LEAF GAS EXCHANGE AND WATER RELATIONS IN YOUNG BEAN (*Phaseolus vulgaris* L.) PLANTS UNDER DROUGHT CONDITIONS

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Introduction

Water stress affects negatively the functional status of plant organism. Most affected are the water exchange, growth and development, uptake and assimilation of mineral nutrients and the photosynthetic carbon assimilation. Special attention is paid to the investigations of the plant water relations, the functional activity of the photosynthetic apparatus, the changes in the activities of main enzyme systems under drought. Ones of the promising methods for assessing drought tolerance of plants are the growth analysis and monitoring of changes in leaf gas exchange and water relation.

The objective of the present study was to establish the effect of soil drought on leaf gas exchange and water relations in two bean genotypes, which were previously selected for their different degrees of inhibition of the main growth analysis parameter - relative growth rate (RGR) - Plovdiv 11M and A 195.

Material and Methods

The plants of two bean genotypes - Plovdiv 11M and A 195, were grown into plastic pots with 1.5 kg of sandy soil. 14 days after the emergence plants were divided into two groups - control and droughted. The second group was subjected to a 10-day drought by withholding watering. The conditions of growing and the drought treatment have been previously described (Berova and Zlatev, 2002). The leaf gas exchange parameters - net photosynthetic rate (A), transpiration rate (E) and stomatal conductance (gs) were determined at the end of the drought period on the petiole of the central leaflet of the first compound leaf. The analyses were conducted with a portable photosynthetic system LCA-4 (ADC, Hoddesdon, England) under the following conditions - light intensity (PAR) - 750 mol m^{-2} s^{-1}, CO_2 concentration - 350 mol mol^{-1} and temperature of 26 °C. Relative water content (RWC) was determined according to Morgan (1986). Leaf water potential was determined using a pressure chamber (Turner, 1988). Transpiration per unit plant weight (T) was calculated as the ratio of water use on the last day before sampling and plant dry weight. Plant water use efficiency (WUE) was calculated as the ratio of biomass increase and water use over the drought period.

Results and Discussion

The results in Table 1 show that after ten-day drought period, the leaf gas exchange rate in the plants of both genotypes was significantly reduced. In cv. Plovdiv 11M, E and gs were reduced to a greater extant than A, while in cv. A 195, A was suppressed more than E and gs. The photosynthetic water use efficiency, expressed as the A/E ratio, increased significantly in cv. Plovdiv 11M, while in cv. A 195 it decreased insignificantly. Stomatal closure is a well-known plant response to water stress, restricting water losses. Here, the photosynthetic rate is undoubtedly reduced. By the end of the drought period, the plants of cv. Plovdiv 11M restricted their transpiration to a greater extent than did the plants of cv. A 195. Plants differ in the stomatal role in maintaining the functional activity of photosynthetic apparatus during periods of drought (Chaves, 1991). In certain plants, the stomatal control is of dominant importance and these plants are characterised by increased water use efficiency. In others, that keep their stomata relatively open, due to either being able to compensate for water losses or to a loss of stomatal control, the water use efficiency could remain unchanged or insignificantly reduced. Our studies related the young bean plants of cv. Plovdiv 11M to the first group, and those of cv. A 195 - to the second.

By the end of the drought period, the changes in the relative water content (RWC) of both cultivars were significant. A greater RWC reduction was established in Plovdiv 11M. Ψ_w decreased significantly in both cultivars. The changes in RWC and Ψ_w were probably due to some structural and functional changes, ensuring plant adaptation to the drought treatment (Paleg *et al.*, 1984).

Table 1. Leaf gas exchange parameters in two bean genotypes (Plovdiv 11M and A195) after ten days of soil drought. A-net photosynthetic rate [μmol m^{-2} s^{-1}]; E-transpiration rate [mmol m^{-2} s^{-1}]; gs-stomatal conductance [mmol m^{-2} s^{-1}]; A/E-photosynthetic water use efficiency [μmol $mmol^{-1}$]. Values are the means ± SE of five replicates. *, **, ***, indicate significant difference at P<0.05, P<0.01, P<0.001, respectively, between control and soil drought for each genotype.

parameters	Plovdiv 11M control	Plovdiv 11M Drought	A195 Control	A195 drought
A	12.78±0.49	9.73±0.37 **	12.94±0.43	8.33±0.32 ***
E	4.11±0.14	2.58±0.11 ***	3.97±0.14	2.83±0.12 **
gs	175±12	115±12 *	180±14	140±11
A/E	3.10±0.09	3.77±0.10 **	3.26±0.10	2.94±0.08

Table 2. Changes in the leaf relative water content (RWC [%]), leaf water potential (Ψ_w [MPa]), transpiration per unit plant weight (T (g g^{-1} day^{-1}]), and plant water use efficiency (WUE [mg g^{-1}]) of two bean genotypes (Plovdiv 11M and A195) after ten days of soil drought. Values are the means ± SE of five replicates. *, **, ***, indicate significant difference at P<0.05, P<0.01, P<0.001, respectively, between control and soil drought for each genotype.

parameters	Plovdiv 11M control	Plovdiv 11M Drought	A195 Control	A195 drought
RWC	92.40±0.80	77.30±0.70 ***	94.50±0.90	82.60±0.70 **
Ψ_w	-0.43±0.03	-1.60±0.06 ***	-0.36±0.02	-1.30±0.05 ***
T	16.70±0.90	8.70±0.50 ***	17.20±0.40	10.10±0.80 ***
WUE	11.40±0.60	11.80±0.80	11.10±0.50	9.30±0.40 *

The plants of tested genotypes showed identical response in terms of the water relation parameters - relative water content and water potential. RWC decreased to a lesser extent, while the Ψ_w reduction was by more than two times. Water use efficiency (WUE) increased slightly in cv. Plovdiv 11M and decreased significantly in cv. A 195.

References

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