University of Birjand

تنشهای محیطی در علوم زراعی
Environmental Stresses In Crop Sciences
*Vol. 14, No. 3, pp. 747-758*
*Fall 2021*
http://dx.doi.org/10.22077/escs.2020.3123.1801

***Original article***

# Evaluation of drought tolerance indices of hybrids from potato commercial cultivars

**M.R. Vesali[1], R. Baradaran [*2], D. Hassanpanah[3], M.J. Soqa al-Islami [2]**

*1. PhD student in Plant Breeding, Department of Agriculture and Plant Breeding, Birjand Branch, Islamic Azad University, Birjand, Iran*
*2. Associate Professor, Department of Agriculture and Plant Breeding, Birjand Branch, Islamic Azad University, Birjand, Iran*
*3. Associate Professor of Crop and Horticultural Research, Agricultural Research, Education and Extension Organization (AREEO), Ardebil, (Maghan) Iran*

Received 16 March 2019; Accepted 4 November 2019

***Extended abstract***

## Introduction

Potato (*Solanum tuberosum* L.) is one of the most important crop plants in the world. Different indices have been introduced to determine stress tolerance, but in general, indices that are highly correlated with yield under both stress and non-stress conditions are considered as the best indices. Because these indices are capable of identifying high yield genotypes in both stress and non-stress environments, they can be used to estimate yield stability. Therefore, the purpose of this study was to compare different drought tolerance and susceptibility indices and group hybrids from potato cultivars in Ardabil province based on these indices.

## Materials and methods

In order to study drought tolerance indices of 12 hybrids obtained from crossover of experimental potato cultivars in a randomized complete block design with three replications at two irrigation levels (100 and 65% of plant water requirement) in Zareh Agricultural Company greenhouse Gostar Arta was performed. The first year was for genetic variation, and the second year was for greenhouse cultivation. Drought tolerance indices were also calculated for the studied genotypes in order to determine the tolerance of cultivars to different water deficit conditions. The susceptibility and stress tolerance indices (GMP, MP, STI, SSI and TOL) were used to evaluate drought tolerance and drought resistance of potato genotypes.

Drought tolerance indices were calculated and after computing the indices, these indices were analyzed and compared with 100% and 65% water requirement using SPSS-22 software. Relationship between gland function in two environments and calculated tolerance indices were performed and three-dimensional graphs were plotted using SPSS-22 software. Minitab15 software was used for better evaluation of relationships by principal component analysis and biplot charts. Also, WARD method was used to select the desired hybrids for hybridization and the obtained results were obtained. A dendrogram chart form was provided. The dendrogram was plotted by Minitab15 software.

[*]Correspondent author: Reza Baradaran; E-Mail: r.baradaran@yahoo.com

## Results

Results of analysis of variance of yield under normal conditions and 65% water use and stress tolerance indices showed variation among 12 hybrids from crosses. Under normal conditions (100% plant water requirement) the highest yield of tuber with average of 53.55 ton /h belonged to R12 hybrid (♀Luca×Esprit♂). The highest tuber yield under drought stress conditions (65% plant water requirement) was observed in S13 (♂Luca×Esprit♀) and S14 (♂Luca × Esprit♀) hybrids with 34.41 and 35.47 ton / ha, respectively. In stress conditions (65% plant water requirement) the highest tuber yield and the highest harmonic mean, geometric mean yield and stress tolerance index belonged to hybrid R14 (♀Luca × Esprit♂). The results of correlation analysis showed tuber yield under normal and stress conditions (65% of available water) and drought tolerance index, Geometric mean productivity index and average productivity index are the most appropriate indices for determining potato-tolerant hybrids. Multivariate biplot charts showed that the two hybrids R14 (♀Luca × Esprit♂) and S13 (♂Luca × Esprit♀) were adjacent to vectors related to important drought tolerance indices namely productivity mean, geometric mean productivity And stress tolerance. Also distribution of hybrids in biplot showed genetic variation among hybrids relative to drought stress. Cluster analysis showed that the highest genetic distance was between R14 (♀Luca × Esprit♂) and R12 (♀Luca×Esprit♂) hybrids and S12 (♂Luca × Esprit♀) susceptible hybrids.

## Conclusions

Based on the results, it can be concluded that the ability of separation of drought tolerant hybrids from potato cultivars by geometric mean productivity and average productivity index and tolerance index is more appropriate and two hybrids R14 and S13 can be used as stress tolerant hybrids.


***Keywords*:** Potato hybrid, Tolerance indices, Water deficit stress

**Table 1. Analysis of variance of drought tolerance and tuber yield indices under normal conditions (100% 65% plant water requirement) and water deficit stress (65% plant water requirement).**

| S.O.V | df | Yield of Normal (100% plant water requirement) | Yield of Strees(65% plant water requirement) | TOL | MP | GMP | STI | SSI |
|---|---|---|---|---|---|---|---|---|
| **Replication** | **2** | $15.18^{ns}$ | $75.23^{**}$ | $79.4^{**}$ | $38.3^{**}$ | $48.9^{**}$ | $0.05^{**}$ | $0.04^{**}$ |
| **Genotypes** | **11** | $150.3^{**}$ | $68.73^{**}$ | $92.1^{**}$ | $85.1^{**}$ | $81.1^{**}$ | $0.12^{**}$ | $0.03^{**}$ |
| **Error** | **22** | 22.893 | 0.685 | 6.174 | 1.767 | 1.617 | 0.003 | 0.003 |
| **C.V (%)** | | 11.34 | 2.83 | 20.23 | 3.73 | 3.63 | 7.6 | 23.81 |

*, ** Significant at p≤0.05 and 0.01, respectively

**Table 2. Comparison of mean tuber yield of hybrids obtained from potato cultivars under normal conditions (100% plant water requirement) and water deficit stress (65% plant water requirement) and stress tolerance indices**

| Hybrid number | (Hybrids from the crossing of commercial potato cultivars) | Mean tuber yield and stress tolerance indices | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Yp (t ha-1) | Ys (t ha-1) | TOL | MP | GMP | STI | SSI |
| 1 | S12 (♂Luca × Esprit♀) | 49.75 $^{abc}$ | 23.95 $^{f}$ | 19.86 $^{b}$ | 34.72 $^{b}$ | 33.28 $^{c}$ | 0.64 $^{cd}$ | 0.41 $^{a}$ |
| 2 | S13 (♂Luca × Esprit♀) | 46.61 $^{a-d}$ | 34.41 $^{a}$ | 11.87 $^{c}$ | 40.02 $^{a}$ | 39.55 $^{a}$ | 0.89 $^{a}$ | 0.21 $^{d}$ |
| 3 | S14 (♂Luca × Esprit♀) | 43.30 $^{b-e}$ | 35.47 $^{a}$ | 8.38 $^{cd}$ | 40.52 $^{a}$ | 40.25 $^{a}$ | 0.93 $^{a}$ | 0.10 $^{ef}$ |
| 4 | S23 (♂Banba × Esprit♀) | 41.15 $^{cde}$ | 27.56 $^{d}$ | 11.96 $^{c}$ | 34.85 $^{b}$ | 34.29 $^{bc}$ | 0.67 $^{bc}$ | 0.20 $^{d}$ |
| 5 | S24 (♂Banba × Agria♀) | 41.09 $^{cde}$ | 32.79 $^{b}$ | 5.40 $^{d}$ | 36.73 $^{b}$ | 36.61 $^{b}$ | 0.77 $^{b}$ | 0.06 $^{f}$ |
| 6 | S34 (♂Esprit × Agria♀) | 28.86 $^{f}$ | 18.70 $^{g}$ | 11.12 $^{c}$ | 23.73 $^{b}$ | 23.05 $^{e}$ | 0.31 $^{f}$ | 0.31 $^{bc}$ |
| 7 | R12 (♀Luca × Esprit♂) | 53.56 $^{a}$ | 30.24 $^{c}$ | 24.13 $^{a}$ | 42.04 $^{a}$ | 40.22 $^{a}$ | 0.93 $^{a}$ | 0.38 $^{ab}$ |
| 8 | R13 (♀Luca × Esprit♂) | 36.33 $^{ef}$ | 26.05 $^{e}$ | 9.27 $^{cd}$ | 31.00 $^{c}$ | 30.64 $^{d}$ | 0.54 $^{e}$ | 0.21 $^{d}$ |
| 9 | R14(♀Luca × Esprit♂) | 50.39 $^{ab}$ | 31.70 $^{bc}$ | 18.03 $^{b}$ | 42.26 $^{a}$ | 41.14 $^{a}$ | 0.97 $^{a}$ | 0.24 $^{cd}$ |
| 10 | R23(♀Banba × Esprit♂) | 35.25 $^{ef}$ | 26.69 $^{de}$ | 10.56 $^{c}$ | 31.48 $^{c}$ | 31.02 $^{d}$ | 0.55 $^{de}$ | 0.23 $^{cd}$ |
| 11 | R24 (♀Banba × Agria♂) | 40.37 $^{de}$ | 31.68 $^{bc}$ | 8.56 $^{cd}$ | 35.67 $^{b}$ | 35.42 $^{bc}$ | 0.72 $^{bc}$ | 0.18 $^{de}$ |
| 12 | R34 (♀Esprit × Agria♂) | 39.31 $^{ef}$ | 30.74 $^{c}$ | 8.19 $^{cd}$ | 34.83 $^{d}$ | 34.57 $^{bc}$ | 0.68 $^{bc}$ | 0.16 $^{de}$ |

**Table 3. Correlation between different stress tolerance indices of potato hybrids under normal irrigation conditions (100% plant water requirement) and severe water deficit stress (65% plant water requirement)**

| | Yp | Ys | GMP | MP | TOL | SSI |
|---|---|---|---|---|---|---|
| **Yp** | 1 | | | | | |
| **Ys** | 0.507 | 1 | | | | |
| **TOL** | 0.706* | -0.183 | 1 | | | |
| **MP** | 0.875** | 0.841** | 0.361 | 1 | | |
| **GMP** | 0.83** | 0.888** | 0.268 | 0.995** | 1 | |
| **STI** | 0.832** | 0.869** | 0.3 | 0.994** | -0.995** | 1 |

*, ** Significant at p≤0.05 and 0.01, respectively

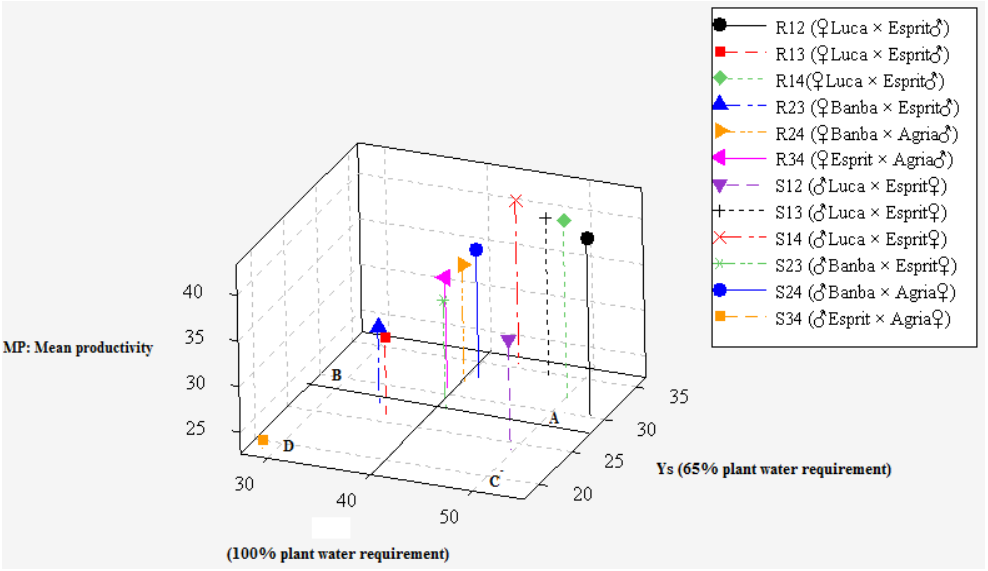


**Fig. 1. Distribution of hybrids based on tuber yield in normal irrigation (100% water requirement) and mild stress (65% water requirement) and Mean productivity index**

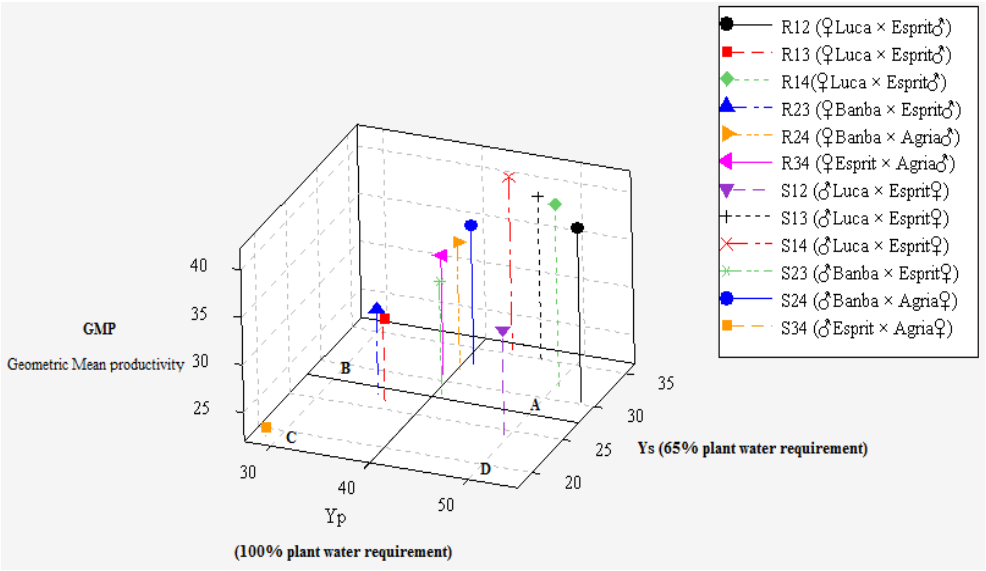


**Fig. 2. Distribution of hybrids based on tuber yield in normal irrigation (100% water requirement) and mild stress (65% water requirement) and geometric mean productivity index**

**Table 4. Principal Coefficients of Coefficients between Normal Irrigation (100% plant water requirement) and Mild Stress (65% plant water requirement) and Stress Tolerance Index**

| Evaluated variables | PCA1 | PAC2 | Subscription rate |
|---|---|---|---|
| **Yp** | 0.877 | 0.445 | 0.967 |
| **Ys** | 0.847 | -0.512 | 0.979 |
| **TOL** | 0.352 | 0.928 | 0.986 |
| **MP** | 0.999 | 0.006 | 0.999 |
| **GMP** | 0.995 | -0.091 | 0.999 |
| **STI** | 0.993 | -0.062 | 0.991 |
| **SSI** | -0.141 | 0.98 | 0.981 |
| **Eigenvalues** | 4.605 | 2.296 | |
| **Variance (percent)** | 65.789 | 32.799 | |
| **Experimental variance (percent)** | 65.789 | 98.589 | |

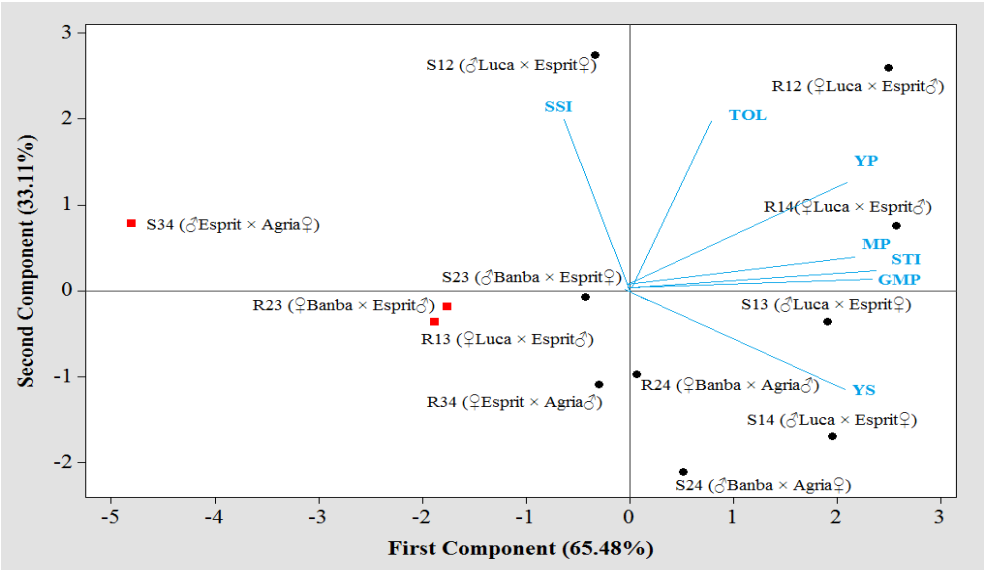


**Fig. 3. Biplot representation of five drought tolerance indices in 12 hybrids derived from potato cultivars based on the first and second components**

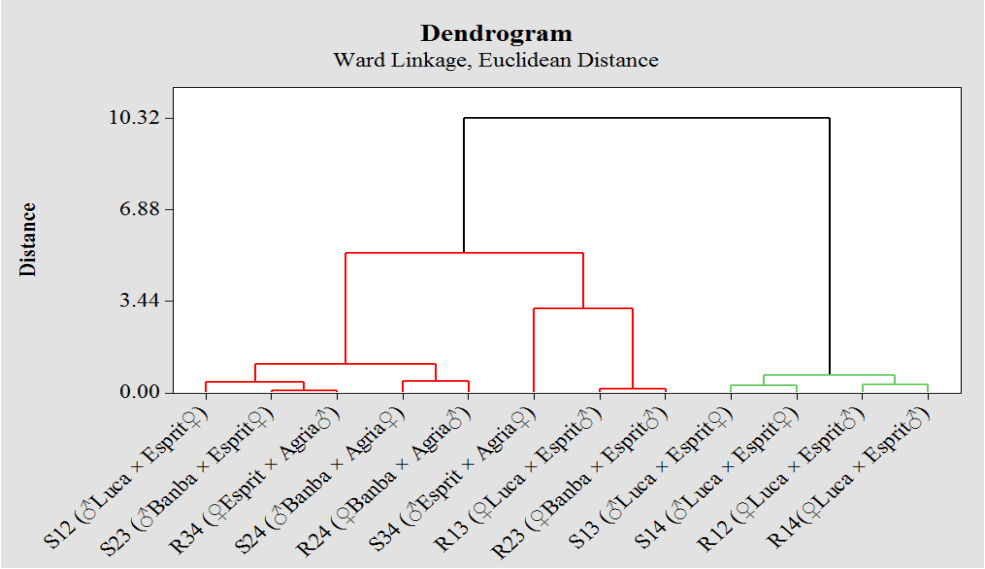


**Fig. 4. Dendrograms obtained from cluster analysis based on data on MP, GMP and TOL**