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Evaluating Foliar Responses of Sunflower Genotypes under Drought Stress

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ABSTRACT

As a summer crop, sunflower (*Helianthus annuus* L.) is influences commonly by drought stress due to growing generally in rain fed regions without irrigation. Drought affects severely not only seed yield both also other important yield traits which plays important roles on yield formation in sunflower. Therefore, drought resistance became one of the most important goals in the sunflower breeding programs in the world. The study was conducted to determine drought tolerance levels of sunflower genotypes under controlled environmental conditions in Edirne which is a border city in Trakya region which is European part of Turkey and has about 50% of Turkish sunflower production areas. Sunflower restores lines which developed in National Project were evaluated foliar responses against drought stress. Based on study results, the most affected foliar trait was leaf area and it was reduced until 75%. Similarly, leaf number of plants also influenced severely especially from earlier droughts and plants responded about 60% leaf number decreases. On the other hand, on the chlorophyll content of plant leaves, sunflower genotypes responded differently both in earlier (R.3) and later (R.5.1) plant growth stages. While chlorophyll content of sunflower lines increased about 40-50%, some of them decreased about 30%. Similarly, sunflower genotypes responded differently drought stress in their foliar traits depending on when stress applied early or late. As results, sunflower genotypes had different tolerance to drought and higher tolerant ones will be considered to develop tolerant hybrids and will be used as initial material for further breeding purposes.

Keywords: Environmental Conditions, SPAD, Total Stress Response Index, Drought Response Index ,Seed , crops, Drought Stress

I. INTRODUCTION

Sunflower is one the most important oil crops in the world. It grows generally in drylands so it is affected much from environmental conditions. Water stress is common factor limiting and reducing seed and oil yield especially in these rainfed and marginal regions [1]. To compete with other profitable crops in the rotation increasing hot temperature due global warming in recent years, new sunflower cultivars should be drought tolerant.

Sunflower plants protect themselves against drought stress altering some morphological, physiological or phonological responses based on genotypic capabilities. Since drought tolerance is so complex and quantitative trait, it is so difficult to improve through conventional plant breeding. Therefore, drought tolerance studies conduct generally under controlled conditions because it is not easy to understand of mechanism of drought and to define drought tolerant cultivars current environmental conditions where the occurrence because timing and severity of water stress may fluctuate from year to year [2], [3], [4].

Water deficiency lessens also net assimilation rate, dry weight of leaves, stem, and root and causes total dry weight and slow growth rate during the vegetation period in hot summer seasons. Plant responses to drought stresses involving processes at anatomical, cellular and molecular levels with resulting decreases in

plant photosynthesis too [5], [6], [7], [8], [9], [10], [11], [12].

Leaf area index is the most important growth indicator in sunflower because sunflower plants perform maximum photosynthesis with reaching the highest leaf area if there is not any stress [6]. In any water stress during these growing stages, crop growth rate could reduce because of decreasing in leaf area with falling leaves and with rapid aging of leaf especially after flowering stage [13], [14]. Especially in earlier growing period of sunflower (4 to 8 leaves), drought stress rapidly leads reduction of number and size of leaves, less leaf area index and less absorption at maturity stage, also shorter plants and lower plant dry matter. These earlier water stresses reduce leaf growth rate and leaf number among vegetative phase then it results initiating of decreases leaf area index after that [15], [16], [17]. Fereres et al. (1983) found that leaf area was decreased rapidly by drought stress and affected grain yield negatively and Goksoy et al. (2004) observed that restricted irrigations reduced leaf area due to yellowing and falling leaves too.

The chlorophyll content is one of the main indicators of plant foliage development and quantity changes could be considered for measuring of drought tolerance [18], [19]. However, when some of them indicated that the total chlorophyll content was reduced under drought conditions, especially after two weeks under water stress conditions, some of them observed increases on chlorophyll content after drought stress [20], [21].

The study was conducted to determine drought tolerance levels on foliar traits of sunflower male inbred lines developed in National Sunflower Project conducted by Trakya Agricultural Research Institute (TARI) under controlled environmental conditions in Edirne, Turkey.

II. METHODS AND MATERIAL

The study was carried out in TARI research fields with fifty male inbred lines originated different genetic sources in 2014i Tunca commercial hybrid belonging Limagrain Co were used as control selected as one of the most stabile sunflower hybrids in different environments in Turkey. Trials were conducted with RCBD with one row and three replications. In each row, there were five plants and the distance between rows was 70 cm and 30 cm in rows. Trials were planted by hand in 29 May and plants were harvested and threshed by hand in 24 September.

The rainfall and humidity in 2014 is over longer year averages while average temperatures were the same and daily rainfalls in 2014 (Table 1) and applied irrigations to put water availability for field capacity during vegetation period were given Table 2. Drip irrigation was applied and as covering rain shelters, drought stress conditions were set up like below in the experiments.

Table 1. Daily rainfalls during the study (mm)

Months and Rainfalls (R) (mm)							
5	R	6	R	7	R	8	R
31st	28,0	4th	38,7	4th	0,9	7th	11,2
		5th	6,6	5th	0,3	18th	5,6
		6th	2,2	16th	39,5		
		26th	42,2	17th	40,1		
				20th	3,0		

Table 2. Irrigation amounts applied in the experiment plots (mm)

Irrigation time	Irrigation (mm)	Irrigation time	Irrigation (mm)
10.06.2014	50	10.08.2014	75
25.06.2014	70	18.08.2014	60
10.07.2014	65	28.08.2014	60
25.07.2014	40		

Sunflower yield consist three main characters as plant per area, seeds per plant and seed weight. Consequently, if any biotic and abiotic stress in these critical stages, sunflower plants influence more or less depends on severity of stress [1]. Therefore drought stress groups were determined based on these vital periods in the study.

Stress group 1, 2 and 3 were set up in 23.06.2014, in 22.07.2014 and 04.08.2014, respectively. **Control:** All plant water requirement were supplied by drip irrigation (when field capacity reduced until 50%); **Stress group 1 (S_1):** When plants were 50 cm, **Stress group 2 (S_2):** at bud development, **Stress group 3 (S_3):** at the milky stage.

Leaf number (number/plant), leaf area (cm^2/plant), amount of chlorophyll as SPAD units at R3 and R5-1 growth stages were counted and measured with Hansatech Instruments (Chlorophyll Content Meter (CL-01).

Total Stress Response Index (TSRI) was calculated according to Singh et al. (2008) with minor modification. TSRI was calculated as the sum of drought response index (DRI) of individual plant attribute responses to the three levels of water deficit (Stress 1, 2 and 3) compared to the control. Positive or less negative value stated that more drought tolerance. DRI was calculated as:

DRI = [(RVt – RVc) / RVc] * 100;

RV = individual response variable for each measured parameter.

TSRI= DRILn + DRILa + DRIChlR3 + DRIChlR5

(Where Ln= leaf number, La= leaf area, ChlR3 and ChlR5= amounts of chlorophyll at R3 and R5-1 growth stages respectively)

III. RESULT AND DISCUSSION

It was observed that drought stress seriously affected foliar development of male sunflower lines in the study. Based on observations, drought stress effects leaf development directly while water stress prolonged. In longer drought stress (S1), leaf numbers reduced about 20-60% comparing control application in the study (Table 3). However, in lower water stresses S2 and S3 groups), these influences observed about 0-40% levels.
Leaf number was the most influenced foliar trait after leaf area. The numbered of 38, 4, 8, 39, 7, 9, 11 and 25 males lines at S1 stress application, 8, 4, 7, 9, 20, 13, 11 and 38 numbered lines at S2 and the numbered 7, 4, 8, 5, 34, 11, 38 and 14 lines at S3 stress conditions affect less from drought stress (Table 3).

Leaf areas of sunflower male inbred lines were reduced 40-70% at S1 drought stage, 10-30% S2 and S3 stress groups comparing each of lines control applications in the study. Less influenced inbred lines were number of 8, 11, 10, 39, 49, 30, 7, 50 and 9 lines at S1 group, number of 4, 12, 8, 11, 7, 49, 34, 38 and 10 lines at S2 and number of 4, 8, 7, 11, 34, 10, 12 and 38 male lines at S2 stress application (Table 4).

The chlorophyll contents of sunflower male inbred lines responded differently drought stress applications both in earlier and late plant developments in the study (Table 5 and 6).

The changes among total chlorophyll contents of lines at R5-1 growth stage were insignificant while all other observed traits were significant statistically. At R5-1 stage, while total chlorophyll contents of 14 lines at S1 group, 17 lines of them at S2 and 20 lines of contents at S3 stress group were decreased about 10-30%, other lines of content were increased about 0-50% (Table 5). On the other hand, while the decreases on in total chlorophyll contents were observed in only five lines (10-30%) at S1 group and in 6 lines (10-20%) at S2 stress application, the increases were measured about 0-50% level in other lines of total chlorophyll contents in the study (Table 5).

Based on measured data of total chlorophyll contents in R5-1 stage, the numbered of 51, 49, 27, 41, 10, 46, 40 and 32 lines at stress 1 application; 5, 4, 7, 35, 20, 51, 43, 49 and 29 numbered lines at stress 2 and the numbered 30, 21, 16, 29, 50, 23 and 49 lines at stress 3 period were less affected from these stress conditions (Table 5).

Based on measured data of total chlorophyll contents in R3 stage, the numbered of 4, 1, 7, 43, 39, 26 and 50 lines at stress; 25, 50, 27, 26, 14 and 45 lines at S2 conditions were affected less from drought stress (Table 6).

The male inbred lines were categorized based on measured parameters against drought stress conditions with calculated total stress response index (TSRI) (Figure 1 and Table 7). While the having less negative valued lines were affected less from drought stress, higher negative valued sunflower male lines were influenced more from drought stress conditions. In other words, the inbred lines having values closer to 0 were labeled as more drought tolerant lines and distant valued lines could be more susceptible (Figure 1 and Table 7).
Based on the study results, while the male inbred lines were categorized five groups, especially three of them

(10004-2 R, 70352 R and 8129 R) were noticed as significant values (as less affected from drought stress) among other lines. 70352 R and 8129 R inbred lines were observed also the highest drought lines in previous study with measured other sunflower yield traits too [23].

Table 3: The effect of drought stress on leaf numbers (number/plant) in sunflower inbred lines

#	Name of Line	Control	Stress 1	Tolerance Index (%)	Stress 2	Tolerance Index (%)	Stress 3	Tolerance Index (%)
38	TT 199 R	20,67	16,33	**79,0**	17,67	**85,5**	18,33	**88,7**
4	25712 R	19,67	15,33	**78,0**	18,67	**94,9**	18,67	**94,9**
8	70352 R	22,67	17,67	**77,9**	21,67	**95,6**	20,33	**89,7**
39	TT 205 R	25,67	19,33	**75,3**	21,33	83,1	21,00	81,8
7	6973 R	22,00	16,33	**74,2**	20,33	**92,4**	21,33	**97,0**
9	7820 R	21,67	16,00	**73,8**	19,67	**90,8**	18,67	86,2
11	8129 R	21,33	15,67	**73,4**	18,33	**85,9**	19,00	**89,1**
25	9947 R	23,33	17,00	**72,9**	18,67	80,0	19,67	84,3
1	0536 R	23,33	16,33	70,0	18,33	78,6	18,33	78,6
3	010018 R	25,33	17,33	68,4	20,67	81,6	21,33	84,2
24	9889 R	25,00	17,00	68,0	19,33	77,3	19,67	78,7
43	TT 216 R	24,33	16,33	67,1	19,33	79,5	20,00	82,2
26	9979 R	26,67	17,67	66,3	21,67	81,3	20,33	76,2
2	01001 R	24,67	16,33	66,2	19,33	78,4	21,33	86,5
40	TT 207 R	24,67	16,33	66,2	18,67	75,7	21,33	86,5
51	Tunca	28,33	18,67	65,9	23,00	81,2	23,33	82,4
14	TT 326 R	23,33	15,33	65,7	19,67	84,3	20,67	**88,6**
30	9993 R	22,33	14,67	65,7	17,00	76,1	18,33	82,1
41	TT 212 R	25,00	16,33	65,3	20,33	81,3	21,67	86,7
27	9987 R	24,00	15,67	65,3	19,00	79,2	21,00	87,5
44	TT 317 R	26,67	17,33	65,0	22,33	83,7	22,67	85,0
13	8267 R	25,67	16,67	64,9	22,33	**87,0**	21,67	84,4
5	3510 R	25,33	16,33	64,5	21,00	82,9	22,67	**89,5**
34	10004-2 R	25,33	16,33	64,5	20,67	81,6	22,67	**89,5**
21	9759 R	27,00	17,33	64,2	21,67	80,2	22,67	84,0
17	9753-1 R	21,33	13,67	64,1	15,67	73,4	15,67	73,4
42	TT 214 R	23,33	14,67	62,9	17,67	75,7	17,00	72,9
20	9758 R	26,67	16,67	62,5	23,33	**87,5**	21,33	80,0
16	9702 R	21,33	13,33	62,5	16,33	76,6	17,33	81,2
35	TT 119 R	24,67	15,33	62,2	20,67	83,8	20,33	82,4
22	9761 R	27,33	17,00	62,2	21,33	78,0	21,00	76,8
31	9997-7 R	23,67	14,67	62,0	16,67	70,4	18,00	76,1
33	10004-1 R	25,33	15,67	61,8	19,00	75,0	18,33	72,4
10	7887-1 R	22,67	14,00	61,8	16,67	73,5	18,00	79,4
50	CL 217 R	20,33	12,33	60,7	15,67	77,0	17,00	83,6
23	9786 R	23,67	14,33	60,6	17,33	73,2	17,67	74,6
12	8165 R	25,33	15,33	60,5	20,00	78,9	19,67	77,6
28	9990 R	25,33	15,33	60,5	19,67	77,6	18,67	73,7
49	98920 R	24,33	14,67	60,3	19,67	80,8	20,33	83,6
37	TT 138 R	26,00	15,67	60,3	18,67	71,8	19,67	75,6
47	K9 R SN 1	24,33	14,33	58,9	19,33	79,5	18,67	76,7
6	62301 R	28,33	16,67	58,8	19,67	69,4	24,33	85,9
29	9992 R	23,33	13,67	58,6	16,67	71,4	18,33	78,6
32	9999 R	24,67	14,33	58,1	17,67	71,6	17,67	71,6
36	TT 135 R	27,00	15,67	58,0	19,33	71,6	21,00	77,8
48	9868 R	23,00	13,00	56,5	17,33	75,4	16,67	72,5
46	TT 330 R	26,33	14,67	55,7	19,33	73,4	20,33	77,2

15	9487 R	25,33	13,67	53,9	18,33	72,4	19,67	77,6
45	TT 321 R	20,67	10,67	51,6	14,67	71,0	15,33	74,2
18	9753-2 R	22,33	10,67	47,8	14,33	64,2	15,33	68,7
19	9753-3 R	22,67	9,33	41,2	14,67	64,7	16,33	72,1
$\bar{x}$: LSD (0,01):0,61		24,18 A	15,39 C		19,02 B		19,61 B	

Table 4: The effect of drought stress on leaf area (cm^2/plant) in sunflower inbred lines

#	Name of Line	Control	Stress 1	Tolerance Index (%)	Stress 2	Tolerance Index (%)	Stress 3	Tolerance Index (%)
8	70352 R	2085,7	1351,3	**64,8**	1890,3	**90,6**	1936,4	**92,8**
11	8129 R	3900,3	2361,0	**60,5**	3366,9	**86,3**	3546,9	**90,9**
10	7887-1 R	2914,7	1761,1	**60,4**	2326,3	**79,8**	2549,3	**87,5**
39	TT 205 R	2626,0	1585,3	**60,4**	1953,3	74,4	1990,9	75,8
49	98920 R	3929,0	2345,3	**59,7**	3241,0	**82,5**	3336,5	84,9
30	9993 R	2547,7	1465,7	**57,5**	1909,8	75,0	2163,7	84,9
7	6973 R	3151,7	1748,0	**55,5**	2612,5	**82,9**	2866,8	**91,0**
50	CL 217 R	2389,3	1279,3	**53,5**	1885,0	78,9	1962,4	82,1
9	7820 R	3589,0	1909,0	**53,2**	2581,7	71,9	2698,0	75,2
38	TT 199 R	2716,7	1425,7	52,5	2170,3	**79,9**	2341,7	**86,2**
25	9947 R	2794,7	1466,3	52,5	2186,8	78,2	2271,9	81,3
41	TT 212 R	4816,3	2472,0	51,3	3452,5	71,7	3570,7	74,1
34	10004-2 R	2329,3	1173,3	50,4	1878,7	**80,7**	2092,0	**89,8**
13	8267 R	3517,0	1769,3	50,3	2634,3	74,9	2541,9	72,3
21	9759 R	3324,0	1652,7	49,7	1997,3	60,1	2125,6	63,9
51	Tunca	8563,7	4122,3	48,1	6566,7	76,7	6787,7	79,3
14	TT 326 R	3030,7	1439,3	47,5	2208,7	72,9	2353,0	77,6
44	TT 317 R	4203,0	1990,7	47,4	3158,7	75,2	3203,3	76,2
26	9979 R	3054,3	1445,3	47,3	1942,9	63,6	2089,3	68,4
1	0536 R	2829,4	1309,0	46,3	2111,1	74,6	2187,3	77,3
12	8165 R	4231,7	1949,3	46,1	3931,0	**92,9**	3671,7	**86,8**
40	TT 207 R	3186,3	1467,3	46,1	2083,3	65,4	2241,6	70,4
24	9889 R	3199,3	1404,7	43,9	1989,7	62,2	2215,2	69,2
4	25712 R	2347,3	975,3	41,6	2186,3	**93,1**	2309,7	**98,4**
45	TT 321 R	2356,0	955,7	40,6	1747,3	74,2	1830,3	77,7
16	9702 R	2279,7	904,0	39,7	1609,3	70,6	1795,9	78,8
42	TT 214 R	3075,3	1204,3	39,2	1806,9	58,8	1830,8	59,5
22	9761 R	4003,3	1552,3	38,8	2350,4	58,7	2475,1	61,8
36	TT 135 R	2848,3	1099,3	38,6	1573,1	55,2	1847,3	64,9
20	9758 R	4136,3	1574,7	38,1	2872,6	69,4	2832,9	68,5
23	9786 R	3764,3	1431,0	38,0	2305,9	61,3	2316,2	61,5
48	9868 R	3174,3	1194,7	37,6	1929,9	60,8	2010,1	63,3
33	10004-1 R	2812,7	1033,3	36,7	1758,1	62,5	1807,8	64,3
6	62301 R	3019,3	1106,0	36,6	1549,4	51,3	2247,2	74,4
28	9990 R	3823,3	1378,7	36,1	2381,0	62,3	2404,3	62,9
29	9992 R	3819,3	1329,0	34,8	1968,1	51,5	2070,6	54,2
47	K9 R SN 1	6510,0	2213,0	34,0	3668,9	56,4	3574,4	54,9
17	9753-1 R	2067,7	700,3	33,9	1250,7	60,5	1258,3	60,9
32	9999 R	2702,3	903,0	33,4	1682,5	62,3	1757,3	65,0
31	9997-7 R	3677,7	1223,7	33,3	1745,2	47,5	1882,7	51,2
37	TT 138 R	2492,0	822,7	33,0	1430,3	57,4	1470,3	59,0
46	TT 330 R	2169,3	696,7	32,1	1249,3	57,6	1312,7	60,5
2	01001 R	2598,7	792,9	30,5	1476,4	56,8	1832,3	70,5
5	3510 R	3624,7	1087,0	30,0	2294,3	63,3	2816,0	77,7
43	TT 216 R	2869,3	853,3	29,7	1530,3	53,3	1647,1	57,4
35	TT 119 R	3579,0	1052,3	29,4	1786,3	49,9	1845,0	51,6
27	9987 R	4819,7	1394,0	28,9	2382,1	49,4	2631,9	54,6

19	9753-3 R	1830,3	522,7	28,6	1330,0	72,7	1417,0	77,4
18	9753-2 R	1820,7	506,0	27,8	1067,7	58,6	1429,7	78,5
3	010018 R	3807,0	982,3	25,8	2511,7	66,0	2664,7	70,0
$\bar{x}$: LSD (0,01):152,4		3303,4 A	1403,1 C		2226,0 B		2357,3 B	

Table 5: The effect of drought stress on chlorophyll amount at R5-1 growth stage in sunflower

#	Name of Line	Control	Stress 1	Tolerance Index (%)	Stress 2	Tolerance Index (%)	Stress 3	Tolerance Index (%)
47	K9 R SN 1	13,93	20,37	146,2	17,34	124,4	16,79	120,5
11	8129 R	13,93	18,90	135,6	16,67	119,6	15,30	109,8
34	10004-2 R	11,77	15,03	127,7	14,16	120,3	14,91	126,7
36	TT 135 R	19,30	23,63	122,5	21,13	109,5	21,00	108,8
2	01001 R	16,20	19,67	121,4	18,28	112,8	17,84	110,1
16	9702 R	12,97	15,20	117,2	14,59	112,5	13,03	**100,5**
13	8267 R	10,91	12,67	116,1	12,02	110,1	12,01	110,1
15	9487 R	14,73	16,73	113,6	16,38	111,2	15,31	103,9
9	7820 R	12,04	13,63	113,2	13,21	109,7	13,60	112,9
14	TT 326 R	14,73	16,63	112,9	15,87	107,7	14,99	101,7
8	70352 R	15,77	17,73	112,5	16,55	104,9	16,62	105,4
22	9761 R	12,90	14,30	110,8	13,94	108,0	12,37	95,9
31	9997-7 R	15,53	17,18	110,6	16,45	105,9	15,78	101,6
23	9786 R	13,20	14,59	110,5	14,03	106,3	13,10	**99,2**
30	9993 R	13,73	15,14	110,2	15,13	110,2	13,93	**101,4**
29	9992 R	18,70	20,60	110,1	19,15	**102,4**	18,71	**100,1**
1	0536 R	10,65	11,69	109,8	11,67	109,5	12,18	114,4
48	9868 R	15,07	16,55	109,8	15,89	105,5	16,17	107,3
20	9758 R	14,97	16,37	109,4	14,70	**98,2**	15,24	101,8
21	9759 R	16,50	18,01	109,2	17,23	104,4	16,68	**101,1**
50	CL 217 R	20,53	22,40	109,1	21,30	103,8	20,49	**99,8**
3	010018 R	12,27	13,23	107,9	13,75	112,1	13,13	107,0
35	TT 119 R	15,37	16,53	107,6	15,27	**99,3**	15,73	102,4
12	8165 R	17,07	18,31	107,3	18,27	107,0	16,28	95,4
5	3510 R	15,80	16,88	106,8	15,80	**100,0**	15,03	95,1
37	TT 138 R	18,17	19,31	106,3	18,75	103,2	17,83	98,2
28	9990 R	16,03	16,94	105,6	15,44	96,3	14,68	91,6
7	6973 R	16,03	16,83	105,0	16,29	**101,6**	15,31	95,5
51	Tunca	14,27	14,59	**102,2**	13,97	**97,9**	13,88	97,3
49	98920 R	12,20	12,40	**101,6**	12,47	**102,2**	12,06	**98,9**
27	9987 R	12,80	12,57	**98,2**	12,08	94,3	12,31	96,2
41	TT 212 R	11,30	11,05	**97,8**	10,84	96,0	9,57	84,7
10	7887-1 R	17,43	16,94	**97,2**	15,18	87,1	16,30	93,5
46	TT 330 R	12,70	12,33	**97,1**	11,94	94,0	11,47	90,3
40	TT 207 R	9,03	8,70	**96,3**	8,34	92,4	8,47	93,7
32	9999 R	9,60	9,21	**96,0**	8,29	86,4	8,58	89,4
4	25712 R	13,93	13,24	95,0	13,94	**100,1**	15,00	107,7
33	10004-1 R	15,13	14,13	93,4	13,41	88,6	13,67	90,3
43	TT 216 R	14,17	13,20	93,2	13,86	**97,8**	12,71	89,7
26	9979 R	15,20	13,93	91,7	13,47	88,6	13,28	87,4
38	TT 199 R	16,83	15,43	91,7	14,51	86,2	14,58	86,6
42	TT 214 R	15,37	14,00	91,1	13,38	87,1	13,08	85,1
6	62301 R	18,13	16,43	90,6	16,09	88,7	16,60	91,5
18	9753-2 R	12,17	10,84	89,1	10,48	86,1	10,53	86,5
25	9947 R	19,73	17,37	88,0	17,93	90,8	18,46	93,5
17	9753-1 R	16,13	14,03	87,0	12,83	79,5	12,42	77,0
44	TT 317 R	12,10	10,51	86,8	11,56	95,5	10,06	83,1
45	TT 321 R	17,47	14,97	85,7	15,87	90,8	15,20	87,0
19	9753-3 R	12,33	10,53	85,4	9,26	75,1	8,53	69,1

24	9889 R	22,73	17,93	78,9	17,93	78,9	17,23	75,8
39	TT 205 R	15,73	10,96	69,7	11,05	70,2	12,17	77,3
$\bar{x}$:		14,81	15,30		14,66		14,31	

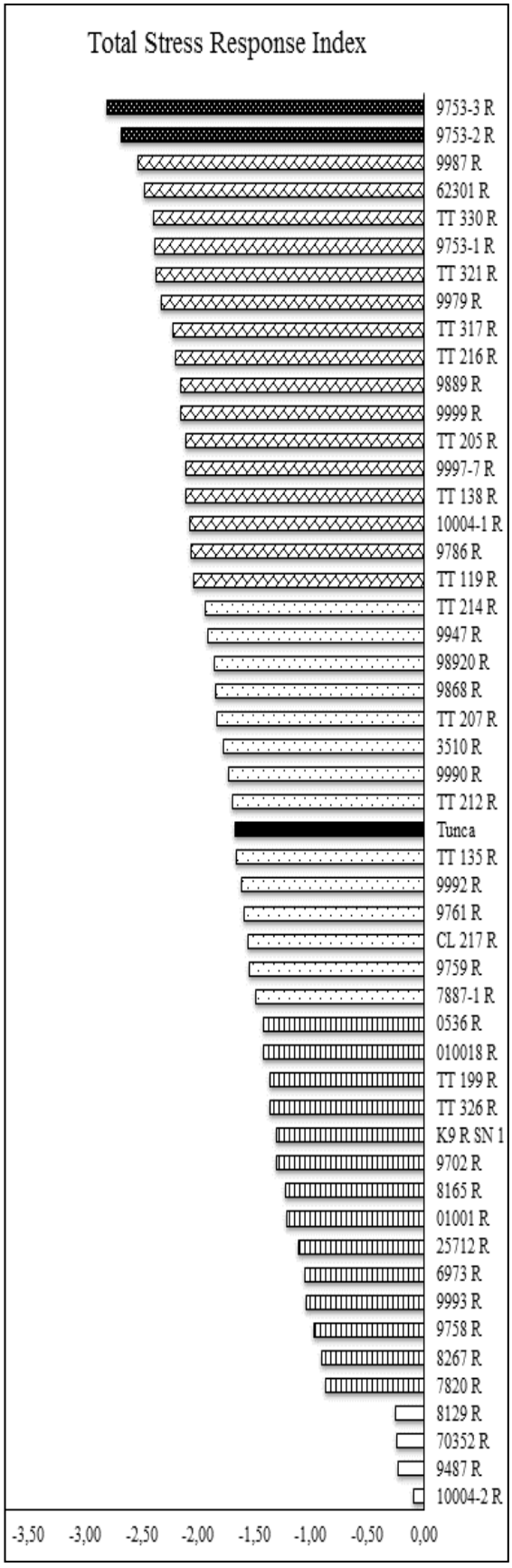

Figure 1. Total stress response index (TSRI) of leaf number, leaf area, amount of chlorophyll at R3 and R5-1 growth stages in sunflower lines subjected to drought stress.

Table 6: The effect of drought stress on chlorophyll amount at R3 growth stage in sunflower

#	Name of Line	C	S1	TI (%)	S2	TI (%)
20	9758 R	6,58	9,83	149,5	9,11	138,6
29	9992 R	9,25	13,28	143,6	12,33	133,3
8	70352 R	7,94	11,07	139,4	8,18	103,1
28	9990 R	9,08	12,15	133,7	11,51	126,8
32	9999 R	5,14	6,75	131,2	6,18	120,1
42	TT 214 R	8,24	10,73	130,2	11,87	144,1
24	9889 R	10,86	14,14	130,2	13,20	121,5
15	9487 R	7,88	10,16	129,0	9,12	115,8
22	9761 R	7,29	9,30	127,5	8,92	122,3
16	9702 R	8,51	10,85	127,4	8,77	103,0
3	010018 R	8,21	10,44	127,2	8,91	108,6
38	TT 199 R	9,01	11,19	124,3	9,31	103,4
13	8267 R	6,99	8,64	123,6	8,09	115,8
30	9993 R	7,27	8,96	123,1	7,97	109,6
17	9753-1 R	8,82	10,83	122,8	11,40	129,3
21	9759 R	10,93	13,36	122,2	11,63	106,5
33	10004-1 R	5,25	6,29	119,8	6,71	127,8
48	9868 R	8,69	10,40	119,7	9,31	107,1
9	7820 R	6,51	7,77	119,4	6,98	107,2
37	TT 138 R	10,31	12,17	118,1	11,01	106,8
2	01001 R	8,93	10,53	117,9	11,43	128,0
11	8129 R	7,74	9,04	116,8	8,28	106,9
35	TT 119 R	8,71	10,09	115,8	9,73	111,8
36	TT 135 R	9,69	11,19	115,5	10,88	112,3
19	9753-3 R	8,56	9,86	115,2	10,10	118,0
23	9786 R	7,37	8,49	115,2	6,91	93,8
31	9997-7 R	7,75	8,71	112,4	9,19	118,5
45	TT 321 R	10,74	11,99	111,6	10,56	**98,3**
46	TT 330 R	8,94	9,97	111,4	9,97	111,5
12	8165 R	8,73	9,60	110,0	10,02	114,8
5	3510 R	9,30	10,17	109,3	9,63	103,5
18	9753-2 R	8,55	9,22	107,9	9,99	116,8
40	TT 207 R	6,82	7,34	107,7	7,96	116,7
51	Tunca	8,44	9,09	107,7	7,96	94,3
47	K9 RSN1	9,60	10,30	107,3	10,60	110,5
10	7887-1 R	9,00	9,63	107,0	11,18	124,2
41	TT 212 R	7,34	7,84	106,8	8,48	115,6
34	10004-2 R	5,71	6,09	106,7	8,74	153,1
14	TT 326 R	9,39	9,98	106,2	9,25	**98,5**
4	25712 R	8,83	9,32	**105,6**	7,11	80,5
1	0536 R	9,58	10,01	**104,5**	9,10	95,0
7	6973 R	8,56	8,94	**104,4**	8,22	96,0
43	TT 216 R	7,87	8,16	**103,7**	9,96	126,6
39	TT 205 R	8,90	9,13	**102,6**	10,53	118,4
26	9979 R	8,98	8,79	**98,0**	8,88	**98,9**
50	CL 217 R	12,43	11,90	**95,7**	12,43	**100,0**
27	9987 R	8,27	7,77	94,0	8,25	**99,7**
6	62301 R	8,81	7,80	88,6	10,27	116,5

25	9947 R	14,00	12,00	85,7	14,30	**102,1**
44	TT 317 R	9,43	8,04	85,3	8,91	94,6
49	98920 R	8,83	6,17	69,8	7,97	90,2
x̄: LSD (0,05):0,56		8,59 B	9,71 A		9,55 A	

Table 7: The effect of drought stress as TSRI on chlorophyll amounts at leaves in sunflower

Lines / Treatments	Leaf number				Leaf area *(cm²/plant)*			Chl R3		Chl R5-1		
	C	S1	S2	S3	S1	S2	S3	S1	S2	S1	S2	S3
0536 R	1,0	0,7	0,8	0,8	0,5	0,7	0,8	1,0	0,9	1,1	1,1	1,1
01001 R	1,0	0,7	0,8	0,9	0,3	0,6	0,7	1,2	1,3	1,2	1,1	1,1
010018 R	1,0	0,7	0,8	0,8	0,3	0,7	0,7	1,3	1,1	1,1	1,1	1,1
25712 R	1,0	0,8	0,9	0,9	0,4	0,9	1,0	1,1	0,8	1,0	1,0	1,1
3510 R	1,0	0,6	0,8	0,9	0,3	0,6	0,8	1,1	1,0	1,1	1,0	1,0
62301 R	1,0	0,6	0,7	0,9	0,4	0,5	0,7	0,9	1,2	0,9	0,9	0,9
6973 R	1,0	0,7	0,9	1,0	0,6	0,8	0,9	1,0	1,0	1,0	1,0	1,0
70352 R	1,0	0,8	1,0	0,9	0,6	0,9	0,9	1,4	1,0	1,1	1,0	1,1
7820 R	1,0	0,7	0,9	0,9	0,5	0,7	0,8	1,2	1,1	1,1	1,1	1,1
7887-1 R	1,0	0,6	0,7	0,8	0,6	0,8	0,9	1,1	1,2	1,0	0,9	0,9
8129 R	1,0	0,7	0,9	0,9	0,6	0,9	0,9	1,2	1,1	1,4	1,2	1,1
8165 R	1,0	0,6	0,8	0,8	0,5	0,9	0,9	1,1	1,1	1,1	1,1	1,0
8267 R	1,0	0,6	0,9	0,8	0,5	0,7	0,7	1,2	1,2	1,2	1,1	1,1
TT 326 R	1,0	0,7	0,8	0,9	0,5	0,7	0,8	1,1	1,0	1,1	1,1	1,0
9702 R	1,0	0,6	0,8	0,8	0,4	0,7	0,8	1,3	1,0	1,2	1,1	1,0
9753-1 R	1,0	0,6	0,7	0,7	0,3	0,6	0,6	1,2	1,3	0,9	0,8	0,8
9753-2 R	1,0	0,5	0,6	0,7	0,3	0,6	0,8	1,1	1,2	0,9	0,9	0,9
9753-3 R	1,0	0,4	0,6	0,7	0,3	0,7	0,8	1,2	1,2	0,9	0,8	0,7
9758 R	1,0	0,6	0,9	0,8	0,4	0,7	0,7	1,5	1,4	1,1	1,0	1,0
9759 R	1,0	0,6	0,8	0,8	0,5	0,6	0,6	1,2	1,1	1,1	1,0	1,0
9761 R	1,0	0,6	0,8	0,8	0,4	0,6	0,6	1,3	1,2	1,1	1,1	1,0
9786 R	1,0	0,6	0,7	0,7	0,4	0,6	0,6	1,2	0,9	1,1	1,1	1,0
9889 R	1,0	0,7	0,8	0,8	0,4	0,6	0,7	1,3	1,2	0,8	0,8	0,8
9947 R	1,0	0,7	0,8	0,8	0,5	0,8	0,8	0,9	1,0	0,9	0,9	0,9
9987 R	1,0	0,7	0,8	0,9	0,3	0,5	0,5	0,9	1,0	1,0	0,9	1,0
9990 R	1,0	0,6	0,8	0,7	0,4	0,6	0,6	1,3	1,3	1,1	1,0	0,9
9992 R	1,0	0,6	0,7	0,8	0,3	0,5	0,5	1,4	1,3	1,1	1,0	1,0
9993 R	1,0	0,7	0,8	0,8	0,6	0,7	0,8	1,2	1,1	1,1	1,1	1,0
9999 R	1,0	0,6	0,7	0,7	0,3	0,6	0,7	1,3	1,2	1,0	0,9	0,9
10004-2 R	1,0	0,6	0,8	0,9	0,5	0,8	0,9	1,1	1,5	1,3	1,2	1,3
TT 119 R	1,0	0,6	0,8	0,8	0,3	0,5	0,5	1,2	1,1	1,1	1,0	1,0
TT 135 R	1,0	0,6	0,7	0,8	0,4	0,6	0,6	1,2	1,1	1,2	1,1	1,1
TT 138 R	1,0	0,6	0,7	0,8	0,3	0,6	0,6	1,2	1,1	1,1	1,0	1,0
TT 199 R	1,0	0,8	0,9	0,9	0,5	0,8	0,9	1,2	1,0	0,9	0,9	0,9
TT 205 R	1,0	0,8	0,8	0,8	0,6	0,7	0,8	1,0	1,2	0,7	0,7	0,8
TT 207 R	1,0	0,7	0,8	0,9	0,5	0,7	0,7	1,1	1,2	1,0	0,9	0,9
TT 212 R	1,0	0,7	0,8	0,9	0,5	0,7	0,7	1,1	1,2	1,0	1,0	0,8
TT 214 R	1,0	0,6	0,8	0,7	0,4	0,6	0,6	1,3	1,4	0,9	0,9	0,9
TT 216 R	1,0	0,7	0,8	0,8	0,3	0,5	0,6	1,0	1,3	0,9	1,0	0,9
TT 317 R	1,0	0,6	0,8	0,9	0,5	0,8	0,8	0,9	0,9	0,9	1,0	0,8
TT 321 R	1,0	0,5	0,7	0,7	0,4	0,7	0,8	1,1	1,0	0,9	0,9	0,9
TT 330 R	1,0	0,6	0,7	0,8	0,3	0,6	0,6	1,1	1,1	1,0	0,9	0,9
K9 R SN 1	1,0	0,6	0,8	0,8	0,3	0,6	0,5	1,1	1,1	1,5	1,2	1,2
9868 R	1,0	0,6	0,8	0,7	0,4	0,6	0,6	1,2	1,1	1,1	1,1	1,1
98920 R	1,0	0,6	0,8	0,8	0,6	0,8	0,8	0,7	0,9	1,0	1,0	1,0

CL 217 R	1,0	0,6	0,8	0,8	0,5	0,8	0,8	1,0	1,0	1,1	1,0	1,0
Tunca	1,0	0,7	0,8	0,8	0,5	0,8	0,8	1,1	0,9	1,0	1,0	1,0

IV. CONCLUSION

As a conclusion, sunflower male inbred lines exhibited different tolerance to drought stress on foliar traits in the study. Higher tolerant ones such as 70352 R and 8129 R inbred lines will be considered to develop tolerant hybrids with crossing other tolerant female lines and they will be used as also initial material for further breeding purposes.

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