IJTA © Serials Publications
National Academy of Agricultural Science (NAAS) Rating : 3. 03

Study of the Effect of Drought Stress on Qualitative and Quantitative Characteristics of Different Types of Sugar Beet

Khalid Abassi[1] *and Esmail Nabizadeh**[2]

Abstract: *Droughtis one of the most important plants' growth and production limiting factors inlarge areas of the world. In order to study the effect of drought on sugarbeet types, anexperiment was performe dinnormal conditions and drought stress based on factorial randomized complete block design with three replications. The results of data combined variance analysis showed the effect of the environment, variety and their mutual effecton the root productivity; pure sugar process percentage and productivity were significant. But the effect of the environment on pure and impure sugar percentage was not significant. In this study, drought stress decreased the amount ofroot and pure sugar productivity as much as 56 percent. Genotypes 1 and 2 with the highest root and pure sugar productivity and the highest values of indices MP, GMP, STI and HARM, and also a small amoun to findex SSI are among drought tolerant genotypes and genotype 5 due to having small amount so findices MP, GMP, STI and HARM and high a mount of SSI index was identified as drought sensitive genotype. Correlation coefficients between root productivity under stress and non-stress conditions were positive and significant with indices of MP, GMP and STI.*

Keywords: *Sugarpercentage, tolerance index, root productivity.,*

INTRODUCTION

Drought stress is considered as one of the major problems of crop production in Iran and world and a serious threat to successful crop production around the world, and it has been reported that drought stress is the main cause of productivity loss in sugar beet(13). In general, it is proved that under stress conditions, solutes that play an important role in osmoticmo dification are increased (10). Lack of water in sugar beet causes decreasing root wet weight but root sugar percentage is increased due to root waste process. Decreased root wet weight occurs due to leaves and roots waste process but sugar production is rarely affected by lack of water, even if only sugar beet is provided with 70% of needed amount of water (2). Conducted studies show there is a considerable genetic variationin sugar beet germplas minterms of drought tolerance of water use efficiency, and using selection water use efficiency can be increased in different genotypes of sugar beet(13). While there is a considerable genetic variation in sugar beet germplasm in terms of drought tolerance and water use efficiency that can be used to increase drought tolerance in the plant. The results of the study showed that among genetic materials available in the country, some types of sugar beet that have acceptable productivity under drought stress conditions and non-stress environment can be selected and continu ing choice in the two environments is very effective on increasing the quantity and quality of sugar beet(3). By increasing the stress, sugar extract percentage was increased but sugar purity and productivity was decreased in the root. Two masses of sugar beet called 111 and 110 were tested under the field humidity stress and

1 Mahabad Salahaddin Department Keshavarzi Bank, West Azar aijan, Iran
2 Department of Agronomy, Mahabad Branch, Islamic Azad University, Mahabad, Iran
* Corresponding Author. *E-mail: esmaeil_nabizadeh@yahoo.com*

non-stress conditions, it was said under stress conditions in terms of the root productivity, sugar productivity and qualitative characteristics such as sugar percentage in the two studied masses asignificant difference was found. Humidity stress caused decreasing root productivity in genotypes of both masses, but both masses' sugar percentage was increased due to humidity stress(23).

Some researchers believe that drought tolerant genotypes' selections hould be done in both normal and stress environment (7 and 11). For this purpose, different in dices of stress tolerance and tolerance; that are presented in the form of mathematical equations, are used. Tolerance indices (TOL) and mean productivity (MP) have been presented in order to select stress tolerant types(17). Some researchers in identifying sugar beet salinity and drought tolerant masses using quantitative indices among drought tolerance indices (SSI) with indices of STI, GMP, and MP observed a negative and significant correlation and stated based on SSI and STI indices, genotypes of 7233, 8001 and the second generation of Mashhad PB population were the most tolerant and genotype of 191 was the most sensitive genotype(10).

Also a number of populations of sugar beet were evaluated under drought stress conditions using tolerance quantitative indices, that indices of HARM, MP, GMP and STI has high correlation with white sugar productivity under non- stress and drought stress conditions and can be used as the best indices in order to achieve high productivity genotypes under stress and non-stress conditions(20). Therefore regarding the above the most important purpose of the study was to examine quantitative and qualitative characteristics of sugar beet under normal and drought conditions and identify beet drought tolerant genotypes using drought tolerant indices available.

MATERIALS AND METHODS

In order to investigate the relationships between the characteristics of sugar beet genotypes an experiment was performed incrop year 2012 in Research Station of Agriculture and Natural Resources of Miandoab. The above station is located in five kilometers to north west of thecity in geographical location of 46 degrees 90 minutes of east longitude and 36 degrees 58 minutes of north latitude and at an altitude of 1314 meters above sea level. This area in terms of weather division of the country has Frick temperature regime(average annual temperature is between 8 to 15°C) and Xeric Humidity Regime (semi- arid) and sites oil had silty loam texture (Table 1).

In this study, 12 genotypes of sugar beet (Table 2) were tested in a randomized complete block design with three replications under both normal and drought stress conditions. Irrigation under drought stress conditions was performed when 85-90% of processing water was removed from the plant and in the treatment without irrigation stress the amount was 50-55% process water.In order to measure the amount of soil humidity each time as ample was prepared from adepth of 0-30 and 0-60 cm of soil and dried in oven and as soon as reaching required humidity (50 and 85 percent of process water) irrigation was done.

In order to measure the amount of irrigation water flow measurement flumes (WSC) were used.Before running the test, land preparation operations including farm plowing, disc, leveling and ploting were done uniformly and phosphors and potash fertilizers were used based on soil analysis test results at the time of land preparation and nitrogen fertilizer was used as plant base and/ or a starter.

Each row interval was considered 60 cm and on row interval was 15 cm. The size of each plot included three eight-meter-long planting lines. Crop operations were done including irrigation, dealing with pest and diseases and rotary cultivator. And during crop season different characteristics were recorded and harvest was done in the first half of November of 2012. In this study, characteristics of root productivity, pure sugar percentage, impure sugar percentage, pure sugar productivity and process percentage were measured.

Studied characteristics and their measurement are as follows.

$STI = \frac{Y_P \cdot Y_S}{(Y_P)^2}$	Stress tolerance index (5)
$STI = \frac{1-\left(\frac{ys}{yp}\right)}{SI}$	Stress Suleranceindex (6)
$SI = 1 - \frac{\overline{ys}}{\overline{\overline{yp}}}$	
$GMP = \sqrt{(Y_P)(Y_S)}$	Geometric Mean Productivity (5 and 8)
$HARM = \frac{2(y_P \cdot y_s)}{y_p + y_s}$	Mean harmonic index (8)
$TOL = YP - YS$	Tolerance index (17)
$MP = \frac{YS + YP}{2}$	Mean Productivity (17)

Finally data analysis was done using statistical software SAS 9.2 and SPSS.

Table 1
Physical and chemical characteristics of site soil

Value	*Measured parameters*
Soil depth	0-30
(%SP)	38
(EC(ds/m))	2.14
(PH)	8
(%T.N.V)	8
(%O.C)	0.78
(%N)	0.13
(P (ppm))	8.05
(K (ppm))	255
(%Sand)	34
(%Silt)	42
(%Clay)	24
Silty loam	(Tex.-Soil)

Table 2
Studies sugar beet genotypes

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
6118	6120	6125	6122	6128	6119	6124	6127	6121	6123	6126	6117

RESULTS AND DISCUSSION

The results of data combined variance analysis showed the effect of the environment, type and their mutual effect on the root productivity, process percentage and pure sugar productivity was found to bea significant at 1 percent possibility level. But the effect of the environment on pure and impure sugar percentage was not significant that it can be attributed to different reactions of different genotypes to different environmental conditions such as drought stress and control conditions (Table 3).

Comparison of the two environments in terms of root productivity showed normal conditions with the average of 62.22 ton/ ha had higher productivity than drought stress area with the average of 27.5 tons per hectare. In this study, drought decreased root productivity compared to the level of 56 percent non- drought. It can be suggested lack of water

Table 3
Combined variance analysis of studied characteristics in the two environments

sov	*df*	*Root productivity (ton per ha)*	*Impure sugar percentage*	*pure sugar percentage*	*Process percentage*	*Pure sugar productivity*
Environment	1	28922.45**	0.09ns	0.04*ns*	9.83**	36.79**
Ea	–	345.99	0.36	0.21	0.27	8.25
Genotype	1	158.45**	2.78**	29.84**	3.43**	4.03**
Genotype × environment	1	155.50**	2.43**	27.89**	1.34*ns*	4.24**
Eb	6	47.12	0.17	19.62	0.64	1.14

* and * :nonsignificant and significante at $p \leq 0.05$ and $p \leq 0.01$, respectively.

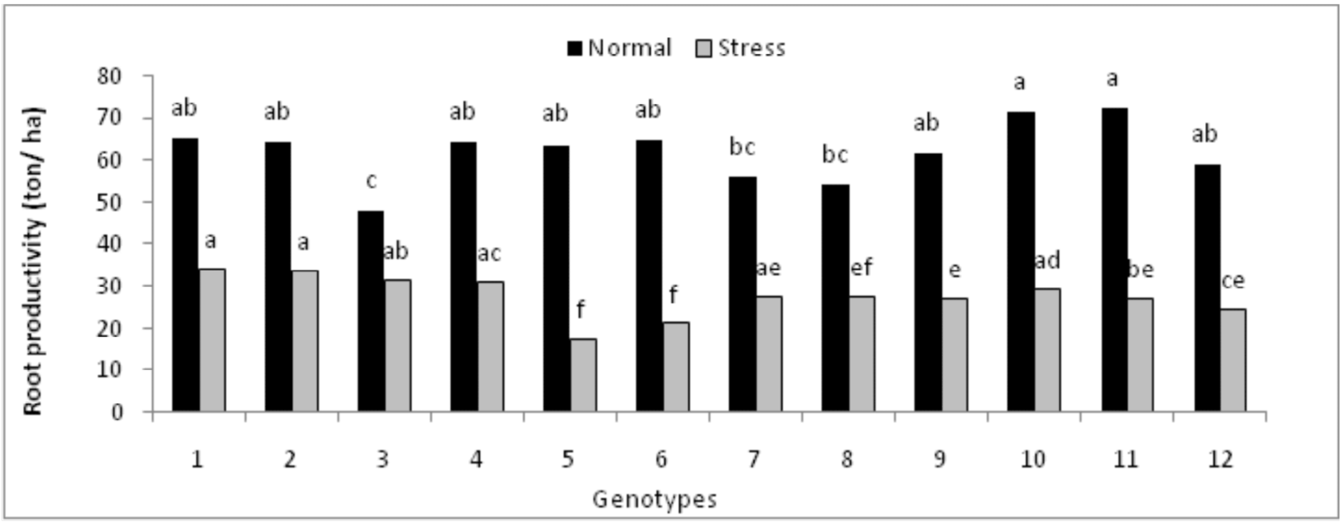

Figure 1: Comparison ofaverage genotypes in stress and drought environment in terms of root productivity

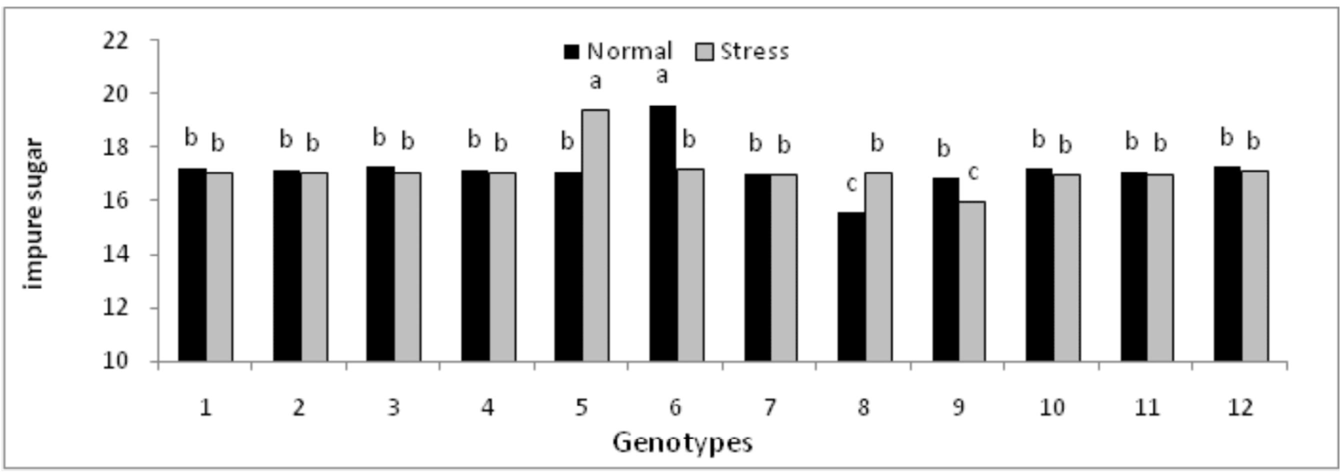

Figure 2: Comparison of average genotypes in stress and drought environment in terms of impure sugar percentage productivity.Similar letters indicate no significant difference at 1% level between averages according to Duncan's test.

caused increased leaf area, the percentage of green cover and increased respiration and also energy intake for the growth of leaves and shoots that finally caused increasing root productivity.

The maximum decrease of root productivity of sugar beet genotypes under drought stress conditions compared to normal humidity conditions has also been reported in other researchers 'studies. A comparison of mean studied genotypes showed genotype 10 with an average root productivity of 50.35 tons per hectare assigned the highest root productivity and genotype 8 with an average root productivity of 37.43 tons per hectare assigned the lowest root productivity.A comparison of mean genotypes under normal conditions showed genotypes 10 and 11 with an average of 72.5 and 71.7 tons per hectare to 48 tonnes per hectare assigned the highest root productivity, genotype 3 with an average of 48 tonnes per hectare assigned the lowest root productivity, respectively.Under drought conditions it was observed genotypes 2 and 1 with an average of 37.37 and 34.12 tons per hectare assigned highest root productivity, respectively andgenotype 5 with an average of 17.25 tons per hectare assigned the lowest root productivity (Fig.1).

Similar letters indicate no significant difference at 1% level between averages according to Duncan'stest.

Impure Sugar Percentage

In evaluating genotypes interms of impure sugar percentage under normal conditions it was observed

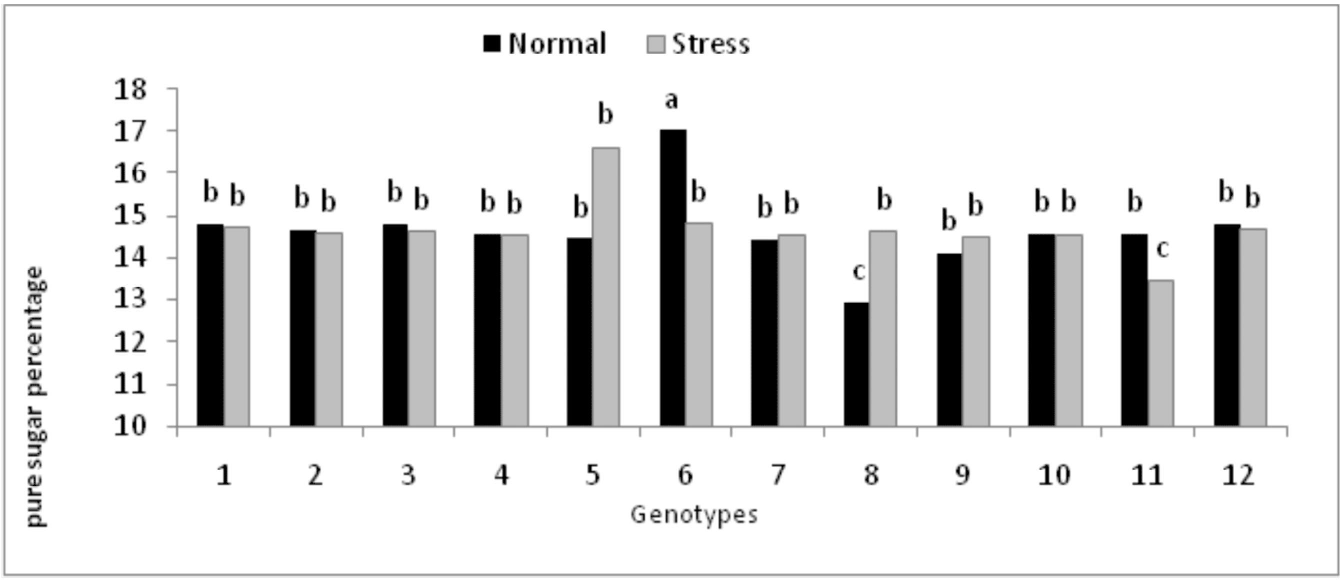

Figure 3: Comparison of average genotypes in drought stress environment in terms of pure sugar percentage. Similar letters indicateno significant difference at 1% level between averages according to Duncan's test.

genotype 6 with an average of 19.55 percent assigned the highest impure sugar percentage and genotype 8 with an average of 15.75 percent assigned the lowest impure sugar percentage but under drought conditions the highest and lowest sugar prcentage belongs to genotypes 5 and 9, respectively, with an average of 19.37 and 15.95, respectively (Figure 2).

Pure Sugar Percentage

A comparison of average studied genotypes in terms of pure sugar percentage in both environments showed that genotypes 6 and 5 assigned the highest pure sugar percentage and genotype 8 assigned the lowest mentioned amount. Also under drought conditions, the highest and lowest pure sugar percentage was related to genotypes 5 and 11, respectively (Figure 3). In a study, the highest impure sugar percentage under bot hnormal and humidity stress conditions was reported in genotype HS-17 and the lowest impure sugar percentage under normal and drought stress conditions was reported in genotypes HS-19 and HS-1(8) that are consistent with our results.

Comparison of the two normal and drought environments in terms of the effect on the percentage of process showed totally drought conditions led to increased the percentage of process so that under drought stress conditions average process percentage was equal to 85.67 percent and the average of mentioned characteristic under normal conditions was equal to 85.03 percent. Process percentage increase under drought stress conditions can be attributed to increased impure and pure sugar percentage under humidity stress conditions. It has been reported under humidity stress conditions sugar process percentage is increased (8).

Regarding the fact that drought stress causes increasing pure and impure sugar percentage in sugar beet root (1), increased sugar process percentage under drought stress conditions can be attributed to drought effect on increasing sugar and sucrose compounds in the root. A comparison of mean genotypes in terms of process percentage showed genotype 1 with the average of 86.64% assigned the highest process percentage and genotype 11 with the average of 84.05 percent assigned the lowest process percentage.

A comparison of both normal and drought conditions in terms of the effect on pure sugar productivity showed normal conditions with the average of 9.17 tons per hectare showed higher pure sugar productivity to drought conditions with the average of 4.02 tons per hectare. In this study, drought decreased pure sugar productivity 56 percent compared to normal conditions. Pure sugar productivity that is obtained from multiplying

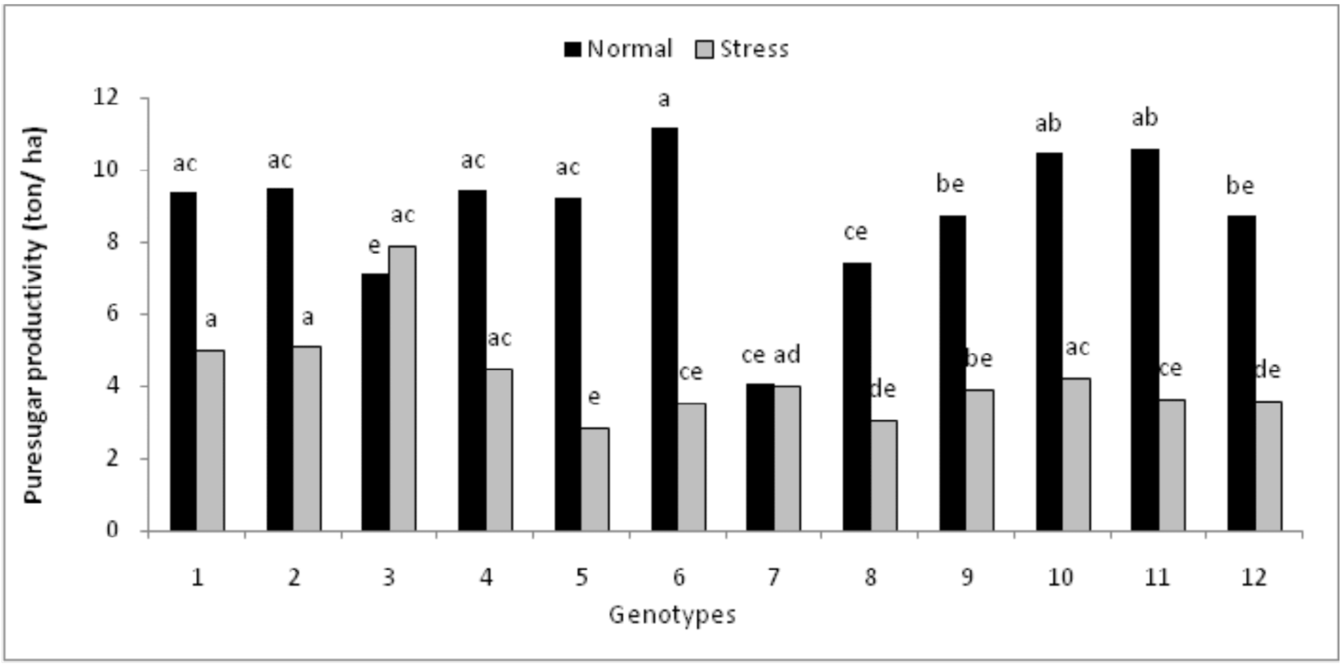

Figure 4: Comparison of average genotypes in drought stress environment in terms of pure sugar productivity.Similar letters indicate no significant difference at 1% level between averages according to Duncan's Test.

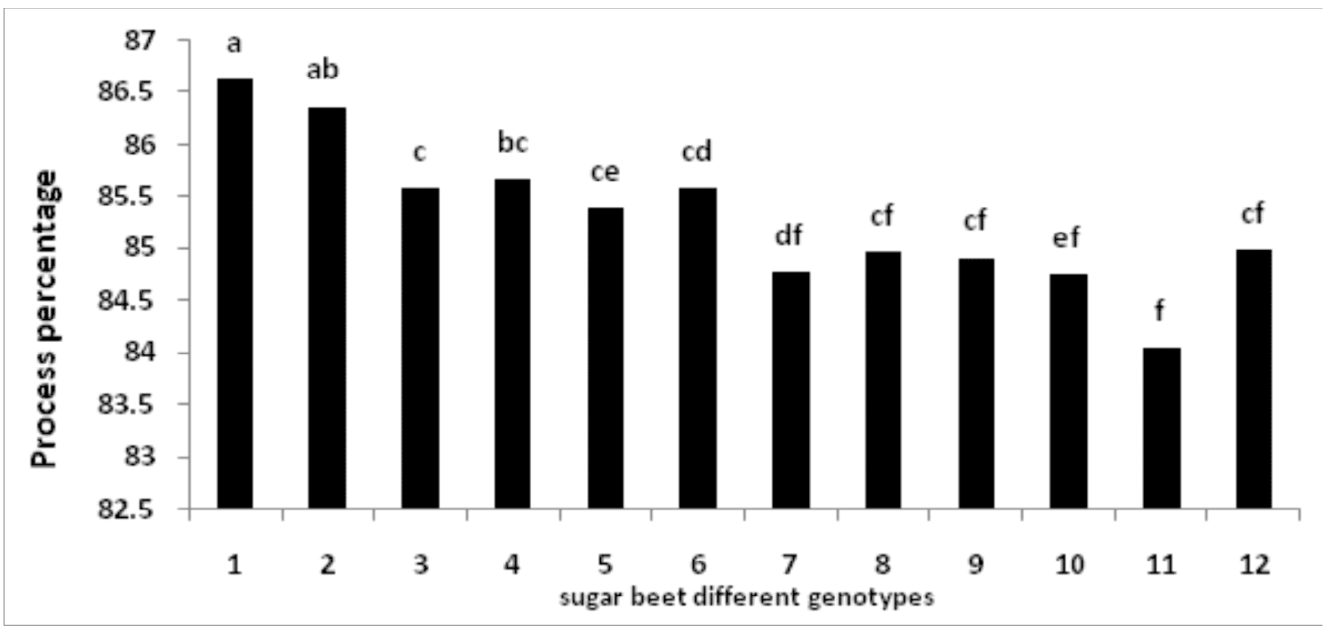

Figure 5: Comparison of average effect of different genotypes of sugar beet on process percentage.Similar letters indicate no significant difference at 1% level between averages according to Duncan's test.

root productivity by processing sugar percentage is considered the most important determinant in sugar beet industry.Drought stress has caused 31 percent decrease in pure sugar productivity in sugar beet (5). In evaluating genotypes' reaction in both normal and drought conditions it was observed genotypes 10 with the average of 7.35 tons per hectare assigned the highest pure sugar productivity also the lowest pure sugar productivity with the average of 5.23 tons per hectare was related to genotype 8.A comparison of mean genotypes in terms of pure sugar productivity under normal conditions showed genotype 6 with the average of 11.15 tons per hectare assigned the highest pure sugar productivity and genotype 3 with the average of 7.09 tons per hectare assigned the lowest pure sugar productivity.Genotypes 2 and 1 under drought conditions with the average of 5.01 tons per hectare assigned the highest pure sugar productivity and genotype 5 with the average of 2.86 tons per hectare assigned the lowest pure sugar productivity (Figure 4). In evaluating different genotypes of sugar beet it has been reported a significant difference was found between sugar beet different genotypes and genotypes of 5 and 14 assigned the highest pure sugar productivity in both normal and stress environments (5).

Genotypes' Evaluation Based on Drought Tolerance Indices

Productivity is subject to numerous conditions, such as planting date, density, amount of fertilizer, irrigation, growth type, soil and water conditions and by changing the conditions, these genotypes' productivity is changed under normal and drought stress conditions, because it is the basis of indices' calculation to the productivity under stress and normal conditions. Hence these indices are used as appropriate bench marks to identify tolerant genotypes.

Arithmetic mean index (MP)

Evaluating genotypes using this index showed that the most tolerant lines to drought stress were genotypes one and two and the most tolerant was genotype 5 (Table 4).

Geometric Mean Index (GMP)

Evaluation types using GMP index showed that genotypes 1 and 2 were identified as the most tolerant genotypes and genotype 5 was identified among drought tolerance types (Table 4).

Stress tolerance index (STI)

Evaluating genotypes using STI index showed that genotypes 1 and 2 with the highest amount of mentioned index were among tolerant types and genotype 5 with the lowest amount of stress tolerance index was among tolerant genotypes (Table 4).

Stress sensetive index (SSI)

Evaluating genotypes using SSI index showed that genotypes 3 , 2 and 1 assigned the lowest amount of mentioned index and were identified as genotypes with low sensetive to drought stress while genotype 5 with the highest amount of mentioned index was among genotypes with high sensetive to drought stress (Table 4).

Table 4
Stress tolerance indices

Genotype	*MP*	*GMP*	*STI*	*TOL*	*SSI*	*HARM*
1	49.77	47.24	0.53	31.30	0.85	44.84
2	49.4	47.07	0.52	30.12	0.83	44.8
3	40.75	40.09	0.38	14.4	0.53	39.46
4	47.8	44.75	0.47	33.61	0.92	41.89
5	40.55	33.19	0.26	46.61	1	41.89
6	44.81	39.68	0.37	41.63	1.13	35.14
7	41.77	39.3	0.36	28.31	0.9	36.97
8	40.93	38.72	0.35	26.53	0.87	36.63
9	44.40	40.85	0.39	34.81	1.3	37.58
10	50.36	45.62	0.49	42.66	1.06	41.33
11	49.83	44.34	0.46	45.43	1.11	39.48
12	56.69	46.57	0.51	46.65	1.29	38.26

Tolerance Index (TOL)

Evaluating studied genotypes using TOL index showed that the most tolerant genotypes to drought were genotypes 3, 2 and 1 and their most sensetive were genotypes 12 and 5 (Table 4).

Mean Harmonic Index (HARM)

Evaluating types using HARM index showed that the most tolerant genotypes to drought were genotypes 1 and 2 and their most sensetive was genotype 5. According to Table 4, genotypes 1 and 2 had low SSI and high STI, indicating higher tolerance to drought compared to other genotypes. Lower SSI and higher STI in agenotype, there is better drought tolerance (Table 4). Also genotypes 1 and 2 showed relatively low TOL compared too ther genotypes as well asin terms of seed productivity were superior to other lines. Therefore genotypes 1 and 2 that in both environments had relative high productivity can be placed in group Fernandez A.

Also, in terms of indices MP, GMP, STI and HARM , among studied lines, lines 1and 2 were identified as superior genotypes and assigned rank 1 with root productivity 65.42 and 64.46 tons/ha.

respectively, under normal conditions and 34/34 and 34.12 tons/ha under stress conditions (Table 4).

Therefore, mentioned genotypes that have higher relative productivity in normal and stress environment are considered as an ideal line.

Evaluating genotypes using SSI stresss sensetive index, merely genotypes are classified based on the tolerance and sensetivity indices to stress and in other words, using this index sensetive and tolerance genotypes can be identified regardless of their productivity and in order to find tolerant genotypes this index has very high efficiency(11).

STI drought tolerance index has a very strong relationship with indices of MP, GMP and Harm and the indices can be used to determine drought tolerant genotypes. Indices of SSI, TOL and DSI have a very strong relationship to each other. According to methods used in the experiment, when a genotype has more indices of STI, MP and GMP and the values of TOL and SSI less than other genotypes, will have better tolerance to stress conditions(19).

Also the researchers believe that the best index for screening stress tolerant genotypes is an index that under both stress and normal conditions has a high correlation with grain productivity (4, 15 and 12).

In a study in order to determine the best index of drought tolerance in wheat, STI drought tolerance index and also of geometric mean productivity (GMP)index were introduces as the best indices selected for desirable genotypes with high productivity potential and also tolerance drought genotypes(12).

The relationships between stress tolerance indices In this study, a poor and insignificant correlation was found between the productivity under drought stress and normal humidity conditions that the correlation (r = 0/29) indicates productivity independence under the two conditions and regarding productivity independence under the two conditions modification should be done separately for the two conditions. Which it self implies that high-productivitying genotypes under normal humidity conditions may not be successful genotypes under drought stress conditions(5). Correlation coefficients between root productivity under stress and non-stress conditions were positive and significant with indices of MP, GMP and STI (Table 5).

Correlation coefficients of the root productivity under normal conditions were positive and significant with indices of SSI and TOL but under drought stress conditions, root productivity correlation was negative and significant with two mentioned indices (Table 5).

Table 5
Correlation between drought tolerance indices

	Normal productivity	*Stress productivity*	*MP*	*GMP*	*STI*	*TOL*	*SSI*
Stress productivity	0.29*ns*						
MP	0.88**	0.68**					
TOL	0.92**	–0.62*	0.62*				
SSI	0.74**	–0.82**	0.36ns	0.92**			
STI	0.65*	0.64*	0.86**	0.18ns	–0.10ns		
GMP	0.61*	0.66**	0.85**	0.16ns	–0.13ns	0.99**	
HARM	0.09ns	0.91**	0.54ns	0.27ns	–0.52ns	0.88**	0.88**

* and * indicate nonsignificance and significance at 0/05 and 0/01 levels, respectively.

The researchers when assessing drought tolerance of genotypes of sugar beet using drought tolerance indices reported indices of STI, GMP, MP and HARM are most suitable indices to identify drought tolerant genotypes(3).

CONCLUSION

According to the above results we can say that the amount of productivity and percentage of sugar beet genotypes under different crop conditions is different. The genotypes of 10 and 11 had the highest root productivity under normal conditions.

The highest sugar percentage was related to 5 and 6 genotypes, but the amount of sugar was relatively low in the 2 genotypes per hectare and the maximum amount of sugar per hectare was seen in 1 and 2 genotypes.

References

AbdollahianNoghabi M, Radaei-al-amoli Z, Akbari GA and Sadat Nuri SA (2011), Effect of sever water stress on morphological, quantitative and qualitative characteristics of 20 sugar beet genotype. Iranian Journal of Crop Sciences 42(3): 453-464.

AL-Jbawi1 E and Abbas F (2013), The Effect of Length during Drought Stress on Sugar Beet (*Beta vulgaris* L.) Yield and Quality. Persian Gulf Crop Protection. Volume 2 Issue 1, March 2013 Pages 35-43.

Bazrafshan M., Matloubi F., Mesbah M., Jowkar L., Evaluating drought tolerance of sugar beet genotypes with drought tolerance indices, Journal of Sugar Beet 24 (2): 15-35.

Blum A (1989), Osmotic adjustment and growth of barley genotypes undert drought stress. Crop Sci. 29: 230-233.

Fernandez GC (1992), Effective selection criteria for assessing stress tolerance. In: Kuo, C.G. (ed.), Proceedings of the International Symposium on Adaptation of Vegetables and other Food Crops in Temperature and Water Stress. 257-270 pp. AVRDC Publications. Tainan, Taiwan.

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

Foroozesh f, ajidiHeravan EM, Bihamta MR, FatollahTaleghani D and Habibi D (2012), Physiological Evaluation of Sugar Beet Genotypes under Drought Stress American-Eurasian J. Agric. and Environ. Sci., 12 (6): 820-826,

Jafari A, Paknejada F and Jami Al-Ahmadi M (2009), Evaluation of selection indices for drought tolerance of corn (*Zea mays L.*) hybrids. International Journal of Plant Production, 3, 33-38.

Khorshid AM., Eivazi AV., and Pedram A., and Fotouhi K., (2012), Identification of drought and salt tolerant types of sugar beet using quantitative indicators, Research Journal of agricultural sciences, Fifth year, No. 17. p. 85-106

Morillo-Velarde R and Ober Eric S (2006), Water use and irrigation. In: Draycott AP (ed.): Sugar Beet. Blackwell Publishing. 2006; 221-255.

Naderi A, Majidi-Harvan E, Hashemi-Dezfoli A, Rezaei A and Normohamadi Gh (1999), Analysis of efficiency of drought tolerance indices in crop plants and introduction of a new criteria. Seed and Plant 15(4): 390-402.

Noormandmoayed F, Rostami M and Ghanadiha M (1997), Morphoghysiological traits of bread weath and them relation with yield in stress and no stress condition. Iranian griculture Science Journal. 32:2. 785-794.

Ober ES, Clark CJA, Bloa ML, Royal A, Jaggard KW and Pidgeon JD (2004), Assessing the genetic resource to improve drought tolerance in sugar beet: Agronomic traits of diverse genotypes under drought and irrigated conditions. Field Crops Res, 90: 213-234.

ParviziAlmani M., Sadeghiyan S., FathollahTaleghani J., and Mohamadian R., (1998), Examining indices of drought tolerance for sugar beet important characteristics, Abstracts of Karaj fifth Crop congress, seed and plant Improvement Research Institute, August 13- 19, p. 25.

Radmehr M, Lotfali GA and Kajbaf AV (1996), Evaluation of Drought Tolerance of Barley (Hordeumvulgare L.) Genotypes Using Physiological Characteristics and Drought Tolerance Indices. Iranian, J. Iranian Journal of Crop Sciences. 9(1): 1-13.

Rajaram S and Van Ginkle M (2001), Mexico, 50 years of international wheat breeding. In: Bonjean, A.P., Angus, W.J. (Eds.), the World Wheat Book: A History of Wheat Breeding. Lavoisier Publishing, Paris, France, pp. 579-604.

Rosielle AA and Hamblin J (1987), Theoretical aspects of selection for yield in stress and non-stress environments. Crop Sci. 21: 943.946.

SadeghianMotahar SY, Mohammadan R, Taleghani DF and Khorshid A (2001), Evaluation of sugar beet drought tolerance genotypes using of halfsib-family recurrent selection. Final report, SBSI.

Sadegh-Zadeh-Ahari (2006), Evaluation for tolerance to drought stress in dryland promising durum wheat genotypes. Iranian, J. Agric. Sci. Vol. 8, No. 1, 30-47.

Sharifi M, Mesbah M and Gohari J (2004), Studing drought tolerance indices in difference sugar beet genotypes. Journal of Sugar Beet. 19(1): 51- 64. (In persian).

Shehata MM, Azer SA, Mostafa SN (2000), The effect of soil moisture on some sugar beet varieties.

Taleghani F., SadeghzadehHemayati S., Matloubi F., and Khyamym S., (2009), Examining some of qualitative and quantitative characteristics of sugar beet promising genotypes under drought stress conditions, Sugar Journal, Volume 25, No. 2, p. 113-123.

Vahidi H, Rajabi A, Seyed M.R., Hadi, Fathollah D (2013), Screening of suger beet (*Beta vulgaris* L.) genotype for drought tolerance International Journal of Agriculture and Crop Sciences. 1113-1104.