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Effect of Water Deficit Stress on Growth and Chlorophyll Pigments in Two Cultivars of Groundnut

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ABSTRACT

Two cultivars of groundnut (Arachis hypogaea L. cv. K-134 and cv. JL-24) subjected different water stress regimes were compared for their growth parameters and chlorophyll pigments in relation to drought tolerance. Drought stress was imposed at 75, 50, and 25% of field capacity respectively from day-30 to day-42 after sowing, while controls were maintained 100% field capacity throughout the growth period. Root length increased over control in both cultivars at mild stress treatments and inhibited at severe stress conditions. Severe stress treatments had caused significant inhibition in shoot growth of both cultivars. As the leaf relative water content (RWC) was dropping progressively with the severity of treatment, the values of leaf area, leaf dry weight, and chlorophyll content were declined in all stress treatments and differed between the cultivars. cv. JL-24 was more affected due to water deficit when compared to cv. K-134.

KEYWORDS Drought tolerance; Groundnut; Growth; Water stress; RWC

Introduction

Drought stress limits plant growth and productivity more than any other biotic or abiotic stress, especially in arid and semi-arid areas. However in certain tolerant crop plants morphological and metabolic changes occur in response to drought, which contribute towards adaptation to such unavoidable environmental constraints (Sairam & Sirvastava, 2001). Groundnut, an important legume is grown primarily for its high quality edible oil and protein. As peanut is largely grown under rain-fed areas (Reddy et al., 2003), where drought stress is a recurring problem and access to irrigation in these areas is limited, utilization of drought resistant genotypes is a viable alternative to alleviate the problem. The breeding approaches to develop new or improved cultivars against stress need a thorough understanding of the reactions of plant tissues or organs against the specific stress. Thus, it is very important to identify those groundnut genotypes which have the ability to tolerate water stress. These stress tolerant genotypes can be used as reliable selection criteria in the breeding programs. The objective of the present investigation is to study the effect of drought stress on some aspects of growth, RWC and chlorophyll pigments in leaves of two groundnut cultivars in relation to drought tolerance.

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. Data were collected on day-12 after stress induction for analysis of various parameters. The length of the root and shoot was measured after inducing water stress. The plants were washed with deionized water and blotted dry with filter paper. Root and leaves were separated and dry weights were recorded. For the determination of dry mass, the roots and leaves were separately dried at 80^{o} C in a hot air oven until a constant mass was formed. The leaf area of the expanding leaf (second leaf from the apex) was measured in a leaf area meter. RWC of leaf discs were measured in both control and stressed plants according to the method of Turner (1981). The total chlorophyll content was estimated in the leaves according to the method of Arnon, (1949). The data were analyzed statistically using Duncan's multiple range (DMR) test to drive significance (Duncan, 1955).

Result and Discussion

Production of ramified root system under drought is important to above ground dry mass and the plant species or varieties of a species show great differences in the production of roots (Jaleel et al., 2009). There were no significant changes in root length of both cultivars during mild and moderate stress treatments. A slight increase in root length in both cultivars during mild in the present study indicated that root growth continued up to sub-optimal conditions. Similar reports of increased root length at sub-optimal moisture conditions were observed in groundnut (Suma et al., 2006) and in other plants (Sankar et al., 2007). Enhancement of root growth under drought conditions allows the plant to extract more water from deeper zones (Kavas et al., 2013). The ability of groundnut to maintain a viable root system during water stress may contribute to the crop's drought resistance (Sanders et al., 1993). However, at severe stress treatments the root length was significantly inhibited to 15% and 9% in cultivars JL-24 and K-134, respectively when compared to control and it is ascribed to the reduced turgor, sufficiently enough to stop cell elongation or to dry soil conditions. The decreased shoot growth during water stress has been reported by many workers in groundnut (Srinivasan et al., 1987) and in other plants (Sankar et al., 2007). The present study also revealed a reduction in shoot length during stress conditions in both cultivars, and the reduction in plant growth could be attributed to decline in rapid cell division, elongation and enlargement due to low turgor pressure in the plant under water stress. (Sankar et al., 2007). Further, this decrease was more pronounced in cv. JL-24 (25%) than in cv. JL-24 (12%) at severe stress level. In our experiment, root growth is less inhibited than shoot growth under water stress. This differential response of root and shoot in groundnut is an adaptation by groundnut plants to avoid excessive dehydration while tapping moisture available at low depths of dehydrating soil (Suma et al., 2006). Root and leaf dry mass was decreased in water stressed plants of both cultivars when compared to controls. These results agree with earlier reports in groundnut (Madhusudan et al., 2002; Latha and Reddy, 2007) and other plants (Fazeli et al., 2006, Kavas et al., 2013). The decreased dry matter as a result of water stress may be attributed to the altered carbon and nitrogen metabolism (Kluge, 1976) and also due to both senescence and death of leaves, which was considered as avoidance mechanism that allows minimizing water losses (De Herralde et al., 1998). However, cv. K-134 roots showed a slight increase (insignificant) in root dry mass upon exposure to mild stress when compared to control. An increase in root weight provides a relatively large absorption surface and alleviates the stress effect. Though both cultivars registered a decline in leaf area during water stress at all stress levels, the magnitude of inhibition was relatively less in the cv. K-134 than cv. JL-24. These observations are similar to the results obtained by Babitha (1996) in groundnut, where there was significant variation in leaf area among groundnut genotypes under water stress and drought tolerant cultivar (DH-43) had lower decline in leaf area. Researchers suggested that inhibition of leaf growth by water stress can be considered to be an adaptive response as it limits leaf area production and eventually rates of transpiration in plants and reduced transpiration may then prolong plant survival by extending the period of availability of essential soil-water reserves in the root zone (Lu and Neumann, 1998). Drought treatment produced a decrease in leaf area paralleled by a substantial decrease in dry weight of leaves of the cultivar which is in agreement with earlier results (Fazeli et al., 2006). The decline in RWC was reported by several investigators under stress conditions in groundnut (Madhusudan, et al., 2002; 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. 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). Drought treatment produced a marked decrease in leaf RWC paralleled by a substantial decrease in dry weight of leaves of both cultivars. These results confirm previous findings in groundnut plants (Madhusudan, et al., 2002). It is suggested that the relative water content could help the tolerant cultivar to perform physio-chemical processes more efficiently leading to the maintenance better dry matter than the sensitive cultivar. The total chlorophyll content was significantly declined in both cultivars with increase in the intensity of stress, but with a greater degree of decline in cv. JL-24 than in cv. K-134.The decrease in total chlorophyll content in the leaves of water stressed plants was reported in groundnut (Babitha, 1996). The decrease of chlorophyll under water stress may be also due to decreased rate of its synthesis or enhanced chlorophyllase activity (Drazkiewicz, 1994). Vyas, (2001) found cholorophylls are closely associated with drought tolerance and suggested that these parameters as biochemical markers for the identification of drought tolerant genotype in cluster bean, and as such K-134 seems to be relatively drought tolerant.

Conclusion

From the results of this investigation, it can be concluded that among the groundnut cultivars studied (cv. JL-24 and cv. K-134), the cv. K-134 with a smaller inhibition in growth parameters, RWC and chlorophyll content may support its better adoptive potential under water stress. This information is of great importance in plant breeding experiments.

Table 1. Root length, Shoot length, Dry weight (DW) of roots, Dry weight (DW) of leaves, Leaf area and Total chlorophylls of control and water stressed groundnut cultivars on day-12, after induction of water stress.

Parameters	Cultivar	Control	Mild	Moderate	Severe
Root length (cm plant-1)	JL-24	28.12a (100)	29.09a (100.94)	26.80a (94.00)	24.58b (85.28)
	K-134	29.94a (100)	31.15a (104.05)	30.11a (100.57)	27.47a (91.78)
Shoot length (cm plant-1)	JL-24	15.72a (100)	14.52a (92.36)	13.68b (87.02)	11.72c (74.55)
	K-134	16.32a (100)	15.82a (96.94)	15.02a (92.03)	14.32b (87.74)
DW of root (g plant-1)	JL-24	0.2145a (100)	0.2041a (95.16)	0.1691b (78.84)	0.1299c (60.56)
	K-134	0.2594a (100)	0.2549a (100.28)	0.2258b (87.05)	0.1822c (70.23)
DW of leaves (g plant-1)	JL-24	1.078a (100)	0.9432b (87.50)	0.7755c (71.94)	0.5400d (50.09)
	K-134	0.6872a (100)	0.6214b (90.42)	0.5326c (77.50)	0.4217d (67.37)
Leaf area (cm2)	JL-24	33.21a (100)	32.02a (96.42)	26.83b (80.79)	23.12c (69.62)
	K-134	31.57a (100)	30.63a (97.04)	28.89a (91.50)	25.37b (80.37)
Total chlorophylls (mg g-1 FW)	JL-24	1.887a (100)	1.636b (86.73)	1.234c (65.42)	0.768d (40.72)
	K-134	1.692a (100)	1.512b (89.37)	1.263c (74.67)	0.938d (55.47)
RWC (%)	JL-24	91.58a	83.52b	62.34c	37.68d
	K-134	90.12a	81.62b	65.01c	48.53d

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

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