Reaction of drought tolerance in grain maize hybrid using drought tolerance indices

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Abstract: In order to examine effects of drought stress in yield of maize grain hybrid in moisture stress condition and non-stress with use tolerance indices, this study carried out in 2007 at experimental field of Seed and plant Improvement Institute, Karaj, Iran in four separate experiments, normal irrigation, vegetative period stress, reproductive period stress and general stress condition using randomized complete block design in three repetition. Six tolerance indices are Mean Productivity (MP), Geometrical Mean Productivity (GMP), Harmonic mean (Harm), Tolerance Index (TOL), Stress Susceptibility Index (SSI) and Stress Tolerance Index (STI) to determine for all of hybrid. In attention to correlation between tolerance indices and yield in drought stress condition and non drought stress condition GMP and STI indices were identified as the best and a reliable criteria to select also between 20 hybrid of study hybrids KLM76005/7-1-2-1-1-1XK19/1 and KSC 704 were identified as tolerant to vegetative period stress condition, hybrids ZP 677, ZP 684 and KLM 76005/7-1-2-1-1-1 X K19/1 were identified as tolerant to reproductive period stress condition and hybrids KSC 720, KLM 76005/7-1-2-1-1-1 X K19/1 and KSC 704 were identified as tolerant to general period stress condition. Hybrid KLM 76005/7-1-2-1-1-1 X K19/1 is the best hybrid in each four experiments, vegetative period stress, reproductive period stress, general period stress and non-stress after those hybrids ZP 677, KSC 720 and KSC 720 introduced as tolerant hybrids to moisture stress condition.
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1. Introduction

Water is one of the most important restricting factors, which especially in dry and semidry regions would cause reduce in productivity in different ways. Our country has dry and semidry weather, so occurrence of drought stress during plants growth is inevitable [1]. Drought is due to low rainfall, high temperature and blowing wind. The reaction of plant to it is dependent on that in what stage of plants growth it will occur [2]. Stress especially at pollination and grain growth stage will cause to sever reduction in grain maze productivity. Moghaddam and Hadizadeh [3] studied the reaction of maze hybrids and their parent line to drought using different tolerance indices to stress, and the results show that between four calculated indices of STI, SSI, To1 and MP; STI has more benefits for selecting favorable variety in stress condition and without it, and between studied genotypes KSC704 hybrid with high productivity potential is suitable for stress lack condition and SC704M hybrid is suitable for stress conditions.

Chokan and coworkers [4] studied the reaction of lines which were tolerance to drought stress and announced that between studied indices, STI and GMP had a high correlation with productivity in stress and lack stress conditions, and K3615/2, K3640/6 and K19/1 lines were the best ones at optimal, vegetative period stress and reproductive period stress conditions respectively. Ahmadi and coworkers[5] investigated diversity of values traits which show drought resistivity and its relation with productivity and its effects, and announced that there is an impressive diversity in maze hybrid vegetative growth trait , vegetative stages, productivity and productivity performance, and between three irrigation type there is a meaningful difference in some traits.

Khalili and coworkers [6] also investigated drought stress effects on productivity and productivity components in eight serotinous maze genotype at stress lack condition and reproductive period stress and vegetative period stress conditions, and they showed based on GMP and STI indices, high productivity hybrids in both stress and stress lack conditions will be selected using SSI, hybrids with mean high productivity in stress condition. Sameeazadeh and coworkers [7], had an experiment to identify best drought tolerance indices between pea varieties, and they showed GMP and STI indices are suitable for estimation of productivity stability and access to yeiliding varieties in stress and stress lack conditions. Based on their result, correlation coefficient between productivity at normal condition and stress condition is -0/061 and the ratio of calculated productivity genetic variance of two conditions is 0/127. At these conditions geometric mean was less than arithmetic mean.

Sanjri and coworkers [8] investigated the reaction of wheat new varieties to stress condition

which are grain productivity and some crop and physiologic traits in 24 new genotype of wheat. They concluded that based on GMP, STI and MP indices, wheat genotype are tolerant to stress but have high productivity. Correlation of tolerance indices and drought sensitivity showed that MP, GMP and STI had a positive and meaningful correlation with Y_P, Y_{S1} and Y_{S2}, but TOL and SSI had respectively a positive meaningful and no meaningful correlation with Y_P, and TOL and SSI had often negative correlation with Y_{S1} and Y_{S2}. Hashemi and coworkers [9] investigated maze reaction against bush density stress. They investigated three maze hybrids at six different density (0.25, 3, 4.5, 6, 9, 12 bush per m^2). They announced that grain productivity at any of maze hybrid decreased linearly with increase of bush density. They reported that reduction in grain productivity was due to reduction of grain number at any row.

Blum [10] expressed that; genotype with high productivity may not tolerate drought stress and their high productivity may just be because of their high productivity potential.

Fernandez [11] investigated genotype productivity at stress environment and stress lack environment and devised plants pretence regarding two environments into four groups:

Group A: genotypes with high and identical pretence at both environments.

Group B: genotype with good pretence at stress lack environment.

Group C: genotype with good pretence at stress environment.

Group D: genotype with weak pretence at both environments.

For selecting drought tolerant genotype based on productivity, different indices were suggested. Rosielle and Hambelen [12] offered tolerance indices (To1) and mean productivity indices (MP) which high quantities of (MP) indices and low quantities of (To1) indices show stress tolerance.

Fischer and Maurer offered stress sensitive indices (SSI), lower amount of SSI shows the higher drought resistivity. Selecting based on SSI would lead to selecting of genotype with low productivity at stress lack condition and high productivity at stress condition. So, SSI cannot separate and identify group A from group C.

Fernandez [11] offered stress tolerant indices (STI) and mean geometric productivity (GMP) for identification of genotype with high productivity at both stress condition and stress lack condition. High quantities of the both indices show drought tolerance, a GMP index has lower sensitivity to different amount of Y_S and Y_P. MP index (which is based on arithmetic mean) has an orbit toward up (Y_P) when there is a high relative difference between Y_S and Y_P. So, GMP index has higher power at separating group A from other groups comparing to MP index. So Fernandez made the STI index based on GMP. The other offered index is Harm index which its high values represent stress tolerance.

Yahoian [13] had an experiment of evaluation of drought tolerance indices and understanding of soya reaction to drought stress and expressed that genotypes reaction at both conditions are different and best indices are mean geometric index and Fernandez index.

Campos and coworkers [14] had an experiment for improvement of maze resistivity to drought and they concluded that maze is more sensitive to drought at flowering, pollination and pen growth stages. They reported that productivity at stress condition at flowering stage has a high dependence to number of grain at any maze.

Plaut [15] reported that lack of irrigation at flowering stage and maze formation of corn has more effect on productivity reduction in comparison to other stages. Nevertheless low and uniform water reduction at vegetative period would cause meaningfully a low loss at grain production even if total used water amount is identical to irrigation lack condition. Cakir [16] carried out an experiment to study humidity stress effect on different stage of vegetative and reproductive period of maze, and he concluded that drought stress during topknot period would cause to reduction of plant height and also extension of leaf surface at maze. Reducing water during vegetative period would cause to 28-32% reduction of final dry material weight.

Mohammadi and coworkers [17] investigated selecting index for drought tolerance at wheat bread, and introduced STI, GMP and Harm indices as best drought tolerance indices for use at wheat eugenic program, because these indices had highest correlation with grain productivity under water and diem conditions.

Purpose of this work is to investigate drought stress effect on grain maze productivity at different stress conditions (vegetative stress, reproductive stress, general stress) and identify most tolerant hybrids at each condition and most tolerant hybrid at all four experiments.

2. Materials and methods

This study carried out in 2007 at experimental field of Seed and plant Improvement Institute, Karaj, Iran. This study is containing 20 maze hybrids of same groups at four separate experiments as below:

1. Normal irrigation which depending on plant water need is once during 8-10 days

2. Vegetative period stress: cutting off water from beginning of growth to appearance of top of crowning flower
3. Reproductive period stress : cutting off water after pollination stage till grain get jagged
4. General stress: cutting off water one of the other

Any experiment was done using randomized complete block design in three repetitions.

For crop operation at first a deep plow was done at the land of experiment at the beginning of using randomized complete block design in three repetition fall, and then at the spring a hard disk was done and the land got flat. Before implant we added 6 liter per hectare Ordikan poison, 300Kg Ammonium phosphate and 200Kg urea dung, then they were mixed with soil with a light disk and then at the stage of 7-9 leaf 200Kg urea dung per hectare was added to the land.

In order to identify drought tolerance index GMP or MP, STI, Harm, SSI indices were used, and To1 was used for identifying stress sensitivity and their calculation method are as below:

$$Tol = Y_P - Y_S \quad (1)$$

$$SSI = \frac{1-(\frac{Y_S}{Y_P})}{SI} \quad (2)$$

$$MP = \frac{Y_P + Y_S}{2} \quad (3)$$

$$SI = 1 - \left(\frac{\overline{Y_S}}{\overline{Y_P}}\right) \quad (4)$$

$$STI = \frac{(Y_P)(Y_S)}{(\overline{Y}_P)^2} \quad (5)$$

$$G_{MP} = \sqrt{(Y_S)(Y_P)} \quad (6)$$

$$Harm = \frac{2(Y_P.Y_S)}{Y_P + Y_S} \quad (7)$$

Where Y_P is genotype operation at normal condition, YS is genotype operation at stress condition, $\overline{Y_S}$ is the operation mean of all genotypes at stress condition, $\overline{Y_P}$ is the operation mean of all genotypes at normal condition and SSI and SI are stress sensitivity index and environment harness respectively. MP is productivity arithmetic mean, GMP is productivity geometric mean, Harm is productivity harmonic mean, To1 is tolerance index and STI is Fernandez stress tolerance index. In order to identify best indices their correlation was calculated using SAS software at stress condition and stress lack condition. In order to draw three dimensional plot STATISTICA software was used.

3. Result and discussion

In order to identify tolerant hybrids, at both stress and stress lack conditions the stress resistivity values of tables (1, 2, 3) and productivity values at both conditions and also four region category of Fernandez [11] was used and the result were as below:

Table 1. Drought tolerance indices for grain hybrid in vegetative stage under drought stress

Harm	SSI	STI	GMP	MP	TOL	Ys	Yp	
11.1	0.22	14.1	11.1	11.2	0.3	11	11.3	KSC 704
8.63	0.13	8.43	8.63	8.63	0.14	8.56	8.7	KSC 700
9.1	0.73	9.39	9.11	9.12	0.83	8.7	9.53	KSC 720
8.05	0.1	7.34	8.05	8.05	0.1	8	8.1	20 NSX K 19
8.28	1.36	7.83	8.32	8.35	1.48	7.61	9.09	KLM 76002/4-2-1-2-1-1 X K 19/1
8.07	0.07	7.38	8.07	8.08	0.07	8.04	8.11	20 NS X K 19/1
9.69	0.17	10.6	9.69	9.69	0.2	9.59	9.79	K 47/2-2-1-2-1-1-1 X K 19/1
11.4	0.58	14.8	11.4	11.5	0.83	11.04	11.87	KLM 76005/7-1-2-1-1-1 X K 19/1
8.4	0.05	8	8.4	8.41	0.05	8.38	8.43	K 47/2-2-1-2-3-1-1 X K 19/1
6.4	-0.3	4.64	6.4	6.4	-0.2	6.5	6.3	K 74/1 X MO17
7.47	1.06	6.34	7.48	7.5	1.02	6.99	8.01	KLM 75010/4-4-1-2-1-1 X MO17
3.5	2.62	1.44	3.56	3.63	1.36	2.95	4.305	KLM 75010/4-4-1-2-1-1 X B73
6.65	0.93	5.03	6.66	6.68	0.79	6.28	7.07	BC 666
8.88	0.58	8.94	8.88	8.89	0.64	8.57	9.207	BC 678
11.1	0.58	13.9	11.1	11.1	0.8	10.68	11.48	ZP 677
8.9	3.46	9.63	9.22	9.56	5.01	7.05	12.06	ZP 684
5.87	0.99	3.91	5.88	5.89	0.74	5.52	6.26	G- 3393
5.91	2.53	4.08	6	6.1	2.18	5.01	7.19	NS 540

6.25	2.95	4.63	6.4	6.55	2.82	5.14	7.96	G- 3261
5.4	4.22	3.73	5.74	6.1	4.14	4.03	8.17	G- 72019

Table 2. Drought tolerance indices for grain hybrid in reproductive stage under drought stress

Harm	SSI	STI	GMP	MP	TOL	Ys	Yp	
1.56	1.06	1.07	3.08	6.07	10.46	0.84	11.3	KSC 704
0.9	1.09	0.47	2.04	4.58	8.22	0.477	8.7	KSC 700
0.86	1.1	0.49	2.07	4.99	9.08	0.45	9.53	KSC 720
1.2	1.06	0.6	2.29	4.37	7.45	0.65	8.1	20 NSX K 19
1.91	1.01	1.1	3.12	5.08	8.02	1.07	9.09	KLM 76002/4-2-1-2-1-1 X K 19/1
2.57	0.93	1.41	3.52	4.82	6.58	1.53	8.11	20 NS X K 19/1
1.73	1.04	1.05	3.04	5.36	8.84	0.94	9.79	K 47/2-2-1-2-1-1-1 X K 19/1
2.39	1.02	1.79	3.97	6.6	10.54	1.33	11.87	KLM 76005/7-1-2-1-1-1 X K 19/1
1.84	1.01	0.98	2.95	4.73	7.4	1.03	8.43	K 47/2-2-1-2-3-1-1 X K 19/1
2.49	0.87	1.11	3.12	3.92	4.75	1.55	6.3	K 74/1 X MO17
2.4	0.95	1.28	3.36	4.71	6.6	1.41	8.01	KLM 75010/4-4-1-2-1-1 X MO17
1.88	0.83	0.59	2.28	2.75	3.1	1.2	4.3	KLM 75010/4-4-1-2-1-1 X B73
3.46	0.78	1.83	4.02	4.68	4.78	2.29	7.07	BC 666
2.01	1.01	1.18	3.23	5.16	8.07	1.13	9.2	BC 678
2.87	0.99	2.13	4.34	6.56	9.84	1.64	11.48	ZP 677
2.75	1	2.12	4.32	6.8	10.51	1.55	12.06	ZP 684
0.73	1.08	0.28	1.56	3.32	5.87	0.39	6.26	G- 3393
2.59	0.9	1.29	3.37	4.38	5.61	1.58	7.19	NS 540
2.12	0.97	1.1	3.12	4.59	6.74	1.22	7.96	G- 3261
2.59	0.93	1.42	3.55	4.85	6.63	1.54	8.17	G- 72019

Table 3. Drought tolerance indices for grain hybrid in general stage under drought stress

Harm	SSI	STI	GMP	MP	TOL	Ys	Yp	
4.27	1.01	3.37	5.45	6.97	8.67	2.63	11.3	KSC 704
2.4	1.11	1.37	3.48	5.05	7.31	1.39	8.7	KSC 700
5.08	0.84	3.73	5.74	6.5	6.07	3.46	9.53	KSC 720
4.02	0.88	2.45	4.65	5.39	5.43	2.67	8.1	20 NSX K 19
2.47	1.11	1.47	3.61	5.26	7.66	1.43	9.09	KLM 76002/4-2-1-2-1-1 X K 19/1
1.27	1.2	0.63	2.37	4.4	7.42	0.69	8.11	20 NS X K 19/1
4.2	0.96	2.96	5.11	6.23	7.12	2.67	9.79	K 47/2-2-1-2-1-1-1 X K 19/1
6.59	0.81	6.13	7.36	8.22	7.31	4.56	11.9	KLM 76005/7-1-2-1-1-1 X K 19/1
1.72	1.17	0.92	2.84	4.7	7.47	0.96	8.43	K 47/2-2-1-2-3-1-1 X K 19/1
3.81	0.75	1.95	4.15	4.52	3.57	2.73	6.3	K 74/1 X MO17
2.25	1.1	1.19	3.24	4.66	6.7	1.31	8.01	KLM 75010/4-4-1-2-1-1 X MO17
2.43	0.8	0.82	2.7	3	2.62	1.69	4.31	KLM 75010/4-4-1-2-1-1 X B73
4.02	0.79	2.25	4.46	4.94	4.26	2.81	7.07	BC 666
3.79	0.97	2.49	4.69	5.8	6.82	2.39	9.21	BC 678
3.73	1.06	2.9	5.06	6.86	9.25	2.23	11.5	ZP 677
2.65	1.15	2.04	4.24	6.78	10.6	1.49	12.1	ZP 684
2.93	0.91	1.35	3.46	4.09	4.35	1.91	6.26	G- 3393
3.23	0.94	1.69	3.87	4.64	5.11	2.08	7.19	NS 540
2.22	1.1	1.16	3.2	4.63	6.67	1.29	7.96	G- 3261
3.71	0.93	2.22	4.43	5.29	5.77	2.402	8.17	G- 72019

GMP= Geometrical Mean Productivity
MP= Mean Productivity
TOL= Tolerance Index
Harm= Harmonic mean
SSI= Stress Susceptibility Index
STI= Stress Tolerance Index
Yp= Yield potential
Ys= Yield stress

3.1. Arithmetic mean index (MP)

Regarding high values of this index which are represent of stress tolerance, at vegetative stress experiment of KLM 76005/7-1-2-1-1-1 X K 19/1, KSC 704 and ZP677 hybrids were selected as hybrids with productivity arithmetic mean at stress and stress lack condition. At reproductive stress, ZP684 and ZP677 hybrids were identified as hybrids with arithmetic mean and productivity at stress and stress lack conditions. At general stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1, KSC 704 and ZP677 hybrids were selected as hybrids with arithmetic mean and productivity at stress and stress lack conditions. As it can be seen at general stress experiment ZP677 hybrid has productivity mean of 2.23 ton per hectare at stress condition and KSC720 hybrid has the productivity mean of 3.46 ton per hectare at stress condition, regarding high value of KSC720 hybrid toward ZP677 hybrid, it was identified as tolerant hybrid. At reproductive period stress experiment, the BC666 hybrid with productivity mean of 2.29 ton per hectare at stress condition and KSC704 hybrid with productivity mean of 0.84 ton per hectare at stress condition, it can be seen that BC666 hybrid has the higher productivity mean than KSC704 hybrid but it was not a tolerant hybrid because of higher value of productivity (KSC704 hybrid at reproductive period stress and ZP677 hybrid at general stress experiment) at stress lack condition which caused to increase of arithmetic mean . So, MP index is not suitable at selecting hybrids with high productivity at stress condition and it cannot separate group A of B [17].

3.2. Tolerance index (To1)

As at this index, low values of To1 show stress tolerance, at vegetative period stress K 74/1 X MO17, K 47/2-2-1-2-3-1-1 X K 19/1, 20 NS X K 19/1, 20 NSX K 19, KSC 704 hybrids have low values of To1 and regarding productivity value at stress and stress lack conditions, only KSC704 was selected as tolerant hybrid at vegetative period stress condition. At the experiment of reproductive period stress KLM 75010/4-4-1-2-1-1 X, B73, K 74/1 X MO17 and BC 666 were identified as hybrids with low values of To1, and based on productivity at stress and stress lack condition BC 666 hybrid was identified as tolerant hybrid, and at the general stress experiment K 74/1 X, MO17, BC 666, NS 540, K 47/2-2-1-2-1-1-1 X K 19/1 hybrids were identified as hybrids with low To1, and regarding productivity at stress and stress lack conditions K 47/2-2-1-2-1-1-1 X K 19/1 hybrid was identified as tolerant hybrid. So TOL index was successful at identifying hybrids with high productivity at stress condition and low productivity at stress lack condition, in fact this index cannot identify group A of C, and when we consider productivity we can To1 index is reliance [17].

3.3. Harmonic mean index (Harm)

As high values of this index represent stress tolerance, at the vegetative period stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1 and KSC704 hybrids were identified with high harmonic mean and high productivity at stress and stress lack conditions, and at the reproductive period experiment BC666, ZP 677 and ZP 684 hybrids were introduced as hybrids with high harmonic mean and high productivity at stress and stress lack conditions. At the general stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1 and KSC 720 hybrids, were hybrids with high harmonic mean and high productivity at stress and stress lack conditions.

3.4. Stress sensitivity index (SSI)

The lower values of this index show stress tolerance, so regarding SSI values at vegetative period stress experiment , K 74/1 X MO17, K 47/2-2-1-2-3-1-1 XK 19/1, 20 NS X K 19/1, K 47/2-2-1-2-1-1-1 X K 19/1 and KSC 704 hybrids were identified as hybrids with low values of SSI, and BC 666 hybrids with high productivity was identified as tolerant hybrid at stress and stress lack condition. At the general stress experiment K 74/1 X MO17, BC 666, KLM 75010/4-4-1-2-1-1 X B73, KLM 76005/7-1-2-1-1-1 X K 19/1hybrids with low values of SSI were identified, but considering productivity value at stress and stress lack conditions only KLM 76005/7-1-2-1-1-1 X K 19/1 hybrid was identified as a tolerant hybrid. There is a component which is called SI or stress intensity at the calculation and the higher values of this component would cause the lower values of SSI [3]. SSI index would response to changes or damages of hybrids due to stress in addition of response to amount of hybrid productivity at stress condition. It means if a hybrid at both conditions show a high productivity, and high change percent but it cannot be identified as tolerant hybrid, such as KLM 76005/7-1-2-1-1-1 X K 19/1hybrid at vegetative period stress experiment which had high productivity at both conditions but due to high change percent was not identified as tolerant hybrid.

3.5. Stress tolerance index (STI)

Another used index is STI, which high values of this index show tolerant genotype. At the vegetative period stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1, KSC 704 and ZP 677 hybrids have high STI and productivity values at stress and stress lack conditions, and were identified as tolerant hybrids. At the reproductive period stress experiment BC 666, ZP 677and ZP 684 hybrids were selected as hybrids with high values of GMP, but regarding productivity at stress and stress lack conditions ZP677 and ZP684 hybrids were stand at A region. At

general stress experiment K47/2-2-1-2-3-1-1XK19/1, KSC 720 and KSC704 hybrids were identified as hybrids with high productivity and high STI values at both stress and stress lack conditions. These hybrids indices which have high productivity at stress and stress lack condition were identified as tolerant hybrids and they can separate group A of other groups (B, Cand D).

3.6. Productivity geometric mean index (GMP)

As it was described before high values of this index shows stress tolerance. At the vegetative period stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1, KSC 704, ZP 677 hybrids were selected as tolerant hybrids. At the reproductive period stress experiment BC 666, ZP677 and ZP684 hybrids were selected as hybrids with high values of GMP , but considering productivity at stress and stress lack condition ZP677 and ZP684 were stood at A region. At the general stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1, KSC 700 and KSC 704 hybrids with high productivity were identified as tolerant hybrids at stress and stress lack conditions. This index could also identified tolerant hybrids successfully and act as a suitable index to separate A region from other regions (B, C, D).

Correlation of indices can be used as an estimate and approximation of one index to another index at different conditions. Tables 4, 5 and 6 can be used as a criterion to select drought tolerant genotypes at vegetative, reproductive and general stress conditions. In general indices with high correlation to productivity at both stress and stress lack conditions were introduced as best indices [11].

Table4. Correlation analysis results between selection indices in vegetative stage on the drought condition

	YP	YS	TOL	MP	GMP	STI	SSI
YS	0.792**	1					
TOL	0.162^{ns}	-0.475*	1				
MP	0.940**	0.901**	-0.184^{ns}	1			
GMP	0.932**	0.966**	-0.233^{ns}	0.999**	1		
STI	0.922**	0.953**	-0.225^{ns}	0.98**	0.988**	1	
SSI	-0.11^{ns}	-0.679**	0.938**	-0.434^{ns}	-0.476^{ns}	-0.442^{ns}	1
HARM	0.900**	0.970**	-0.277^{ns}	0.995**	0.999**	0.987**	-0.513*

* and **: Significant at 5% and 1% probability level, respectively
ns: Non-significant

Table5. Correlation analysis results between selection indices in reproductive stage on the drought condition

	YP	YS	TOL	MP	GMP	STI	SSI
YS	-0.056	1					
TOL	0.973**	-0.285^{ns}	1				
MP	0.971**	0.183^{ns}	0.890**	1			
GMP	0.585*	0.836**	0.272^{ns}	0.677**	1		
STI	0.533*	0.821**	0.293^{ns}	0.690**	0.991**	1	
SSI	0.523*	-0.827**	0.724**	0.345^{ns}	-0.42^{ns}	-0.395^{ns}	1
HARM	0.061^{ns}	0.990**	-0.171^{ns}	0.295^{ns}	0.900**	0.883**	-0.764**

* and **: Significant at 5% and 1% probability level, respectively
ns: Non-significant

Table 6. Correlation analysis results between selection indices in general stage on the drought condition

	YP	YS	TOL	MP	GMP	STI	SSI
YS	0.303^{ns}	1					
TOL	0.982**	-0.161^{ns}	1				
MP	0.930**	0.614**	0.671**	1			
GMP	0.644**	0.921**	0.23^{ns}	0.874**	1		
STI	0.646**	0.919**	0.225^{ns}	0.865**	0.984**	1	
SSI	0.35^{ns}	-0.763**	0.724**	0.00	-0.469^{ns}	-0.45^{ns}	1
HARM	0.41^{ns}	0.991**	-0.046^{ns}	0.709**	0.962**	0.948**	-0.685**

* and **: Significant at 5% and 1% probability level, respectively
ns: Non-significant

At the vegetative period stress experiment Y_P and Y_S have positive and meaningful correlation (r=0.792**) and MP index has highest correlation with Y_P (r=0.940**) and GMP index has the highest correlation with Y_S (r=0.966**).

In general regarding our results GMP (rp=0.932** and rs=0.96**) and STI (rp=0.922** and rs=0.953**) indices, are indices with high correlation at both stress and stress lack condition and they can be used as indices to reach suitable hybrids at both conditions. At the reproductive period stress experiment, productivity has a negative and non meaningful correlation ($r=-0.056^{ns}$) at stress and stress lack conditions. Also To1 index has the highest correlation with YP (r=0.973**) and Harm index has the highest correlation with YS (r=0.99**). But considering result it can be clear that both of above indices are not that high at the environment, so other GMP indices (rp=0.585** and rs=0.836**) and STI (rp=0.533** and rs=0.821**) were identified as indices with high correlation at both stress and stress lack conditions. At the general stress experiment Y_P and Y_S has positive and non meaningful correlation ($r=0.30^{ns}$), MP index has highest correlation with Y_P (r=0.933**), and Harm index has highest correlation with Y_S (r=0.991**) at the general stress condition. Based on result it can be identified that MP, GMP and STI indices have high and positive correlation at both environment. [MP (rp=0.930** and rs=0.614**), GMP (rp=0.644** and rs=0.921**) and STI (rp=0.646** and rs=0.919**)]. In general GMP and STI indices were selected as best indices at vegetative period stress experiment, reproductive period stress experiment and general stress experiment. Using three dimensional diagrams the relation of productivity at stress and stress lack conditions and stress indices (GMP and STI) can be shown. Dividing of X-Y page (Y_S, Y_P) to four A, B, C, D sections is used to identify tolerant genotypes with high productivity at stress and stress lack conditions. At three dimensional diagrams Y_P, Y_S and STI, long lines show tolerance; at the vegetative period stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1, KSC 704, ZP 677 hybrids were stand at A region (Fig. 1) and were identified as tolerant hybrids. At the reproductive period stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1, ZP 677, ZP 684 hybrids at A region, were identified as most tolerant hybrids (Fig. 2).

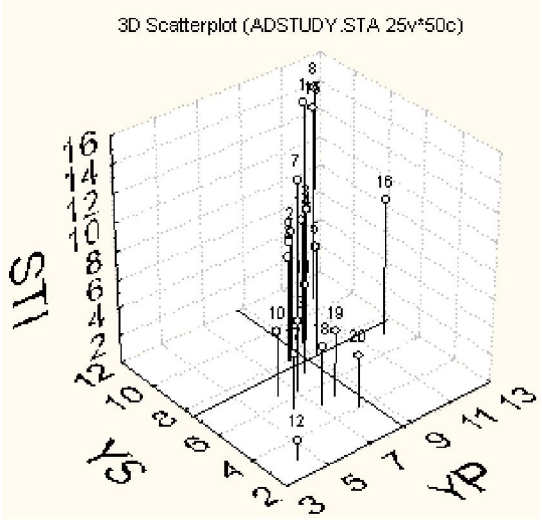

Figure 1.The 3-D plot among STI, Ys and Yp in vegetative stage under drought condition

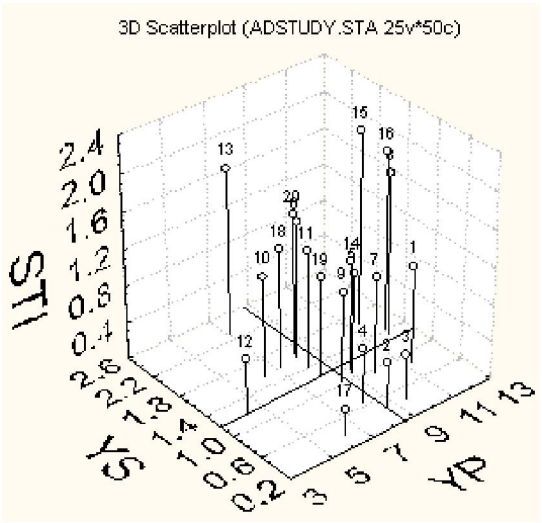

Figure 2. The 3-D plot among STI, Ys and Yp in reproductive stage under drought condition

It can also be seen that BC 666 hybrid due to low productivity and in spite of getting longest line at stress lack condition cannot be identified as tolerant hybrid at it would stand at B region. At the general stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1, KSC 720, ZP 677 hybrids (Fig. 3) were stand at A region and were identified as tolerant hybrids. At Y_P, Y_S, GMP three dimensional diagram the longest lines show tolerance , so at the vegetative period stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1, KSC 704, ZP 677 hybrids (Fig. 4) were at the A region and were identified as tolerant hybrids. At the reproductive period stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1, ZP 684, ZP 677 hybrids were at the A region and were identified as tolerant hybrids (Fig. 5). As it can be seen BC 666 hybrid due to glow

Y_P and in spite of its longest line were stand at B region, and at the general stress experiment KLM 76005/7-1-2-1-1-1 X K 19/1 , KSC 720, KSC 704 hybrids were stand at A region (Fig. 6).

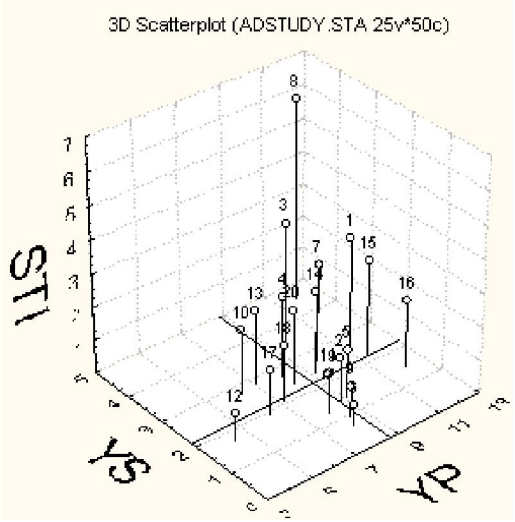

Figure 3. The 3-D plot among STI, Ys and Yp in general stage under drought condition

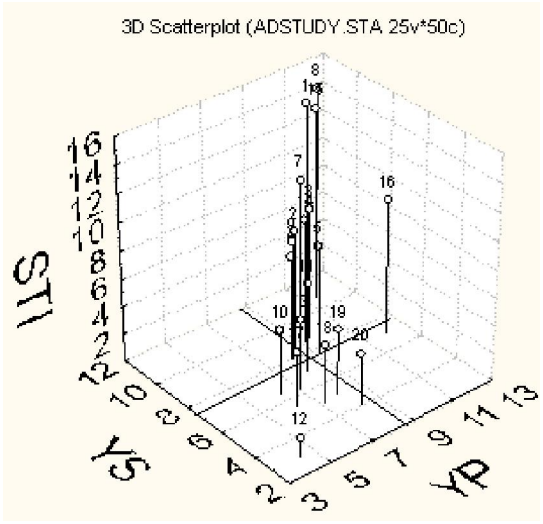

Figure 4. The 3-D plot among GMP, Ys and Yp in vegetative stage under drought condition

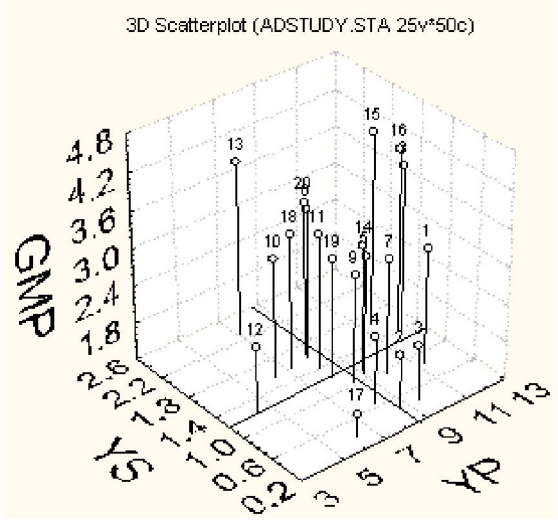

Fig.5. The 3-D plot among GMP, Ys and Yp in reproductive stage under drought condition

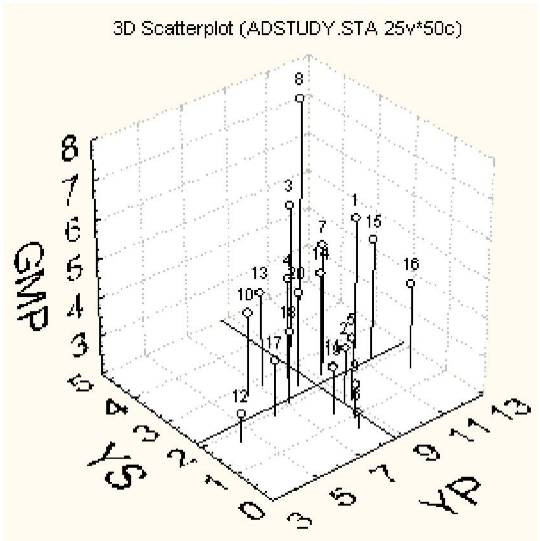

Fig.6. The 3-D plot among GMP,Ys and Yp in general stage under drought condition

In this study considering mean of all hybrids at both stress and stress lack conditions it can be seen in investigating x.y.z surface that KLM 76005/7-1-2-1-1-1 X K19/1, ZP 677 , ZP 684 hybrids were tolerant at vegetative period stress condition, and KLM 76005/7-1-2-1-1-1 X K19/1, ZP 677, ZP 684 hybrids were tolerant at reproductive period stress condition , and KLM 76005/7-1-2-1-1-1 X K 19/1, KSC 704, KSC 720 hybrids were tolerant at general stress condition, and KLM 76005/7-1-2-1-1-1 X K19/1hybrid was tolerant at vegetative, reproductive and general stress conditions and ZP 677, KSC 720, KSC 704 hybrids , stand after it.

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