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Evaluation of Elite Sorghum (*Sorghum* B*icolor (L) Moench)* Inbred Lines for Yield and Related Traits Under Moisture Stress Areas of Ethiopian

Temesgen Begna*

Chiro National Sorghum Research and Training Center, Ethiopian Institute of Agricultural Research, Chiro, Ethiopia.

Abstract

Drought is the major constraint for sorghum production in Ethiopia causing high yield loses every year. However, there were no more sorghum varieties developed and released in Ethiopia that can highly adapt drought stress and perform well in moisture stress areas. Therefore, developing and using drought tolerant or resistant sorghum varieties is one of the available solutions to cope with the e ects of drought. The objectives of this study were to evaluate promising sorghum genotypes for drought tolerance and other agronomic traits. A total of 42 sorghum genotypes were evaluated in an alpha-lattice design with two replications in 2019 main cropping season at Mieso and Kobo. The combined analysis of variance revealed that there was a highly signiýcant di erence (p<0.01) among the genotypes for all the traits. Among the tested genotypes, the top better performing genotypes were 4x14 (6.32 tha^{-1}) followed by genotype 8x15(5.92 tha^{-1}), 1x15 (5.88 tha^{-1}), 13x14 (5.78 tha^{-1}) and 6x15 (5.57 tha^{-1}) with a yield advantage of 32.49%, 24%, 23%, 21% and 16.68% over the check (ESH4) (4.77 tha^{-1}), respectively. The sorghum genotypes showed substantial genetic variation for studied traits under drought stress condition and could be utilized by sorghum breeders to develop new and economically important sorghum varieties. Finally, the study identiýed the most promising and potential genotypes which could be exploited commercially after critical evaluation for their superiority and yield stability across the locations over years.

***Corresponding author:** Temesgen Begna, Chiro National Sorghum Research and Training Center, Ethiopian Institute of Agricultural Research, Chiro, Ethiopia, Tel: 251921196966; E-mail: bilisummaa2006@gmail.com

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in both stressors. Variability in rainfall patterns and increasing air temperature in semi-arid regions are linked to lower sorghum grain yields. As a result, it's critical to understand the characteristics and mechanisms that are affected directly or indirectly by drought and high temperatures in sorghum [3].

Understanding trait-associated mechanisms will help breeders build drought-resistant or high-temperature sorghum varieties or hybrids that can sustain grain yield. In general, compared to vegetative phases, reproductive stages of sorghum development are more vulnerable to environmental (abiotic) stimuli. The panicle development, flowering and grain filling phases of sorghum are drought stress-sensitive. Various biotic and abiotic factors contribute to the low productivity of sorghum. Among the abiotic factors, drought is the major cause for low productivity of the crop. Worldwide, the annual yield loss due to drought is estimated to be around 10billion US dollar. In Ethiopia it is a major problem leading to food shortages and challenging small-holder farmers in Ethiopia to produce enough sorghum grain when rainfall is low and erratic. The effect of drought on crop yield is dependent on the stage of plant development. Assefa (2010) has reported that water stress occurring during the vegetative stage alone could reduce yield by > 36% and > 55% at the reproductive stage. In Ethiopia, complete yield loss due to drought was recorded in some parts of the country, such as Mehoni area (EIAR, 2014) [4].

However, only a small number of drought tolerant varieties have been developed for enhancing sorghum production and productivity. In many areas where sorghum is produced, farmers continue to use their local varieties with low yield potential. Therefore, there is a need to increase productivity of this crop through development of high yielding varieties with resistance to drought and farmers preferred varieties. Drought tolerance in sorghum is a function of various physiological and morphological traits contributing towards tolerance. Evaluation of root characterized sorghum genotypes under target environments provides an opportunity to identify promising parental which combines desirable drought tolerance traits. However, very limited works have been done to evaluate Ethiopian sorghum germplasm for drought tolerance.

In sorghum, there are two primary types of drought responses including pre-flowering and post-flowering, which are under the control of two different sets of genetic mechanisms. Pre-flowering refers to the stage from panicle differentiation to flowering, while post-flowering refers to the stage between flowerings to grain development (GS-3). Pre-flowering drought tolerance responses of sorghum includes reductions in panicle size, seed number, and grain yield. Post-flowering drought tolerance encompasses rapid premature senescence, which leads to reductions in seed size, yield loss and stalk lodging. Efforts have also been made to develop early maturing sorghum varieties that are adapted to areas where regular moisture scarcity is detrimental to sorghum production. In Ethiopia, more than 51 early maturing sorghum varieties are currently available for use in such environments [5].

Despite, the long-term efforts made to breeding for tolerance to drought in sorghum, advances made in developing improved varieties with adequate levels of drought tolerance using indigenous landraces combined with farmers' and market-preferred grain, and above ground biomass traits have been limited. Farmers still prefer to plant local sorghum landraces rather than introduced varieties because local landraces produce larger volumes of biomass for animal fodder, fuel, and construction material in good cropping seasons. Therefore, sorghum breeding programs should ensure that the new varieties satisfy the preferences of the farmers through developing drought tolerant or resistant to create sustainable adaptation of the released varieties and their production packages [6].

Generally, sorghum genotypes characterized by early flowering and early maturity, small number of leaves per plant, small leaf area, erect leaf type, larger stem diameter, small number of productive tiller, small leaf area, high grain yield per unit area and short plant height are most suitable for lowland areas with a limited rain fall and short growing season. Hence, the development of locally adapted improved sorghum varieties to a particular environment is one solution to overcome the challenges of both local adaptation and local farmers' end user requirements. The objectives of the experiment were to evaluate the performance of elite sorghum genotypes for drought tolerance and identifying promising genotypes for drought prone areas.

Materials and Methods

Location of the experiment

A study was carried out in two different dry lowland sorghum growth environments. These were Mieso and Kobo, where sorghum is the primary crop and drought is a major productivity constraint. These sites represent the country's sorghum-growing regions in the east and north. Mieso is located 302 kilometers east of Addis Ababa, Ethiopia's capital city, in the Oromia regional state. Its elevation is 1470 meters above sea level, and it is located at 8^o30 N latitude and $39^o21'$ E longitudes, with average maximum and minimum temperatures of 14.0^oC and 30.01^oC, respectively, with an average annual rainfall of 763 millimeters. Vertisols with a p^H of 5.4 are the most common soil type (EIAR, 2014). Kobo is located 437 kilometers north of Addis Ababa, Ethiopia's capital city, in the Amara regional state. It is located at 12^o09 N latitude and 39^o

of one meter. ere were seven plots per block and six blocks each replication in this experiment. Seeds were drilled at a rate of 12 $kgha^{-1}$ in each row. e seedlings were thinned to 0.20 m spacing between plants a er three weeks a er sowing. All of the standard agronomic packages were applied to basal, as well as fertilizer rates of 100 $kgha^{-1}$ DAP and 50 $kgha^{-1}$

(g) at both Mieso and Kobo testing sites. is implies the presence of su cient variation to make selection among the tested genotypes.

Combined analysis of variance for yield and yield related

Table 4: Description of the genotypes included in the experiment at Mieso and Kobo in 2019 cropping season.

S.N	Lines	Pedigree	S.N	Hybrids	Pedigree
1	TX-623B	TX-623B	21	P-851015A x ICSR -14	P-851015A x ICSR-14
2	P-9501B	P-9501B	22	P-850341A x ICSR-14	P-850341A x ICSR-14
3	P-9505B	P-9505B	23	A5 x ICSR-14	A5 x ICSR-14
4	P-9534B	P-9534B	24	A6 x ICSR-14	A6 x ICSR-14
5	P-851015B	P-851015B	25	MARC1A x ICSR-14	MARC1A x ICSR-14
6	P-850341B	P-850341B	26	MARC2A x ICSR-14	MARC2A x ICSR-14
7	B5	B5	27	MARC3A x ICSR-14	MARC3A x ICSR-14
8	B6	B6	28	MARC6A x ICSR-14	MARC6A x ICSR-14
9	MARC1B	MARC1B	29	P9511A x ICSR-14	P9511A x ICSR-14
10	MARC2B	MARC2B	30	TX-623A x Melkam	TX-623A x Melkam
11	MARC3B	MARC3B	31	P-9501A x Melkam	P-9501A x Melkam
12	MARC6B	MARC6B	32	P-9505A x Melkam	P-9505A x Melkam
13	P9511B	P9511B	33	P-9534A x Melkam	P-9534A x Melkam
	Testers		34	P-851015A x Melkam	P-851015A x Melkam
14	Melkam	WSV387	35	P-850341A x Melkam	P-850341A X Melkam
15	ICSR-14	ICSR-14	36	A5 x Melkam	A5 x Melkam
	Check		37	A6 x Melkam	A6 x Melkam
16	ESH-4	PU20AxPU304	38	MARC1A x Melkam	MARC1A x Melkam
	Hybrids		39	MARC2A x Melkam	MARC2A x Melkam
17	TX-623A x ICSR-14	TX-623Ax ICSR-14	40	MARC3A x Melkam	MARC3A x Melkam
18	P-9501A x ICSR-14	P-9501A x ICSR-14	41	MARC6A x Melkam	MARC6A x Melkam
19	P-9505A x ICSR-14	P-9505A x ICSR-14	42	P9511A x Melkam	P9511A x Melkam
20	P-9534A x ICSR-14	P-9534A x ICSR-14			

development of drought tolerance genotypes were suggested.

Days to flowering and maturity are among the most important attributes that need to be considered in selecting genotypes for drought affected areas. In this study, the mean number of days to flowering ranged from 68 days in the early flowered genotype (35) to 77 days in the late flowered genotypes (31). Similarly, mean number of days to maturity ranged from 108 to 114 for the same group of genotypes. Both early and late maturing genotypes had the same grain fill duration, However, variation was detected for grain yield and related yield components among these genotypes, indicating that, the variation in the other attributes might be associated with factors other than duration of grain fill.

The top yielder genotypes (17) required 69 days to flower and 108 days to mature which was close to the average for genotypes, 70 days for flowering and 111 days for maturity. This indicates that, the yielding potential is not necessarily associated with crop phenology provided that genes for high yield potential are incorporated in the genotypes. The global successes in improving sorghum yield by deploying high yielding early maturing hybrids also supports this idea. Meanwhile, delayed flowering for genotypes encountered severe drought condition was reported, which would have considerable effect on the productivity of the crop Similarly, the actual mean values showed variation among genotypes for plant height and leaf area and these appeared to be under strong genetic control, although environment could have marked effect (Table 5).

Mean plant height ranged from 107.50cm to 271cm, and leaf area ranged from (220.36cm² to 405.63cm²).Breeding for shorter plant height was one of the major goals of the sorghum breeding program for dry lowland areas where drought adversely affects the plants which had prolonged vegetative growth and to make commercial genotypes fit to mechanical harvesting. Drought resistance is a complex trait, expression of which depends on action and interaction of different morphological traits (earliness and reduced leaf area). Among the

Entry	DTF	PHT	DMT	PY	GY	SG	TSW	PL	PW	LN	LL	LW	LA	PE	PAS
1	70	185.9	108.5	107.8	5.88	2.25	30.7	31.4	9.65	11.3	68.3	7.5	353.8	7.95	1.75
2	69.25	183.7	108	106.8	4.78	3.5	27.3	28.8	8.2	11	65.8	7.08	325.9	6.35	2.5
3	69.25	181.8	109	89.6	4.76	2.75	24.1	29.3	7.6	10.8	66.3	7.75	366	12.6	3.13
4	69.25	176.5	108.5	89.25	4.75	2.5	28.6	30.9	8.2	11.4	65.3	6.92	316.3	6.55	2.25
5	71	206.7	110	99.4	4.94	2.5	26.3	29.9	9.1	11.5	68.1	8	378.6	6.35	2.5
6	69.75	198	109.3	83.6	5.57	3	23.6	30.1	9.9	10.9	63.7	7.75	341	13.35	2.5
7	69.5	184.9	109	96.55	4.81	3.25	24.6	31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

hybrids compared to testers and the significant difference was revealed between hybrids and check for days to maturity trait.

Summary and Conclusion

Sorghum is a high-yielding, nutrient-efficient, and drought-tolerant crop that can be grown on more than 80% of the world's agriculture. Farmers can satisfy the growing demand for sustainable food, feed and biomass production while lowering the cost of inputs like water due to the special characteristics of grain sorghum. For different traits at individual and combined locations, the mean squares due to genotypes revealed substantially great variation among all genotypes. Since genotypes differ genetically, selection may be an efficient way to improve genotypes for such traits.

For the traits evaluated, the presence of significant differences among sorghum genotypes indicated the presence of substantial genetic variations that may be enhanced through selection. Since the genetic materials had a huge variation, it was possible to improve the genotypes using simple selection for the traits that were being researched. To address the greatest genetic yield potential of crops and harness these variations through effective selection for subsequent

the productive tiller, small leaf area, stay in greenness, high grain yield per unit area, and short plant height have been identi ed.

References

1. Spaenij-Dekking L, Kooy-Winkelaar Y, Koning F (2005) The Ethiopian Cereal Tef in Celiac Disease. N Engl J Med 353: 1748-1749.
2. Ketema S (1993) Tef (*Eragrostis tef*): Breeding, Genetic Resources, Agronomy, Utilization and Role in Ethiopian Agriculture. Addis Ababa: Agri Rese.
3. Assefa K, Yu JK, Zeid M, Belay G, Tefera H, et al. (2011) Breeding tef [*Eragrostis tef (Zucc.) trotter*]: Conventional and molecular approaches. Plant Breed 130: 1-9.
4. Bediye S, Fekadu D (2001) Potential of tef straw as livestock feed. Proceedings of the International Workshop Tef Genetics and Improvement. Agri Res: 245-254.
5. Yami A (2013) Tef Straw: A Valuable Feed Resource to Improve Animal Production and Productivity. Livestock Feed: 244-379.
6. Habte E, Muktar MS, Negawo AT, Lee S, Lee K, et al. (2019) An Overview of Tef (*Eragrostis tef Zuccagni) Trotter*) as a Potential Summer Forage Crop in Temperate Systems. J Korean Soci Gras for Sci 39: 185-188.
7. Girija A, Jifar H, Jones CS, Yadav R, Doonan J, et al. (2021) Tef, a tiny grain with enormous potential. Trends Plant Sci.
8. Sugg JD, Sarturi JO, West CP, Ballou MA, Henry DD (2021) Tef grass for continuous stocking in the Southern High Plains by growing beef steers receiving protein supplements. Transl Anim Sci 5:1-11.
9. Ketema S (1997) Tef-Eragrostis Tef (Zucc.) Promoting the conservation and use of underutilized and neglected crops. 12. Addis Ababa: Bioversity International.
10. Lascano CE, Schmidt A, Barahona Rosales R (2001) Forage quality and the environment.