

EFFECT OF WATER STRESS ON YIELD COMPONENTS OF IRANIAN WHEAT LANDRACES UNDER IRRIGATED, RESTRICTED IRRIGATED AND RAIN-FED CONDITIONS

Amandeep Kaur* and Rashpal Singh Sarlach²

¹Department of Botany, Punjab Agricultural University, Ludhiana 141004

²Department of Plant Breeding & Genetics, Punjab Agricultural University, Ludhiana, 141004
Email: deepaman3305@gmail.com

Received-03.06.2019, Revised-25.06.2019

Abstract: Drought stress is one of the most important environmental factor retard the formation of the yield components which are most actively developing at the time of stress which results in 17% to 70% of grain yield. The aim of present study was to investigate the effect of water stress on morphological traits of 27 Iranian landraces along with commercial relevant checks under irrigated, restricted irrigated and Rain-fed conditions. These lines were selected on the basis of minimum reduction of vigor index under water stress induced by Polyethylene glycol (6000) as compared to control lines. A field experiment was carried out at experimental area of Department of Plant Breeding & Genetics, Punjab Agricultural University Ludhiana, Punjab during 2016 with three replications. On the basis of performance of Iranian lines under field conditions these three lines IWA 8600064, IWA 8600179 and PETERSON ML68-10 are considered as water stress tolerant.

Keywords: Drought stress, Iranian landraces, Yield parameters

INTRODUCTION

Wheat is the staple food contributing 20% calories to world's population, with total harvest area of 2.1 million km² and global production of 700 million tonnes (Shiferaw *et al.*, 2013 and Lobel and Gourdjji 2012). In rain fed areas wheat is ranked first as far as the area of cultivation is concerned and under irrigated conditions, it is ranked second after rice based on total cultivation area (Porter and Semenov 2005). Water deficit, is one of the major constraint in agricultural production including wheat, which has devastated the economy of many countries. Water is also becoming a scarce commodity and its severity has been forecast further in this area as well, in the years to come. Drought is one of the most important natural features that affect plant growth and limits crop yield. Drought stress affects growth of plant from seedling to full maturity stage which results in reduction of yield (Bilal *et al.*, 2015). Under drought condition decreasing pattern is experienced in morphological yield contributing characters like grains per spike, spikes per plant, 1000 grain weight in wheat (Kilic and Yagbasanlar 2010). Sensitive growth stages of wheat to soil water deficits are from stem elongation to booting, followed by anthesis and milking (Zhang and Oweis 1999). The reduction is more severe when the water stress occurs at early stages of grain filling rather than at later stages (Stone and Nicholas 1995). During drought stress number of spikes have more effective role in reducing yield. Drought tension increase spikelet unproductivity and decrease 1000 grain weight and economic yield of grain (Kheialla *et al.*, 1997). Under

different irrigation conditions and deficit moisture, grain yield, number of spikes, number of grains per spike and 1000 grain weight change. As the global environment fluctuate, it is necessary to screen the germplasm which respond better under stress conditions. One of the important goal of plant breeders to evaluate wheat genotypes by studying their morphological character. There is urgent need to explore these morphological attributes for screening drought resistant genotypes in wheat to overcome the effect of stress (Saini and Westgate 1999). There have been considerable efforts in the past, in breeding for improved drought tolerance in field crops. The main objective of this work is to investigate morphological traits spikelets per spike, grains per spike, thousand grain weight, grain yield and harvest index which are associated with drought tolerance in wheat that could be used for yield improvement in wheat breeding programmes.

MATERIALS AND METHODS

In order to evaluate grain yield and yield components in wheat cultivars affected by drought stress, 27 lines were selected on the basis of vigor index from preliminary screening. Selected Iranian landraces on the basis of minimum reduction of vigor index under stress as compared to control experiment. These lines showed minimum reduction as compared to control in all seedling parameters (germination percentage, coleoptile length, root length, shoot length, root and shoot fresh and dry weight at 14% Polyethylene glycol (6000) treatment (Kaur *et al.*, 2018). 27 Iranian landraces were grown under irrigated, restricted irrigated and rain-fed conditions.

*Corresponding Author

Sr.No.	Landraces	Minimum reduction as compared control
1	PETTERSON ML68-10	302
2	Cltr 15395	100
3	IWA 8600064	399
4	IWA 8600091	473
5	IWA 8600179	180
6	IWA 8600191	439
7	IWA 8600232	136
8	IWA 8600397	261
9	IWA 8600435	320
10	IWA 8600440	179
11	IWA 8600542	298
12	IWA 8600567	215
13	IWA 8600596	185
14	IWA 8600715	185
15	IWA 8600795	274
16	IWA 8600796	239
17	IWA 8600841	79
18	IWA 8600846	174
19	IWA 8600883	24
20	IWA 8606258	279
21	IWA 8606633	296
22	IWA 8606661	292
23	IWA 8606739	200
24	IWA 8606753	200
25	IWA 8606741	264
26	IWA 8607572	200
27	IWA 8607576	275

Control treatment (Irrigated) was well watered throughout the growing period (five irrigations). Drought environment was created by withholding irrigation (two irrigations) and created temporary rain shelter from water during rain. The experiment was carried out in RBD design with three treatments with three replications. Sowing was done in last week of November 2016.

Vigor index is calculated according to formula = Germination percentage x Mean of seedling length (Root length + Shoot length)

Number of spikelets was counted from 3 randomly selected spikes for each line. From each line 5 spikes were randomly selected and thrashed at maturity was recorded as grain per spike. 5 spikes which were randomly selected earlier from each line were thrashed and then number of grains was counted and grains were weighted to calculate thousand grain weight. Grain yield was recorded from each line. At the time of harvesting biological yield weight of mature plants harvested was recorded. Later these

were thrashed for grain yield and harvest index was calculated by formula

Harvest index = Grain yield/biological yield

Statistical analysis: The statistical analysis was carried out with the help of CPCS-1 software using RBD (Randomized block design) factor

RESULTS AND DISCUSSIONS

Analysis of variance for all the morphological traits was conducted. The mean square under drought stress were highly significant for all the characters under irrigated condition spikelets per spike, grain per spike, grain yield, thousand grain weight and harvest index. (Table 1). Under restricted irrigation mean square is significant for all the characters except spikelets per spike, grain per spike (Table 2). Under rain-fed conditions mean square is highly significant for all the characters (Table 3). Mean value of Iranian landraces along with checks under irrigated condition are presented in (Table 7), under

restricted irrigated condition in (Table 8) and under rain-fed condition in (Table 9).

Spikelets per spike

Under irrigated condition spikelet per spike varied between 15.0 to 20.7 with an average of 17.8 (Table 4). Among commercial relevant checks C-591 maximum (23.0) spikelet per spike whereas PBW 660 had lowest (19.2) spikelets per spike (Table 4). In Iranian lines IWA 8600179 had maximum (20.7) whereas IWA 8600440 had minimum (15.0) spikelet per spike (Table 7). In case of restricted irrigated condition spikelet per spike varied between 11.0 to 17.9 with a mean of 14.4 (Table 5). In commercial relevant checks, C-591 had maximum (20.0) spikelet per spike whereas PBW 175 had lowest (16.0) spikelets per spike (Table 5). Among Iranian lines IWA 8600179 had maximum (17.9) whereas minimum (11.0) spikelet per spike was recorded in IWA 8600796 (Table 8). Spikelet per spike among genotypes ranged between 9.5 to 15.7 with a mean of 12.6 in case of rain-fed condition (Table 6). Among commercial relevant checks, C-591 had maximum (19.2) spikelets per spike whereas Gladius had minimum (15.0) spikelets per spike (Table 6). Among Iranian lines PETERSONML68-10 had maximum (15.7) and minimum (9.5) spikelets per spike was observed in IWA 8600796 (Table 9).

Grains per spike

Under irrigated condition grains/spike varied between 21.5 to 34.5 with a mean of 28.0 grains per spike (Table 4). Among checks C-306 and C-518 had maximum (37.5) while C-273 had minimum (29.8) grains/ spike (Table 4). Iranian lines, IWA 8600179 had more (34.5) grains per spike followed by PETERSONML68-10 (33.5) whereas minimum (21.5) grains per spike was recorded in IWA 86007576 (Table 7). Grains per spike among genotypes ranged between 17.5 to 25.5 with an average of 21.5 grains per spike under restricted irrigated conditions (Table 5). In commercial relevant checks PBW 660 had maximum (29.8)

while BWL 5233 had minimum (23.5) grains/ spike (Table 5). Among the Iranian lines, PETERSONML68-10 had maximum (25.5) grains per spike whereas minimum (17.5) grains per spike was recorded in IWA 8600232 (Table 8). In case of rain-fed condition grains/spike varied between 14.0 to 23.5 with a mean of 27.5 grains per spike (Table 6). Among checks C-306 had maximum (26.5) grains/ spike whereas minimum grains per spike was recorded in C-591 (16.5) (Table 6). In Iranian lines, Ctr 15395 (23.5) had more grains per spike and IWA 8600440 (14.0) had minimum grains per spike (Table 9).

Thousand grain weight

Under irrigated condition, thousand grain weight varied 17.5 g to 29.8 g with a mean of 23.6 (Table 4). Among checks C-306 had highest (34.5g) whereas C-273 had lowest (26.5 g) thousand grain weight (Table 4). In case of Iranian lines, PETERSON ML68-10 had maximum (29.8g) thousand grain weight followed by IWA 8600064 (29.6) whereas minimum thousand grain weight was recorded in IWA 8606739 (17.5 g) (Table 7). In case. In case of restricted-irrigated thousand grain weight among genotypes varied between 13.5g to 24.5 g with a mean of 19.00 (Table 5) Among checks C-306 had maximum (28.5g) while Gladius had minimum (22.5g) thousand grain weight (Table 5). In Iranian lines, maximum (24.5) thousand grain weight was recorded in PETERSON ML68- lowest (13.5) was in IWA 8600596 (Table 8). In rain-fed condition thousand grain weight varied between 11.6 g to 20.5g with an average of 16.05g (Table 6). In commercial relevant checks, C-306 had highest (24.5g) whereas BWL 5233 had lowest (18.1g) thousand grain weight (Table 6). Among Iranian lines, PETERSON ML 68-10 had maximum (20.5g) thousand grain weight whereas IWA 8600596 had lowest (11.6g) thousand grain weight (Table 9).

Table 1. Analysis of variance for morphological traits in 27 Iranian lines along with 8 checks under Irrigated conditions during 2016-2017

Mean Square of characters						
Source of Variation	Df	SPS	GPS	TGW	GY	HI
Block	1	4.029	12.017	4.5276	1651.286	0.823
Treatment	34	26.66*	147.06*	162.84*	38968.73*	0.171*
Error	34	1.92	60.80	49.40	5551.433	0.13
Total	69					

Table 2. Analysis of variance for morphological traits in 27 Iranian lines along with 8 checks under Restricted irrigated condition during 2016-17

Mean Square of characters						
Source of variation	Df	SPS	GPS	TGW	GY	HI
Block	1	0.36	86.91	46.08	115.45	0.14
Treatment	34	0.94	92.86	76.01*	23601.68*	0.43*

Error	34	1.48	76.23	39.18	8918.6	0.489285
Total	69					

Table 3. Analysis of variance for morphological traits in 27 Iranian lines along with 8 checks under Rain-fed under condition during 2016-17

Abbreviations: DF –Degree of freedom, SPS- Spikelets per spike, GPS- Grains per spike, TGW- Thousand

Mean Square of characters						
Source of variation	Df	SPS	GPS	TGW	GY	HI
Block	1	0.148	751.12	6.035	1462.629	0.412
Treatment	34	7.68*	72.63*	101.21*	17491.18*	0.152*
Error	34	0.851	84.24	53.03	4595.217	0.78
Total	69					

grain weight, GY- Grain yield and HI- Harvest index

Table 4. Ranges and mean values of morphological traits of Iranian lines and checks under Irrigated conditions

Characters		SPS	GPS	TGW	GY	HI
Landraces	Min	15	21.5	17.5	135.4	0.13
	Max	20.7	34.5	29.8	300.4	0.24
	Mean	17.8	28.0	23.6	217.9	0.18
Mean value of checks	Gladius	20.5	36	30.5	440	0.25
	BWL 5233	20	35	27.8	365.5	0.27
	C-306	23	37.5	34.5	410.4	0.3
	PBW 660	19.2	32.5	30.5	350.1	0.28
	C-518	20	37.5	28.5	345.2	0.25
	C-591	23.0	30	30.5	250.5	0.27
	C-273	20.1	29.8	26.5	350.4	0.24
PBW 175	20.2	32.5	27.4	325.2	0.26	

Table 5. Ranges and mean value of morphological traits of Iranian lines and checks under Restricted Irrigated conditions

Characters		SPS	GPS	TGW	GY	HI
Landraces	Min	11	17.5	13.5	100	0.09
	Max	17.9	25.5	24.5	245.4	0.20
	Mean	14.4	21.5	19	122.7	0.15
Mean value of checks	Gladius	19	25.5	22.5	440.4	0.24
	BWL 5233	19.1	23.5	24.5	300.4	0.22
	C-306	19.1	27.5	28.5	365.2	0.27
	PBW 660	19.25	29.8	22.5	320.2	0.24
	C-518	19.3	27.5	24.5	340.4	0.19
	C-591	20	26.5	27.1	250.2	0.2
	C-273	19	24.5	24.5	250.4	0.22
PBW 175	16.0	27.8	20.5	220.2	0.21	

Abbreviations: SPS- Spikelets per spike, GPS- Grains per spike, TGW- Thousand grain weight, GY- Grain yield and HI- Harvest index

Table 6. Ranges and mean values of morphological traits of Iranian lines and checks under Rain-fed conditions

Characters		SPS	GPS	TGW	GY	HI
Landraces	Min	9.5	14	11.6	40.7	0.02
	Max	15.7	23.5	20.5	210.3	0.18
	Mean	12.6	27.5	16	125.5	0.10
Mean value of checks	Gladius	15	23.5	22	355.2	0.18
	BWL 5233	15.75	18.5	18.1	225.1	0.16
	C-306	15.25	26.5	24.5	330.2	0.19
	PBW 660	15.75	19.5	20.5	300	0.2
	C-518	17.25	23	22.6	330.5	0.17
	C-591	19.25	16.5	19.5	305.6	0.14
	C-273	17.5	18.5	20.5	225.4	0.17
	PBW 175	19.1	20	17.5	200.4	0.18

Abbreviations: DF –Degree of freedom, , SPS- Spikelets per spike, GPS- Grains per spike, TGW- Thousand grain weight, GY- Grain yield and HI- Harvest index,

Table 7. Mean values of Iranian wheat landraces with 8 checks under irrigated conditions

S. N.	Landraces	Spikelets/ spike	Grains/ spike	1000 Grain weight	Grain yield	Harvest index
1	PETTERSON ML68-10	20.5	33.5	29.8	255.5	0.22
2	Cltr 15395	17.5	27.5	24.5	200	0.2
3	IWA 8600064	20.3	32.5	29.6	300.4	0.24
4	IWA 8600091	19	27.5	24.5	205.4	0.19
5	IWA 8600179	20.7	34.5	27.8	280	0.23
6	IWA 8600191	19.5	24	19.5	155.4	0.15
7	IWA 8600232	18	24.5	18.5	200.2	0.2
8	IWA 8600397	17.5	25.5	24.6	185.5	0.18
9	IWA 8600435	18	27.4	19.1	135.4	0.15
10	IWA 8600440	15	28.5	22	180.4	0.19
11	IWA 8600542	18.5	25.5	26.5	150.4	0.2
12	IWA 8600567	20	30.5	21.5	245.4	0.19
13	IWA 8600596	19	24.5	19.5	180.4	0.14
14	IWA 8600715	17	27.4	18.5	160.4	0.18
15	IWA 8600795	19.8	24.5	27.1	190.2	0.17
16	IWA 8600796	17	22.5	18.5	155.1	0.2
17	IWA 8600841	18	28	20.5	210.4	0.18
18	IWA 8600846	19	30.5	21.5	210.4	0.13
19	IWA 8600883	19.5	31	25.5	165.6	0.2
20	IWA 8606258	20	22.5	24	225.7	0.13
21	IWA 8606633	19	23.5	20.5	175.9	0.2
22	IWA 8606661	18	28.5	25.6	135.8	0.17
23	IWA 8606739	17	22.5	17.5	200	0.2
24	IWA 8606753	16.5	31	25.5	210.4	0.18
25	IWA 8606741	19	22.5	20.5	225.5	0.18
26	IWA 8607572	19.1	30.5	22.5	165.7	0.19
27	IWA 8607576	20	21.5	24.5	190.5	0.2
28	Gladius	20.5	36	30.5	440	0.25
29	Bwl 5233	20	35	27.8	365.5	0.27
30	C-306	23	37.5	34.5	410.4	0.3
31	PBW660	19.2	32.5	30.5	350.1	0.28
32	C-518	20	37.5	28.5	345.2	0.25
33	C-591	23.0	30	30.5	250.5	0.27

34	C- 273	20.1	29.8	26.5	350.4	0.24
35	PBW175	20.2	32.5	27.4	325.2	0.26
	CD (5%)	20.8	15.8	14.3	151.4	0.73

Table 8. Mean values of Iranian wheat landraces with 8 checks under Restricted Irrigated conditions

S. N.	Landraces	Spikelets/ spike	Grains/ spike	1000 Grain weight 245.5	Grain yield	Harvest index
1	PETTERSON ML68-10	17	25.5	24.5	245.5	0.19
2	Cltr 15395	15.5	18.5	20.5	180	0.15
3	IWA 8600064	17.5	24.5	23.5	200.5	0.20
4	IWA 8600091	12	18.5	18.5	180.5	0.17
5	IWA 8600179	17.9	24.5	24.5	195.1	0.19
6	IWA 8600191	15.5	18.5	16.5	130	0.14
7	IWA 8600232	16	17.5	16	150.5	0.17
8	IWA 8600397	13.5	20.5	17.5	100.4	0.13
9	IWA 8600435	13	18.5	14.5	100.7	0.13
10	IWA 8600440	12.5	19.5	19.5	170.7	0.12
11	IWA 8600542	16.5	18.5	20.3	105.4	0.16
12	IWA 8600567	12	17.8	17.0	115.7	0.17
13	IWA 8600596	14.5	20.5	13.5	120.4	0.12
14	IWA 8600715	14	21	14.5	150.4	0.12
15	IWA 8600795	12.5	19	22.3	145.5	0.14
16	IWA 8600796	11	20.5	14.5	130.4	0.17
17	IWA 8600841	14.5	21	17.5	150.5	0.12
18	IWA 8600846	11.5	20.4	20.5	100	0.12
19	IWA 8600883	14	19.5	17.8	140.5	0.10
20	IWA 8606258	14.5	24.5	20.8	150.5	0.09
21	IWA 8606633	13.5	18.5	17.6	170.4	0.14
22	IWA 8606661	12	20.5	21	110.4	0.13
23	IWA 8606739	15.5	23	14.5	150.9	0.15
24	IWA 8606753	16.5	20.	19.5	160.8	0.16
25	IWA 8606741	15.5	20.5	18.5	140.5	0.15
26	IWA 8607572	14.5	23.5	19.3	175.8	0.14
27	IWA 8607576	15.5	23	17.8	145.5	0.18
28	Gladius	19	25.5	22.5	440.4	0.24
29	Bwl 5233	19.1	23.5	24.5	300.4	0.22
30	C-306	19.1	27.5	28.5	365.2	0.27
31	PBW660	19.2	29.8	22.5	320.2	0.24
32	C-518	19.3	27.5	24.5	340.4	0.19
33	C-591	20	26.5	27.1	250.2	0.20
34	C- 273	19	24.5	24.5	250.4	0.22
35	PBW175	16	27.8	20.5	220.2	0.21
	CD (5%)	NS	NS	12.7	191.2	0.14

Table 9. Mean values of selected Iranian wheat landraces with 8 checks under Rain-fed conditions

S. N.	Landraces	Spikelets/ spike	Grains/ spike	1000 Grain weight	Grain yield	Harvest index
1	PETTERSON ML68-10	15.7	18.5	20.5	210.3	0.17
2	Cltr 15395	13.5	23.5	17.1	90.5	0.13
3	IWA 8600064	14.3	17.5	19.5	180.5	0.18
4	IWA 8600091	9.8	16.5	12.5	100.4	0.09
5	IWA 8600179	14.5	21	19.1	145.4	0.18
6	IWA 8600191	10.5	16.5	14.5	120.3	0.16
7	IWA 8600232	12.5	14.5	12.5	140.2	0.12

8	IWA 8600397	12	17.5	12.5	80.2	0.04
9	IWA 8600435	11.5	15.6	12	45.6	0.11
10	IWA 8600440	9.8	14	17.8	80.7	0.05
11	IWA 8600542	12.5	20.7	17.8	40.7	0.14
12	IWA 8600567	9.8	20.5	15.4	95.7	0.13
13	IWA 8600596	12.5	18.5	11.6	90.5	0.09
14	IWA 8600715	11.5	17.5	13.1	100.5	0.11
15	IWA 8600795	10.5	18.5	14.5	80.5	0.13
16	IWA 8600796	9.5	17.5	12.6	125.4	0.13
17	IWA 8600841	12.5	16.5	15.2	100.4	0.04
18	IWA 8600846	10.2	16.5	14.5	95.9	0.03
19	IWA 8600883	11.5	18.7	15.4	105.8	0.03
20	IWA 8606258	12.5	15.6	13.5	100.7	0.02
21	IWA 8606633	10.5	15.5	14.4	50.4	0.04
22	IWA 8606661	9.8	14.5	16.4	90.4	0.04
23	IWA 8606739	10.5	17.5	12.3	130.5	0.13
24	IWA 8606753	12.5	15	15.5	140.5	0.12
25	IWA 8606741	11.5	18.5	15.5	90.5	0.12
26	IWA 8607572	12	17	14.1	120	0.09
27	IWA 8607576	12	17.5	14.5	85.6	0.16
28	Gladius	15	23.5	22	355.2	0.18
29	Bwl 5233	15.7	18.5	18.1	225.1	0.16
30	C-306	15.2	26.5	24.5	330.2	0.19
31	PBW660	15.7	19.5	20.5	300	0.20
32	C-518	17.2	23	22.6	330.5	0.17
33	C-591	19.2	16.5	19.5	305.6	0.14
34	C-273	17.5	18.5	20.5	225.4	0.17
35	PBW175	19.1	20	17.5	200.4	0.18
	CD (5%)	1.877	18.6	14.7	137.76	0.56

Abbreviations: SPS- Spikelets per spike, GPS- Grains per spike, TGW- Thousand grain weight, GY- Grain yield and HI- Harvest index

Grain yield

Under irrigated condition grain yield showed variation between 135.4g to 300.4g with an average of 217.9 g (Table 4). Among checks, Gladius had highest (440.0g) whereas C-591 had lowest (250.5g) grain yield (Table 4). In Iranian lines, IWA 8600064 had highest (300.4g) grain yield whereas minimum grain yield was recorded in IWA 8600435 (135.4g) (Table 7). In case of restricted-irrigated genotypes varied between 100.0 g to 245.4 g with a mean of 122.7 g (Table 5). Among checks Gladius had maximum (440.4g) while PBW 175 had minimum (220.2g) grain yield (Table 5). Iranian lines, PETERSON ML 68-10 had highest (245.4g) whereas IWA 8600846 had lowest (100.0g) grain yield (Table 8). Grain yield under rain-fed conditions varied between 40.7 g to 210.3 g with an average of 125.5 g (Table 6). In commercial relevant checks, Gladius had maximum (355.2g) while PBW 175 had minimum (200.4g) grain yield (Table 6). Among Iranian lines, PETERSON ML68-10 had maximum (210.3g) grain yield whereas minimum grain yield was recorded in IWA 8600542 (40.7g) (Table 9).

Harvest index

Under irrigated condition, harvest index varied between 0.13 to 0.24 with a mean of 0.18 (Table 4). Among checks C-306 had highest (0.30) whereas

minimum harvest index was recorded in C-273 (0.24) (Table 4). Among Iranian lines, IWA 8600064 had maximum (0.24) harvest index whereas minimum (0.13) harvest index was recorded in IWA 8600846 (Table 7). In case of restricted-irrigated harvest index among genotypes varied between 0.09 to 0.20 with a mean of 0.14 (Table 5). Among commercial relevant checks C-306 had maximum (0.27) while C-518 had lowest (0.19) harvest index (Table 5). In Iranian lines IWA 8600064 had highest (0.20) whereas IWA 8606258 had lowest (0.09) harvest index (Table 8). In rain-fed condition harvest index range between 0.02 to 0.18 with a mean of 0.10 (Table 6). Among commercial relevant checks, PBW 660 had highest (0.20) whereas minimum harvest index was recorded in C-591 (0.14) (Table 6). In Iranian lines, IWA 8600064 and IWA 8600179 had maximum (0.18) whereas minimum harvest index was recorded in IWA 8606258 (0.02) (Table 9).

REFERENCES

Kaur, A., Sarlach, R.S., Sharma, A. and Bains, N.S. (2018). Identification of drought tolerant Iranian wheat landraces under water stress conditions. *Vegetos* 31: 68-73.

- Bilal, M., Rashid, R.M., Rehman, S.U., Iqbal, F., Ahmed, J., Abid, M.A., Ahmed, Z. and Hayat, A.** (2015). Evaluation of wheat genotypes for drought tolerance. *J G*
- Kheiralla, K.H., Ismai, A.A. and El-Negar, G.R.** (1997). Drought tolerance and stability of some spring wheat cultivars. *Assiut J. Agriculture Sciences* 28: 75-80.
- Kilic, H. and Yağbasanlar, T.** (2010). The effect of drought stress on grain yield, yield components and some quality traits of durum wheat (*Triticum turgidum*) cultivars. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 38: 164-70.
- Lobell, D. B. and Gourdji, S. M.** (2012). The influence of climate change on global crop productivity. *Plant Physiology* 160: 1686–1697
- Porter, J. R. and Semenov, M. A.** (2005). Crop responses to climatic variation. *Philosophical Transactions of the Royal Society B: Biological Sciences* 360: 2021–2035.
- Saini, H.S. and Westgate, M.E.** (1999). Reproductive development in grain crops during drought. *Advance Agron* 68: 59-96.
- Shiferaw, B. et al.** (2013). Crops that feed the world . Past successes and future challenges to the role played by wheat in global food security. *Food Security* 5:291–317.
- Stone, P.J. and Nicholas, M. E.** (1995). Comparison of sudden heat stress with gradual exposure to high temperature during grain filling in two wheat varieties differing in heat tolerance. I Grain growth. *Aust. Journal of Plant Physiol.*, 22: 935-944.
- Zhang, H. and Oweis, T.** (1999). Water yield relation and optimal irrigation scheduling of wheat in the Mediterranean region. *Agric. Water Management.*, 38:195-211.