Research Paper

Water Relations in the Leaves of Two High Yielding Groundnut Cultivars Subjected to Drought Stress

BOTANY

KEYWORDS : Groundnut; Water relations; Leaf water potential; RWC; Drought tolerance

*** Dr. K.V. MADHUSUDHAN** — Lecturer in Botany, Department of Botany, Government Degree College for Men, KURNOOL, 518 002, Andhra Pradesh, India * Corresponding author

Prof. C. SUDHAKAR — Professor, Department of Botany, S.K.University, ANANTAPUR, 515 002, AP, India

ABSTRACT

In the current study, water relations in leaves of two high yielding cultivars of groundnut (Arachis hypogaea L cv. K-134 and cv. JL-24 respectively) grown under control and water stress conditions were studied. One month old healthy groundnut cultivars were subjected to different soil moisture regimes characterized as control, mild, moderate and severe stress, represented by 100, 75, 50 and 25% soil moisture levels (SMLs) respectively, and the data were collected at different time intervals (days-4, 8 and 12) after induction of stress. Leaf water potential was found to be decreased in the leaves of both cultivars during all stress regimes over controls on all days of sampling. However, the per cent decrease was relatively less in cv. JL-24 than in cv. K-134. The leaves of cv. JL-24 showed greater reduction in relative water content (RWC) when compared to cv. K-134 with increasing stress. The changes in these parameters were dependent on stress severity and duration, and differed between cultivars. These results clearly support the better drought tolerance nature cv. K-134 compared to cv. JL-24.

Introduction

Drought is one of the most common environmental constraints to world agricultural production and has been the focus of much research. It limits the productivity of groundnut under rainfed agricultural systems even up to 60 percent depending upon severity. Better understanding of the mechanism that enables plants to adapt to water deficit and maintain growth will ultimately help in the selection of stress tolerant cultivars for exploiting drought hit soils. Plant water status is determined by the rate of exchange of water between soil and atmosphere through plants. There is a continuous movement of water from the soil to the atmosphere through plant across the water potential gradients. Understanding water relations is fundamental to improve crop management in regions where irrigation is practiced or where dry conditions cannot be avoided. In the present study an attempt is made to assess the tolerance potentials in two groundnut cultivars with different sensitivity to drought stress based on water relation parameters.

Material and methods

Seeds of groundnut (Arachis hypogaea L.) cultivars namely (K-134 and JL-24) were sown in earthen –pots containing 8kg of red loamy soil and farm yard manure (3:1 proportion). Pots were maintained for one month in the departmental botanical garden under natural photoperiod of 10-12 h and temperature 28 ± 4 ^{0}C. One-month-old plants of each cultivar were divided into four-sets and arranged in randomized complete black design. One set of pots received water daily to field capacity and served as control (100 %). Water stress was induced by adding of water daily to 75, 50 and 25 % soil moisture levels respectively. Leaf samples were collected on day-4, 8 and 12 after stress induction for analysis of various parameters. Leaf water potential was measured using a portable PR-55 psychrometer microvoltmeter with C-52 sample chamber. (Wescor, Logan, Utah, USA). The readings were measured between 8.00 to 10.00 AM. The measurements were the average of twenty discs to obtain a mean water potential for the leaf. RWC of leaf discs were measured in both control and stressed plants according to Turner (1981). The data were analyzed statistically using Duncan's multiple range (DMR) test to drive significance (Duncan, 1955).

Result and Discussion

The two basic parameters which describe the degree of plant water deficits are the water status expressed as water potential and relative water content (Turner, 1981). From the table, it is clear that the leaf water potential decreased at all stress regimes and on all days of sampling (days-4, 8 and 12) of both cultivars. The decrease was significant in all stress treatments except in mild stress treatments on the day-4 and 8 of both cultivars. The reduction was more in K-134 (-1.60 M.Pa) than JL-24 (-1.18 M.Pa) at the end of experiment. It remained nearly constant in control plants of both cultivars throughout the experimentation. In general, the decrease of water potential was dependent on the intensity and duration of stress. The relative water content in leaves decreased over controls in all stress treatments and over duration. However, the decrease was significant at moderate, severe treatments of both cultivars, except on day-12, where it was significant from mild stress to severe stress treatments. The degree of decrease in RWC of stressed leaves increased with increase in stress intensity and also on stress duration. Drought induced reduction in RWC occurred greater extent in JL-24 (63%) and to a lesser degree in the cv. K-134 (52%) at severe stress treatments on the 12th day. The decrease in RWC was relatively less at all stress treatments in the cultivar K-134, compared to JL-24.

Drought stress has adverse influence on water relations of groundnut (Babu and Rao 1983). Leaf water potential is the primary index of plant water status. In the present study, leaf water potential decreased with increase in stress intensity and duration of stress. A similar decline in leaf water potential as a result of drought stress is noticed in groundnut (Subramanian et al., 1993; Clavel et al., 2005) and in other legumes (Martinez et al., 2007). Singh et al., (1997) suggested that decreased leaf water potential under stress may be due to decreased absorption and translocation of water a result of loss of gradient in water potential between the soil and roots. The present investigation also revealed that groundnut maintained high leaf water potentials under prolonged stress treatments on the days-4 and 8 thereby performing various physiological and biochemical processes to continue more efficiently even under low soil moisture condition developed by scarcity of water is an indicative of moisture stress endurance. This may be due to marked osmotic adjustment occurred in growing leaves of groundnut allowing them to maintain higher turgor during periods water stress (Ali Ahamad and Basha, 1998). Neverthless, cv. K-134 had showed a relatively a greater decrease in water potential, compared to cv. JL-24, at the end of experimentation. Maintenance of low (more negtive) water potential in drought resistant cultivars has been reported to be an adaptation to water stress in groundnut (Reddy et al., 2003), and as such K-134 seems to be drought tolerant. RWC is considered as an alternative measure of plant water status, reflecting the metabolic activity in tissues and used as a most meaningful index for identifying legumes with contrasting differences in dehydration tolerance (Sinclair and Ludlow, 1986). The decline in RWC was reported by several investigators under stress conditions in groundnut (Madhusudhan, et al., 2002; Clavel et al., 2005, Akcay et al., 2010) and in other plants (Fazeli et al., 2006, Kavas et al., 2013). Similarly in the present study, there was gradual reduction in leaf RWC in groundnut cultivars with the increase of stress severity, but decrease in RWC was least in cv. K-134. Numerous studies have

Volume : 3 | Issue : 4 | April 2014 • ISSN No 2277 - 8179

evidenced that drought tolerant genotypes are better able to maintain higher RWC than drought sensitive ones under water deficit conditions (Madhusudhan et al., 2002; Fazeli et al., 2006, Kavas et al., 2013). This genotypic variation in RWC may be attributed to difference in the ability of varieties to absorb more water from soil and /or the ability to control water loss through stomata (Fazeli et al., 2006). According Nautiyal et al., (1991) water relation in drought resistant groundnut cultivars were characterized by low water potential at relatively higher RWC, than the sensitive cultivars, and as such cv. K-134 seems to be relatively drought tolerant.

The present study indicates that water relation parameters were affected during drought stress. The cv. K-134 seems to be relatively drought tolerant by the maintenance of better water relations (low water potential coupled with high relative water content).

Table 1. Water potential and Relative water content (RWC) in leaves of control (100%) and water stressed (mild-75%, moderate-50%, and severe-25%) groundnut cultivars (±SD). The mean values (n=5) in a row followed by different letter for each plant species are significantly different (P≤0.05) according to Duncan's multiple range (DMR) test. Figures in parentheses represent per cent of control

Parameter	Day	JL-24				K-134			
		100%	75%	50%	25%	100%	75%	50%	25%
Leaf water potential (-M Pa)	04	0.77a (100) ± 0.060	0.80a (103.89) ± 0.54	0.84a (109.09) ± 0.048	0.89b (115.58) ± 0.067	0.83a (100) ± 0.039	0.87a (104.52) ±0.042	0.93b (111.72) ±0.081	0.99c (119.94) ±0.071
	08	0.79a (100) ± 0.036	0.86a (108.86) ± 0.042	0.93a (117.72) ± 0.029	1.05c (132.91) ± 0.051	0.85a (100) ± 0.056	0.91a (107.53) ±0.087	1.12b (131.76) ±0.014	1.25c (147.05) ±0.052
	12	0.78a (100) ± 0.038	0.87b (111.83) ±0.034	0.99a (126.92) ±0.054	1.16d (148.71) ±0.048	0.87a (100) ±0.042	1.02b (117.24) ±0.051	1.24c (142.53) ±0.065	1.60d (183.90) 0.058
RWC (%)	04	92.96a ±3.86	86.05b ± 3.52	78.57c ±4.02	69.92c ±2.92	91.07a ±1.06	88.15b ±4.06	83.52b ±3.84	75.84c ±2.70
	08	92.04a ±1.96	85.38b ±2.74	71.02c ±4.21	54.56d ±3.98	90.87a ±4.80	85.37b ±4.20	77.19c ±3.21	68.92d ±1.78
	12	91.58a ±2.08	83.52b ±3.21	62.34c ±3.56	37.68d ±2.54	90.12a ±1.09	81.62b ±1.72	65.01c ±2.94	48.53d ±3.88

REFERENCE

Akcay U.C., Ercan O., Kavas M., Yildiz L., Yilmaz C., Oktem H.A., Yucel M. 2010 Drought-induced oxidative damage and antioxidant responses in peanut (Arachis hypogaea L.) seedlings, Plant Growth Regul., 61: 21–28. | Ali Ahmad, M. and Basha, S.M. 1998. Effect of water stress on composition of peanut leaves. Peanut Sci., 25: 31-34. | Babu, V.R. and Rao, D.V.M. 1983. Water stress adaptations in groundnut (Arachis hypogaea L.) foliar characteristics and stress adaptations to moisture stress. Indian J. Plant Physiol., 10: 64-80. | Clavel, D., Drame, N.K., Macauley, H.R., Braconnier, S. and Laffray, D. 2005. Analysis of early responses to drought associated with field drought adaptation in four Sahelian groundnut (Arachis hypogaea L.) cultivars. Environ. Exp. Bot. 54: 219-230. | Duncan, M. Multiple range and multiple tests. 1955. Biometrics, 42:1-47. | Fazeli, F., Ghorbanli, M. and Niknam V. 2006. Effect of drought on water relations, growth and solute accumualation in two sesame cultivars Pak. J. Bio. Sci., 9: 1829-1835. | Kavas M., Avas M., Baloglu C., Akca O., Kose F.S., Gokcay D. 2013. Effect of drought stress on oxidative damage and antioxidant enzyme activity in melon seedlings. Turk. J. Biol.,37: 491-498. | Madhusudan, K.V., Giridarakumar, S., Ranganayakulu, G.S., Chandraobulreddy, P. and Sudhakar, C. 2002. Effect of water stress on some physiological responses in two groundnut (Arachis hypogaea L.) cultivars with contrasting drought tolerance. J. Plant Bio., 29: 199-202. | Martinez, J.P., Silva, H. Ledent, J.F., and Pinto, M. 2007. Effect of drought stress on the osmotic adjustment, cell wall elasticity and cell volume of six cultivars of common beans (Phaseolus vulgaris L.). Euro. J. Agron., 26: 30–38. | Nautiyal P.C., Ravindra V. and Joshi Y.C. 1991. Physiological and biochemical basis for viability differences in spanish groundnut biophsysical characteristics in response to soil moisture stress. Oleagineux, 46: 153–158. | Reddy, T.Y., Reddy, V.R. and Anbumozhi, V. 2003. Physiological responses of groundnut (Arachis hypogaea L.) to drought stress and its amelioration: a critical review. Plant Growth Regul., 41: 75-88 | Sinclair, T.R. and Ludlow, M.M. 1986. Influence of soil water supply on the plant water balance of four tropical grain legumes. Aust. J. Plant Physiol., 13: 329-341. | Singh, N., Chhokar, V., Sharma, K.D. and Kuhad, M.S. 1997. Effect of potassium on water relations, CO2 exchange and plant growth under quantified water stress in chick pea. Indian J. Plant Physiol., 2: 202-206. | Subramanian, V.B., Reddy, G.J. and Maheswari, M. 1993. Photosynthesis and plant water status of irrigated and dryland cultivars of groundnut. Indian J. Plant Physiol., 36: 236-238. | Turner, N.C. 1981. Techniques and experimental approaches for the measurement of plant water status. Plant Soil, 58: 339-366. |