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ФИЗИОЛОГИЧЕН ТЕСТ ЗА ОЦЕНКА НА ГЕНОТИПНАТА ТОЛЕРАНТНОСТ НА ДОМАТИ (*SOLANUM LYCOPERSICUM*) КЪМ ВОДЕН СТРЕС
PHYSIOLOGICAL TEST FOR EVALUATION OF GENOTYPES TOLERANCE OF TOMATO (*SOLANUM LYCOPERSICUM*) TO WATER STRESS

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Резюме

Целта на изследването беше да се разработи подходящ физиологичен тест за бърза и надеждна диагностика на устойчивостта на растенията към воден стрес и впоследствие да се оцени толерантността на някои генотипове при домати (*Solanum lycopersicum*). Експериментите бяха проведени през периода на засушаване, както и след отстраняване на стреса. Оценката на толерантността на растенията беше извършена с помощта на физиологичен тест. Беше установено, че засушаването оказва инхибиращ ефект върху физиологичното състояние на доматените растения. Показателите листен газообмен и хлорофилна флуоресценция бяха посочени като особено подходящи индикатори за оценка на толерантността на различни генотипове домати към воден стрес.

Abstract

The purpose of this study was to develop an appropriate physiological test for rapid and reliable diagnosis of plant resistance to water stress and subsequently to assess the tolerance of some tomato genotypes (*Solanum lycopersicum*). Experiments were carried out during the stress period and after its recovery. Valuation of the tolerance of plants was carried out by means of a physiological test. It was observed that the water stress has an inhibitory effect on the physiological state of tomato plants. Leaf gas exchange and chlorophyll fluorescence were identified as particularly suitable indicators for assessing the tolerance of tomato genotypes to water stress.

Ключови думи: *Solanum lycopersicum*, воден стрес, физиологичен тест.
Key words: *Solanum lycopersicum*, water stress, physiological test.

INTRODUCTION

During their ontogenetic development, plants are subjected to the unfavorable effect of environmental factors, water stress being one of the most common of them (Yordanov et al., 2000). Water stress has a negative effect on the functional status of plants organisms. It reduces the functional activity of plants, changes their normal functions and induces damages leading ultimately to a decrease in their productivity (Hay and Walker, 1989; Blum, 1996).

One of the promising methods for assessing drought tolerance of plants is tracking changes in leaf gas exchange, chlorophyll fluorescence and others (Zlatev et al., 2003).

The objective of the present research was to offer a fast and efficient assessment of the tolerance to water stress of some tomato genotypes with the help of an appropriate physiological test.

MATERIAL AND METHODS

The studies were conducted with two cultivars tomato (*Solanum lycopersicum*). Seeds were surface-treated with 1% (w/v) solution of Ca $(OCl)_2$ in 10% (v/v) ethanol and sown in tarred plastic pods of 5 l. Soil moisture was raised to 65% of soil humidity and maintained weight. In each pod were grown in two plants. Plants of each cultivar were divided in 2 groups: (1) plants with water regime 65% of full soil humidity and (2) plants, with water regime 40% of soil humidity for 10 days period. After drought soil humidity was restored to a level 65%.

The parameters of the leaf gas exchange were measured with an infrared analyzer LCA-4 (ADC, Hoddesdon, England). Chlorophyll fluorescence parameters were measured using a pulse amplitude modulation chlorophyll fluoremeter MINI-PAM (Walz, Effeltrich, Germany). The first leaves over the first bunch were used for the analyses. The measurements were carried out with intact plants. The content photosynthetic pigments were defined spectrophotometrically and calculated by Lichtenthaler (1983). The water potential was determined using digital pressure chamber (measure ELE International). The free proline content in the leaves was determined by Bates (1973).

The results were statistically processed. The authenticity of the differences was determined according to the criterion *t* of Student.

RESULTS

One of the primary physiological consequences of drought is photosynthesis and transpiration inhibition (Chaves, 1991; Shanggaun et al., 2000). The reduced CO_2 diffusion from the atmosphere to the site of carboxylation in the leaf, as results of both stomata closure and reduced mesophyll conductance, is the main cause of decreased photosynthesis under water stress conditions (Chaves and Oliviera, 2004). The data presented in Tables 1 show that after ten-day drought period, the leaf gas exchange rate in the plants of both genotypes was significantly reduced. In cv. Yana, A and E were reduced to a greater extant than in cv. Marty. The photosynthetic use efficiency, expressed as the A/E ratio, increased significantly in both genotypes. After

Таблица 1. Листен газообмен, хлорофилна флуоресценция и воден статус при домати, подложени на воден стрес; A - интензивност на фотосинтезата (μmol CO_2 $m^{-2}s^{-1}$); E - интензивност на транспирацията (mmol $m^{-2}s^{-1}$); Ψ_w – воден потенциал в листата (Bar); Proline - съдържание на пролин (mg.g^{-1} fresh weight); F_v/F_m - вариабилна/максимална флуоресценция

Table 1. Leaf gas exchange, chlorophyll fluorescence and water status in tomato plants exposed to water stress; A - intensity of photosynthesis (μmol CO_2 $m^{-2}s^{-1}$); E – transpiration (mmol $m^{-2}s^{-1}$), Ψ_w – leaf water potential (Bar), Proline - content of proline (mg.g^{-1} fresh weight), F_v/ F_m - maximum/variable fluorescence

Показатели Parameters	Период на засушаване Drought period		Възстановяване Recovery	
	Control	Drought-stressed	Control	Drought-stressed
cv. Marty				
A	13.35±0.42	7.62±0.38** (57%)	13.88±0.52	11.40±0.25* (82%)
E	2.36±0.32	1.15±0.06* (48%)	2.88±0.12	2.45±0.11 (85%)
A/E	5.65	6.62 (117%)	4.81	4.65 (97%)
Ψ_w	-15.3	-23.7* (155%)	-17.3	-20.1* (116%)
Proline	0.535±0.02	0.774±0.05** (144%)	0.610±0.02	0.650±0.08* (106%)
F_v/ F_m	0.811±0.045	0.732±0.048* (90%)	0.792±0.05	0.738±0.06* (92%)
cv. Yana				
A	14.59±0.65	7.45±0.62** (51%)	15.44±0.15	12.12±0.33* (78%)
E	2.79±0.33	1.16±0.44 * (41%)	2.95±0.22	2.66±0.25 (90%)
A/E	5.22	6.42** (122%)	5.23	4.55* (87%)
Ψ	-16.7	-25.3* (151%)	-16.3	-19.3* (118%)
Pro	0.485±0.04	0.725±0.03* (149%)	0.500±0.05	0.608±0.02* (121%)
F_v/ F_m	0.8310±0.047	0.640±0.045* (77%)	0.790±0.040	0.737±0.058 (93%)

* $P < 0.05$; ** $P < 0.01$

the recovery from the stress A and E in the plants of both cultivars largely recovered.

By the end of the drought period, the plants of tested genotypes showed similar response in terms of water potential. The ψ_w reduction was more than 50% in both cultivars. After recovery for 10 days period ψ_w was 16-18% above the control plants. The changes in ψ_w were probably due to some structural and functional changes, ensuring plant adaptation to the drought treatment (Paleg et al., 1984).

The accumulation of obsolete compounds (e.g. proline) in the cells as a result of water stress is often associated with a possible mechanism to tolerate the harmful effect of water stress (Turner and Jones, 1980). After the drought period in tomato leaves (cv. Marty and cv. Yana) were observed substantial accumulation of proline (44-49% above the control). After the recovery from the stress a greater proline content was established in Yana.

Chlorophyll fluorescence measurements have been widely used to determine the plant response behavior to environmental stress conditions (water, temperature, salinity, heavy metal stress etc.) (Glynn et al., 2003). In dark-adapted leaves, the ratio F_v/F_m is a parameter for the potential PS2 efficiency in the photochemical reactions (Ranjbarfordoei et al., 2006). It is known that in healthy leaves this ratio is in the range of 0.75-0.85 (Bolhar-Nordenkampf and Oquist, 1993). Stress factors, affecting mainly PS2 function, reduce the value of this ratio (Krause and Weis, 1991). The significant F_v/F_m decrease in the plants of cv. Yana subjected to water stress (by 23%) was indicative of PS2 disturbances. The plants of cv. Marty maintained that ratio at a higher level. This demonstrated the higher tolerance of their photosynthetic apparatus to water stress.

The photosynthetic pigments are one of the internal factors which can limit the photosynthetic activity to a large extent. It is proven that the reduction of the pigment concentration is an indicator of stress in cases as water and temperature stress, insufficiency or excess of mineral elements, etc. (Hendry and Grime, 1993). The data from Table 2 show that water stress cause disturbances in the photosynthetic apparatus in both genotypes. As a result of their influence the content of chlorophyll *a* in the leaves of the studied plants is reduced by 21-27%. The content of

Таблица 2. Съдържание на фотосинтетични пигменти (mg. g^{-1} св. тегло) в растения от домати, подложени на воден стрес

Table 2. Content of photosynthetic pigments (mg.g^{-1} fresh weight) in tomato plants exposed to water stress

Показатели Parameters	Период на засушаване Drought period		Възстановяване Recovery	
	Control	Drought-stressed	Control	Drought-stressed
cv. Marty				
Chlorophyll *a*	2,37±0,01	1,74±0,10** (73%)	2,86±0,42	2,33±0,11* (81%)
Chlorophyll *b*	0,73±0,01	0,64±0,00 (87%)	0,81±0,07	0,73±0,01 (90%)
Carotenoids	0,69±0,02	0,65±0,00 (94%)	0,70±0,03	0,88±0,02 (125%)
Chl *a*/ Chl *b*	3,24±0,08	2,71±0,38 (83%)	3,51±0,09	3,40±0,09 (97%)
Chl *a*+ Chl *b* /carotenoids	4,29±0,39	3,88±0,01 (90%)	5,22±0,42	5,31±0,14 (101%)
cv. Yana				
Chlorophyll *a*	2,07±0,09	1,64±0,02* (79%)	3,42±0,04	2,96±0,00* (86%)
Chlorophyll *b*	0,64±0,03	0,61±0,02 (95%)	0,97±0,02	0,88±0,02 (91%)
Carotenoids	0,68±0,01	0,63±0,00 (93%)	0,70±0,01	0,86±0,00* (122%)
Chl *a*/ Chl *b*	3,27±0,20	2,88±0,43 (88%)	3,99±0,20	3,62±0,21 (91%)
Chl *a*+ Chl *b* /carotenoids	4,97±0,13	4,78±0,19 (96%)	4,33±0,09	4,86±0,05 (112%)

* P ‹ 0.05; ** P ‹ 0.01

chlorophyll *b* following the same tendency. According Kaiser (1982) reduced photosynthetic pigments is due of disturbances of their biosynthesis and the enhanced destructive processes.

CONCLUSION

On the basis of the conducted studies the following conclusions can be drawn**:**

1. Leaf gas exchange and chlorophyll fluorescence are particularly suitable indicators for assessing the tolerance of tomato genotypes to water stress. Since these measurements are non-destructive, fast and reliable, this makes them an attractive tool for environmental research purposes.
2. On the basis of the presented data we can conclude that the plants of cv. Marty are more tolerant to the applied water stress compared with cv. Yana.

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