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A study of drought-tolerance of soybeans using tolerance indices

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Abstract

In order to identify the best drought-tolerance indicator an experiment was conducted on four soybean genotypes in a completely random block design with three replications in Moghan plain. Genotypes were grown in the form of two separate plans of normal irrigation and drought stress. In studying the drought-tolerance indices, stress-tolerance indicator (SITI), geometric mean productivity (GMP) and mean productivity (MP) they were highly correlated with yield potential (YP) and yield stress conditions (YS) and were known as the best indicator. The results from STI appear to be more optimal than the other indicators. Genotypes of Hamilton and Apollo are of the highest performance in both stress and non-stress media with 0.408 and 0.485 STI, respectively. Studying mean yield of the grains of these genotypes in normal conditions is 5155 kg/ha and 6068 kg/ha, respectively. Also their mean yield in stress conditions has been 2235, and 2218 kg/ha, respectively indicating a higher yield of these genotypes in both above conditions than other studied cultivars. Hamilton and Apollo genotypes had acceptable and superior potential in both normal and drought-stress conditions and could be considered as superior lines in breeding programs. The first component was termed as yield potential and drought-tolerance justifying 52.334 percent of variance changes and the second component was called stress-sensitive interpreting 47.544 percent of total variations.

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Introduction

Soybean (*Glycine max* L) is a plant of Fabacea family which is accounted as the most important in terms of oil and protein production in all around the world. It is valuable due to high oil and abundant protein in its corn including its seed weight 20 and 40 percent, respectively (Latifi, 1994). Iran is located in the desert belt of the world, and is considered as arid and semiarid zone. Average rainfall in Iran is about 250mm which is one-third mean rainfall of the world, and 1.2% of the world's dry-land is in Iran. On the other hand from 18.5 million hectares of agricultural 6.2 million hectare is devoted to dry-land farming. About 1.2 million hectares of lands under dry lands farming and receives more than 400mm rainfall (Mohammadi *et al*, 2006). 40-year old statistics shows that rainfall in western- and eastern Azarbaijan, Khorasan, Ardabil, Zanjan and Hamedan is 301,347, 386, 310, 438 and 340mm respectively which is mainly occurred in fall, winter and early in the spring (Anonymous, 2010). The drier climate, the greater is its fluctuations and rainfall distributions so that years of low rainfall and wetter than average is occurred alternatively. Thus such cultivars should be selected for this area that could produce economical and stable yield during low rainfall years and show drought-tolerance and in desired wet conditions could take advantage of stored moisture in soil (Yousefi Azar and Rezaei, 2007).

Fernandez (1992) divided genotypes reaction into 4 groups based on their yield in stress and non- stress media. Groups A are genotypes of high yield in both media. Group B are high yield genotypes in non-stress conditions. Group C include genotypes that are of good yield in stress medium and Group D include genotypes with low yield in both media. He believes that the most appropriate criteria for selecting for stress, is a criteria that could distinguish Group A from other groups. Rosielle and Humblin (1981) proposed tolerance indicator (TOL) and mean productivity (MP).

High levels of tolerance index indicates more susceptibility of genotypes to drought and the lower the indices, the more optimal it will be. Rosielle and Hamblin (1984) used tolerance (TOL) and mean productivity (MP) indices for selecting cultivars of drought-resistance. Using TOL index is better when yield improving is considered in stress conditions. If increased yield is considered in both stress and non-stress media. Using MP index will be better MP is not able to differentiates genotypes A from B and selection is done on the basis of high levels of MP. Fisher and Maurer (1987) suggested stress-susceptibility index for studying stress-tolerant cultivars. Election on the basis of this index causes low yield genotypes selection in normal conditions but high yield in drought stress. This index is not able to differentiate Group A from B. Fernandez (1992) offered stress- tolerance indices. High levels of STI index for a genotype showing higher drought-tolerance pand more potential yield of that genotype. This index suggested another index called GMP (Geometry mean Potential) which is of low susceptibit to yield in normal and stress conditions. GMP is of higher power to differentiate Group A from other groups.

This study was conducted to study and select drought-tolerance genotypes using multi variance statistics.

Materials and methods

Position of Test Location

To select drought- tolerance genotype or genotypes, an experiment was conducted in a completely random block design with 4 genotypes and 3 replications in Moghan plain. The project was performed in the from of two separate experiments of normal irrigation and drought- stress. The grains were cultured on rows with 50 cm distance and 4-6 cm rows and 1-3 cm depth. All agricultural operations were done according to the process of the area from cultivation to harvest stages.

Experiment plot

In order to determine drought-tolerance genotypes, mean productivity (MP), Geometry mean potential (GMP), stress-tolerance index, Tolerance index (TOL), stress-susceptibility index (SSI) and stress-tolerance index were altered using following relationships:

$GMP = \sqrt{YPi \times Ysi}$ $MP = (YPi + YSi) / 2$ $STI = (YPi \times YSi)/Yp2$

$TOL = (YPi - YSi)$ $SSI = (1-(Ysi/Ypi)) / SI$; $SI = 1- (Ys/Yp)$

Where YPi is grain yield in non-stress conditions YSi is grain yield in stress conditions. Ys is mean yield of genotypes in stress conditions Yp is mean yield of genotypes in non-stress conditions. Then the simple correlations were calculates among these indices and cluster analysis was done in ward minimum variance method based on standard mean of drought-tolerance indices. Statistical calculations were done drought-tolerance indices.

Statistical analysis

Statistical calculations were done using MSTAT-C snagit-8 Minitab-15, SPSS 18 soft wares and excel is used to draw diagrams.

Results and discussions

Traits and family of studied soybean genotypes are shown in Table 1.

Table 1. Genotype names used

Number	cultivars
1	Hamilton
2	Williams
3	Apollo
4	L.17

Table 2 shows drought-tolerance indices and grain yield in normal and drought- stress conditions. Based on STI and according to Fernandez using STI can yield more optimal grouping than other indices. It is identified according to STI that Hamilton and Apollo genotypes are of higher efficiency in both stress and non-stress media with 0.408 and 0.485 STI, respectively. Studying the mean grain yield of these genotypes in normal conditions are 5155 kg per ha and 6068 kg ha respectively. Also their mean yield in stress conditions are 2235, 2218 kg/h respectively showing that these genotypes in both above conditions have higher yield than other studied cultivars. The results from STI seem more optimal than the other indices. Also Williams and L17 genotypes which have the lowest STI, 0.355 and 0.368 respectively are of the lowest mean yield in both normal (5257, 4128 kg) and stress (1958, 2468 kg) conditions. Hamilton and Apollo genotypes have acceptable and superior potential in both normal and drought-stress conditions and can be considered as superior lines in breeding projects.

Table 2. Estimation of rate of tolerance and sensitivity of soybean cultivars with relevant indices

Number	Genotyoe	YP	YS	STI	SSI	MP	GMP	TOL
1	Hamilton	5155	2235	.408	1.25	3790.00	3506.00	2926.00
2	Williams	5257	1958	.355	1.46	3660.00	3325.00	3390.00
3	Apollo	6068	2218	.485	1.38	4295.00	3708.00	3950.00
4	L.17	4128	2468	.368	.79	3358.00	3395.00	1545.00

Yp: Yield in normal condition Ys: Yield in stress condition

SSI : Stress Susceptibility Index STI :Stress Tolerance Index

TOL : Tolerance MP : Mean Productivity

GMP : Geometric Mean Productivity

The first component has a higher correlation with MP, YP GMP and STI just if ying 52.334% of variance changes in data matrix, this component should have greater numeric value for better efficiency, so it can be called as a yield potential and drought-tolerance component. The second component interpreted

47.544% of total variations and was highly correlated with SSI and Tol. Thus the second component can be considered as the stress-sensitive one. The positive correlation of these indices with second component having less value results in stabler genotypes selection, and less numeric values should be selected this component separates SSI and Tol in stress conditions. These results are in consistent with Rosielle and Hamblin (1981) and Mohammadi *et al* (2006). Fernandez (1992) found that there was a significant correlation between stress- sensitive indices and grain yield. Shafazadeh *et al* (2002) in studying wheat genotypes reported a positive and highly significant correlation between yield in stress medium and MP, GMP and STI indices. Also they found a positive and significant correlation between yield in non- stress medium and all drought-tolerance and drought- sensitive indices. They stated that the positive and significant correlation between indicates and yield in both stress an non-stress conditions indicative suitability of these indices for studying drought- tolerant genotypes.

Table 3. Vectors and Eigen values for five tolerance and susceptibility indices in 4 soybean cultivars

Component	Eigen value	% of Variance	YP	YS	STI	SSI	MP	GMP	TOL
1	3.663	52.334	0.706	0.18	0.997	0.247	0.883	0.999	0.547
2	3.328	47.544	0.708	-0.984	0.076	0.966	0.47	-0.006	0.837

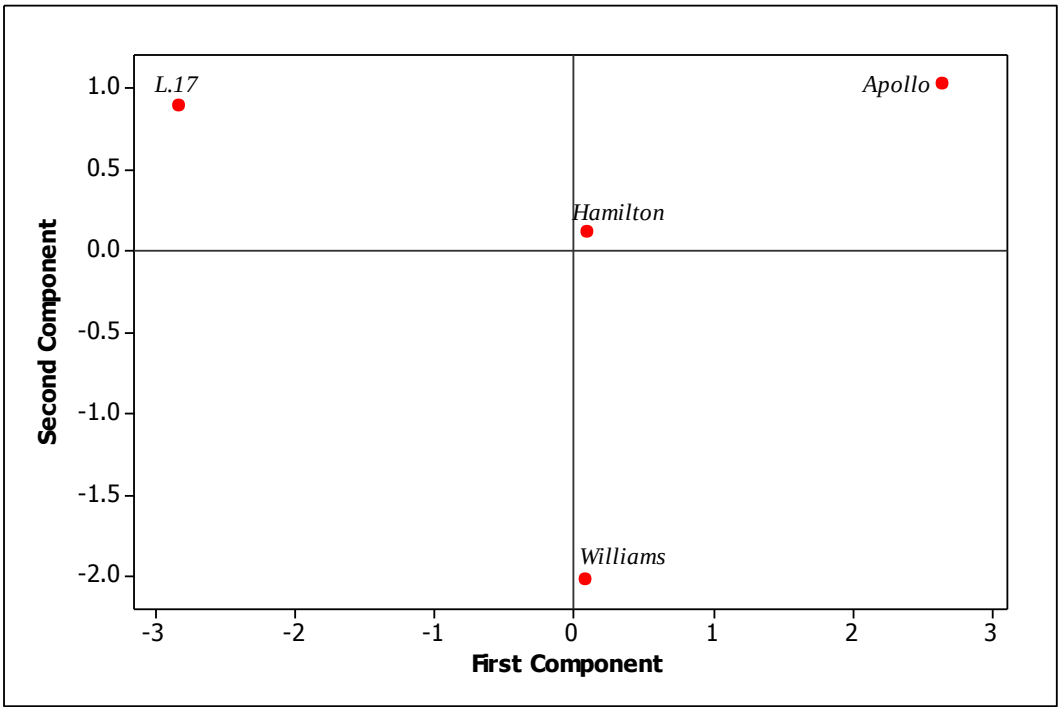

Fig. 1. Biplot for five tolerance and susceptibility indices in 4 soybean cultivars on the basis of first and second components

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