American-Eurasian J. Agric. & Environ. Sci., 10 (6): 1064-1067, 2011
ISSN 1818-6769

Selection of Index for Drought Tolerance in Wheat Genotype

Houman Homayoun

Department of Agronomy and Plant Breeding, Saveh Branch, Islamic Azad University, Saveh, Iran

Abstract: This experiment was conducted on 10 wheat genotypes in Research Farm of Lion University, France. Five drought tolerance and susceptible indices (SSI, TOL, MP, STI and GMP) were calculated on the basis of genotypes grain yield in both stressed (Ys) and non-stressed (Yp) conditions. There is a significant difference between genotypes for indices MP, GMP, TOL and STI; while the maximum of MP, STI and GMP was belonged to genotype 35. Genotypes 35, 25 and 6 had the most amount of STI index. Results of correlation analysis between indices and mean of yield in both conditions showed that the most suitable indices to screen genotypes in drought stress condition are MP, STI and GMP. The results of calculated gain from indirect selection from moisture stress environment would improve yield in moisture stress environment better than selection from non moisture stress environment. Wheat breeders should, therefore, take into account the stress severity of the environment in choosing an index. Finally results showed that STI and MP indices are better than other indices.

Key words: Wheat · Drought · Stress indices

INTRODUCTION

Biotic and abiotic stresses result in decreasing yield of agricultural plants and prevent yield potential occurrence, annually. Among abiotic environmental stresses, drought stress is one of the most important factors for decreasing yield in the majority of cultivation areas for agricultural plants [1]. Drought stress and dryness affected 40 to 60 percent of the world's agriculture lands [2]. Iran is among dry and semidry areas with on average atmospheric descents in every year (240mm) [3]. In dry and semidry areas, the most important factor to limiting economical yield is water and its availability in critical growth stages of different agricultural plants [1, 4]. Due to occurrence of different forms of stress, especially drought stress in different stages of wheat growth, the average yield which was obtained in such areas every year, is 30 percent of the maximum yield which can be harvested [5].

Drought tolerance consists of ability of crop to growth and production under water deficit conditions. A long term drought stress effects on plant metabolic reactions associates with, plant growth stage, water storage capacity of soil and physiological aspects of plant. Drought tolerance in crop plants is different from wild plants. In case crop plant encounters severe water deficit, it dies or seriously loses yield while in wild plants their surviving under this conditions but no yield loss, is taken into consideration. However, because of water deficit in most arid regions, crop plants resistance against drought, has always been of great importance and has taken into account as one of the breeding factors [6]. Achieving a genetic increase in yield under these environments has been recognized to be a difficult challenge for plant breeders while progress in yield grain has been much higher in favorable environments [7]. Thus, drought indices which provide a measure of drought based on yield loss under drought conditions in comparison to normal conditions have been used for screening drought-tolerant genotypes [8]. These indices are either based on drought resistance or susceptibility of genotypes [9]. Drought resistance is defined by Hall [10] as the relative yield of a genotype compared to other genotypes subjected to the same drought stress. Drought susceptibility of a genotype is often measured as a function of the reduction in yield under drought stress [11] whilst the values are confounded with differential yield potential of genotypes [12]. Rosielle and Hamblin [13] defined stress tolerance (TOL) as the differences in yield between the stress (Ys) and non-stress (Yp)

Corresponding Author: Houman Homayoun, Department of Agronomy and Plant Breeding, Saveh Branch, Islamic Azad University, Saveh, Iran. Tel: +9192058725, E-mail: hooman_homayoon@yahoo.com.

environments and mean productivity (MP) as the average yield of Ys and Yp. Fischer and Maurer [14] proposed a stress susceptibility index (SSI) of the cultivar. Fernandez [15] defined a new advanced index (STI = stress tolerance index), which can be used to identify genotypes that produce high yield under both stress and non-stress conditions. Other yield based estimates of drought resistance are geometric mean (GM), mean productivity (MP) and TOL. The geometric mean is often used by breeders interested in relative performance since drought stress can vary in severity in field environment over years [12]. Clark *et al*. [16] used SSI for evaluation of drought tolerance in wheat genotypes and found year-to-year variation in SSI for genotypes and their ranking pattern. In spring wheat cultivars, Guttieri *et al*. [17] using SSI criterion suggested that SSI more than 1 indicated above-average susceptibility to drought stress. Golabadi *et al*. [18] and Sio-Se Mardeh *et al*. [19] suggested that selection for drought tolerance in wheat could be conducted for high MP, GMP and STI under stressed and non-stressed environments. Selection of different genotypes under environmental stress conditions is one of the main tasks of plant breeders for exploiting the genetic variations to improve the stress-tolerant cultivars [16]. This study was done for selection better stress tolerant index in wheat genotypes.

MATERIALS AND METHODS

This experiment was carried out in Research Farm of lion University, France in 2010 agricultural year using ten wheat genotypes. Seeds were hand drilled and each genotype was sown in five rows of 1.5 m, with row to row distance of 0.2 0 m. The experiment was laid out in randomized complete block design (RCBD) with two replications. Two levels of stress treatments including:

- Full irrigation (100 percent water based on plant needs wheat cultivars at different growth stages).
- Limited irrigation (Supply plant water needs until pollination stage and then format water until the end of wheat growth and development).

Every line in 5 rows and 20 cm intervals and 150 cm in width were planted. Immediately after planting the field was irrigated to soil moisture profiles in root development and saturated and identical for all treatments in addition to the germination easily is done. Irrigation was done with leaking method. After harvest to evaluate the factors affecting the performance traits, plant height, tiller number total , fertile tillers, number of internodes, peduncle length, length of main spike, spike original weight, awn length, total dry weight, number of seeds per main spike and main spike grain weight were measured.

The irrigation process was conducted by the flooding way. Irrigation was twice prevented after anthesis for drought treatments. The weeds were manually removed.

Each plot was harvested after physiological maturity; and follow drought tolerance and drought susceptibility indices calculated by yield of genotypes in both normal irrigation and drought stress conditions:

$$SI = 1 - (Y_s/Y_p)$$
$$SSI = (1 - (Y_{si} / Y_{pi})) / SI$$
$$MP = (Y_{Pi} + Y_{Si}) / 2$$
$$TOL = (Y_{Pi} - Y_{si})$$
$$STI = (Y_{pi} \times Y_{Si})/Yp^2$$
$$GMP = v Y_{Pi} \times Y_{si}$$

Data were analyzed using SPSS16 for analysis of variance and Duncan's multiple range tests was employed for the mean comparisons.

RESULTS AND DISCUSSION

Achieved results from variance analysis of grain yield in both drought stress and normal irrigation conditions showed that there is a significant difference between under-study genotypes in normal irrigation condition, while there was no difference significantly between under-study genotypes in drought stress condition (Table 1). Therefore it seems that genotypes had different susceptibility or resistance for grain yield reaction to stress. Similar results were obtained byO, Bruckner and Frfhberg, [20].

With respect to results of correlation coefficients of different indices (Table 2) and grain yield in two drought stress and normal irrigation conditions, It was observed that indices STI, MP, GMP and HM had the above-mentioned characteristic. These indices have positive and significant correlation with grain yield of genotypes at probability level of 1% in two drought stress and normal irrigation conditions. Therefore, genotypes which had higher amount of these indices identified as the most tolerant genotypes. In relation to other indices it has been seen that TOL index has a positive and significant correlation with yield in normal irrigation condition, but its correlation with yield in drought stress condition was

Table 1: Results of analysis of variance for drought tolerance indices

		MS							
S.O.V	df	YP	YS	SSI	MP	GMP	TOL	STI	HM
Replication	2	-	-	-	-	-	-	-	-
Genotype	9	**	-	-	**	**	**	**	**
Error	18	2.68	1.59	0.98	1.025	1.89	4.65	0.017	0.96

ns: non significant differences; *: significant at $p<0.05$; **: significant at $p<0.01$

Table 2: Correlation coefficient between different indices and grain yield

	YP	YS	SSI	MP	GMP	TOL	STI
YS	0.005	1					
SSI	0.731**	-0.331**	1				
MP	0.818**	0.256*	0.507**	1			
GMP	0.710**	0.448**	0.355**	0.860**	1		
TOL	0.799**	-0.261*	0.833**	0.616**	0.434**	1	
STI	0.704**	0.436**	0.337**	0.850**	0.875**	0.443**	1

significantly negative. Since genotypes which had lower amounts of this index, identified as tolerant genotypes, selection process according to this index lead to choosing genotypes which had high yield in drought stress conditions, but their yield is low in normal irrigation condition. So this index and SSI can not be helpful to identifying tolerant genotypes. Relevant findings to GMP, MP and STI in these conditions are compatible with Fernandez, [15].

DISCUSSION

Yield and yield-related traits under stress were independent of yield and yield-related traits under non-stress conditions, but this was not the case in less severe stress conditions. As STI, GMP and MP were able to identify cultivars producing high yield in both conditions. When the stress was severe, TOL, YSI and SSI were found to be more useful indices discriminating resistant cultivars, although none of the indicators could clearly identify cultivars with high yield under both stress and non-stress conditions (group A cultivars). It is concluded that the effectiveness of selection indices depends on the stress severity supporting the idea that only under moderate stress conditions, potential yield greatly influences yield under stress [21, 22]. Two primary schools of thought have influenced plant breeders who target their germplasm to drought-prone areas. The first of these philosophies states that high input responsiveness and inherently high yielding potential, combined with stress-adaptive traits will improve performance in drought-affected environments [7, 23, 24, 25]. The breeders who advocate selection in favorable environments follow this philosophy. Producers, therefore, prefer cultivars that produce high yields when water is not so limiting, but suffer a minimum loss during drought seasons [26]. The second is the belief that progress in yield and adaptation in drought-affected environments can be achieved only by selection under the prevailing conditions found in target environments [27, 28, 29]. The theoretical framework to this issue has been provided by Falconer [30] who stated that yield in low and high yielding environments can be considered as separate traits which are not necessarily maximized by identical sets of alleles. Over all, drought stress reduced significantly the yield of some genotypes and some of them revealed tolerance to drought, which suggested the genetic variability for drought tolerance in this material. Therefore, based on this limited sample and environments, testing and selection under non-stress and stress conditions alone may not be the most effective for increasing yield under drought stress. The significant and positive correlation of Yp and MP, GMP and STI showed that these criteria indices were more effective in identifying high yielding cultivars under different moisture conditions. The results of calculated gain from indirect selection in moisture stress environment would improve yield in moisture stress environment better than selection from non-moisture stress environment. Wheat breeders should, therefore, take into account the stress severity of the environment when choosing an index.

REFERENCES

1. Emam, Y. and M.J. Seghatoleslami, 2005. Crop Yield: Physiology and Processes. Shiraz University Press, pp: 593.

2. Bray, E.A., 1997. Plant response to water deficit trends. Plant Sci., 2: 48-54.
3. Kordovani, P., 2000. Agriculture in drought areas. Tehran University Press, pp: 211.
4. Emam, Y., 2007. Cereal production. 3rd Edition. Shiraz University Press, pp: 190.
5. Denge, X.P., L. Shan, S. Inanaga and M. Inoue, 2005. Water saving approaches for improving wheat production. J. Sci. Food Agric., 85: 1379-1388.
6. Talebi, R., 2009. Effective selection criteria for assessing drought stress tolerance in durum wheat (*Triticum durum* Desf.). General and Applied Plant Physiol., 35(1-2): 64-74.
7. Richards, R.A., G.J. Rebetzke, A.G. Condon and A.F. Herwaarden, 2002. Breeding opportunities for increasing the efficiency of water use and crop yield in temperate cereals. Crop Sci., 42: 111-121.
8. Mitra, J., 2001. Genetics and genetic improvement of drought resistance in crop plants. Curr Sci., 80: 758-762.
9. Fernandez, G.C.J., 1992. Effective selection criteria for assessing plant stress tolerance. In Proceeding of the Symposium. Taiwan, 13-16 August pp: 257-270.
10. Hall, A.E., 1993. Is dehydration tolerance relevant to genotypic differences in leaf senescence and crop adaptation to dry environments? In: T.J. Close and E.A. Bray, (Eds.), Plant Responses to cellular Dehydration During Environmental Stress, pp: 1-10.
11. Blum, A., 1988. Plant Breeding for Stress Environments. CRC Press, Florida, pp: 212.
12. Ramirez, P. and J.D. Kelly, 1998. Traits related to drought resistance in common bean. Euphytica, 99: 127-136.
13. Rosielle, A.A. and J. Hamblin, 1981. Theoretical aspects of selection for yield in stress and non-stress environment. Crop Sci., 21: 943-946.
14. Fischer, R.A. and R. Maurer, 1978. Drought resistance in spring wheat cultivars. I., Grain yield response. Aust. J. Agric. Res., 29: 897-907.
15. Fernandez, G.C.J., 1992. Effective selection criteria for assessing stress tolerance. In: C.G. Kuo, (Ed.), Proceedings of the International Symposium on Adaptation of Vegetables and Other Food Crops in Temperature and Water Stress, Publication, Tainan, Taiwan.
16. Clarke, J.M., R.M. De Pauw and T.M. Townley-Smith, 1992. Evaluation of methods for quantification of drought tolerance in wheat. Crop Sci., 32: 728-732.
17. Guttieri, M.J., J.C. Stark, K. Brien and E. Souza, 2001. Relative sensitivity of spring wheat grain yield and quality parameters to moisture deficit. Crop Sci., 41: 327-335.
18. Golabadi, M., A. Arzani and S.A.M. Maibody, 2006. Assessment of drought tolerance in segregating populations in durum wheat. Afr. J. Agric. Res., 5: 162-171.
19. Sio-Se Mardeh, A., A. Ahmadi, K. Poustini and V. Mohammadi, 2006. Evaluation of drought resistance indices under various environmental conditions. Field Crop Res., 98: 222-229.
20. Bruckner, P.L. and D.B. Frfhberg, 1989. Influence of crop water environment and dry matter accumulation on grain yield of no-till winter wheat. Can. G. [NBE2] Plant. Sci., 69: 367-375.
21. Blum, A., 1996. Crop responses to drought and the interpretation of adaptation. Plant Growth Regul, 20: 135-148.
23. Van Ginkel, M., D.S. Calhoun, G. Gebeyehu, A. Miranda, C. Tian-you, R. Pargas Lara, R.M. Trethowan, K. Sayre, L. Crossa and S. Rajaram, 1998. Plant traits related to yield of wheat in early, late, or continuous drought conditions. Euphytica, 100: 109-121.
24. Rajaram, S. and M. Van Ginkle, 2001. Mexico, 50 years of international wheat breeding, In: A.P. Bonjean and W.J. Angus, (Eds.), The World Wheat Book: A History of Wheat Breeding, Lavoisier Publishing, Paris, France, pp: 579-604.
25. Betran, F.J., D. Beck, M. Banziger and G.O. Edmeades, 2003. Genetic analysis of inbred and hybrid grain yield under stress and nonstress environments in tropical maize. Crop Sci., 43: 807-817.
26. Nasir Ud-Din, B.F. Carver and A.C. Clutte, 1992. Genetic analysis and selection for wheat yield in drought-stressed and irrigated environments. Euphytica, 62: 89-96.
27. Ceccarelli, S., 1987. Yield potential and drought tolerance of segregating populations of barley in contrasting environments. Euphytica, 40: 197-205.
28. Ceccarelli, S. and S. Grando, 1991. Selection environment and environmental sensitivity in barley. Euphytica, 57: 157-167.
29. Rathjen, A.J., 1994. The biological basis of genotype - environment interaction: its definition and management. In: Proceedings of the Seventh Assembly of the Wheat Breeding Society of Australia, Adelaide, Australia.
30. Falconer, D.S., 1952. The problem of environment and selection. Am. Nat., 86: 293-298.