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# Water Osmotic Absorption in *Coleus blumei* Plants under Salinity Stress

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## ABSTRACT

*Three month old Coleus blumei plants in pots were treated with different NaCl concentrations: 0.00, 0.25, 0.50 and 1.00%. To determine the water osmotic absorption, the plants had their stems cut at 10 cm from the soil surface. The remaining stems were linked to glass tubes by flexible rubber tubes. Readings of the water column level in the glass tubes were performed at each 30 minutes, corresponding to the water osmotic absorption, with a total of eleven readings. Other Coleus blumei, with the same age, received the NaCl concentrations, and were evaluated under field conditions in terms of transpiration and stomatal resistance. A randomized complete block analysis was used with five replications. An increase of osmotic absorption was verified for all treatments up to three hours after application. Then a proportional reversion of osmotic absorption to the increases on saline concentration was observed, with a higher effect in the treatment with NaCl 1.00%, showing the increase of water loss by the roots. During this period time, the treatment showed a normal linear growth of the osmotic absorption. Transpiration was reduced proportionally to the increase of salinity concentration.*

**Key words:** Water relations, water potential, transpiration, stomatal resistance

## INTRODUTION

The xylem´s osmotic potential drops to its lowest levels in a leafless bushy plant whose transpiration is zero. If it was connected by a manometer to the highest part of a pot plant, from where most of the shoots were removed, it could possible to demonstrated the development of a positive pressure in the xylem by the water osmotic absorption (Sutcliffe, 1980). The water potential gradient that occurs between an external solution and the plant's xylem sap that is exudating is due to the tension development ($\psi_p$ negative) in the xylem because of water loss in the vapor form. Another contributing fact is the accumulation of solutes in the xylem´s sap, which makes its $\psi_\pi$ (osmotic potential) smaller than its external solution. The $\psi$ value in the xylem´s sap does not depend only on the solutes transportation intensity but also on the transpiration/exudation speeds. The concentration of substances dissolved in the xylem is low when the plant exudes intensely and, high when there is no transpiration. Thus, whilst the $\psi_\pi$ partly contributes for the xylem´s water potential in plants that transpire rapidly, it becomes important at low transpiration speeds, leading to

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the development of a positive root pressure (Sutcliffe, 1980; Sutcliffe and Baker, 1974).

It was observed that the water osmotic absorption might be more efficient than the passive absorption under high humidity conditions. It was also observed that the calcium transportation occurred more efficiently to the leaves covered with a transparent polyethylene bag than to the uncovered one when the plant was kept in a nutritive solution (Tibbitts, 1979). The water moves to the inner of the leaf especially through the vascular tubes, which form continuous channels from the root to the stem and through the petiole to the leaf's vascular fibers. The water moves from the vascular terminals to the leaves from where the water loss in the vapor phase occurs. There are two water movements to the out of the plant. The first and the main one considers the water movement through the leaf parenchyma towards the liquid-aerial interface in the inner part of leaf, and then in the vapor phase through the leaf intercellular filled with air towards the stomatal pores of the leaf epidermis. The second way, which is an auxiliary one and runs parallel to the first, it can be verified through the parenchyma to the liquid-aerial interface in the outer layer of the epidermis cells and, during the vapor phase, through the cuticle to the atmosphere. When there is a minimum transpiration, the water in the liquid phase is transferred to the outer layer of the leaf and expelled like drops: this phenomenon is known as exudation. This phenomenon occurs by the hydathodes. It is produced by a positive pressure developed in the xylem as a consequence of radicular pressure. The volume of water exudated by the phenomenon varies from a few drops to hundreds of milliliters, having an extremely variable composition (Wilkins, 1985). Generally, it can be said that the roots function as passive absorption surfaces by which the water is pushed up through developing forces in the stem loss surfaces. However, when the transpiration level is low and the soil is humid, hot and aired, the roots work as osmometers, producing radicular pressure, which sometimes causes exudation (Kramer, 1983).

Water absorption can be affected by the variation in the solutes accumulation in the xylem, which occurs as a result of metabolic fluctuation activity (Hales, 1727; Arisz et al., 1951). This way, the radicular pressure is reduced by the temperature decrease, inorganic nutrients retention and metabolic inhibitors (Sutcliffe, 1980).

The roots absorb ions from the diluted soil solution and transport them to the xylem. The solutes accumulation in the xylem's sap leads to an osmotic potential reduction, pressure potential increase and then, a water potential decrease in the xylem. This water potential decrease in the xylem, causes a motor force to the water absorption, resulting in positive hydrostatic pressure in the xylem. Thus, the whole root acts as a cell and the multicelular radicular tissue behaves as an osmotic membrane, establishing a positive hydrostatic pressure in the xylem responding to the accumulation of solutes. The radicular pressure is more evident in well-moisten (hydrated) plants under low transpiration and humidity conditions. In dryer conditions, when the transpiration level is higher, the water is rapidly absorbed by the leaves and is lost in the atmosphere, not developing a positive pressure in the xylem. In spite of that questions, the objective of this study was evaluated the comportment of *Coleus blumei* plants under stress salinity conditions.

## MATERIALS AND METHODS

The experiment was carried out at the Plant Physiology laboratory of the Biological Science Department at ESALQ/USP, when three-months-old *Coleus blumei* plants were cultivated in pots with 5.0 kg of soil. The shoots were cut at 10 cm from the soil surface and the remaining stems interlinked to glass tubes (3 mm x 1.20 m) by flexible rubber tubes (Figs. 1 and 2). Then, the soils were treated with different NaCl concentrations of 0.00; 0.25; 0.50 and 1.00 %. Readings were taken in a sunny day without atmospheric turbulence at 12 p.m., 1:30 p.m., 3:00 p.m. and 4:30 p.m. The transpiration and stomatal resistance were evaluated by using a Li-Cor 1600 porometer. The experiments were performed randomly in linear blocks, with five replications, and the data was submitted to variance analysis and polynomial regression.

## RESULTS AND DISCUSSION

An increase of water osmotic absorption up to three hours after solutions addition for all of the treatments with saline solutions, including the control was observed (Fig. 1). This showed that the solutions were absorbed osmotically for a certain time independently of its saline concentration. Later on, a proportional reversion of osmotic absorption process to the NaCl concentration increase was observed.

The equations showed greater reversion with 1% NaCl, medium reversion with 0.5% NaCl and smaller reversion with 0.25% NaCl, compared to control that presented a linear pattern of osmotic absorption (Fig. 1). *Coleus blumei* plants, treated with the same solutions, appeared inversely proportional to the NaCl concentration applied (Fig. 2). Stomatal resistances appeared directly proportional to the used saline concentrations (Fig. 3) These effects were probably due to a reduction on osmotic potentials and of pressure, consequently reducing the cell water potential of root surfaces and increasing the endogen abscisic acid (ABA). As the volume of water applied in the soil and water leaf loss would be the same for all of the treatments because of solar energy absorption, it could be said that both the increase of NaCl concentration added and the concentration of electrolytes in the soil solution, reduced the cells' water potential in the roots surface, which became more negative with the increase of salt concentration. More water absorption would cause more electrolyte absorption. To reduce the excessive electrolyte absorption as in $Na^+$ and $Cl^-$, which would harm the cells and would result in plant physiological problems, the reduction of transpiration levels would be a good solution and, consequently an increase of stomatal resistance. This would only be possible by using abscisic acid, one of the stomatal mechanism regulation factors. This way, the transpiration reduction seen with the applied NaCl concentrations increase, was probably due to the increase of the ABA endogen concentration, which would act inhibiting the expelling of $H^+$ of the stomata guard cells, blocking the $K^+$ absorption or speeding up its loss. The consequences of the inhibitor's concentration increase would be the closing of the stomata induced by the osmotic and water potentials increase, and by the decrease of the pressure potential with the guard cells´ hardening reduction (Awad and Castro, 1992; Awang et al., 1993). Besides the ABA concentration increase (Zhao et al., 1992; Mahmood and Quarrie, 1993), reduction of photosynthesis levels (Bethke and Drew, 1992), alteration on cell walls in tissues of the outer layers, roots, and growth inhibition in plants under conditions of salinity stress (Neumann et al., 1994) have also been noticed. Besides salinity, stress as mineral salts with lower movement in plants deficiency (calcium), water deficits and frost, which could promotes damage in plants, were related to the water disposable in the plant and with osmotic absorption. The efficiency of root pressure should be tested in herbs through the method adopted in this work to study possible tolerance or susceptibility of this plants to these stress conditions.

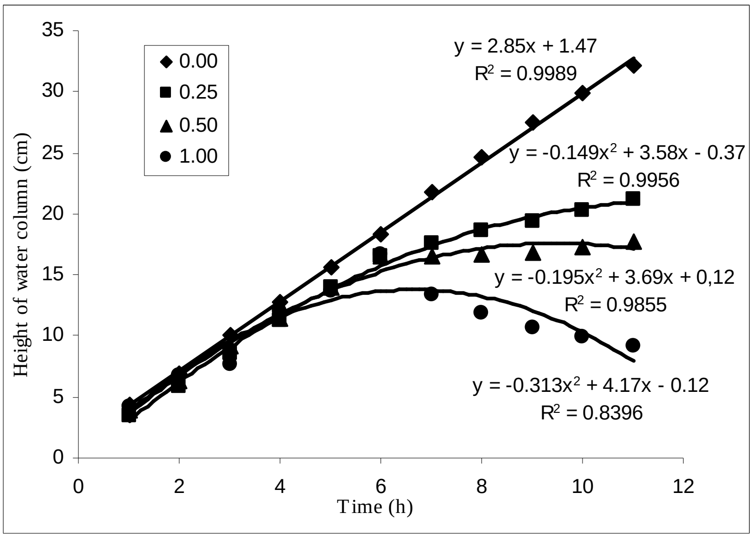


**Figure 1 -** Water height column concerning the water osmotic absorption for *Coleus blumei* in relation to NaCl concentrations (%), in time

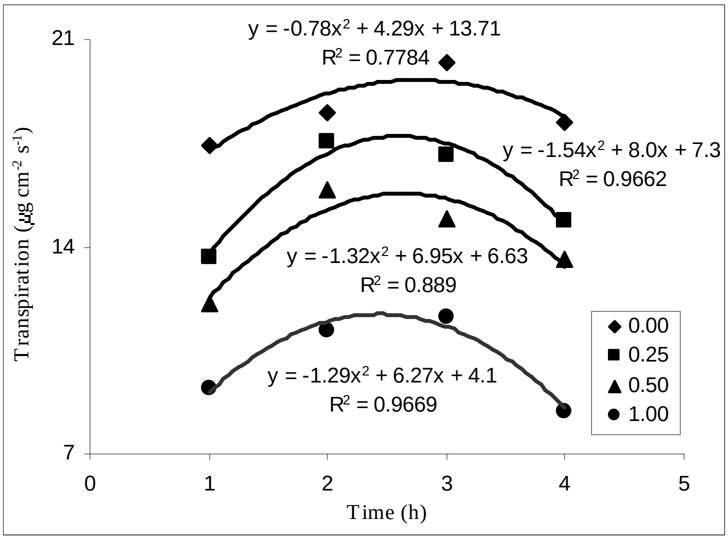


**Figure 2 -** Transpiration of *Coleus blumei* plants according to NaCl concentrations (%) and reading time. Average of 5 replications

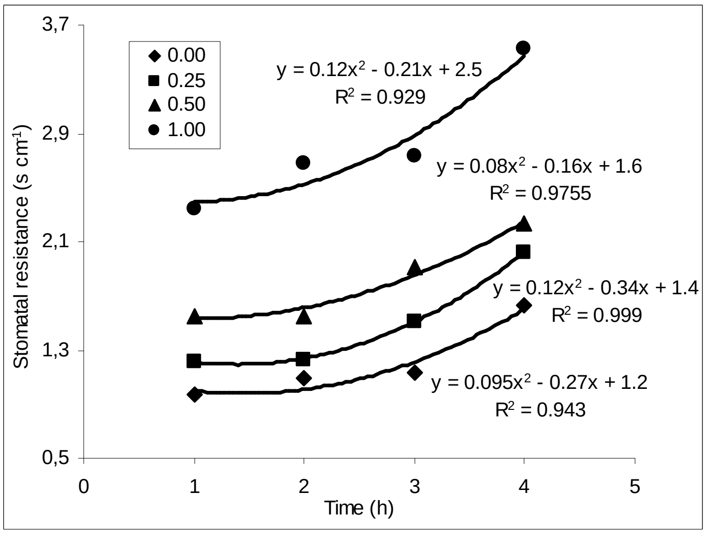


**Figure 3 -** Stomatal resistance in *Coleus blumei* plants according to NaCl concentrations (%) and reading time. Average of 5 replications

## CONCLUSIONS

For all of the treatments, it was verified an increase of osmotic absorption up to three hours after the solutions addition.
From this moment on, reversion of osmotic absorption occurred proportionally to the saline concentration increase. This happened more intensely in 1.00% NaCl concentration, reflecting crescent water loss by the roots.

## RESUMO

Mudas envasadas de *Coleus blumei*, com três meses de idade, foram submetidas a diferentes concentrações de cloreto de sódio (NaCl: 0,00;

0,25; 0,50 e 1,00%). Visando determinar a absorção osmótica, as mudas tiveram seus caules cortados a 10 cm acima do solo. Os caules remanescentes foram interligados a tubos de vidro por tubos flexíveis de borracha. Foram feitas leituras (cm) a cada 30 minutos dos níveis das colunas de água nos capilares, correspondentes às absorções osmóticas de água, sendo ao todo realizadas onze leituras. Em outro momento, mudas de *C. blumei*, com a mesma idade das anteriores, receberam as mesmas concentrações de NaCl descritas anteriormente, e, ao ar livre, foram avaliadas em termos de transpiração e resistência estomática, usando-se para isto porômetro LI 1600. Usou-se delineamento em blocos casualizados, com cinco repetições, submetendo-se os dados à análise de variância e regressão polinomial. Verificou-se para todos os tratamentos aumento da absorção osmótica até três horas após a adição das soluções. A partir desse momento observou-se reversão da absorção osmótica proporcional ao aumento da concentração salina, sendo esse efeito mais pronunciado em 1,00 % de NaCl, o que reflete perdas crescentes de água pelas raízes. No controle a absorção osmótica apresentou comportamento crescente e linear com o passar do tempo. A transpiração foi proporcionalmente reduzida com o aumento da concentração salina.

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