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RESEARCH ARTICLE

Morpho-Physiological Characters Influencing Groundnut (*Arachis Hypogaea* L.) Yield during Drought at Different Flowering Phases

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ABSTRACT

A pot culture study was conducted in Tamil Nadu Agricultural University, Coimbatore, to assess the morpho-physiological characters of different groundnut genotypes *viz.,* CO 7, COGn 4, TMV 7 and TMVGn 13 to water stress at different flowering phases *viz*., Pre Flowering Drought (PFD) between 15- 30 DAS, Flowering Drought (FD) between 35-50 DAS and Post Flowering Drought (PoFD) between 75-90 DAS by withholding irrigation and a control was also maintained with irrigation to field capacity for comparison. Observations on various morphological (Plant height and Leaf area) and physiological aspects (Relative water content, SPAD chlorophyll Index and Photosynthetic rate) were studied during stress period and after stress recovery. Among the treatments higher value of morphological and physiological parameters were observed under PFD after recovery and CO 7 performed better followed by TMV 7, TMVGn 13, COGn 4.

Keywords: *Groundnut, Morphological parameter, Physiological parameter, Pre-flowering drought, Yield.*

INTRODUCTION

Groundnut, the king of oil seeds originates from South America. It is one of the important legume crops of tropical and semiarid tropical countries including India, where it provides a major source of oil, carbohydrates and proteins. Drought is one of the major environmental factor that affects the groundnut yield and food safety worldwide. Severity of drought depends on the stage of crop development, the duration of stress period and the magnitude of drought. Drought affects membrane lipids and photosynthetic responses (Lauriano *et al*., 2000). The effects of soil moisture deficit on groundnut have been extensively studied and it has been concluded that water stress at the vegetative or early flowering stage is not detrimental and actually increases the yield. The dry spells during critical pheno-phases like flowering and post flowering stages severely affects the morphological and physiological parameters also yield substantially (Nautiyal *et al*. 1999). The present investigation is to find out the morpho physiological characters which support to increase yield under PFD.

MATERIAL AND METHODS

A pot culture study was conducted in Rain Out Shelter (ROS), Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore during *Kharif* '2015. Four genotypes *viz.,* CO 7, COGn 4, TMV 7 and TMVGn 13 were taken up with four treatments *viz*., 1.control, 2.Pre Flowering Drought (PFD), 3.Flowering Drought (FD), 4. Post Flowering Drought (PoFD). Water was withheld between 15-30 days for PFD, 35-50 days for FD and 75-90 days after sowing (DAS) for PoFD. Soil moisture content was observed once in two days by using ML2 Theta Probe moisture meter (Delta T, UK). Observations on various morphological and a physiological aspects were studied during stress period *viz.,* PFD (25-30 DAS), FD (45-50 DAS) and PoFD (85-90 DAS) and after stress recovery *viz*., PFD (40-45 DAS), FD (60-65 DAS) and PoFD (100-105 DAS).

Plant height was measured from the base of the shoot to the tip of the plant and expressed in cm. Leaf area was measured by using leaf area meter (LICOR Model 3100, USA) and expressed as cm^2 $plant^{-1}$. The relative water content (RWC) was estimated according to Barrs and Weatherly (1962) and expressed as per cent. SPAD readings were recorded using chlorophyll meter (SPAD 502) designed by the Soil Plant Analytical Development (SPAD) section, Minolta, Japan. Photosynthetic rate was recorded using an advanced portable photosynthesis system (LI-6400 XT, Licor Inc, Nebraska, USA) and expressed as µmol CO_2 m^{-2} s^{-1}.

RESULTS AND DISCUSSION

Plant height (cm plant^{-1})

Plant height of groundnut genotypes varied significantly in control, stress and recovery of

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Table 1. Effect of water stress on plant height (cm) of groundnut genotypes

Genotypes	At Stress						At Recovery					
	Pre flowering drought		Flowering drought		Post flowering drought		Pre flowering drought		Flowering drought		Post flowering drought	
	Control	Stress	Control	Stress	Control	Stress	Control	Recovery	Control	Recovery	Control	Recovery
CO 7	28.43	20.87	45.67	35.24	49.02	43.21	36.04	32.05	48.35	42.92	49.81	43.24
COGn 4	21.91	12.52	48.82	34.85	52.58	41.52	38.09	25.63	50.81	38.51	53.74	41.56
TMV 7	36.24	19.86	51.03	34.61	60.01	44.35	43.41	32.57	59.27	40.77	60.19	45.67
TMVGn 13	32.52	15.59	50.82	36.95	58.47	42.29	41.36	31.08	56.79	41.34	59.23	43.14
Mean	29.78	17.21	49.09	35.41	55.02	42.84	39.73	30.33	53.81	40.89	55.74	43.40
	G	S	T	GxS	SxT	GxT	G	S	T	GxS	SxT	GxT
SEd	0.36	0.31	0.25	0.62	0.44	0.51	0.46	0.40	0.32	0.79	0.56	0.64
CD (0.05)	0.72	0.63	0.51	1.25	0.89	1.02	0.92	0.94	0.65	1.59	1.12	1.30

different stages of drought. Among the genotypes, CO 7 recorded more plant height (20.8 cm) followed by TMV 7 (19.86 cm) in PFD compared to control of 28.43 and 36.24 cm respectively but in after recovery, both these genotypes were on par with each other.

Among the stages of drought, PFD affected more in reducing plant height (17.21cm) but it recovered soon after re-watering (30.33 cm) compared to other drought treatments (Table 1). Among the genotypes, CO 7 recorded more plant height followed by TMV 7 at PFD compared to control but in after recovery, both these genotypes were on par with each other.

Table 2. Effect of water stress on leaf area (cm^2 plant^{-1}) of groundnut genotypes

Genotypes	At Stress						At Recovery					
	Pre flowering drought		Flowering drought		Post flowering drought		Pre flowering drought		Flowering drought		Post flowering drought	
	Control	Stress	Control	Stress	Control	Stress	Control	Recovery	Control	Recovery	Control	Recovery
CO 7	425.8	289.7	854.1	709.3	883.1	398.4	792.2	736.5	876.9	731.2	898.9	399.4
COGn 4	451.3	119.7	525.3	361.7	825.3	117.3	752.8	325.1	880.1	366.7	841.6	116.6
TMV 7	403.8	260.5	831.7	695.2	873.2	272.1	770.3	680.4	852.3	715.1	884.7	275.5
TMVGn 13	395.4	240.6	823.3	672.4	862.3	284.3	705.2	650.7	843.7	690.3	872.6	283.3
Mean	419.1	227.6	758.6	609.6	860.9	268.0	755.1	598.1	863.2	625.8	874.4	268.7
	G	S	T	GS	ST	GT	G	S	T	GS	ST	GT
SEd	4.21	3.65	2.98	7.30	5.16	25.98	18.37	15.91	12.99	31.83	22.50	25.98
CD (0.05)	8.47	7.34	5.99	14.68	10.38	52.25	36.95	32.00	26.12	64.00	45.25	52.25

Madhusudhan and Sudhakar (2014) observed drastic reduction in shoot length in groundnut grown under severe moisture stress condition. Water stress at early stage of plant decreases rapid cell division, elongation and enlargement due to low turgor pressure which might have ultimately lead to the reduction in plant height and resume growth after recovery as reported by Herralde *et al*. (1998).

Table 3. Effect of water stress on relative water content (%) of groundnut genotypes

Genotypes	At Stress						At Recovery					
	Pre flowering drought		Flowering drought		Post flowering drought		Pre flowering drought		Flowering drought		Post flowering drought	
	Control	Stress	Control	Stress	Control	Stress	Control	Recovery	Control	Recovery	Control	Recovery
CO 7	93.92	67.17	97.51	55.32	86.77	49.97	95.44	86.38	92.12	77.39	83.47	52.47
COGn 4	90.62	43.98	96.32	28.59	81.41	18.32	93.41	71.46	90.47	31.61	69.28	19.03
TMV 7	92.51	61.38	96.77	42.32	82.17	38.71	94.79	79.80	92.76	71.82	78.51	39.97
TMVGn 13	91.33	55.71	94.38	37.97	79.56	32.11	93.34	76.11	91.78	66.34	75.92	32.98
Mean	92.10	57.06	96.25	41.05	82.48	34.78	94.25	78.44	91.78	61.79	76.80	36.11
	G	S	T	GxS	SxT	GxT	G	S	T	GxS	SxT	GxT
SEd	0.53	0.46	0.38	0.93	0.65	0.76	0.57	0.50	0.40	0.99	0.70	0.81
CD (0.05)	1.07	0.93	0.76	1.86	1.32	1.52	1.15	1.00	0.81	1.99	1.41	1.62

Leaf area (cm^2 plant^{-1})

Among the stages of drought, 68.87 per cent reduction was observed in PoFD in leaf area over control and lower reduction per cent was observed in FD (19.63%) during stress (Table 2). After recovery, PFD recorded less leaf area reduction per cent (20.78 %) than FD (27.50 %) and PoFD (69.37 %). Turner (1986) reported that, even small lowering of the leaf water potential caused considerable inhibition of enlargement. Thiyagarajan *et al*. (2009) found that, leaf area for irrigated treatment was greater than water stress treatment. These responses are in agreement with findings of Puangbut *et al*. (2009) who reported that, drought reduced leaf area during stress and that was slightly increased after recovery.

Physiological parameters:

Relative Water Content (RWC %)

Relative water content (RWC) represents the ability of the genotypes to retain tissue water status under water stress and the genotypes retaining

Table 4. Effect of water stress on chlorophyll index (SPAD) of groundnut genotypes

	At Stress						At Recovery					
Genotypes	Pre flowering drought		Flowering drought		Post flowering drought		Pre flowering drought		Flowering drought		Post flowering drought	
	Control	Stress	Control	Stress	Control	Stress	Control	Recovery	Control	Recovery	Control	Recovery
CO 7	32.34	25.47	37.25	31.07	32.38	24.46	35.81	38.92	38.41	34.13	27.70	22.02
COGn 4	32.11	22.37	36.17	24.54	30.15	19.17	34.13	29.15	37.32	28.47	21.48	15.21
TMV 7	31.74	23.42	35.91	28.27	31.24	22.65	33.80	36.17	36.93	31.61	25.24	19.17
TMVGn 13	30.19	21.92	35.11	26.12	30.27	21.86	32.32	31.09	35.99	30.18	23.78	18.95
Mean	31.5	23.30	36.11	27.50	31.01	22.04	34.02	33.83	37.16	31.10	24.55	18.84
	G	S	T	GxS	SxT	GxT	G	S	T	GxS	SxT	GxT
SEd	0.44	0.38	0.31	0.75	0.53	0.62	0.58	0.51	0.41	1.01	0.71	0.83
CD (0.05)	0.88	0.76	0.62	NS	NS	1.24	1.17	1.02	0.83	NS	1.44	1.66

more tissue water are expected to perform better. The stress treatments reduced RWC during all the stages. During stress, compared to control, highest percent reduction was observed in PoFD (75 %) followed by FD (42%) but, PFD recorded lowest reduction (38 %) as presented in Table 3. After re-watering, PFD and FD recovered immediately but PoFD has not recovered positively.

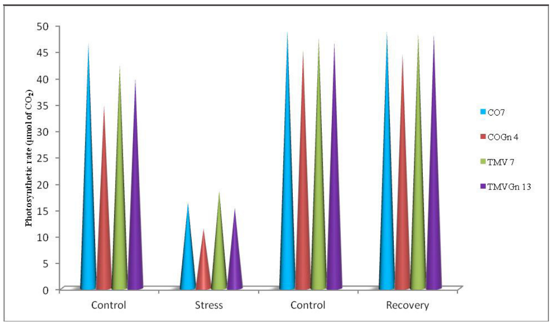

Figure 1. Effect of water stress on photosynthetic rate (µmol of CO_2 m^{-2} s^{-1}) of groundnut genotypes in Pre flowering drought

Among the genotypes, CO 7 was superior in recording more RWC after recovery (86.38 %). COGn 4 recorded lowest recovery in PFD (71.46 %) but not recovered in FD (31.61 %) and PoFD (19.03%) compared to other genotypes (Table 3). All the genotypes at all the stages of drought showed declined RWC as observed by Jongrungklang *et al*. (2013). Vurayai *et al.* (2010) found that, pod filling stage had the lowest RWC amongst the stress treatments and did not recover fully after rewatering. This may be because the plants were on their last stage of the growth and aged exhibiting the ability to recover as a function of plant age.

SPAD chlorophyll Index

SPAD chlorophyll value is expressed as cholorophyll index. An increasing trend was observed from pre flowering to flowering stage and suddenly declined at post flowering stage in control and all other treatments. In all the stress treatments, all the genotypes recorded less chlorophyll index than control. But soon after irrigation, PFD imposed plants recovered (from 23.00 to 33.83) quickly, FD imposed plants recovered slowly from 27.50 to 31.10 and PoFD stressed plants not recovered and reduced drastically (22.04 to 18.84). Among the genotypes, low recovery percent was observed in COGn 4 but at the same time, recovery percentage was very high in CO 7 at PFD. Highly significant variation was observed between treatments and genotypes (Table 4). Awal and Ikeda (2002) described that, limitation of the water supply induced faster degradation of chlorophyll pigments. Moreover, stressed plants failed to take up sufficient water and mineral nutrients from soil and many biochemical activities were arrested resulting in reduction of leaf chlorophyll concentrations.

Photosynthetic rate (µmol of CO_2 m^{-2} s^{-1})

The photosynthetic rate was highly reduced under stress with the mean value of 15.28 µmol of CO_2 in PFD followed by PoFD (7.79) and FD (2.81). After re-watering, PFD recorded the photosynthetic rate (48.67) equal to control (47.79) and on par with each other but drastic reduction was observed under FD (33.89) and PoFD (17.93) in all the genotypes. Among the genotypes, CO 7 performed better in all the stages of stress and also in recovery. Poorest performance was observed in COGn 4 especially during stress at all the stages (Figure 1). Vurayai *et al*. (2010) reported reduced photosynthetic efficiency during water stress. Plants stressed during the vegetative stage completely recovered their photosynthetic efficiency after re-watering. Recovery of photosynthetic efficiency may be due increased carbon dioxide diffusion into the leaves to attain higher photosynthetic rates as corroborated in the present study.

Total Dry Matter Production

Irrespective of the genotypes, appreciable reduction in TDMP was observed under FD and PoFD treatments showing significant difference from each other. More reduction was observed in FD (48.55 g $plant^{-1}$) followed by PoFD (44.25 g $plant^{-1}$) over control. Among the genotypes, COGn4 was affected

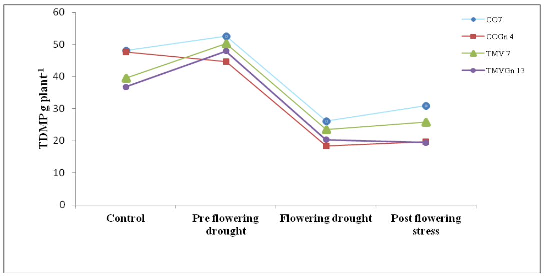

Figure 2. Effect of water stress on TDMP (g plant^{-1}) of groundnut genotypes

significantly by stress treatments accounting for high percent reduction of TDMP in FD and PoFD respectively. CO 7 recorded the highest TDMP (52.6 g plant^{-1}) under PFD than control (Figure 2).

CONCLUSION

It is concluded that, morphological and physiological parameters were recorded high in PFD after recovery but not in FD and PoFD. Drastic reduction in morphological and physiological parameters was observed in COGn 4 while CO 7 followed by TMV 7 and TMVGn 13 recording lesser effects in all the characters. The changes in turn, led to higher total dry matter production by CO 7 followed by TMV 7, TMVGn 13 and COGn 4. Among the stages of water stress treatments, all the genotypes showed higher TDMP under PFD and better than control.

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