ICID2015
26th ERC & 66th IEC

Assessment of drought tolerance in Tomato germplasm based on quantitative indices (*Solanum spp.*)

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INTRODUCTION

Tomato is an important, popular and nutritious vegetable all over the world. Climate change and increasing incidence of drought worldwide have highlighted the need for improvement of drought tolerance in tomato.

Tomatoes are very sensitive to water deficits during and immediately after transplanting, at flowering and during fruit development (Nuruddin, 2001). A lot of research on drought tolerance was done in PEG or pot experiments and less in open field experiments.

The objectives of the present investigation was to screen quantitative indicator of drought tolerance and to identify drought-tolerant tomato germplasm.

MATERIAL AND METHODS

Seeds of eighteen tomato genotypes consisted of released varieties , germplasm and wild species were procured from different tomato research centers all over the world.

Table 1. List of tomato germplasm accessions of different species

S.N	Name	Species	Source	S.N.	Name	Species	Source
1	Arka abha	*S. lycopersicum*	IIVR	10	EC 541101	*S.pimpinellifolium*	NBPGR
2	Arka alok	*S. lycopersicum*	IIVR	11	WR 3957	*S. L.* cerseforme	AVRDC
3	EC 771612	*S. lycopersicum*	NBPGR	12	EC 771590	*S. L.* cerseforme	NBPGR
4	EC 771584	*S. lycopersicum*	NBPGR	13	LA 1311-18	*S. L.* cerseforme	TGRC
5	EC 771597	*S. lycopersicum*	NBPGR	14	EC 771590	*S. L.* cerseforme	NBPGR
6	EC 771610	*S. lycopersicum*	NBPGR	15	WR 3969	*S. cheesmanii*	AVRDC
7	EC 676596	*S. lycopersicum*	NBPGR	16	EC 520044	*S. cheesmanii*	NBPGR
8	VRCT 17	*S. lycopersicum*	IIVR	17	LOO 882	*S. peruvianum*	AVRDC
9	EC 514109	*S.pimpinellifolium*	NBPGR	18	EC 771608	*S. peruvianum*	NBPGR

Field experiment was done in Department of Genetics and Plant Breeding Farm, in University of Agricultural Sciences, Bangalore, India during summer 2014.

Experiment was conducted in Randomized complete block design with two replications under moisture -stress and irrigated conditions.

Moisture- stress was imposed by with-holding irrigation for a period of 20 days from 80-110 days after sowing which coincides with tomato fruit development stage

Various quantitative indices were calculated for selection of drought tolerant genotypes based on their yield performance in stress and non-stress environments (Farshadfar and Elyasi, 2012)

Correlation coefficient analysis and principal component analysis (PCA), based on the rank correlation matrix and biplot analysis were performed by SPSS ver. 16, STATISTICA ver. 8 and Minitab ver.16.

Table 2. List of Quantitative Indices used for Screening for Drought tolerance

S.N.	Name	Full form	Formula	author
1	TOL	Tolerance index	$= Y_P - Y_S$	Rosielle and Hamblin,1981
2	MP	Mean productivity	$= (Y_P + Y_S)/2$	Rosielle and Hamblin,1981
3	GMP	Geometric mean productivity	$= \sqrt{(Y_P x Y_S)}$	Fernandez, 1992
4	HM	Harmonic mean	$= 2*(Y_P x \bar{Y}_S)/(Y_P + \bar{Y}_S) \sqrt{(Y_S x Y_P)}$	Kristin et al., 1997
5	STI	Stress tolerance index	$= (Y_P x Y_S)/(Y_P)^2$	Fischer and Maurer, 1978
6	RDI	Relative drought index	$= (Y_S/Y_P)/(Y_S/\bar{Y}_P)$	Fischer and Wood, 1979
7	ATI	Abiotic tolerance index	$= [(Y_P - \bar{Y}_S)/(Y_P/\bar{Y}_S)] x \sqrt{(Y_P x Y_S)}$	Moosavi et al., 2008
8	SSPI	Stress susceptibility percentage index	$= 100 x [(Y_P - \bar{Y}_S)/2Y_P) \sqrt{(Y_P x Y_S)}$	Moosavi et al., 2008
9	SNPI	Stress non-stress production index	$=\{\sqrt[3]{(Y_P + Y_S)/(Y_P - Y_S)}\} x \{\sqrt[3]{(Y_P x Y_S x Y_S)}\}$	Moosavi, 2008
10	YI	Yield index	$= Y_S/\bar{Y}_S$	Gavuzzi, 1997
11	YSI	Yield stability index	$= Y_S/Y_P$	Bouslama and Schapaugh, 1984
12	KSTI	Modified stress tol. index	$K_1STI = Y_P^2/\bar{Y}_P^2$ $K_2STI = Y_S^2/\bar{Y}_S^2$	Farshadfar and Sutka, 2002
14	DI	Drought resistance index	$= [Y_S x (Y_S/Y_P)]/Y_S)$	Lan, 1998
15	SSI	Stress susceptibility index	$= (1 - Ys/Y_P)/SI$ Where, $SI = 1 - (Y_S/Y_P)$	Fischer and Maurer, 1978

Where, Y_P: Fruit yield under control condition, Y_S: Fruit yield under moisture- stress condition, Y_P: Fruit yield mean under control condition and Y_S: Fruit yield mean under stress condition.

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among all the genotypes for traits in both stress and non-stress conditions indicating the presence variability and provides scope for improvement upon selection.

Water stress consistently lowered the fruit yield of tomato genotypes in moisture-stress rather than irrigated condition

The genotypes WR 3969 (2.77%), EC 514109(3.06%), and LA 1311-18(3.56%) recorded lowest *per cent* of fruit yield reduction under moisture- stress condition over control condition.

CORRELATION ANALYSIS

ATI, SSPI, TOL and SSI indices had positive and significant correlation with Yp and negative significant association with Ys, suggest that selection based on these indices will result in reduced yield under well-watered conditions.

Geometric mean productivity, Mean productivity, Harmonic mean and Stress tolerance index indices showed positive and significant correlation with the yield under stress and non-stress condition. We conclude that these indices were able to discriminate tolerant genotypes under stress conditions.

MP, HM, GMP and STI were better predictors of Yp and Ys than ATI, SSPI, TOL and SSI. Therefore, selection for stress tolerance should give a positive yield response under moisture-stress environment.

Over all, drought stress reduced significantly the yield of some genotypes and some of them revealed tolerance to drought, which suggested the genetic variability for drought tolerance in this material.

Table 3. . Association between drought tolerance indices with fruit yield per plant under irrigated(Yp) and reproductive stage moisture-stress(Ys)

	YI	MP	HM	GMP	K2STI	STI	YP	YS
YI	1.000	0.704**	0.926**	0.842**	0.882**	0.873**	0.317	1.000**
MP		1.000	0.907**	0.973**	0.587*	0.930**	0.897**	0.702**
HM			1.000	0.980**	0.782**	0.972**	0.634**	0.925**
GMP				1.000	0.706**	0.975**	0.775**	0.840**
K2STI					1.000	0.811**	0.235	0.881**
STI						1.000	0.698**	0.872**
YP							1.000	0.514**
YS								1.000

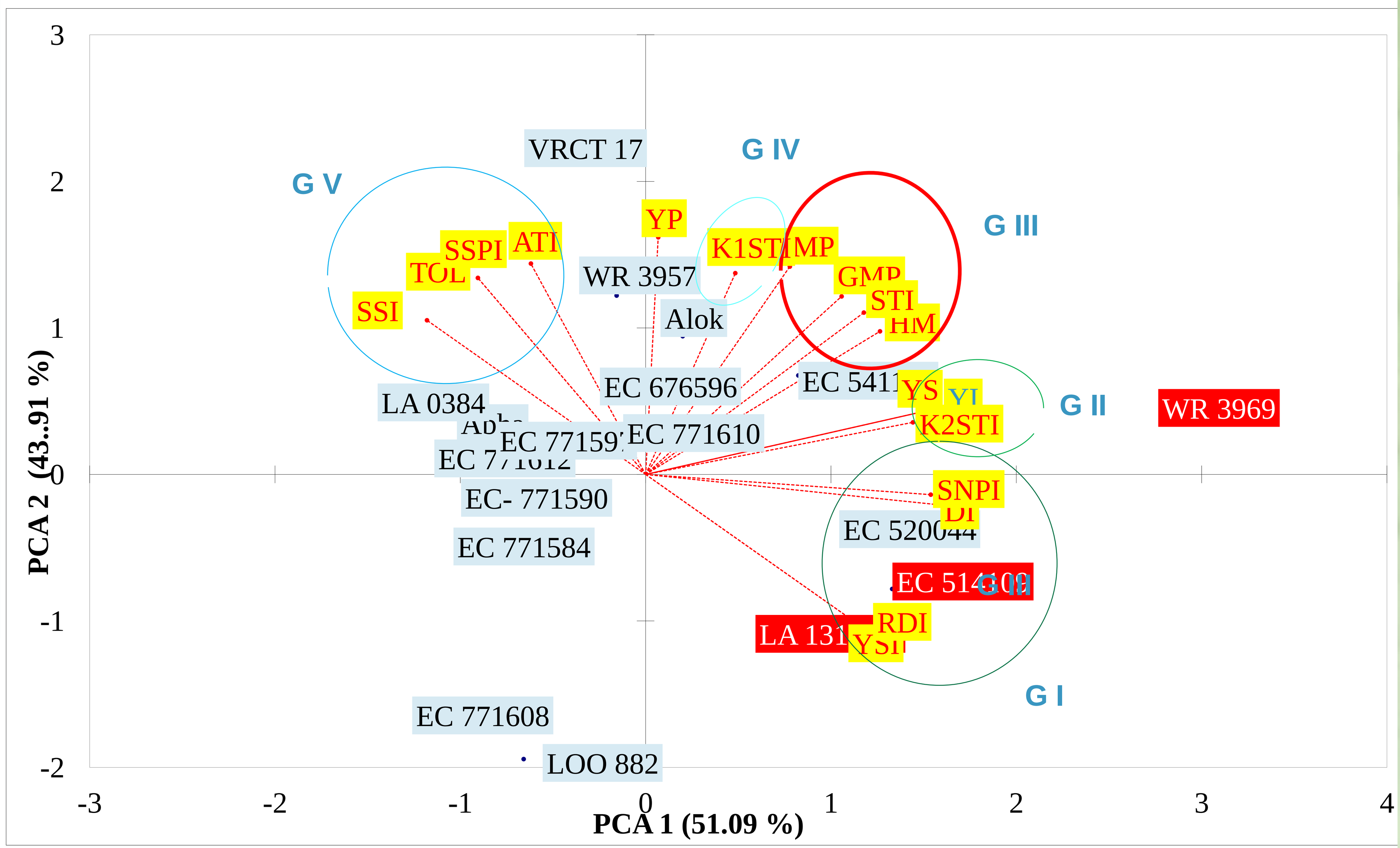
PRINCIPLE COMPONENT ANALYSIS

PCA divides total variation into 8 components of which, first (PCA1)and second (PCA2) components justified 94.99% of the variations between criteria.

The PCs axes separated YSI, RDI, DI, and SNPI in group 1 (GI), YS and K_2STI in group II (GII), HM, STI, GMP and MP in group III (GIII), K_1STI in group IV (GIV) and ATI, SSPI, TOL and SSI in group V (GV).

Genotypes LA 1311-18, EC 514109, WR 39699, EC 520044 and EC 541109 are located near the vectors of these groups hence, they are discriminated as drought tolerant with high performance for stress and non-stress environments (group III).

Figure 1. Principle component analysis and Biplot analysis



CONCLUSION

Four identified drought tolerant indices **MP, HM,GMP and STI** which were significantly positively correlated with fruit yield under stress and control condition could be used for identifying drought tolerant genotypes

Based on biplot and ranking method, genotypes LA 1311-18 (*S. lycopersicum* var cerasiforme) , EC 514109(*S.pimpinellifolium)*, and WR 39699 (*S. cheesemanii*) were identified as the most drought tolerant accessions which could be used for developing high yielding drought tolerant F_1 hybrids.

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ACKNOWLEDGMENT: INDO-EU WATER 4 CROPS Project, Department of Biotechnology, Government of India for financial support for the Research programme.