Original Research

EAST AFRICAN JOURNAL OF PASTORALISM

Volume 2 Issue 2

Grain Yield Performance of Pearl Millet (*Pennisetum glaucum*) Genotypes in Kebribeya District of Somali Region, Ethiopia

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ABSTRACT

Pearl millet is a staple food source in arid and semi-arid regions of Africa and Asia, especially for people living in harsh environments. Despite the importance of millet in dryland agriculture, improved varieties are still limited. In Ethiopia, only one variety (*Kola-1*) has been released so far. Therefore, this experiment was conducted to select pearl millet genotypes with high yield and pest resistance as well as determine the relationship between yield and yield-related traits. It was carried out in rain fed conditions in the "Kebribeyah" district of the Somali region, Ethiopia. Fifteen pearl millet genotypes were arranged in a Randomized Complete Block Design (RCBD) with three replications. Analysis of variance results showed that significant differences between millet genotypes were observed in six traits. There were significant differences ($p < 0.05$) between genotypes tested for all traits except days to maturity. Grain yield had a significant positive correlation ($r^2 = 0.41$) with the number of productive tillers. So lines: HuARC12; HuARC51; and HuARC115 were selected based on their grain yield potential. Finally, the superior adhesion needs to be tested in multiple environments.

Key Words: Correlation, Genotypes, Lines, Millet, Yield

1. Introduction

1.1. Background

Pearl millet (*Pennisetum glaucum*) is an important crop that produces food and fodder for millions of people living in arid and semi-arid regions, where growing conditions are too dry and infertile to grow most other cereal crops (Jukanti et al., 2016). It is grown as a food crop in tropical Africa and India, with most production concentrated in Sahelian Africa and northwestern India (Charrier, 2001). High temperatures, short growing seasons, frequent droughts, and infertile sandy soils characterize these regions. Pearl millet is mainly used as human food but is also used as animal feed, as a construction material, and as a fuel source (Jukanti et al., 2016; Katrien M D and A, 2006).

Pearl millet most likely originated in North Africa, in the area from Western Sudan to Senegal (Harlan, 1971). According to Archaeological evidence of domestic millet use dates back to 3,500 BC reviewed by Zach and Klee (2003), it grows best in light, sandy, well-drained soil. Although it grows better than most cereals under low moisture and fertility conditions, it responds readily to more favorable growing conditions (Poncet et al., 2000).

Pearl millet is an annual sexual diploid species ($2n = 2x = 14$) and its chromosomes are designated as genome A (P.P. and W.W., 1998). Pearl millet is very diverse in morphology. This is a hardy annual grass, usually 1.5 to 3 m tall but can reach 5 m. The inflorescence is cylindrical, stiff, and very dense and is usually 15 to 45 cm long but can be up to 150 cm long. The spikelets have short stems, divided into two in a cluster, and are 3.5 to 4. 5 mm long, oval, and swollen. The leaf blade is flat, stringy, and up to 1 m long and 5 cm wide (ICRISAT, 1996).

In Ethiopia, pearl millet research began two decades ago with the aim of providing improved pearl millet varieties and complementary agronomic practices to the country's lowland growing regions. Although progress is limited, only one variety (Kola-1) has been released to date (of Agriculture, 2018). It was more or less introduced to the lowlands of the Southern and Benishangul regions through participatory adaptation trials in 2008 and 2009 (Center, 2009). Although

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Article Information:
Article Received for review: 8 February 2021
Article Reviewed: 14 April 2021
Revised Comments: 10 June 2021
Accepted for publication: 10 August 2021 Available Online: 31 December 2021
How to Cite this Article:
Yohannes S E, Tesfu M W, Zelalem F G,Abdikadir S A (2021): Grain Yield Performance of Pearl Millet (*Pennisetum glaucum*) Genotypes in Kebribeya District of Somali Region, Ethiopia East African Journal of Pastoralism, 2(2):1-4.

the information on the introduction of millet into the Somali region is scarce or unavailable, production of this crop has now expanded to dry lowland areas such as "Konso", "Alamata", and “Meiso" and in the south of Omo. According to the “Jinka” Agricultural Research Center (Center, 2009), this crop is in high demand among the agricultural community in water-stressed areas due to its early growth and drought tolerance, alternative use as animal feed, and reasonable productivity (Andrews and Kumar, 1992; Choudhary et al., 2020; Srivastava et al., 2020).

The Somali region is often characterized by low, erratic, and uneven rainfall, so frequent droughts are a common phenomenon (van Velthuizen et al., 1995; Zerga and Gebeyehu, 2016). The frequent occurrence of drought stress is believed to be the main factor limiting the yield potential of most crops in the region (Ayal and Leal Filho, 2017; Mekuria, 2012; Thornton et al., 2014). This situation is now further complicated by ongoing climate variability and change, with profound impacts on the livelihoods of dryland communities. To address low agricultural output and low productivity in drylands, the National Agricultural Research System “NARS”; the whole country is making efforts to develop drought-resistant, heat-resistant, early-maturing, and pest-resistant crop varieties. In sharp contrast to national/regional efforts to improve the productivity and efficiency of cereal crops, through selective breeding, the current decline in agricultural productivity, along with access and Agricultural breeders’ restrictions on improved breed’s results in a significant gap. In this regard, millet, due to its many characteristics of early maturity, drought resistance, and high food and feed value, is considered a promising crop in dry lands in general and the Somali region in particular. However, efforts to date to introduce this crop to the farming community in the region have been negligible. Therefore, this study was initiated to introduce and select pearl millet genotypes with high grain and biomass yields in rain fed areas of the region.

1.2. Objectives

1.2.1. General Objective

The main objective of the study was to generate the best pearl millet genotypes in the Somali region by testing the yield performance of different genotypes in the rain-fed system.

1.2.2. Specific Objectives

The specific objectives were to:

- Select pearl millet genotypes with high grain yield under the rain-fed system in drought-prone areas of the SRS.
- Determine the association between yield and yield-related traits.

2. Materials and Methods

2.1. Study Location

The experiment was conducted in ‘Kaho’ kebele, ‘Kebribeyah’ district, ‘Fafen’ zone, Somali Regional State, Ethiopia. ‘Kaho’ is located at an altitude of 1410 meters above sea level, latitude of 9°27N and a longitude of 42°59E. The areas’ average mean minimum and maximum temperatures are 17 and 32 °C, respectively. It has erratic rainfall distribution with annual rainfall ranging from 300 to 500 mm and is characterized as semi-arid (van Velthuizen et al., 1995). The major crops grown in the districts are sorghum and maize.

Table 1: List and description of genotypes tested in the experiment

Entry no	Accession	Seed source	Entry no	Accession	Seed source
1	HuARC12	HARC*	9	HuARC96	>>
2	HuARC19	>>	10	HuARC98	>>
3	HuARC51	>>	11	HuARC105	>>
4	HuARC55	>>	12	HuARC109	>>
5	HuARC56	>>	13	HuARC112	>>
6	HuARC57	>>	14	HuARC115	>>
7	HuARC92	>>	15	HuARC117	>>
8	HuARC94	>>			

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2.2. Treatment, Design, and Field Management

Fifteen early maturing advanced genotypes were tested in the study area (Table 1). The experiment was laid out in a Randomized Completely Block Design (RCBD) with three replications. Seeds of each genotype were drilled at a rate of 10kg ha^{-1} in a plot consisting of two rows each 4m long with 0.75m inter-row spacing resulting in a plot size of 22.5 m^2. Thinning was done when seedlings were reached at 0.12-0.15 m height (two weeks after planting) by maintaining 0.15 m spacing between plants. Urea and NPS fertilizers were applied each at a rate of 50 kg ha^{-1}. The fertilizers were applied so that the full dose of NPS and half of urea were applied at planting, while the remaining half was side-dressed at the tillering stage.

2.3. Data Collection

Morphological and physiological data were collected in the middle column. For data recorded on a single-plant basis, five plants were randomly selected from the net harvested area, and marked, and their average was used for statistical analysis. Plant height (from the ground to the top of the plant). Number of tillers (counting basic tillers other than the mother plant). Number of productive tillers (counting the number of tillers with fertile heads), days to maturity (number of days from planting until 95% of the plant is ripe (seed structure hardens)), grain yield (measured weight of grain). In moisture of seeds). If the content was less than 12, we recorded the weight of 1,000 seeds (the weight in grams of 1,000 seeds randomly sampled from the seed set in each plot).

2.4. Data Analysis

Data on yield and yield components collected in the field were subjected to analysis of variance using statistical analysis software (SAS) version 9.4 (Institute., 2018). Mean separation was performed using least significant difference (LSD) with 5% probability. The correlation matrix between

Table 2: Mean performance of 15 genotypes for different traits

Entry no	Accession	NT	NPT	PH	GY	TSW
1	HuARC12	6.27b	4.33^a	132.13abc	3757.04a	7.61cdef
2	HuARC19	4.67cde	2.87^bcd	134.13ab	2465.19de	6.89f
3	HuARC51	5.47bc	3.53^abc	108.93def	3650.37ab	8.20abc
4	HuARC55	5.73bc	2.53^cd	129.60abcd	2405.93de	8.04bc
5	HuARC56	4.93cde	3.20^bc	97.40f	2571.85de	8.68ab
6	HuARC57	4.87cde	2.53^cd	102.27ef	2388.15e	7.12def
7	HuARC92	4.53cde	2.07^d	109.33def	2690.37de	9.07a
8	HuARC94	4.07e	2.60^cd	110.13def	2951.11cde	6.95ef
9	HuARC96	4.67cde	3.47^abc	114.73bcdef	3063.70bcd	7.85bcde
10	HuARC98	5.13bcde	3.40^abc	114.53bcdef	2488.89de	7.07def
11	HuARC105	5.33bcde	3.13^bc	111.33cdef	2785.19cde	7.57cdef
12	HuARC109	4.33de	$2.87b^cd$	123.00abcde	2998.52bcd	7.96bcd
13	HuARC112	4.67cde	3.13^bc	128.07abcd	3045.93bcd	8.63ab
14	HuARC115	7.87a	3.80^ab	142.80a	3407.41abc	6.79f
15	HuARC117	5.73bc	3.00^bcd	115.87bcdef	2725.93de	7.09def
LSD		1.28	1.00	21.11	659.98	0.91
Mean		5.21	3.09	118.28	2893.03	7.70

Means with a similar letter(s) in a column are not significantly different, LSD (5%), a least significant difference. DM=days to maturity, NT=number of tillers, NPT=number of productive tillers, PH=plant height, GY=grain yield, and TSW=thousand seed weight

observed yield and other traits was evaluated using Minitab 17 software (Minitab, 2014).

3. Results and Discussion

3.1. Results

3.1.1. Plant Height

There were significant differences ($P < 0.05$) among the tested genotypes for plant height (Table1). Lines HuARC115, HuARC19, HuARC12, HuARC55, and HuARC112 were the five lines with the longest plant height in descending order, while HuARC56 and HuARC57 were the two lowest lines with the lowest plant height in descending order (Table2). Plant height had a high positive significant correlation only with the number of tillers ($r^2 = 0.43659$) and no correlation with all other traits (Table3).

3.1.2. Number of Tillers and Productive Tillers

The results of the analysis of variance (Appendix Table 1) revealed that there were significant ($P < 0.05$) differences in the number of tillers and the number of productive tillers for the tested genotypes. Lines HuARC115, HuARC12, HuARC117, HuARC55, and HuARC51 were the five accessions with the highest number of tillers in descending order, while HuARC109 and HuARC94 had the lowest number of tillers. Regarding the number of productive tillers, accessions HuARC12, HuARC115, HuARC51, HuARC96, and HuARC98 were the five accessions with the highest number of productive tillers, while HuARC92 and HuARC57 had the lowest number of productive tillers (Table2). The number of tillers was significantly correlated with the number of productive tillers and plant height. Besides, the number of productive tillers was significantly associated with days to maturity and grain yield. Additionally, days to maturity showed a high significant correlation (r^2=0.62) with grain yield (Table3).

Table 3: Pearson coefficients of correlation for yield and yield-related traits

	NPT	MD	PH	GY	TSW
NT	0.54**	0.12	0.44**	0.22	-0.24
NPT		0.34**	0.2	0.41**	0
MD			0.17	0.62**	0.18
PH				0.24	-0.19
GY					0.2

*, ** . Correlation is significant at 0.05 and 0.01 levels respectively, and values without asterisks are not significant. DM=days to maturity, NT=number of tillers, NPT=number of productive tillers, PH=plant height, GY=grain yield, TSW=thousand seed weight.

3.1.3. Grain yield and thousand-grain weight

Lines HuARC12, HuARC51, HuARC115, HuARC96, HuARC112 and HuARC109 had the highest grain yield, while HuARC57, HuARC55 and HuARC19 had the lowest grain yield (Table 3). The highest thousand grain weights were achieved with accessions HuARC92, HuARC56, HuARC112, and HuARC51. While accessions, HuARC115 and HuARC19 had the lowest thousand-grain weight (Table2). Grain yield showed a positive and significant correlation with the number of productive tillers, days to maturity, and harvest index (Table3). However, thousand-grain weight had no significant correlation with other traits ($p<0.05$).

4. Discussion

As a result of the analysis of variance, the presence of significant variation among the 15 pearl millet genotypes was observed. This indicates genotypic differences in grain yield and other yield-related traits in the study area (moisture-stressed area) due to genetic differences. Millet is widely distributed in semi-arid regions, and many authors have reported the genetic potential of millet response to moisture stress (Patil et al., 2018; Gebre, 2014).

There was a positive association between growth parameters. For instance, plant height had a positive correlation with tiller number. Accessions with a higher number of tillers had higher plant height than accessions with lower plant height (HuARC115, HuARC19, HuARC12; 142.80 cm, 134.13 cm, and 132.13 cm, respectively). Reduction in plant height may be associated with a reduction in cell elongation and thus a reduction in the number of tillers produced (Bhatt and Srinivasa, 2005). Contrary to this finding Patil et al. (2018) reported on millet a negative correlation between plant height and number of tillers (Patil et al., 2018).

Yield is the sum of main crop grains and tiller grains. Therefore, the number of productive tillers is directly correlated with grain yield. Accessions HuARC12, HuARC51, HuARC115, HuARC96, and HuARC112 had the highest grain yield. Additionally, these lines also had medium to high productive tiller numbers and matured later than lines with lower grain yields. A previous study by Dehinwal et al. (2017) and Patil et al. (2021) also reported a strong relationship between grain yield and the number of productive tillers. In semi-arid regions, the reproductive stage of maize was reduced, resulting in a significant reduction in grain yield and maturation time (Liu and Wiatrak, 2011). A yield reduction of 28.05% was also recorded in barley (Vaezi et al., 2010). Therefore, correlation analysis of morphological trait results suggested that the number of productive tillers and days to maturity may be important traits for improving pearl millet grain yield.

5. Conclusion and Recommendation

Pearl millet is a staple food for people living in arid and semi-arid regions of Africa and Asia. This study investigates the existence of variation among lines in terms of yield and yield-related morphological traits. The following lines are selected based on grain yield potential, HuARC12, HuARC51, and HuARC115. Superior material should be promoted for further breeding programs in multi-location trials to develop new varieties.

Conflict of Interest

The author declares that they don’t have conflict of interest.

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