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Characterization of Pearl Millet (*Pennisetumglaucum* (L.) R. Br) Selected Accessions for Agronomic Traits at Kashafi in Menge Woreda, Assosa, Ethiopia

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Abstract: ***Characterization and agronomic evaluation of genetic resources is imperative and a prerequisite to identify trait-specific germplasm for crop improvement in maximization of crop yield. Twenty-one pearl millet accessions were collected from five geographical areas using passport data. Morphological characterization results depicted the presence of sufficient morphological traits variability among the genotypes. AGM3, AGM7 and AGM11 accessions had relatively higher yield. High heritability coupled with higher genetic advance as percentage of mean were recorded for days to maturity, stem girth, ear head length, flag leaf area, leaf per plant, TSW and grain yield whereas inter node length showed moderate heritability combined with high GAM indicated that additive gene action on the expression of these characters which revealed an effective selection of desirable genotypes. Days to maturity, leaf per plant, stem girth, tiller number and TSW were significantly positively correlated whereas leaf area and panicle length were significantly negatively associated with grain yield. As this investigation revealed that pearl millet materials had a wide range of variability and favorable mean performance for the traits studied that could be exploited as potential hybrids aimed for simultaneous improvement of grain yield and other yield related traits.***

Keywords: Morphological trait, Fertility, Correlation, Green fodder, Heritability, Pearl Millet.

Abbreviations:
GAM: Genetic Advance Mean
GA: Genetic Advance
X: Mean Value
TSW: Thousand Seed Weight
TSW: Thousand Seed Weight
MSG: Mean Squares Due to Genotypes
MSE: Mean Squares Due to Error
GCV: Genotypic Coefficient of Variation
σ2p: Estimate of Phenotypic Variances
σ2g: Genotypic Variance
PCV: Phenotypic Coefficient of Variation
DF: Days to Flowering
DM: Days to Maturity
PH: Plant Height
IL: Inter Node Length
LA: Leaf Area
FLA: Flag Leaf Area
LPP: Leaf Per Plant
SG: Stem Girth
EHL: Ear Head Length
EHD: Ear Head Diameter
PL: Panicle Length
TN: Tiller Number
TSW: Thousand Seed weight
GY: Grain Yield

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I. INTRODUCTION

Pearl millet (P*ennisetumglaucum (L.)* R. Br) with chromosome number 2n = 2x = 14 belongs to a highly heterozygous group that encompasses both wild and cultivated [13]. Millets are small-seeded grasses that are hardy and grow well in dry zones of sub-Saharan Africa as rain-fed crops under marginal conditions of soil fertility and moisture [12]. Thus, pearl millet is often referred to as the "Camel"because of its exceptional ability to tolerate drought. Even with minimal rainfall pearl millet can typically produce a reasonable yield. The crop is one of the most important staple cereals for subsistence farmers living in semiarid tropics of Africa and Asia due to its high tolerance to drought, high temperatures, saline and marginal soils and high capacity to buffer variable environmental conditions [9]. Approximately, 500 million people depend on pearl millet and it is currently grown on 28 million hectares throughout the world [21]. It has higher protein, fat and balanced amino acid for human nutrition than that of wheat, maize or polished rice [15]. Its green fodder is a valuable feed for livestock and it also makes an excellent annual pasture grass without prussic acid, a poisoning potential commonly found in sorghum and sudan grass [22]. Pearl millet offers an excellent choice for this purpose [20]. It is more tolerant to low soil fertility and drought, and often has higher protein concentrations than sorghum and corn [3].

Pearl millet has wide genetic diversity which is of little value unless it is characterized, evaluated and documented properly to enhance its utilization in crop improvement. Continuous targeted diversification of breeding populations is important to assure long-term selection gains. To meet its growing demand, high fodder yielding and nutritious varieties of fodder crops are needed. Characterization and agronomic evaluation of genetic resources is imperative and a prerequisite

to identify trait-specific germplasm for crop improvement. Hence, the current study was designed with objective to characterize and evaluate pearl millet genotypes on the basis of different qualitative traits and quantitative to analyze the variability exist among the genotypes.

II. MATERIALS AND METHODS

A. Experimental Site

A field experiment was conducted during 2023/24 cropping season at Kashafi testing site of Menge district in Northwestern Ethiopia. Approximate geographical coordinate is 10º38'55'' N latitude and 34º20'45'' E longitude having an altitude of 950 meters above sea level. The area is characterized by a unimodal rainfall pattern that starts at the end of April and extends to mid-November where maximum rainfall occurs from June to October. The average annual rainfall of the area is 1375 mm with minimum and maximum temperatures of 22 and 36^{0}C, respectively. The soil type of experimental area is nitosols with soil pH 5.5 which was slightly acidic.

B. Treatments And Experimental Design

Treatments consisted in twenty-one pearl millet accessions (AGM1, AGM2, AGM3, AGM4, AGM5, AGM6, AGM7, AGM8, AGM9, AGM10, AGM11, AGM12, AGM13, AGM14, AGM15, AGM16, AGM17, AGM18, AGM19, AGM20 and AGM21) were collected from five geographical areas of Benshangul region using passport data. Pearl millet accessions, area and location of collection is shown in (Table I). The treatments were laid out in a randomized complete block design with three replications. Plot size was 3 m wide and 5 m long with total gross area of 15 m^2. Before planting, the experimental field was plowed, pulverized and leveled in order to have smooth seedbed for planting. Seeds were hand planted by placing two seeds per hill at row spacing of 75 cm and plant spacing of 15 cm with seed rate of 70 kg/ha. The morphological data recorded on qualitative and quantitative agronomic traits were collected during the cropping season according to descriptors trait of pear millet. All recommended agronomic practices such as cultivation, weeding etc., were employed during crop growing period [4].

Table-I: Pearl Millet Accessions and Area and Location of Collection

Accession	Region	District	Specific Site	Latitude	Longitude
AGM1	Beneshangul	Menge	Ashafi	10o33'31"N	34o20'30" E
AGM2	Beneshangul	Homesha	Biloha	10o33'27"N	34o23'60" E
AGM3	Beneshangul	Homesha	Ashula	10o33'25"N	34o23'50" E
AGM4	Beneshangul	Homesha	Alementema	10o33'15"N	34o23'50" E
AGM5	Beneshangul	Homesha	Dungaheromela	10o30'28"N	34o22'43" E
AGM6	Beneshangul	Homesha	Shula	10o31'43"N	34o23'37" E
AGM7	Beneshangul	Homesha	Alfashere	10o30'16"N	34o24'40" E
AGM8	Beneshangul	Homesha	Sherkole	10o30'05"N	34o10'34" E
AGM9	Beneshangul	Homesha	Ashura	10o05'06"N	34o12'55" E
AGM10	Beneshangul	Assosa	Amba7	10o05'59"N	34o33'48" E
AGM11	Beneshangul	Sherkole	Dizene	10o34'54"N	34o19'48" E
AGM12	Beneshangul	Sherkole	Tyba	10o38'57"N	34o18'41" E
AGM13	Beneshangul	Assosa	Mengele 29	10o05'76"N	34o33'32"E
AGM14	Beneshangul	Assosa	Amba 12	10o04'56"N	34o23'38"E
AGM15	Beneshangul	Assosa	Amba18	10o05'43"N	34o35'44"E
AGM16	Beneshangul	Assosa	Amba7	10o05'44"N	34o36'48"E
AGM17	Beneshangul	Assosa	Amba14	10o04'56"N	34o42'22"E
AGM18	Beneshangul	Bambasi	Sonka	9o45'42" N	34o47'32"E
AGM19	Beneshangul	Bambasi	Sonka	9o45'44"N	34o47'23"E

C. Data Collection and Analysis

Agronomic traits recorded were days to flowering, days to maturity, ear head diameter, stem girth, ear head length, inter node length, flag leaf area, panicle length, plant height, leaf area, leaf per plant, tiller per plant, nodes per plant, thousand seed weight (TSW) and grain yield. Similarly, morphological traits recorded were growth habit, leaf shape, leaf colour, midrib colour, tillering, seed covering, panicle density, panicle shape, green fodder potential and stem diameter. The estimation of genetic parameters was done to identify and ascertain the genetic variability among the accessions and to determine the extents of environmental effect on various characters. Variance components due to phenotype ($\sigma 2p$) , genotype ($\sigma 2g$) and the environment($\sigma 2e$) were calculated by adopting the following formula as suggested by [6].

Genotypic variance ($\sigma 2g$) = $\frac{MSg-MSe}{r}$

Phenotypic variance ($\sigma 2g$) = $\sigma 2g + \sigma 2e$

Environmental variance($\sigma 2e$) = Error mean square

Where,

MSg = Mean squares due to genotypes

MSe = Mean squares due to error

R= Number of replications

According to the phenotypic genotypic coefficients of variances were expressed as [27]:

$$PCV = \frac{\sqrt{Phenotypic\ variance}}{Population\ mean\ for\ trait} \quad \text{or} \quad PCV = \frac{\sigma 2p}{X} \times 100$$

Where PCV = phenotypic coefficient of variation

$$GCV = \frac{\sqrt{Genotypic\ variance}}{Population\ mean\ for\ trait} \quad \text{or}$$

$$GCV = \frac{\sigma 2g}{X} \times 100$$

Where GCV = Genotypic coefficient of variation
x=the grand mean of a character

Heritability in broad sense was calculated for each trait by using the formula as [2]:

$$H2\ (\%) = \frac{\sigma 2g}{\sigma 2p} \times 100$$

Where: - H = heritability in broad sense
$\sigma^2 g$ = genotypic variance
σ^2_p = phenotypic variance

Genetic advance (GA) under selection, assuming the selection intensity of 5% was calculated as proposed by as [14]:

$$GA = K\sqrt{\sigma 2p}\frac{\sigma 2g}{\sigma 2p} = K.H^*\sqrt{\sigma 2p}$$

Where: GA = Expected genetic advance
K = the selection differential (K= 2.06 at 5% selection intensity)

Genetic advance as percent of mean was calculated to compare the extent of predicted advances of different traits under selection, using the formula given by as [11]:

$$GAM = \frac{GA}{x} \times 100$$

GAM = Genetic advance as percent of mean
GA = Genetic advance under selection
X = Mean value

III. RESULTS AND DISCUSSION

A. Qualitative Traits

The morphological descriptors used to characterize the pearl millet were growth habit, leaf shape, leaf colour, midrib colour, tillering, seed covering, panicle density, panicle shape, green fodder potential, stem diameter, shattering, seed shape and node type are depicted in (Table II). The accessions displayed two types of growth habits where the erect types dominated and amounted to be 82% and intermediate was 12% whereas no spreading types of growth habit was observed for accessions. The leaf shape variation was seen among accessions with rounded ovate 56%, pointed ovate 28%, lanceolate 8% and triangular 8%. The leaf colour showed noticeable variation from light to dark green where 60% of accessions had light green while 40% retained dark green leaf colour. With respect to midrib colour, all accessions had white midrib colour. Information recorded on tillering displayed that all accession had erect type of tillers. With respect to seed covering, 75% of accessions had intermediate seed covering, 24% fully covered and the remaining 1% of accessions exposed with no seed covering. Regarding the panicle density, the accession displayed two types of panicle density with intermediate type of 58% and compact one was 42%. As to panicle shape, about 57% of accessions were cylindrical, 33% were candle cylindrical and 10% were observed to be candle shaped. Occurrence of green fodder potential varies across the pearl millet germplasms where 51% of accessions were with good potential, 39% with poor potential and 10% of accessions were with intermediate fodder production potential. Variability of stem diameter among accessions was observed where 60% had medium stem diameter and the remaining accessions had thin and thick stem diameter of 20% each. With respect shattering, about 85% of accessions depicted low shattering and the remaining 15% exhibited medium shattering condition. Variation was observed in the seed shape with 58% of the genotypes had spherical flattened, 32% spherical and 10% of accessions displayed elongated flattened seed shape. Difference was observed among the studied accessions of pearl millet for node type. Both pubescent and glabrous types of nodes were observed where 55% of accessions displayed pubescent nodes while 45% genotypes showed glabrous nodes. For 21 accessions of pearl millet considered, the qualitative traits dominated were erect growth habit, rounded ovate leaf shape, light green leaf colour, white midrib colour, erect tillers, intermediate seed covering, intermediate panicle density, cylindrical panicle shape, good green fodder production potential, medium stem diameter, low shattering character, spherical flattened seed shape and pubescence node type (Table II) and hence morphological characterization results depicted the presence of sufficient morphological traits variability among the genotypes.

Table-II: Frequency of Qualitative Traits of Pearl Millet

Trait	Variable	Frequency (%)
Growth habit	Erect	82
	Intermediate	18
	Spreading	0
Leaf shape	Rounded ovate	56
	Pointed ovate	28
	Lanceolate	8
	Triangular	8
Leaf colour	Light colour	60
	Dark green	40
Midrib colour	White	100
	Other	0
Tillering	Erect	100
	None	0
Seed covering	Intermediate	75
	Covered	24
	Exposed	1
Panicle density	Intermediate	58
	Compact	42
	Loose	0
Panicle shape	Cylindrical	57
	Candle cylindrical	33
	Candle	10
Green fodder potential	Good	51
	Poor	39
	Intermediate	10
Stem diameter	Medium	60
	Thin	20
	Thick	20
Shattering	Low	85
	Medium	15
	high	0
Seed shape	Spherical flattened	58
	Spherical	32
	Elongated flattened	10
Node type	Pubescence	55
	Glabrous	45

i. Days to Flowering and Maturity

Analysis of variance indicated that significant differences were observed for pearl millet accessions with

respect to days to flowering and maturity (Table III). Days to flowering varied from 59.67 to 77.00 whereas maturity from 64.00 to 128.67. Days to flowering serve as a useful criterion of determining the maturity range of the genotypes. The longest days to flowering (77.00) was observed for accession AGM3 followed by accessions AGM7 with mean days to flowering of 74.67. The shortest day to flowering (59.67) was seen for accession AGM17. The difference of 17.33 days was observed between the longest and shortest days to flowering. The variation among the accessions in days flowering probably might be attributed to their inherent differences [26]. observed genetic variation among germplasm of pearl millet for days to flowering. Likewise, days to maturity had considerable variations among the accessions and could possibly be categorized into early maturing (≤ 75 days), medium maturing (76-100 days) and late maturing (> 100 days). Based on this classification, accessions AGM4, AGM5, AGM10 and AGM17 were relatively early maturing ones. On the other hand, AGM1, AGM2, AGM6, AGM9, AGM12, AGM13, AGM14, AGM15, AGM16 and AGM21 were grouped in medium maturing classes and remaining accessions AGM3, AGM7, AGM8, AGM18, AGM19 and AGM20 were late maturing genotypes that took over 100 days to maturity. Regarding the overall effect, the longest days to maturity (128.67) was recorded for accession AGM11 followed by accession AGM3 with mean days to maturity of 123.67. The shortest days to maturity (64.00) was seen for accession AGM5. The difference of 64.67 days was observed between the longest and shortest days to maturity which an indication that there was a wide variation in days to maturity among the accessions.

Table-III: Mean Performance of Pearl Millet for Phonological Traits

Genotype	Days to Flowering	Days to Maturity
AGM1	65.33d-f	75.67l
AGM2	61.33ef	83.00k
AGM3	77.00a	123.67ab
AGM4	61.67ef	68.00m
AGM5	65.33d-f	64.00m
AGM6	72.33a-c	85.33jk
AGM7	74.00ab	119.00bc
AGM8	65.67d-f	105.67ef
AGM9	66.00c-f	98.33gh
AGM10	61.33ef	68.67lm
AGM11	62.00ef	128.67a
AGM12	67.00c-e	99.33fg
AGM13	69.00b-d	94.33g-i
AGM14	64.67d-f	98.33gh
AGM15	72.33a-c	93.00g-i
AGM16	67.33c-e	88.33i-k
AGM17	59.67f	71.00lm
AGM18	63.67d-f	115.67cd
AGM19	66.33c-e	106.67e
AGM20	66.67c-e	108.67de
AGM21	65.00d-f	91.33h-j
LSD	6.44	7.08
CV (%)	5.88	4.54

B. Quantitative Traits

ii. Plant Height and Inter Node Length

Considerable variation was observed among the studied germplasm lines for plant height (Table IV). Plant height among the genotypes ranged from 155.00 3 to 212.67 and the tallest plant height (212.33 cm) was achieved from accession AGM7 followed by accession AGM19 with mean plant height of 210.00 cm. The shortest plant height (155.00 cm) was obtained from accession AGM19. The differences in plant among genotypes were probably attributed to genotypic variations [18]. reported significant differences among pearl millet genotypes for plant height while evaluating nine varieties of pearl millet. Moreover reported that height of the crop plants is mainly controlled by the genetic makeup of a genotype and it can also be affected by the environmental factors [24]. Inter node length among the accessions of pearl millet ranged from 14.67 to 20.33 cm. The longest inter node length (20.33 cm) was recorded for accession AGM7 closely followed by accession AGM10 with mean inter node length of 19.67 cm. The shortest inter node length (14.67 cm) was seen for accession AGM8.

iii. Leaf Area and Flag Leaf Area

Leaf area and flag leaf area for pearl millet accessions were significantly differed (Table IV) where leaf area varied from 188.00 to 269.67 cm^2 and that of flag leaf area from 44.67 to 115.02 cm^2. Accessions exhibited wide variations in leaf area which could play a crucial role in increasing grain yield. As this investigation revealed that accession AGM17 produced the greatest leaf area (269.67 cm^2) and accession AGM7 yielded the least leaf area (188.00 cm^2). This finding is compatible with the finding of observed considerable variation among pearl millet germplasm for leaf area [7]. Likewise, maximum flag leaf area (115.02 cm^2) was produced by accession AGM10 followed by accession AGM5 with mean flag area of 109.00 cm^2. The minimum flag leaf area (44.67 cm^2) was recorded for accession AGM1.

iv. Leaf Number and Stem Girth

Pearl millet genotypes exhibited significant differences for leaf number per plant and stem girth (Table IV). Generally, leaf number per plant varied from 9.33 to 16.00 where accessions AGM11 and AGM12 had maximum leaf number (16.00) whereas accessions AGM1 and AGM16 produced minimum leaf number per plant of9.33. With respect stem girth, it varied for accessions from 0.48 to 0.94 cm. The highest stem girth (0.94 cm) was observed for accession AGM11 closely followed by accession by AGM3 with mean stem girth of 0.89 cm. The lowest stem girth (0.48 cm) was obtained from accession AGM2.

Table-IV: Mean Performance of Pearl Millet Accessions for Growth Traits

Genotype	Plant Height (cm)	Inter Node Length (cm)	Leaf Area (cm2)	Flag leaf Area (cm2)	Leaf Per Plant	Stem Girth (cm)
AGM1	186.67b-f	16.00e-g	256.00a-e	44.67f	9.33f	0.54i
AGM2	203.33a-c	17.00c-g	259.00a-d	100.00a-c	10.33d-f	0.48j
AGM3	184.00c-f	15.00g	210.00ij	93.67cd	12.00bc	0.89b
AGM4	176.00d-g	16.33e-g	246.67c-g	100.00a-c	9.67ef	0.51j
AGM5	195.67a-d	16.33e-g	266.33ab	109.00ab	11.00c-	0.51j
AGM6	176.67d-g	16.67d-g	258.00a-d	97.33bc	11.33cd	0.54ij
AGM7	212.33a	20.33a	188.00k	71.67e	13.33b	0.87b
AGM8	203.33a-c	14.67g	231.00gh	104.67a-c	10.00d-f	0.72d
AGM9	162.67fg	15.67fg	224..00hi	96.00bc	10.33d-f	0.69de
AGM10	184.67c-f	19.67ab	240.00e-h	115.02a	9.67ef	0.51j
AGM11	188.33a-e	15.33fg	189.00k	102.67a-c	16.00a	0.94a
AGM12	187.33b-e	17.67b-f	247.00c-g	100.33a-c	16.00a	0.69ef
AGM13	166.33e-g	14.69g	247.33c-g	94.67b-d	10.00d-f	0.64g
AGM14	182.33c-f	16.67d-g	252.33b-f	95.67bc	10.33d-f	0.72d
AGM15	155.00g	16.33e-g	254.00a-e	107.67a-c	11.33cd	0.64g
AGM16	187.33b-e	19.00a-d	255.33a-e	75.67e	9.33f	0.57h
AGM17	179.67c-f	18.33a-e	269.67a	75.67e	11.33cd	0.54ij
AGM18	183.67c-f	16.67d-g	206.00j	94.67b-d	13.00b	0.79c
AGM19	210.00ab	17.67b-f	237.00f-g	76.00e	11.33cd	0.66fg
AGM20	194.33a-d	17.67b-f	242.33d-g	78.00e	10.67c-f	0.72d
AGM21	183.33c-f	19.33a-c	260.67a-c	80.33de	11.33cd	0.64g
LSD	24.41	2.53	16.75	15.03	1.52	0.02
CV (%)	7.96	9.02	4.23	9.99	8.35	2.66

v. Ear head Length and Ear Head Diameter

Analysis of variance showed that accessions of pearl millet were significantly differed for ear head length and ear head diameter (Table V). Ear head length for accessions ranged from 10.17 to 17.74. The greatest ear head length (17.74 cm) was observed for accession AGM12 followed by accession AGM13 with mean ear head length of 16.28 cm. The lowest ear head length (10.17 cm) was seen for accession AGM2. The differences among accessions for the parameter might be attributed to their inherent variations in the growing environment. Such wide variations indicated the scope of improving for this trait. On the other hand, pearl millet accessions did not show significant difference for ear head diameter and hence they exhibited similarities in their ear head diameter (Table V).

vi. Panicle Length, Thousand Seed Weight and Tiller Number

Considerable variation among the pearl millet accessions was observed in panicle length and TSW (Table V). The values for this trait among the genotypes ranged in between 27.67 and 35.00 cm [17]. Accession AGM14 yielded the highest (35.00 cm) panicle length followed by accession AGM1 with mean panicle length of 34.00 cm. Accession AGM7 displayed the least panicle length of 25.67 cm [23]. reported that there was considerable variation in panicle length of millets. Similarly, TSW for pearl millet accessions varied from 51 to 96 g with maximum TSW (96 g) achieved from accession AGM11 closely followed by accession AGM3 with mean TSW of 87 g. The lowest TSW (51 g) was obtained from accession AGM10. Conversely, pearl millet accessions did not show significant differences for number of tillers per pant (Table V).

vii. Grain Yield

Variance analysis revealed that grain yield was significantly varied for pearl millet accessions and it varied from 690 to 2883 kg/ha (Table V). The accession could possibly be categorized into three classes as low yielders (< 1000 kg/ha), medium yielders (1000-2000 kg/ha) and high yielders (> 2000 kg/ha) [19]. Low yielders accessions encompass AGM1, AGM4, AGM5, AGM6, AGM10, AGM16, AGM17 and AGM18 whereas accessions within medium yielders include AGM2, AGM8, AGM9, AGM12, AGM13, AGM14, AGM15, AGM19, AGM20 and AGM21. Accessions AGM3, AGM7 and AGM11 were in category of relatively higher yielder that gave grain yield greater than 2000 kg/ha [31]. With respect to the overall effect, the highest grain yield (2883 kg/ha) was recorded for accession AGM11 followed by accession AGM3 with mean grain yield of 2680 kg/ha. The lowest grain yield (690 kg/ha) was achieved from accession AGM5 [32]. This finding clearly displayed that there were considerable variations among the genotypes for grain yield indicating the existence of prominent genetic variation in the experimental materials [33]. reported significant differences among the pearl millet genotypes for grain yield [34].

Table-V: Mean Performance of Pearl Millet Accessions for Yield Components and Yield

Genotype	Ear Head Length (cm)	Ear Head Diameter (cm)	Panicle Length (cm)	Tiller Number	TSW (g)	Grain Yield (kg/ha)
AGM1	10.25gh	1.9	34.00ab	11.67	56f-g	913ij
AGM2	10.17h	1.61	32.33a-e	11	56f-g	1020hi
AGM3	16.28b	2.44	28.67d-g	15	87b	2680b
AGM4	11.76d-f	1.4	34.33ab	12.33	52gh	750kl
AGM5	12.67cd	1.55	33.33a-c	11.67	55f-h	690l
AGM6	11.21f	1.11	28.67d-g	12.33	54f-h	960ij
AGM7	13.58c	1.91	25.67g	15.33	84b	2346c
AGM8	11.63ef	1.6	31.33a-e	14	68cd	1730d
AGM9	11.61ef	1.31	32.67a-d	13	63de	1233fg
AGM10	11.04f-g	1.12	32.67a-d	12	51h	743kl
AGM11	11.05f-h	2.86	27.00fg	14.33	96a	2883a
AGM12	17.74a	1.13	28.33f-g	12.67	63de	1252f
AGM13	11.10fg	1.13	31.33a-e	13	58e-g	1110gh
AGM14	11.61ef	1.15	35.00a	13	66cd	1486e
AGM15	11.66ef	1.37	29.00d-g	14.33	58e-g	1143f-g
AGM16	11.08f-h	1.23	29.67c-g	13.33	57e-g	936ij
AGM17	11.79d-f	1.47	32.33a-e	12	59ef	830jk
AGM18	13.50c	1.65	30.33b-f	13	72c	2216c
AGM19	12.17de	1.43	31.33a-e	12.33	62de	1256f
AGM20	11.88d-f	1.85	29.67c-g	12	72c	1816d
AGM21	11.47ef	1.18	28.67d-g	11.33	63de	1166fg
LSD	0.93	NS	4.29	NS	5	130
CV (%)	4.62	6.7	8.46	27.2	6.17	5.69

C. Phenotypic and Genotypic Variations

Estimate of phenotypic variances (σ^2p), genotypic variance (σ^2g), phenotypic coefficient of variation (PCV) and the genotypic coefficient of variation (GCV) are presented in (Table VI). It was seen that PCV and GCV estimates were high for days to maturity, flag leaf area, plant height, leaf area and grain yield whereas days to flowering exhibited moderate GCV estimate. Panicle length was the only a trait that had moderate PCV estimate [10]. As this investigation revealed that pearl millet materials had a wide range of variability and favorable mean performance for these traits that could be exploited as potential hybrids aimed for simultaneous improvement of grain yield and other yield related traits [14]. Moreover, the traits considered exhibit a more negligible difference between PCV and GCV values demonstrating a high degree of genetic variability present in these characters and consequently greater scope for selection based on those characters. Thus, the traits are less influenced by the environment and show high genetic variability which implied equal importance of additive and non-additive gene action for the traits recorded. Higher estimates of PCV than GCV have also been reported for above mentioned traits. Likewise, similar results found by [30]. In contrast, traits ear head diameter, stem girth, ear head length, internode length, leaf per plant, tiller number and TSW had low PCV and GCV estimate values and hence could be evidenced as the prominent influence of environment for the expression of these traits [25]. These results are in conformity with the findings of [17].

D. Broad Sense Heritability and Genetic Advance

The concept of heritability enables us to know whether phenotypic variations noticed among various genotypes are cause of genetic changes or environment. Traits days to maturity, stem girth, ear head length, flag leaf area, leaf per plant, TSW and grain yield had high heritability (($H^2 \geq 60\%$) values while the traits days to flowering, internode length, panicle length, plant height and tiller number attained moderate heritability (30-60% H^2) values (Table VI) [29]. Thus, high heritability indicates that expression of the characters is least influenced by the environment whereas moderate H^2 values evidences due to relative influence of the environment on the polygenic nature of these traits [16]. On the other hand, traits ear head diameter and leaf area had low heritability values (< 30% H^2) and hence limits the possibility of including the traits in selection of desirable genotypes in breeding program [28]. This may be due to higher impact of environment for the expression of phenotypic variation than genotypic variation. Present results are in accordance with the findings of [30]. Genetic advance as a percent mean was ranged from 1.73% for leaf area to 95.38% for grain yield (Table VI) [29]. This result indicated that selecting the top 5% of the accessions could result in an advance of 1.73 to 95.38% over the respective population mean [28]. High heritability coupled with higher genetic advance as percentage of mean were recorded for days to maturity, stem girth, ear head length, flag leaf area, leaf per plant, TSW and grain yield whereas inter node length showed moderate heritability combined with high GAM indicated that additive gene action on the expression of these characters which revealed an effective selection of desirable genotypes [5]. In such cases improvement by the recurrent selection and development of synthetics and composites may be proved beneficial. Similar results were reported by [26].

Table-VI: Phenotypic and Genotypic Coefficient of Variability, Heritability and Genetic Advance for Pearl Millet

Trait	σ2p	σ2g	σ2e	PCV (%)	GCV (%)	H2 (%)	GA	GA (%)
Days to flowering	30.27	15.07	15.20	8.29	5.84	49.79	5.64	8.50
Days to maturity	365.57	347.17	18.40	20.21	19.70	94.97	37.41	39.55
Ear head diameter	1.47	0.17	1.30	71.74	24.40	11.56	0.29	17.16
Stem girth	0.03	0.03	0.00	26.24	26.24	100.00	0.36	54.55
Ear head length	3.50	3.20	0.30	15.31	14.64	91.43	3.52	28.81
Inter node length	4.23	1.83	2.40	16.53	7.96	42.36	1.79	10.53
Flag leaf area	313.60	230.70	82.90	19.44	16.67	73.57	26.84	29.46
Panicle length	10.83	4.03	6.80	10.69	6.52	37.21	2.52	8.19
Plant height	355.60	136.70	218.90	10.15	6.29	38.44	14.93	8.03
Leaf area	125.63	22.53	103.10	4.67	1.98	17.93	4.14	1.73
Leaf per plant	3.03	2.13	0.90	15.74	13.20	70.30	2.52	22.78
Tiller number	0.37	0.17	0.20	35.99	23.40	45.95	0.58	34.32
TSW	0.03	0.03	0.00	27.06	27.06	100.00	0.36	56.25
Grain yield	4259.70	4197.20	62.50	46.99	46.65	98.53	132.47	95.38

E. Analysis of Variance

The results of the analysis of variance for agronomic traits of pearl millet accessions are shown in (Table VII). Analysis results revealed that mean squares due to pearl millet accessions for agronomic traits were significant with exception of ear head diameter and tiller number [14]. This probably evidences the presence of prominent level of differences among accessions for most of the traits considered and hence this disparity might be attributed to their inherent variability [28]. The results of the study indicated the presence of substantial amount of genetic variation in the current population for yield and yield related traits, which could be exploited in pearl millet improvement programs [4]. These variations in mean values of genotypes might come from variations either in genetic or environmental factor under growing conditions [28].

Table-VII: Mean Squares from Analysis of Variance for Agronomic Traits of Soybean Accessions

Trait	Rep (DF=)	Genotype (DF=20)	Error (DF=40)	CV (%)	Grand Mean
Days to flowering	2.7	60.4*	15.2	5.88	66.37
Days to flowering	102.4	1059.9*	18.4	4.54	94.6
Ear head diameter	0.7	1.8^{NS}	1.3	6.7	1.69
Stem girth	0	0.1*	0	2.66	0.66
Ear head length	8.5	9.9*	0.3	4.62	12.22
Internode length	34.6	7.9*	2.4	9.02	17
Flag leaf area	206.1	775.5*	82.9	9.99	91.11
Panicle length	42.2	18.9*	6.8	8.46	30.78
Plant height	14.3	629.0*	218.9	7.96	185.86
Leaf area	598.1	1707.7*	103.1	4.23	239.98
Leaf per plant	1.9	7.3*	0.9	8.35	11.06
Tiller number	0.1	0.7^{NS}	0.2	27.2	1.69
TSW	0.1	0.1*	0	6.17	0.64
Grain yield	4071	12654.1*	62.5	5.69	138.88

*= significant at 5% probability level, NS= not significant

F. Correlation of Agronomic Traits

The data for correlation coefficients of agronomic trait of pearl millet accessions are depicted in (Table VIII). Correlation investigation provides a natural relationship among diverse plant traits on yield and its related components on the selection of genotypes for crop improvement in yield maximization [1]. Days to maturity (=0.93), leaf per plant (r=0.60), stem girth (r=0.96), tiller number (r=0.70) and TSW (r=0.97) were significantly positively correlated with grain yield whereas leaf area (r=-0.87) and panicle length (r=-0.60) were significantly negatively associated with grain yield [8]. Days to maturity was positively significantly associated with leaf per plant (r=0.58), stem girth (0.95), tiller number (0.70) and TSW (r=0.89) while it was negatively significantly correlated with leaf area (r=-0.81) and panicle length (r=-0.65). Leaf area was only significantly positively associated with panicle length (r=0.53) whereas it was negatively significantly related with stem girth (r= -0.86), tiller number (r= -0.53) and TSW (r= 0.84) [29]. Likewise, leaf per plant was positively significantly correlated with stem girth (r=0.64), ear head length (r=0.61) and TSW (r=0.65) while it was negatively significantly associated with panicle length (r= -0.67). Similarly, stem girth was positively significantly related with ear head length (r=045), tiller number (r=0.76) and TSW (r=0.96) whereas it was negatively significantly correlated with panicle length (r= -0.62) [10]. obtained similar results of correlation of agronomic traits of pearl millet.

Table-VIII: Correlation of Agronomic Traits of Pearl Millet Accessions

Trait	DF	DM	PH	IL	LA	FLA	LPP	SG	EHL	EHD	PL	TN	TSW	GY
DF	-	0.44*	-0.08^{NS}	-0.10^{NS}	-0.27^{NS}	-0.09^{NS}	0.13^{NS}	0.39^{NS}	0.43^{NS}	-0.13^{NS}	-0.55*	0.62*	0.31^{NS}	0.34^{NS}
DM		-	0.22^{NS}	-0.18^{NS}	-0.81*	-0.05^{NS}	0.58*	0.95*	0.38^{NS}	0.06^{NS}	-0.65*	0.70*	0.89*	0.93*
PH			-	0.33^{NS}	-0.24^{NS}	-0.26^{NS}	0.15^{NS}	0.17^{NS}	0.10^{NS}	0.06^{NS}	-0.16^{NS}	-0.03^{NS}	0.28^{NS}	0.26^{NS}
IL				-	0.09^{NS}	-0.28^{NS}	0.04^{NS}	-0.18^{NS}	0.02^{NS}	-0.26^{NS}	-0.25^{NS}	-0.19^{NS}	-0.14^{NS}	-0.20^{NS}
LA					-	-0.06^{NS}	0.01^{NS}	-0.86*	-0.31^{NS}	-0.33^{NS}	0.53*	-0.73*	-0.84*	-0.87*
FLA						-	0.16^{NS}	-0.01^{NS}	0.13^{NS}	0.02^{NS}	0.04^{NS}	0.12^{NS}	-0.06^{NS}	-0.01^{NS}
LPP							-	0.64*	0.61*	0.09^{NS}	-0.67*	0.38^{NS}	0.65*	0.60*
SG								-	0.45*	0.17^{NS}	-0.62*	0.76*	0.96*	0.96*
EHL									-	0.03^{NS}	-0.40^{NS}	0.37^{NS}	0.37^{NS}	0.38^{NS}
EHD										-	0.06^{NS}	0.18^{NS}	0.28^{NS}	0.26^{NS}
PL											-	-0.56*	-0.62*	-0.60*
TN												-	0.69*	0.70*
TSW													-	0.97*
GY														-

Keys: Days to flowering (DF), Days to maturity (DM), Plant height (PH), Inter node length (IL), Leaf area (LA), Flag leaf area (FLA), Leaf per plant (LPP), Stem girth (SG), Ear head length (EHL), Ear head diameter (EHD), Panicle length (PL), Tiller number (TN), Thousand seed weight (TSW), Grain yield (GY).

IV. CONCLUSION

The present study revealed sufficient genetic diversity in the available pearl millet germplasm for different traits. Different genotypes of pearl millet displayed potential for selection of the desired traits depicting the presence of sufficient morphological traits variability among the genotypes. With respect to agronomic traits, the accessions AGM3, AGM7 and AGM11 were in category of relatively higher yielder that gave grain yield greater than 2000 kg/ha. High heritability coupled with higher genetic advance as percentage of mean were recorded for days to maturity, stem girth, ear head length, flag leaf area, leaf per plant, TSW and grain yield whereas inter node length showed moderate heritability combined with high GAM indicated that additive gene action on the expression of these characters which revealed an effective selection of desirable genotypes. As this investigation revealed that pearl millet materials had a wide range of variability and favorable mean performance for the traits studied that could be exploited as potential hybrids aimed for simultaneous improvement of grain yield and other yield related traits.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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