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Pisum SUSTAINABILITY SYSTEM TO Na_2SO_4

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МЕХАНИЗМ УСТОЙЧИВОСТИ РАСТЕНИЙ ГОРОХА К Na_2SO_4

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Abstract. Salinity is a major abiotic stress limiting growth and productivity of plants in many areas of the world due to increasing use of poor quality of water for irrigation and soil salinization. Plant adaptation or sustainability to salinity stress involves complex physiological traits, metabolic pathways, and molecular or gene networks. A comprehensive understanding on how plants respond to salinity stress at different levels and an integrated approach of combining molecular tools with physiological and biochemical techniques are imperative for the development of salt-stable varieties of plants in salt-affected areas. Recent research has identified various adaptive responses to salinity stress at molecular, cellular, metabolic, and physiological levels, although mechanisms underlying salinity tolerance are far from being completely understood. This paper provides a comprehensive review of major research advances on biochemical, physiological, and molecular mechanisms regulating plant adaptation and sustainability to salinity stress.

Аннотация. Засоление является основным абиотическим стрессом, ограничивающим рост и продуктивность растений во многих регионах мира из-за увеличения использования воды низкого качества для орошения и засоления почвы. Адаптация растений или устойчивость к солевому стрессу включает в себя сложные физиологические признаки, метаболические пути и молекулярные или генные сети. Всестороннее понимание того, как растения реагируют на солевой стресс на разных уровнях, и комплексный подход, сочетающий молекулярные инструменты с физиологическими и биохимическими методами, необходимы для создания солеустойчивых сортов растений в засоленных районах. Недавние исследования выявили различные адаптивные реакции на солевой стресс на молекулярном, клеточном, метаболическом и физиологическом уровнях, хотя механизмы, лежащие в основе устойчивости к солености, еще далеко не полностью поняты. В этой статье представлен всесторонний обзор основных достижений в исследованиях биохимических, физиологических и молекулярных механизмов, регулирующих адаптацию и устойчивость растений к солевому стрессу.

Keywords: salinity, *Pisum*, stress, toxicity.

Ключевые слова: соленость, горох, стресс, токсичность.

Salinity stress involves changes in various physiological and metabolic processes, depending on severity and duration of the stress, and ultimately inhibits crop production [4–7]. Initially soil salinity is known to represses plant growth in the form of osmotic stress which is then followed by ion toxicity [4, 5]. During the initial phases of salinity stress, water absorption capacity of root

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systems decreases and water loss from leaves is accelerated due to osmotic stress of high salt accumulation in soil and plants, and therefore salinity stress is also considered as hyperosmotic stress [6]. Osmotic stress in the initial stage of salinity stress causes various physiological changes, such as interruption of membranes, nutrient imbalance, impairs the ability to detoxify reactive oxygen species (ROS), differences in the antioxidant enzymes and decreased photosynthetic activity, and decrease in stomatal aperture [3, 5 into the cells causes severe ion imbalance and excess uptake might cause significant physiological disorder(s). High Na^+ concentration inhibits uptake of K^+ ions which is an essential element for growth and development that results into lower productivity and may even lead to death [4].

Genetic variations in salt tolerance exist, and the degree of salt tolerance varies with plant species and varieties within a species. Among major crops, barley (*Hordeum vulgare*) shows a greater degree of salt tolerance than rice (*Oryza sativa*) and wheat (*Triticum aestivum*). The degree of variation is even more pronounced in the case of dicotyledons ranging from *Arabidopsis thaliana*, which is very sensitive towards salinity, to halophytes such as *Mesembryanthemum crystallinum*, *Atriplex sp.*, *Thellungiella salsuginea* (previously known as *T. halophila*) [3].

The present study aimed at determining the morphological and physiological response of five different *Coleus* species under salinity stress. Salinity is one of the major abiotic stress factor shows negative effect on different agricultural activities. Thus, demands the need of developing salt tolerant plant varieties. *Coleus* is one of the important medicinal plants with several therapeutic properties, but the information related to physiological and morphological response which helps in determining the level of salt tolerance in *Coleus* species has not been reported yet. Study carried out to investigate the effect of different salinity concentrations (100, 200 and 300 mM NaCl) on carbohydrate content, plant growth, leaf area and biomass. Salinity stress significantly reduced the plant growth, leaf water potential (LWP) and relative water content (RWC) in all five *Coleus* species whereas, the content of carbohydrates, water uptake capacity (WUC) and electrolyte leakage (EL) was increased. Among the five different *Coleus* species considered for the present study, *Coleus aromaticus* and *Coleus amboinicus* have shown better tolerance to the salinity stress with respect to their morphology, carbohydrate content, decreased water potentials, increased electrolyte leakage and water uptake capacity. The increased accumulation of carbohydrates with increased salinity suggests that they act either as respiratory substrates or as osmolytes confer salinity stress tolerance [1, 2].

Material and method

Pea (Pisum) is an annual herbaceous plant belonging to the legume family. Like wheat, barley and beans, the pea plant is an agricultural plant of strategic importance. This plant, which is rich in protein substances, has been cultivated by people since ancient times. Its homeland is Afghanistan and India.

Pea is considered a valuable agricultural plant because it is rich in starch, mineral elements and vitamins in addition to proteins. Both its green and dry forms are used in cooking.

As with other legumes, the pea plant lives a symbiotic lifestyle with nitrogen-fixing bacteria, which have the ability to use atmospheric nitrogen in their roots and form tubers, making the pea plant a good, natural source of nitrogen.

Like most agricultural plants, the pea plant is a halophyte, that is, it belongs to the group of plants sensitive to salinity and salt stress. Therefore, it is of great theoretical and practical importance to investigate the biochemical basis of the effect of salt stress on the germination, growth and development of pea seeds and to understand the mechanisms of adaptation of these processes to extreme environmental conditions.

Results and discussion

Table 1 presents the results of the effect of Na_2SO_4 salt solutions of different concentrations on the total weight of pea seedlings, the growth dynamics of the root and stem system during the 7-day incubation period.

As can be seen from the figures presented in the table, the effect of Na_2SO_4 salt solutions on the course of this process depends on the concentration of salt solutions and the exposure time, as in the experiments conducted with NaCl salt solutions. The difference between the control and experimental variants in the total weight of 3-day-old pea seeds sprouts is almost non-existent. However, as the incubation period increases, this difference begins to manifest itself. The development dynamics of seedlings exposed to the salt solution is significantly weakened and increasing the concentration of the salt solution strengthens this effect even more. For example, if there was no difference in the total weight of 3-day-old sprouts between the control and 25 mM Na_2SO_4 variants, then in 5-day-old sprouts this difference is already 250 mg/sprout on average, and in 7-day-old sprouts it is 280 mg/sprout. In addition, increasing the concentration of Na2SO4 salt in the incubation medium leads to a consistent and noticeable increase in this difference.

Table

EFFECT OF Na_2SO_4 SALT SOLUTIONS ON GROWTH DYNAMICS OF PEA SEEDLINGS

Indicators	*Various*			
	Na_2SO_4 (mM)	*3 days*	*5 days*	*7 days*
Total weight, mg/plant	0	860	1140	1260
	25	860	890	980
	50	870	870	920
	100	880	880	900
Seed weight, mg/plant	0	790	860	840
	25	800	820	800
	50	830	810	810
	100	840	830	820
Root wet weight, mg/plant	0	70	160	240
	25	60	60	100
	50	40	60	70
	100	40	50	60
Stem wet weight, mg/plant	0	—	120	180
	25	—	10	80
	50	—	—	40
	100	—	—	20

Undoubtedly, one of the important indicators in the growth dynamics of pea seedlings is the development dynamics of the root and stem system. It is the root system of seedlings that is first in contact with the salt solution and the stress conditions created by it in the incubation environment and is negatively affected by it. The development of other organs of sprouts depends on the development of the root system and its physiological state. Therefore, the effect of these solutions on the development dynamics of the root system is one of the important indicators.

As can be seen from the figures presented in the table, Na_2SO_4 salt solutions disrupt the normal development dynamics of pea seed sprouts and have a negative effect on the course of this process. This negative effect begins to manifest itself in 3-day-old sprouts, and it becomes more pronounced in 5- and 7-day-old sprouts. As expected, as the concentration of salt in the medium increases, the development of the root system of the seedlings becomes more difficult, the weight difference between the root system of the seedlings of the control variant and the experimental variants increases. So, if in 3-day-old sprouts, the ratio of the control variant's sprouts to the weight of the root system is 1.17, in 5-day-old sprouts it already reaches 2.40. The maximum inhibiting effect is observed in 100 mM Na_2SO_4 salt solution. Compared to the control, the corresponding figures for 100 mM Na_2SO_4 solution are 1.75, 3.20, and 4.00 in 3, 5, and 7-day-old seedlings.

It should be noted that the strengthening of the negative effect of salt solutions, including Na2SO4 salt solutions, on the development of the root system of sprouts due to the extension of the incubation period is clear and understandable to some extent. In the first stage, the negative effect seems to be mainly due to the osmotic stress created by the salt solution. In addition to osmotic stress due to the absorption of salt ions by the root system and its accumulation inside the cell, ion toxicity effect also occurs, which causes certain difficulties in the course of intracellular physiological and biochemical processes. The development of the root system exposed to the double stress factor is both inhibited and retarded.

Changes in the course of normal physiological processes in the root system or disruption of these processes are reflected in the development of the stem sprout system. The development of the stem system of pea seed sprouts begins to be observed in 5-day-old seedlings, not in 3-day-old seedlings. By itself, control and low concentration of Na_2SO_4 salt. The weight difference between control and experimental variants is characterized by a large number. The ratio of the weight of control sprouts to the weight of 25 mM Na_2SO_4 salt solution sprouts is equal to 12. At relatively high concentrations of Na_2SO_4 salt (50 and 100 mM), the development of the stem system is completely inhibited during this period.

In contrast to 5-day-old pea sprouts, the stem system appears in all 7-day-old pea sprouts, and its development proceeds in the most intensive form in the control variant. At this stage of incubation, the development of the stem system is significantly inhibited even at the lowest applied concentration of Na_2SO_4 salt. Thus, the ratio of the weight of the stem system of seedlings of the control variant cultivated in distilled water to the weight of the stem system of seedlings cultivated in 25 mM Na_2SO_4 salt solution is 2.25 during the 7-day incubation stage. As the hardness increases, the value of this ratio increases. The corresponding value for the 50 mM experimental variant is 5.50, and for the 100 mM variant it is 9.00. The obtained results show that Na_2SO_4 salt solution actually has a stronger negative effect on the development of the stem system of pea seedlings than on the development of their root system.

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