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INVOLVEMENT OF SALICYLIC ACID DERIVATIVES IN PLANT WATER POTENTIAL ADJUSTMENT UNDER CONDITIONS OF INSUFFICIENT MOISTURE

ANTRENAREA DERIVAȚILOR ACIDULUI SALICILIC ÎN REGLAREA POTENȚIALULUI APEI PLANTELOR ÎN CONDIȚII DE INSUFICIENȚĂ DE UMIDITATE

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Abstract. *The greenhouse experiments were conducted to evaluate the effect of salicylic acid and salicylate* NH_4^+, K^+, Mg^{++} *on the possibility of adjusting the water status of the Zea mays, L. and Sorghum bicolor L. Moench plants in the drought conditions. It has been shown that drought causes significant changes in the stomatal conductance, intensity of transpiration, coupled with the change in the value of water potential* (Ψ_w) *and the hydrostatic pressure* (Ψ_p) *of the plants leaves of both species. Salicylic acid and salicylates* NH_4^+, K^+, Mg^{++} *have the property of the plant water haemostatis by increasing the degree of hydration of the tissue, reducing the water deficits, increased turgidity organs and retention of water, adjusting the hydraulic and stomatal conductivity, thus ensuring the maintenance of a higher level* Ψ_w *in both favourable and at moderate deficiency moisture conditions.*
Key words: plants, drought, salicylic acid, derivate, water potential, resistance.

Rezumat. *În experiențe cu umiditatea dirijată s-a studiat posibilitatea reglării status-ului apei plantelor de Zea mays L. şi Sorghum bicolor L., Moench în condiții de secetă moderată prin utilizarea acidului salicilic şi salicilaților de* NH_4^+, K^+, Mg^{++}. *S-a demonstrat că seceta condiționează schimbări semnificative atât în intensitatea transpirației apei, cuplate cu modificarea conductanței stomatelor, cât şi în valoarea potențialelor apei* (Ψ_w) *şi presiunii hidrostatice* (Ψ_p) *ale frunzelor plantelor. AS şi salicilații de* NH_4^+, K^+, Mg^{++} *au proprietatea de homeostatare a apei în organismul vegetal prin majorarea gradului de hidratare a țesuturilor, micşorarea deficitului de saturație, creşterea turgescenței organelor şi capacității de reținere a apei, reglarea conductibilității hidraulice şi stării stomatelor, ceea ce asigură menținerea* Ψ_w *la un nivel mai ridicat atât în condiții favorabile de umiditate, cât şi la un deficit moderat de apă.*
Cuvinte cheie: plante, secetă, acid salicilic, derivați, potențialul apei, rezistență

INTRODUCTION

It is known that living organisms are totally dependent on the presence of water, their predominant component. The smallest disturbance of the water balance in them are accompanied by serious changes in absolutely all life

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processes. The plants, being sedentary organisms, are constantly exposed to fluctuating of hydro-thermal conditions, often extreme ones. Agriculture as a priority branch of the country is highly vulnerable to risk factors, both to the ecological ones of climatic origin, such as lengthy droughts, early autumn or late spring frosts, scorching heat, etc., and to the fluctuation in their extreme range during ontogeny.

In this connection it is particularly important to develop the methods of induction of tolerance to reduce the impact of drought and stabilize plant productivity. In this aspect along with improving agricultural technique and application of new technologies in complex outcome measure, an important role is assigned to the creation and implementation in practice of new varieties with high potential for productivity and resistance, not only tolerant to drought, cold, etc., but also to fluctuation in wide range of external environmental factors. It is widely accepted that the change in the water status is the primary reaction of the organism to changing of environmental conditions, and is a trigger of cascade of protection reactions, as well as, is a commutator of cell functional activity from normal regime to one, characteristic of stress conditions. Given the fact that the regulation and coordination of growth, development and productivity of plants come under the control of plant hormones, more and more researches in phyto-physiology are geared toward elucidating of mechanisms of their action and to explore ways of exogenous regulating of functional status of plants under moderate drought. Lately particular attention was given to such effect of salicylic acid (SA). There have data that demonstrated the role of SA in maintaining of homeostasis by enhancing water absorption and stomatal apparatus reactivation (Raskin, 1992; Shachirova *et. al.,* 2003). It was established that exogenous SA in high concentrations (10^{-3} M) conditioned the closing of desmotubule of plasmodesmata (Лялин *et. al,* 1993), and SA in low concentrations (10^{-5} - 10^{-7} M) - the unlocking of water channels (Безрукова, Сахабутдинова, Шакирова, 1999). But few researches have been undertaken to elucidate the effect of AS and its derivatives on adjusting of plants water status in dry conditions. It was assumed that SA is able to change turgor-dependent valve diameter of desmotubule of plasmodesmata in a short time (Wilkinson and Davies, 2002). These data motivated the study of the SA effect on the peculiarities of regulating of the water status in plants to ensure adaptation, tolerance and productivity both in optimal conditions and under moderate drought.

MATERIALS AND METHODS

As the study objects served plants *Zea mays* L., cultivar (cv.) P459 and *Sorgum bicolor* L., cv. Piscevoi 1, grown in Mitcherlih containers with a capacity 30 kg absolutely dry soil under controlled water content conditions. The scheme of experiences: 1 - control plants grown on permanent soil water content - 70% from the total water capacity of soil (TWC); 2 - plants exposed to the drought (30 % TWC) for 10 days. The parallel treatments included the plants pre-treated through grain soaking and foliar with an aqueous solution of SA and salicylates NH_4^+, K^+.

Hydraulic conductivity of plant was calculated from the diurnal relationship of the water potential gradient of leaves and stems; and transpiration rate – according to equation:

$F = L_p (\Psi_{w\ fr} - \Psi_{w\ tulp})$, where F - the rate of transpiration, or water flow; L_p – a proportionality factor defined as hydraulic conductivity of the plant (Blatt, 2000; Moreshet *et al*, 1990). Given that the water flow through the plant is maintained due to soil water potential gradient and leaves site, which transpires, just its value was considered as transpiration rate (Steudle *et al,* 1987). Water potential (Ψ_w) was determined by the compensation method (Колесник and Егоров, 1989).

Turgor potential (Ψ_p) was obtained from the difference of water and osmotic potential: $\Psi_p = \Psi_\pi - \Psi_w$. Cellular juice concentration was determined by refractometer type Carat (1989) accortding to Larcher (1976). The intensity daytime transpiration of different leaves that differed by age was performed using transpirometer (Корнеску 1981). Data on the water status parameters in organs have been shown as mean value ± standard error of 5 reproductions, and as the average modification degree in 3-5 experiments. The results were statistically analyzed using the software package "Statistics 7" for computers.

RESULTS AND DISCUSSION

The research results have shown that plants treated with SA and salicylates exhibited more pronounced self-regulating properties of water exchange, optimization of the degree of hydration, and turgidity of tissue, both in optimal and moderate deficit of soil water content conditions (tab. 1).

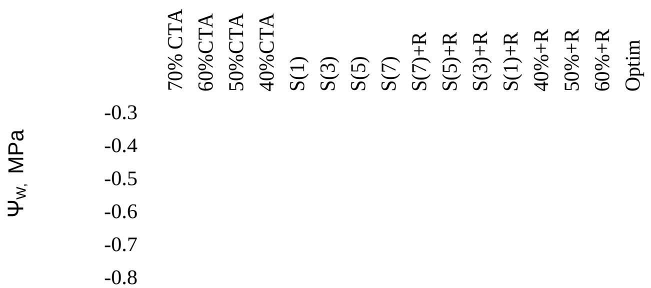
Table 1

Water status parameters modification of maize and sorghum plants under the influence of salicylic acid and moderate deficit of soil water content

Treatments	Water content (WC), g 100 g^{-1} f. m.		Saturation deficiency (SD), % of full saturation		Intensity of transpiration (IT), Mg dm^{-2} h^{-1}	
	M ± m	Δ,% of control	M ± m	Δ,% of control	M ± m	Δ,% of control
Zea mays L., cv. P459						
Control	74.9 ± 0.5 69.4 ± 0.4	-7.3	7.8 ±0.24 28.4±0.32	264.1	828.3±23.0 482.8±12.0	-41.71
SA	77.0 ± 0.3 73.5 ± 0.1	-4.6	3.8 ± 0.04 21.1±0.22	170.5	894.0 ± 10.8 556.2 ± 7.6	-32.85
Salicylates NH_4^+, K^+.	80.12 ± 0.6 77.72 ± 0.9	-3.0	2.0±0.03 18.12±0.09	132.1	976.64±22.4 622.32±12.8	-24.86
Sorghum bicolor (L.) Möench, cv. Pişcevoi 1						
Control	72.68±0.38 69.55±0.23	-4.31	8.66±0.11 30.55±0.21	252.77	636.38±22.87 460.06±25.34	-27.71
SA	74.40±0.15 73.98±0.60	-0.56	7.18±0.14 23.71±0.34	230.25	1015.18±30.45 874.58±13.46	-13.85
Salicylates NH_4^+, K^+.	76.0 ± 0.54 75.78 ± 0.7	-0.29	5.98 ± 0.15 19.81±0.21	128.75	1128.18±29.27 992.85±27.14	-11.99

*- in optimal soil water content conditions; **- in drought conditions

Under moderate deficiency of soil water content, the WC in the leaves of the plants *Zea mays* L. cv. P459 treated with SA was 5.97% greater than of the control plants at the same condition. SA assured the reduction of SD with 25.7% of the value of this parameter in untreated maize plants and with 22.5% - in sorghum plants. Due to the increase of tissue turgidity, the water consumption in transpiration process of treated plants maintained at the highest level both in optimal soil water content conditions and in insufficient ones (tab. 1). The IT in the plants, treated with SA and salicylates, under moderate drought conditions was greater compared to control plants by 73.4 and 139.7 mg dm^{-2} h^{-1} for maize and by 414.5 and 532.8 mg dm^{-2} h^{-1} –for sorghum plants. The plant was able, to some extent, compensate for water loss due to the increase of hydraulic conductivity and transport the water from the roots to the leaves (Raschke, 1987).



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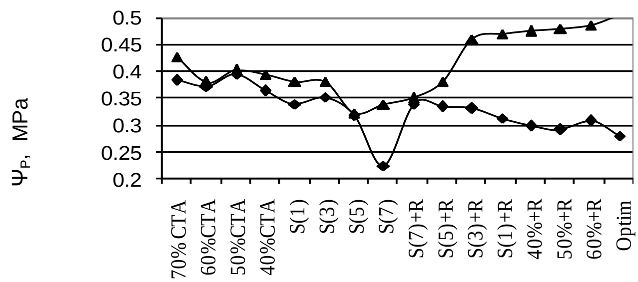

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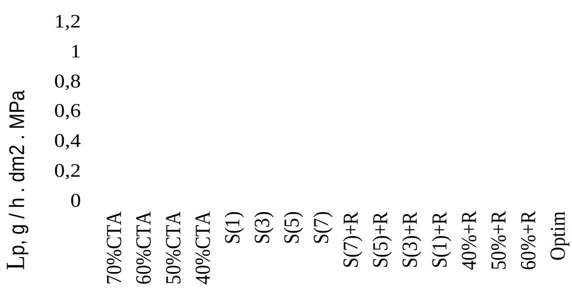

Fig. 1 Changing Ψ_W, Ψ_P (MPa) in leaves and hydraulic conductivity (L_p) in connection stem-leaf of maize plants, cv. P459 and sorghum cv. Pişcevoi (II) under fluctuation of water content and water stress of various durations. Legend: 1 - sorghum plants; 2 - maize plants.

The investigation results (fig. 1) have shown that in spite of higher tolerance of anisohydric plants and they were proned to hydraulic deficiencies because of the limit of hydraulic system narrowed during drought conditions.

Decreasing of soil water content below the critical threshold prompted changes both in the degree of hydration and in value of the water potentials and hydrostatic pressure of plant leaves. The reduction of the water flow to the leaves (IT) and the increase of gradients Ψ_w and Ψ_p under unsufficient soil water content were associated with reduced hydraulic conductivity of the tissues - most significant for isohydric plants (fig. 1). Typical anisohydric plants were able to maintain hydraulic conductivity and water supply to the leaves at a relatively constant level. As soil water content decreased and tissues were dehydrated the stomatal resistance increased and their conductivity to water vapor decreased. The plants treated with the combination of salicylic acid with NH_4^+, K^+ under drought conditions kept the hydraulic conductivity at a higher level as compared with untreated ones (fig. 2).

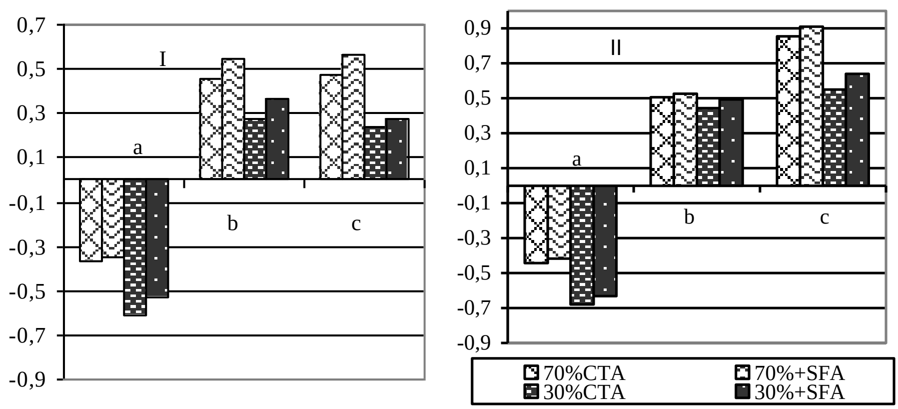

Fig. 2 Influence of water stress on water potential, Ψ_w, MPa (a), turgidity, Ψ_p, MPa (b) and hydraulic conductivity, L_p, g / h.dm^2.MPa (c) in segments "stem - leaves" of plants *Zea mays* L., cv. P459 (I) and *Sorghum bicolor* L. Moench, cv. Pişcevoi 1 (II), treated with the combination of the salicylic acid with NH_4^+, Mg^{2+}, K^+.

Due to the fact that the stomatal conductance in plants treated with SA and salicylates was reduced to a lesser extent under water content deficit, the flow of water continued to keep, which ensured the maintenance of a higher level of Ψ_w. Under optimum water content a trend of intensified transpiration of treated plants can be expected, which, incidentally, can be also a consequence of the optimization of water potential and turgor pressure (fig. 2).

The experimental results led to the conclusion that salicylic acid reduced the impact of water stress, caused by insufficient water content, by adjusting the hydraulic conductivity, stomatal conductance, and water consumption in the process of transpiration during the action of hydric stress, and by a compensatory reaction and repair of physiological parameters after improving water content conditions. Salicylates increased the Ψ_w and ability of water attraction.

CONCLUSIONS

1. Drought conditioned the significant changes both in the intensity of transpiration of water, coupled with the change in stomatal conductance, and in the values of water potential (Ψ_w), and the hydrostatic pressure (Ψp) of the plant leaves.

2. Salicylic acid and salicylates NH_4^+, K^+, Mg^{2+} demonstrated the property of maintaining of water homeostasis in the vegetal organism by increasing the degree of hydration of the tissue, reducing the saturation deficiency, increasing turgidity of organs and capacity of water retention, adjusting the hydraulic conductivity, and the stomata state, both at the favourable water content conditions and at a moderate water deficiency.

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