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Evaluation of maize inbred lines for drought tolerance under contrasting soil moisture regimes

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Abstract: Drought, one of the major abiotic stress factor that severely limit grain yield production, often causing extensive economic loss to agriculture. Improving drought tolerance in maize has become one of the top priorities in maize breeding programs. Identification of maize germplasm with superior drought tolerance is an essential and prerequisite for such propose. One hundred maize inbred lines were evaluated under field conditions and 15 inbred lines were identified *viz.,* DMIL101, DMIL103, DMIL112, DMIL117, DMIL122, DMIL125, DMIL129, DMIL130, DMIL136, DMIL140, DMIL145, DMIL147, DMIL150, DMIL152 and DMIL160 that showed high tolerance to drought. Tolerant inbred lines were able to maintain shorter anthesis-silking interval (ASI), low canopy temperature, lower drought susceptibility index (DSI), higher chlorophyll content and comparatively higher grain yield when subjected to drought stress. Whereas, inbred lines *viz.,* DMIL270, DMIL273 and DMIL431 showed wider ASI and recorded lowest grain yield among the inbred lines under water stress situation. Drought tolerant inbred lines identified in this study could be utilized for future breeding programme for the development of drought tolerant maize hybrids. Potential use of these lines to produce maize hybrids that are able to alleviate the negative impacts of drought on growth and development of maize plants is underway.

Key words: Anthesis to silking interval, Drought, Drought susceptibility index, Grain yield, Inbred lines

Introduction

Maize (*Zea mays* L.) is most important crop in global agriculture and ranks third next to wheat and rice in terms of production. Maize is physiologically more efficient, has higher grain yield potential and wider adaptation over a range of environmental conditions. Maize is a principal source of carbohydrates and proteins and is on par with other cereals in its other nutritional qualities. It has diversified uses as food, feed and as raw material for various industrial products. It has also become a key resource for industrial applications and bio energy production. In 2020, demand for maize in developing countries is expected to exceed 500 mt and will surpass the demand for both rice and wheat (Pingali and Heisey, 2001).

Maize is highly productive under optimal environmental and crop management conditions. However, maize plants are also very susceptible to abiotic stresses particularly, drought and heat; each year, an average of 15 to 20 per cent of the potential world maize production is lost due to these stresses (Lobell *et al.,* 2011). It is anticipated that the negative impacts of abiotic stresses on agricultural production are likely to be more in future. Now-a-days, climatic change adversely affect distribution pattern of rainfall, that will result in poor and scanty rainfall in one area and heavy rainfall in other area causing severe water deficit. Occurrence of drought is unpredictable, it can occur at any stage of the crop. Drought occurring between two weeks before and after the silking stage can cause significant yield loss to an extent of 20 to 50 per cent (Nielson, 2007).

To mitigate these effects, comprehensive and fully integrated approaches needed to sustain and enhance agricul-tural productivity in future. Soil conservation and water manage-ment practices can enhance the efficiency of agricultural water use and the control of soil erosion (Delgado *et al.,* 2007), but development of stress tolerant plant varieties will play more important role (Tester and Langridge, 2010). Identification and characterization of variations for drought tolerance in maize germplasm is a first and foremost step in devel-oping drought tolerant maize hybrids (Chen *et al.,* 2012). In this context, field experiments were conducted to screen 100 inbred lines for drought tolerance.

Material and methods

In the present investigation, 100 inbred lines received from Maize Scheme, University of Agricultural Sciences, Dharwad were utilized in the present study. These inbred lines included diverse genetic base and derived from CIMMYT, Mexico and IIMR, New Delhi and others were derived from popular public/ private hybrids (Table 1). These diverse inbred lines were evaluated for drought tolerance by following two factorial randomized block design with two replications under normal (without stress) and stress conditions. Hot and dry environments during the growing season are ideal for field evaluation of drought stress tolerance in maize. The weather data during the crop growth period till physiological maturity indicated that there were virtually no rains from December to March, thus facilitating a good evaluation for drought stress. Each entry was grown at a spacing of 60 x 30 cm with a row length of 4 m. Two seeds were dibbled per hill and later thinned to retain one seedling per hill. The genotypes under normal conditions were given recommended cultural practices besides regular irrigation (furrow) at an interval of 10-12 days to avoid water stress. In stress situation also, the same set of genotypes were given same recommended cultural practices but irrigation was withheld from 40 days after sowing till harvest so that they should experience moisture stress during flowering and grain filling period. The irrigated and managed stress experiments were separated by a four meter buffer zone of maize crop.

Table1. List of inbred lines used for drought screening study

S.No.	Inbreds	Pedigree / source population	S.No.	Inbreds	Pedigree / source population
1	DMIL101	CML337*CML338-X-X-X-3	51	DMIL339	DMWNY4197-2-3
2	DMIL210	CML337*CML338-X-X-X-5	52	DMIL343	DMWQPMY4256-1-2-3-4
3	DMIL215	CML337*CML338-X-X-X-11	53	DMIL140	DMWSCY4259-2-4-1
4	DMIL103	CML430*CML338-X-X-X-4	54	DMIL347	DMWQPMY4261-3-4-1
5	DMIL218	CML430*CML338-X-X-X-8	55	DMIL349	DMWHOY4321-1-3-1
6	DMIL112	CML430*CML338-X-X-X-14	56	DMIL350	DMWY5775-3-6-7
7	DMIL221	CML411*CML468-X-X-X-4	57	DMIL356	DMWY7381-1-4
8	DMIL224	CML411*CML468-X-X-X-10	58	DMIL359	DMWY6025-2-4-3-4
9	DMIL230	CML411*CML468-X-X-X-17	59	DMIL364	DMWY6013-1-3-12-
10	DMIL233	NK6240*CML412-X-X-X-4	60	DMIL366	DMWY6025-2-9-11
11	DMIL235	NK6240*CML412-X-X-X-5	61	DMIL368	DMWY8968-5-8-9-4-
12	DMIL237	NK6240*CML412-X-X-X-8	62	DMIL374	CM123*CM142-2-3-5-11
13	DMIL240	NK6240*CML451-X-X-X-8	63	DMIL380	CM213*CM21-1-3-10-38
14	DMIL117	NK6240*CML451-X-X-X-13	64	DMIL382	CM136*CM111-1-4-7-42
15	DMIL242	NK6240*CML451-X-X-X-20	65	DMIL386	CM115*P1-1-2-6-101
16	DMIL244	NK6240 * NE1412004 -X-X-X-3	66	DMIL389	CM205*P5-1-4-7-121
17	DMIL245	NK6240 * NE1412004 - X-X-X-5	67	DMIL395	CM215*CM201-1-2-6-142
18	DMIL247	NK6240 * NE1412004 - X-X-X-11	68	DMIL401	CM203*P2-5-6-8-149
19	DMIL250	900GOLD * NE1412004-X-X-X-2	69	DMIL408	CML432*CML425-2-4-8-3
20	DMIL252	900GOLD * NE1412004-X-X-X-14	70	DMIL412	CML450*CML415-4-8-5
21	DMIL122	900GOLD * NE1412004-X-X-X-18	71	DMIL418	CML422*CML161-3-5-9-6
22	DMIL255	NS*052030-X-X-X-X-5	72	DMIL431	CML422*CML435-1-4-5-7
23	DMIL257	NS*052030-X-X-X-X-7	73	DMIL435	CML412*CML445-2-3-5-4
24	DMIL260	NS*052030-X-X-X-X-13	74	DMIL439	CML332*CML325-6-5-20
25	DMIL125	KS*4901-X-X-X-X-6	75	DMIL441	CML422*CML429-2-3-1
26	DMIL262	KS*4901-X-X-X-X-10	76	DMIL445	D9081-5-4-7-18
27	DMIL264	KS*4901-X-X-X-X-11	77	DMIL449	(K244)-1-5-4-47
28	DMIL265	KI32*KI50-X-X-X-2	78	DMIL455	VA-2-3-65
29	DMIL266	KI32*KI50-X-X-X-4	79	DMIL460	S-NK30-6-8-7-112
30	DMIL270	KI32*KI50-X-X-X-21	80	DMIL463	DMH8255-6-8-4-42
31	DMIL273	NK6240*KI21-X-X-X-4	81	DMIL466	25K60-5-1-4-139
32	DMIL275	NK6240*KI21-X-X-X-10	82	DMIL145	M-IG8011-6-2-4-147
33	DMIL280	NK6240*KI21-X-X-X-11	83	DMIL469	NK-61-6-3-22
34	DMIL283	NK6240*KI45-X-X-X-5	84	DMIL147	CLQ-RCYQ12-B-B-B
35	DMIL286	NK6240*KI45-X-X-X-7	85	DMIL150	25K55-3-9-7-55
36	DMIL288	NK6240*KI45-X-X-X-11	86	DMIL152	DMH8255-4-2-6-52
37	DMIL292	30V92*KI32-X-X-X-4	87	DMIL475	900M-2-3-1
38	DMIL296	30V92*KI32-X-X-X-12	88	DMIL480	NK6240-6-4-2-2
39	DMIL297	30V92*KI32-X-X-X-15	89	DMIL485	BIO6891-6-5-3
40	DMIL301	30V92*KI45-X-X-X-6	90	DMIL160	CML146/CML176)-B-29-1-1
41	DMIL129	30V92*KI45-X-X-X-11	91	DMIL489	DMH8255-3-4-8-41
42	DMIL308	30V92*KI45-X-X-X-17	92	DMIL492	NK6240-6-4-3-6
43	DMIL130	PINNACLE*KI32-X-X-X-7	93	DMIL493	NK6240-6-7-2-7
44	DMIL136	PINNACLE*KI32-X-X-X-14	94	DMIL497	NK6240-6-8-15-8
45	DMIL314	PINNACLE*KI32-X-X-X-18	95	DMIL499	900M-8-9-12-9
46	DMIL318	NK6240*CML412-X-X-X-1-2	96	DMIL501	900M-9-11-10
47	DMIL322	NK6240*CML412-X-X-X-5-6-7	97	DMIL504	NK6240-6-4-2-2
48	DMIL326	NK6240*CML412-X-X-X-10-12	98	DMIL510	NK6240-6-9-12-12
49	DMIL330	DMWNY4183-1-3-4-5	99	DMIL516	NK6240-6-8-12-13
50	DMIL335	DMWNY4195-2-3-4	100	DMIL518	900M-5-8-6-14

The traits *viz.,* plant height (cm), anthesis to silking Interval, cob height (cm), cob length (cm), cob girth (cm), number of kernel rows per cob, number of kernels per row, test weight (g) and chlorophyll content (mg cm^{-2}) were recorded on five randomly selected competitive plants per replication per inbred line under both normal and stress conditions. The mean of five plants observations were computed for statistical analysis. The traits *viz.,* days to 50 per cent anthesis, days to 50 per cent silking, days to 75 per cent brown husk and grain yield per plot (later expressed as kg ha^{-1}) were recorded on plot basis. Anthesis to silking interval was computed as the difference between silking and anthesis dates. Drought susceptibility index (DSI) was computed as suggested by Fisher and Maurer (1978). The chlorophyll content of the third leaf from the top was measured at 60 DAS on five random leaves using SPAD chlorophyll meter (SPAD-502, Konica Minolta make) in both normal and stress conditions. Canopy temperature was measured from top five leaves at 11.00 am to 12.00 noon using Infrared Thermometer in both normal and stress conditions. Analysis of variance for individual characters was carried out on the basis of mean value of the genotype per replication.

Results and discussion

Drought is a complex trait, expression of which depends on action and interaction of different morpho-physiological and biochemical reactions. The analysis of variance revealed that variation due to moisture stress was significant for all the traits. Similarly, variation due to genotypes and interaction between stress and genotypes was also significant for all the traits including grain yield. Significant effect of moisture stress was observed in almost all the traits studied however, moisture stress increased significantly the days required to 50 per cent silking, ASI and canopy temperature (Table 2). These results are similar to the findings of Kuchanur *et al.* (2013). The relative performance of inbred lines for drought related traits and in turn grain yield will give an idea of drought tolerance ability of the genotype. The performance promising drought tolerant maize inbred lines under normal and stress conditions are presented in Table 3. The inbred lines *viz.*, DMIL136 (50.6 days), DMIL221 (51.0 days), DMIL262 (51.5 days), DMIL275 (53.0 days) and DMIL125 (53.3 days) showed the early flowering under water stress conditions and exhibited drought escape mechanism. Drought escape allows the plant to complete its life cycle during the period of sufficient water supply before the onset of drought.

The effect of moisture stress on morphological traits was drastic and significantly reduced the expression of many traits but significantly increased days to silking and ASI. The inbred lines *viz.,* DMIL101 (3.5 days), DMIL210 (2.6 days), DMIL112 (3.0 days), DMIL125 (3.0 days), DMIL117 (3.3 days), DMIL122 (3.8 days), DMIL145 (3.5 days) and DMIL150 (3.4 days) showed shorter ASI under water stress conditions. Therefore, these lines could be effectively utilized for developing maize hybrids suitable for drought/rainfed conditions. However, inbred lines *viz.,* DMIL270 (14.5 days), DMIL273 (15.0 days), DMIL431 (13.0 days) showed wider ASI coupled with low grain yield under water stress which clearly indicated that these genotypes were very much susceptible to water stress conditions. These findings are similar to the report of Meena Kumari *et al.* (2004) who suggested that under severe stress, the anthesis-silking interval ranged from 3-5 days in drought tolerant inbreds whereas 9-17 days in drought sensitive inbreds.

In the present findings, reduction in the plant height and cob height was observed in all the inbred lines. Ahsan *et al.* (2011) also observed the reduction in the shoot length in S_1 maize families during water stress condition. The inbreds *viz.,* DMIL112 (188.2 cm), DMIL130 (185.1 cm), DMIL145 (183.9 cm) and DMIL117 (181.2 cm) recorded highest plant height, whereas DMIL136 (117.5 cm), DMIL339 (109.9 cm) and DMIL335 (107.0 cm) exhibited maximum cob height under stress condition. Inbred lines *viz.,* DMIL112 (29.4 g), DMIL136 (29.5 g), DMIL122 (32.0 g) and DMIL103 (29.2 g) recorded maximum hundred seed weight under water stress conditions and can be employed in maize breeding programme for developing drought tolerant hybrids.

Among the morpho-physiological traits studied, grain yield showed maximum reduction per cent due to water stress. Inbred lines *viz.,* DMIL101 (3755 kg/ha), DMIL103 (3525 kg/ha), DMIL112 (3850 kg/ha), DMIL117 (4382.5 kg/ha), DMIL122 (4045 kg/ha), DMIL125 (3972.5 kg/ha), DMIL129 (3750 kg/ha), DMIL130 (3902.5 kg/ha), DMIL136 (3827.5 kg/ha), DMIL140 (4085 kg/ha), DMIL145 (3592.5 kg/ha), DMIL147 (3720 kg/ha), DMIL150 (3517.5 kg/ha), DMIL152 (3567.5 kg/ha) and DMIL160 (4352.5 kg/ha) produced highest grain yield under water stress conditions and exhibited lowest drought susceptibility index. These inbred lines could be used as parents for developing drought tolerant single cross hybrids. Hossien *et al.* (2013) indicated that plant height, cob leaf area, tassel weight and thereby grain yield per ha decreased under water limitation at grain filling stage.

Meena Kumari *et al.* (2004) reported that chlorophyll content and stability index decreased under drought stress. The similar results are also observed in the present study but DMIL140

Table 2. Mean sum of squares and effect of moisture stress on morpho-physiological traits, grain yield and its components traits

Traits	Mean sum of square				Effect of moisture stress			
	Normal / Stress	Genotypes	Interaction	Error	Normal	Stress	Difference	CD at 5 %
Days to 50 per cent Anthesis	679.124**	76.571**	10.459**	3.84	64.0	61.4	2.6*	0.18
Days to 50 per cent silking	3840.281**	128.121**	35.169**	6.32	66.1	72.3	-6.2*	0.22
Anthesis to silking interval	7649.281**	33.481**	34.517**	1.22	2.1	9.5	-7.4*	0.21
Days 75 per cent brown husk	7204.614**	59.440**	22.472*	7.69	111.1	102.7	8.4*	0.37
Plant height (cm)	70883.738**	1857.889**	337.944*	75.66	167.7	141.6	26.1*	0.55
Cob height (cm)	23786.584**	760.664**	187.188*	30.87	88.9	73.5	15.4*	1.09
Cob length (cm)	711.289**	27.212**	5.428*	2.50	16.6	13.9	2.7*	0.24
Cob girth (cm)	376.748**	9.913**	2.427	1.90	13.8	11.8	2.0*	0.18
Number of kernel rows per cob	1048.141**	12.894**	4.926	1.93	14.5	11.3	3.2*	0.27
Number of kernels per row	5526.436**	146.193**	32.983*	6.83	27.2	19.8	7.4*	0.38
Test weight (g)	5742.608**	103.312**	33.899*	3.58	25.6	18.0	7.6*	0.28
Grain yield (kg/ha)	255532213.891**	3224474.857**	854430.557**	32787.28	3707.7	2109.1	1598.6*	35.70
Chlorophyll content (mg cm^{-2})	1128.624**	183.910**	118.580*	3.23	48.0	37.1	10.9*	0.11
Canopy temperature (° C)	380.444**	38.97**	15.131*	2.56	29.9	34.5	-4.6*	0.13

* and ** significance at 0.05 and 0.01 level of probability, respectively.

Table 3. Promising drought tolerant maize inbred lines identified from the study

Inbred lines	Days to 50 % anthesis		Anthesis to silking interval (days)		Plant height (cm)		Cob height (cm)		Test weight (g)		Grain yield (kg/ha)		Chlorophyll content (mg cm^{-2})		Canopy temperature (°C)		Drought suscepti-bility index
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	
DMIL101	57.3	56.0	2.8	3.5	177.7	167.2	80.5	77.8	29.9	22.4	4535.0	3755.0	57.9	46.9	26.6	28.8	0.61
DMIL103	63.0	61.1	2.5	3.8	185.4	170.5	121.5	86.5	29.8	29.2	4297.5	3525.0	50.9	50.0	28.4	31.4	0.64
DMIL112	63.0	62.5	2.5	3.0	193.9	188.2	122.0	106.6	31.7	29.4	4427.5	3850.0	43.9	41.3	30.6	27.8	0.46
DMIL117	63.0	61.3	2.0	3.3	194.7	181.2	97.1	94.7	27.3	25.5	4647.5	4382.5	41.9	40.0	30.0	32.6	0.20
DMIL122	62.8	59.7	1.8	3.8	165.1	142.0	80.7	61.6	35.8	32.0	4410.0	4045.0	52.9	48.8	29.1	33.1	0.30
DMIL125	60.0	53.3	2.0	3.1	179.9	176.7	102.9	94.1	21.9	16.9	4592.5	3972.5	52.0	47.5	32.1	32.4	0.48
DMIL129	61.8	55.5	3.3	4.0	184.0	175.6	79.6	55.0	28.5	28.6	4297.5	3750.0	45.1	39.1	31.5	32.0	0.45
DMIL130	61.5	58.2	1.5	4.3	190.7	185.1	86.2	84.4	25.9	21.9	4495.0	3902.5	55.0	44.9	26.4	28.5	0.46
DMIL136	56.0	50.6	1.5	4.4	180.1	168.5	123.0	117.5	29.3	29.5	4395.0	3827.5	51.0	43.1	30.2	31.9	0.46
DMIL140	63.8	61.6	1.8	4.1	192.9	173.1	109.5	81.5	31.7	27.3	4645.0	4085.0	58.1	53.3	30.1	31.9	0.43
DMIL145	62.0	60.5	3.0	3.5	193.2	183.9	110.9	99.4	25.7	25.1	4752.5	3592.5	51.7	42.3	23.4	29.9	0.87
DMIL147	59.8	56.0	1.8	4.9	191.4	174.0	66.6	60.5	28.7	12.1	4360.0	3720.0	49.8	42.0	27.9	28.3	0.52
DMIL150	58.5	60.2	3.5	3.5	185.1	170.5	121.9	89.7	33.6	22.1	4255.0	3517.5	51.8	47.5	24.4	27.2	0.61
DMIL152	60.5	61.0	3.5	4.8	200.2	170.6	115.2	99.1	25.5	23.1	3992.5	3567.5	51.8	44.0	28.4	30.0	0.38
DMIL160	62.0	57.7	2.0	4.0	198.3	179.7	101.2	94.7	30.2	19.6	4552.5	4352.5	51.8	47.1	29.1	26.9	0.43
DMIL221	60.0	51.0	1.5	14.5	177.5	175.4	91.0	89.1	22.3	12.2	3892.5	2387.5	41.9	27.5	34.0	43.8	1.38
DMIL242	60.8	60.0	1.8	12.5	164.4	130.0	77.0	64.1	26.0	23.6	4100.0	3617.5	50.9	49.1	31.7	38.2	0.42
DMIL262	59.3	51.5	3.3	11.2	196.5	139.8	102.7	96.6	20.7	22.4	4302.5	1402.5	49.7	39.5	31.0	36.9	2.41
DMIL270	67.3	67.5	2.3	14.5	169.9	142.4	84.2	73.5	27.9	16.3	4155.0	1205.0	49.9	26.6	32.2	40.5	2.53
DMIL273	63.0	55.2	2.5	15.0	142.4	136.5	76.1	72.4	66.0	17.6	3952.5	2855.0	53.0	43.0	30.8	36.8	0.99
DMIL275	62.5	53.0	2.5	8.0	147.9	100.2	72.4	68.7	22.2	16.5	2035.0	570.0	40.0	29.1	29.9	35.2	2.56
DMIL335	63.0	61.0	2.0	11.5	192.0	180.1	115.6	107.0	21.4	16.5	3850.0	2595.0	59.3	28.0	29.5	34.0	1.16
DMIL339	60.8	59.8	1.8	7.2	188.5	162.8	110.8	109.9	22.0	11.4	4130.3	2995.0	46.9	35.0	27.9	38.0	0.96
DMIL374	61.5	60.2	2.5	7.3	167.4	150.5	87.6	70.1	28.3	19.8	3802.5	2695.0	51.9	34.0	29.1	32.4	1.04
DMIL431	66.3	63.1	1.3	13.0	146.5	144.0	66.5	57.2	29.5	12.5	3720.0	727.5	44.9	40.9	30.2	33.9	2.89
DMIL460	61.8	58.5	1.8	6.1	166.5	153.0	81.8	73.4	24.2	22.3	4227.5	2792.5	51.0	31.1	27.2	29.6	1.21
DMIL475	67.0	65.0	5.5	11.0	177.2	131.1	113.9	70.4	21.8	20.2	3617.5	2202.5	45.9	35.6	29.1	28.0	1.40
DMIL485	59.8	54.5	1.8	8.2	167.5	160.7	74.4	67.4	31.6	21.4	4070.0	3001.3	45.9	34.2	30.0	27.0	0.94
Mean	64.0	61.4	2.2	9.6	167.7	141.1	88.8	73.4	25.6	18.0	3707.7	2109.1	48.0	37.1	29.9	34.5	1.60
S.E.(d)	0.81	1.23	0.77	1.20	2.49	3.10	3.15	7.22	1.24	1.04	206.3	147.84	2.32	1.18	1.71	1.57	0.15
C.D. at 5%	1.61	2.45	1.52	2.38	4.94	6.16	6.26	14.32	2.46	2.06	409.34	293.55	4.60	2.34	3.40	2.48	0.29
C.D. at 1%	2.13	3.24	2.01	3.15	6.53	8.15	8.28	18.96	3.26	2.72	541.83	388.30	6.09	3.10	4.49	3.29	0.39

Table 4. Mean reduction (%) of morpho-physiological traits due to water stress

Traits	Normal	Stress	Mean reduction (%)
Days to 50 per cent Anthesis	64.00	61.40	4.10
Days to 50 per cent silking	66.10	72.30	-9.40
Anthesis to silking Interval	2.10	9.50	-78.90
Days 75 per cent brown husk	111.10	102.70	7.60
Plant height (cm)	167.70	141.60	15.60
Cob height (cm)	88.90	73.50	17.30
Cob length (cm)	16.60	13.90	16.30
Cob girth (cm)	13.80	11.80	14.50
Number of kernel rows per cob	14.50	11.30	22.10
Number of kernels per row	27.20	19.80	27.20
Test weight (g)	25.60	18.00	29.70
Grain yield (kg/ha)	3707.70	2109.10	43.10
Chlorophyll content (mg cm^{-2})	48.00	37.10	22.70
Canopy temperature (°C)	29.90	34.50	-15.40

(53.3 mg cm^{-2}), DMIL103 (50.0 mg cm^{-2}) and DMIL242 (49.1 mg cm^{-2}) recorded the maximum chlorophyll content under water stress condition and these could be utilized for development of maize genotypes with enhanced chlorophyll content during drought conditions. The present study also revealed that increase in canopy temperature under stress when compared to normal conditions. However, inbred lines *viz.,* DMIL160 (26.9°C), DMIL485 (27.0°C), DMIL150 (27.2°C), DMIL112 (27.8 °C) and DMIL475 (28.0°C) showed the minimum canopy temperature under stress conditions. The effect of stress is not uniform at all the stages of plant and its effect on various morphological traits depends not only on the magnitude but also on the physiological stage at which it occurs. Present study revealed that the traits grain yield (43.10%) showed maximum reduction per cent followed by test weight (29.70%) and number of kernels per row (27.20%) and minimum reduction per cent was observed in days to 50 per cent anthesis (4.10%) followed by days to 75 per cent brown husk (7.61%) (Table 4).

Maize is widely regarded to be more susceptible to drought at flowering than other rainfed crops. This is due to a combination of several factors including physical separation of male and female flowers, floral asynchrony, non receptivity of silk, tassel blasting, trapped anther and embryo abortion (Lu *et al.,* 2011). Breeding for drought tolerant hybrids is a feasible strategy to increase/sustain yield levels under challenging environments. Identification of inbred lines with superior stress tolerant trait(s) is prerequisites for the success of such a breeding program. This study evaluated a set of maize inbred lines for drought tolerance under field conditions and identified 15 inbred lines *viz.,* DMIL101, DMIL103, DMIL112, DMIL117, DMIL122, DMIL125, DMIL129, DMIL130, DMIL136, DMIL140, DMIL145, DMIL147, DMIL150, DMIL152 and DMIL160 based on shorter ASI, higher grain yield, chlorophyll content, lower canopy temperature and low drought susceptibility index (Table 3). These inbred lines with superior drought tolerance traits could be used as genetic materials for the breeding of drought-tolerant hybrids suitable for rainfed ecosystem and further development of drought tolerant population.

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