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Study of Drought Tolerance of Durum Wheat Genotypes under Drought and Irrigated Conditions

[1]Roza Gholamin, [2]Mohammad Zaeifizadeh and [1]Majid Khayatnezhad

[1]Young Researchers Club, Islamic Azad University, Ardabil Branch, Ardabil, Iran
[2]Islamic Azad University, Ardabil Branch, Ardabil, Iran

Abstract: As with the durum wheat characteristics interms of tolerance against environmental stresses and disease and also, water deficits, study of drought tolerance in this plant is of great importance. Twenty five durum wheat genotypes under both stress and normal conditions were examined in Ardabil, Iran, in 2008-2009 cropping year. Results showed that there were significant differences among genotypes and interactions of genotypes under drought conditions for the majority of growing traits. Rate of drought tolerated by Fernandez index (STI). Boeuffi and Leucurum genotypes showed the highest index among the sub convar genotypes. Classification of genotypes based on STI was performed using Cluster procedure and were Classified into three categories from which, sub convars of Hordeiforme (Ahar), Leucurum, Hordeiforme (Langan) and Boeuffi gained the highest STI an account of high seed weight per main spike, weight of main spike, seed number per main spike and 1000-seed weight. Results of Cluster were in accordance with those of drought tolerance.

Key words: Drought tolerance · Durum · Stress · Ardabil · STI · Cluster

INTRODUCTION

For thousands of years, durum wheat (*Triticum turgidum*, L. var. Durum Defs) has been cultivated both irrigated and rain-fed in the west of Iran. Tetraploid durum wheat (*T. durum*) or hard wheats mainly are used to produce semolina flour used in the food industries especially pasta spaghetti. However, under cultivated area of this plant is less than other hexaploid wheats, but their resistance against disease and environmental stresses such as common consistencies, is more and remarkable in drought conditions [1]. Wheat production in Mediterranean region is often limited by sub-optimal moisture conditions. Visible syndromes of plant exposure to drought in the vegetative phase are leaf wilting, a decrease in plant height, number and area of leaves and delay in accuracy of buds and flowers [2]. 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 [2]. 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 [3]. 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 [4]. With regard to these features and increasingly demand for durum wheat to extend pasta industry in the country, such researchers are important. Drought is one the most important limiting factors of crop plants such as wheat in the world and Iran. This is of great importance especially in the arid and semi arid regions [5]. Over the one fourth of the earth includes dry areas and it has been cleared that nearly one third of the cultivated lands suffer from water deficit [5]. In an experiment done on the 84 Syrian native durum cultivars, Elgin [6] recorded dry to earring, length and width flag

Corresponding Author: Roza Gholamin, Young Researchers Club, Islamic Azad University, Ardabil Branch, Ardabil, Iran, Tel: +989144521606, E-mail: gholamein@yahoo.com.

leaf, plant height, awn and spikelet height and color, number pf spikelet per spike and seed Shrinkage to explain relations among the different native cultivars and also, relations among the different geographical sites using three main variables describing 20, 29 and 51 percent of total variation of data. The first variable positively was associated with the day to earring and color and length of the awn and spike. In the second variable, width of the flag leaf and number of spikelet per spike had the higher coefficients. In the third variable, only the seed Shrinkage was greater. By study the relations between genotype and environmental conditions (drought and normal) on the rate of chlorophyll content and Superoxide Dismutase, Zaefizadeh *et al*, [7] reported that in the tolerant cultivars, Superoxide Dismutase is increased by increasing drought stress while, insignificant increase or even, decrease in the chlorophyll Superoxide Dismutase (SOD), takes place. They revealed a remarkable variation among the native durum cultivars of the north-east of Iran and Azerbaijan in term of resistance to drought and sequence related amplified polymorphism (SRAP) molecule marker but did not find significant relation between drought tolerance coefficient and SRAP. The aim of this study was to evaluate tolerance ability of native durum wheat cultivars to drought for selecting resistant genotypes. Also, the object of this work was to evaluate drought impact on yield and yield components and assessment of tolerance and susceptibility indices to extend knowledge about physiological behaviors of this plant.

MATERIALS AND METHODS

The present work was carried out at the agriculture research center, Islamic Azad university, Ardabil branch, Ardabil, Iran, in 2008-2009 cropping year using 25 Iran and Azerbaijan oriented durum wheat cultivars, arranged as randomized complete block design (RCBD) under irrigated and rain fed conditions with four replications.

Stress Treatments Included:

- Whole irrigated (100 percent used water based on the plant demand at various growing stages)
- Limited irrigation (water supply until anthesis and after wards drought employing as water withholding until the end of growing stage).

Each genotype was planted on five rows placed 150 cm apart. Distances between irrigated and drought blocks were 1 m but were 2 m between the two irrigated or drought blocks. Upon the planting, irrigated was performed for whole blocks to moistent soil profile in the rhizosphere of all cultivars to facilitate germination. Irrigation was done as flooding at the harvest time, to prevent border effect, 50 cm of each row from both sides were eliminated to harvest and following traits were measured: plant height, total number of tillers, fertile tillers, peduncle length, main spike length, main spike weight, total plant dry weight, number of seeds per spike, number of seed seeds per main spike and seed weight per main spike. Also, seed yield of each block was measured. To determine the susceptibility and tolerance rates of the genotypes, stress tolerance index (Fernandez, 1992) was used:

Stress Tolerance Index (STI):

$$STI= (Ypi*Ysi)/Yp^2$$

(Fernandez, 1992)

Ysi = Yield of cultivar in stress condition,
Ypi = Yield of cultivar in normal condition
Yp = Total yield mean in normal condition

Data were subjected to analysis by MSTAT-C and Spss16 softwares and graphs were prepared by Excel.

RESULTS

Results showed that the drought stress affected majority of traits (Table 1).

It was cleared that the differences between irrigated and drought, were significant for the majority of traits. Plant height, peduncle length, main spike length, Total plant weight, grains per main spike, Grain weight per main spike, 1000-seed weight, yield ($P<0.01$) and harvest index ($P<0.05$) were significant and the rest, were insignificant. Investigation of interaction effect between genotypes and irrigation status illustrated that except plant height, peduncle length and yield ($P<0.01$), harvest index and total tillers ($P<0.05$) were significant and the rest did not show significant difference traits. Golibagh and barakatli genotypes possessed the higher yields under rain fed than irrigation while mean yield of genotypes under irrigated significantly was more. By exerting stress, yield was decreased in the majority of genotypes but in Germi, Sarab, Sharg, 110117, Golibagh and barakatli, genotypes this trend was increasingly which caused interaction effect.

Table 1: Results of Analysis of variance for studied traits

	MS						
S.O.V	df	Plant height	Total tillers	Fertile tillers	Peduncle length	Main spike length	Main spike weight
Rep	1	739.96**	2.13	0.031	649.80**	1.77*	0.012
Condition	1	7040.78**	0.13	1.65	2465.03**	10.09**	3.64**
Genotype	21	713.54**	3.041	4.15*	179.01**	1.71**	0.406**
C*G	21	278.74**	3.78*	2.906	150.54**	0.36	0.07
Error	43	113.36	2.205	2.46	37.63	0.61	0.15

	MS						
S.O.V	df	Total plant weight	Grains per main spike	Grain weight per main spike	1000 grain weight	Yield	Harvest index
Rep	1	77.4	1.11	0.013	50.16	15.72	64.96
Condition	1	747.17**	120.11**	4.11**	217.54**	1216.901**	647.09*
Genotype	21	71.84	15.44	0.23**	32.41**	1516.86**	45.35*
C*G	21	58.17	12.72	0.05	23.13	953.4**	46.48*
Error	43	64.36	17.16	0.07	18.63	474.41	27.84

** And * significant at the 0.01 and 0.05 levels, respectively

Table 2: values based on measured parameters for traits Fernandez

Genotypes	Yield in normal	Yield in stress	Total tillers	Fertile tillers	Plant height	Internodes	Peduncle	Awn length	Main spike length	Main spike grain number	Main spike weight	Main spike grain weight	1000 grain weight	Harvest index	Yield	Plant performance
hordeiforme(Mi	100.95	87	1.45	1.55	0.54	0.87	0.48	1.06	1.11	0.97	0.91	0.73	0.95	1.57	0.88	1.39
africanum(Sana	97.85	79.55	1.57	1.35	0.51	0.77	0.53	0.77	0.87	0.9	0.84	0.71	0.96	1.46	0.78	1.04
(Omrabi15)	104	56.5	0.91	1.11	0.41	0.76	0.38	0.91	0.95	0.82	0.72	0.62	0.81	1.82	0.59	0.92
hordeiforme(Ma	62.45	64	1.22	1.02	0.6	0.78	0.63	0.83	1.06	0.84	0.84	0.73	1.08	1.26	0.4	0.92
leucurum(Tabriz)	105.55	95.65	0.71	0.87	0.6	0.93	0.42	1.1	1.06	1	1.15	0.71	0.9	1.2	1.01	1.69
melanopus(Chei	83.55	94.3	1.52	1.5	0.47	0.78	0.55	0.68	0.7	0.77	0.58	0.7	1.1	0.89	0.79	0.64
leucurum(Germi	91	61.5	1.04	1.46	0.5	0.7	0.56	0.63	0.6	0.81	0.54	0.6	0.76	1.86	0.56	1.07
reichenbachi(1	135.6	82.2	1.39	1.96	0.54	0.81	0.61	0.72	0.69	0.66	0.61	0.59	0.92	1.38	1.11	0.69
hordeiforme(sh	144.7	54.9	0.79	0.63	0.67	1.18	0.67	0.86	0.83	1.09	1.53	0.97	1.5	1.22	0.79	1.17
apulicum(xanla	156.55	86.4	0.94	1.02	1.19	1.02	1.27	1.02	1.21	0.9	1.06	0.7	0.93	0.74	1.35	1.02
boeuffi(shaxi)	73.45	71.75	0.6	0.55	0.4	0.92	0.37	1.27	1.27	1.34	1.53	0.92	1.09	1.07	0.53	1.58
leucumelan(Nax	74	77.5	0.87	0.96	1.23	1.17	1.04	1.21	1.29	0.88	1.13	0.7	0.98	0.7	0.57	0.79
melanopus(Naxc	98.4	96	1.07	1.26	0.88	1.14	0.62	1.5	0.93	1.17	1.66	0.94	1.28	1.17	0.94	1.55
albiprovincial	71.55	69	0.74	0.52	0.89	1.01	0.77	0.97	0.92	0.75	0.82	0.69	1.1	0.63	0.49	0.35
murceinse(Naxc	68.95	72.9	0.52	0.55	1.22	1.06	1.1	0.83	1.34	0.56	0.85	0.67	1.35	0.6	0.5	0.47
africanum(Naxc	119.45	115.3	0.69	0.89	1.14	1.14	0.94	0.82	0.8	1.09	1.03	0.76	0.89	1.39	1.37	0.99
leucurum(Qax)	145.3	89.5	1.18	1.11	1	0.95	1.05	1.1	1.05	1.08	1.01	0.73	0.84	0.91	1.3	1.04
hordeiforme(Naxc)	128.45	125.05	1.51	1.52	0.96	1.14	0.73	0.87	0.87	1.37	1.18	0.84	0.89	1.12	1.6	1.9
niloticum(Naxc	129.55	84.68	1.25	1.44	1.14	1.1	0.52	0.72	0.68	0.99	0.56	0.55	0.5	0.53	1.1	0.59
africanum(Naxc	100.15	96.5	0.66	0.76	1.06	0.96	1.04	0.75	1.05	1.17	1.26	0.84	1.07	0.89	0.96	0.71
boeuffi(Naxciv	96.1	78.2	0.66	0.52	0.86	1.09	1.12	0.97	1.16	1.15	1.37	0.79	0.96	1.03	0.75	0.44
leucumelan(langan)		107.7	106.1	1.05	1.32	0.93	1.2	0.78	1.43	0.97	1.4	1.81	1.01	1.26	1.48	1 . 1 4
	2.33															
apulicum(Shama	67.7	59.1	0.83	0.76	1.35	1.14	1.3	1.07	1.04	1.03	1.35	0.79	1.06	0.59	0.4	0.73
erythromelan(S	116.45	127.75	0.9	1.09	0.96	1.05	0.89	1.44	1.12	1.23	1.7	0.97	1.3	1.26	1.48	1.53
Barakatly-95	74.7	82	1.18	1.22	0.45	0.83	0.39	0.9	0.75	0.75	0.55	0.51	0.61	1.1	0.61	0.65

Fernandez [8] in study the yield of genotypes in two environments and without drought stress than plants in two environments appears to be divided into four groups:

- The genotypes that have high yield in stress and non stress environments (group A).
- The genotypes that have high yield only in non stress environments (group B).
- The genotypes that have high yield in stress environments (group C).
- The genotypes that have weak yield in stress and non stress environments (group D).

Based on Fernandez opinion, appropriate measure that can separate the first group from other groups. How much the STI index value is higher, Represents

Drought tolerance of specific genotypes. With this index genotypes of group A, B and C are separated. Selected based on SSI selection index caused some genotypes with low yield but high yield under normal environmental conditions are stressful. The major drawback of this index is able to identify group A, group C is not.

To evaluate drought tolerance rates, genotypes were arranged by Fernandez (1992) procedure using mean yield and traits. Langan and Golibagh genotypes gained the highest tolerance index (Table2).

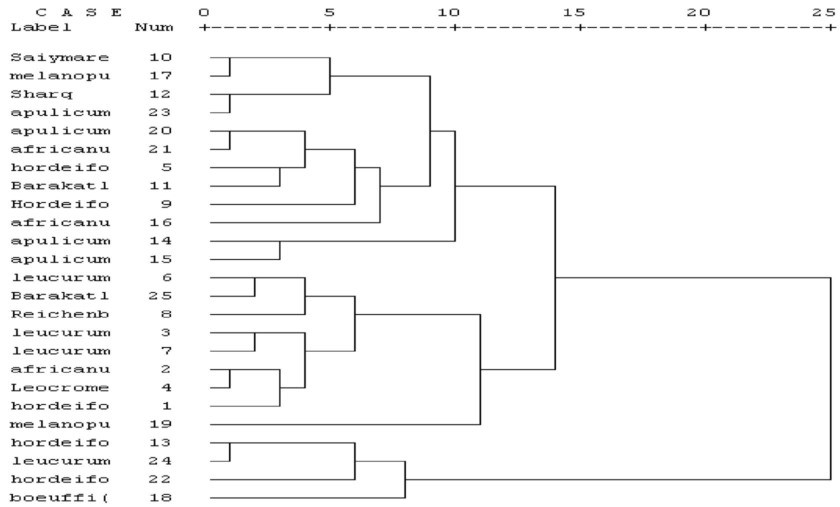

Fig. 1: Cluster classification based on STI

Based on this index, genotypes were classified into three groups performed using Cluster method from which, sub convars of Hordeiforme (Ahar), Leucurum, Hordeiforme (Langan) and Boeuffi had the highest tolerance due to the highest seed weight per main spike, main spike weight, number of seed per main spike and 1000-seed weight. Results of the cluster classification were in accordance with those of drought tolerance (Fig. 1).

DISCUSSION

According to the various researches, a genotype with high yield is not merely a drought one. But a genotype with a low yield difference between normal and stress conditions is called tolerant. Eventually it was cleared that Boeuffi genotype possesses an optimum yield under irrigated and stress conditions. It could save yield components favorably. Sub convar directly can be used as marker provided that is accordance with other researches because, genetic structure and ability of seed against drought tolerance is well understood. 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.

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