

## Gas exchange and leaf water relations in two peanut cultivars of different drought tolerance

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### Abstract

In summer seasons of 1991 and 1992 the gas exchange and leaf water relations were analysed in two peanut cultivars: drought tolerant cv. GG 2 (DT) and drought sensitive cv. JL 24 (DS). Soil moisture stress was imposed by withholding irrigation at pod development phase. The decrease in photosynthesis ( $P_N$ ) under stress was associated with a decrease in stomatal conductance ( $g_s$ ) and relative water content (RWC). The  $P_N$  and RWC were significantly higher under stress in DT than DS. On relief of stress the  $g_s$  and RWC recovered more quickly in DT than DS. The maintenance of higher RWC (>80 %),  $g_s$  and  $P_N$  under stress appears to be imparting drought tolerance in peanut.

*Key words:* drying cycle, photosynthesis, relative water content, soil moisture stress, summer season.

### Introduction

The identification of the physiological processes imparting drought tolerance help to develop plant types suitable for drought regions. The present investigation was carried to study photosynthesis and leaf water relations in two peanut cultivars under soil moisture stress with the aim to identify a parameter that could be used in screening for drought tolerance.

### Materials and methods

Two Spanish peanut (*Arachis hypogaea* L.) cultivars - drought tolerant cv. GG 2 (DT) and drought-sensitive cv. JL 24 (DS) (Joshi *et al.* 1988 ) were grown in plots of 5 × 3 m in January-May of 1991 and 1992 in a completely randomised block design with three replicates. The soils were medium black calcareous with a pH of 8.2 and a gravimetric soil moisture content of about 20 % at field capacity. Soil moisture stress

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(SMS) was imposed from pod-initiation to pod-development phase by withholding irrigation for 18 d (1991) and 26 d (1992). The normal-plants were irrigated to field capacity regularly at 10 (1991) and 3 (1992) day intervals. Nitrogen (urea, 25 kg ha<sup>-1</sup>) and phosphorus (P<sub>2</sub>O<sub>5</sub>, 40 kg ha<sup>-1</sup>) were given as basal doses. Soil moisture at 0 - 15 and 15 - 30 cm depths was estimated gravimetrically after recording the gas exchange parameters.

During drying cycle net photosynthetic rate (P<sub>N</sub>), stomatal conductance (g<sub>s</sub>), internal carbon dioxide concentration (c<sub>i</sub>), and leaf temperature (T<sub>l</sub>) were recorded on recent fully expanded top leaflets at 09.00, 12.00 and 15.00 local time concurrently on normal and stressed plants using LI 6200 (LI-COR, Lincoln, USA) portable photosynthesis system. Relative water content (RWC) was measured on recent fully expanded leaves of the plant on which gas exchange parameters were recorded following Barrs and Weatherley (1962).

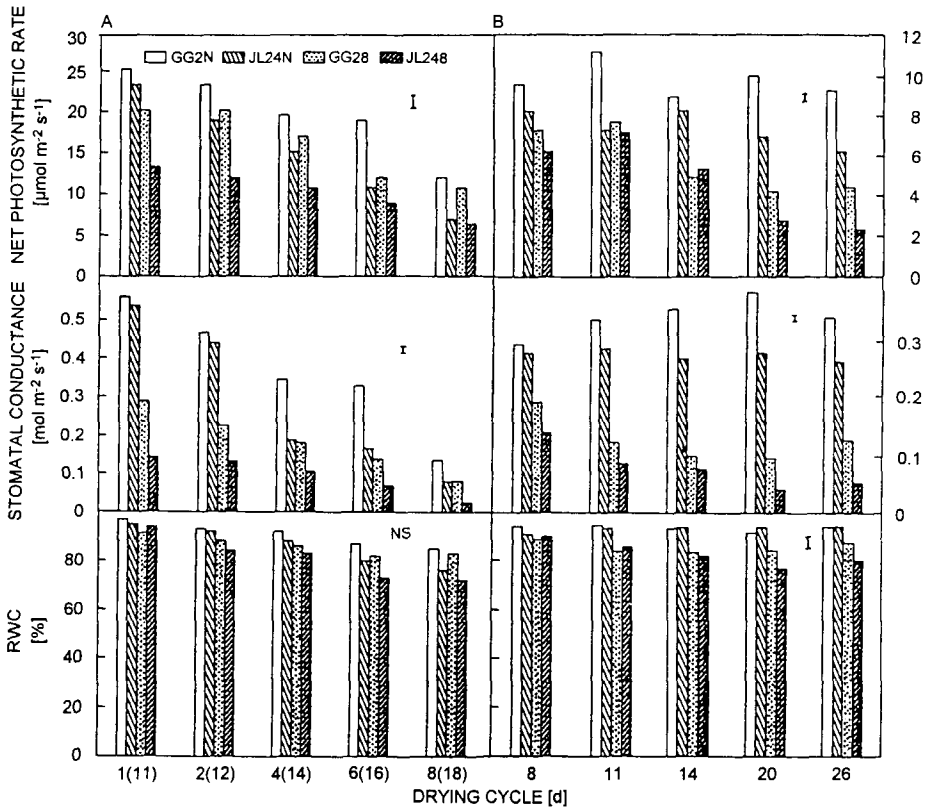


Fig. 1. Net photosynthetic rate (P<sub>N</sub>), stomatal conductance (g<sub>s</sub>) and relative water content (RWC) of control and stressed plants in 1991 (a) and 1992 (b) of two peanut cultivars, drought tolerant cv. GG 2 and drought sensitive cv. JL 24. In column a the values in parenthesis are corresponding days for stressed plants. Bars indicate S.E.

## Results

The both peanut cultivars showed significant reduction in net photosynthetic rate ( $P_N$ ) and stomatal conductance ( $g_s$ ) with soil moisture stress. The decline was significant from 4<sup>th</sup> day of a drying cycle. DT maintained a higher  $g_s$  than DS (Fig.1). At 9 h  $g_s$  and  $P_N$  were maximum and decreased thereafter. The leaf temperature ( $T_l$ ) was above ambient temperature ( $T_a$ ) and their difference ( $T_l - T_a$ ) was higher under stress. The  $T_l$  in DT was closer to  $T_a$  than in DS. Relative water content (RWC) declined significantly during drying cycle (Fig.1). In DT, RWC remained above 80 % whereas it declined below 80 % in DS. The RWC in control plants was above 90 % and maximum at 9 h. Under stress, though the  $P_N/g_s$  ratio increased initially it decreased at peak stress. The  $P_N/RWC$  ratio decreased with increasing soil moisture stress. After relief of stress the mean  $P_N$  was higher and steady in DT but DS showed a diurnal trend. The DT also showed quicker and better recovery in  $g_s$  and RWC (Table 1).

Table 1. Net photosynthetic rate [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ], stomatal conductance [ $\text{mol m}^{-2} \text{s}^{-1}$ ] and relative water content [%] in two peanut cultivars drought tolerant cv. GG 2 and drought sensitive cv. JL 24 18 h after relief of stress.

	time [h]	Control cv. GG 2	cv. JL 24	Stressed cv. GG 2	cv. JL 24
$P_N$	9	10.42	7.75	9.14	2.74
	12	8.78	4.58	8.35	5.85
	15	3.37	5.53	8.83	4.67
LSD ( $P = 0.05$ )		3.16			
$g_s$	9	0.374	0.291	0.179	0.145
	12	0.417	0.236	0.195	0.140
	15	0.357	0.375	0.172	0.172
LSD		0.055			
RWC	9	96.7	94.8	94.9	94.4
	12	92.8	94.9	93.7	90.8
	15	91.1	91.0	89.6	88.2
LSD		NS			

## Discussion

The decrease in  $P_N$  during drying cycle was concurrent with a decrease in  $g_s$  and RWC. The strong relationship between  $P_N$  and  $g_s$  obviously indicate that  $P_N$  in peanut is highly related to  $g_s$ , which apparently also regulates RWC and transpiration (Farquhar and Sharkey 1982). In our experiments  $P_N$  and  $g_s$  were affected from the 4<sup>th</sup> day of a drying cycle. However, Allen *et al.* (1976) observed such decrease from the 7<sup>th</sup> day of a drying cycle; Bhagsari *et al.* (1976) observed that  $P_N$  of stressed peanut plants in pots decreased after 1 or 2 d of drying and ascribed it to stomatal

closure. The DT was able to maintain higher  $P_N$  than DS even at peak stress in both the years indicating better drought tolerance. The higher photosynthetic capacity of DT under stress might be due to factors that control internal  $CO_2$  assimilation. Maintenance of a large reproductive sink size even under stress may also be contributing to higher  $P_N$  in DT (Ravindra *et al.* 1990, 1995). In fact, DT had significantly higher  $g_s$  than DS throughout (Fig. 1). The greater tolerance to water stress showed by DT may also be due to osmoregulation in leaves. The recovery in  $g_s$  and RWC after relief of stress was much faster in DT than DS. Joshi *et al.* (1988) observed that quick recovery of stomatal activity after relief of stress imparts better drought-tolerance. Therefore, detailed studies with large number of genotypes are required to exploit  $P_N$  as a trait to screen for drought tolerance in peanut.

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