



## Morphological responses of two high yielding Groundnuts Cultivars (*Arachis hypogaea* L.cv. KCG-6 and GPBD-4 ) of Karnataka with Contrasting Drought tolerance.

B.V.KRISHNAPPA <sup>[1\*]</sup> CHINTA SUDHAKAR. <sup>[2]</sup>

1 Department of Botany, Government First Grade College, Frazer town, Bangalore,

2 Department of Botany, Sri Krishnadevara University, Anantapur 515003. India

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### ABSTRACT

The present study was undertaken to ascertain the morphological responses of two different groundnut (*Arachis hypogaea* L.) cultivars (KCG-6 and GPBD-4), under different water stress regimes characterized as control, mild, moderate and severe stress represented by 100, 75, 50 and 25% soil moisture for 12 days. However, the percent increase of root length, shoot length, dry mass accumulation in roots, dry mass accumulation in leaves and leaf area was higher in cv KCG-6 and lower in cv. GPBD-4. Data analysis of increase of root length, shoot length, dry mass accumulation in roots, dry mass accumulation in leaves revealed quantitative changes occurred during water stress in both cultivars. The present study indicated that cv. KCG-6 is water stress tolerant than cv. GPBD-4

**Key words:** Groundnut (*Arachis hypogaea* L.), Water stress

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### INTRODUCTION

Groundnut, 'the unpredictable legume' *Arachis hypogaea* L. a member of fabaceae, is the choice oilseed-food-feed-fodder forage crop especially among the small and medium farmers of the semi-arid tropical region of the world. 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. Despite its agronomic and economic importance of groundnut very little is known about its adaptive responses to drought (Clavel *et al.*, 2005). The reactions of the plants to water stress differ significantly at various organizational levels depending upon intensity and duration of stress as well as plant species and its stage of development (Chaves *et al.*, 2003; Jaleel *et al.*, 2008b). Understanding plant responses to drought is of great importance and also a fundamental part for making the crops stress tolerant (Reddy *et al.*, 2004; Zhao *et al.*, 2008). Water stress is known to influence various root attributes such as root size, morphology, depth, length, density and hydraulic conductance (Passioura, 1982). Pandey *et al.*, (1984) showed that peanut had greater root length density deeper in the soil than other legumes when grown under drought stress.

Increased root to shoot ratio was reported in *Arachis hypogaea* (Vorasoot *et al.*, 2004). Ramos *et al.*, (1999) established that water deficit inhibits accumulation in fresh plant mass in

greater extent than dry biomass. Under conditions of mild water deficit the relative allocation of biomass to roots usually increases (Hamblin *et al.*, 1991: In *Arachis hypogaea* a significant inhibition in dry mass yield under drought stress was noticed (Srinivasan *et al.*, 1987: Kulkarni *et al.*, 1988: Ramanarao, 1994: Babitha, 1996: Nautiyal *et al.*, 2002),

Leaf growth is the most sensitive and the first plant organ affected by water deficit (Chaves *et al.*, 2003). Continuous water deficit results in fewer and smaller leaves which have smaller and more compact cells and greater specific leaf weight (Chung *et al.* 1997). Water deficit stress mostly reduced leaf growth and in turn the leaf areas in many plant species (Zhang *et al.*, 2004: Wullschleger *et al.*, 2005: Yadav *et al.*, 2005: pagter *et al.*, 2005: Yin *et al.*, 2005: Fazeli *et al.*, 2006) and in groundnut (Reddy *et al.*, 1980: Ramanarao, 1994: Babitha, 1996).

## MATERIALS AND METHODS

The seeds of groundnut (*Arachis hypogaea* L. cv. KCG-6 and GPBD-4) were procured from Agricultural Research Station, Chintamani and Dharwad of Karnataka. The seeds were sterilized for 5 minutes with frequent shaking and thoroughly washed with tap water. The disease free and uniform size seeds were sown in earthen pots (60 x 50 cm) containing air-dried 8 kgs of red loamy soil and farm yard manure in 3:1 proportion. The pots were watered once a day

Pots were maintained for one month in the departmental botanical garden under natural photoperiod of 10-12 hrs and temperature  $28 \pm 4$  °C. One-month-old plants were then divided into four-sets and arranged in randomized complete block design. One set of pots received water daily to field capacity and served as control (100 %). The remaining three sets received water daily to 75, 50 and 25 % of the field capacity and were characterized as mild, moderate and severe stresses, respectively. After induction of stress, the pots were maintained for another 12 days and the experimental data were collected at different time intervals i.e. on day-4, 8 and 12. 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 fresh weights were recorded. For the determination of dry mass, the leaves were dried at 80 °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. 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

**Table 1. Root length (cm per plant) in control and water stressed groundnut cultivars ( $\pm$  SD)**

	KCG-6				GPBD-4			
	Control	Mild	Moderate	Severe	Control	Mild	Moderate	Severe
<b>4</b>	25.77a (100) $\pm$ 0.45	27.21a (105.59) $\pm$ 0.37	26.03a (101.00) $\pm$ 0.42	24.48a (94.99) $\pm$ 0.83	27.21a (100) $\pm$ 0.32	29.36a (107.90) $\pm$ 0.75	28.37a (104.27) $\pm$ 0.51	26.94a (99.00) $\pm$ 0.66
<b>8</b>	27.14a (100) $\pm$ 0.37	28.20a (103.90) $\pm$ 0.92	26.76a (98.60) $\pm$ 1.01	24.56b (90.49) $\pm$ 0.48	28.52a (100) $\pm$ 0.26	30.38a (106.52) $\pm$ 0.42	29.30a (102.73) $\pm$ 0.54	27.35a (95.90) $\pm$ 0.63
<b>12</b>	28.12a (100)	29.09a (103.45)	26.80a (95.30)	24.58b (87.41)	29.94a (100)	31.15a (104.04)	30.11a (100.57)	27.47a (91.78)

	± 0.28	± 0.24	± 0.35	± 0.59		± 0.34	± 0.22	± 0.48	± 0.51
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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 parenthesis represent per cent of control.

**Table 2. Shoot length (cm per plant) in control and water stressed groundnut cultivars (± SD)**  
**KCG-6** **GPBD-4**

	Control	Mild	Moderate	Severe		Control	Mild	Moderate	Severe
<b>4</b>	13.14a (100) ± 0.27	12.86a (97.90) ± 0.46	12.36a (94.07) ± 0.53	11.29b (85.92) ± 0.74		14.26a (100) ± 0.27	14.10a (98.90) ± 0.25	13.84a (97.05) ± 0.47	13.72a (96.21) ± 0.32
<b>8</b>	14.46a (100) ± 0.56	13.74a (95.02) ± 0.58	13.30a (91.97) ± 0.45	11.54b (79.80) ± 0.72		15.48a (100) ± 0.38	15.01a (96.10) ± 0.40	14.56a (94.05) ± 0.18	14.10a (91.08) ± 0.45
<b>12</b>	15.72a (100) ± 0.21	14.52a (92.37) ± 0.48	13.68b (87.02) ± 0.39	11.72c (74.55) ± 0.59		16.32a (100) ± 0.19	15.82a (96.94) ± 0.56	15.02a (92.03) ± 0.30	14.32b (87.74) ± 0.63

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 parenthesis represent per cent of control.

**Table 3. Dry mass accumulation (g per plant) in roots of control and water stressed groundnut cultivars (± SD)**

	Control	Mild	Moderate	Severe		Control	Mild	Moderate	Severe
<b>4</b>	0.1518a (100) ± 0.002	0.1546a (101.90) ± 0.005	0.1483a (97.69) ± 0.004	0.1214b (80.01) ± 0.005		0.2073a (136.5) ± 0.006	0.2128a (140.1) ± 0.009	0.2085a (144.0) ± 0.008	0.1761b (116.0) ± 0.005
<b>8</b>	0.1854a (100) ± 0.004	0.1808a (97.5) ± 0.006	0.1696a (91.49) ± 0.002	0.1318b (71.12) ± 0.004		0.2305a (124.32) ± 0.006	0.2325a (125.40) ± 0.003	0.2250a (121.35) ± 0.007	0.1800b (97.08) ± 0.008
<b>12</b>	0.2145a (100) ± 0.003	0.2041a (95.16) ± 0.004	0.1691b (78.84) ± 0.002	0.1299c (60.56) ± 0.006		0.2594a (121.0) ± 0.004	0.2549a (118.8) ± 0.003	22.58b (105.3) ± 0.006	0.1822c (85.0) ± 0.007

The mean values (n=5) in a row followed by different letter for each plant species are significantly different ( $P \leq 0.05$ ) according to Duncan's multiple range (DMR) test. Figures in parenthesis represent per cent of control.

**Table 4. Dry mass accumulation (g per plant) in leaves of control and water stressed groundnut cultivars ( $\pm$  SD)**

	KCG-6					GPBD-4			
	Control	Mild	Moderate	Severe		Control	Mild	Moderate	Severe
<b>4</b>	0.7983a (100) $\pm$ 0.029	0.7614a (95.4) $\pm$ 0.051	0.6990b (87.56) $\pm$ 0.044	0.5206c (65.21) $\pm$ 0.036		0.3421a (42.85) $\pm$ 0.048	0.3314a (41.51) $\pm$ 0.051	0.3079a (38.56) $\pm$ 0.029	0.2687b (33.65) $\pm$ 0.019
<b>8</b>	0.9625a (100) $\pm$ 0.018	0.8861a (92.06) $\pm$ 0.025	0.7406b (76.94) $\pm$ 0.016	0.5320c (55.27) $\pm$ 0.031		0.5064a (52.61) $\pm$ 0.034	0.4793a (49.80) $\pm$ 0.018	0.4372b (45.42) $\pm$ 0.025	0.3494c (36.30) $\pm$ 0.032
<b>12</b>	1.078a (100) $\pm$ 0.036	0.9432b (87.50) $\pm$ 0.058	0.7755c (71.94) $\pm$ 0.064	0.5400d (50.09) $\pm$ 0.048		0.6872a (63.75) $\pm$ 0.029	0.6214b (57.64) $\pm$ 0.047	0.5326c (49.40) $\pm$ 0.042	0.4217d (39.11) $\pm$ 0.040

The mean values (n=5) in a row followed by different letter for each plant species are significantly different ( $P \leq 0.05$ ) according to Duncan's multiple range (DMR) test. Figures in parenthesis represent per cent of control.

**Table 5. Leaf area (cm<sup>2</sup>) in control and water stressed groundnut cultivars ( $\pm$  SD)**

	KCG-6					GPBD-4			
	Control	Mild	Moderate	Severe		Control	Mild	Moderate	Severe
<b>4</b>	24.17a (100) $\pm$ 0.46	23.98a (99.21) $\pm$ 0.32	22.17a (91.72) $\pm$ 0.18	21.32b (88.21) $\pm$ 0.25		22.04a (91.18) $\pm$ 0.38	22.81a (94.37) $\pm$ 0.94	21.28a (88.04) $\pm$ 0.18	20.80a (86.06) $\pm$ 0.27
<b>8</b>	28.79a (100) $\pm$ 0.28	28.11a (97.64) $\pm$ 0.74	25.38b (88.15) $\pm$ 0.56	22.58c (78.43) $\pm$ 0.32		27.13a (94.23) $\pm$ 0.92	26.84a (93.22) $\pm$ 1.01	24.99a (86.80) $\pm$ 0.24	23.45b (81.45) $\pm$ 0.18
<b>12</b>	33.21a (100) $\pm$ 0.53	32.02a (96.42) $\pm$ 0.48	26.83b (80.79) $\pm$ 0.67	23.12c (69.62) $\pm$ 0.59		31.57a (95.06) $\pm$ 0.28	30.63a (92.23) $\pm$ 0.35	28.89a (86.99) $\pm$ 0.52	25.37b (76.39) $\pm$ 0.58

The mean values (n=5) in a row followed by different letter for each plant species are significantly different ( $P \leq 0.05$ ) according to Duncan's multiple range (DMR) test. Figures in parenthesis represent per cent of control.

**RESULTS AND DISCUSSION**

The extent and the pattern of root development are closely related to the ability of the plants to absorb water and hence is of greater significance in drought resistance. An increase in root length during mild and moderate stress treatments 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 [KCG-6] and in GPBD-4

Root length data analysis is presented in table 1. Increase root length was noticed on day-4, day 8 and day-12 in both cultivars [KCG-6] and in GPBD-4 Nevertheless, the magnitude of increase in root length was relatively more in cultivar KCG-6 than in GPBD-4 at all stress regimes on all days of sampling Thus, in cultivar KCG-6 on day-12, severe stress treatment brought about 27.47 over the respective control 29.94 While in cultivar GPBD-4, on day-12, at severe stress approximately 24.58 increases. In root length was observed as compared to the control 28.12 (Table 1)

**Table 1. Root length (cm per plant) in control and water stressed groundnut cultivars ( $\pm$  SD)**

	KCG-6				GPBD-4			
	Control	Mild	Moderate	Severe	Control	Mild	Moderate	Severe
<b>4</b>	25.77a (100) $\pm$ 0.45	27.21a (105.59) $\pm$ 0.37	26.03a (101.00) $\pm$ 0.42	24.48a (94.99) $\pm$ 0.83	27.21a (100) $\pm$ 0.32	29.36a (107.90) $\pm$ 0.75	28.37a (104.27) $\pm$ 0.51	26.94a (99.00) $\pm$ 0.66
<b>8</b>	27.14a (100) $\pm$ 0.37	28.20a (103.90) $\pm$ 0.92	26.76a (98.60) $\pm$ 1.01	24.56b (90.49) $\pm$ 0.48	28.52a (100) $\pm$ 0.26	30.38a (106.52) $\pm$ 0.42	29.30a (102.73) $\pm$ 0.54	27.35a (95.90) $\pm$ 0.63
<b>12</b>	28.12a (100) $\pm$ 0.28	29.09a (103.45) $\pm$ 0.24	26.80a (95.30) $\pm$ 0.35	24.58b (87.41) $\pm$ 0.59	29.94a (100) $\pm$ 0.34	31.15a (104.04) $\pm$ 0.22	30.11a (100.57) $\pm$ 0.48	27.47a (91.78) $\pm$ 0.51

The mean values (n=5) in a row followed by different letter for each plant species are significantly different ( $P \leq 0.05$ ) according to Duncan's multiple range (DMR) test. Figures in parenthesis represent per cent of control.

Shoot length data analysis is presented in table 2. Increase Shoot length was noticed on day-4, day 8 and day-12 in both cultivars [KCG-6] and in GPBD-4 Nevertheless, the magnitude of increase in shoot length was relatively more in cultivar KCG-6 than in GPBD-4 at all stress regimes on all days

of sampling Thus, in cultivar KCG-6 on day-12, severe stress treatment brought about 14.32 over the respective control 16.32 While in cultivar GPBD-4, on day-12, at severe stress approximately 11.72 increases in shoot length was observed as compared to the control 15.72 (Table 2)

**Table 2. Shoot length (cm per plant) in control and water stressed groundnut cultivars ( $\pm$  SD)**

	KCG-6					GPBD-4			
	Control	Mild	Moderate	Severe		Control	Mild	Moderate	Severe
<b>4</b>	13.14a (100) $\pm$ 0.27	12.86a (97.90) $\pm$ 0.46	12.36a (94.07) $\pm$ 0.53	11.29b (85.92) $\pm$ 0.74		14.26a (100) $\pm$ 0.27	14.10a (98.90) $\pm$ 0.25	13.84a (97.05) $\pm$ 0.47	13.72a (96.21) $\pm$ 0.32
<b>8</b>	14.46a (100) $\pm$ 0.56	13.74a (95.02) $\pm$ 0.58	13.30a (91.97) $\pm$ 0.45	11.54b (79.80) $\pm$ 0.72		15.48a (100) $\pm$ 0.38	15.01a (96.10) $\pm$ 0.40	14.56a (94.05) $\pm$ 0.18	14.10a (91.08) $\pm$ 0.45
<b>12</b>	15.72a (100) $\pm$ 0.21	14.52a (92.37) $\pm$ 0.48	13.68b (87.02) $\pm$ 0.39	11.72c (74.55) $\pm$ 0.59		16.32a (100) $\pm$ 0.19	15.82a (96.94) $\pm$ 0.56	15.02a (92.03) $\pm$ 0.30	14.32b (87.74) $\pm$ 0.63

The mean values (n=5) in a row followed by different letter for each plant species are significantly different ( $P \leq 0.05$ ) according to Duncan's multiple range (DMR) test. Figures in parenthesis represent per cent of control.

Dry mass accumulation in roots data analysis is presented in table 3. Increase in Dry mass accumulation in roots was noticed on day-4, day 8 and day-12 in both cultivars [KCG-6] and in GPBD-4 Nevertheless, the magnitude of increase in Dry mass accumulation in roots was relatively more in cultivar KCG-6 than in GPBD-4 at all stress regimes on all days of sampling Thus, in cultivar KCG-6 on day-12, severe stress treatment brought about 0.1822 over the respective control 0.2594 While in cultivar GPBD-4, on day-12, at severe stress approximately 0.1299 increases in Dry mass accumulation in roots was observed as compared to the control 0.2145 (Table 3)

**Table 3. Dry mass accumulation (g per plant) in roots of control and water stressed groundnut cultivars ( $\pm$  SD)**

	KCG-6				GPBD-4			
	Control	Mild	Moderate	Severe	Control	Mild	Moderate	Severe
<b>4</b>	0.1518a (100) $\pm$ 0.002	0.1546a (101.90) $\pm$ 0.005	0.1483a (97.69) $\pm$ 0.004	0.1214b (80.01) $\pm$ 0.005	0.2073a (136.5) $\pm$ 0.006	0.2128a (140.1) $\pm$ 0.009	0.2085a (144.0) $\pm$ 0.008	0.1761b (116.0) $\pm$ 0.005
<b>8</b>	0.1854a (100) $\pm$ 0.004	0.1808a (97.5) $\pm$ 0.006	0.1696a (91.49) $\pm$ 0.002	0.1318b (71.12) $\pm$ 0.004	0.2305a (124.32) $\pm$ 0.006	0.2325a (125.40) $\pm$ 0.003	0.2250a (121.35) $\pm$ 0.007	0.1800b (97.08) $\pm$ 0.008
<b>12</b>	0.2145a (100) $\pm$ 0.003	0.2041a (95.16) $\pm$ 0.004	0.1691b (78.84) $\pm$ 0.002	0.1299c (60.56) $\pm$ 0.006	0.2594a (121.0) $\pm$ 0.004	0.2549a (118.8) $\pm$ 0.003	22.58b (105.3) $\pm$ 0.006	0.1822c (85.0) $\pm$ 0.007

The mean values (n=5) in a row followed by different letter for each plant species are significantly different ( $P \leq 0.05$ ) according to Duncan’s multiple range (DMR) test. Figures in parenthesis represent per cent of control.

Dry mass accumulation in leaves data analysis is presented in table 4. Increase in Dry mass accumulation in leaves was noticed on day-4, day 8 and day-12 in both cultivars [KCG-6] and in GPBD-4 Nevertheless, the magnitude of increase in dry mass accumulation in leaves was relatively more in cultivar KCG-6 than in GPBD-4 at all stress regimes on all days of sampling Thus, in cultivar KCG-6 on day-12, severe stress treatment brought about 0.4217 over the respective control 0.6872 While in cultivar GPBD-4, on day-12, at severe stress approximately 0.5400 increases in Dry mass accumulation in leaves was observed as compared to the control 1.078 (Table 4)

**Table 4. Dry mass accumulation (g per plant) in leaves of control and water stressed groundnut cultivars ( $\pm$  SD)**

	KCG-6				GPBD-4			
	Control	Mild	Moderate	Severe	Control	Mild	Moderate	Severe
<b>4</b>	0.7983a	0.7614a	0.6990b	0.5206c	0.3421a	0.3314a	0.3079a	0.2687b

	(100) ± 0.029	(95.4) ± 0.051	(87.56) ± 0.044	(65.21) ± 0.036		(42.85) ± 0.048	(41.51) ± 0.051	(38.56) ± 0.029	(33.65) ± 0.019
<b>8</b>	0.9625a (100) ± 0.018	0.8861a (92.06) ± 0.025	0.7406b (76.94) ± 0.016	0.5320c (55.27) ± 0.031		0.5064a (52.61) ± 0.034	0.4793a (49.80) ± 0.018	0.4372b (45.42) ± 0.025	0.3494c (36.30) ± 0.032
<b>12</b>	1.078a (100) ± 0.036	0.9432b (87.50) ± 0.058	0.7755c (71.94) ± 0.064	0.5400d (50.09) ± 0.048		0.6872a (63.75) ± 0.029	0.6214b (57.64) ± 0.047	0.5326c (49.40) ± 0.042	0.4217d (39.11) ± 0.040

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 parenthesis represent per cent of control.

Increase in leaf area data analysis is presented in table 5. Increase in leaf area was noticed on day-4, day 8 and day-12 in both cultivars [KCG-6] and in GPBD-4 Nevertheless, the magnitude of increase in leaf area was relatively more in cultivar KCG-6 than in GPBD-4 at all stress regimes on all days of sampling Thus, in cultivar KCG-6 on day-12, severe stress treatment brought about 25.37 over the respective control 31.57 While in cultivar GPBD-4, on day-12, at severe stress approximately 23.12 increases in Dry mass accumulation in leaves was observed as compared to the control 33.21 (Table 5)

**Table 5. Leaf area (cm<sup>2</sup>) in control and water stressed groundnut cultivars (± SD)**  
**KCG-6** **GPBD-4**

	Control	Mild	Moderate	Severe		Control	Mild	Moderate	Severe
<b>4</b>	24.17a (100) ± 0.46	23.98a (99.21) ± 0.32	22.17a (91.72) ± 0.18	21.32b (88.21) ± 0.25		22.04a (91.18) ± 0.38	22.81a (94.37) ± 0.94	21.28a (88.04) ± 0.18	20.80a (86.06) ± 0.27
<b>8</b>	28.79a	28.11a	25.38b	22.58c		27.13a	26.84a	24.99a	23.45b



	(100)	(97.64)	(88.15)	(78.43)		(94.23)	(93.22)	(86.80)	(81.45)
	± 0.28	± 0.74	± 0.56	± 0.32		± 0.92	± 1.01	± 0.24	± 0.18
<b>12</b>	33.21a	32.02a	26.83b	23.12c		31.57a	30.63a	28.89a	25.37b
	(100)	(96.42)	(80.79)	(69.62)		(95.06)	(92.23)	(86.99)	(76.39)
	± 0.53	± 0.48	± 0.67	± 0.59		± 0.28	± 0.35	± 0.52	± 0.58

The mean values (n=5) in a row followed by different letter for each plant species are significantly different ( $P \leq 0.05$ ) according to Duncan's multiple range (DMR) test. Figures in parenthesis represent per cent of control.

### CONCLUSION

In conclusion exposure of two groundnut cultivars KCG-6 and GPBD-4 to drought resulted in decrease of root growth, shoot growth, fresh and dry weights of roots and leaves and leaf area. Based on morphological parameters, in the present investigation, culti var KCG-6 with a smaller inhibition of root and shoot growth, biomass accumulation and leaf area may supports its better adaptive potential under water stress.

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