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Evaluating the best indicators and identifying the most tolerant varieties to draught in potato varieties

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Abstract

In order to evaluate the drought tolerance indicators in six potato varieties of Agria, Asterix, Serenad, Draga, Diamant and Cosima and determine the best indicators and identifying the most tolerant varieties using performance measurement in normal irrigation and drought stress conditions, Two separate experiments at two irrigation regimes in a split plot design (split-plot) based on a randomized complete block were performed in Three replications in Ardabil Agricultural Research Station located in Alaroq village (12 km south of Ardabil). Six drought tolerance indices were calculated for tuber yield varieties. Geometric mean productivity index, mean productivity and stress tolerance index were highly correlated significantly with performance in both environments and were introduced as suitable indicators of identifying the probable varieties to water shortage in potato. Principal components analysis showed that 95% of the total variation is justified with the first component (tuber yield by 62%) and second component (with a tolerance of 33%). Agria and Serenad were presented d as appropriate figures in this study with high yield potential and tolerance to water deficit conditions in the experimental conditions of this study.

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Introduction

Potato is belonging to Solanum genus and the family Solanaceae. It is the species of *solanum tuberosum*. It is in the form of Autotetraploid and including genomic formula 2n=2x=48. It is the only tuber species of solanum genus which is cultivated outside its native area (Arzani, 2008). Potato is one the sensitive to water deficit plants (Deblonde, 2001). It is widely distributed in the world after corn (Rezaei and Soltani, 1995). Potato is considered one of the most valuable food and the most important products that provide the vast majority of human needs. It is the country's second-largest food crop after wheat in terms of production (Jami Moeini, 2001 and Goldust *et al*, 2012). Potato is a valuable food and one of the most important crops. This product contains starch and necessary amino acids by the human especially vitamins B and C have a high nutritional value (Hassan Panah *et al*, 2008). Iran has ranks 12th in the world in terms of potato production and the third in Asia after China and India (FAO, 2011).

Fernandez (1992) and Mozaffari (1995) also introduced STI and GMP as drought tolerance indices. Fernandez (1992) had divided genotypes reaction on the basis of their yields into 4 categories under stressed and non-stressed conditions: group A are genotypes which have high yield in both of conditions; group B are genotypes which have a high yield under non-stressed conditions; group C including genotypes which have a good yield under stressed conditions, and finally group D are genotypes which have a low yield in both conditions. He believed the most suitable standard to select about stress, is a standard which can recognize group A from other groups. Rosielle and Hamblin (1981) presented tolerance index (TOL) and mean of proficiency (MP). High amounts of tolerance indicated sensitivity of more genotypes to drought, and also the lower tolerance, the better. Rosielle and Hamblin (1984) used from TOL and MP to choose stress tolerance varieties. It is better to use from TOL, when the yield increasing under stressed condition was considered. If the yield increasing was considered in both conditions (stressed and non-stressed), It's better to use from MP index. MP can not separate genotypes of group A from Group B, and selection process had performed on the basis of high amounts of MP. Fischer and Maurer (1978) proposed stress sensitive index (SSI) to evaluate stress tolerance varieties. Choosing according to this index cause to selection of low yield genotypes under normal conditions, but also lead to selection of high yield genotypes under drought stress conditions. This index can not separate group A from C. Fernandez (1992) presented stress tolerance index (STI). High amounts of STI for one genotypes means higher drought tolerance and more drought potential yield of that genotype. This index can not separate group A from C and B. He presented another index as called geometry mean (GMP) which has less sensitivity to yield under normal and stressed conditions.GMP has high ability to separate group A from other groups in comparison with MP. According to Fernandez (1992), indices which have high correlation with grain yield under both conditions (stressed and normal), selected as the best indices. Sio-se Mardeh *et al,* (2006) expressed that SSI is suitable index to reform under low stresses, if STI, GMP and MP suggested for high stresses. They also explain that selection of varieties on the basis of TOL cause to reducing yield under non-stressed conditions, SSI is suitable for reformation under low stresses, but MP, GMP and STI are suitable indices for high stresses.

Due to the lack of water in most parts of the country and lack of rainfall during the time of adoption of potato cultivation and importance of this product as one of the country's agricultural production, especially in Ardabil province, identifying the possible varieties in water deficit condition using drought tolerance index seems necessary. These varieties can be used to increase the cultivation of rainfed and irrigated area. Using the performance to evaluate the corrective streaks in a wide range of different environments is important for researchers.

The purpose of this investigation was to evaluate the drought tolerance of six varieties of potato and choose the most appropriate indicators of drought tolerance

in this plant.

Materials and methods

Location of testing

The study was carried out in Ardabil Agricultural Research Station located at Alaroq a village at 12 km south of Ardabil. The location was a semi-arid and cold climate that in winter is often below zero. Region has a long dry season, especially in summer. Altitude is reported 1350 m, latitude and longitude, respectively 20' 48 ° and 15' 38°, the mean minimum, and maximum temperatures were 1.98, 15.8 and 21.58 ° C and the precipitation annual average is 310.9 mm.

Herbal material

In this study, six potato varieties with medium to late maturity were used. Agria and Draga as the control varieties of the region with Diament, Cosima, Serenad and Asterix, which had nearly the same growth period were evaluated in this experiment. The varieties l was prepared from agricultural research station of Ardabil.

How to Run Test

The experiments were conducted to evaluate drought tolerance indicators in the form of shredded varieties (split-plot) based on a randomized complete block with three replications. In this study the main factor in stress levels (A1: Regular watering and A2: Watering once every 18 days) were place in the main plots and sub-plots in six potato varieties. To prepare the ground, the ground was to be plowed in the autumn and the Phosphorus and potash fertilizer dose of 110 kg per hectare and the amount of soil was mixed with 55 kg per hectare. In April, after superficial plowing, land leveling, furrow created by the device Furrower and It coincides with the planting at May 14, half of the 55 kg of nitrogen fertilizer per hectare of land was given to the road. To start germination after planting, all plots were irrigated. It should be noted that the rate of fertilization was performed according to the procedure based on soil tests carried out at the station. After growing at four times during the growing season, weeds were combated and feet of soil and plants was conducted simultaneously with fighting weeds. When plant height reached to 20 cm (45 days after planting), the other half of it was given to the land 55 kilograms of fertilizer per hectare. Irrigating plots was done in the same hot water.

Statistical calculations

For statistical calculations, we used from software's like Minitab-15, SPSS-16 and MSTAT-C. In order to determine drought tolerance genotypes, indices MP, GMP, STI, TOL, SSI and MSTI were calculated by following relations:

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

In above relations, YPi, YSi, Ys, and Yp refer to grain yield of each genotype under non-stressed conditions, grain yield under stressed conditions, mean yield of genotypes under stressed condition and mean yield of genotypes under non-stressed condition, respectively. Then, the simple correlations between these indices were calculated and Principal Component Analysis of drought tolerance indices.

Results and Discussion

In this project, the stress intensity (SI) is equal to 46%.It is essential to say that this index is just calculable to measuring drought stress intensity in experiment and it has no efficiency to measuring stress intensity in varieties (Fischer and Maurer, 1978). Calculation results and susceptibility to drought tolerance indices (Table 1) showed that mean productivity (MP), geometric mean productivity (GMP) and stress tolerance index (STI), they show that high levels of stress tolerance and Agria and Serenad genotypes, respectively, with yields of 73.18 and 88.20 t ha-tolerant genotypes were identified. SSI numerical index that low doses (less than unity), show high tolerance to stress is compared (Chokan *et al*, 2006), and the lower values of their parameters TOL and SSI represent relative tolerance to tension genotypes Serenad and performance respectively 19.79 and 20.88 tons per hectare as tolerant and

Agria cultivars with yield 18.73 hectares were identified as susceptible genotypes.

Mp, GMP and STI indices identified genotype AGRIA as a tolerant genotype, but TOL index introduced it as a sensitive variety. Evaluation of genotypes by SSI, had divided experimental materials just on the basis of stress tolerance and stress sensitive, that is we can determine tolerant and sensitive genotypes regardless of their yield potential by this index (Naderi *et al*, 2000). Stress sensitive index evaluated on the basis of proportion of each variety yield under stressed to non-stressed condition in comparison with this proportion in total varieties. Thus, two varieties with low/high yield can have equal SSI rate in both conditions, so selection process on the basis of this index cause to reformers to mistake (Naeimi *et al*, 2008). According to investigators (Fernandez 1992; Khalilzade and Karbalaei Khiavi, 2002 and Sadeghzade-Ahari, 2006).the best index to select varieties, is stress tolerance one (STI), as it can separate varieties which has a have a high yield in both stressed and non-stressed conditions (group A) from two groups of varieties which have just relatively yield under non-stressed (group B) or stressed (group C) conditions.

Table 1. Estimation of sensitivity rate of 6 Potato genotypes by different drought tolerance indices under normal and stressed conditions.

Genotyoe	YP	YS	MP	GMP	STI	TOL	SSI
Agria	38.32	18.73	28.52	26.79	0.68	19.59	1.26
Asterix	28.93	19.79	24.36	23.93	0.54	9.14	0.72
Serenad	36.61	20.88	28.75	27.65	0.58	15.73	0.98
Draga	32.25	16.19	24.22	22.85	0.49	17.06	1.13
Diamant	35.66	17.03	26.35	26.24	0.57	18.63	1.19
Cosima	33.76	16.73	25.22	23.74	0.53	16.99	1.15

Achieved results from correlation between drought tolerance and yield indices (Table 2) can be applied to select the best genotypes and indices as a suitable standard. Yield in normal condition show positive and meaningful correlation with mean proficiency(r = 0.885**), geometric mean (r = 0.8*) and stress tolerance (r = 0.852**) in probability level of 5%. These results are compatible with Roiselle and Hamblin (1981) and Mohammadi *et al,* (2006). They show that in a majority of comparative experiments, the correlation yield between MP and Yp and also MP and Ys is positive.

Table 2. Correlation between drought tolerance indices with grain yield under normal irrigation and drought stress conditions.

	YP	YS	MP	GMP	STI	TOL	SSI
YSi	0.099	1					
MP	0.885*	0.759*	1				
GMP	0.800*	0.826*	0.949**	1			
STI	0.852*	0.876*	0.822*	0.769	1		
TOL	0.508	-0.826*	0.471	0.348	0.399	1	
SSI	0.739	-0.587	0.344	0.207	0.356	0.983**	1

* and ** Significantly at p < 0.05 and < 0.01, respectively.

Performance in terms of productivity, the average stress index , geometric mean index, stress tolerance index showed a significant positive correlation but bear with index (r=-0.826*) significant at the 5% level showed negative correlation said. Khalil Zadeh and karbalaei khiyav (2002), Farshadfar *et al* (2001) and Chokan *et al* (quoted Moghaddam and H.Zadeh, 2003) believe that the most appropriate index for

selecting tolerant varieties is a marker associated with relatively high yield in both stress and non-stress conditions is. Therefore, to evaluate the correlation between stress tolerance index and grain yield in both stress and non-stress environment, it is possible to identify the most suitable index. Since the average productivity indexes, index and Fernandez geometric mean productivity, stress and normal stress were highly correlated, as they are the best indicators.

Table 3. Vectors and special amounts, relative and cumulative variance for three main components from principal components over drought tolerance indices of 6 potato genotypes under normal irrigation and drought stress conditions.

Special vectors of component Tolerant indices	1	2	Communalities
Yp	0.983	-0.147	0.987
YS	0.235	0.964	0.984
MP	0.934	0.328	0.98
GMP	0.863	0.433	0.932
STI	0.845	0.264	0.783
TOL	0.731	-0.676	0.991
SSI	0.640	-0.767	0.997
Special amount	4.294	2.36	
Relative variance	61.348	33.717	
Cumulative variance	61.348	95.065	

Farshadfar *et al,* (2001) in a research about pea reported that all of indices show positive and meaningful correlation with yield under non-stressed condition, and also they expressed that TOL has a negative and unmeaningful correlation with yield under stressed condition. Fernandez (1972) in a three years study in normal and low-water stress conditions realize that there is a meaningful correlation between grain yield and stress sensitive indices. Rosielle and Hamblin (1981) showed that in a majority of comparative experiments, the correlation yield between MP an Yp and also MP and Ys are positive. According to their reports, selection on the basis of MP generally cause to increasing yield in both normal and stressed conditions. Fernandez (1972) declared that sensitivity of GMP index is less than different amounts of Yp and Ys, while MP index which is on the basis of computation mean, has up-curve, as there is relatively high difference between Yp and Ys, thus GMP has the highest capability to separate major genotypes in comparison with MP. Correlation between drought tolerance and yield indices (Table 2) can be applied as a suitable standard to select better genotypes and indices.

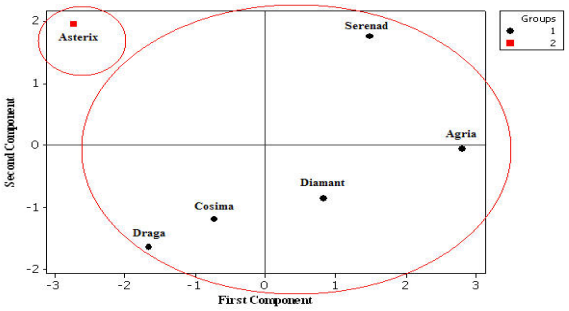

Fig. 2. Dispersion of under-study genotypes according to first and second components of principal components over drought tolerance indices of 6 potato genotypes under normal irrigation and drought stress conditions.

Second component had justified 31.77% of the rest total variations and shows positive and high correlation with YS and SSI. Therefore, we can call this component as tolerant index. Table 3 shows static roots and special vector of under-study genotypes about three first components and first vector shows

61.35% of varieties and with respect to which GMP, MP, YP, STI and TOL indices have the highest positive coefficient to providing this component, so selection process selected high-yield genotypes on the basis of first component, thus this component can be called as Tuber yield component.

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