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Morphological Responses of Guar (*Cyamopsis Tetragonoloba* L. Taub.) to Drought Stress

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ABSTRACT

Faced with scarcity of water resources, drought is the single most critical threat to world food security. The aim of the present work was to study certain morphological responses of six guar (*Cyamopsis tetragonoloba* L. Taub.) genotypes (HG-365, RGC-936, RGC-1025, RGC-1066, JG-2, and JJ-1) during the vegetative phase in response to drought stress to determine the difference in their sensitivities to drought. The experiment was laid out in complete randomized design with three replicates each control and drought stress. Twenty days old guar genotypes were subjected to water stress for ten days by withholding water. The results showed that water stress had considerable effect on plant height, root length, dry weight of root and shoot. The changes in these parameters differed between genotypes. However, RGC-1025 performed better than other genotypes to drought stress.

Key words: Drought, Guar, Morphology, Water stress.

INTRODUCTION

Plants are frequently exposed to a plethora of abiotic stress conditions such as salinity, drought, heat, flooding and heavy metal toxicity among others, where the various anthropogenic activities have accentuated the existing stress factors [1]. Among the various abiotic stresses, drought stress is the most important factor limiting crop productivity throughout the world and has been focus of much research [2]. Keeping in view the considerable demand for food, crop improvement for drought stress tolerance is of prime importance. However, understanding about the morphological and physiological basis is vital to select and breed plants for improving crop water tress tolerance [3]. The development of cultivars with improved productivity under water stress is important because of severe limitations imposed by drought in specific regions. Guar or cluster bean, (*Cyamopsis tetragonoloba* L.) is a drought-tolerant annual legume native to India and Pakistan, whose seeds contain galactomannans which is being used in wide range industries such as pharmaceutics, textile, paint, cosmetics, detergents and food industry [4]. In view of these agrobotanical characters of this crop, this is gaining considerable attention to grow on abiotic stress hit areas. India is the world-leader for cluster bean production as it contributes 80% shares of its total production. Due to high drought and salinity tolerance, guar could be a valuable alternative crop for the exploitation of the semiarid environments, where high temperature, poor erratic rainfall and elevated water salt content do not allow the cultivation of many crops. As guar is largely grown under rain-fed areas, 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. Thus, it is very important to identify those guar genotypes which have the ability to tolerate water stress and a 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. Hence, the present study was initiated in order to examine the morphological responses of guar plants to water stress.

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MATERIALS AND METHODS

Seeds of six guar (*Cyamopsis tetragonoloba* L. Taub.) genotypes (HG-365, RGC-936, RGC-1025, RGC-1066, JG-2 and JJ-1) were sown in earthen–pots containing 8kg of red loamy soil and farm yard manure (3:1 proportion). Pots were maintained for twenty days in the departmental botanical garden under natural photoperiod of 10-12 h and temperature 28 ± 4 ^{0}C. Twenty days-old plants were then divided into two-sets and arranged in randomized complete block design. One set of pots received water daily to field capacity and served as control (100 % SML). The second set received no water daily (0% SML). After induction of stress, the pots were maintained for another 10 days and the experimental data were collected. 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 shoot were separated and dry weights were recorded. For the determination of dry weight, the leaves were dried at 80^{o}C in a hot air oven until a constant mass was formed. Means of five individual estimations were taken from both control and stressed plants. The data were analyzed statistically using Duncan's multiple range (DMR) test to drive significance [5].

RESULTS AND DISCUSSION

It has been established that drought stress is a very important limiting factor at the initial phase of plant growth and establishment. The results of the present study showed that considerable variations among genotypes were observed when grown under drought stress and non-stress conditions (Table 1). The extent and pattern of root development are closely related to the ability of the plant to absorb water and hence are of great significance in drought tolerance. From the table 1, it is clear that, root length decreased significantly during stress treatment when compared to control in all guar genotypes. The percent decrease of root length of different genotypes varied from 17 to 23. Surprisingly, all the genotypes showed more than 76% root length under drought stress over the controls. However, an insignificant increase (5%) in root length was noticed in RGC-1025 during water stress treatment over the control. Enhancement of root growth under drought conditions allows the plant to extract more water from deeper zones [6] and the ability of guar to maintain a viable root system during water stress may contribute to the crop's drought resistance. Guar plants have a degree of water stress tolerance due to its ability to extract water from deep soil layers by its deep tap root system [4]. The reduced root growth under drought stress in the current study is ascribed to the reduced turgor, sufficiently enough to stop cell elongation or to dry soil conditions [7]. One of the classical manifestation of drought in many plant species is marked reduction in plant height. The decreased shoot growth during water stress has been reported by many workers in guar [8, 9]. The present study also revealed a significant reduction in shoot length in guar genotypes during stress conditions. During water stress, the lowest percentage of decrease in shoot length over control was recorded in RGC-1025 with a value of 12.33%, HG-365 followed with 27.54%. The rest of the genotypes did have a percent of decrease in shoot length ranging between 37 to 48 percent. 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 [10]. The present study also reveals that root growth is less inhibited than shoot growth under water stress. This differential response of root and shoot is an adaptation by plants to avoid excessive dehydration while tapping moisture available at low depths of dehydrating soils.

Plant productivity under drought stress is strongly related to the processes of dry matter partitioning and temporal biomass distribution. The decreased root dry weight during water stress has been reported by many workers in guar [8, 9] and in other plants [2, 7, 10]. Root dry weight of stressed guar genotypes significantly decreased over controls, except in RGC-1025, which recorded a significant increase upon exposure to stress (1.25 g) when compared to control (1.13g). The other genotypes relatively reduced root dry weight from 19 to 76% under drought stress, as compared to the control. Despite the severity of the stress, some genotypes still show good traits reflecting in their dry matter accumulation. The highest root dry matter of 110.61% was recorded in RGC-1025 and this was followed by RGC-1066 (80.66%) and RGC-936 (50.78%) (Table1). The rest of the cultivars had mean values ranging between 37 to 45 % with the lowest of 37.87 recorded in JG-2.The genotypic variation among guar genotypes for root dry weight subjected to water deficit may be attributed to the differences in root morphology and growth. It seems that RGC-1025 had the ability to develop deep and extensive rooting system, in order to enhance water and nutrient uptake under water-stressed condition. An increase in root biomass in water-stressed genotypes may be due to ability of the guar to divert assimilates to enhance the growth of the roots so as to exploit deeper parts of the soil water and also provides a relatively large absorption surface and alleviates the stress effect. It has been established that drought stress affects both elongation and expansion of plant height [7, 10]. There was a significant difference among the cultivars in the percentage of shoot dry weight under stress treatment, the highest was recorded in RGC-1025 having 81.56% and it was followed by HG-3656 with 48.29%. The lowest of 29.02% was found in RGC-936. The dry weight of the shoots of stressed guar genotypes decreased significantly when compared to controls. These results agree with earlier reports in guar [8, 9] and in other plants [2, 6, 7, 10]. The decreased dry matter as a result of stress may be attributed to the altered carbon and nitrogen metabolism [7, 11] and also due to both senescence and death of leaves, which was considered as avoidance mechanism that allows minimizing water losses [12]. Root mass rarely increases under stress, whereas root length and root volume often increase in response to mild stress. Severe stress conditions often decrease root growth. Timing of drought stress also has great influence on partitioning of carbohydrates and nitrogen. If drought stress occurs during early vegetative growth stages, there is a shift of partitioning toward roots rather than shoots, increasing the root-to-shoot ratio. This increase is due mainly to decreased shoot weight rather than increased root weight. Researchers suggested that inhibition of plant 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

Table - 1 : Root length (RL, cm plant-1), Shoot length (SL, cm plant-1), Root dry weight (RDW, g plant-1) and Shoot dry weight (SDW, g plant-1) in control and water stressed (WS) guar genotypes. 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

Genotype	Treatment	Morphological Parameters			
		RL	SL	RDW	SDW
HG-365	Control	12.82a (100)	30.94a (100)	1.48a (100)	24.66a (100)
	WS	11.22b (87.52)	22.42b (72.46)	0.68b (45.94)	11.91b (48.29)
RGC-936	Control	15.01a (100)	38.50a (100)	1.28a (100)	38.32a (100)
	WS	11.74b (78.21)	19.82b (51.48)	0.65b (50.78)	11.12b (29.02)
RGC-1025	Control	14.54a (100)	32.94a (100)	1.13a (100)	20.88a (100)
	WS	15.34a (105.5)	28.88b (87.67)	1.25b (110.6)	17.03b (81.56)
RGC-1066	Control	17.90a (100)	39.66a (100)	2.12a (100)	45.23a (100)
	WS	14.82b (82.79)	24.82b (62.58)	1.71b (80.66)	14.60b (32.27)
JG-2	Control	19.62a (100%)	39.08a (100)	3.01a (100)	41.82a (100)
	WS	14.94b (76.14)	24.58b (62.89)	1.14b (37.87)	17.20b (41.12)
JJ-1	Control	18.32a (100%)	40.68a (100%)	2.6a (100%)	49.89a (100)
	WS	14.48b (79.03)	20.76b (51.03)	1.25b (48.07)	15.42b (30.91)

the period of availability of essential soil-water reserves in the root zone [13].

CONCLUSIONS

The present findings suggested the guar genotypes were affected to drought resulting in decrease of root and shoot growth, dry weights of roots and shoots, but RGC-1025 might be grown better than other genotypes. Further study is required to assess its physiological basis of drought tolerance.

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