Indian J. Plant Genet. Resour. 33(1): 60–67 (2020)
DOI 10.5958/0976-1926.2020.00009.1

RESEARCH ARTICLE

Evaluation of Teosinte derived Maize Lines for Drought Tolerance

Amarjeet Kumar[1], NK Singh[2], AS Jeena[2], JP Jaiswal[2] and SS Verma[2]

[1] *Department of Genetics and Plant Breeding, College of Horticulture, Thenzawl, Central Agriculture University, Imphal–795004, Manipur, India*

[2] *Department of Genetics and Plant Breeding, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar–263145, India*

(Received: 18 December, 2018; Revised: 17 January, 2019; Accepted: 02 February 2019)

Maize plants grown in subtropical and temperate regions are often subjected to moisture stress. The wild progenitors of the crop species are the important source of genes of various abiotic and biotic stress tolerance. Teosinte (*Z. mays* ssp. *parviglumis*), the progenitor of maize possesses several important genes of agronomic importance, majority of which were lost during the process of domestication. In the present investigation, 203 modern maize BC_1F_2 introgressed lines (encoded as AM-1 to AM-203) were developed and evaluated under irrigated and moisture stressed environments. In order to introduce the genes of agronomic importance from the progenitor teosinte to modern maize, DI-103 inbred were crossed with teosinte. The present study involved evaluation of 203 lines (encoded as AM-1 to AM-203). These lines were grown in a single row in two environmental conditions i.e. irrigated and stress condition during *Rabi* 2016-17 for the phenotyping of morpho-physiological traits *viz*., anthesis silking interval (ASI), leaf rolling, leaf firing, canopy temperature depression (CTD), chlorophyll content, ear length, ear diameter, kernel rows/ear, kernels/row, tip filling, grain filling, grain yield per plants (g), and 1000-kernel weight and drought tolerance index, stress tolerance index, yield index associated with drought tolerance. Overall sum of rank scores over thirteen traits associated with drought tolerance revealed that AM-39 was the most drought tolerant line among all the 203 lines under study with a total score of one hundred eight, followed by AM-64, AM-16, AM-42, and AM-102, whereas, AM-116 was the most susceptible, with the least score of thirty-four.

Key Words: BC_1F_2, Drought, Maize, Morpho-physiological trait, Teosinte

Introduction

Maize (*Zea mays* L., 2n=20) is an important cereal crop belonging to tribe Maydeae, of the grass family, Poaceae. The centre of origin of maize has been recognized as the Meso-American region and about 9000 years ago domestication was started independently in regions of the South-West USA, including Mexico and in Central parts of America. Being C4 plant, it can capture energy efficiently and is capable of producing maximum food grains per unit area as compared to other cereals. Maize grain contains about 10% protein, 4% oil, 70% carbohydrate, 2.3% crude fiber, 10.4% albuminoides and 1.4% ash and sufficient quantities of carotenoids and other vitamins. Besides large number of commercial products it is used for diversified purposes like human food (25%), poultry feed (49%), animal feed (12%), industrial (starch) product (12%), beverages and seed (1% each) (Anonymous, 2014). Teosinte (*Z. mays* ssp. *parviglumis*; hereafter referred to as teosinte) is a wild progenitor of domesticated maize (*Z. mays* ssp. *mays*). Teosinte has greater genetic diversity than maize inbreds and landraces. Exploitation of teosinte as a genetic resource for biotic and abiotic stresses is becoming a burning area of research in the recent years, through wide hybridization. Breeders are also working on the dissection of domestication and evolution phenomena of cultivated maize from teosinte, to know the segregation distortion in maize × teosinte progenies. QTL controlling root aerenchyma formation in a maize × teosinte F_2 population have been identified (Mano *et al*., 2005a; 2007a, b). Teosinte was the donor of several QTLs associated with the increased capacity to form aerenchyma, thus confirming the potential of teosinte genes to develop improved maize germplasm (Qing *et al*., 2011). Thus, there is tremendous interest and demand for improving maize drought tolerance through biotechnology (Wang *et al.,* 2016) and utilization of wild relatives for the same**.** Since the broad utilization

**Author for Correspondence: Email- amarjeetgpb@gmail.com*

of single cross hybrids during the past century, maize genetic base gradually became narrower. The yield is considerably limited due to drought, together with heat, salinity, pests, and diseases. Like all other agricultural crops, the present-day cultivated maize varieties are characterized by narrow genetic composition and fixation of relatively few adapted genes and their allelic variations. Landraces and wild relatives are possible genetic reservoirs to get the genes for moisture stress tolerance and to incorporate them in modern cultivars to improve their status of drought tolerance and thus ensure stability w.r.t. yield potential. Therefore, breeders are in search of new genetic resource i.e. wild relatives to broaden the genetic base by introgression of the desirable genomic region into the inbred lines used in the commercial cultivation. *Zea mexicana, Tripsacum floridanum* and *Z. mays* ssp. *parviglumis*, which are wild relatives of maize, are tremendous sources of novel genes for improvement of tolerance against drought and other stresses (Singh, 2010). BC_1F_3 lines of three maize-teosinte crosses exhibited significant variance for most of the characters. Mean, range, PCV and GCV for different characters analyzed across the three populations indicated that teosinte derived lines were diversified probably because of the allelic reshuffling between maize and teosinte genome. Thus, teosinte can be used effectively for diversification as well as enhancement of maize germplasm. The genetic narrowing formed by domestication followed by selective breeding, can be broadened using teosinte (Singh *et al*., 2017).

Maize crop is more sensitive to abiotic stresses, particularly moisture stress (drought) and water logging stress during the growing season, especially the reproductive stage. During reproductive growth stage, 8–9 mm water is needed per day by a single plant. Four weeks are most crucial regarding water requirement which includes two weeks before and two weeks after pollination. Pollination is the most critical growth stage for water requirement and all leaves are kept unfolded and grain yield is also decided at this stage (Aslam *et al.,* 2015). Plant breeder exploits the term drought according to his objective. In a given region, there may not be drought over an entire growing season but a small spell of moisture stress during reproductive stage may lead to drought. Here, we define drought (also referred to as agricultural drought) as the time point when the amount of moisture in the soil no longer meets the needs of the crop (Mannocchi *et al.,* 2009). Drought is the single most common cause of severe reduction in crop production in developing countries like India, and high temperature is predicted to further exacerbate drought's impact. Therefore, there is a need of breed genotypes which are able to maintain a stable yield over a range of water supply. This apparently seems simple but it is not an easy task and has several reasons behind it. Drought tolerance is a very complex trait, affected by a wide range of mechanisms spanning both the time scale and their plant geometry. In this regard, crop phenology is considered a very important feature of drought tolerance (Passioura, 1996) and the plant adaptation will be effective where climate changes are slow and consistent over the time. It has been observed for many crops, that there is a low genetic correlation for yield in high- and low-productivity environments, indicating that different sets of genes may be important in regulating the yield in different environments (Johnson and Geadelmann, 1989; Atlin and Frey, 1990). Extensive genetic dissections of drought tolerance traits have been carried out in maize over the last decade. It leads to the identification of numerous QTLs involved in the determination of morphological traits and physiological traits imparting drought tolerance. But still we are not able to develop hybrids and other varieties to overcome problems of drought. Therefore we need to search new resources of genes or QTLs for drought tolerance which can be exploited in breeding program.

Keeping in view the changing scenario of water availability and erratic rainfall, present experiment has been designed to evaluate the BC_1F_2 teosinte derived maize lines using morpho-physiological traits and therefore, our hypothesis was to identify the teosinte derived drought tolerant lines with the help of rank score assigned on the basis of least reduction or positive increase between the performance of genotype in irrigated condition and drought condition.

Materials and Methods

The present investigation was conducted at N.E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The planting materials were developed by introgressing the genomic regions from wild progenitor teosinte (*Z. mays* ssp. *parviglumis*) to the genetic background of modern cultivable maize inbred line DI-103. Teosinte was used a pollen parent to pollinate the maize inbred line DI-103 in *Kharif* 2015, followed by one backcrossed with DI-103 as a recurrent parent to develop BC_1F_1 lines. In *Kharif* 2016, BC_1F_1 plants were selfed to produce 203 BC_1F_2 lines (encoded as AM-1 to AM-203), which were evaluated in the *Rabi* season 2016-2017 for drought tolerance. The lines were grown as 2m single row with spacing of 75cm in two environmental conditions i.e. irrigated condition and moisture stress condition during *Rabi* 2016-17, for the phenotyping of morpho-physiological traits associated with drought tolerance. The lines were challenged with moisture stress before anthesis and silking stage. The rainfall data was recorded during the experiment period and data revealed that on 16th May there was rain of 29 mm.

Ten morpho-physiological traits *viz*., Anthesis-silking interval (ASI), days to 75 per cent senescence (D75S), canopy temperature depression (CTD), chlorophyll content (CC), ear length (EL), ear diameter (ED), kernel row per ear (KE), kernels per row (KR), grain yield per plant (GY) and 1000 kernel weight (KW) were recorded as per standard protocols. The average value of genotypes for all the characters were used for the statistical analysis and calculation of drought tolerance, stress tolerance and yield indices.

Drought tolerance index, stress tolerance index and yield index were calculated with following formulae;

Drought tolerance index (DI) $= \frac{Y_s \times \frac{Y_s}{Y_p}}{\bar{Y}_s} = \frac{Y_s \times \frac{Y_s}{Y_p}}{\bar{Y}_s}$ (Lan, 1998).

Yield index (YI) $= \frac{Y_s}{\bar{Y}_s} = \frac{Y_s}{\bar{Y}_s}$ (Gavuzzi *et al.,* 1997).

Stress tolerance index $= \frac{Y_s \times Y_p}{\bar{Y}_p^2} = \frac{Y_s \times Y_p}{\bar{Y}_p^2}$ (Fernandez, 1992)

Where, *Ys*, *Yp*, are the yield of each genotype in stress (drought) and irrigated conditions for each genotype, respectively; $\bar{Y}$ s and $\bar{Y}$ p are the mean yield in drought and irrigated condition, respectively.

In order to identify the tolerant genotypes for the trait, irrigated and stress conditions were compared for percentage change and the genotypes showing least changes in both the environment was given maximum rank in the ranking scale of 1to10. First twenty genotypes showing least changes were considered most tolerant and accorded the rank value 10. Next twenty lines were given 9 and subsequently, at last twenty-three lines were given rank value 1.

Results and Discussion

The mechanism of drought tolerance is complex in nature. Therefore, none of the traits evaluated under investigation can be solely called responsible for drought tolerance *in toto*. Accounting of all the traits which have contributed towards tolerance, would help to screen drought tolerant lines in a comprehensive manner. Considering the multi-traits associated with drought tolerance mechanism, each genotype was given a rank score for each of the 10 morpho-physiological traits and three indices. The basis of ranking was the least reduction or positive increase between the performance of genotype in irrigated condition and moisture stress condition. All the lines were given a rank score in decreasing order of their tolerance for each trait from 1 to 10. Higher score corresponded to higher tolerance of that line to water stress for respective drought associated traits.

The mean values of the trait along with respective mean deviation were presented in the Table 1. The highest mean value (in days) of ASI in normal and drought condition was reflected by AM-115(2.60), AM-92 (4.00) and the lowest value -1.80 (AM-100), AM-18 (-6.00) exhibited respectively. The maximum and minimum mean deviation was found for AM-92(3.67) and AM-18(-7.35) respectively. For anthesis silking interval in drought stress, maximum tolerance was registered in AM- 39 (10), AM-115(10), AM-83(10) and AM-18(10). The least tolerance was exhibited by AM-193(1), AM-92(1) and AM-53 (1) (Table 4). For 75 per cent days to senescence in normal and drought condition, the maximum mean value showed by AM-92 (131), AM-137 and AM-92 (119) and the minimum value of 120 days was observed in AM-16, AM-99; 104 days in AM-115, AM-83. The highest and lowest mean deviation was found for AM-193 (-4.99) and AM-83 (-17.20). For 75 per cent days to senescence the highest tolerance to drought was shown by line AM-193 (10), AM-116 (10) and AM-53 (10), while the lowest was found in AM-71(1), AM-83 (1), AM-115 (1) and AM-102 (1). The highest mean value of canopy temperature depression (CTD) in normal and drought condition was reflected by AM-16(5.90), AM-138 (10.00) and the lowest value of 0.40 in AM-137 and AM-184 (1.70). The maximum and minimum mean deviation was found for AM-138(8.80) and AM-18(-3.80) respectively. Similarly, genotype AM-138 (10) showed highest tolerance to physiological trait, CTD and, AM-16 and AM-18 found as least tolerant to the same (1). For chlorophyll content

Table 1. List of Mean (normal and stress), Mean Deviation (MD) of ten most tolerant and most susceptible teosinte derived BC_1F_2 lines

	Anthesis silking interval (ASI)			Days to 75% senescence(days)			Canopy temperature depression (CTD)			Chlorophyll content (SPAD unit)		
TL	M		MD	M		MD	M		MD	M		MD
	N	S		N	S		N	S		N	S	
AM-39	-0.40	-1.50	-1.10	127.80	117.50	-8.06	4.60	4.90	0.30	43.60	42.10	-3.44
AM-64	-0.40	1.20	1.60	123.40	112.60	-8.75	1.90	6.40	4.50	45.00	46.50	3.33
AM-16	-2.0	-1.0	1.00	120.00	111.60	-7.00	5.90	3.40	-2.50	46.00	47.20	2.61
AM-42	-0.40	0.00	0.40	127.00	113.00	-11.02	4.00	3.70	-0.30	53.50	46.00	-14.02
AM-102	0.60	0.86	0.26	125.00	105.66	-15.47	2.10	8.70	6.60	40.80	54.30	33.09
AM-178	0.20	1.34	1.14	124.00	114.00	-8.06	1.10	7.30	6.20	40.00	39.10	-2.25
AM-115	1.40	-0.50	-1.90	123.80	104.00	-15.99	2.20	6.20	4.00	38.60	37.40	-3.11
AM-138	0.75	1.20	0.45	121.75	108.80	-10.64	1.20	10.00	8.80	36.50	35.70	-2.19
AM-83	2.60	-1.00	-3.60	125.60	104.00	-17.20	2.10	5.60	3.50	45.60	45.80	0.44
AM-99	0.60	1.00	0.40	120.20	109.00	-9.32	3.20	8.60	5.40	44.00	44.80	1.82
SL												
AM-116	-1.00	0.83	1.83	123.80	116.33	-6.03	0.80	5.00	4.20	49.60	40.50	-18.35
AM-193	-0.40	2.50	2.90	124.20	118.00	-4.99	1.40	5.50	4.10	51.10	41.00	-19.77
AM-18	1.35	-6.00	-7.35	126.60	114.00	-9.95	6.40	2.60	-3.80	54.40	49.30	-9.38
AM-90	1.20	0.50	-0.70	127.00	113.25	-10.83	2.60	6.20	3.60	51.50	50.30	-2.33
AM-137	0.60	1.80	1.20	130.60	119.00	-8.88	0.40	3.90	3.50	40.70	40.20	-1.23
AM-100	-1.80	-1.75	0.05	126.40	114.00	-9.81	2.70	7.70	5.00	50.50	44.60	-11.68
AM-92	0.33	4.00	3.67	131.00	119.00	-9.16	2.20	8.40	6.20	46.00	38.40	-16.52
AM-71	-0.50	1.00	1.50	129.00	113.00	-12.40	2.10	7.60	5.50	47.60	39.80	-16.39
AM-184	0.40	1.84	1.44	127.40	115.00	-9.73	1.90	1.70	-0.20	47.40	43.00	-9.28
AM-53	-1.75	1.33	3.08	123.75	117.16	-5.33	3.40	5.20	1.80	41.00	42.20	2.93

TL: Tolerant line SL: Susceptible line N: Normal S: Stress

in normal and drought condition, the maximum mean value was shown by AM-18 (54.40), AM-102 (54.30) and the minimum value was observed as 36.50, 35.50 for AM-138. The highest and lowest mean deviation was found for AM-102 (33.09) and AM-116 (-18.35). Chlorophyll content is another physiological trait for which the most stress tolerant line AM-102 (10) was identified, whereas, least tolerance was found in AM-116 (2) and AM-193(2) (Table 1).

Among the yield contributing traits, the highest mean value of ear length in normal and drought condition was showed by AM-102 (13.00 cm,13.80 cm) and the lowest value 5-6.60 cm by AM-39, AM-16 and AM-42; 5.60 cm by AM-100. The maximum and minimum per cent mean deviation was found 90.91 (AM-42, AM-16) and AM-18(-61.67) respectively. For ear diameter the highest mean value was reflected by AM-100 (2.90 cm), AM-42 (3.80 cm) and the lowest value (1.00 cm) for AM-16 and AM-18 in normal and drought condition respectively. The maximum and minimum percent mean deviation was found in AM-16 (180.00) and AM-18 (-64.29) respectively. For ear length and ear diameter, highest tolerance was exhibited in AM-39 (10), AM-64 (10), AM-16 (10), AM-42 (10) for both the traits and AM-83 (10) and AM-99 (10) for ear length only and AM-102 (10) for ear diameter. The lowest tolerant lines were found AM-100 (1), AM-90 (1), AM-18 (1) for both the traits. Ear length alone contributed to drought tolerance in lines AM-92 (1) and AM-53 (1), whereas, AM-137(1) and AM-116 (1) were marked for ear diameter. The highest mean value of kernel row per ear in normal and drought condition was showed by AM-116(13.20 cm), AM-42 (13.33 cm) and the lowest value of 4.80 cm by AM-16, and 3.60 cm by AM-53, respectively. The maximum and minimum percent mean deviation was found to be 113.33 (AM-42) and -66.67 (AM-53) respectively. For kernels per row in normal and drought condition, the maximum mean value was shown by AM-102 (23.20 cm, 22.60 cm) in both conditions and the minimum value was observed as 5.20 cm (AM-16) in normal and 4.20 cm (AM-18) in drought condition. The highest and lowest percent mean deviation was found for AM-42

Table 2. List of Mean (normal and stress), Per cent Mean Deviation (PMD) of ten most tolerant and most susceptible teosinte derived BC_1F_2 lines

TL	Ear length (cm)			Ear diameter (cm)			Number of kernel row/ear			Number of kernel /row		
	M		PMD	M		PMD	M		PMD	M		PMD
	N	S		N	S		N	S		N	S	
AM-39	6.60	8.00	21.21	2.00	2.60	30.00	7.60	9.60	26.32	8.80	9.40	6.82
AM-64	8.80	11.66	32.50	2.00	3.00	50.00	9.60	10.50	9.38	11.20	20.00	78.57
AM-16	6.60	12.60	90.91	1.00	2.80	180.00	4.80	9.20	91.67	5.20	13.20	153.85
AM-42	6.60	12.60	90.91	2.00	3.80	90.00	6.00	12.80	113.33	6.20	20.80	235.48
AM-102	13.00	13.80	6.15	2.70	3.50	29.63	11.60	12.00	3.45	23.20	22.60	-2.59
AM-178	8.30	6.00	6.45	2.30	1.00	-9.38	6.20	6.00	-3.57	10.80	8.20	34.72
AM-115	11.40	12.40	8.77	2.70	3.30	22.22	9.60	10.00	4.17	18.80	17.20	-8.51
AM-138	11.80	11.00	-6.78	2.80	2.80	0.00	8.80	10.00	13.64	19.80	16.00	-19.19
AM-83	11.60	13.80	18.97	2.70	2.70	0.00	10.00	10.80	8.00	15.20	21.00	38.16
AM-99	7.60	9.00	18.42	2.20	2.80	27.27	10.00	9.60	-4.00	15.60	15.60	0.00
SL												
AM-116	11.20	8.50	-24.11	2.20	1.50	-31.82	13.20	6.50	-50.76	20.20	9.25	-54.21
AM-193	9.80	7.50	-23.47	2.80	2.00	-28.57	9.60	10.00	4.17	12.20	6.50	-46.72
AM-18	12.00	4.60	-61.67	2.80	1.00	-64.29	9.60	4.40	-54.17	16.80	4.20	-75.00
AM-90	11.40	7.20	-36.84	2.80	1.80	-35.71	9.60	5.20	-45.83	12.80	5.20	-59.38
AM-137	10.20	6.96	-31.76	2.20	1.50	-31.82	9.20	5.60	-39.13	13.60	5.00	-63.24
AM-100	12.20	5.60	-54.10	2.90	1.80	-37.93	8.80	5.20	-40.91	14.20	6.20	-56.34
AM-92	9.80	6.66	-32.04	2.50	2.16	-13.60	12.00	10.00	-16.67	17.00	9.66	-43.18
AM-71	10.60	8.20	-22.64	2.50	2.00	-20.00	11.20	6.80	-39.29	14.80	9.60	-35.14
AM-184	9.80	7.33	-25.20	2.20	2.00	-9.09	11.20	8.00	-28.57	16.20	7.66	-52.72
AM-53	10.20	6.00	-41.18	2.00	1.90	-5.00	10.80	3.60	-66.67	12.60	4.80	-61.90

TL: Tolerant line SL: Susceptible line N: Normal S: Stress

(235.48) and AM-18 (-75.00). For kernel row per ear and kernels per row the most tolerant lines were AM-16 (10) and AM- 42 (10), while, AM-64 (10), AM-178 (10), AM- 83 (10) were found tolerant for kernels per row. The maximum mean value of 1000 kernel weight reflected by AM-102 (211.05 g, 204.75 g) in both the condition respectively and the minimum value (124.00 g) for AM-64 and AM-100 (94.25 g) in normal and drought condition respectively. The highest and lowest percent mean deviation was found in AM-64 (30.56) and AM-100 (-37.70) respectively (Table 3). For 1000 kernel weight the maximum tolerance was observed in AM-64 (10) and AM-42 (10) and least tolerant was found in AM-193 (1), AM-100 (1) and AM-137 (1) (Table 4). For grain yield per plant in normal and drought condition, the maximum mean value was shown by AM-115 (96.00 g) and AM-178 (84.00 g) and the minimum value was observed as 24.00 g (AM-137) and 2.00 g (AM-193) respectively. The highest and lowest mean deviation was found for AM-16 (-6.00) AM-64, AM-16, AM-42, and AM-102. On other hand, AM-116 was found as the most susceptible with the and AM-193 (-93.75) respectively. The contribution of grain yield per plant in drought stress was highest in lines *viz*., AM-39, AM-64, AM-42, AM-16, AM-178 and AM-83, whereas, least in lines AM-116, AM-193, AM-71 and AM-184.

For drought tolerance index, all the tolerant lines exhibited high tolerance except AM-64 (1.13) and AM-99 (1.042), while none of the susceptible lines grouped as tolerant in drought tolerant index. For yield index and stress tolerance indexes the highest tolerant lines were AM-102, AM-178, AM-115 and AM-138; whereas, AM-42 was found tolerant for yield index and AM- 99 for stress tolerance index. The least tolerance for stress tolerance index was exhibited by lines AM-193 and AM-137 (Table 3).

Overall sum of rank scores over ten morpho-physiological traits and three indices associated with drought tolerance revealed that AM-39 was most drought tolerant genotype with a total score of 108, among all the two hundred and three lines, which is followed by

Table 3. List of Mean (normal and stress), per cent mean deviation (PMD) along with indexes of ten most tolerant and most susceptible teosinte derived BC_1F_2 lines

	1000 kernel weight (g)			Grain yield per plant (g)			Drought Tolerant Index (DTI)	Yield Index (YI)	Stress Tolerance Index (STI)
TL	**Mean**		**PMD**	**Mean**		**PMD**			
	N	S		N	S				
AM-39	138.70	143.80	3.68	52.00	46.00	-11.54	1.43	0.78	0.68
AM-64	124.00	161.90	30.56	40.00	36.00	-10.00	1.13	0.61	0.41
AM-16	199.00	191.70	-3.67	50.00	47.00	-6.00	1.547	0.794	0.670
AM-42	178.55	215.80	20.86	62.00	56.00	-9.68	1.772	0.946	0.990
AM-102	211.05	204.75	-2.99	92.00	70.00	-23.91	1.866	1.182	1.836
AM-178	161.00	156.10	-3.04	92.00	84.00	-8.70	2.686	1.418	2.204
AM-115	188.00	194.95	3.70	96.00	72.00	-25.00	1.891	1.216	1.971
AM-138	177.25	196.50	10.86	90.00	60.00	-33.33	1.401	1.013	1.540
AM-83	188.00	174.45	-7.21	52.00	48.00	-7.69	1.552	0.811	0.712
AM-99	171.85	144.70	-15.80	84.00	50.00	-40.48	1.042	0.844	1.198
SL									
AM-116	141.15	115.70	-18.03	80.00	6.00	-92.50	0.02	0.10	0.14
AM-193	171.85	125.90	-26.74	32.00	2.00	-93.75	0.004	0.034	0.018
AM-18	147.70	137.31	-7.03	40.00	10.00	-75.00	0.088	0.169	0.114
AM-90	150.40	119.35	-20.64	60.00	12.00	-80.00	0.084	0.203	0.205
AM-137	129.00	95.95	-25.62	24.00	12.00	-50.00	0.210	0.203	0.082
AM-100	151.20	94.20	-37.70	50.00	14.00	-72.00	0.137	0.236	0.200
AM-92	141.90	123.79	-12.76	46.67	10.00	-78.57	0.075	0.169	0.133
AM-71	153.00	150.00	-1.96	62.50	12.00	-80.80	0.081	0.203	0.214
AM-184	140.00	156.50	11.79	80.00	10.00	-87.50	0.044	0.169	0.228
AM-53	143.15	122.84	-14.19	48.00	10.00	-79.17	0.073	0.169	0.137

TL: Tolerant line SL: Susceptible line N: Normal S: Stress

least score of thirty-four. Our findings were also at par with the results of Shadakshari and Shantakumar (2014) who screened inbred lines under water stress condition. Fifteen inbreds viz., DMIL 101, DMIL103, DMIL112, DMIL117, DMIL122, DMIL125, DMIL129, DMIL130, DMIL136, DMIL140, DMIL145, DMIL147, DMIL150, DMIL152 and DMIL160 were exhibiting superior performance for various morpho-physiological traits and identified as drought tolerant inbreds, whereas, inbreds *viz*., DMIL480, DMIL492, DMIL493, DMIL510 and DMIL518 recorded the maximum ASI, drought susceptibility index and leaf senescence under water stress condition. Based on secondary traits and stress indices, the hybrids RML-4/RML-17, RML-32/RML-17, RML-8/RML-17, and RML-32/RL-111 were found to be more tolerant compared with other hybrids (Parajuli *et al*., 2018). The identification of promising drought tolerant line is an essence of a breeding program. We found several drought tolerant lines in our investigation and similar findings were reported by Wattoo *et al*. (2018) in his population and found significant variation in maize genotypes for drought tolerance.

Conclusion

Maize is highly cross pollinated crop Because of the monoecious plant habit and protandrous nature. It is more sensitive to abiotic stresses, particularly drought stress and water logging stress during the growing season, specific to the reproductive stage. Exploitation of teosinte as a genetic resource for biotic and abiotic stresses becoming a burning area of research in the recent years through wide hybridization. Therefore, teosinte derived maize lines were evaluated to identify the drought tolerant lines. It was found that for anthesis silking interval in moisture stress, maximum tolerance was registered in AM- 39, AM-115, AM-83 and AM-18. Whereas, the least tolerance was exhibited by AM-193 and AM-92. For 75 per cent days to senescence the highest tolerance to water stress was shown by line AM-193, AM-116 and AM-53, while, the lowest was

Table 4. Ranking of ten most tolerant and most susceptible lines of teosinte derived BC_1F_2 maize lines

Tolerant line	Anthesis silking interval (ASI)	Days to 75 per cent senescence	Canopy temperature depression (CTD)	Chlorophyll Content	Ear length (cm)	Ear diameter (cm)	Kernel row per ear	Kernels per row	Grain yield per Plant (g)	1000 kernel weight (g)	Drought tolerance index (DTI)	Yield index (YI)	Stress tolerance index (STI)	Total Score
AM-39	10	8	3	6	10	10	9	8	10	7	10	9	8	108
AM-64	4	7	6	8	10	10	8	10	10	10	9	8	6	106
AM-16	5	9	1	8	10	10	10	10	10	6	10	9	7	105
AM-42	7	3	2	3	10	10	10	10	10	10	10	10	9	104
AM-102	7	1	9	10	8	10	7	7	9	6	10	10	10	104
AM-178	5	8	8	7	8	5	6	10	10	6	10	10	10	103
AM-115	10	1	6	7	9	9	7	7	9	7	10	10	10	102
AM-138	7	4	10	7	6	7	9	6	8	8	10	10	10	102
AM-83	10	1	5	7	10	7	8	10	10	5	10	9	8	100
AM-99	7	6	8	8	10	9	6	8	7	3	9	9	10	100
Susceptible Line														
AM-116	3	10	6	2	3	1	1	1	1	2	1	1	2	34
AM-193	1	10	6	2	3	2	7	2	1	1	1	1	1	38
AM-18	10	5	1	5	1	1	1	1	2	5	2	2	2	38
AM-90	9	3	5	7	1	1	1	1	2	2	2	2	3	39
AM-137	5	6	5	7	2	1	1	1	5	1	3	2	1	40
AM-100	8	5	7	4	1	1	1	1	3	1	2	3	3	40
AM-92	1	6	9	3	1	4	3	2	2	4	2	1	2	40
AM-71	4	1	8	3	3	3	1	3	1	6	2	2	3	40
AM-184	4	5	2	5	2	5	2	1	1	9	1	1	3	41
AM-53	1	10	3	8	1	6	1	1	2	3	1	2	2	41

found in AM-71, AM-83, AM-115 and AM-102. Overall sum of rank scores over thirteen traits associated with drought tolerance revealed that AM-39 was most drought tolerant genotype among all the 203 lines under study with total score of one hundred eight, followed by AM-64, AM-16, AM-42, and AM-102, whereas, AM-116 was the most susceptible with the least score of thirty four. Adaptation of wild allele is important to combat the abiotic stresses in maize and these alleles can further help in broadening the genetic base.

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