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SALINITY STRESS RESPONSES AND PHYTODESALINATION POTENTIAL OF ARMENIAN LOCAL WHEAT GENOTYPE

A. S. HARUTYUNYAN *

Chair of Ecology and Nature Conservation, YSU, Armenia

This study aimed to evaluate the morphological, physiological, and biochemical responses of local wheat ("Sateni-22") under salinity stress and to assess its phytodesalination potential. Experiments were conducted under controlled conditions using different NaCl concentrations. The results showed that under conditions of low NaCl concentrations, as a result of the activation of adaptive mechanisms, morphophysiological indicators were able to be somewhat preserved, but at high concentrations they were significantly reduced. It should also be noted that, in parallel with the increase in salinity, the content of Na^+ and Cl^- ions in the above-ground organs of the plant significantly increased. These findings indicate a moderate adaptive capacity of local wheat and its potential efficiency for soil phytodesalination in saline environments.

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Keywords**:** salinity stress, wheat, phytodesalination, sustainable agriculture.

Introduction. The continuous rise in the global population, which is projected to exceed 10 billion by 2050, intensifies the need for sustainable food production and efficient resource management [1]. However, agricultural productivity is increasingly threatened by the combined impacts of climate change, water scarcity, and soil degradation [2]. Among these challenges, soil salinization stands out as one of the most severe abiotic stresses limiting crop growth and yield. Currently, nearly one-third of the world's irrigated and arable lands are affected by various degrees of salinity caused by improper irrigation practices, high evapotranspiration rates, and groundwater contamination [3]. The situation is particularly alarming in arid and semi-arid regions, where salinity levels continue to increase due to poor drainage and the overuse of saline irrigation water [4, 5].

Salinity stress adversely affects plants at multiple organizational levels. It induces osmotic stress by lowering the external water potential, causing dehydration of root cells and reduced water uptake. Concurrently, it leads to ionic toxicity through excessive accumulation of sodium (Na^+) and chloride (Cl^-) ions, which disrupt metabolic processes and inhibit nutrient absorption [6, 7]. High Na^+ concentration in the cytosol interferes with potassium (K^+) uptake, resulting in an unfavorable Na^+/K^+ ratio that disturbs enzyme activity, photosynthetic efficiency, and stomatal conductance [8]. Maintaining ion homeostasis by selective transport

* E-mail: anna.harutyunyan@ysu.am

and compartmentalization of Na^+ into vacuoles, while retaining K^+ in the cytoplasm, is thus a crucial adaptive mechanism in plants exposed to saline conditions [9, 10].

Salinity also affects physiological parameters such as relative water content, chlorophyll concentration, and gas exchange. Salt-induced nutritional imbalance and oxidative stress reduce chlorophyll biosynthesis and photosynthetic pigment stability, thereby limiting carbon assimilation [11, 12]. Stomatal closure triggered by osmotic stress restricts CO_2 diffusion into leaves, further reducing photosynthetic rate and transpiration [13]. These physiological disruptions ultimately translate into reduced biomass accumulation, plant height, and grain yield [14].

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops globally, serving as a major source of carbohydrates and proteins for a large part of the human population [15]. Despite its economic and nutritiona importance, wheat is considered only moderately tolerant to salinity compared with barley or certain halophytic cereals [16]. Increasing soil salinity has become a critical constraint for wheat cultivation in several regions, including the Ararat Plain of Armenia, where secondary salinization is expanding due to intensive irrigation and groundwater level and high mineralization [17]. Local wheat genotypes, which have evolved under diverse agro-ecological conditions, may possess unique adaptive traits allowing them to withstand saline environments. However, comprehensive evaluations of their salinity tolerance and potential contribution to soil desalination remain limited.

In addition to investigating tolerance mechanisms, evaluating the phyto-desalination potential of crops is gaining attention as an eco-friendly approach to mitigate soil salinity. Phytodesalination involves the absorption, translocation, and sequestration of salt ions (mainly Na^+ and Cl^-) by plants from the soil into their above-ground organs, thereby reducing soil salinity over time [18, 19]. While halophytes are traditionally recognized for this capacity, several glycophytes, including wheat, exhibit moderate ion-accumulating ability and could contribute to salt removal under controlled or field conditions [20]. The dual function of maintaining productivity while simultaneously decreasing soil salinity offers a promising strategy toward sustainable agriculture in salt-affected lands.

Given this background, the present study focuses on evaluating the morphological, physiological, and biochemical responses of a local wheat genotype to different concentrations of NaCl, with the aim of assessing its phytodesalination efficiency. Specifically, the study investigates: I – changes in morphophysiological parameters under incremental NaCl concentrations; II – variations in water-related and chlorophyll indices; III – patterns of Na^+, K^+, and Cl^- accumulation and their ratios in roots, stems, and leaves. The obtained results are expected to enhance understanding of wheat adaptation to saline environments and to provide a scientific basis for utilizing local genotypes in the rehabilitation of salt-degraded soils. Ultimately, this research contributes to the development of sustainable agriculture practices in Armenia and similar arid regions where salinity poses an increasing threat to crop productivity and food security.

Materials and Methods.

Experimental Sites. The pot experiment was conducted at the greenhouse facility available within the Yerevan State University, Republic of Armenia (coordinates: 40° 18' 29.74" N, 44° 52' 66.55" E).

Plant Seeds Collection. Seeds of the Armenian wheat variety "Sateni-22" were obtained the seed reserve fund of the National Agrarian University of Armenia. This wheat, predominantly cultivated in Armenia, represents an indigenous Armenian variety. Consequently, conducting research and enhancing crop cultivation practices for wheat in this area holds significant importance for improving overall wheat production.

Growth Conditions. The experiments took place within a semi-controlled greenhouse setting. The wheat seeds underwent surface sterilization in a 10% sodium hypochlorite solution for 15 *min*, followed by multiple rinses in distilled water. Ten seeds were subsequently sown in individual PVC containers, the pot designed with a height of 13.5 *cm*, a top diameter of 16 *cm*, a bottom diameter of 15 *cm*, and a capacity to contain up to 2 *L* of water. We adopted a completely randomized block (CRD) design, incorporating three replicate pots for each treatment. The pot experiment specifically employed perlite as a root growth medium. Within each pot, we utilized 200 *g* of expanded perlite obtained from "Aragats Perlite" OJSC in the Republic of Armenia. This expanded perlite maintained a density between 850 kg/m^3 and 900 kg/m^3, achieved through an initial heat treatment process. Expanded perlite possesses a density of 120 kg/m^3, showcasing exceptional insulating properties against heat and efficient moisture absorption capabilities. The plants consistently received the recommended 20% Hoagland solution dosage throughout the entire trial period [21]. The nutrient solution used included $MgSO_4$, KNO_3, KH_2PO_4, $MnCl_2 \cdot 4H_2O$, $CuSO_4 \cdot 5H_2O$, H_2MoO_4, $(NH_4)_2SO_4$, K_2SO_4, $Ca(NO_3)_2$, Fe citrate, $ZnSO_4 \cdot 7H_2O$, and H_3BO_3. From seed germination to establishment, after 45 days, wheat plants were watered with varying concentrations of NaCl (0, 100, 200, 300, 400 *mM*, and 500 *mM*) every other day for 15 days. The alternate-day application of NaCl in wheat plants aimed to mitigate potential osmotic shock. Morphophysiological measurements were performed 10 days after salt treatment at 10-day intervals. Then, after the last, third measurement, the plants were collected for further studies.

Morphological Indices. The wheat genotypes were evaluated based on two primary morphological traits. When measuring shoot length, the distance from the top leaf tip to the base of the stem was measured. Stem diameter was measured immediately after harvest using a Vernier caliper, at a point located approximately 2 *cm* above the root-shoot junction along the basal stem.

Measurement of Biomass. Biomass was assessed for both control and salt-stressed plants. Roots, stems and leaves were collected separately from each plant replication at harvest. We measured stem fresh weight (SFW), root fresh weight (RFW), and leaf fresh weight (LFW). After drying the samples at 70°C until they reached a constant weight, root dry weight (RDW), stem dry weight (SDW), and leaf dry weight (LDW) were determined for each plant.

Physiological Indices.

Measured Roots, Stems, and Leaves Water Contents. RWC%, SWC% and LWC% were calculated using the following formulas [22–24]:

$$\mathrm{RWC\%} = [(\mathrm{FW_{root}} - \mathrm{DW_{root}})/\mathrm{FW_{root}}] \times 100, \tag{1}$$

$$\mathrm{SWC\%} = [(\mathrm{FW_{stem}} - \mathrm{DW_{stem}})/\mathrm{FW_{stem}}] \times 100, \tag{2}$$

$$\mathrm{LWC\%} = [(\mathrm{FW_{leaf}} - \mathrm{DW_{leaf}})/\mathrm{FW_{leaf}}] \times 100, \tag{3}$$

where FM_{root}, FM_{stem}, and FM_{leaf} are a fresh weight of root, stem and leaves, and DW_{root}, DW_{stem}, and DW_{leaf} are a dry weight of root, stem and leaf, respectively.

Estimation of Chlorophyll Content Index (CCI). The chlorophyll content of the studied plants was determined using a Chlorophyll Content Meter (CCM-200 plus, “Opti-sciences”, USA), which was measured in the upper third of the fully developed leaf of the plant. Ten readings were taken per plant, and the Chlorophyll Content Meter calculated the average of these readings immediately.

Gas Exchange Parameters. A portable photosynthesis system (CI-340, “CID Bio-Science”, USA) was employed to monitor gas exchange parameters including transpiration rate (*E*) and photosynthetic rate (*Pn*). Following salt treatment, measurements were performed on one young, fully expanded leaves from each plant, with three replicates per leaf, between 8:00 a.m. and 11:00 a.m., after 30 days of salt treatment [25]. The water use efficiency (WUE) was calculated as the ratio of net carbon uptake to the water lost through transpiration in the leaf area:

$$WUE = Pn/E. \quad (4)$$

Biochemical Indices. Plant parts were dried and ground into a powder and then 1 *g* sample of each plant part (root, stem, and leaf) was then digested in a 0.5% HNO_3 solution at 100℃ for 30 *min* to extract ions. After digestion, the solution was filtered through filter paper, and the ions were analyzed immediately [26]. Concentrations of Na^+ and K^+ were determined using a flame photometer (FP-I6431, “Bioevopeak”, PRC), while Cl^- concentration was measured with a laboratory ionometer (I-160 M, “Anatech”, Belarus).

For the determination tissue samples (TDS) were autoclaved for 15 *min* at 121℃ to remove residual ions. The material was cooled to room temperature, and the TDS was measured using a laboratory conductometer (MARK 603, Russia).

Statistical Analysis. Statistical analysis was conducted using Microsoft Excel 2021 and SPSS-19 software. Fisher’s least significant difference (LSD) test was employed to determine statistical significance. The error bars in the figures denote 95% confidence intervals.

Results and Discussion.

Effect of Salinity Stress on Morphological Indices of Wheat. Salinity can have positive or negative effects on plant growth parameters, such as length, biomass, stem diameter, viability, and threshold responses, depending on the salinity level and tolerance of the plant [27].

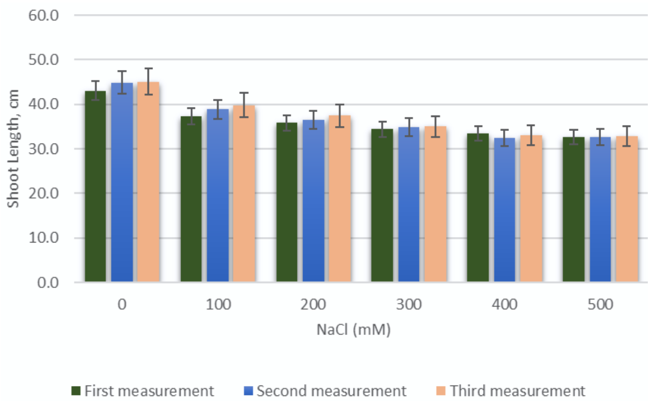

Fig. 1. Effect of NaCl stress on growth of wheat during salt treatment ($n = 30$, $p < 0.05$).

In essence, the length of wheat exhibited a notable decrease with escalating NaCl concentration. 10 days following the cessation of salt addition, the shoot length of the plant cultivated in different NaCl medium, in comparison to the control (0 *mM*), was as follows: 100 *mM* – 86.6%, 200 *mM* – 83.3%, 300 *mM* – 79.9%, 400 *mM* – 77.5%, and 75.9% at 500 *mM* concentration. After 30 days, during the third measurement, a shift in the dynamics of wheat growth inhibition occurred, marked by a decline in growth observed at a concentration of 500 *mM* NaCl. The heights of the wheat compared to the control in concentrations of 100–500 *mM* were 88.3%, 83.1%, 77.6%, 73.4%, 72.8%, respectively (Fig. 1). NaCl treatment affected also the stem diameter of wheat (Fig. 2). The stem diameter exhibited a typical increase up to a concentration of 100 *mM*, followed by a more pronounced decrease at 400 *mM* and 500 *mM* NaCl concentrations compared to the control.

Salinity stress restricts vegetative growth in wheat by impairing water uptake, disturbing nutrient balance, ultimately resulting in suppressed shoot elongation and biomass accumulation [7]. The increase in stem diameter under mild salinity suggests an osmotic adjustment response, while the subsequent decline at higher NaCl levels reflects structural damage driven by ionic toxicity and reduced assimilate allocation. These morphological alterations collectively indicate that both osmotic effects and long-term sodium accumulation define the physiological tolerance threshold of the plant [28].

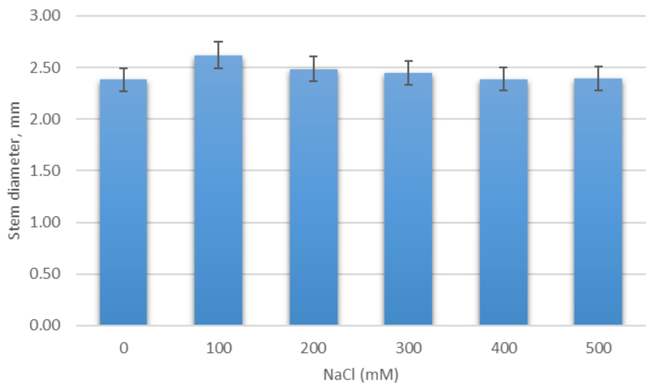

Fig. 2. Effect of NaCl stress on stem diameter of wheat ($n = 30$, $p < 0.05$).

Evaluation of Physiological Indices of Wheat under Salinity Stress. Plant biomass serves as a crucial biological indicator for evaluating plant tolerance to NaCl induced stress [29]. The outcomes of the study on fresh and dry weight (FW and DW) of roots, stems, and leaves in the crop are presented in Tab. 1. The wheat root, stem, and leaf exhibited maximum fresh and dry masses primarily in plants cultivated at 0 and 100 *mM* NaCl concentrations, while both FW and DW decreased with the rising NaCl concentration. It's worth noting that the decrease was largely proportional, with the minimum fresh and dry biomass values observed at a concentration of 500 *mM*.

The fresh and dry masses of roots in plants growing at 500 *mM*, compared to those at 0, were reduced by 1.82 and 1.93 times, respectively in the stem, the reduction was 1.93 and 1.35 times, while in the leaf, it was 2.79 and 1.96 times. With the rise in salinity, the RWC% value increased (by 0.97% compared to plants growing at 0 *mM*), while SWC% and LWC% values decreased (by 9.73% and 10.43%, respectively, compared to 500 *mM*). The progressive decrease in fresh and dry biomass under higher NaCl levels reflects the combined impacts of osmotic stress and ionic toxicity, which restrict water uptake, nutrient balance, and metabolic performance in wheat. The increased root-to-shoot ratio indicates an adaptive allocation of resources toward root development to improve access to water and ions under stress. These patterns align with established evidence that biomass reduction is one of the most sensitive physiological indicators of salt intolerance in cereals [12].

CCI values exhibited variation in response to both changes in NaCl content in the root medium and the growth stages of the crops (Fig. 3). Notably, during the wheat's growth and transitions through vegetation stages (such as sprouting, flowering, earing, etc.), an initial increase in the CCI value was observed, followed by a subsequent decrease. Nevertheless, as salinity increased, there was a notable reduction in the CCI value in the crop.

The first measurements after the completion of salt treatment revealed a 44.76% decrease in the CCI value of plants grown in a 500 *mM* NaCl medium compared to those grown in a 0 *mM* NaCl medium.

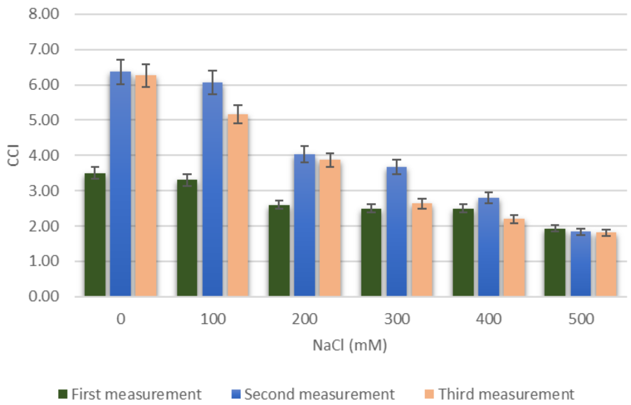

Fig. 3. Effect of NaCl stress on CCI of wheat (n = 30, p < 0.05).

Table 1

Effect of NaCl stress on some growth parameters and tissue water content of wheat (n = 30, p < 0.05)

Salinity degree NaCl, *mM*	RFW	RDW	SFW	SDW	LFW	LDW	RFW/ SFW	RDW/ SDW	RWC%	SWC%	LWC%
0	2.405	0.344	0.735	0.135	1.551	0.306	1.053	0.779	85.711	81.662	80.244
100	2.161	0.315	0.715	0.143	1.302	0.284	1.072	0.738	85.447	80.056	78.217
200	1.584	0.245	0.582	0.108	0.996	0.235	1.004	0.715	84.551	81.506	76.423
300	1.573	0.201	0.485	0.106	0.763	0.190	1.260	0.679	87.222	78.144	75.098
400	1.311	0.178	0.403	0.100	0.564	0.156	1.357	0.694	86.459	75.259	72.284
500	1.324	0.178	0.380	0.100	0.556	0.156	1.414	0.695	86.543	73.716	71.872

The highest CCI values were recorded during the second measurements, attributed to both the growth stages of the plants and their adaptation. Specifically, there was an 81.90% increase in the CCI value at 0 *mM*. In the range of 100–400*mM*, where the rise in CCI was also influenced by adaptation processes, the increase ranged from 12.00% to 83.84%. At 500 *mM*, the plant's adaptation potential was not satisfied, leading to a decrease in CCI to 5.17%. In parallel with this, during the second measurement, a decrease in the CCI value was observed along with the increase in NaCl concentration, in particular, in plants grown at a concentration of 500 *mM* compared to the control group, it was 71.20%.

Subsequently, during the third measurement, a decrease in the CCI value was observed, both compared to the second measurement, and with the increase in NaCl concentration, in particular the CCI value at 500 *mM* concentration decreased significantly compared to 0 *mM*, amounting to 71.12%.

The study results, presenting the photosynthetic rate, transpiration rate, and WUE under various salt treatment conditions, are detailed in Tab. 2.

Table 2

Effect of NaCl stress on gas exchange of wheat ($n=90$, $p < 0.05$)

Salinity degree NaCl, *mM*	*Pn*	*E*	WUE
0	7.80	3.88	2.01
100	8.54	4.41	1.94
200	4.50	1.40	3.22
300	4.33	1.97	2.19
400	4.65	0.83	5.60
500	3.82	0.31	12.32

The results reveals that the photosynthesis intensity was notably high at NaCl concentrations of 0 *mM* and 100 *mM*. It then experienced a sharp decline, reaching 63.68% at the concentration of 200 *mM*. Subsequently, no significant differences were observed within the range of 300–500 *mM* (62.50%–69.17%). The transpiration rate of crops grown in a 500 *mM* NaCl medium decreased by 92.00% compared to those grown in a 0 *mM* NaCl medium. With increasing NaCl concentration, no significant changes in WUE were recorded in the wheat.

The decline in CCI values under elevated NaCl indicates progressive impairment of chlorophyll content and pigment stability, reflecting weakened photosynthetic machinery under salt stress. The temporary increase in CCI during intermediate growth stages suggests short-term adaptive regulation of pigment synthesis; however, this capacity is lost once salinity exceeds the physiological tolerance threshold. The concurrent reductions in photosynthetic and transpiration rates confirm that both stomatal limitations and metabolic disruption constrain carbon assimilation under severe stress. Overall, these responses demonstrate that chlorophyll integrity and gas-exchange performance are highly sensitive indicators of salinity-induced physiological decline in wheat [30].

Effects of Salt Stress on Biochemical Indices of Wheat. The table provided in Tab. 3 displays the analysis of various ions and total dissolved solids (TDS) found in the roots, stems, and leaves of wheat. It reveals that the accumulation of ions in these plant parts fluctuated in response to varying concentrations of NaCl [31]. Essentially, as the NaCl concentration in the root medium increased, the potassium (K^+) content in the roots, stems, and leaves of the crop exhibited an initial rise followed by a significant decline. As the NaCl concentration increased, the levels of Na^+ and Cl^- in the roots, stems, and leaves of wheat rose. The highest value of Na^+ content in the root, stem, and leaf was observed at 500 *mM* (increased by 3.15, 24.25, and 17.71 times, respectively, compared to 0 *mM*). In the case of the leaf, it experienced a slight decrease at the concentration of 400 *mM*, followed by subsequent growth, a phenomenon that can be attributed to the plant's adaptive response. In the case of Cl^-, the highest concentrations were observed near the stem, with Cl^- content sharply increasing in concentration of 100 *mM* and 200 *mM*. In the roots, there was a notable rise in concentration at 400 *mM*, while in the leaves, the peak Cl^- content was observed at a concentration of 500 *mM*. Overall, the greatest Cl^- content values in the root, stem, and leaf were seen at a concentration of 500 *mM* with increases of 135.51, 548.69, and 712.94 times, respectively, compared to 0 *mM*.

Table 3

Effect of NaCl stress on ionic content of wheat root, stem, and leaf (mg/g, n = 30, p < 0.05)

Salinity degree NaCl, *mM*	K^+			Na^+			Cl^-			TDS		
	root	stem	leaf	root	stem	leaf	root	stem	leaf	root	stem	leaf
0	2.84	22.20	19.00	5.65	1.20	1.53	0.06	0.06	0.04	24.69	46.39	46.39
100	5.02	30.90	27.20	13.10	6.65	11.20	0.73	2.41	1.85	40.41	69.05	68.48
200	3.80	27.87	22.30	15.80	12.37	19.00	2.35	27.00	6.15	45.81	80.39	80.21
300	3.17	19.40	15.80	16.50	18.80	22.70	3.68	28.10	9.17	47.13	87.09	87.37
400	2.85	15.20	12.40	17.20	25.70	22.00	7.53	29.00	17.20	47.27	89.91	88.89
500	2.65	13.90	13.10	17.80	29.10	27.10	8.75	35.50	30.30	47.52	95.95	99.81

The Na^+/K^+ ratio in the roots, stems, and leaves of wheat exhibited a dynamic rise in tandem with the increasing NaCl concentration (in plants grown at 500 *mM* compared to 0 *mM*, the increase in root, stem, and leaf was 3.38, 38.73, and 25.69 times, respectively). The examination of the roots, stems, and leaves of the crop revealed that a rise in the TDS value was primarily observed alongside the increasing NaCl concentration.

The increase in Na^+ and Cl^- accumulation with rising external salinity indicates intensive ion uptake and sequestration, reflecting the plant's attempt to balance osmotic potential under stress; however, excessive ion buildup ultimately leads to toxicity and cellular damage. The initial rise and subsequent decline in K^+ content highlight competitive inhibition of K^+ uptake by Na^+ and disruption of membrane transport systems, which deteriorates metabolic stability. The sharp elevation of the Na^+/K^+ ratio confirms a loss of ionic homeostasis, a key determinant of reduced physiological performance in salt-sensitive crops. The parallel increase of TDS further demonstrates intensified salt loading in tissues, consistent with constrained ion exclusion mechanisms under high NaCl stress [32].

Phytodesalination Capacity of Wheat. After NaCl treatment, when the plants were harvested and biochemical measurements were performed, a significant increase in Na^+ and Cl^- accumulation was observed in wheat roots, stems, and leaves compared to control plants (Fig. 4). From a phytosalination perspective, the accumulation of Na^+ and Cl^- in the above-ground biomass of plants is paramount. As a result of the research, it became clear that sharply changes in the amount of Na^+ and Cl^- in the aboveground part of one plant were observed during the transitions of 0–100 *mM* and 400–500 *mM*.

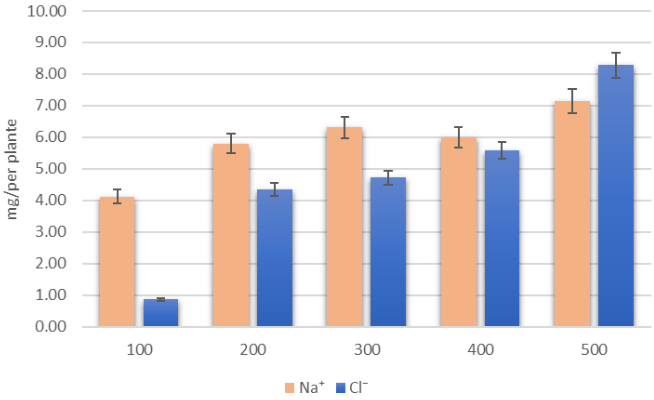

Fig. 4. The mass of Na^+ and Cl^- (*mg*) accumulated in the above-ground parts of wheat per plant ($n = 30$, $p < 0.05$).

Overall, as the NaCl content increased, the above-ground mass of the wheat decreased, while the levels of Na^+ and Cl^- increased, respectively. Specifically, varying with the soil salinity level, per plant above-ground mass can remove between 4.12 *mg* to 7.15 *mg* of sodium and 0.87 *mg* to 8.29 *mg* of chlorine from the soil. Considering these findings, it can be concluded that wheat exhibits phytodesalination potential.

Under salinity stress, wheat exhibited significant morphological, physiological, and biochemical alterations, indicating a decline in growth and productivity with increasing NaCl concentration. The reduction in shoot height, biomass, and chlorophyll content reflects osmotic and ionic imbalances that impair photosynthetic efficiency and water relations. Concurrently, the pronounced accumulation of Na^+ and Cl^- in the shoots and roots, along with the rising Na^+/K^+ ratio, highlights disrupted ion homeostasis and adaptive mechanisms. Nevertheless, the considerable uptake and translocation of Na^+ and Cl^- to the aboveground organs demonstrate the species' moderate phytodesalination potential under saline conditions.

The substantial accumulation of Na^+ and Cl^- in the aerial parts of wheat under salinity stress demonstrates active ion uptake and translocation mechanisms, which help maintain osmotic balance but simultaneously contribute to growth inhibition [33]. Although shoot biomass decreases as salt concentration rises, the consistent removal of salt ions from the soil through above-ground tissues indicates that wheat can partially mitigate soil salinity. This ion sequestration capacity reflects a moderate phytodesalination potential, even though disrupted ionic homeostasis and reduced physiological performance limit overall efficiency. These findings align with evidence that glycophytic cereals possess restricted but measurable phytoremediation capabilities under saline conditions [7].

Based on the results of our research and the analysis performed, we can conclude that at low salinity levels wheat activated adaptive mechanisms that helped maintain key morphophysiological characteristics, whereas higher salinity concentrations resulted in a pronounced decline in these indicators. Ion analysis confirms a pronounced disruption of ionic homeostasis, characterized by elevated Na^+ and Cl^- accumulation and a sharply rising Na^+/K^+ ratio with increasing NaCl concentration. These stress induced alterations collectively indicate moderate salinity tolerance supported by limited but measurable adaptive responses. Despite growth reductions, the plant's ability to accumulate and translocate salt ions to above-ground tissues highlights a moderate phytodesalination potential under saline conditions.

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REFERENCES

1. Tilman D., Clark M., et al. Future Threats to Biodiversity and Pathways to Their Prevention. *Nat.* **546** (2017), 73–81.
https://doi.org/10.1038/nature22900
2. Lobell D.B., Gourdji S.M. The Influence of Climate Change on Global Crop Productivity. *Plant Physiol.* **160** (2012), 1686–1697.
https://doi.org/10.1104/pp.112.208298
3. Isayenkov S.V., Maathuis F.J.M. Plant Salinity Stress: Many Unanswered Questions Remain. *Front. Plant Sci.* **10** (2019), 80.
https://doi.org/10.3389/fpls.2019.00080
4. Rengasamy P. Soil Processes Affecting Crop Production in Salt-Affected Soils. *Funct. Plant Biol.* **37** (2010), 613–620.
https://doi.org/10.1071/FP09249
5. Qadir M., Oster J. D., et al. Salinity and Sodicity Effects on Plant Nutrients: Mechanisms and Management. *Land Degrad. Dev.* **17** (2006), 661–681.
https://doi.org/10.1002/ldr.751
6. Corwin D.L., Oster J.D., et al. Salinity and Sodicity Assessments for Soil Survey. *Catena* **71** (2007), 197–206.
https://doi.org/10.1016/j.catena.2007.04.002
7. Munns R., Tester M. Mechanisms of Salinity Tolerance. *Annu. Rev. Plant Biol.* **59** (2008), 651–681.
https://doi.org/10.1146/annurev.arplant.59.032607.092911
8. Zhu J.-K. Regulation of Ion Homeostasis under Salt Stress. *Curr. Opin. Plant Biol.* **6** (2003), 441–445.
https://doi.org/10.1016/s1369-5266(03)00085-2
9. Flowers T.J., Galal H. K., Bromham L. Evolution of Halophytes: Multiple Origins of Salt Tolerance in Land Plants. *Funct. Plant Biol.* **37** (2010), 604–612.
https://doi.org/10.1071/FP09269
10. Shahbaz M., Ashraf M. Improving Salinity Tolerance in Cereals. *Critical Reviews in Plant Sciences* **32** (2013), 237–249.
https://doi.org/10.1080/07352689.2013.758544
11. Shabala S., Pottosin I. Regulation of Potassium Transport in Plants under Hostile Conditions: Implications for Abiotic and Biotic Stress Tolerance. *Physiol. Plant.* **151** (2014), 257–279.
https://doi.org/10.1111/ppl.12165

12. Parida A.K., Das A.B. Salt Tolerance and Salinity Effects on Plants: A Review. *Ecotoxicol. Environ. Saf.* **60** (2005), 324–349.
https://doi.org/10.1016/j.ecoenv.2004.06.010
13. Gill S.S., Tuteja N. Reactive Oxygen Species and Antioxidant Machinery in Abiotic Stress Tolerance in Crop Plants. *Plant Physiol. Biochem.* **48** (2010), 909–930.
https://doi.org/10.1016/j.plaphy.2010.08.016
14. Hao S., Wang Y, et al. A Review on Plant Responses to Salt Stress and Their Mechanisms of Salt Resistance. *Hortic.* **7** (2021), 132.
https://doi.org/10.3390/horticulturae7060132
15. El Sabagh A., Islam M.S., et al. Salinity Stress in Wheat (*Triticum aestivum* L.) in the Changing Climate: Adaptation and Management Strategies. *Front. Agron.* **3** (2021), 661932.
https://doi.org/10.3389/fagro.2021.661932
16. Jafar M.Z., Farooq M., et al. Improving the Performance of Wheat by Seed Priming under Saline Conditions. *Journal of Agronomy and Crop Science* **198** (2012), 38–45.
https://doi.org/10.1111/j.1439-037X.2011.00485.x
17. Ghazaryan K.A., Harutyunyan A.S., et al. Study of Tolerance and Phytodesalination Potential of Wheat, Oat, Emmer, and Barley for Sustainable Saline Agriculture. *Appl. Ecol. Environ. Res.* **21** (2023), 4853–4882.
https://doi.org/10.15666/aeer/2105_48534882
18. Kachout S.S., Dhane S., et al. Sustainable Phytoremediation of Saline Soils Using *Atriplex hortensis* L.: A Case Study from Bizerte Lagoon, Northern Tunisia. *Front. Plant Sci.* **16** (2025), 1613594.
https://doi.org/10.3389/fpls.2025.1613594
19. Boorboori M.R., Zhang H. The Role of Halophytes in Phyto-desalination: Mechanisms and Potential. *Environ. Pollut. Bioavailab.* **37** (2025), 1–19.
https://doi.org/10.1080/26395940.2025.2552171
20. Manasathien J., Khanema P. Assessment of Salt Tolerance in Phytodesalination Candidates: Two Varieties of Fimbristylis – *F. ferruginea* and *F. tenuicula*. *J. Environ. Qual.* **53** (2024), 208–220.
https://doi.org/10.1002/jeq2.20544
21. Hoagland D.R., Arnon D.I. *The Water-Culture Method for Growing Plants without Soil*. California Agricultural Experiment Station, Circular-347 (1950).
22. Al Hassan M., López-Gresa M.D.P., et al. Stress Tolerance Mechanisms in Juncus: Responses to Salinity and Drought in Three Juncus Species Adapted to Different Natural Environments. *Funct. Plant Biol.* **43** (2016), 949–960.
https://doi.org/10.1071/FP16007
23. Garnier E., Shipley B., et al. A Standardized Protocol for the Determination of Specific Leaf Area and Leaf Dry Matter Content. *Funct. Ecol.* **15** (2001), 688–695.
https://doi.org/10.1046/j.0269-8463.2001.00563.x
24. Slama I., Ghnaya T., et al. Combined Effects of Long-term Salinity and Soil Drying on Growth, Water Relations, Nutrient Status, and Proline Accumulation of *Sesuvium portulacastrum. C. R. Biol* **331** (2008), 442–451.
https://doi.org/10.1016/j.crvi.2008.03.006
25. Rabhi M., Castagna A., et al. Photosynthetic Responses to Salinity in Two Obligate Halophytes: *Sesuvium portulacastrum* and *Tecticornia indica*. *S. Afr. J. Bot.* **79** (2012), 39–47.
https://doi.org/10.1016/j.sajb.2011.11.007
26. Zouhaier B., Najla T., et al. Salt Stress Response in the Halophyte *Limoniastrum guyonianum* Boiss. *Flora* **217** (2015), 1–9.
https://doi.org/10.1016/j.flora.2015.09.003
27. Singh N., Maurya V., et al. Chapter Five – Salinity Stress in Crop Plants: Effects and Eco-friendly Management. *Advances in Food Security and Sustainability* **9** (2024), 103–143.
https://doi.org/10.1016/bs.af2s.2024.07.001
28. Flowers T.J., Munns R., Colmer T.D. Sodium Chloride Toxicity and the Cellular Basis of Salt Tolerance in Halophytes and Glycophytes. *Ann. Bot.* **115** (2015), 419–431.
https://doi.org/10.1093/aob/mcu217
29. Souana K., Taïbi K., et al. Salt-tolerance in *Vicia faba* L. is Mitigated by the Capacity of Salicylic Acid to Improve Photosynthesis and Antioxidant Response. *Sci. Hortic.* **273** (2020), 109641.
https://doi.org/10.1016/j.scienta.2020.109641

30. Stępień P., Kłbus G. Water Relations and Photosynthesis in *Cucumis sativus* L. Leaves under Salt Stress. *Biologia Plantarum* **50** (2006), 610–616.
https://doi.org/10.1007/s10535-006-0096-z
31. Assaha D.V.M., Ueda A., et al. The Role of Na^+ and K^+ Transporters in Salt Stress Adaptation in Glycophytes. *Front. Physiol.* **8** (2017), 509.
https://doi.org/10.3389/fphys.2017.00509
32. Shabala S., Cuin T.A. Potassium Transport and Plant Salt Tolerance. *Physiol. Plant.* **133** (2008), 651–669.
https://doi.org/10.1111/j.1399-3054.2007.01008.x
33. Qadir M., Oster J.D., et al. Phytoremediation of Saline and Sodic Soils. *Adv. Agron.* **96** (2007), 197–247.
https://doi.org/10.1016/S0065-2113(07)96006-X

Ա. Ս. ՀԱՐՈՒԹՅՈՒՆՅԱՆ

ՑՈՐԵՆԻ ՀԱՅԿԱԿԱՆ ՏԵՂԱԿԱՆ ԳԵՆՈՏԻՊԻ ԱՂԱՅԻՆ ՍԹՐԵՍԻ ՆԿԱՏՄԱՄԲ ԱՐՁԱԳԱՆՔՆԵՐԸ ԵՎ ՖԻՏՈԱՂԱԶԵՐԾՄԱՆ ՆԵՐՈՒԺԸ

Այս ուսումնասիրությունը նպատակ ունի գնահատել տեղական ցորենի (“Sateni-22”) մորֆոլոգիական, ֆիզիոլոգիական և կենսաքիմիական արձագանքներն աղային սթրեսի պայմաններում, ինչպես նաև որոշել դրա ֆիտոաղազերծման ներուժը: Փորձը իրականացվել է վերահսկվող պայմաններում՝ օգտագործելով NaCl տարբեր կոնցենտրացիաների լուծույթներ: Արդյունքները ցույց տվեցին, որ NaCl-ի ցածր կոնցենտրացիաների պայմաններում հարմարվողական մեխանիզմների գործարկման արդյունքում կարողացել է որոշակիորեն պահպանել մորֆոֆիզիոլոգիական ցուցանիշները, բայց արդեն բարձր կոնցենտրացիաների դեպքում դրանք զգալիորեն նվազել են: Հարկ է նշել նաև, որ աղակալվածության աճին զուգահեռ բույսի վերգետնյա օրգաններում Na^+ և Cl^- իոնների պարունակությունը զգալիորեն ավելացել է: Սա վկայում է տեղական ցորենի տեսակների որոշակի աղապտիվ կարողության և ֆիտոաղազերծման արդյունավետության մասին:

А. С. АРУТЮНЯН

РЕАКЦИИ МЕСТНОГО ГЕНОТИПА ПШЕНИЦЫ НА СОЛЕВОЙ СТРЕСС И ЕЕ ПОТЕНЦИАЛ ФИТОРАССОЛЕНИЯ ПОЧВЫ

Целью исследования было оценить морфологические, физиологические и биохимические реакции местной пшеницы (“Sateni-22”) на солевой стресс и определить ее потенциал для фиторассоления. Эксперименты проводились в контролируемых условиях при различных концентрациях NaCl. Результаты показали, что в условиях низких концентраций NaCl в результате активации адаптивных механизмов морфофизиологические показатели в некоторой степени сохранялись, но при высоких концентрациях они значительно снижались. Следует также отметить, что параллельно с повышением солености значительно увеличивалось содержание ионов Na^+ и Cl^- в надземных органах растения. Это указывает на умеренную адаптационную способность местной пшеницы и ее эффективность в процессе фиторассоления почвы.