Turkish Journal of Agriculture - Food Science and Technology, 7(8): 1088-1093, 2019
DOI: https://doi.org/10.24925/turjaf.v7i8.1088-1093.1808

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology

Water Deficit Tolerance of Some Pepper Inbred Lines

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ARTICLE INFO

Research Article

Received : 22/01/2018
Accepted : 26/02/2019

Keywords:
Capsicum annuum
Water deficit
Screening
Selection
Yield

ABSTRACT

Water deficit is one of the main limiting factors affecting plant growth. Selection in water-limited environments can result in populations or species with improved response to drought. Water deficit decreases yield and quality, therefore, it is important to identify genotypes that are tolerant to deficit irrigation conditions. In this study, the water-deficit tolerance of 59 pepper-inbred lines was determined. Experiments were conducted in a growth chamber and under field conditions (Şanlıurfa) with a control (100% full-irrigation) and water-deficit treatment (50% irrigation). Fruit weight, fruit length and number of fruits were recorded. Pepper lines 1900, 896 A-W, 74, 760, 1560-W, 912 A-W, 405-A, 953-W, 226, 1105-W and 441 were identified as the most tolerant to water deficit conditions. Present findings revealed that these pepper lines could be used to develop cultivars that have satisfactory yield under water deficit conditions.

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Introduction

Drought is one of the most important environmental factors affecting agricultural production. Selections in water-limited environments can result in populations or species with improved response to drought. Decreases in yield and quality occur because of drought and when the water resources were not correctly managed. It is important to identify genotypes that will tolerate deficit-irrigation conditions in peppers. If the amount of water per capita is less than 1000 m^3/year in a country, that country is considered to face problems with water production which in turn, affects vegetal production, economic development and conservation of natural resources (Tekinel, 1996).

There is an absolute water shortage in the Middle East and North Africa. In the near future, the effects of this problem are expected to spread to more areas around the world. The global warming that climate scientists predict presents us with an inevitable reality. The sector most affected by climate change is anticipated to be agriculture. Since priority has been given for the limited water to be used for urban and industrial use, the agriculture sector has to search for ways to get more products with less water to feed the growing human population (Van Tuijl, 1993).

There are two ways in which plants can cope with drought stress. The first is to avoid stress and the second is tolerance. It has been reported that in order to avoid drought stress, beans regulate the expansion of their root system and the closure of their stomata (Trejo and Davis, 1991; Barradas et al., 1994). At the cellular level, the mechanism of drought tolerance has been reported to involve osmotic regulation and protection of membranes (Mullet and Whitsitt, 1996). Osmotic regulation allows the plant to protect its turgor in low water conditions (Alian et. al., 2000). The cell, in response to the lowering of the water potential around it, accumulates some organic and inorganic substances, thereby reducing the osmotic potential and thus preserving the turgor state (Zhang et. al, 1999; Akram, 2007). In this way, the plant can survive under drought and salinity stress. The organic substances that accumulate in the cell include glycinebetaine, proline, free amine acids, sugars and ectoin with the types and amounts depending on stress intensity and duration (Delauney and Verma, 1993; Di Martino et. al., 2003). Some researchers (Akram, 2007) stated that the mechanisms of adaptation at the cell level were different in salinity and drought stress. According to this hypothesis, while osmotic regulation is achieved by accumulation of inorganic ions such as Na^+, K^+ and Cl^- ions in salt stress, organic substances are increased in the cell during drought stress.

There are two main approaches to improve economical yield. i.e., the empirical approach in which the plant breeder directly selects the breeding material for yield or yield components and the analytical approach which emphasizes the improvement of yield through indirect selection for morphological, physiological or biochemical traits associated with yield. Because plants respond to their changing environment in a complex and integrated way that allows them to react to the specific set of conditions and constraints present at a given time, the genetic control of yield under abiotic stress is not only very complex, but also highly influenced by the other environmental factors and development stages of the plant. Drought avoidance/tolerance in plants refers to yield stability under water deficit. Yield under drought environment conditions can be increased through genetic improvement of traits influencing drought adaptation. Therefore, conventional breeding for adaptation to drought requires an evaluation of the genetic variability of drought tolerance-related traits among crop varieties or among sexually compatible species, and introgression of these traits into lines with suitable agronomic characteristics. The tolerance levels of existing genetic resources must be known in order to obtain genotypes tolerant to drought stress. In this study, 67 different inbred lines of pepper were screened for drought tolerance both in pots and in the field at two different locations.

Material and Methods

In the first experiment, 59 inbred pepper lines were screened under control (100% full-irrigation) and 50% water-deficit conditions (using a class-A evaporation pan in a semi-controlled glass greenhouse) with pot experiments after 3 leaf stage until fruit set at Alata Horticulture research Institue, Mersin-Turkey. Seeds were sowed 3:1 peat and perlite mixture on January 30, 2012. Seedlings were transferred to pots on March 10, 2012. Each pot contained 3 kg soil mixture: (2 parts forest soil + 1 part sandy soil + 1 part manure). Fertilization was done using Hoagland solution. The experiment was conducted until fruit set and harvest; shoot and root fresh and dry matter weights were determined.

In the second experiment, 67 pepper lines were screened under open field conditions (soil type was clay-loam) (at GAP International Agricultural Research and Training Center, Koruklu Experiment Station fields using a class-A evaporation pan (100% and 50% water) between June 1, 2012 and September 1, 2012 from 3 leaf stage to the end of harvest. Seeds were sowed 3:1 peat and perlite mixture on April 15, 2012. Seedlings were transferred to soil on June 1, 2012. 25 pepper plants were used in each application with 3 replications. Randomized complete block design were used. The fruits were harvested four times. Yield (total fruit weight and number of fruits) and quality parameters (fruit shape) were recorded.

Results and Discussion

In this study, 59 pepper genotypes were tested under control (100% water) and 50% water-deficit in a growth chamber (Table 1). According to the findings, the mean decrease in fresh weight of pepper genotypes was 21.75%, while the highest decrease was observed in 405A (44%) genotypes in restricted water application.

Mean dry shoot weight decrease was 24.97%, while the lowest dry shoot weight decrease was obtained from 1530-W (1.5%) genotype and the highest decrease was observed in genotype 405A (44.3%). On the other hand, mean dry root weight decrease was 22.67%, while the lowest value was obtained from 762-2B (-28.1%) and the greatest value from 926W (62.4%).

The second trial was conducted under the conditions of Şanlıurfa-Turkey (dry and hot weather in summer season). Some genotypes were removed from the study due to insufficient seed supply and some commercially available varieties were included. In the study, control (100% of water requirement) and drought treatment (50% of water requirement) were applied during the whole vegetation period and four harvests were done to determine fruit weight and number of fruits (Table 2). Then the % reductions in both properties under deficit irrigations were calculated. The mean decrease in total fruit weight was 33.49% while the lowest value of decrease was 2% (977W) and the highest decrease was observed in the commercial F1-2 genotype (82.8%). The mean decrease in the number of fruits was obtained as 30.91%. While the lowest decrease value was obtained from genotype 1780 (-0.4%), standard pepper variety Demre (77.1%) gave the highest decrease value as compared to the control (Table 3).

Findings for both trials indicate that there was wide variation between pepper genotypes in response to limited water application. Moreover, in open field conditions, all genotypes performed better than commercial varieties. Similarly, there was a corresponding decrease in number of branches, plant height, number of flower buds, number of floral anthesis, number of fruits, fruit yield and an increase in number of aborted flowers from 2 under control to 11 under severe drought (data not shown). Similar results were reported by Gummuluru et al. (1989), Pinter et al. (1990) in durum wheat and by Filipetti and Ricciardi (1993) in faba beans.

Drought is a very complex trait. In 1997, a program was launched to develop drought-tolerant rice in China. This project consisted of four harmonious sections: screening, assessment standards, collection; evaluation of drought-tolerant resources; drought-tolerant gene/QTL discovery; and rice breeding. More than 200 rice accessions from China were collected and screened with a strong water management system. Eighty-six of them were selected for the core collection. Under drought conditions, 187 pure lines were created for genetic mapping. Many drought tolerant rice varieties have been adapted in Central and South China. Drought-tolerant CMS lines have also been developed and distributed to many parts of China to develop drought-tolerant lines or to develop hybrids that require less water (Liu et. al., 2006).

Table 1 Shoot fresh and dry weight, root dry weight and % decrease in shoot fresh and dry weight, root dry weight in pot experiment under 100% and 50% irrigation

N	GN	Shoot				Root		Decrease Rate (%)		
		Fresh Weight (g)		Dry Weight (g)		Dry Weight (g)		Shoot		Root
		IR	C	IR	C	IR	C	FW	DW	DW
1	405-A	76.1	135.9	12.8	22.9	2.1	3.6	44	44.3	42,8
2	15	100.2	132.6	14.7	22.7	1.9	2.7	24.4	35.2	27,3
3	32	122.8	139.9	15.7	21.3	1.8	2.2	12.2	26.4	16,3
4	36	95.9	137	12.4	20.1	1.5	2.5	30	38.3	40,5
5	74	95.1	105.3	10.1	12.5	1.9	2.1	9.7	19.2	8,9
6	99	83.3	111.9	12.1	14.9	2	2.1	25.5	19	4,8
7	100	100.3	133.4	14	18.7	1.7	2.3	24.8	25.4	27,7
8	107	101.3	137.7	16.1	22.3	2	2.7	26.4	27.9	27,2
9	173	95.6	127	13.8	19.5	2.2	2.7	24.7	29.5	20,6
10	202	89.1	122.6	13.1	17.4	1.9	2.3	27.3	25	14,3
11	226	98.6	131.6	12.7	19.1	1.3	2	25.1	33.5	33
12	253	109.5	167.4	15.3	23.7	2.5	4	34.6	35.6	37,2
13	269	101.1	125.3	14.5	17.8	1.4	1.6	19.3	18.5	11,9
14	276	118.9	153.8	13.6	17.6	1.3	2	22.7	22.6	32,8
15	304	110.9	149	15.8	21.6	3	3.3	25.6	26.7	9,1
16	342	112.4	158.3	16.7	24.1	1.9	3.1	29	30.9	36,7
17	351	103.2	136.6	14	18.1	1.8	2	24.4	22.7	6,9
18	390	97.8	130.6	12.8	20.4	1.9	2.6	25.1	37.2	29,4
19	441	89	127.2	12.3	21.4	1.9	3.1	30	42.8	39,9
20	760	103.2	115.5	15	16.3	2.3	2.6	10.6	8	14,2
21	1676	115.7	130.2	15.3	16.4	2.6	3.1	11.1	6.7	16,1
22	1719	98.7	145.6	14.2	19	2.2	2.6	32.2	24.9	15,4
23	1779	78.9	112	11.6	17.8	1.7	3	29.5	34.6	45,4
24	1780	106.6	150.8	15.6	18.2	2	2.2	29.3	14.3	10,5
25	1787	123.1	144.1	16.4	24.1	2.5	3	14.6	31.8	18,3
26	1838	95.8	115.4	14.1	21.8	2.2	2.2	17	35.6	3,1
27	1866	51.4	54.2	6.7	7.2	1.3	1.4	5.2	6.9	6,9
28	1895	105.3	137.5	13.7	17.3	2.3	2.4	23.4	20.8	5,7
29	1900	112.9	135.7	13.1	17.4	1.7	1.8	16.8	24.6	5,3
30	776-7	103.5	121.4	12.6	16	2.1	2.2	14.7	21.1	4,5
31	776-8	92.7	112.3	12.9	17	0.9	1.6	17.5	24	42,4
32	1105-W	153.1	187.1	18	24.7	1.8	2.6	18.2	27.2	31,1
33	1119-W	130.4	142	16.7	18.5	1.8	2.4	8.2	9.6	25,4
34	1121-A	87.2	113.1	12.3	16.2	1.7	2.9	22.9	24	39,4
35	1131-W	126.3	167.9	16	22.1	1.7	2.9	24.7	27.5	42,4
36	1530-W	90.1	96.2	11.4	11.6	1.7	2.7	6.4	1.5	36,3
37	1695-W	97.8	144.7	13.7	19.3	2.1	2.2	32.4	29	4,5
38	1763-1-B	99.8	144.7	12.8	20.8	2.7	3.2	31.1	38.5	17,8
39	242-B	103.2	152.5	13.1	18.1	1.4	2.2	32.3	27.7	36,1
40	253	101	129.8	14.4	18.7	3	3.1	22.2	23.2	3,2
41	475-A	93.8	102.3	13.6	13.9	1.8	2.3	8.3	1.8	21,7
42	762-2B	95.5	126.5	11.8	15.1	2.7	2.1	24.5	22.3	-28,1
43	771-8	97.8	112.5	15.3	21.9	2	2.2	13.1	29.9	9,1
44	875-W	117.8	158.4	14.6	24.2	1.9	2.8	25.6	39.7	33,1
45	877-W	112.6	139.6	14.8	17.8	1.7	2.4	19.4	16.9	26,8
46	895-W	119.1	164.1	14.9	23	2	3	27.4	35.2	33,9
47	896-W-A	107	145.6	15	21.3	1.8	3	26.6	29.9	38,2
48	899-W	100	138.3	13.7	19.3	1.6	3.5	27.7	28.9	55,6
49	912-A-W	131.8	160.2	18	19.8	2.7	2.7	17.8	9.2	2,5
50	921-W	141.8	221.4	16.9	25.4	1.6	2.3	36	33.4	29,5
51	926-W	140.7	171.1	17.8	19.5	1.5	4.1	17.8	8.8	62,4
52	938-A-W	128.8	148.7	15.5	18.4	2	2.2	13.3	16	7,3
53	945-W	131.9	170.5	18.3	24.1	2.1	3.8	22.6	24	44,4
54	953-W	119.7	162.1	15.3	22.9	2.9	3	26.2	33.3	4
55	954-W	116.1	145.3	17	22.7	2.3	3.1	20.1	25.2	23,7
56	977-W	147.8	154.3	14.9	20.8	1.7	2.3	4.2	28.7	28,5
57	979-W	112.7	152.5	14.7	21.2	1.8	1.9	26.1	30.7	2,3
58	3363	95.5	116.7	13.6	19	1.8	2.7	18.2	28.3	33,1
59	Sm-53	76.4	79	11.3	12.4	1.5	1.9	3.4	8.9	18,6
Mean		106.1797	137.0322	14.22203	19.27627	1.950847	2.584746	21.75254	24.97119	22.67627
Minimum		51,4	54.2	6.7	7.2	0.9	1.4	3.4	1.5	-28.1
Maximum		153,1	221.4	18.3	25.4	3	4.1	44	44.3	62.4

GN: Genotype Number, IR: 50% Irrigation, C: Control, FW: Fresh Weight (g), DW: Dry Weight (g)

Table 2 MTotal fruit weight and % decrease in fruit weight under open field conditions under 100% and 50% irrigation

GN	Control					50% Irrigation					
	Fruit Weight (g)				Total	Fruit Weight (g)					FW
	1st Harv	2nd Harv	3rd Harv	4th Harv		1st Harv	2nd Harv	3rd Harv	4th Harv	Total	DR
15	2411	310	1121	980	4822	812	356	276	180	1624	66.3
32	2722	306	1031	1385	5444	966	422	238	306	1932	64.5
36	2929	598	408	1923	5858	1349	553	319	477	2698	53.9
74	1728	252	216	1260	3456	1483	658	430	395	2966	14.2
99	2366	598	408	1923	5295	1521	499	639.5	383	3043	42.5
107	1693.5	379	621.5	693	3387	1424	396	662	366	2848	15.9
202	950	154	422	374	1900	844	434	267	143	1688	11.2
226	2826.5	341	948	1537	5653	2290	1144	620	526	4580	19
276	990	110	357	523	1980	848	311	308	229	1696	14.3
304	2308	476	617	1215	4616	1026	291	504	231	2052	55.5
342	2051	355	641	1055	4102	1556	660	496	400	3112	24.1
351	2621	733	528	1360	5242	1283	491	472	320	2566	51
441	1702	297	793	612	3404	1391	706	239	446	2782	18.3
760	1592	485	337	770	3184	1186.5	645	250.5	291	2373	25.5
945	3123.5	453	441.5	2229	6247	2645.5	1239.5	554	852	5291	15.3
1105	2994	1246	1454	294	5988	2561	429	404	1728	5122	14.5
1131	3138	1011	487	1640	6276	1444	359	937	148	2888	54
1676	1164	492	68	604	2328	833	531	68	234	1666	28.4
1719	3032	338	1166	1528	6064	1740.5	661.5	461	618	3481	42.6
1779	1809	396	508	905	3618	776.5	274	246	256.5	1553	57.1
1780	2140	432	964	744	4280	1210	640	124	446	2420	43.5
1787	2970	530	770	1670	5940	1548	504	668	376	3096	47.9
1838	1926	102	1023	801	3852	808	308	302	198	1616	58
1895	1436	449	705	282	2872	1324	141	289	894	2648	7.8
1900	3200	1607	1419	174	6400	3040	1009	324	1707	6080	5
1105-W	2561	429	404	1728	5122	2444	986	1070	388	4888	4.6
1119-W	3704	1340	1299	1065	7408	2118	457	1144	517	4236	42.8
1121-A	1358	650	256	452	2716	893.5	180	358	355.5	1787	34.2
1530-W	2618	168	1104	1346	5236	2124	454	1142	528	4248	18.9
16.Oca	2562	68	972	1522	5124	515	349	86	80	1030	79.9
1695-W	2816	366	1194	1256	5632	1746	695	771	280	3492	38
1763-1-B	3183	551	1109.5	1522.5	6366	1568	756	676	136	3136	50.7
242-B	1469	307	735	427	2938	1210	137	435	638	2420	17.6
405-A	1020	320	138	562	2040	990	378	270	342	1980	2.9
475-A	1810	255	653	902	3620	1329	504	322	503	2658	26.6
868-A-W	2544	550	883	1111	5088	1785	855	665	265	3570	29.8
875-W-1	2455	828	598	1029	4910	1604	1186	237	181	3208	34.7
877-W	3827	231	856	2740	7654	1519	306	965	248	3038	60.3
895-W	3568.5	724	1400	1444	7137	2395.5	834	1236	325.5	4791	32.9
896-A	1840	880	720	240	3680	1613	681	477	455	3226	12.3
899-W	3063	947	1467	649	6126	2320.5	363	400.5	1557	4641	24.2
912-A-W	3058	244	2316	498	6116	2889	427	1088	1374	5778	5.5
921-W	3247	734	960	1553	6494	3164.5	1729.5	895	540	6329	2.5
938-A-W	3572	538	968	2066	7144	1938.5	693	550.5	695	3877	45.7
953-W	3931	729	1154	2048	7862	1660	866	334	460	3320	57.8
954-w	2642.5	554	509.5	1579	5285	2214	918	991	305	4428	16.2
977-W	2318	714	552	1052	4636	2272	1061	895	316	4544	2
979-W	3349	699	700	1950	6698	1703	1008	516	179	3407	49.1
F1-1	3832	558	1152	2122	7664	2108	658	885	565	4216	45
F1-2	2566	400	622	1544	5132	442	52	210	180	884	82.8
F1-4	608	180	340	88	1216	524	76	228	220	1048	13.8
3363	888	94	528	266	1776	810	124	290	396	1620	8.8
F1-3	2824	1088	1046	690	5648	981.5	396	329.5	256	1963	65.2
S-M-5-3	2827	1088	652.5	1086	5654	1314	534	417	363.5	2629	53.5
Mean	2442.287	531.1852	791.5278	1129.972	4895	1557.5	580.1019	518.1759	459.2407	3115.056	33.49259
Minimum	608	68	68	88	1216	442	52	68	80	884	2
Maximum	3931	1607	2316	2740	7862	3164.5	1729.5	1236	1728	6329	82.8

GN: Genotype Number, F1-1: Commercial F1-1, F1-2: Commercial F1-2, F1-4: Commercial F1-4, F1-3: Commercial F1-3, IR: 50% Irrigation, C: Control, FW: Fresh Weight (g), DW: Dry Weight (g), DR: Decrease Rate (%)

Table 3 Number of fruits and % decrease in number of fruits under open field conditions under 100% and 50% irrigation

N	GN	Control					50% Irrigation					DR
		Number of Fruits					Number of Fruits					
		1. Harv	2. Harv	3. Harv	4. Harv	Total	1. Harv	2. Harv	3. Harv	4. Harv	Total	FN
1	15	231	27.5	96	107.5	462	94	33	29	32	188	59,3
2	32	418	46	146.5	225.5	836	288	105	102	81	576	31,1
3	36	317	80.5	60.5	176	634	266	61.5	62.5	142	532	16,1
4	74	86.5	40	20.5	26	173	85	13	11	61	170	1,7
5	99	317	80.5	60.5	176	634	240	75.5	100	64.5	480	24,3
6	107	452	120	207	125	904	387	103	142	142	774	14,4
7	202	281.5	161	64.5	56	563	141	37	56	48	282	49,9
8	226	256	44	98	114	512	203	104	75	24	406	20,7
9	276	154	48.5	40.5	65	308	150.5	19.5	45	86	301	2,3
10	304	232.5	41.5	52.5	138.5	465	157	33.5	82	41.5	314	32,5
11	342	469.5	162.5	183	124	939	265	58.5	81.5	125	530	43,6
12	351	402	123	52	227	804	300.5	83	93.5	124	601	25,2
13	441	355.5	89	141	125.5	711	306.5	138	38	130.5	613	13,8
14	760	147	30.5	38	78.5	294	115.5	53.5	18.5	43.5	231	21,4
15	945	187.5	79	35.5	73	375	160	22.5	28.5	109	320	14,7
16	1105	299	108	166	25	598	195	20	46	129	390	34,8
17	1131	220.5	70.5	60.5	89.5	441	124	50.5	64.5	9	248	43,8
18	1676	93.5	42.5	6.5	44.5	187	43	14	8	21	86	54
19	1719	309	27	109	173	618	187	71.5	48	67.5	374	39,5
20	1779	174	20.5	41.5	112	348	50.5	19.5	16	15	101	71
21	1780	224	123	15	86	448	225	63	96	66	450	-0,4
22	1787	167	35	56	76	334	94	28	39	27	188	43,7
23	1838	443	27.5	244.5	171	886	172	96	55	21	344	61,2
24	1895	470.5	174.5	194	102	941	442.5	45	157	240.5	885	6
25	1900	163.5	77	71.5	15	327	108	39.5	12	56.5	216	33,9
26	1105-W	195	20	46	129	390	134	39	67	28	268	31,3
27	1119-W	178	59	64	55	356	134.5	30.5	45.5	58.5	269	24,4
28	1121-A	372	170	68	134	744	154	28.5	68.5	57	308	58,6
29	1530-W	218	16	78	124	436	200	42	110.5	47.5	400	8,3
30	16.1	371	20	158	193	742	131.5	46	45.5	40	263	64,6
31	1695-W	209	18	89	102	418	170	77	66.5	26.5	340	18,7
32	1763-1-B	222.5	28	84	110.5	445	79	38	27	14	158	64,5
33	242-B	175.5	32.5	74	69	351	134	23	44	67	268	23,6
34	405-A	71	24	20	27	142	46	12	8	26	92	35,2
35	475-A	264.5	91.5	49	124	529	217	33	99	85	434	18
36	868-A-W	292.5	95	79.5	118	585	105	24.5	38.5	42	210	64,1
37	875-W-1	145	29	47.5	68.5	290	111.5	81	17.5	13	223	23,1
38	877-W	247	32	74	141	494	88	18	46	24	176	64,4
39	895-W	171.5	33	56.5	82	343	155	53.5	70.5	31	310	9,6
40	896-A	90	42	37	11	180	84	36.5	26.5	21	168	6,7
41	899-W	165.5	44.5	54	67	331	123	17	45	61	246	25,7
42	912-A-W	187	12	82	93	374	121	12.5	44.5	64	242	35,3
43	921-W	291	148	73	70	582	200.5	42.5	73.5	84.5	401	31,1
44	938-A-W	203	38	56	109	406	151.5	55	34	62.5	303	25,4
45	953-W	175	44	35	96	350	155	28.5	46.5	80	310	11,4
46	954-w	211.5	29.5	28	154	423	168	64.5	61	42.5	336	20,6
47	977-W	200	64.5	52.5	83	400	142	52.5	68.5	21	284	29
48	979-W	258.5	52.5	92.5	113.5	517	120.5	62	45.5	13	241	53,4
49	F1-1	181	36.5	48.5	96	362	153	42.5	68	42.5	306	15,5
50	F1-2	292	23	90	179	584	276	24	122	130	552	5,5
51	Demre	433	62	166	205	866	99	21	62	16	198	77,1
52	3365	79	10	47	22	158	64	12	26	26	128	19
53	F1-3	105	48	33	24	210	85	19	28.5	37.5	170	19
54	S-M-5-3	294	114	76	104	588	213	87	72.5	53.5	426	27,6
Mean		243,8704	61.39815	78.12037	104.3519	487.7407	163.2407	46.48148	57.11111	59.64815	326.4815	30.91111
Minimum		71	10	6.5	11	142	43	12	8	9	86	-0.4
Maximum		470,5	174.5	244.5	227	941	442.5	138	157	240.5	885	77.1

GN: Genotype Number, DR: Decrease Rate (%), FN: Fruit Number, F1-1: Commercial F1-1, F1-2: Commercial F1-2, F1-3: Commercial F1-3

In another study, Peanut (*Arachis hypogaea* L.) genotypes with high water use efficiency (WUE) were identified using chlorophyll meter readings (SCMR) and special leaf area (SLA) and to evaluate the relationships between relative SCMR and SLA in these genotypes. Thirty-seven characters were examined and 184 mini core collections were created. They consisted of 37 fastigiata, 58 vulgaris, 85 hypogaea, 2 peruviana varieties, and one of each of aequitoriana and hirsuta varieties, as well as 4 control variants of M13 and Gangapuri. The genotypes in the core collections were compared with control varieties according to SLA and SCMR values. Five vulgaris and 13 hypogaea genotypes were selected and these and the control varieties were grouped according to the first 15 principal components (PCs). According to UPGMA analysis, these genotypes were different from the control and they could also be used to improve the genetics of these genotypes due to their broad genetic base (Upadhyaya, 2005).

The linear relationship between the measurement of leaf water potential (LWP) and leaf-relative water content (LRWC), two basic parameters in plants, and their relationship to drought stress in plants has been the subject of numerous investigations. By measuring these parameters, the lowest irrigation levels that some fruit species and varieties can tolerate have been determined. Leaf water potential value decreases rapidly as the amount of water in the soil decreases (Kaynas and Eris, 1995). The leaf in the plants is falling towards the end of the vegetation and this decrease is exacerbated under water stress (Kaynas et. al., 1997).

A study was conducted using four irrigation regimes (control, 3, 7 and 14-day irrigation intervals) to simulate drought conditions. Mean comparison of agronomic traits indicated trait responsiveness to different water regimes and duration of water stress. Fruit yield decreased from 1.37 t ha^{-1} under control to 0.01 t ha^{-1} under severe drought. Yield and yield components are most affected by drought; 99% yield loss followed by 88% reduction in number of fruits, 79% reduction in number of flower buds and an increase of 81% in floral abortion under severe drought was obtained. Drought tolerance indices; tolerance index, mean productivity and percent injury were calculated and used in formulation of screening and selection criteria for drought tolerance in pepper (Showemimo and Olarewaju, 2007).

As a conclusion, pepper lines 1900, 896 A-W, 74, 760, 1560-W, 912 A-W, 405-A, 953-W, 226, 1105-W and 441 were determined to be the most tolerant to water deficit. The results of this study show that these pepper lines could be used to develop cultivars which do not have yield losses under water deficit.

References

Akram HM. 2007. Drought tolerance of wheat as affected by different growth substances application at various growth stages. PhD Thesis. Punjab University, Lahore.

Alian A, Altman A, Heuer B. 2000. Genotypic difference in salinity and 'water stress tolerance of fresh market tomato cultivars. Plant Sci., 152: 59-65.

Barradas VL, Jones HG, Clark JA. 1994. Stomatal responses to changing irradiance in *Phaseolus vulgaris* L. J. Exp. Bot., 45: 931-936.

Delauney AJ, Verma DPS. 1993. Proline biosynthesis and osmoregulation in plants. The Plant Journal, 4: 215-223.

Di Martino C, Sebastiano D, Pizzuto R, Loreto F, Fuggi A. 2003. Free amino acid and glycine betaine in leaf osmoregulation of spinach responding to increasing salt stress. New Phytol., 158(3): 455-463.

Filipetti A, Ricciardi L. 1993. Faba Bean (*Vicia faba* L.). In: Kalloo G, Berg BO. (eds.). Genetic improvement of vegetable crops. Oxford: Pergamon Press. pp: 355-385.

Gummuluru S, Hobbs SLA, Jana, S. 1989. Genotypic variability in physiological characters and its relationship to drought tolerance in durum wheat. Can. J. Plant Sci., 69: 703-711.

Kaynas N, Eris A. 1995. Bazı nektarin çeşitlerinde toprak su noksanlığının biyokimyasal değişimler üzerine etkileri. Turk. J. Agric. For., 22: 35-41.

Kaynaş N, Kaynaş K, Burak M. 1997. Bazı elma çeşitlerinde kuraklığın bitkideki morfolojik değişimler üzerine etkileri. Yumuşak Çekirdekli Meyveler Sempozyumu. 203-210, Yalova.

Liu JX, Liao DQ, Oane R, Estenor L, Yang XE, Li ZC, Bennett J. 2006. Genetic variation in the sensitivity of anther dehiscence to drought stress in rice. Field Crops Res., 97(1): 87-100.

Mullet JE, Whitsitt MS. 1996. Plant cellular responses to water deficit. Plant Growth Regul., 20: 119-124.

Pinter JPJ, Zipoli G, Reginato RJ, Jackson RD, Idso SB, Hohman JP. 1990. Canopy temperature as an indicator of differential water use and yield performance among wheat cultivars. Agr. Water Manage., 18: 35-48.

Showemimo FA, Olarewaju JD. 2007. Drought tolerance indices in sweet pepper (*Capsicum annuum* L.). J. Plant Breed. Genet., 1: 29-33.

Tekinel O. 1996. Suggestions for water-deficit problem in middle east countries. 1st Symposium on Vegetable in Southeastern Anatolian Project Area. Turkey.

Trejo CL, Davies WJ. 1991. Drought-induced closure of *Phaseolus vulgaris* L. stomata precedes leaf water deficit and any increase in xylem ABA concentration. J. Exp. Bot., 42: 1507-1515.

Van Tuijl W. 1993. Improving water use in agriculture: experiences in the Middle East and North Africa (English). World Bank technical paper; no. WTP 201. Washington DC: The World Bank.

Upadhyaya HD. 2005. Variability for drought resistance related traits in the mini core collection of peanut. Crop Sci., 45(4): 1432-1440.

Zhang DY, Sun GJ, Jiang XH. 1999. Donald’s ideotype and growth redundancy: a game theoretical analysis. Field Crops Res., 61: 179-187