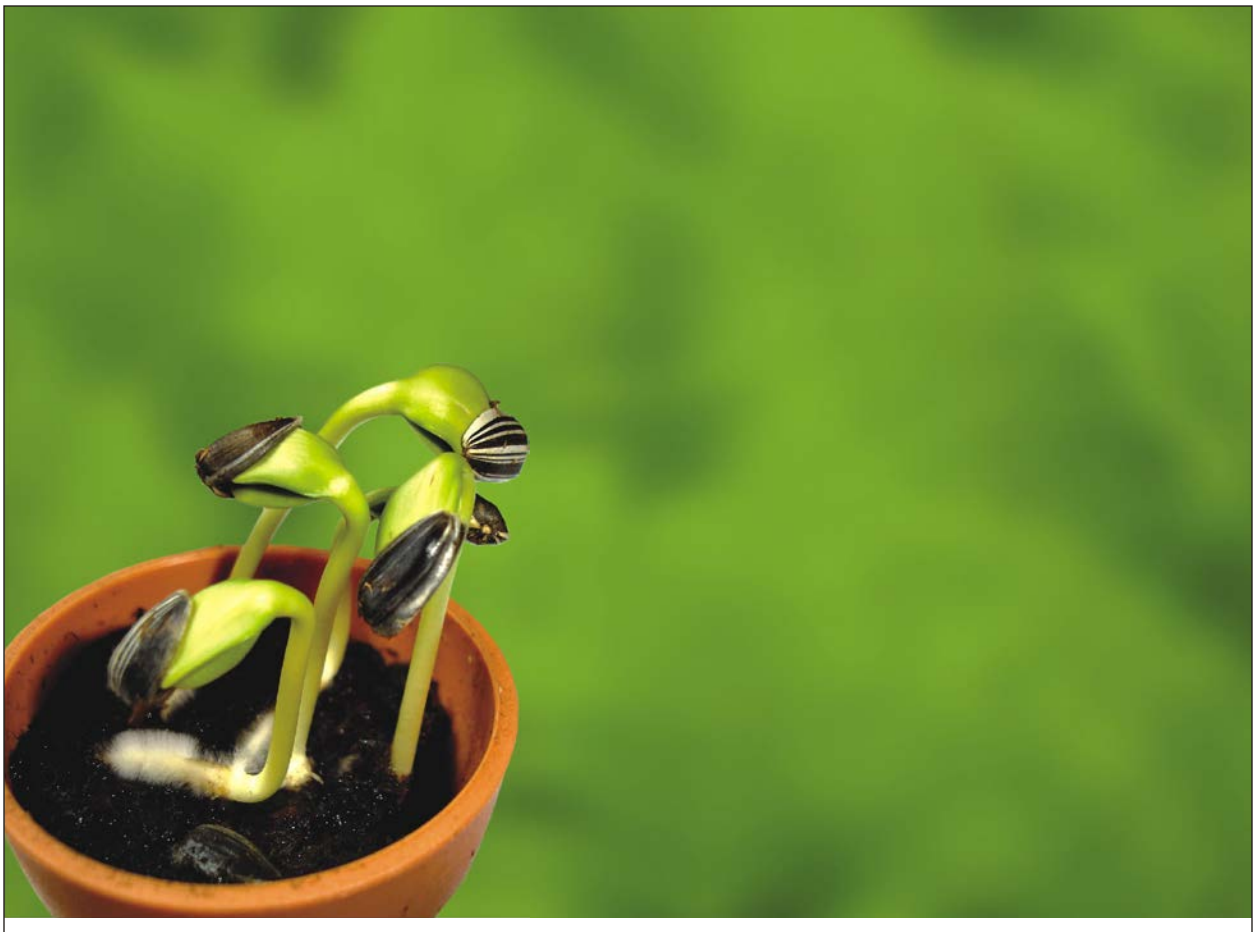

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Drought Tolerance Indices in Sweet Pepper (*Capsicum annuum* L.)

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Abstract: Drought is one of the important factors limiting crop productivity in the arid and semi-arid areas of the world. A study was conducted using four watering regime (daily watering as control, 3, 7 and 14 day Watering Interval) to simulate drought condition. The experiment was laid in randomized complete block design with three replications on the research field of Institute for Agricultural Research, Samaru, Zaria. Mean comparison of agronomic traits indicated trait responsiveness to different water regime and duration of water stress. Fruit yield reduced from 1.37 t ha^{-1} under control to 0.01 under severe drought. Yield and yield components are most affected by drought; 99% yield loss followed by 88% reduction in no. of fruits, 79% reduction in No. of flower buds and an increase of 81% in floral abortion under severe drought was obtained. Drought tolerance indices; Tolerance Index (TI), Mean Productivity (MP) and percent Injury (%I) were calculated and used in formulation of screening and selection criteria for drought tolerance in pepper.

Key words: Quantitative indices, pepper, selection criteria, traits, water stress

INTRODUCTION

Water stress or drought is an important limiting factor in crop production in the arid and semi-arid regions of the world. The inadequate amount, temporal and erratic distribution of available moisture often expose crops especially horticultural crops to long period of drought, high temperature, salinity and other associated consequences (Bramel-Cox *et al*., 1991; Zavala-Garcia *et al*., 1992; Ricciardi *et al*., 1996).

Garden pepper also known as sweet pepper (*Capsicum annuum*) belong to the family *Solanaceae* is mostly cultivated in the northern part of Nigeria which fall into the semi-arid and arid region. This area is characterized by unimodal, inadequate, erratic and uneven distribution of rainfall. Moisture becomes unavailable in the most critical phenological stages of crop growth; reproductive and fruiting and in most cases irrigation becomes necessary (Norman, 1992; Olarewaju and Showemimo, 2002).

Pepper used to be a major income earner for farmers in Nigeria in the early 1970s and 1980s with a 10 years production average of 882.07 t ha^{-1} cultivated in an average area of about 30 ha (Hegde, 1989; FAO, 2000; Olarewaju and Showemimo, 2002). Pepper used to be a cash crop for exportation and for local usage in form of soap making, preservatives, flavour, relish spices for various local and international dishes. In recent times (2000-2005) there had been decline in pepper production principally due to limited supply of water in the northern part of Nigeria leading to an average yield loss of 40% (Showemimo and Olarewaju, 2004; FAO, 2005).

Breeding for drought tolerance/resistance by selecting for yield in pepper may not be successful (Fernandaz, 1992; Ehdaie, 1993). Various physiological criteria have been proposed by several authors in different crops, however, there is limited information on the use of drought tolerance indices on important agronomic traits of pepper (Rosielle and Hambling, 1981; Gummuluru *et al*., 1989;

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Pinter *et al*., 1990; Filippetti and Ricciardi, 1993; Kristin *et al*., 1997). This study is aimed at measuring agronomic trait responsiveness to different watering regime, application of tolerance indices and formulating selection criteria in pepper.

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 two years (2004 and 2005) dry season. Seedlings of a pepper variety L5962-2 (an advanced breeding line) were raised in nursery for four 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 ramdomized complete block design and replicated three 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, at 3 and 6 WAT split application of urea (46%) was done. 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. The treatments are four watering regimes; daily (control), 3 days watering interval (DWI), 7 DWI (moderate drought) and 14 DWI (severe drought). Daily watering was maintained up till 4 WAT then the other treatments were applied.

Data on the following traits were recorded under the applied watering regimes; number of leaves, number of branches, plant height (cm), number of flower buds, number of flower anthesis, number of aborted flowers, number of fruits and fruit yield (t ha^{-1}). 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 and Percent Injury (%I) = (Y_P-Y_S)/Y_P x 100. Y_P is mean trait performance under control and Y_S is mean trait performance under watering regime. 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).

RESULTS AND DISCUSSION

Mean differences for all the agronomic traits are presented in Table 1. All the agronomic traits differed significantly (LSD 0.05) at control, 3, 7 and 14 DWI, except number of branches between 3 and 7 DWI (Table 1). There was reduction in number of leaves from 69 under control to 38 under severe drought condition (14 DWI), similarly, there was a corresponding decrease in number of branches, plant height, number of flower buds, number of floral anthesis, number of fruits, fruit yield and an increase in number of aborted flowers from 2 under control to 11 under severe drought, similar result was reported by Gummuluru *et al*. (1989), Pinter *et al*. (1990), in durum wheat; Filipetti and Ricciardi (1993) in faba beans. Fruit yield reduced from 1.37 t ha^{-1} under control to 0.01 under severe drought. Yield and yield components are most affected by drought; 99% yield loss followed by 88%

Table 1: General means values of pepper traits across weeks of induced drought stress

	Irrigation interval				
Traits	Daily	3 days	7 days	14 days	LSD (p = 0.05)
No. of leaves	69.02	46.87	41.07	37.98	4.85
No. of branches	46.14	35.27	31.77	21.99	4.63
Plant height (cm)	88.47	79.05	66.18	62.82	6.69
No. of flower buds	53.11	40.28	19.94	11.01	2.74
No. of flower anthesis	27.17	18.69	6.02	4.73	1.47
No. of aborted flowers	2.03	5.19	7.32	10.92	1.09
No. of fruits	36.22	21.58	9.18	4.19	0.97
Fruit yield (t ha^{-1})	1.37	0.89	0.53	0.01	0.24

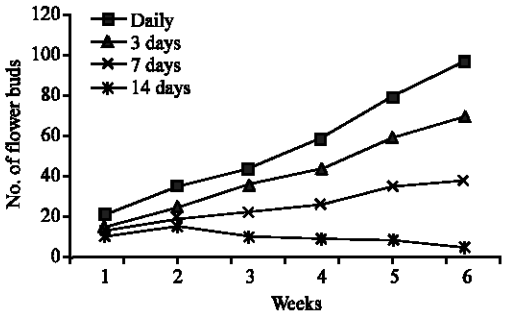

Fig. 1: No. of flower buds/week as influenced by water stress

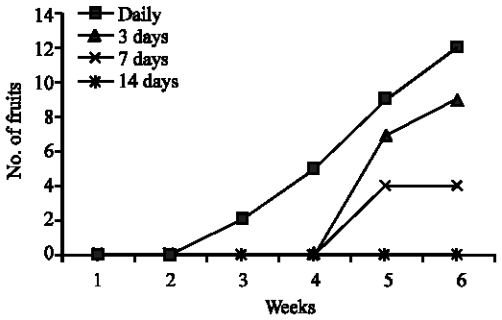

Fig. 2: No. of fruits/week as influenced by water stress

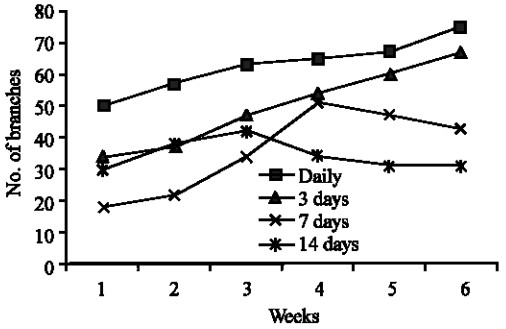

Fig. 3: No. of branches/week as influenced by water stress

reduction in number of fruits, 79% reduction in number of flower buds and an increase of 81% in floral abortion under severe drought were recorded, these results were in agreement with those of Caketa (1981), Mosherefi (1987) and Ehdaie (1993).

Figure 1-4, revealed the responsiveness of four most important agronomic traits of pepper as influenced by water stress for duration of 6 weeks. The duration of water stress application did not affect number of flower buds at control, 3 DWI and 7 DWI. However, the duration of various water stress application led to decline in number of fruits at 7 and 14 DWI (Fig. 2), similar trend was obtained for number of branches and fruit weight at 3, 7 and 14 DWI. These implied that number of flower buds and number of fruits can endure drought condition for a longer duration at mild, moderate and severe drought condition than other traits. Similar findings were also reported in previous studies (Hegde, 1989; Zavala-Garcia *et al*., 1992; Ricciardi *et al*., 1996).

Table 2: Drought tolerance criteria of pepper traits at extreme water stress at 6th week

	*TI		MP		I (%)	
Traits	7 days	14 days	7 days	14 days	7 days	14 days
No. of leaves	75	82	96.5	93	56	61.2
No. of branches	21	39	76.5	52.5	29.2	54.2
Plant height (cm)	50.3	58.1	111.8	107.9	36.7	42.4
No. of flower buds	60	94	68	51	61.2	95.9
No. of flower anthesis	35	46	31	26	71	93.9
No. of aborted flowers	-11	-25	9.5	16.5	ne	ne
No. of fruits	8	10	6	5	80.0	100
Fruit yield (t ha^{-1})	0.8	1.1	0.9	0.8	61.5	100

* TI = Tolerance Index; MP = Mean Productivity and I (%) = Percent Injury; ne = not estimatable

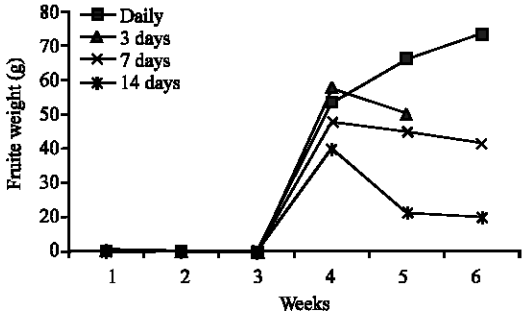

Fig. 4: Fruit weight/week as influenced by water stress

Drought tolerance criteria of agronomic traits of pepper under moderate and severe water stress condition are presented in Table 2. Least tolerance index was obtained for fruit yield, followed by number of fruits and number of aborted flowers. These same traits had the highest percent injury, thus, confirming that these agronomic traits are most affected by drought, therefore, they need considerable improvement for drought tolerance. MP was high for plant height, no. of leaves, number of branches and number of flower buds thus, implying that these traits should also be considered when formulating selection criteria in breeding for drought tolerance in pepper. These results are inconformity with those of Araghi and Assad (1998), Ricciardi *et al*. (2001) and Farshadfar and Sutka (2003).

CONCLUSION

Based on the results obtained, the semi-controlled environment used to simulate water stress was effective in studying agronomic trait responsiveness and could be used in further crop improvement research in drought tolerance. The three drought tolerance indices; TI, MP and %I were appropriate in identifying important agronomic traits such as fruit yield, number of fruits and number of aborted flowers meanwhile, the inclusion of plant height, increased number of leaves and branches could be used in formulating screening and selection criteria for drought tolerance in pepper.

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