ASIAN J. EXP. BIOL. SCI.SPL .2010 :65-68

ISSN 0975-5845
AJEBS
http://www.ajebs.com

ORIGINAL ARTICLE

Physiological Responses of Groundnut (*Arachis Hypogaea* L.) Varieties to Drought Stress

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ABSTRACT

Drought, one of the environmental stresses, is the most significant factors restricting plant production on majority of agricultural fields of the world. Groundnut is usually grown on arid agricultural fields and drought often causes serious problems in groundnut production on these fields. In the current study drought stress was assessed in terms of Relative Water Content (RWC), Membrane Stability Index (MSI), Harvest Index (HI) and Drought Tolerance Index (DTI) for pod yield. Physiological responses were studied under water stress by keeping soil moisture level under four regimes of water (100%, 80%, 60% and 40%). Pot experiments were conducted to evaluate four groundnut varieties (TAG-24, TG-26, WEST-20 and WEST-44). A 4×4 factorial experiment in complete randomized block design with 3 replications was conducted in Botanical garden of Fergusson College, Pune 411 004. Concomitant reductions were observed in RWC, MSI, HI and DTI in these varieties with increasing water stress levels. Among the four varieties var. TG-26 and var. WEST-20 were found to be more sensitive to drought stress, as compared to var.TAG-24 and var.WEST-44.

KEYWORDS: *Groundnut, Drought stress, water content, membrane stability, harvest index*

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is popularly known as peanut. It is one of the world`s most popular and universal crops, cultivated in more than 100 countries of six continents. China and India are the largest producers of groundnut. Groundnut is the largest source of edible oils in India and constitutes roughly about 50% of the total oilseeds production. Among the major groundnut growing states there has been consistent increase in area under cultivation in Andhra Pradesh, Tamilnadu, and Karnataka. However, in Gujarat and Maharashtra, the area under groundnut cultivation has shown continuous decreasing trend. The decrease in groundnut cultivation in Gujarat and Maharashtra is ascribed by bad weather conditions, drought, and high temperature and salinity stresses [7, 11].

Among the environmental stresses the drought stress is the most important factors, which limits production of groundnut. The water stress affects the crop at different growth stages during growing season. In groundnut drought stress during flowering and pod filling stage is critical for yield and agronomic characters. This would result in drastic reduction in crop yield, and magnitude of reduction would depend on groundnut varieties. Not only the yield of groundnut but also the quality of products decreases under drought stress [9]. The environmental stresses such as drought, temperature, salinity, and soil pH are major limiting factors in crop production, because, they affect almost all plant functions [4]. Under drought stress conditions, drought-tolerant varieties produce more than susceptible ones.

Therefore, in present study the response of four groundnut varieties to drought stress was investigated to evaluate their sensitivity to drought stress during vegetative and reproductive growth stage under pot experiment.

MATERIALS AND METHODS

This study was carried out in Botanical garden at the Department of Botany, Fergusson College, Pune-411004. Certified seeds of four groundnut varieties *viz*. TAG-24, TG-26, Western-20, and Western-44 were procured from Mahatma Phule Agriculture College, Pune and tested for drought stress tolerance.

A 4×4 factorial experiment in complete randomized block design with 3 replications was conducted in earthen pots. Pot having a diameter of 35 cm and height of 30 cm. were used for pot experiments. Pots were filled with pot mixture

containing garden soil and farmyard manure (3:1). The crop water requirements for 4 water regimes (100%, 80%, 60% and 40%) were calculated on the basis of water holding capacity of soil.

Seeds pretreated with fungicide were used for sowing. Uniform and undamaged 10 seeds were used per pot. On day 15 after emergence, seedlings were thinned to obtain 5 uniform seedlings per pot. After this, soil moisture status for each treatment was maintained until the plants were harvested. Normal cultural practices were followed during the growing season. Samples were collected from control and stressed plants. The response of drought stress was assessed in terms of MSI, RWC, DTI (PY) and HI according to the methods given below.

Leaf Membrane Stability Index (MSI) was determined according to the method of Premachandra *et al.* [8] modified by Sairam [10]. Leaf discs (0.5g) of uniform diameter were taken in test tubes containing 10ml of double distilled water in two sets. Test tubes in one set were kept at 40^0 C in a water bath for 30 min and electrical conductivity of the sample was measured (C_1) using a conductivity meter. Test tubes in the other set were incubated at 100^0 C in the boiling water bath for 15 min and their electrical conductivity was measured(C_2). MSI was calculated using the formula given below:

$$MSI = [1-C_1/C_2] \times 100$$

Relative Water Content (RWC) was recorded from four leaflets of the second fully expanded leaf form the top of the main stem for each pot. Once leaves were harvested and transported to the laboratory, leaf fresh weight was recorded. The leaf samples were then soaked in distilled water for 8 hrs and blotted for surface drying and water saturated leaf weight was determined. The samples were oven-dried at 80^0 C until reaching constant weight and leaf dry weight could be determined. RWC was calculated based on the formula suggested by Gonzalez and Gonzanlez-Vilar [2] as follows.

$$RWC\ (\%) = (FW-DW) / (TW-DW) \times 100$$

Where, FW is the sample fresh weight, TW is the sample turgid weight and DW is the sample dry weight. Drought Tolerance Index (DTI) was calculated for pod yield as suggested by Nautiyal *et al.* [5] Using the relationship as follows;

DTI (PY) = Pod yield under stressed conditions / Pod yield under non-stressed conditions

Harvest index was calculated using the following relationship:

HI = Pod yield / Pod yield + Shoot and root dry weight.

RESULTS AND DISCUSSION

Membrane Stability Index (MSI)

The plasma membrane is generally protected from desiccation-induced damage by the presence of membrane - compatible solutes, such as sugars and amino acids. Therefore, a link may exist between the capacity for osmotic adjustment and the degree of membrane protection from the effect of dehydration [3]. Maintenance of membrane integrity and function under given level of dehydration stress has been used as a measure of drought tolerance by various workers Premchandra *et al* [8] and Deshmukh *et al* [1]. There was a significant effect of soil moisture regimes on Membrane Stability Index (MSI) in groundnut crop (Table 1). MSI of plant was higher at unstressed conditions 93.51, 96.71, 95.86 and 96.81 in TAG-24, WEST-44, WEST-20 and TG-26 respectively which were linearly decreased with increase water stress level. At higher water stress level (40%) the groundnut varieties TAG-24, WEST-44, WEST-20 and TG-26 showed 4.88%, 4.99%, 5.98, and 8.22% decrease in MSI over control

(Table1). **Table 1 Effect of different water regimes on Membrane Stability Index (MSI)**

Soil water	Varieties of groundnut			
	TAG-24	WEST-44	WEST-20	TG-26
100% (Control)	93.51 (0.00)	96.71 (0.00)	95.86 (0.00)	96.81 (0.00)
80%	93.02 (0.52)	94.47 (2.32)	94.49 (1.43)	94.64 (2.24)
60%	91.26 (2.41)	93.25 (3.57)	92.60 (3.40)	92.36 (4.60)
40%	88.94 (4.88)	91.89 (4.98)	90.32 (5.78)	88.85 (8.22)

*Values given in parenthesis indicate percent decrease over control

Relative Water Content (RWC)

The drought stress considerably reduced RWC and considerable differences among groundnut varieties were observed (Table 2).

Table 2 Effect of different water regimes on Relative Water Content in percent (RWC %)

Soil water	Varieties of groundnut			
	TAG-24	WEST-44	WEST-20	TG-26
100% (Control)	82.51 (0.00)	80.48 (0.00)	86.86 (0.00)	83.74 (0.00)
80%	80.87 (1.99)	77.88 (3.23)	82.06 (5.53)	78.82 (5.88)
60%	78.32 (5.08)	75.40 (6.31)	78.22 (9.95)	72.42 (13.52)
40%	74.49 (9.72)	70.23 (12.74)	74.17 (14.61)	67.74 (19.11)

At control conditions all varieties showed maximum RWC % where as at higher water stress level the variety TG-26 showed maximum reduction in RWC % (19.11%) over control, while variety TAG-24 showed minimum reduction (9.72 %). In general, the RWC was decreased remarkably in response to declining soil water availability (Table 2). The results obtained are in tune with Painawadee *et al* [6], who found significant difference in RWC % between drought treatment and control treatment in 4 peanut varieties.

Harvest Index (HI)

There was a significant interaction between soil water regimes and groundnut varieties for HI (Table 4). At control condition there was significant difference in HI. But the Harvest Index decreased with water deficit. Among all varieties the variety TAG-24 showed less reduction (20.58 %) in HI at higher water stress level while variety TG-26 showed maximum reduction (55.99 %) over control, remaining varieties showed moderate reduction in HI.

Table 4 Effect of different water regimes on Harvest Index (HI)

Soil water	Varieties of groundnut			
	TAG-24	WEST-44	WEST-20	TG-26
100% (Control)	5.22 (0.00)	6.18 (0.00)	8.84 (0.00)	7.68 (0.00)
80%	4.70 (10.00)	5.50 (11.00)	7.62 (13.80)	6.08 (20.83)
60%	4.45 (14.81)	4.96 (19.74)	5.76 (34.84)	5.35 (30.34)
40%	4.15 (20.58)	4.00 (35.28)	4.56 (48.42)	3.38 (55.99)

Drought Tolerance Index (DTI) for pod yield

Under water–limited conditions DTI for PY per plant showed decreasing trend with respect to drought stress level (Table 3). At control conditions all varieties showed maximum DTI per plant where as at higher water stress level the variety TG-26 showed maximum reduction in DTI per plant 73.50 %, while variety TAG-24 showed minimum reduction 46.20 % over control as compare to other varieties.

Table 3 Effect of different water regimes on Drought Tolerance Index (DTI) for PY

Soil water	Varieties of groundnut			
	TAG-24	WEST-44	WEST-20	TG-26
100% (Control)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
80%	0.81 (18.60)	0.74 (25.80)	0.81 (19.10)	0.63 (37.30)
60%	0.66 (34.40)	0.54 (45.80)	0.47 (53.30)	0.43 (57.50)
40%	0.54 (46.20)	0.43 (56.80)	0.27 (73.50)	0.27 (72.60)

The results obtained in present investigation are in tune with the Vorasoot *et al* [14]. They observed significant decrease in dry matter production, pod yield; number seed per plant in four peanut cultivars under two water stress regimes. Similarly, Seghatoleslami *et al*. [12] concluded that drought stress reduces seed yield and its component in five Proso millet. Tas Sibel and Tas Birol [13], also found significant reductions in MSI, RWC and chlorophyll content in different wheat genotypes under water stress. Aforesaid results indicate that the groundnut varieties TAG-24 and West-44 are drought stress tolerant; conversely TG-26 and West-20 are highly sensitive to water stress.

ACKNOWLEDGMENT

First author is thankful to the authorities of UGC New Delhi, for sanctioning fellowship under FIP. Authors are thankful to Prof. (Mrs.) S. S. Kate, Head, Dept. of Botany and Dr. R.G. Pardeshi, Principal, Fergusson College, Pune, for providing all necessary field, laboratory and library facilities required for this research work.

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