J. Appl. Environ. Biol. Sci., 4(5)128-133, 2014

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Selection for Drought Tolerance in Bread Wheat Genotypes with Drought Tolerance and Susceptibility Indices

Moharram johari-pireivatlou

Moghan agricultural education center

Received: February 7, 2014
Accepted: April 9, 2014

ABSTRACT

To evaluate and selection the wheat genotypes regarding their response to drought stress, 10 genotypes were studied in a randomized complete block design with three replications in normal and stress conditions in two separate experiments in 2010 year in the farm of Moghan agricultural education center. The results showed that there were significant differences the between genotypes regarding grain yield in non-stress (normal) conditions. The highest mean grain yield under stress conditions was observed in Koohdasht genotypes (3160 kg/ha) while the highest mean grain yield under non-stress conditions was observed in Chamran genotypes (7100 kg/ha). MP, GMP, HAR, STI, TOL and SSI indices were used to investigate the tolerance of the genotypes under study. The results obtained from this investigation showed that STI, MP, SSI, and TOL indices had higher heritability than other indices. In addition, TOL, MP, GMP, HAR and grain yield indices had the highest coefficients of genetic variation. Based on MP, GMP, HAR, STI and grain yield indices under stress and non-stress conditions, Chamran, Kuhdasht, N-81-18, N83-3 and N-84-10 genotypes were identified as the tolerant genotypes with the highest grain yield. Based on the method used to select the genotypes as well as the heritability coefficients, MP and STI indices had better performance in cultivar selection compared to other indices. Using cluster analysis, the genotypes were classified into two groups. The tolerant genotypes were included in the first cluster while the susceptible genotypes were included in the second cluster. Assigning the genotypes to the different groups using cluster analysis had appropriate compliance with the drought tolerance of the genotypes.

KEYWORDS: diversity, heritability, grain yield, water stress.

INTRODUCTION

Bread Wheat (*Triticum aestivum L.*) is the most important crop in terms of acreage and production in the world. It has an important role in supplying nutritional requirements of human societies. The wheat alone provides the staple food for 35% of world population. About 35-38% of total cropping area is under wheat as the first top crop around the world. About 19% and 17% of total cropping area is under rice and maize respectively as the second and third top crop around the world (Hessadi, 2006; FAO, 2009).

Drought stress is one of the most important and the most common environmental stresses, which is a barrier to agricultural production and reduces yield in semi-arid and dry areas(Golparvar, 2003). Approximately 32% of the wheat growing regions in developing countries face some type of drought stress during the cropping season (Rajaram, and Van Ginkel, 1999). Iran is classified as a dry zone in worldwide view with 240 mm average rainfall. Therefore, identification of drought tolerant genotypes in these areas will be important in increasing the production.

To evaluate drought tolerance of different genotypes, different indices are used. Rosielle and Hamblin (1981)introduced tolerance index(TOL) and mean productivity(MP), Fisher and Maurer (1978) stress susceptibility index (SSI), Fernandez (1992) stress tolerance index (STI) and geometric mean productivity (GMP), and Kristin et al. (1997), harmonic mean(HAR). Considering evaluation of bread wheat genotypes, Sio-se Mardeh et al. (2006) and Golparvar. (2003) reported that STI, MP and GMP indices are considered as suitable kind of indices for identification of the genotypes with high grain yield in mild stress and stress and non-stress conditions.

Assessment of genetic diversity of crop plants for breeding programs and conservation of plant biodiversity (Bagheri et al. 1996) and management of genetic resources are considered as major components of plant breeding projects (Ghareyazi, 1996). In this regard, various methods are evaluated for estimating genetic diversity of plant species. Breeding specialists classify different cultivars and varieties in different groups in order to clarify the genetic distance between them and use the existing diversity among the plants in crosses programs. From this point, different methods such as multivariate analysis, cluster analysis are most widely used (Mohammadi and Prasanna, 2003). Amini et al. (2005) investigated 500 Iranian wheat genotypes under limited irrigation (only one time irrigation at planting time) and reported that the traits including grain yield, harvest index, biological yield, grain per spike, spike length, thousand-grain weight and length of the terminal node have appropriate diversity.

Naghavi et al. (2002) investigated both genetic diversity and various traits of 108 Mexican, Italian and Turkish genotypes of durum wheat. The genotypes under study were significantly different from each other for most of the traits. They concluded that traits such as number of grains per spike and thousand-grain weight could

***Corresponding Author:** Moharram Johari-Pireivatlou, Moghan agricultural education center.
Email: Moharramjohari@yahoo.com

be considered as appropriate indices for selection with the purpose of improving the grain yield. Golparvar (2003) evaluated 567 genotypes of bread wheat from the collection of Karaj College of Agriculture in an Augmented design under severe drought stress. They proposed that grain per plant and grain yield per spike are considered as the best selection criteria to improve grain yield in drought conditions.

This study aimed to evaluate the genetic diversity of genotypes of wheat under study in terms of drought tolerance. Then, it aimed to select the best drought tolerance indices and identify the most suitable drought-tolerant genotypes.

MATERIALS AND METHODS

In order to evaluate and selection wheat cultivars and lines in response to drought stress, an experiment with 10 genotypes (including 5 lines and 5 cultivars) was performed in 2010 crop year in farm of Moghan agricultural education center, located in North West of Iran with longitude of 47 degrees and 49 minutes and latitude of 39 degrees and 39 minutes. The cultivars under study included: Zagros, Niknajad, Koohdasht, Shiroodi, Chamran, N-78-14, N-80-60, N-81-18, N-83-3, N-84-10. Seed bed preparation included plowing, disc harrow and leveler. Chemical fertilizers were used with respect to soil test. Each line was planted separately in six rows with 15 cm distance in 8 m length plots in which 350 plants per m^2 were planted. In this study, two separate experiments were performed in both full irrigation and drought stress conditions during the growing season in randomized complete block design (RCBD) with three replications. During the crop growth, routine crop care including control of weeds, pests and diseases was equally observed for all the lines. Given the yield of the cultivars in both normal and stress conditions, following indices were calculated:

$$MP = \frac{Yp + Ys}{2}$$ (Rosielle and Hamblin, 1981)

$$GMP = \sqrt{(Ys)(Yp)}$$ (Fernandez, 1993)

$$TOL = Yp - Ys$$ (Rosielle and Hamblin, 1981)

(Fernandez, 1992)

$$STI = \frac{(Yp)(Ys)}{(\overline{Yp})^2}$$

(Fisher and Maurer, 1978)

$$SI = 1 - (\frac{\overline{Ys}}{\overline{Yp}})$$

$$SSI = \frac{1-(Yp/Ys)}{SI}$$

(Kristin et al., 1997)

$$HARM = \frac{2(Yp \times Ys)}{Yp + Ys}$$

as follows where Yp and Ys respectively show grain yield in each line or cultivar in non-stress and drought stress conditions while $\overline{Y}s$ and $\overline{Y}p$ respectively show the mean grain yield of all genotypes respectively in stress and normal conditions. To classify the genotypes under study into groups, cluster analysis with Ward algorithm method with squared Euclidean distance were used. Software MSTAT-C, SPSS (Ver.15) and EXCEL were used for data analysis. Mean values were compared using the least significant difference test (Duncan`s multiple rang test) at the 0/01 and 0/05 probability levels.

RESULTS AND DISCUSSION

Analysis of variance revealed that the genotypes under study are significantly different in terms of grain yield in non-stress condition at 1% probability level (Table 1). This indicated the existence of genetic diversity among the genotypes under study. This variation can be used as a genetic reserve by the breeder in breeding programs. The comparison between the means of the genotypes showed that the mean grain yield was 5572.33 kg/ha, the least grain yield was equal to 4546.667 kg/ha in N-80-60 line while the maximum grain yield was equal to 7100 kg/ha in Chamran line. In stress conditions, there was no significant difference between the genotypes in terms of grain yield. This indicated that due to drought stress, the grain yield of the genotypes under study did not differ from each other much. This reduced the difference between the genotypes in terms of grain yield. Thus, since the genetic variance among the genotypes was reduced, the phenotypic variation was insignificant as well. However, in stress condition Koohdasht and Niknajad genotypes had the highest (3160 kg/ha) and least grain yield (2300 kg/ha) grain yield respectively (Table 2).

Genetic variation refers to genetic differences both within and among population. Comparing the genetic variance in both conditions showed that the drought stress has significantly reduced the genetic variance for grain yield. This causes difficulty in selection of wheat genotypes under drought stress. The high genetic variance within the genotypes can be used as a criterion to increase the grain yield of the genotypes whose mean is high.

Considering drought tolerance and susceptibility indices, TOL, MP, GMP and HAR showed the greatest genetic variation within the genotypes. In addition, SSI and STI showed the lowest genetic variation (Table 1). Therefore, this index functions better and more advantageously regarding selection of the genotypes because most of their changes are genetic and heritable to the next generation.

Phenotypic variance of the grain yield in normal condition was higher than the one in stress condition. Because in non –stress condition, the situations for gene expression are available, Thus, the rate of phenotypic variation in non –stress condition was higher than stress condition. Regarding the indices under study, TOL, MP, GMP, and HAR indices showed the greatest amount of phenotypic variance. These changes were consistent with changes in the genetic variance (Table 1).

Heritability is the proportion of genetic variance to phenotypic variance. The relative importance of genetic factors in determining the phenotypic value is known as the heritability. In this study, the highest heritability of the grain yield was observed in normal condition (0.93), TOL (0.81), SSI (0.53), MP (0.77), GMP (0.51), and STI (0.52). The lowest general heritability for the yield stress was observed in the stress condition (0.16) and the HAR (0.25/0) (Table 1). Reduction in the heritability of grain yield in stress condition causes the fact that selection for this trait in stress condition is less effective and improving. The high heritability of the grain yield and the above-mentioned indices represent greater contribution of genetic variation compared to environmental variance. Therefore, due to high heritability of these traits, they can be used in indirect selection for grain yield despite the fact that the heritability of traits alone is not a suitable criterion for evaluating efficiency of the breeding with selection. However, heritability along with genetic gain criteria can be valuable measures in assessing efficiency of breeding with selection.

Table 1- Analysis of variance for grain yield, drought tolerance and susceptibility Indices and genetic parameters									
S.O,V	D.F	Yp	Ys	TOL	SSI	MP	GMP	HAR	STI
Replication	2.00	271463.33	148213.33	433423.33	0.00	101482.50	121780.20	163953.87	0.009
Genotypes	29.00	2229311.48 **	218583.70 n.s	2480135.19 **	0.07**	603913.80**	351643.97**	251804.49 n.s	0.021 **
Environmental variance(VE)	58.00	56500.37	139094.82	177864.07	0.02	53331.57	85366.23	125890.93	0.005
Genetic variance (VG)	-	724270.37	26496.30	767423.70	0.02	183527.41	88759.25	41971.19	0.005
Phenotypic variance (VP)	-	780770.74	165591.11	945287.78	0.04	236858.98	174125.48	167862.11	0.010
General heritability (H^2)	-	0.93	0.16	0.81	0.53	0.77	0.51	0.25	0.516
Genetic coefficient of variance(CVG)	-	12997.61	1030.72	25566.59	1.93	4507.61	2180.01	1030.85	0.000
Phenotypic coefficient of variance(CVP)	-	15.86	15.83	32.39	19.32	11.95	10.25	10.06	0.002
Environmental coefficient of variance(CVE)	-	4.27	14.51	14.05	13.28	5.67	7.18	8.71	0.002
Genetiv gain(Ga)	-	1688.52	134.13	1626.00	0.21	776.83	438.18	211.03	0.108
% Genetiv gain(%GA)	-	30.30	5.22	54.17	21.01	19.08	10.76	5.18	0.003

n.s, * and **: Not significant, significant at 5% and 1% probability levels, respectively.

Table 2- The mean of grain yield, drought tolerance and susceptibility Indices.								
Genotypes	Yp	Ys	TOL	SSI	MP	GMP	HAR	STI
(Zagros)	4916.67	2633.33	2283.33	0.85	3775.00	3579.87	3398.05	0.42
(Niknajad)	4836.67	2300.00	2536.67	0.98	3568.33	3330.00	3108.88	0.36
(Koohdasht)	5423.33	3160.00	2263.33	0.78	4291.67	4138.59	3991.12	0.55
(Shiroodi)	5300.00	2456.67	2843.33	0.99	3878.33	3598.44	3341.59	0.42
(Chamran)	7100.00	2683.33	4416.67	1.15	4891.67	4359.41	3886.95	0.61
N-78-14	4813.33	2866.67	1946.67	0.75	3840.00	3713.72	3591.69	0.45
N-80-60	4546.67	2366.67	2180.00	0.90	3456.67	3275.12	3104.00	0.35
N-81-18	6633.33	2450.00	4183.33	1.16	4541.67	4014.14	3554.34	0.52
N-83-3	6186.67	2390.00	3796.67	1.14	4288.33	3842.41	3443.84	0.48
N-84-10	5966.67	2400.00	3566.67	1.12	4183.33	3777.80	3413.71	0.46

Talei and Noor Mohammadi (1994) studied the general and specific heritability of important agronomic traits in wheat in three crosses. In this study, the general heritability of grain yield per plant was more than 70%. Khaghani, et al. (2007) obtained general heritability of grain yield per plant as 56%. Naderi, et al. (2000) crossed two Iranian lines and three foreign lines in order to estimate general and specific heritability of the grain yield and its components using mean generation analysis. The range of general heritability for all traits was moderate to high (50% to 91%). Hockett and Nilan (1985) reported that the range of heritability of the grain yield was from 0.24 to 0.96. However, the level of heritability depends on the existing amount of genetic diversity, environmental factors and the trait type.

Given that the coefficient of genetic variation lacks scale, it is a more appropriate criterion than the genetic variance in measuring the diversity. In this study, the grain yield and TOL, MP, GMP, and HAR indices had the highest coefficient of genetic variation (Table 1). This indicated the high difference between the genotypes.

In terms of percentage of genetic gain, the highest value of this parameter relevant to grain yield was observed in non-stress condition (30.30%) and TOL (54.17%), SSI (21.01%), MP (19.08%), GMP (10.76%). The lowest value of this parameter relevant to grain yield was observed in stress condition (5.22%) and the HAR (5.18%) and STI (0.00%) (Table 1). Therefore, these criteria can be used in selection or elimination of the desired genotypes with confidence.

The results obtained from analysis of variance showed that there is a significant difference between genotypes regarding drought tolerance indices (Table 1).

If the TOL index decreases, the tolerance of the genotype to drought increases. Therefore, based on this index, N-78-14, N-80-60, Koohdasht and Zagros genotypes were selected. These genotypes had low grain yield in both conditions (Table 2). Thus, this index select the genotypes, which have low grain yield in the normal condition while have high potential grain yield in the stress condition. Therefore, this index alone cannot be considered an appropriate index for selection of group A. Using SSI Index, N-78-14, Koohdasht, Zagros and N-80-60 genotypes were identified as less susceptible genotypes to drought stress. This index, like the TOL index, selects the genotypes with low yield and less susceptibility. Then, it results in selection of the genotypes with low grain yield. Therefore, this index is not also able to identify the genotypes, which have high grain yield in both normal and stress conditions.

Chamran, Koohdasht, N-81-18, N-83-3 and N-84-10 cultivars had the highest MP, GMP, HAR and STI indices. These genotypes had high grain yield in both normal and stress conditions (Table 2). Therefore, they result in selection of drought-tolerant genotypes with high grain yield. Thus, this index, better than TOL and SSI indices, identified tolerant genotypes with high potential grain yield. Among these indices, since STI index free of scale, it was more paid attention to compared to other indices. These results are agreement with the findings obtained by Alavi and Shoaei Deilami (2004) who indicated the superiority of STI index in identification of tolerant genotypes.

Grouping of genotypes based on grain yield and drought tolerance indices using Ward method based on squared Euclidean distance were performed on the standardized data. The dendrogram cut with five units distance generated two clusters (Figure 1). The first cluster included N-83-3, N-84-10, Chamran and N-81-18 genotypes. This can be divided into two subgroups. The first subgroup of the first cluster included N-83-3 and N-84-10 genotypes while the second subgroup of the first cluster included Chamran and N-81-18 genotypes. The latter genotypes had high grain yield and the highest values of MP, GMP, HAR and STI indices. Therefore, this cluster included tolerant genotypes.

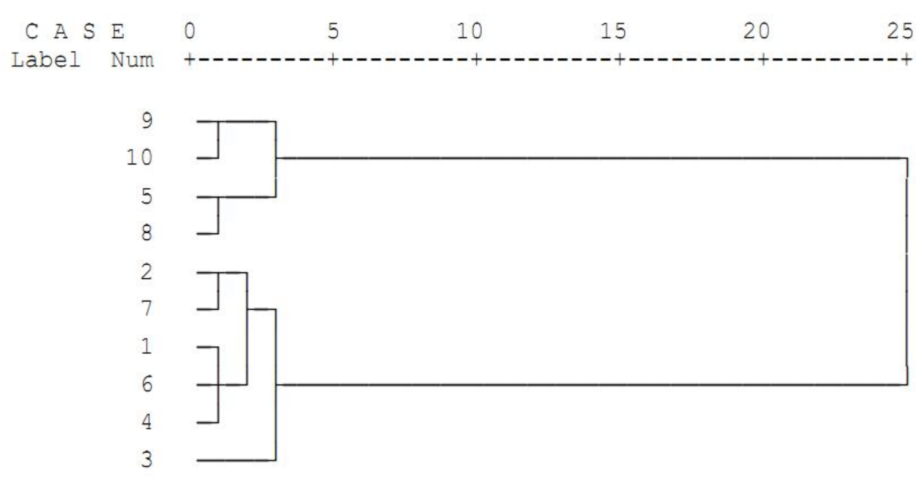

Figure 1. Dendrogram of cluster analysis of genotypes based on grain yield and tolerance and susceptibility indices.

The second cluster included six genotypes. The first subgroup of the second cluster included Niknajad, N-80-60, Zagros, N-78-14 and Shiroodi genotypes while the second cluster in the second subgroup included Koohdasht genotype. All genotypes of the second cluster had the lowest values of MP, GMP, HAR and STI indices and grain yield under stress and non-stress conditions. Therefore, this group included susceptible genotypes. It can be concluded that cluster analysis could appropriately divide the genotypes into two groups of susceptible and tolerant genotypes based on grain yield and drought susceptibility and tolerance indices.

In general, based on the obtained results, Chamran genotype is the most appropriate genotype to be planted in the stress condition based on the grain yield and drought tolerance indices.

REFERENCES

Alavi R, Shoaie Deilami M (2004) Selection of different tobacco cultivars for resistance to drought in Rasht regions. Proceedings of the 8th Agronomy and Plant Breeding os Iran. College of Agricultural Sciences of Guilan, Rasht. P 78. (In Persian)

Amini A, Esmailzade-Moghadam M, Vahabzadeh M (2005) Genetic diversity based on agronomic performance among Iranian wheat landraces under moisture stress. The 7th International Wheat Conference, Nov. 27, Dec 2, 2005. Mardel Plata, Argentina.

Bagheri A, Koochaki A, Zand E (1996) Plant Breeding in Sustainable Agriculture. Mashhad University Jihad Publications, Mashhad, Iran. (In Persian)

FAO. (2009) FAO STAT. Food and agricultural commodities production. Available at online http://faostat.fao.org/site/339/default.aspx (verify Ed 29 June 2010). FAO, Rome, Italy.

Fernandez GC J (1992) Effective selection criteria for assessing plant stress tolerance. Proceeding of the International Symposium, Taiwan, 13-16 Aug. 1992. pp: 257-270.

Fischer RA, Maurer R (1978) Drought resistance in spring wheat cultivars. Part 1: Grain yield responses. Australian Journal of Agricultural Research. 29: 897-912.

Ghareyazi B (1996) Using DNA markers in plant breeding. Key Papers Book of the 4th. Iranian Congress of Agronomy and Plant Breeding Science. Isfahan University of Technology, Isfahan, Iran. 328-380 (In Persian)

Golparvar AA, Ghanadha MR, Zali A A, Ahmadi A (2003) Determine of the best selection criteria for improvement of yield of bread wheat genotypes under drought stress condition. Journal of Seed Plant. 18: 144- 156.

Hessadi P (2006) Selection for drought resistance in lines of barley in Kermanshah region. Journal of Agricultural Sciences. 1: 143- 153.

Hockett EA, Nilan RA (1985) Genetics of Barley. ASA, CSSA, Madison, W1, USA.

Khaghani S, Ghannadha MR, Changhizi M, Dorri HM, Moshayedi MA (2007) Evaluation and study of qualitative and quantitative traits in red bean and chitti bean. Proceedings of the 2nd National Pulse Crops Symposium of Iran. Islamic Azad University, Science and Research Branch, Tehran, Iran. (In Persian)

Kristin AS, Serna RR, Perez FI, Enriquez BC, Gallegos YAA, Valleyo PR, Wassimi N, and DKelly J (1997) Improving common bean performance under drought stress. Crop Sci. 37: 51-60.

Mohammadi SA, Prasanna BM (2003) Analysis of genetic diversity in crop plants, salient statistical tools and considerations. Crop Sci. 43:1235- 1248.

Naderi A, Majidi-Heravan E, Hashemi-Dezfuli A, Rezaie A, Nour-Mohammadi G (2000) Efficiency analysis of indices for tolerance to environmental stresses in field crops and introduction of a new index. Seed and Plant. 15 (4): 390-402.(In Persian)

Naghavi MR, Shahbaze PA, Talei A (2002) Study of genetic variation in durum wheat germplasm for some morphological and agronomic characteristics. Iranian Journal of Crop Sci. 4(2): 81-86.

Rajaram S, Van Ginkel M (1999) CIMMYT's approach to breeding for wide adaptation. Euphytica. 92: 147-153.

Rosielle AT, Hambelen J (1981) Theatrical aspect of selection for yield in stress and non-stress environment. Crop Sci. 21: 493-500.

Sio-se Mardeh A, Ahmadi A, Poustini K, Mohammadi V (2006) Evaluation of drought resistance indices under various environmental conditions. Field Crops Research. 98: 222-229.

Talei A, Noormohammadi Gh (1994) Estimation of broadence and narrowsence heritability in three crosses of bread wheat. Iranian Journal of Agricultural Sciences. 25(4): 79-86.