UDC 681.3
AGRIS L50
https://doi.org/10.33619/2414-2948/89/16

EFFECTS OF NaCl SALT STRESS ON BIOMETRIC PARAMETERS IN *Pisum* VARIETIES

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ВЛИЯНИЕ СОЛЕВОГО СТРЕССА NaCl НА БИОМЕТРИЧЕСКИЕ ПАРАМЕТРЫ СОРТОВ ГОРОХА

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Abstract. Salinity is a major threat to modern agriculture causing inhibition and impairment of crop growth and development. Here, we not only review recent advances in salinity stress research in plants but also revisit some basic perennial questions that still remain unanswered. In this review, we analyze the physiological, biochemical, and molecular aspects of Na^+ and Cl^- uptake, sequestration, and transport associated with salinity. We discuss the role and importance of symplastic versus apoplastic pathways for ion uptake and critically evaluate the role of different types of membrane transporters in Na^+ and Cl^- uptake and intercellular and intracellular ion distribution. Our incomplete knowledge regarding possible mechanisms of salinity sensing by plants is evaluated. Furthermore, a critical evaluation of the mechanisms of ion toxicity leads us to believe that, in contrast to currently held ideas, toxicity only plays a minor role in the cytosol and may be more prevalent in the vacuole. Lastly, the multiple roles of K^+ in plant salinity stress are discussed.

Аннотация. Засоление представляет собой серьезную угрозу для современного сельского хозяйства, вызывая угнетение и нарушение роста и развития сельскохозяйственных культур. Здесь мы не только рассматриваем последние достижения в исследованиях солевого стресса у растений, но и возвращаемся к некоторым основным многолетним вопросам, которые до сих пор остаются без ответа. В этом обзоре мы анализируем физиологические, биохимические и молекулярные аспекты поглощения, секвестрации и транспорта Na^+ и Cl^-, связанные с соленостью. Рассматривается роль и важность симпластических и апопластических путей для поглощения ионов и критически оцениваем роль различных типов мембранных транспортеров в поглощении Na^+ и Cl^-, а также межклеточном и внутриклеточном распределении ионов. Оцениваются наши неполные знания о возможных механизмах восприятия солености растениями. Кроме того, критическая оценка механизмов токсичности ионов приводит нас к мысли, что, в отличие от существующих в настоящее время представлений, токсичность играет незначительную роль в цитозоле и может быть более распространена в вакуоли. Наконец, обсуждаются множественные роли K^+ в стрессе растений от засоления.

Keywords: growth, *Pisum*, soil salinization, abiotic stress.

Ключевые слова: рост, горох, засоление почвы, абиотический стресс.

Growth and development of plants are affected by various stresses. Salinity is one of the major abiotic stresses which adversely affects the overall growth and yield of crops. It is estimated that >1 billion ha of the world land is salinized and continued salinization of the ever-decreasing agricultural land further exacerbates food insecurity as human population surges. Some of the major world crops such as maize, wheat, rice, tomato and sunflower are reviewed here where, salinity resulted in the reduction of the yield. The compromised performance causing poor yield could be due to the reduction in photosynthesis efficiency, chlorophyll, total protein, biomass, stomata closure and increasing the oxidative stress.

To improve productivity in salt-affected soils, selection and adoption of plant varieties with high salt tolerance has always been a preferred choice. This selection is based on morphological, physiological and molecular markers. Among morphological markers, root or shoot morphology, visible early senescence, biomass of grains is some of the important parameters that are considered. Physiological and biochemical markers examine chlorophyll content, accumulation of proline, sucrose, stress protectants, membrane stability and hormones content. These physiological markers, especially hormonal, polyamine and proline changes in plants are important to increase salt tolerance of plants. For example, such can be boosted by exogenous treatments with hormones, glycine betaine, proline, polyamines, paclobutrazol, nanoparticles. The molecular markers include salt stress tolerant genes, transcription factors, metabolic pathway related genes. These molecular markers have led to significant progress in genetic engineering of plants with salt tolerance. Altogether, all stress markers in plants help in identification of specific genes involved in salt tolerance. Plant responses to salinity have been divided into two main phases. An ion-independent growth reduction, which takes place within minutes to days, causes stomatal closure and inhibition of cell expansion mainly in the shoot [1-3]. A second phase takes place over days or even weeks and pertains to the build-up of cytotoxic ion levels, which slows down metabolic processes, causes premature senescence, and ultimately cell death [1, 4]. Tolerance to both types of stress is governed by a multitude of physiological and molecular mechanisms: osmotic tolerance, ionic tolerance, and tissue tolerance [5, 6]. Osmotic tolerance initiates relatively quickly and includes a rapid decrease in stomatal conductance to preserve water. It employs fast long-distance (root to shoot) signaling mechanisms [5, 7], which largely do not discriminate between osmotic effects created by NaCl, KCl, mannitol, or polyethylene glycol [6].

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 shows the results obtained from the effect of different concentrations of NaCl salt solutions on the dynamics of changes in the total weight of pea seedlings, root and stem system during the 7-day incubation period.

Table

EFFECTS OF NaCl SALT SOLUTIONS ON GROWTH DYNAMICS OF PEA SEEDS

Indicators	*Various*			
	NaCl (mM)	*3 day*	*5 day*	*7 day*
Total weight mg/plant	0	860	1140	1260
	25	900	980	1240
	50	800	970	1080
	100	770	930	840
Seed weight (mg/plant)	0	790	860	840
	25	820	770	720
	50	740	800	760
	100	740	860	720
Root weight (mg/plant)	0	70	160	240
	25	80	130	260
	50	60	110	180
	100	30	70	90
Stem wet weight (mg/plant)	0	—	120	180
	25	—	80	160
	50	—	60	140
	100	—	—	30

As can be seen from the figures presented in the table, NaCl salt at a low concentration (25 mM) had almost no significant effect on the dynamics of changes in the total weight of pea seedlings. Doubling the concentration of the NaCl salt solution has already started to show its inhibiting effect on the course of this process during the incubation period. The inhibitory effect was more clearly manifested in 7-day-old sprouts. Compared to the control option of the same period, the weight of the sprouts incubated at 50 mM NaCl salt concentration decreased by approximately 14.3%.

As expected, doubling the concentration of NaCl salt was accompanied by further strengthening of the inhibitory effect. The inhibitory effect of salt on the total weight of seedlings at a concentration of 100 mM was already manifested in 3-day-old seedlings, and the delay in the growth dynamics of the weight of seedlings was accelerated, and as a result, the difference between the control variant and the experimental variants became even sharper. So, compared to the control, this difference was about 10.5% in 3-day-old sprouts, 18.4% in 5-day-old sprouts, and 33.3% in 7-day-old sprouts.

The high concentration of NaCl salt seems to prevent the water absorption by the seedlings and the seedlings to increase their mass at the expense of the reserve nutrients of the seeds. Na^+ and Cl^- ions absorbed by the sprouts lead to the inhibition of the physiological processes in the sprouts in a relatively high concentration [1, 7]. What has been said is also confirmed by the growth dynamics of the root and stem system of pea sprouts. The low concentration of NaCl salt solution has almost no negative effect on the growth dynamics of pea sprouts. The weight of the roots of the seedlings incubated at this density should be compared with the weights of the seedlings in the control variant at the corresponding development stages.

At a concentration of 50 mM NaCl salt solution, the negative effect of salt on the growth dynamics of sprouts begins to manifest itself clearly, and the weight difference between the control and experimental variants becomes sharper due to the extension of the incubation period. So, if the difference shown in 3-day-old sprouts is 10 mg/sprout, in 5-day-old sprouts this difference is already 50 mg/sprout, and in 7-day-old sprouts it is 60 mg/sprout. The subsequent hardness of the salt slows down the growth of the roots of the sprouts, making them even more gray. This causes the difference between the control variant and the experimental variant to increase even more. This difference reaches 40 mg/sprout in 3-day-old sprouts, 90 mg/sprout in 5-day-old sprouts, and 150 mg/sprout in 7-day-old sprouts. As can be seen from the listed figures, relatively high concentrations of Na^+ and Cl^- make it difficult for physiological processes to proceed normally.

Undoubtedly, these ions create osmotic stress and ion toxicity and affect the physiological and biochemical processes in the root cells in different ways and to different degrees, hindering the normal development of the root system of seedlings [2, 4, 6]. Although the root system of pea sprouts can prevent the stress situation created by salt solutions with a relatively moderate concentration, the defense system of the sprouts has difficulty in neutralizing the negative effects of unfavorable conditions when the concentration increases.

The negative effect of the stress caused by NaCl salt solutions on the development of the stem system of pea seedlings is stronger than the negative effect on the development dynamics of the root system. By itself, this negative effect manifests itself clearly even in weak concentrations in 3-day-old seedlings, the stem system is not observed in either the control or the seedlings grown in salt solutions. In 5-day-old seedlings, the stem system begins to develop in all variants, except for the seedlings incubated at high salt concentration, but its development is inhibited proportionally to the salt concentration. A similar gingering effect is also characteristic for 7-day-old sprouts. It should also be noted that at this stage of sprout development, the development of the stem system can be observed in the sprouts incubated in 100 mM NaCl salt. From the results presented in the table, it is clear that the NaCl salt solution has both inhibiting and retarding effects on the development of pea sprouts, as in the case of other seed (wheat, bean) sprouts. The retardation effect is apparently related to the time required for the formation of the defense response in the seedlings and the activation of the adaptation mechanisms under salt stress conditions [2, 5].

Conclusion

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, NaCl 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.

References:

1. Parvaiz, A., & Satyawati, S. (2008). Salt stress and phyto-biochemical responses of plants-a review. *Plant soil and environment*, *54*(3), 89.

2. Akça, Y., & Samsunlu, E. (2012). The effect of salt stress on growth, chlorophyll content, proline and nutrient accumulation, and K/Na ratio in walnut. *Pak. J. Bot*, *44*(5), 1513-1520.

3. Akram, M. S., & Ashraf, M. (2011). Exogenous application of potassium dihydrogen phosphate can alleviate the adverse effects of salt stress on sunflower. *Journal of Plant Nutrition*, *34*(7), 1041-1057. https://doi.org/10.1080/01904167.2011.555585

4. Cabot, C., Sibole, J. V., Barceló, J., & Poschenrieder, C. (2009). Abscisic acid decreases leaf Na^+ exclusion in salt-treated Phaseolus vulgaris L. *Journal of Plant Growth Regulation*, *28*, 187-192. https://doi.org/10.1007/s00344-009-9088-5

5. Cabot, C., Sibole, J. V., Barceló, J., & Poschenrieder, C. (2009). Sodium-calcium interactions with growth, water, and photosynthetic parameters in salt-treated beans. *Journal of Plant Nutrition and Soil Science*, *172*(5), 637-643. https://doi.org/10.1002/jpln.200800124

6. Etehadnia, M., Waterer, D. R., & Tanino, K. K. (2008). The method of ABA application affects salt stress responses in resistant and sensitive potato lines. *Journal of plant growth regulation*, *27*, 331-341. https://doi.org/10.1007/s00344-008-9060-9

7. Fu, Z. Y., Zhang, Z. B., Liu, Z. H., Hu, X. J., & Xu, P. (2011). The effects of abiotic stresses on the NADP-dependent malic enzyme in the leaves of the hexaploid wheat. *Biologia plantarum*, *55*, 196-200. https://doi.org/10.1007/s10535-011-0030-x

Список литературы:

1. Parvaiz A., Satyawati S. Salt stress and phyto-biochemical responses of plants-a review // Plant soil and environment. 2008. V. 54. №3. P. 89.

2. Akça Y., Samsunlu E. The effect of salt stress on growth, chlorophyll content, proline and nutrient accumulation, and K/Na ratio in walnut // Pak. J. Bot. 2012. V. 44. №5. P. 1513-1520.

3. Akram M. S., Ashraf M. Exogenous application of potassium dihydrogen phosphate can alleviate the adverse effects of salt stress on sunflower // Journal of Plant Nutrition. 2011. V. 34. №7. P. 1041-1057. https://doi.org/10.1080/01904167.2011.555585

4. Cabot C., Sibole J. V., Barceló J., Poschenrieder C. Abscisic acid decreases leaf Na+ exclusion in salt-treated Phaseolus vulgaris L // Journal of Plant Growth Regulation. 2009. V. 28. P. 187-192. https://doi.org/10.1007/s00344-009-9088-5

5. Cabot C., Sibole J. V., Barceló J., Poschenrieder C. Sodium-calcium interactions with growth, water, and photosynthetic parameters in salt-treated beans // Journal of Plant Nutrition and Soil Science. 2009. V. 172. №5. P. 637-643. https://doi.org/10.1002/jpln.200800124

6. Etehadnia M., Waterer D. R., Tanino K. K. The method of ABA application affects salt stress responses in resistant and sensitive potato lines // Journal of plant growth regulation. 2008. V. 27. P. 331-341. https://doi.org/10.1007/s00344-008-9060-9

7. Fu Z. Y. Zhang Z. B., Liu Z. H., Hu X. J., Xu P. The effects of abiotic stresses on the NADP-dependent malic enzyme in the leaves of the hexaploid wheat // Biologia plantarum. 2011. V. 55. P. 196-200. https://doi.org/10.1007/s10535-011-0030-x

Работа поступила
в редакцию 24.02.2023 г.

Принята к публикации
09.03.2023 г.

Ссылка для цитирования:

Asadova B. Effects of NaCl Salt Stress on Biometric Parameters in *Pisum* Varieties // Бюллетень науки и практики. 2023. Т. 9. №4. С. 125-130. https://doi.org/10.33619/2414-2948/89/16

Cite as (APA):

Asadova, B. (2023). Effects of NaCl Salt Stress on Biometric Parameters in *Pisum* Varieties. *Bulletin of Science and Practice, 9*(4), 125-130. https://doi.org/10.33619/2414-2948/89/16