FEAUTURES OF WATER STATUS AND ANTIOXIDANT PROTECTION OF PLANTS WITH DIFFERENT ADAPTATION STRATEGIES TO DROUGHT

PARTICULARITĂȚILE STATUS-ULUI APEI ȘI PROTECȚIEI ANTIOXIDANTE LA PLANTE CU DIFERITE STRATEGII DE ADAPTARE LA SECETĂ

BRÎNZĂ Lilia[1]
e-mail: liliabrinza@mail.ru

Abstract. *There have been registered differences caused by drought in competitive relationships between plant organs of Phaseolus vulgaris L., Phaseolus acutifolius Gray, and Phaseolus lunatus L. The inflorescences and pods of resistant plants possessed a better water homeostasis by account of water reserve from the stems, of root system activity and reactivity of stomata. Reactivity of stomata, hydraulic conductivity adjustment, high ability to restore the water status of the tepari and Lima beans reflected the conservative strategy of tolerant plants. Low tolerance of Phaseolus vulgaris L. plants to drought could be explained as the result of lower stomatal conductance, the occurrence of reactive oxygen species, acceleration of lipid peroxidation, accelerating oxidative destructions.*
Key words: *water status, adaptation, protective antioxidant enzyme, drought*

Rezumat: *S-au înregistrat deosebiri în relațiile competitive dintre organele plantelor de Phaseolus vulgaris L., Phaseolus acutifolius Gray, şi Phaseolus lunatus L., condiționate de secetă. La plantele rezistente, inflorescențele şi păstăile posedă o mai bună homeostatare a apei din contul rezervei de apă din tulpini, activității sistemului radicular şi reactivității stomatelor. Reactivitatea stomatelor, reglarea conductibilității hidraulice, capacitatea înaltă de restabilire a status-ului apei, plantelor de fasolea Phaseolus acutifolius Gray, şi Phaseolus lunatus L., reflectă strategia conservativă a plantelor tolerante. Toleranța scăzută a plantelor de Phaseolus vulgaris L. la secetă este o urmare a diminuării conductibilității stomatelor, apariției speciilor reactive de oxigen, intensificării procesului de oxidare peroxidică a lipidelor, accelerării destrucțiilor oxidative.*
Cuvinte-cheie: *status-ul apei, adaptare, enzimele de protecție antioxidantă, secetă*

INTRODUCTION

Plant property to minimize the impact of drought and to adapt to sub-optimal soil water content is due to a complex of functional and structural features, which were formed during phylogenesis (Cherry, 1989; Bray, 1993; Smith

[1] Institute of Genetics, Plant Phyisiology and Protection of Academy of Sciences, Chisinău, Republic of Moldova

and Griffiths, 1993; Kramer and Boyer, 1995; Ingram and Bartels, 1996; Shinozaki and Yamaguchi-Shinozaki, 1999). However, so far it is not clear their role in development of the response reaction to the change of soil water within the meaning of not only the survival of plants, but also in the aspect of "reproductive survival". In this context, it was interesting to clarify the physiological particularities of adaptation to drought for crop plants, belonging to species with different potential of tolerance and productivity.

MATERIAL AND METHOD

Investigations were carried out on plants of *Phaseolus lunatus* L., cv. *Fetanisa*; *Phaseolus acutifolius* Gray, cv. *Acutifolius* 5; *Phaseolus vulgaris* L., cv. *Nina* - species with different potential for productivity and tolerance to drought, grown in pots Mitcerlih with a capacity of 30 kg oven dry soil under controlled soil water content. The experiments design included treatments: I - control, permanent soil water content 70% of the total water capacity (TWC); II - plants, which have suffered two cycles of drought - first one - phase trifoliate leaves, and second - flowering stage. The study of functional characteristics was performed after 10 days of water stress and after I-st and VII-th day of restoring of optimal hydric regime. Water status parameters were determined by conventional methods. The testing of lipid peroxidation (LPO) was performed by determining the malone dialdehyde (MDA) content; the activity of antioxidant protection enzymes was measured spectrophotemetrically: catalase CAT – using the method of Chance and Machly (1955); ascorbate peroxidase APX – according to Nacano and Asada (1981); guaiacol peroxidase GwPX, glutathione reductase GR and glutathione peroxidase GPX – according to Schadle and Bassham (1977). Statistical analysis of data was performed using set of programs "Statistica 7" - ANOVA for computers.

RESULTS AND DISCUSSIONS

According to conception of "ecological strategies" (Grime, 1979), the differences of plants with various ecological orientation are determined by physiological nature of adaptation reactions.

Table 1

Peculiarities of the water status of bean plants in drought conditions.

Specia/ cultivar	Soil water content % TWC	WC, $g \cdot 100\ g^{-1}$ f.m.	SD, % of full saturation	WHC, % of water lost after 2h of dehydration	HB, g water $\cdot g^{-1}$ dry soil
Ph. lunatus **L., cv. *Fetanisa***	**70**	83.2 ± 0,5	6.7 ± 0.3	7.4 ± 0.2	4.7 ± 0.1
	30	80.3 ± 0,1	10.1 ± 0.4	2.9 ± 0.1	3.9 ± 0.02
Ph. acutifolius **Gray, cv. *Acutifoliu* 5**	**70**	83.1± 0,2	6.9 ± 0.2	11.7 ± 0.4	5.5 ± 0.04
	30	83.7 ± 0.2	10.5 ± 0.2	4.8 ± 0.2	4.5 ± 0.1
Ph. vulgaris **L., cv. *Nina***	**70**	86.5 ± 0.8	8.0 ± 0.3	14.4 ± 0.5	5.6 ± 0.03
	30	81.3 ± 0.5	12.8± 0.4	6.1 ± 0.2	4.1 ± 0.1

Note. f.m. - fresh mass

The value of SD to some extent depended on the activity of absorption of root system, on the capacity of protoplasm biopolymers to retain water, as well as, on the intensity of transpiration (Fig. 1).

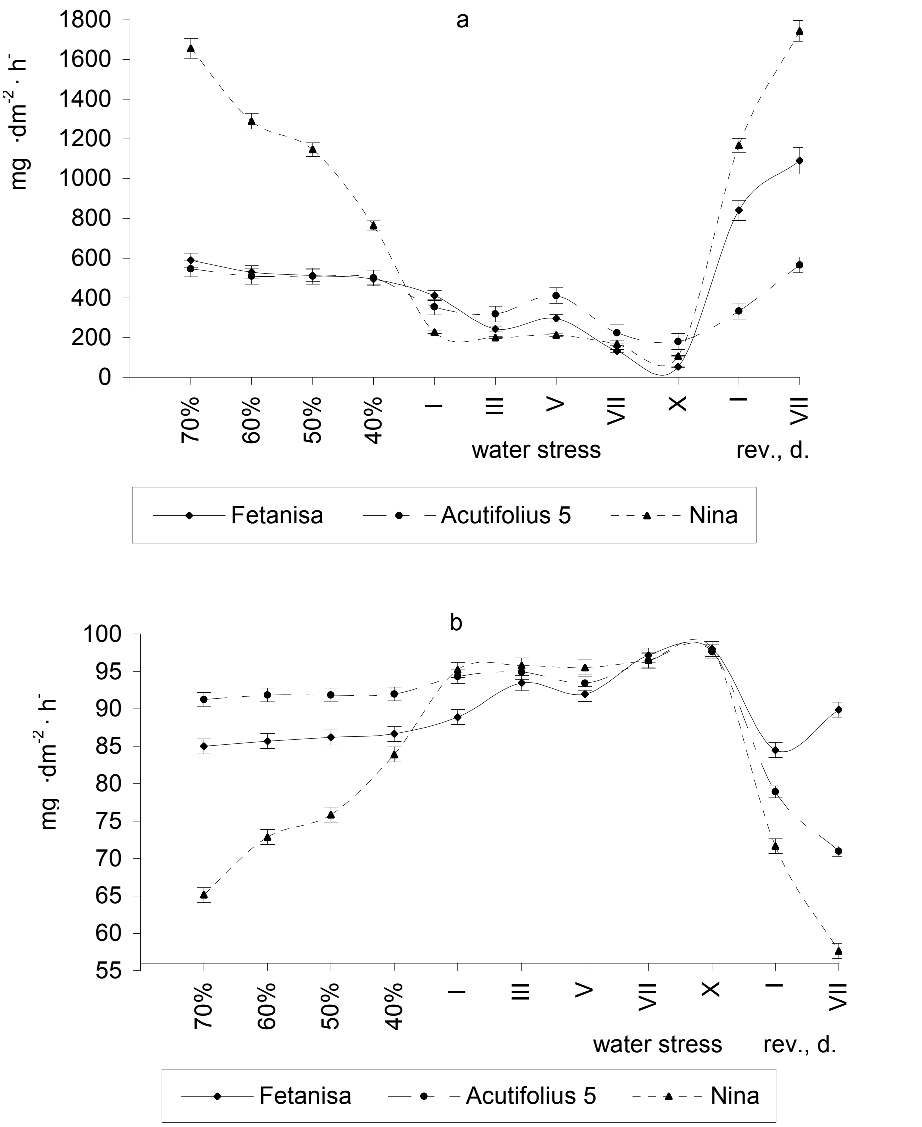

Fig. 1 - Modification in the intensity of transpiration (a) and the resistance to diffusion of water through the stomata (b) of *Phaseolus* leaves depending on the gradual change of soil water content.

The data (Table 1) have demonstrated that plants *Phaseolus* of investigated species distinguished by their reactivity to the variation in hydric regime. In drought conditions, a saturation deficiency of (SD) is formed in plant tissue, by which it can be judged on the relationship between the absorption of water from the soil, its transportation in the organs, and consumption during transpiration. After 10 days of drought (30% TWC) the water content (WC) was higher and the DS in leaves was significantly lower for plants with the high potential of tolerance in comparison to ones *Ph. vulgaris* L.

It was stated that the representatives of the species *Ph. acutifolius* Gray at the optimal level of water content lost the water more easily, leading to assumption that their genotypic tolerance was associated not so much with water retention capacity, but with activity of the root system. By the amount of water retained in the leaves under water deficit in the soil, the plants taken in the investigation could be distributed in descending order as follows: Fetanisa > Acutifolius 5 > Nina. Despite the fact that the plants in drought conditions developed a greater capacity to retain water in tissues, the degree of hydration of biocoloizilor (HB) decreased (table 1). The increase of SD in the tissues under the influence of insufficient soil water content resulted in reducing of water consumption in the process of transpiration. The stomata of bean plant responded promptly to changing of soil water content (fig. 1a, b). The transpiration of plants *Ph. vulgaris L.* has been particularly notable. Already at soil water decrease up to 50% TWC, the stomatal resistance for water vapour diffusion increased, and the intensity of transpiration of these plants was reduced by 1.45 times; at 40% TWC the water consumption decreased by 2.16 times. The same for them, a 10-day drought caused the almost complete blockage (93 %) of transpiration. In the early days of water content shortage (30% TWC), the degree of reduction in transpiration of Lima beans was 5 times lower than the usual beans. A 50 percent reduction in water consumption was recorded after 5-7 days of drought.

The impact of drought on water status of vegetative and generative organs was conducted differently (fig. 2).

The maximum quantitative differences were recorded in the net effect of drought on the water status in the roots and inflorescences of plants. Net action of drought on WC in the roots of *Ph. vulgaris* L. cv. Nina was ≈ 3 times higher than the WC in the stems, and 2.3 times higher than in leaves.

It was shown that the inflorescences did not have the capacity to repair the disruption of the water status even after improving the soil water content (Brinza L., 2003). The lower potential of drought resistance *Ph vulgaris* L. plants was due to the occurrence of reactive oxygen species (table 2), which increased oxidative destructions of cellular components. The degree of activation of antioxidant enzymes did not compensate the MDA formation.

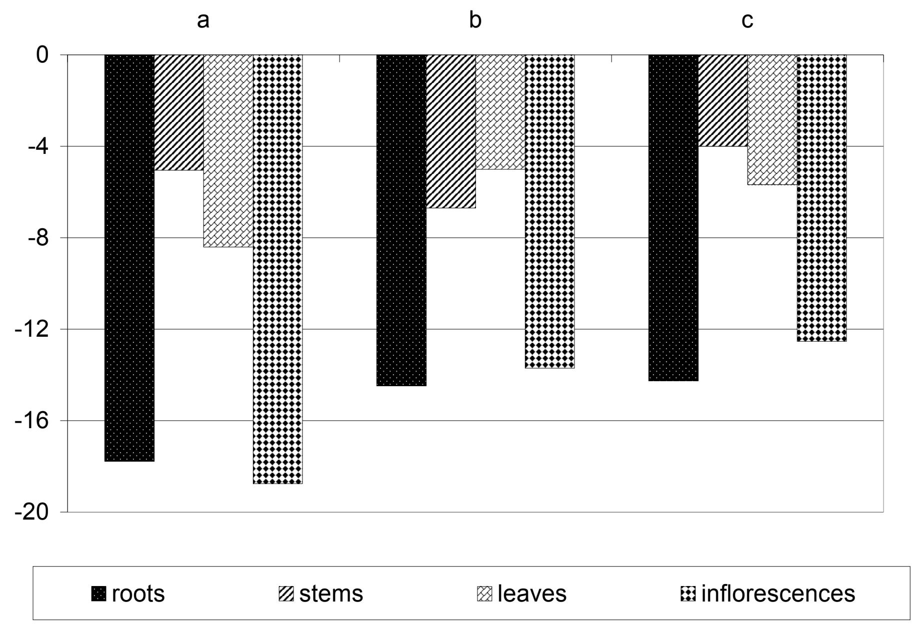

Fig. 2 - The effect of drought on water content in different organs of different species of plants *Phaseolus:* a - *Ph. vulgaris* L., cv. Nina; b - *Ph. acutifolius* Gray, cv. Acutifolius 5; c - *Ph. lunatus* L., cv. Fetanisa.

Table 2

Changing in the amount of phospholipids, MDA, and protective antioxidant enzyme activity in the leaves of *Phaseolus* plants during drought conditions.

Parameters	Soil water content		
	70 % TWC	30 % TWC	Δ, % control
	M ± m	M ± m	
Phospholipids content, mcg.g^{-1} d. s.	741.8 ± 4.2	320.2 ± 3.8	-56,8
MDA content , mcM/g. f. s.	7.44 ± 0.2	16.2 ± 0.4	117,7
SOD activity, conv. un./ g. f. s.	68.3 ±1.1	130.0 ± 2.1	80,9
CAT activity, mM/g. f. s.	12.0± 0.3	21.3 ± 0.2	77,5
APX activity, mM/g. f. s.	9.5 ± 0.1	23.7 ± 0.2	149,5
GPX activity, mM/g. f. s.	126.5 ± 0.9	184.0 ± 1.9	45,5
GwPX activity, mM/g. f. s.	247.7 ± 2.2	392.3 ± 3.3	58,4
GR activity, mM/g. f. s.	156.6 ± 1.2	264.4 ± 2.2	68.4

Note. d. s. - dry substance; f. s. - fresh substance; conv. un. - conventional units

The refore, *Phaseolus* plants adapted to suboptimal soil water content due to the self-regulation the water status: by increasing WHC in tissue, by the activity of water absorption in the root system, and by regulation of water consumption in the process of transpiration. The economical water consumption reflected the conservative strategy of tolerant specia *Ph. lunatus*, L. and *Ph. acutifolius* Gray.

CONCLUSIONS

1. The conservation strategy of plants spp. *Ph. lunatus* L. and *Ph. acutifolius* Gray was achieved by maintaining a relatively stable and balanced water status, which provided preadaptation to sub-optimal soil water content.

2. The compensatory restoration capacity of physiological processes in stress resistant plants was faster after amelioration of hydric regime.

3. The reduced resistance potential of common bean plants was due to inhibition of physiological processes at higher water potential in cells, to drastic decrease of stomata conductance, reactive oxygen species appearance, to the disorder of coordination degree among the enzyme activities involved in antioxidant protection.

Acknowledgments*: This investigations were performed with the financial support of young researchers project 15.819.05.08F.*

REFERENCES

1. Bray E.A., 1993 - *Molecular Responses to Water Deficit* .Plant Physiol. 103: 1035-1040

2. Brînză Lilia, 2003 - *Stres-reacția - expresie particulară a rezistenței plantelor la umiditate redusă*. Teza de doctor în ştiințe biologice. Chişinău. 173 p.

3. Chance B., Machly A., 1955 - *Assay of catalases and peroxidases*. In: Methods in Enzymology, S. P. Colowick and N.O. Kaplan (ed). N.Y.: Acad. Press. 2: 764-775.

4. Cherry J.H., 1989 - *Environmental stress in plants. Biochemical and Physiological Mechanisms.* NATO ASI Series G: Ecological Sciences. Springer-verlag. 19: 369.

5. Grime J.P. 1979 - *Plant Strategies and Vegetation Processes.* Chichester, Brisbane, Toronto: J. Willey and Sons. 222 pp.

6. Ingram J., Bartels D., 1996 - *The molecular basis of dehydration on tolerance in plants.* In: Annu Rev. Plant. Physiol. 47: 377-403.

7. Kramer P.J., Boyer J.S., 1995 - *Water relations of plant and soil*. San Diego: Academic Press. 489 p.

8. Nacano Y., Asada K., 1981.- *Hydrogen Peroxide Is Scavenged by Ascorbate Specific Peroxidase in Spinach Chloroplasts.* In: Plant Cell Physiol. 22: 867-880.

9. Schadle M., Bassham J.A., 1977 - *Chloroplast. Glutathione reductase*. In: Plant Physiology. 59(4): 1011.

10. Shinozaki Kazuo, Kazuko Yamaguchi-Shinozaki. 1999 - *Molecular Responses to Cold, Drought Heat and Salt Stress in Higher plants.* R. G. Landes Company. Austin. Texas. U.S.A. 170 p.

11. Smith J.A.C., Griffiths H. 1993 - *Integrating plant water deficits from cell to community // Water Deficits.* Bioc. Scientific Publishers. pp. 1-5.