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Agro-morphological, Physiological and Yield related Performances of Finger Millet [*Eleusine coracana* (l.) Gaertn.] Accessions Evaluated for Drought Resistance under Field Condition

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Abstract

The study was conducted at Dhera Sub-center of Kulumsa Agricultural Research Center, Oromia Regional State, Ethiopia from July - December 2011; to screen drought tolerance of 96 finger millet accessions (*Eleusine coracana* L. Gaertn.) collected from different agro-ecological zones of the country. Data were collected for plant height (PH), green leaf number (GLN), green leaf area (GLA), ear number (EN), ear length (EL) and relative water content (RWC). Significant difference ($P \leq 0.05$) were obtained between accessions for most selected physiological, morphological and yield related traits such as Chlorophyll Content Index (CCI), RWC, and yield related parameters, such as tiller number (TN), productive tillers (PT), seed weight per head and per plant. Based on high RWC, CCI, GLN, PT, EL, and EN, Grain Yield per head and per plant, a total of 23 accessions were categorized as drought stress tolerance and promoted to the next intensive physiological and yield related evaluation. Moreover, AAUFM-7, AAUFM-2, AAUFM-44 were the first top three accessions with the highest grain yield of 77.5, 72g/plant and 65.4g/plant, respectively. Overall, the higher genetic variability observed among accession in this study should be further utilized for finger millet improvement targeting semi-arid areas of Ethiopia.

Keywords: Accession, drought stress, finger millet, morphological and physiological trait, Ethiopia

Introduction

Millets are in the family of cereals grown globally with differential importance across continents and within regions of the world.

The crop is mostly produced in mixtures (intercropped, double-cropped or relay-cropped) with other cereals like sorghum, legumes and oil crops (groundnuts, cowpeas, pigeon peas and sesame), and root crops mostly cassava (Obilana, 1996). Finger millet (Eleusine coracana L. Gaertn.) [family Poaceae (Gramineae)], ranks third in importance among millets in the world after sorghum (Sorghum bicolor), pearl millet (Pennisetum glaucum) and foxtail millet (Setaria italic).

The crop originated in Africa and has been cultivated for thousands of years in the highlands of Ethiopia and Uganda (Hilu *et al*., 1976). The crop can be cultivated in diverse eco-geographical areas worldwide

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and displays high genetic variability indicating that it can be improved through breeding.

The crop has wide adaptability, probably due to its C4 photosynthetic nature. In Africa, smallholder farmers grow finger millet with area allocated to the crop varying from country to country. In eastern Africa, finger millet is produced in Uganda, Kenya, Tanzania, Rwanda, Burundi and Ethiopia. (Obilana *et al*., 2002, cited in Oduori 2005). Kenya and Uganda are among the leading producers of Finger millet in Africa and the rest of the world (Chrispu, 2008).

Finger millet is one of the important food crops in Ethiopia. It plays a significant role both as food grain and animal feed in areas where production of other cereals are reduced by marginal environments.

Moreover, as a result of increased drought and soil fertility degradation, a growing number of farmers are resorting to finger millet and thus the area allocated for this crop has significantly increased over the last ten years. It occupies ca. 5% (228,000 ha) of the total area covered by cereal production and accounts for 4% of total cereal yield annually.

In Ethiopia, the grain is used for making traditional fermented liquors, *Tella* (local beverage) and *Areki* (local sprit).

The flour of finger millet alone or with mixture of teff (*Eragrostis tef*), maize (*Zea mays*) and barley (Hordeum vulgare) is commonly used for making *injera* (flatbread). Traditionally, porridge prepared from finger millet flour is believed to cure diarrhoea and malaria and the straw is used for animal feed and thatching roof.

In Ethiopia, where agriculture is the foundation of the country's economy, the importance of finger millet in relation to climate variability, especially unpredictable rainfall and recurrent drought cannot be overstated. The purpose of this research was twofold; (1) To screen finger millet accessions adapted to low moisture content and (2) To promote and recommend elite accessions for further drought stress field evaluation.

Material and methods

A total of 96 finger millet (*Eleusine coracana*) accessions were included in the experiment of which 50 and 44 were collected by Bioinnovate Africa project team from Tigray (northern Ethiopia) and Institute of Biodiversity Conservation (IBC) collected from different part of Ethiopia, respectively. Moreover, nationally released improved cultivars, namely Tadesse and Boneya were included as standard check.

Description of the study area

The study was conducted at Dhera, (Sub-Center of Kulumsa Agricultural Research Center) found in Oromia Regional State, 117 km from Addis and located between 08^0 19′06.3″ N latitude 039^0 19′ 0.74″ E longitude at an altitude of 1677 m a.s.l.

Soil analysis and climate data

Soil samples were taken from the depth of 0-15 cm and physicochemical property of the soil was analyzed at Ecophysiology laboratory, Addis Ababa University. The collected samples were air-dried and passed through 2 mm sieve to remove large particles and debris. The sieved samples were analyzed for pH in 1:1 soil to water ratio using pH meter (pH-100 Digital controller, India).

Electrical conductivity was determined using conductivity meter (Conductivity/TDS/ Salinity/Resistivity meter, China). Soil texture (particle size) was determined using hydrometer measurement and organic carbon was determined by Walkley and Black procedure (Magdoff *et al*., 1996).

Total nitrogen was determined by the micro Kjeldahl method (Van Schouwenberg and Walinge, 1973).The physicochemical property of the soil at the experimental site is summarized in table1.

Table 1: Physicochemical property of the soil at Dhera sub-center

Physical characteristics	
Clay %	8
Sand %	51.5
Silt %	40.8
Chemical characteristics	
Soil pH	6.8
Electrical conductivity (dS/m)	2.8
Total nitrogen (%)	0.05
Organic carbon (%)	1.4

Five years averages (2007-2011) of maximum and minimum temperature were 30.8^0 C and 5.2^0 C, respectively, with mean annual rainfall of 834 mm.

Experimental design

The experimental was planted in Randomized Complete Block Design (RCBD) with three replications. To minimize the effect of soil variation on different treatments, both replications were folded to hold 32 accessions with block size of 2 m x 24 m (48 m^2). In each plot, accessions were planted with 75 cm distance between rows.

For plot management and data collection 1.5 m path was left between each block. The seeds were drilled in each line. Fertilizer application was carried out 100 kg ha^{-1} of DAP (Nitrogen = 18% and Phosphate = 46%) as a basal dose, and 100 kg ha^{-1} of urea (nitrogen = 46%) as top dressing following the procedure described by (Upadhyaya *et al.*, 2007), three lines of finger millet was sown to minimize the boarder effect.

After three weeks each row was thinned to have 10 plants with 10 cm gap between each individual plant. According to International Board for Plant Genetic Resources (IBPGR, 1985) plant descriptor for finger millet, five finger millet plants were selected from each plot for measured trait.

Data collection

Agronomic and morphological measurements

Agro-morphological parameters such as plant height (PH), total tiller number (TN) and productive tillers (PT), green leaves number (GLN), total green leaves area (TGLA), finger number (FN) and finger length (FL) were taken following International Board for Plant Genetic Resources (IBPGR, 1985) plant descriptor for finger millet. Physiological and yield related parameters were also scored from five plants randomly sampled from each plot and replication as per the descriptor of IBPGR (IBPGR, 1985).

Morphological traits (plant height, green leaf number and) measurement and yield and yield related traits (tiller number, productive tillers, ear number, ear length, grain yield per head and yield per plant) measurement were taken when 50% of the plot was at maturity. Plant height was measured from the base of ground to the tip of the head. Number tillers and productive tillers were counted other than the mother plant. Number of green leaves was counted when the leaves was 50% and above were green. Total green leaf area was calculated using the formula, GLA= (C* L *W), where L is the length measured from the base to the tip of the leaf, W is the width taken from the widest part of the leaf and C is the correction factor calculated from the ratio of actual leaf area to the estimated leaf area of randomly selected 15 leaves. Total green leaf area can be also calculated as TGLA= Σ (C*L *W). Finger length was measured using a ruler from base to the tip of longest spike.

Physiological measurements

Relative water content (RWC),

Was determined following the procedure of Gonzalez and Gonzalez (2001) at 50% crop maturity. Leaves were collected from the flag and the second leaf from top to down, in order to minimize age effects. A sharp razor blade was used to cut the leaf base.

The leaf was trimmed at 1 cm^2 and immediately fresh weight (FW) was determined. This leaves were floated in distilled water inside a closed Petri dish for 24 hr. After the water was wiped from the leaf surface gently with tissue paper, turgid weight (TW) was determined.

Subsequently the leaves disks were dried in the oven at 80^0 C for 48 hrs to obtain the dry weight (DW). The DW was then determined using the same balance and finally RWC was calculated using the formula below:
RWC= [(FW – DW)/ (TW – DW)] x100 (Where, FW= Fresh weight, DW= dry weight, TW= Turgid weight)

Chlorophyll content Index (CCI)
Triplicate of CCI (leaf greenness) was measured from each six leaves sampled from ninety six accessions using chlorophyll content meter, CCM-200 plus (Opti-Sciences, Inc. 8 Winn Avenue Hudson, USA). CCI measurements were made at 50% plot maturity.

Grain yield per head and per plant
The panicles from each head were trashed from each tagged plants and the seed was kept in the greenhouse and seed weight was taken every other day until at constant seed weight was maintained. Finally seed weight per head and per plant was determined using top load balance when the moisture content was ca12.5%.

Data analysis
All the collected data were subjected to the analysis of variance (ANOVA), using SPSS Software (Version 16, SPSS Inc., Chicago USA). Means of each measured data were separated using Tukey's range test at the 95% level of probability to test the significance of the treatments. 'R' program version 2.11.1 was used to draw Dendrogram.

Result

Agronomic and morphological measurements
Analysis of variance (ANOVA) showed that there were significant ($P \leq 0.05$) differences among accessions in plant height. Moreover, plant height had significant correlation with yield per head and yield per plant and strong significant correlation with $r^2 = 0.430$ and $r^2 = 0.331$ was also observed with number of productive tillers and ear numbers, respectively.

Table 2: Mean ± S.E values of agronomic measurement for top ten finger millet accessions in descending order

Accession	Green leaf number	Accession	Green leaf area (cm^2)	Accession	Total green leaf area (cm^2)
215851	10.8 (1.6)	AAUFM-19	144.2 (3.4)	AAUFM-36	542.1 (0.4)
242132	10.2 (1.2)	AAUFM-36	125.1 (2.4)	AAUFM-19	528.6 (1.1)
AAUFM-15	10.0 (1.6)	238310	36.5 (2.9)	215851	300.3 (0.6)
AAUFM-47	9.4 (0.4)	241618	32.3 (3.8)	241618	245.2 (0.5)
237475	8.4 (2.0)	AAUFM-29	30.2 (3.4)	AAUFM-15	228.9 (0.4)
238300	8.2 (1.0)	230110	30.0 (3.5)	230110	219.7 (0.4)
AAUFM-44	8.0 (1.1)	AAUFM-39	29.2 (1.5)	AAUFM-44	217.3 (0.4)
237465	7.6 (0.6)	215989	28.8 (3.5)	234159	217.1 (0.9)
211618	7.6 (1.5	238325	28.8 (0.2)	AAUFM-47	207.9 (0.2)
234159	7.6 (1.2)	234159	28.6 (0.5)	238300	204.7 (0.6)

Where PH= plant height, GLN= Green Leaf Number, GLA= Green Leaf Area, TGLA= Total Green Leaf Area.

Total green leaf area is the product of the number of green leaves and the number of green leaf area of a plant, showed significant difference between accessions. accessions ($P \leq 0.05$). Moreover, green leaf area had highly significant correlation (r^2=0.669 and r^2 = 0.767) with green Leaf number (r^2 = 0.669) and total green leaf area (r^2 = 0.767) per plant (table 6). CCI reading was also showed significant difference among the accessions measured ($P \leq 0.05$). Except positive correlation with green leaf area and relative water content, there was no correlation so far observed with other parameters.

Table 3: Correlation coefficient among different morpho-physiological traits of ninety six genotypes of finger millet Accessions

	PH	NT	PT	GLN	GLA	TGLA	EN	EL	CCI	RWC	GYPH	GYPP
PH	1											
NT	.091	1										
PT	.430**	.581**	1									
GLN	-.032	.071	.118	1								
GLA	.001	.135	.062	.053	1							
TGLA	.000	.145	.125	.669**	.767**	1						
EN	.331**	.001	.329**	.083	-.049	.029	1					
EL	.166	.155	.283**	.040	-.104	-.054	.364**	1				
CCI	.196*	-.034	.194*	-.060	-.076	-.084	.511**	.201*	1			
RWC	-.153	-.042	-.143	-.144	.062	-.053	-.198*	.095	.004	1		
GYPH	.191*	-.084	.261**	-.152	.037	-.077	.187*	.002	.208*	-.211*	1	
GYPP	.282**	.259**	.614**	-.054	.009	-.053	.111	-.069	.086	-.143	.733**	1

* = Correlation is significant at the 0.05 level

**=Correlation is significant at the 0.01 level

Histological measurements

CCI reading showed significance difference between the accessions (P ≤ 0.05) measured. Except positive correlation with green leaf area and relative water content, there was no correlation so far observed with other parameters. Analysis of variance also indicated that relative water content was significantly different among accessions (P > 0.05). Moreover, relative water content (RWC) was positively correlated with root to shoot ratio, yield per head and per plant as well as with CCI reading, while dry root weight showed a strong significant correlation at $r^2 = 0.905$ with RWC. Three accessions namely 215985, AAUFM-6 and 215989 showed the highest RWC with 100 %, 98.6 % and 93.7 %, respectively.

Table 4: Mean ± S.E values relative water content and chlorophyll contents of top ten finger millet accessions

Accessions	RWC	Accessions	CCI
215985	99.2 (10.0)	AAUFM-14	20.2 (7.0)
AAUFM-5	95.9 (5.2)	AAUFM-44	18.2 (6.3)
515989	93.7 (2.6)	AAUFM-24	18.1 (3.3)
235782	92.3 (2.8)	215965	16.2 (0.2)
242620	91.5 (6.2)	AAUFM-23	15.8 (1.3)
AAUFM-8	88.8 (1.6)	AAUFM-12	15.4 (2.4)
AAUFM-50	87.4 (0.8)	AAUFM-33	15.3 (0.4)
234194	87.0 (0.4)	235785	15.2 (0.5)
AAUFM-21	86.8 (4.6)	AAUFM-20	15.1 (2.1)
238327	86.5 (11.8)	AAUFM-7	14.8 (1.9)

Where; RWC= relative water content, CCI= Chlorophyll Content Index

Yield and yield related parameters

The amount of grain yield per head and grain yield per plant depends on the number of ear, ear size and productive tillers. Analysis of variance showed grain yield per head and grain yield per plant varied significant (P ≤ 0.05) between accessions.

Table 5: Mean ± S.E values yield and yield related parameters of top ten accessions

Accessions	GYPH (g)	Accessions	GYPP (g)
AAUFM-7	5.40 (0.3)	238299	84.50 (3.4)
TADESSE	4.64 (1.4)	238325	80.00 (0.3)
238325	4.00 (0.9)	AAUFM-2	77.50 (2.5)
AAUFM-43	4.00 (0.9)	AAUFM-30	75.20 (1.3)
AAUFM-2	4.00 (0.6)	AAUFM-44	72.00 (1.6)
AAUFM-30	3.85 (0.0)	AAUFM-38	70.50 (1.6)
230109	3.74 (2.3)	AAUFM-21	67.00 (1.5)
AAUFM-42	3.74 (1.7)	230103	65.49 (1.4)
AAUFM-50	3.73 (0.6)	AAUFM-36	64.50 (2.6)
AAUFM-44	3.60 (0.9)	AAUFM-18	63.50 (2.6)

Where GYPH= Grain Yield Per head, GYPP= Grain Yield per Plant

Cluster analysis

Fifteen quantitative traits (morphological, physiological and yield related traits) were used to carry out cluster analysis and all the 96 accessions were grouped in to six major clusters (Fig.1). Overall, in the cluster analysis finger millet accession tend to form group based on their geographic proximity and origin. The first cluster contains forty five accessions, three from Amhara regional state (Gonder, Gojam and Wollo), thirty seven were collected from Tigray and five from Eritrea. The second cluster contains nineteen accessions, i.e., eighteen from

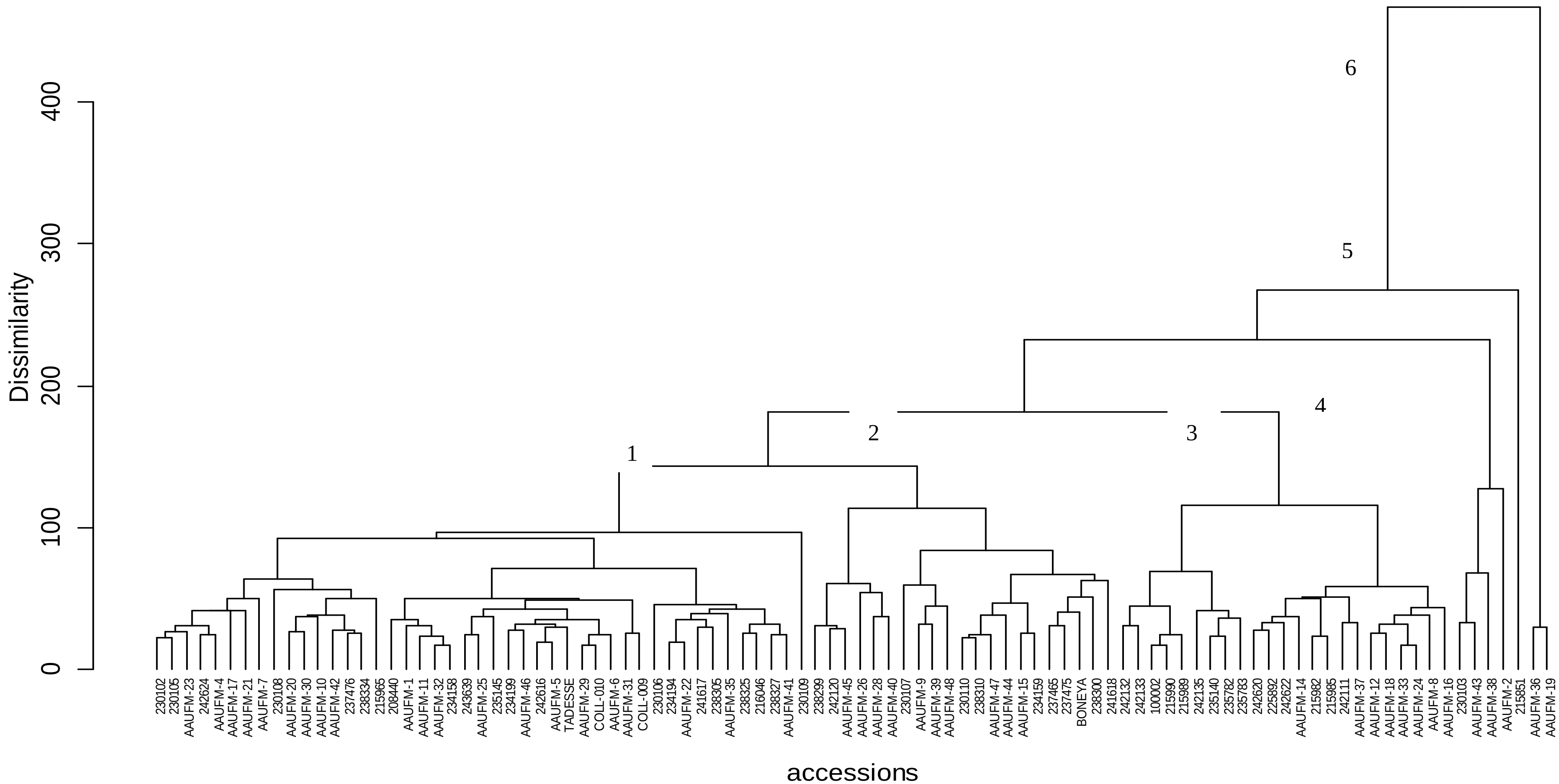

Figure 1: Dendrogram showing similarity among ninety six accessions based on the measured parameters

Tigray and one from Amhara. Cluster-3 contains twenty three accessions (Ten from Tigray and thirteen from Amhara). Cluster-4 contains five accessions, three from Tigray and one accession from Amhara and Eritrea. The fifth cluster contains only one accession from Tigray while the last cluster (Cluster-6) contains two accessions from Tigray.

Correlation coefficient revealed that grain yield per head and per plant showed strong correlation with plant height, productive tillers, number of tillers and productive tillers at 0.01. Strong positive correlation was observed among grain yield per plant and grain yield per head at $r^2 = 0.733$. Moreover, grain yield per head had significant correlation with plant height, productive tillers, ear number and the greenness of the leaf (CCI). Strong positive correlation was also detected among grain yield per plant and grain yield per head at $r^2 = 0.733$. Grain yield per head had also significant correlation with plant height, productive tillers, ear number and the greenness of the leaf (CCI).

Discussion

The genotypes evaluated in this study were variable for most of the traits considered. In this study accessions observed to show variation in days to heading and maturing and both traits were positively correlated with plant height, whereby early maturing accessions were observed to be taller (230107, 230108, 230106 with 105.6 cm, 103.6 cm and 99.4 cm, respectively) than the late maturing accessions (238325, AAUFM-41 and 216046 having plant height of 56.7 cm 52.1 cm and 67.2 cm respectively). In contrast, the shortest plant such as accessions 215982 and 215985 with plant height of 36.4 cm and 36.8 cm, respectively, were recorded for accessions collected from moisture rich area like Amhara Region (North-western part) which was very susceptible to water deficit. Water deficit could reduce plant height during the vegetative and flowering stages, which is attributed to reduction of stem and leaf expansion and resulted in stunted growth (Vurayai, *et al.*, 2001; Mirbahar *et al.*, 2009). It also affects both elongation and expansion growth (Anjum *et al*., 2003a). According to Vaezi, *et al*. (2010) significant reduction in plant height was observed by 14.6% in susceptible chickpea accessions than the irrigated once.

Accessions with the higher number of green leaf retention is another characteristic features of drought stress resistant mechanisms in plants (Blum, 2007). However, when the soil moisture content declines, traits related to leaf mainly green leaf number and total green leaf area could be affected seriously with drought in susceptible plants. This is in agreement with the report of Metcalfe *et al*. (1990); expansion of leaves of the drought-treated plants was slower than that of well watered plants.

Mean TGLA (Total Green Leaf Area) per plant drastically decreased for accessions under soil moisture stress condition. For instance, Accession AAUFM- 49, 242622 and AAUFM -32 collected from Tigray (Northern Ethiopia) showed the lowest TGLA, which resulted in lower yield and agronomic performance. In agreement with the result of this study, reduction in TGLA has been reported for many plant species under moisture stress condition (Zhang *et al*., 2004; Sah and Zamora, 2005; Farooq *et al*., 2009). However, the response varies depending on genotypes and intensity and duration of water stress. Drought stress mostly reduced leaf growth and in turn the leaf areas in many species of plants such as Populus (Wullschleger *et al*., 2005), and rice (Farooq *et al*., 2009).

One of the effects of drought stress has been attributed to the destruction of chlorophyll pigments and the instability of the pigment followed by leaf abscission (Levit, 1980). The same observation was made in this study on susceptible genotypes of finger millet, however, there were some accessions maintaining the green leaves longer than their counterparts.

Table 6: Mean ± S.E values agronomic, physiological and yield related traits of ten finger millet accession selected for its drought stress performance

Acc	PH	TN	NPT	GLN	GLA	TGLA	EN	EL	RWC	CCI	GYPH	GYPP
AAUFM-7	77.9(4.2)	10.2(1.2)	6.4(0.3)	2.0(0.4)	26.2(5.4)	52.5(0.9)	11.5(0.4)	10.5(0.2)	70.9(2.8)	16.4(1.9)	4.0(0.9)	74.8(3.4)
AAUFM-2	79.0(1.6)	18.5(0.2)	16.9(0.0)	7.2(2.0)	23.5(1.7)	169.5(1.1)	10.5(0.3)	10.5(0.2)	74.7(0.8)	15.4(2.5)	1.9(0.6)	64.9(0.3)
AAUFM-44	62.4(6.4)	13.6(0.5)	8.7(0.4)	8.0(4.1)	27.1(2.7)	217.3(0.6)	20.6(0.3)	8.8(0.1)	56.3(7.9)	24.6(6.3)	1.8(1.3)	63.5(2.5)
AAUFM-30	64.5(3.3)	13.2(2.7)	12.1(2.4)	4.3(0.9)	25.0(0.9)	106.2(0.6)	8.9(0.3)	8.0(0.1)	76.3(16.0)	13.3(1.4)	4.2(0.1)	61.4(1.3)
AAUFM-43	79.4(0.4)	16.6(0.1)	12.7(1.5)	1.4(0.5)	17.9(0.4)	25.1(0.5)	10.3(0.2)	8.7(0.1)	70.5(2.3)	15.4(1.1)	2.3(0.8)	60.2(1.6)
TADESSE	83.4(2.6)	9.7(0.7)	6.4(1.9)	2.7(0.8)	23.8(1.2)	63.5(0.2)	6.8(0.1)	7.3(0.0)	81.8(3.6)	11.6(0.6)	4.9(.20)	58.6(1.6)
230109	93.4(1.6)	10.6(0.2)	9.3(0.2)	2.5(0.6)	18.8(1.9)	47.2(1.0)	10.1(0.5)	7.9(0.2)	57.6(0.4)	13.6(1.6)	4.1(0.1)	57.1(1.5)
AAUFM-10	103.4(9)	15.2(1.0)	13.0(0.1)	6.0(1.7)	18.0(4.1)	107.9(0.7)	10.3(0.3)	11.4(0.1)	67.4(18.5)	15.3(3.1)	3.7(0.4)	55.3(1.4)
AAUFM-42	77.4(3.3)	11.8(0.7)	10.9(0.1)	5.0(1.4)	22.8(1.0)	113.9(0.4)	9.2(0.2)	10.7(0.1)	76.0(13.2)	15.5(1.0)	4.1(0.1)	53.3(2.6)
AAUFM-50	69.2(1.0)	11.2(0.0)	10.0(0.2)	1.7(0.4)	25.1(2.2)	41.8(0.4)	9.3(0.2)	9.2(0.1)	87.3(0.8)	14.1(1.2)	4.1(0.1)	51.2(2.6)

Acc- accession, PH- plant height, TN- tiller number, NPT- number of productive tiller, GLN- green leaf number, GLA-Green leaf area, TGLA- total green - leaf area, EN- ear number, EL- ear length, RWC- relative water content, CCI (chlorophyll content index),GYPH-grain yield per head and GYPP- Grain yield per plant

Those accessions with the highest CCI records (AAUFM-14, AAUFM-44 and AAUFM-24) exhibited the highest relative water content, highest number of green leaf area, and the highest yield per head and per plant.

On the other hand accession with the lowest CCI records such as accessions 215982, 216046 and AAUFM-26 had the lowest ear numbers, plant height, green leaf area, relative water content, and yield per head. Overall, the lowest chlorophyll content reading value was recorded in accessions which were susceptible to drought. Similar result were reported for eggplant by Kirnak *et al*. (2001), that water stress resulted in significant decreases in chlorophyll content and the leaf relative water content. Leaf water content is a useful indicator of plant water balance, since it expresses the relative amount of water present on the plant tissues (Pirdashti *et al*., 2009).

Relative water content could decrease as the extent of water stress becomes more severe (Kyparissis *et al*., 1995). According to Pastori and Trippi (1992), higher RWC has been reported to play a role in the stress tolerance of maize. In our study, accessions 242135, 215990 and 225892 which were collected from moisture rich region, Amhara region (Northwest Ethiopia) observed to be more susceptible to drought with the lowest value in RWC. Similarly, Siddique *et al*. (2001) reported that wheat leaves subjected to drought condition were exhibited large reductions in RWC comparing to the control.

Yield is the sum total of the grain from the main plant and the tillers as well and hence, the number of productive tillers directly correlates with seed yield. Accordingly, accessions 238299, 238325, AAUFM-2, AAUFM-30 had the highest yield per head and per plant in the present study.

Moreover, these accessions had moderate to high number of productive tillers, seed weight per head, relative water content, CCI reading, ear size and the aggregated nature of the spikelet in the panicle. This is partly indicated in the clustering analysis whereby out of the total 23 best performing accessions under drought condition, 11 were from the same cluster. Water stress during the flowering and grain filling periods reduced seed yield and seed weight and accelerated maturity of dry bean (Singh, 1995, Bouman and Tuong 2000 and Pirdashti *et al*., 2009) on rice. Insufficient rainfall can also reduce the corn reproductive stage which resulted in significant reduction in grain yields (Liu and Wiatrak, 2011) and 28.05% yield reduction was also recorded in barley (Vaezi *et al*., 2010).

Conclusion

The present study indicated the existence of variability among genotypes collected from different locality in terms of their response to moisture stress condition. A total of 23 out of the 96 accessions evaluated were selected as drought tolerant based on agro-morphological and physiological and yield related parameters. Accessions such as AAUFM-7, AAUFM-2, AAUFM-44, and AAUFM-30 were found to be high yielder with grain yield per head than the nationally released varieties (TADESSE and BONEYA).

The cluster analysis of all the 96 accessions revealed six distinct groups, of which total 23 accessions were selected and promoted based on their good performance against drought. Out of the total 23 selected accessions, 11 accessions belong to cluster 1 of which nine accessions were obtained from one region, Tigray (northern part of Ethiopia).

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