.8	1050.6	380.2^{b}	16.0	15.1	1059.6	240.4
P8	15.0	15.5	961.5	320.3^{c}	28.6	14.8	1932.4	300.0
P9	27.5	16.4	1676.8	340.3^{b}	19.0	13.6	1397.1	320.6
P10	29.0	15.2	1907.9	500.6^{b}	32.4	13.9	2330.9	300.3
P11	25.3	15.1	1675.5	400.4^{b}	38.0	12.6	3015.8	260.3
P12	25.0	15.9	1572.3	420.0^{b}	17.6	13.7	1284.6	240.0
Ashana	20.5	17.2	1191.9	280.7^{c}	12.6	15.7	802.6	320.0
Ombader	26.0	17.0	1529.4	520.6^{a}	29.9	15.4	1941.6	240.0
Faris	25.1	13.1	1916.0	500.9^{b}	31.0	13.1	2366.4	360.3
Mean	29.6	15.5	1719.4	420.7	25.0	14.2	1704.1	280.6
CV%	10.43	9.70	10,1	7.69	12.35	12.11	8.9	8.26

Similar letters are not significant different at the 0.05 level of probability according to Duncan Multiple Range Test

Table 3. Effect of local race on threshing (%), harvest index (%) and straw weight (kg h^{-1}) of pear millet grown during season 2020/2021 and 2021/2022

Local races	2020/2021			2021/2022		
	Threshing (%)	Harvest index (%)	Straw Weight (kg h^{-1})	Threshing (%)	Harvest index (%)	Straw Weight (kg h-1)
P1	0.4	7.3c	1400	0.7	9.7c	1160
P2	0.9	16.5b	1400	2.2	20.2b	1000
P3	0.8	6.4c	2200	0.8	8.3c	1800
P4	7.1	18.5b	1200	0.7	11.2c	1000
P5	2.4	21.8b	1200	3.6	20.7c	1000
P6	1.1	21.1b	800	1.1	15.8c	800
P7	1.1	11.2c	1600	0.9	11.0c	1200
P8	0.6	10.8b	1200	1.2	24.3a	1000
P9	2.0	16.2b	1200	1.6	13.0c	1000
P10	1.2	19.8b	1600	1.9	20.8b	1400
P11	1.6	17.0b	625	3.0	18.2b	800
P12	2.9	22.8a	1125	1.0	22.7a	1200
Ashana	0.5	9.3c	1200	0.8	8.7c	1000
Ombader	2.3	23.1a	1400	2.8	17.3b	1200
Faris	2.8	21.6a	600	1.9	20.2b	400
Mean	1.8	21.4	1250	1.6	22.3	1064
CV%	77.31	23.81	25.54	24.74	19.96	24.03

Similar letters are not significant different at the 0.05 level of probability according to Duncan Multiple Range Test

4. Conclusion

Based on the obtained results, the pearl millet local races with significant and stable on other traits. The local races (P_3 and P_{12}) demonstrated superiority concerning some agronomic characteristics and grain yield, (mainly panicle length (cm), panicle width (cm), seed weight (g panicle^{-1}), 1000-seed weight (g), number of seeds panicle^{-1}, grain yield (Kg ha^{-1}) and thus suitable for western part of Sudan environment and can be recommended to traditional pearl millet growers. Further study needed to local races to be incorporated in breeding programs to improve the productivity and adaptability.

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