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A STUDY OF SOURCE AND SINK RELATIONSHIPS TO SELECT WHEAT LINES AND GENOTYPES FOR DROUGHT TOLERANCE

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ABSTRACT. In current study, 14 genotypes of bread wheat chosen by breeding tests in Zanjan Agricultural Research Institute of Iran were exposed to two experiment under irrigation and late season drought stress. The experiments were conducted between 2012-2013 in a randomized complete block design with three replications. Analysis of variance showed that, under non-stress condition, the differences among genotypes were significant regarding biological yield and grain weight per spike, while under stress condition in addition there were significant differences about grain yield and biological yield at pollination stage. Under normal and stress condition, the highest and the lowest biological yield was observed in genotype 3 (52.6 g per 15 stems), genotype 2 (35 g per 15 stems), respectively. The average weight of grain per spike decreased by 44.38 % under drought stress condition. In flag leaf removal experiment, results showed that the genotypes significantly differed under non-stress condition regarding the spike weight, grain weight per spike and weight of the leaves, except flag leaf, while under stress condition there were significant differences among genotypes in terms of biological yield, spike weight, peduncle weight at pollination stage, grain weight pre spike and weight of the leaves, except flag leaf. In leaves defoliation (except flag leaf), results showed that the differences among genotypes under normal and stress condition regarding spike weight, grain number per spike, biological yield, peduncle weight, and flag leaf weight were significant.

Keywords: wheat; drought stress; grain yield; biological yield; flag leaf defoliation.

INTRODUCTION

High evaporation and transpiration, limited water resources and other factors in dry land areas caused more attention to study the effects of drought and drought-resistant genotypes. Highland regions usually have long winters and short spring, which are coupled with the heat and dryness and temperature changes, in these areas is very

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extensive. Thus wheat and barley grown in these areas not only should have resistance to cold and frost, but also should be drought resistant. Its already reported that the highest sensitivity to drought stress occurs during the stem growth, flag leaf sheath swell and drought stress before the heading particularly before flowering and pollination leads to highest drop in wheat yield. Hard was the first person who attend to the introduction of drought tolerant genotypes by selection under artificial water stress. He claimed that the similarity between experiment environment and the climate of target region is the key factor to success in introducing tolerant genotypes (Jensen, 1988). Many experiments that may be done to reform the genotypes for drought tolerance, generally will run in both stress and non-stress conditions. The main purpose of these tests is to select genotypes which are compatible to both the above conditions. To choose plants based on yield several indicators have been suggested, which involve obtained yield in both stress and non-stress conditions. Wheat is the plant which its yield and its yield components are affected by genotype and environment. Therefore, drought stress during the early stages of regeneration by reducing the number of kernel and during later stages by reducing the grain size, may decline the final yield. On the other hand, the studies on wheat clarified that this plant under severe drought stress produces smaller grains and lower yield. Reynolds *et al.* (2000) reported that in wheat there is a linear relationship between drought stress and yield. This indicates that wheat is relatively drought tolerant. Water stress during grain filling stage in nine genotypes of bread wheat reduces yield, seed weight and seed size (Saint Pierre *et al.,* 2008). Zareie *et al.* (2007), after investigation on 20 bread wheat genotypes regarding drought tolerace, reported that genotypes which exhibited drought tolerance under field condition also showed tolerance under lab condition (germination stage). These findings were approved by Farshadfar *et al.* (2004), but in contrast, Saedi *et al.* (2007) and Aziznia *et al.* (2005) expressed that there is no significant dependence between drought tolerance under field and lab conditions. Leaves have a large share in net production during plant growth and reproduction (Baker 1996). Plant performance in terms of assimilates allocated between different parts of plant has a significant effect on grain yield. In a plant community with high leaf area index, absorption of radiation and absorption of carbon dioxide by leaves located on top of canopy is high and can absorb a lot of material to be transferred to other parts of the plant (Sarmadnia and Kouchaki, 1990). So, in current experiment we carried out different levels of defoliation to evaluate the role of leaves regarding sap transport between source and sink.

MATERIALS AND METHODS

In current study, 14 genotypes of bread wheat chosen by breeding tests in Zanjan Agricultural Research Institute (*Table 1*) were exposed to two experiment under irrigation and late season drought stress. The experiments were conducted between years Oct. 2012 - Jul. 2013 in a randomized complete block design with three replications. The soil texture in experiment place was loam and clay loam. Soil preparation including chisel plow seedbed was conducted in the fall of 2012. Seed cultivation was conducted with 1.2 meter width. The required fertilizer was calculated according to soil analysis results on the basis of 25 kg of urea and 100 kg ammonium phosphate and used by placement beneath the seed before planting. An amount of 20 kg of required phosphorus also was provided from super phosphate triple source at planting time; 30 kg of nitrogen fertilizer (urea) in the spring was applied simultaneous with the irrigation. Whole seeds were sterilized before sowing by fungicides carboxyinthiram at a rate of 2 grams per kilogram and in order to control of broadleaf weeds chemical methods were performed. Experimental plots were designed as 6*6 meters with 20 cm spacing and seeding density was 450 seeds per square meter according to seed weight. In the irrigation experiment, irrigation was done at a rate of 50 mm per hectare. Then, irrigation for both experiments was conducted weekly until heading stage. After this stage, irrigation was done only for irrigation treatment and to determine the genotypes reaction to the stress, the irrigation for the second experiment did not conduct.

Table 1 - The names and properties of used genotypes

Genotype number	Genotype name	Growth habit
1	Col No.3625//Alamoot	w
2	/Vee"s"/3/Gascogne/4/Alamoot	w
3	Alvd//Aldan/Ias58/3/4/Mv17	w
4	Rsh2*/10120//Zagros	w
5	1-72-92/Vratza//Almt	w
6	Bez/90zhong 87/3/Alvd//Aldan/Ias	w
7	Owl/4/Gv/D630//Ald"s"/Azd	w
8	AGRI/BJY//VEE/6/SN64	w
9	1-72-92/Gascogne//Almt	w
10	Gascogne/7/Zarrin	w
11	Gds/4/Anza/3/Nac/6/Gascogne	w
12	1-72-92/Col/No.3617//Owl	w
13	VEE/3/TNMU/4/KS82142/CUPE	w
14	MADSEN/TAM-202//TX89V	w
15	Sardari- HD83//	w

Grains number per spike. After the main stems height per plant was measured, spikes per stem was beaten and the number of grains per spike were counted after purification. This method was carried out on each of 10 harvested plants and the average was calculated.

Grain weight per spike. The number of grain per spike was determined by weighting after counting and the average was reported in gram.

Biological yield. The area of one square meter of each plot was harvested and weight of shoot was determined before harvesting treatments.

1000-grains weight. After harvest, weight of 1000 grains was calculated based on counting 1000 grains by Contador and weighting.

Grain yield. In order to remove marginal effects in all the plots range from 0.5 meters along each side and width of 1.2 meters was eliminated. All treatments were harvested using a combine and grain yield was determined.

Removing flag leaf. At flowering stage 5 main stem were selected and their flag leaf were removed.

Removing all leaves except for flag leaf. At flowering stage, 5 main stem were selected and marked then their leaves except for flag leaf were removed.

Statistical analysis was conducted using SAS software and to means comparison Duncan method was performed.

RESULTS AND DISCUSSION

Genotypes comparisons under normal and stress conditions

Analysis of variance showed that there are significant differences among genotypes in terms of grain weight per spike ($P<0.01$) and biological yield ($P<0.05$) under normal condition. The findings about drought tolerance of new wheat genotypes by Komeili *et al.* (2006) also approve of our data. But, in the mentioned condition, there were no significant difference among genotypes regarding biological yield at pollination stage, spike weight, 1000-grain weight and grain yield (*Table 2)*.

Analysis of variance in late season stress condition showed that there were significant differences between genotypes about grain yield and biological yield at pollination stage ($P<0.05$), and in terms of biological yield and grain weight per spike ($P<0.01$). The differences for weight of 1000-grain wasn’t significant (*Table 2*). The genotypes consistency in terms of most traits resulted from selection of the suitable lines to test the uniformity around the country and this is normal.

Under normal condition, the highest biological yield was observed in genotype 3 with 52.6 g/15 stems, and the lowest was observed in genotype 2 with 35 g/15 stems (*Table 3*). Genotype 3 was semi-dwarf and may be cultivated with high density and because of its tolerance to lodging, its possible to use more level of chemical fertilizers. In the late season stress condition, genotypes 1 and 2 exhibited the greatest biological yield, 26.57 and 26.53 g/15 stems, respectively, while the lowest values were observed in genotypes 9 and 13 with, respectively, 16.71 and 13.50 g/15 stems (*Table 3*). Since genotype 2 had the lowest yield under normal condition, but under stress condition produced the greatest yield, so this genotype exhibited the highest resistance to drought stress.

Table 2 - Analysis of variance for measured traits in 14 wheat lines under non-stress (normal) and late season stress conditions

		MS									
		Non-stress condition					Stress condition				
S.O.V	df	Biological yield at pollination stage	Biological yield	Grain weight per spike	1000-Grain weight	Grain yield	Biological yield at pollination stage	Biological yield	Grain weight per spike	1000-grain weight	Grain yield
Rep	2	21.22*	3.4	15.4	92.52**	2786724.95*	8.8	97.25**	7.57	186.74**	94546.93
Genotype	13	1.35	69.08*	25.9**	34.02	1359193.93	26.64*	29.9**	8.62**	14.83	1003612.19*
Error	26	6.03	27.55	8.42	17.61	773640.44	3.99	6.64	2.6	9.52	476739.47
CV (%)		8.9	11.8	15.01	12.18	18.41	6.96	11.93	11.93	15.22	21.68

df: degree of freedom; MS: mean of square; CV coefficient of variation; *,** significant at 0.05 and 0.01 probability levels, respectively; ns; non-significant.

Table 3 - Mean comparison of measured traits in 14 wheat lines under non-stress (normal) and late season stress conditions

	Non-stress condition		Stress condition			
Genotypes	Biological yield	Grain weight per spike (g/5 plants)	Biological yield at pollination stage	Grain weight per spike (g/5 plants)	Grain yield (kg/ha)	Biological yield
1	42.6 abcd	19.2 bcd	32.7 a	12.4 a	3419.3 ab	26.57 a
2	35 d	20.23 bcd	32.07 ab	11.89 ab	3069.3 ab	26.53 a
3	52.6 a	26.17 a	27.63 cd	9.17 bcd	3074 ab	22.31 abc
4	44.4 abcd	15.23 d	28.93 abc	9.42 bcd	2801 ab	24.1 abc
5	46.5 abc	22.37 ab	28.83 bc	8.19 cd	2313 b	20.43 bcd
6	49.7ab	20.1 bcd	31.83 ab	8.67 cd	3912 a	21.94abc
7	49.2 ab	16.6 cd	29.73 abc	9.08 bcd	2930.3 ab	20.83 bcd
8	37.63 cd	16.13 cd	28.57 bc	7.28 cd	3767.3 a	19.47 cd
9	39.77 cd	16.17 cd	23.23 e	6.88 d	3228.7 ab	16.71 d
10	45.73 abc	17.3 bcd	26.27 cde	7.14 cd	2139 b	20.26 bcd
11	45.3 abc	20.5 bcd	24.03 de	8.03 cd	4134.3 a	19.68 dc
12	47.77 abc	21.07 abc	32.1 ab	10.23 abc	3717.7 a	25 ab
13	43.43 abcd	20.57 bcd	26.27 cde	7.34 cd	3148.3 ab	16.5d
14	42.9 abcd	18.9 Bcd	29.67 abc	8.19 cd	2828.7 ab	22.08 abc

Values in the same column, that are followed by the same letter, do not differ significantly (at 5% level), according to the Duncan's Multiple Range Test.

Austin (1989) carried out an experiment by using semi dwarf and natural lines regarding the effect of irrigation and drought stress on grain yield of wheat. He reported that under the complete irrigation, semi-dwarf lines, had between 13-15% higher yield, compared with control lines and even when this semi-dwarf lines exposed to early and late season drought stress, they exhibited 11% higher yield than control lines. The differences among lines in terms of biological yield at pollination stage weren't significant under normal condition, but under drought stress condition the differences were significant (P<0.05) (*Table 2*). Under stress condition, genotypes 1 and 2, respectively, with 32.7 and 32.07 g/15 stems, produced the highest biological yield and the lowest values were exhibited with 23.23 by genotype 9 (*Table 3*).

Under stress conditions, the highest grain weight per spike was related to genotype 1 with 12.4 g/15 stems and genotype 9 showed the lowest value with 6.88 g/15 stems (*Table 3*). The average weight of grain per spike under irrigation and drought stress conditions was, respectively, 19.33 and 8.58, which indicates that the grain weight per spike increased by 54.21% under irrigation condition, in comparison with drought stress condition. Genotypes that show stability about this trait, often show better tolerance under drought stress (Riaz and Chowdhry, 2003).

There was no significant difference among genotypes in regards of grain yield under irrigation condition, but under stress condition the differences were significant at 5% level (*Table 2*). Under drought stress condition, the highest grain yield was observed in genotype 11 with 4134.3 kg/ha and the lowest was observed in genotypes 10 and 5 with 2139 and 2313 kg/ha, respectively *(Table 3*). By comparing the grain yield of genotypes, it seems that the genotype 11 had high grain yield in both environments. Further investigators also suggested that the best genotype is the one that produce the high yield under both normal and stress conditions (Fernandez, 1992; Fisher and Maurer, 1978; Blum, 1988).

Grain yield is the direct parameter to measure the response of genotypes to stress. Genetic and physiological mechanisms that control the production process are affected by environmental factors. The morpho-physiological traits that have high heritability are important to enhance the yield (Hunter *et al*., 2004). In general, grain yield is an index to determine cereal response to environmental stresses (Ceccarelli and Grando, 1996).

Flag leaf defoliation treatment

The results of flag leaf defoliation test showed that there were significant differences among genotypes in terms of spike weight, leaves (except for flag leaf) weight, biological yield and grain weight per spike at 5% level.

Table 4 - Analysis of variance for measured traits in 14 wheat lines following flag leaf removal treatment under non-stress (normal) and late season stress conditions

		MS											
		Non-stress condition						Stress condition					
S.O.V	df	Peduncle weight	Peduncle weight at pollination	Biological yield	Grain weight per spike	Spike weight	Leaves (except for flag leaf) weight	Peduncle weight	Peduncle weight at pollination stage	Biological yield	Grain weight per spike	Spike weight	Leaves (except for flag leaf) weight
Rep	2	0.04	0.06	2.86	0.18	0.34	0.006	0.0022	0.0044	1.89	0.87	0.57	0.005
Genotype	13	0.1*	0.05	9.01*	2.06*	6.12**	0.015**	0.1	0.1**	5.17**	1.31*	3.52**	0.01**
Error	26	0.04	0.02	3.67	0.85	1.57	0.004	0.22	0.02	1.43	0.69	1.13	0.04
CV (%)			12.43	13.37	12.99	12.43	18.66	16.73	15.15	10.14	13.72	13.82	14.35

df: degree of freedom; MS: mean of square; CV coefficient of variation; *,** significant at 0.05 and 0.01 probability levels, respectively; ns: non-significant.

Table 5 - Mean comparisons for measured traits in 14 wheat lines following flag leaf removal treatment under non-stress (normal) and late season stress conditions

	Non-stress condition					Stress condition			
Genotypes	Spike weight (g/5 plants)	Grain weight per spike (g/5 plants)	Biological yield	Peduncle weight (g/5 plants)	Leaves (except for flag leaf) weight (g/5 plants)	Spike weight (g/5 plants)	Grain weight per spike(g/5 plants)	Peduncle weight at pollination (g/5 plants)	Leaves (except for flag leaf) weight (g/5 plants)
1	10.03 b	7.13 bc	14.93 b	1.63 abc	0.36 abc	9.67 a	6.33 a	1.17 abc	0.42 a
2	9.83 b	7.1 bc	14.67 b	1.63 abc	0.39 abc	9.1 ab	5.57 abc	1.07 abcd	0.4 a
3	14 a	9.3 a	18.97 a	2 a	0.33 bc	8.08 abcd	5.25 abcde	1.34 a	0.3 b
4	10.43 b	7.43 b	14.9 b	1.67 abc	0.31 bc	8.73 abc	6 ab	1.23 abc	0.3 b
5	9.9 b	7.1 bc	14.87 b	1.47 bc	0.18 d	8.97 ab	5.43 abcd	1.07 abcd	0.28 b
6	9.27 b	6.6 bc	13.83 bc	1.5 bc	0.33 bc	7.1 bcd	4.8 bcde	1 bcd	0.25 bc
7	10 b	6.63 bc	15.03 b	1.5 bc	0.38 abc	7.1 bcd	4.83 bcde	1.03 abcd	0.28 b
8	7 c	5.37 c	10.83 c	1.33 c	0.28 cd	7.8 abcd	5.23 abcde	1.27 ab	0.3 b
9	10.47 b	7.2 b	16.07 ab	1.77 ab	0.41 ab	6.5 d	4.3 cde	0.8 d	0.24 bc
10	10.67 b	7.2 b	16.3 ab	1.73 ab	0.32 bc	6.83 cd	4.06 e	0.93 cd	0.32 b
11	9.97 b	7.3 b	15.2 b	1.43 bc	0.49 a	6.1 d	4.17 de	0.76 d	0.25 bc
12	10.07 b	7.47 b	14.97 b	1.3 c	0.41 ab	6.6 d	4.63 cde	1.27 ab	0.29 b
13	9.6b	6.78 bc	15 b	1.5bc	0.37 abc	7.49 bcd	5.27 abcde	0.97 bcd	0.19 c
14	9.87 b	6.67 bc	13.73 bc	1.4 bc	0.43 ab	7.7 abcd	5.03 abcde	0.83d	0.26 bc

Values in the same column, that are followed by the same letter, do not differ significantly (at 5% level), according to the Duncan's Multiple Range Test.

Also, under stress condition by eliminating the flag leaf the differences of genotypes regarding biological yield, spike weight and leaves (except for flag leaf) weight were significant at 1% level and in case of grain weight per spike at 5% level (*Table 4)*.

Wheat flag leaf removal caused reducing the number of grains per spike, which has consequently decreased grain yield per unit area (Aggarwal *et al.,* 1990). Reduction and disruption in wheat leaves photosynthesis causes increased production of sterile pollens due to the disturbed distribution of assimilates.

Mean comparison clarified that the genotype 3 with 18.97 g/5 plants had the highest biological yield under normal condition, while the lowest was genotype 8 with 10.83 g/5 plants. Under stress condition, the highest and the lowest biological yield belonged, respectively, to genotype 1 and genotype 11 with 17.7 g/5 plants and 9.67 g/5 plants (*Table 5)*. Under non-stress (normal) condition, the mean comparison regarding spike weight on main stem showed that the highest value belonged to genotype 3 with 14 g/5 plants, while the lowest was observed in genotype 8. But, under stress condition, the highest value was observed in genotype 1, with 9.67 g/5 plants and the lowest was genotype 11 with 6.1 g/5 plants. Also, genotypes 3 and 8 represented the highest and the lowest biological yields, respectively (*Table 5*). This subject approves the importance of carbohydrates remobilization on spike weight, since following flag leaf removal photosynthesis rate decreases.

Mean comparison for the weight of peduncle in main stem showed that the highest amount was related to genotype 3 with 2 g/5 plants, while the lowest amount was related to genotype 8 with 1.33 g/5 plants. Under stress condition, the highest and the lowest values were, respectively, related to genotype 3 and genotype 11 with 1.34 and 0.76 g/5 plants (*Table 5*). Mean comparison for the grain weight per spike under normal condition showed that the highest amount was related to genotype 3 with 9.3 g/5 plants, while the lowest amount was related to genotype 8 with 5.37 g/5 plants. Under stress condition, the highest and the lowest values were, respectively, related to genotype 1 and genotype 10 with 6.33 and 4.06 g/5 plants *(Table 5*).

Since in wheat and other cereal crops, spikes are located in the upper part of the canopy, which provides the best lighting conditions for photosynthesis, and also since produced photosynthesis materials within spike are close to sink organ (grains) it seems that ears photosynthesis in these plants has a main role in grain yield (Sarmadnia *et al*., 1990).

Ehdaie and Wines (1996) also reported that there is a positive correlation between peduncle length and genotypes yield, and also added that the higher length of internodes (including peduncle) leads to increased carbohydrate storage and considerably affects grain yield.

Researchers estimates that contribution of ear in final grain yield varies from 10 to 76% depending on cultivar and environmental conditions. Wheat cultivars with larger and longer ears, compared with those which have smaller and shorter ears, have the greater ability for partitioning of sap to grains (Demotes and Jeuffroy, 2001).

Under irrigation condition, genotypes with longer ears have greater yield, probably due to higher photosynthetic capacity within ears (Wang *et al*., 2001). Longer spikes have higher storage capacity for nitrogen and remobilization form spike to grain, participates in drought tolerance in wheat genotypes (Slafer and Andrade, 1993).

Mean comparison for the leaves weight (except flag leaf) showed that the highest amount was related to genotype 11 with 0.49 g/5 plants, while the lowest amount was related to genotype 5 with 0.18 g/5 plants. Under stress condition, the highest and the lowest values were, respectively, related to genotype 1 and genotype 13 with 0.42 and 0.19 g/5 plants *(Table 5).*

Leaves defoliation (apart from flag leaf)

In the leaves defoliation (apart from flag leaf) experiment, analysis of variance in non-stress conditions (normal) showed that the genotypes for spike weight in the main stem, peduncle weight, biological yield and grain number per spike and flag leaf weight were significant differences ($P<0.01$) In addition, a significant differences was observed among genotypes in terms of peduncle weight ($P<0.01$), grain number per spike, biological yield, flag leaf weight and spike weight in the main stem ($P<0.05$) (*Table 6).*

Mean comparison for leaf defoliation (except for flag leaf) treatments under non-stress conditions indicated that the highest biological yield was related to genotype 10 with 16.93 g/5 plants and genotype 2 had the lowest value with 11.87 g/5 plants. The highest spike weight was observed in genotype 1 with 11.33 g/5 plants and the lowest one was genotype 13 with 8.2 g/5 plants (*Table 7).*

The highest grain number per spike belonged to genotype 12 with 269.67 grains, while the lowest value was observed in genotype 11 with 138 grains per 5 plants. The greatest flag leaf weight was observed in genotype 12 with 0.42 g/5 plants, while genotype 14 had the lowest value with 0.27 g/5 plants. Defoliation caused peduncle weight loss. In other words, the reduced source strength through defoliation causes higher utilization of carbohydrates storage within stem or lower storage of photosynthesis products within stem.

Mean comparison under stress conditions showed the highest biological yield was gained by genotype 1 with 17.91 g/5 plants, while genotype 9 exhibited the lowest yield by 9.4 g/5 plants.

Table 6 - Analysis of variance for measured traits in 14 wheat lines following leaves (except for flag leaf) removal under non-stress (normal) and late season stress conditions

		MS									
		Non-stress condition					Stress condition				
S.O.V	df	Biological yield	Spike weight	Peduncle weight	Grain number per spike	Flag leaf weight	Biological yield	Spike weight	Peduncle weight	Grain number per spike	Flag leaf weight
Rep	2	2.43	0.75	0.12**	353.34	0.002	6*	2.32	0.031	930.5	0.005*
Genotype	13	5.81**	2.84**	0.09**	4014.19**	0.013**	6.37**	3.13**	0.09*	2432.29**	0.01**
Error	26	1	0.66	0.012	335.95	0.04	1.17	0.86	0.033	756.17	0.036
CV (%)	7		8.37	7.9	8.98	12.85	9.84	13.03	13.52	13.69	12.5

df: degree of freedom; MS: mean of square; CV coefficient of variation; *,** significant at 0.05 and 0.01 probability levels, respectively; ns; non-significant.

Table 7 - Mean comparison in 14 wheat lines following leaves (except for flag leaf) removal under non-stress (normal) and late season stress conditions

	Non-stress condition					Stress condition				
Genotypes	Biological weight	Spike weight (g/5 plants)	Peduncle weight (g/5 plants)	Grain number per spike	Flag leaf weight (g/5 plants)	Biological weight	Spike weight (g/5 plants)	Peduncle weight (g/5 plants)	Grain number per spike	Flag leaf weight (g/5 plants)
1	16.17 ab	11.33 a	1.67 abc	214.67 cde	0.41 ab	14.91 a	9.7 a	1.67 a	253.67 a	0.33 ab
2	11.87 g	8.7 cd	1.67 abc	197 def	0.24 efgh	11.1 bcde	7.8 bc	1.4 abcd	225.33 abc	0.38 a
3	15.1 bc	10.77 ab	1.7 ab	231 bcd	0.23 gh	0.97 cde	6.03 cd	1.37 abcd	157 e	0.26 cd
4	14.7 bcde	10.63 ab	1.73 a	232.33 bc	0.26 defgh	11.53 bcd	7.63 bcd	1.23 bcd	199 bcde	0.3 bc
5	12.6 fg	8.67 cd	1.5 bcd	172 f	0.31 cde	11.77 bc	7.87 b	1.33 abcd	221 abcd	0.3 bc
6	15.1 bc	9.63 bcd	1.73 a	184.67 ef	0.37 abc	9.47 de	6.03 cd	1.2 cd	180.33 cde	0.24 cd
7	14 cdfe	9.83 abc	1.5 bcd	182 ef	0.3 cdefg	10.63 bcde	7.13 bcd	1.33 abcd	185 cde	0.26 cd
8	14.37 bcdef	9.6 cdb	1.83 a	176 f	0.28 defgh	11.4 bcde	7.07 bcd	1.53 abc	209.67 abcde	0.28 bcd
9	14.17 cdef	9.7 bcd	1.67 abc	211.33 cde	0.37 abc	9.4 e	6.3 bcd	1.1 d	170 de	0.29 bc
10	16.93 a	11 ab	1.73 a	231 bcd	0.24 fgh	11.57 bcd	7.77 bcd	1.57 ab	209.67 abcde	0.35 ab
11	14.77 bcd	10 abc	1.37 de	138 g	0.33 bcd	9.5 de	5.97 d	1.13 d	242.23 ab	0.22 d
12	14.43 bcdef	9.43 bcd	1.37 de	269.67 a	0.42 a	12.13 b	7.37 bcd	1.53 abc	206 abcde	0.4 a
13	12.82 efg	8.2 d	1.27 e	254 ab	0.31 cdef	10.06 bcde	6.6 bcd	1.2 cd	170.67 de	0.24 cd
14	12.86 defg	8.5 cd	1.47 cd	171 f	0.21 h	10.37 bcde	6.4 bcd	1.27 bcd	181.33 cde	0.21 d

Values in the same column, that are followed by the same letter, do not differ significantly (at 5% level), according to the Duncan's Multiple Range Test.

Genotype 1 had the highest spike weight (9.7 g/5 plants) and the lowest value was observed in genotype 11 with 5.97 g/5 plants. The highest peduncle weight belonged to genotype 1 with 1.67 g/5 plants, whereas genotype 9 had the lowest amount with 1.1 g/5 plants.

CONCLUSIONS

Under normal condition, genotype 3 showed the highest biological yield. Genotype 3 is a semi-dwarf cultivar and can be cultivated with high density as well as more level of chemical fertilizers. Genotype 2 exhibited the highest resistance to drought stress. Despite of lowest biological yield under normal condition, under stress condition produced the greatest biological yield. Although, in flag leaf defoliation treatment and stress condition, the highest biological yield belonged to genotype 1.

Also, genotype 11 with 4134.3 kg /h showed the highest grain yield under drought stress condition. In spite of changes in peduncle weight and grain number per spike in leaves defoliation and flag leaf defoliation experiments, grain yield did not reduced significantly.

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