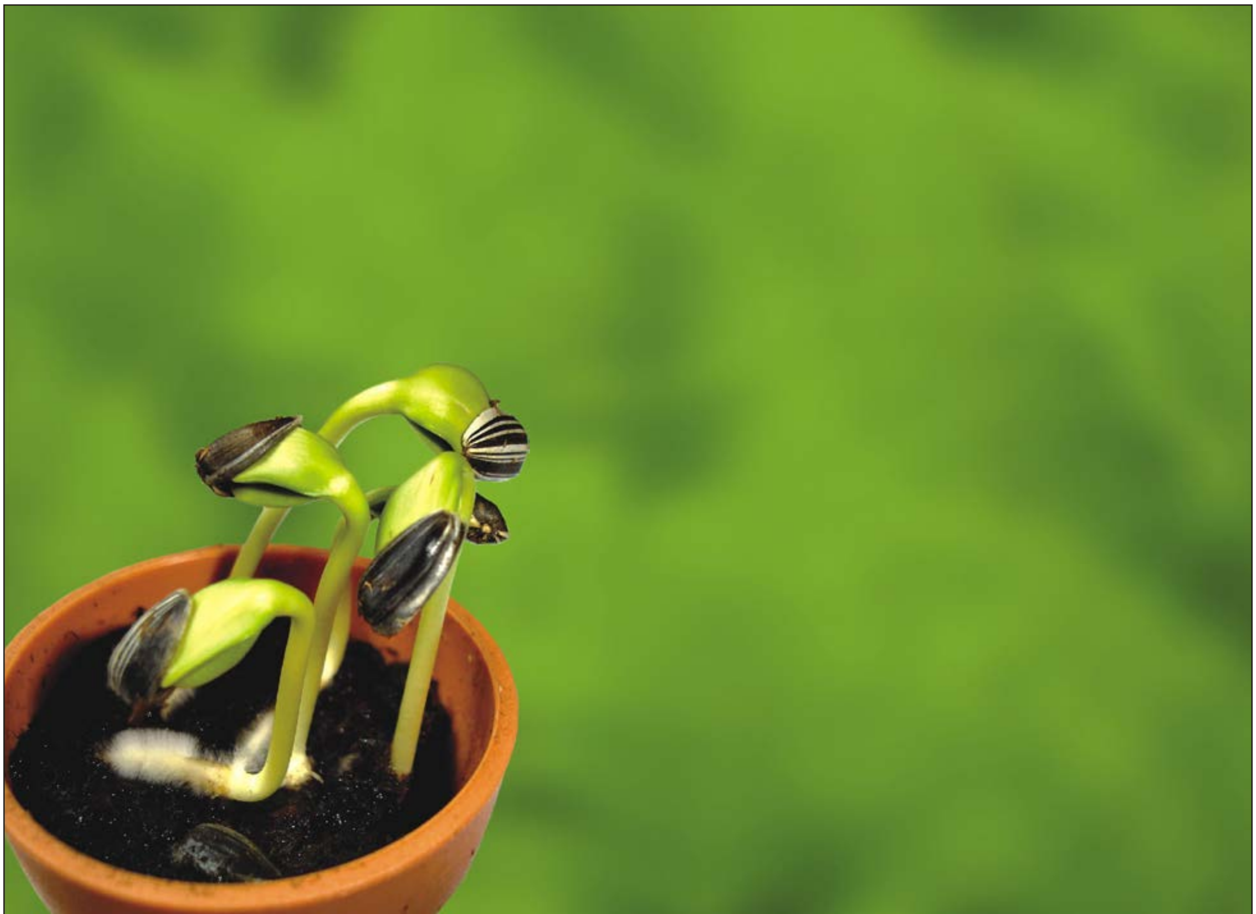

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Genetic Estimates of Water Stress in Tomato (*Lycopersicum esculentum*)

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Abstract: Availability of moisture is a major environmental constraint militating against crop yield world-wide especially in Semi-Arid Tropics. SAMTOM 3 was used to obtain genetic information, assess four drought criteria and their associations. Simulated drought condition was applied (3 and 14 day watering interval). The experiment was Randomized Complete Block Design, replicated 4 times. Differential trait responses were obtained, number of flower abortion, number of fruit/plant, number of flower buds/plant and fruit weight were severely affected by simulated water stress. The calculated quantitative drought tolerance indices; Mean Productivity (MP), Geometric Mean Productivity (GMP) Tolerance Index (TI) and Percent Injury (%I) are effective in improving yield under drought condition. However, correlation analysis indicated that the most suitable drought tolerance criteria are TI and %I. Variance components and heritability estimates were calculated for all the traits studied.

Key words: Crop improvement, drought tolerance, heritability, variance components

INTRODUCTION

Tomato (*Lycopersicum esculentum*) is the most important and popular vegetable crop in West Africa. The crop is grown for domestic consumption both as fresh and for processing. Tomatoes are consumed principally due to high concentration of vitamin A and C and fair concentration of protein, calcium and niacin (Norman 1992; Bodunde, 1999). The establishment of irrigation scheme has lead to commercial large scale tomato production especially in northern and south-western Nigeria (Denton and Swarup, 1981). However, in recent times production has decline drastically due to shortage, erratic and uneven distribution of rainfall. Receding and limited water had led to serious shortage for local and international markets (Atlin and Frey, 1990; Ehdaie, 1993; Bodunde, 2003). Thus, this has become a serious concern for crop breeders in the Semi-Arid Tropics (SAT).

Identification and understanding the genetic architecture of quantitative traits of drought tolerance is prerequisite to crop improvement program. Genotypic performance evaluation in water stress and non stress conditions is the start point for identification of traits related to drought tolerance (Morgan, 1999; Farshadfar, 1998; Farshadfar and Sutka, 2003). Various authors had proposed different screening methods based on genotypic yield performance in contrasting environments to select drought tolerant genotype (Blum, 1988; Cercceralli, 1987; Fernandez, 1992; Ricciardi and Stelluti, 1995; Kristin *et al*., 1997; Ricciardi *et al*., 2001). This has not been very successful because yield and drought tolerance traits are very complex and thus require more sensitive quantitative drought tolerance criteria.

This investigation was designed to screen some quantitative criteria of drought tolerance and their associations and to obtain genetic components information on some agronomic traits evaluated under water stress and non stress conditions.

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MATERIALS AND METHODS

The experiment was conducted at the research field of Institute for Agricultural Research, Samaru, Zaria, Nigeria (11°11'N; 07 °38'E and altitude of 686 m above sea level) for three years (2003, 2004 and 2005) during the dry season. Seedlings of tomato variety; SAMTOM 3 (a high yielding determinate and medium maturing commercial variety) were raised in nursery for three weeks and then transplanted into plots of earlier prepared seed beds of 2×2 m, at inter and intra-row spacing of 30 and 25 cm, respectively.

The experimental design was Randomized Complete Block Design (RCBD) and replicated four times. The plots were fertilized one Week After Transplanting (WAT) with 50 kg ha^{-1} of NPK at 15: 15: 15, with daily watering to field capacity for 3 WAT. Split application of urea (46%) was done at 3 and 6 WAT. The plots were hand weeded regularly and the plants were sprayed with Dithane M45 (2 g L^{-1} of water) fortnightly to control polyphagus insects and fungal foliar diseases. Two watering regimes; 3 Days Watering Interval (DWI) as non water stress condition and 14 DWI (severe drought) as water stress condition were applied.

Data on the following traits were recorded under the simulated non water stress and water stress conditions; Number of leaves, Number of branches, Plant height (cm), Number of flower buds, Number of aborted flowers, Number of fruits and Fruit yield (t/ha). The quantitative drought tolerance criteria were calculated according to Rosielle and Hambling (1981): Tolerance Index (TI) = Y_P-Y_S; Mean Productivity (MP) = $(Y_P+Y_S)/2$; Geometric Mean Productivity $(GMP) = \sqrt{(Y_P)(Y_S)}$ and Percent Injury (%I) = $(Y_P-Y_S)/Y_P\times100$. Y_P is mean trait performance under control and Y_S is mean trait performance under watering regime. Percent trait variability was calculated as difference between minimum and maximum trait mean (range)/trait mean×100 All data were subjected to analysis of variance (not presented), means comparison was done using LSD and graphical comparison were presented using the software SPSS (1999) and Microsoft Excel (2002). Variance components; phenotypic (δ^2_p), genotypic (δ^2_g), environment (δ^2_e), heritability broad sense (h_{BS}%), coefficient of variation (phenotypic and genotypic) and correlations were calculated.

RESULTS AND DISCUSSION

There no significant yearly difference in the trait response to the treatments as measured by ANOVA (data not shown). The entire agronomic trait showed significant differential response between 3D and 14 DWI as determined by LSD0.05 (Table 1). Four traits were highly affected by severe drought as shown by their percent reduction; number of flower abortion (69%), number of fruit/plant (76%), number of flower buds/plant (84%) and fruit weight (85%). Percent trait variability was high for plant height, number of flower buds/plant and number of aborted flower bud/plant under 3DWI (Table 1). However, number of aborted flower/plant, fruit weight/plant and number of fruits/plant were highly variable having above 200% trait variability. Trait variability was expected, thus, it could be

Table 1: Mean, mean range and percent trait variability of tomato cultivar under normal and drought condition across 3 years (2003-2005)

Traits	Mean		$LSD_{0.05}$	Mean range		Trait variability (%)	
	3 DWI	14 DWI		3 DWI	14 DWI	3 DWI	14 DWI
No. of leaves/plant	49.5	35.2	3.81	40-58	27-43	36.46	45.45
No. of flower buds/plant	28.9	4.7	1.03	21-41	2-10	69.20	170.21
No. of aborted flowers/plant	3.6	11.8	0.54	1-4	9-33	83.30	203.39
No. of branches/plant	39.7	20.1	2.68	30-46	13-29	40.30	79.60
No. of fruits/plant	18.5	4.4	0.79	24-29	0-17	20.03	386.36
Plant height (cm)	77.9	58.6	5.01	68-110	37-100	53.66	107.51
Fruit weight/plant (g)	61.4	9.2	4.72	51-81	0.6-20	48.86	210.87

used for possible crop improvement to drought conditions. Many authors had reported genotypic and trait variability under drought condition in different crops (Atlin and Frey, 1990; Ehdaie, 1993; Farshadfar, 1998; Farshadfar and Sutka, 2003).

Quantitative drought tolerance indices were calculated for 3 traits that were highly affected by simulated drought condition (Fig. 1-3). Mean Productivity (MP) and Tolerance Index (TI) were higher for number of flower aborted than number of fruit/plant and fruit weight, thus, selection for low floral abortion under drought condition is an added advantage to high yield. Similar findings had earlier been reported by Blum (1988); Cercceralli (1987) and Fernandez (1992). Percent Injury (%I) was high for number of fruits/plant, fruit weight and number of aborted flowers/plant, thereby indicating the level of loss incurred due to drought.

Table 2 revealed the phenotypic (PCV), Genotypic Coefficient of Variation (GCV), variance components and heritability for five agronomic traits under simulated water regime of 3 and 14 DWI.

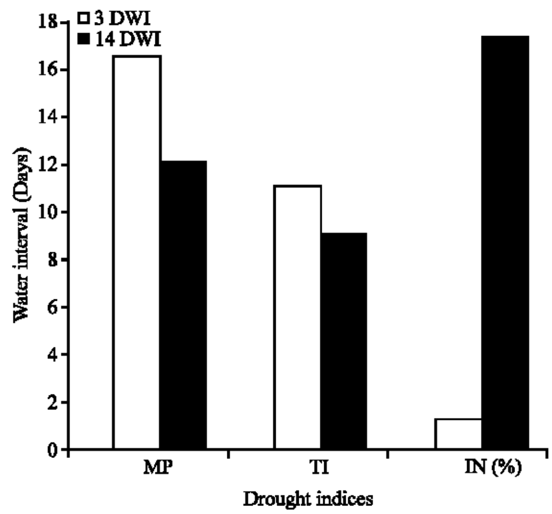

Fig. 1: Drought tolerance estimates for aborted flowers

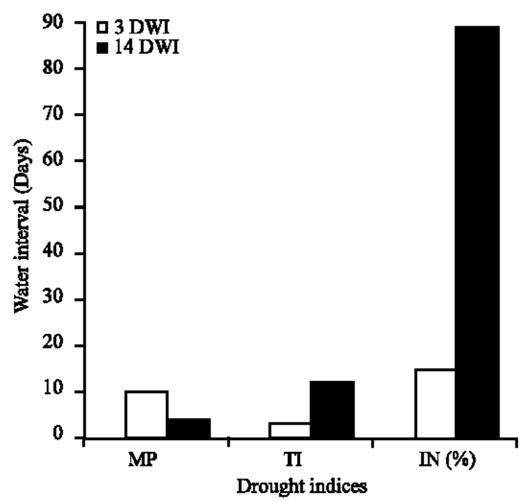

Fig. 2: Drought estimates for No. of fruits

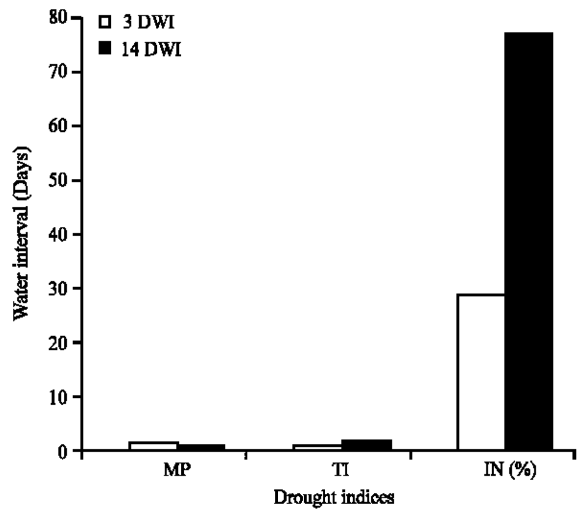

Fig. 3: Drought tolerance estimates fruit weight

Table 2: Coefficient of variations and components of variance of some tomato traits under normal and drought condition

	Coeff. of Var. (%)		Component of Var.			
Traits	PCV	GCV	δ^2_p	δ^2_g	δ^2_e	h_{BS} (%)
No. of flower buds/plant						
3 Days watering interval	5.18	4.99	2.42	1.43	0.99	59.09
14 Days watering interval	16.01	10.11	0.72	0.30	0.42	41.67
No. of aborted flowers/plant						
3 Days watering interval	5.96	5.27	0.05	0.04	0.01	80.00
14 Days watering interval	7.86	5.64	0.98	0.21	0.77	21.43
No. of fruits/plant						
3 Days watering interval	14.04	13.87	8.41	7.95	0.46	95.53
14 Days watering interval	7.14	5.02	0.13	0.02	0.11	15.38
Plant height (cm)						
3 Days watering interval	0.30	0.14	0.05	0.03	0.02	60.00
14 Days watering interval	1.90	1.29	1.28	0.96	0.32	75.00
Fruit weight/plant (g)						
3 Days watering interval	5.43	4.91	12.01	9.27	2.74	77.17
14 Days watering interval	10.66	9.01	2.14	0.93	1.21	43.46

The less than unity difference between PCV and GCV for all the traits under 3 DWI implied that the environment has minimum effects on the traits, however, there was large environment influence on all traits under 14 DWI and this was due to simulated drought condition imposed on the crop. Variance components; phenotypic (δ^2_p), genotypic (δ^2_g) and environmental (δ^2_e) were high for fruit weight/plant at 3 and 14 DWI than all other traits except plant height at 14 DWI. Plant height, fruit weight and number of flower buds/plant were appreciably high, thus, providing opportunity for crop improvement. The environment variance was high for all the traits except plant height under severe drought. Broad sense heritability was high for plant height (75%), fruit weight (43%) and number of flower bud/plant (42%) under severe drought condition; this indicated the presence of additive gene action and these traits are quantitatively inherited. Similar result was reported by Ricciardi and Stelluti (1995) in durum wheat; Kristin *et al*. (1997) in common bean; Bodunde (1999) in tomato; Ricciardi *et al*. (2001) in faba bean.

To determine the most desirable, practicable and applicable drought tolerance criteria, correlation coefficient between yield under non water stress (Y_P), under stress (Y_S) conditions and quantitative

Table 3: Correlation coefficients between tomato yields and drought tolerance indices

Parameters	Ys	Yp	MP	GMP	TI	I (%)
YS	1.00					
YP	0.693**	1.00				
MP	0.982**	0.851**	1.00			
GMP	0.866**	0.761**	0.886**	1.00		
TI	0.722**	0.122	0.222	-0.988**	1.00	
%I	0.881**	0.807**	-0.847**	-0.978**	0.981**	1.00

**Significant at 1% probability level

indices of drought tolerance was presented in Table 3. Y_P and Y_S showed positive and highly significant correlations with MP, GMP, TI and %I, thus, these drought tolerance criteria are desirable indices for drought tolerance breeding. This result agrees with those of Rosielle and Hambling (1981), Cercceralli (1987) Ehdaie (1993) Farshadfar (1998) and Farshadfar and Sutka (2003).

CONCLUSIONS

We concluded that, there was differential trait response to severe drought condition. Number of flower abortion, number of fruit/plant, number of flower buds/plant and fruit weight were severely affected by severe drought. Genotypic variance was influenced by the environmental variance. Plant height, fruit weight and number of flower bud/plant were quantitatively inherited under severe drought condition. MP, GMP, TI and %I can be used as desirable criteria for drought tolerance screening, while TI and %I are the most efficient in improving yield under severe drought condition.

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