Iosr Journal Of Agriculture And Veterinary Science (Iosr-Javs)
E-Issn: 2319-2380, P-Issn: 2319-2372. Volume 18, Issue 3 Ser. 1 (March. 2025), Pp 01-06
www.Iosrjournals.Org

Determination Of The Effect Of Salt Stress On The Growth Of Taro (*Colocasia esculenta* (L.) Schott)

Nilsen Lasso-Rivas[1], Brayan Salazar Rodríguez[1], Yesid Moreno Hinojosa[1]
[1]*(Department Of Agronomy, Universidad Del Pacífico, Colombia)*

Abstract:
Background*: Taro (Colocasia esculenta) is a vital crop in tropical regions, but its growth is threatened by salinity, which limits productivity through osmotic stress and ion toxicity. This study evaluates the impact of salt stress on the 'Maruja' taro variety to assess its potential tolerance to saline conditions.*
Materials and Methods*: A greenhouse experiment was conducted at the University of the Pacific, Colombia. Taro plantlets were grown in a soil-sand mix under controlled conditions and subjected to four salinity treatments (0, 30, 45, and 75 mM NaCl). Each treatment included ten replicates, for a total of 40 plants. Morphological and physiological parameters were assessed, including total biomass, shoot and root dry weight, corm mass, leaf area, relative water content (RWC), chlorophyll content, electrolyte leakage, and root-to-shoot ratio. Data were analyzed using ANOVA followed by Tukey's test ($p < 0.05$).*
Results*: Higher salinity levels significantly reduced total biomass (by 33%, 48%, and 74% at 30, 45, and 75 mM, respectively), shoot dry weight, and corm mass. Root dry weight remained unchanged, but the root-to-shoot ratio increased with salinity. Leaf area declined at 45 and 75 mM NaCl, while LAR increased. Chlorophyll content decreased, electrolyte leakage increased, and RWC was significantly lower under salinity stress, indicating physiological damage.*
Conclusion:*While 'Maruja' taro exhibited some tolerance at moderate salinity (30 and 45 mM NaCl), severe reductions in biomass, chlorophyll content, and water retention at 75 mM NaCl suggest that its adaptive capacity is limited. These results highlight the need for breeding salt-tolerant taro varieties and implementing agronomic strategies to mitigate salinity stress, such as soil amendments and optimized irrigation practices.*
Key Word*: Salinity stress, osmotic stress,tuber crop, plant physiology, chlorophyll content, electrolyte leakage.*

Date of Submission: 22-02-2025 Date of Acceptance: 02-03-2025

I. Introduction

Taro (*Colocasia esculenta* (L.) Schott) is a member of the Araceae family, sub-family Aroideae, is the most commonly cultivated species in genus *Colocasia*. Although is grown primarily for its starchy corm and cormels, other parts of the plant such as leaves, petioles and flowers can also be consumed[1]. Taro is a staple food source in many tropical and subtropical regions, particularly in the Pacific Islands and Southeast Asia. The majority of taro produced worldwide is sourced from developing countries, which are distinguished by smallholder agricultural systems that rely on minimal external resource inputs[2]. In Colombia, taro is grown mainly in the humid areas of the Pacific region where it contributes significantly to food security and is a source of income for the rural population[3]. Some research indicates that, due to the high amounts of starch present in the corm, greater than 80%, taro could become an alternative source of starch for the food industry[4].

One of the biggest environmental factors affecting plant productivity is salinity. A soil is deemed saline when the electric conductivity (EC) reaches 4 dS m^{-1} (equivalent to 40 mM NaCl), most of the crops grown under those circumstances suffer a drastic diminution in their yields[5]. Salt-mediated negative effects on plant growth are commonly explained by two factors: (i) the osmotic or water-deficit effect, and (ii) the salt-specific or ion-excess effect. The former affects plant water relations by creating a more negative osmotic potential in the soil compared to plant cells, leading to reduced water availability[6]. This can cause plants to experience physiological drought, even when water appears to be present in the soil, disrupting cellular processes and potentially stunting growth[7]. The salt-specific or ion-excess effect is due the excessive intake of Na^+ and Cl^- which seriously damages cells and slows down growth[8]. High salt concentrations can also disrupt nutrient uptake, leading to nutrient imbalances[9]. Plants have developed various mechanisms to cope with salt stress, such as salt exclusion (preventing the entry of salts into the vascular system), salt elimination (glands and hairs that actively eliminate salts), salt succulence (the storage volume of the cells increases progressively with the uptake of salt), redistribution, osmotic regulation (accumulation of salt in the cell sap in order to keep osmotic potentials lower than in the soil solution), CO_2 assimilation (accumulation of soluble carbohydrates for maintaining a low osmotic cell sap potential), chlorophyll content and fluorescence , and antioxidant defenses (activity of antioxidative enzymes which scavenge reactive oxygen species)[10]. These responses are mediated by changes in morphology, anatomy, water relations, photosynthesis, hormones, toxic ion distribution, and biochemical adaptation.

In Colombia, 45% of the continental and insular surface presents some degree of susceptibility or propensity to soil degradation due to salinization[11]. Salinity has caused soil deterioration in many parts of Colombia, harming the yields of crops that are crucial to the country's economy[12]. The Institute of Hydrology, Meteorology and Environmental Studies (IDEAM by its Spanish acronym) predicts that climate change will increase the incidence of salt stress in many parts of Colombia, which will have an impact on crop productivity[13]. In spite of its economic importance, taro is a crop that is often ignored and little is known about its physiology or how it responds to environmental stressors, particularly salt stress[14]. Local cultivars of taro in the Pacific region of Colombia have evolved over centuries through domestication and selection by subsistence farmers. Such selection, sometimes in environments with marine influence, may have resulted in cultivars capable of tolerating saline stress, previous studies show that taro cultivars can vary in their tolerance to salt concentration[15,16].

The aim of this research was to evaluate the impact of salinity on the growth of 'Maruja' taro plants by watering with three different concentrations of NaCl (30, 45, and 75 mM) for 12 weeks.

II. Material And Methods

Plant material, greenhouse conditions, and treatments

A greenhouse experiment was conducted at the Experimental Plot, University of the Pacific, Buenaventura D.E., Valle del Cauca, Colombia. 'Maruja'taro plantlets, approximately the upper 1 cm of the corm plus 20 cm of the petiole, were sown in 10 L pots containing soli:sand mix (2:1, volume) and kept in a plastic greenhouse under natural illumination, the environmental conditions during the experiment were 38/23.8 ˚Cmaximum/minimum average temperatures and the relative humidity ranged between 56 and 97%. The plantlets were watered every two days and allowed to grow for 60 days. The plantlets were then separated into four groups: 0 (control), 30, 45, and 75 mM of NaCl. Control plants were watered every two days with 300 ml of distilled water whereas salinity-stressed plants were irrigated with 300 ml of 30, 45, and 75 mM of NaCl solution respectively. Ten replicates were used for each treatment for a total of 40 plants. Four weeks post saline solutions application, plants were harvested.

The harvested samples were washed in distilled water to remove salts and soil remains from the surface tissues. The plants were separated into the leaves, petioles, roots, and corm, and oven-dried at 70 ˚C. Dried plant samples were weighed for the estimation of plant growth. Electrolyte leakage was determined by measuring the conductivity of the aqueous bathing solution containing plant tissues before and after boiling it[17]. To perform the measurements of the leaf area, all leaf blades were digitalized with a table scanner and the public domain ImageJ® software was employed. Fresh samples of leaves were used for the determination of relative water content (RWC)[18]. Plant height was measured from the base of the plant up to the base of the 2nd youngest fully unfolded leaf. Leaf number was counted only for fully unfolded leaves with at least 50% green leaf area. The average chlorophyll content (SPAD reading) was measured on the adaxial surface of the second youngest fully formed, fully unfolded leaf using a SPAD 502 chlorophyll content meter (Minolta Camera Co., Osaka, Japan). The SPAD values were the average of the values at six points of measurement on each selected leaf.

Experimental design and statistical analysis

Pots were arranged in completely randomized design. An analysis of variance (ANOVA) was performed followed by Tukey´s range test ($p < 0.05$) using R 4.4.1 statistical software.

III. Result

The salinity stress had an effect on the morphological and physiological variables evaluated (Table 1). Overall, plants were smaller (biomass) with increasing concentrations of NaCl (Table 1, Figure 1). Compared with the control treatment, plants in the salinity treatments (30, 45, and 75 mM NaCl) showed reductions in total plant biomass of 33%, 48%, and 74%, respectively (Figure 1), a similar pattern was found for the variable shoot dry weight, i.e., increasing concentrations of NaCl resulted in plants with less shoot biomass. For the variable root dry weight there were no significant differences among the salinity treatments, plants from those treatments had lighter roots compared with the control plants (Figure 1). Corm mass was significantly reduced across salt treatments, with a 18%, 36%, and 48% reduction in the mean corm mass in plants in the NaCl treatments (30, 45, and 75 mM NaCl) compared to the control (Figure 1). For the number of leaves per plantlet, the highest number of leaves was observed in the control treatment, whereas the lowest number of leaves per plantlet was observed in the salt treatments (Figure 1). In this study, height did not show significant differences as the plantlets were grown with or without NaCl (Figure 2). There were no significant differences between the leaf area (LA) of the control and 30 mM NaCl treatment plants, the plants at 75 mM showed the smaller values of

LA followed by those at 45 mM NaCl (Figure 2). Plantlets of the salinity treatment had higher values of leaf area ratio (LAR) than those of the control (Figure 2). There were significant differences in root to shoot ratio among the salinity treatments, the highest values were showed by plants at 75 mM followed by those at 45 mM and 30 mM (Table 1, Figure 2).

Table 1. Summary of the mean value and ANOVA results for morphological and physiological variables of taro plant grown in four NaCl concentrations. Comparisons that are significantly different are marked with *($p < 0.05$), **($p < 0.01$), ***($p < 0.001$). Means ± SD with the same letter are not significantly different at $p < 0.05$ by Tukey HSD test.

Growth parameter	0 mM	30 mM	45 mM	75 mM	*df*	*F*	*p*
Total DW (g)	143.36 ± 18 ^{a}	95.56 ± 23.56 ^{b}	74.77 ± 24.67 ^{c}	51.77 ± 25.74 ^{d}	3	4.68	0.0073 **
Shoot DW (g)	71.75 ± 15.04 ^{a}	37.31 ± 11.89 ^{b}	27.09 ± 7.95 ^{bc}	13.9 ± 5.16 ^{c}	3	53.5	2.4e-13 ***
Root DW (g)	3.42 ± 0.22 ^{a}	3.04 ± 0.22 ^{b}	3.02 ± 0.2 ^{b}	3.0 ± 0.2 ^{b}	3	4.68	0.0073 **
Corm mass (g)	68.2 ± 5.89 ^{a}	55.43 ± 6 ^{b}	43.36 ± 6.43 ^{c}	35.7 ± 5.99 ^{c}	3	3.65	0.022 *
Plant height (cm)	41.19 ± 3.17 ^{a}	39.17 ± 3.49 ^{a}	38.471 ± 2 ^{a}	36.71 ± 3.59 ^{a}	3	2.62	0,066
Number of leaves	4.45 ± 0.54 ^{a}	3.76 ± 0.23 ^{b}	3.63 ± 0.34 ^{b}	3.52 ± 0.33 ^{b}	3	12.2	1.2e-05 ***
Leaf area (cm2)	218.97 ± 21.87 ^{a}	191.45 ± 41.77 ^{a}	152.57 ± 28.87 ^{b}	109.7 ± 19.63 ^{c}	3	12.8	7.4e-06 ***
Root/shoot	0.05 ± 0.02 ^{c}	0.09 ± 0.02 ^{bc}	0.13 ± 0.06 ^{b}	0.23 ± 0.09 ^{a}	3	20.4	8e-08 ***
Leaf area ratio	1.54 ± 0.22 ^{b}	2.01 ± 0.33 ^{a}	2.07 ± 0.41 ^{a}	2.13 ± 0.39 ^{a}	3	11.2	2.8e-05 ***
RWC (%)	84.2 ± 7.17 ^{a}	73.4 ± 1.37 ^{b}	70.9 ± 9.81 ^{b}	68.97 ± 8.45 ^{b}	3	8.37	0.00024 ***
Electrolyte leakage (%)	12.7 ± 4.4 ^{b}	20.29 ± 6.56 ^{a}	26.23 ± 4.38 ^{a}	26.13 ± 4.93 ^{a}	3	11	3.4e-05 ***
Chlorophyll content (SPAD)	20.25 ± 6.42 ^{a}	15.53 ± 2.19 ^{b}	14.01 ± 3.41 ^{b}	11.93 ± 2.48 ^{b}	3	7.53	0.00052 ***

The salinity stress had an effect on chlorophyll content (Table 1, Figure 2). The highest chlorophyll content was observed in plants without salinity stress, whereas the lowest chlorophyll contents were observed when salinity stress were applied, however there was no significant differences among saline treatments (Figure 2). Electrolyte leakage was affected by the salinity treatments (Table 1, Figure 2). The highest values of electrolyte leakage were observed on those plants grown under saline stress regardless of the concentration of NaCl. There were significant differences in the relative water content (RWC) among the treatment groups, plantlets grown under salinity stress had less relative water content than plants of the control (Figure 2).

Figure 1. Total dry weight, shoot dry weight, corm mass, root dry weight, plant height, and number of leaves of taroplants grown for five weeks with five different concentrations of sodium chloride. Each histogram is the mean of ten measurements. Values with the same letter are not significantly different by Tukey HSD 0.05 test. Vertical bars on each histogram are S.E. of the mean.

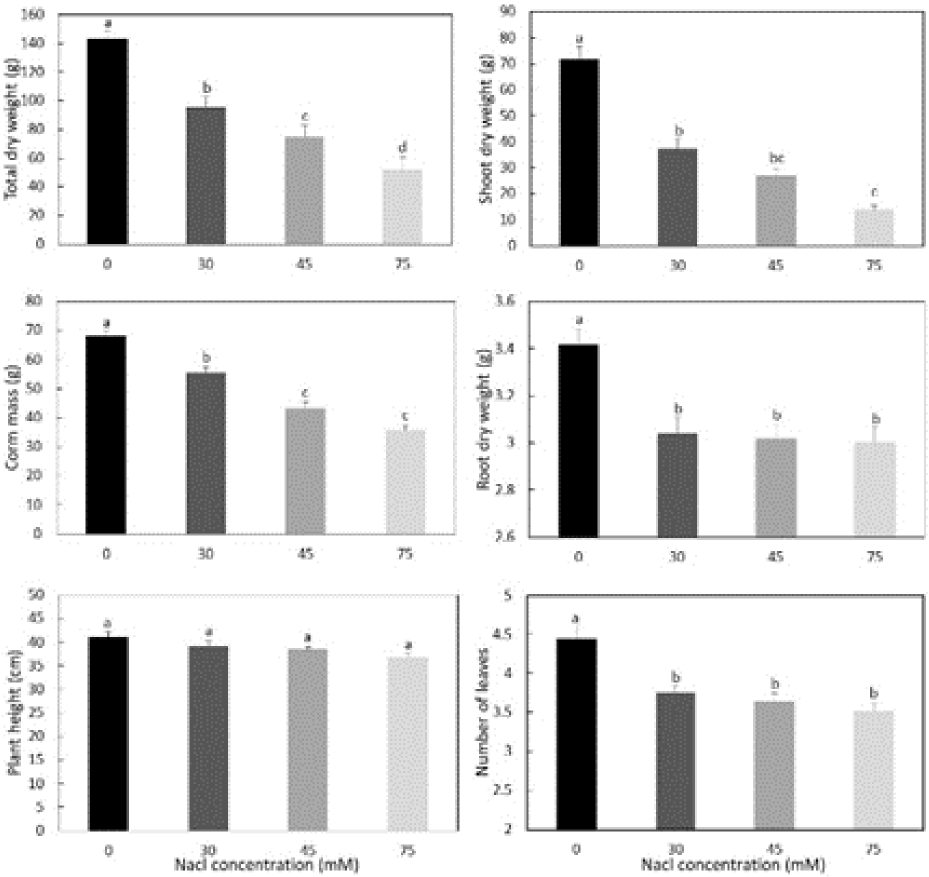
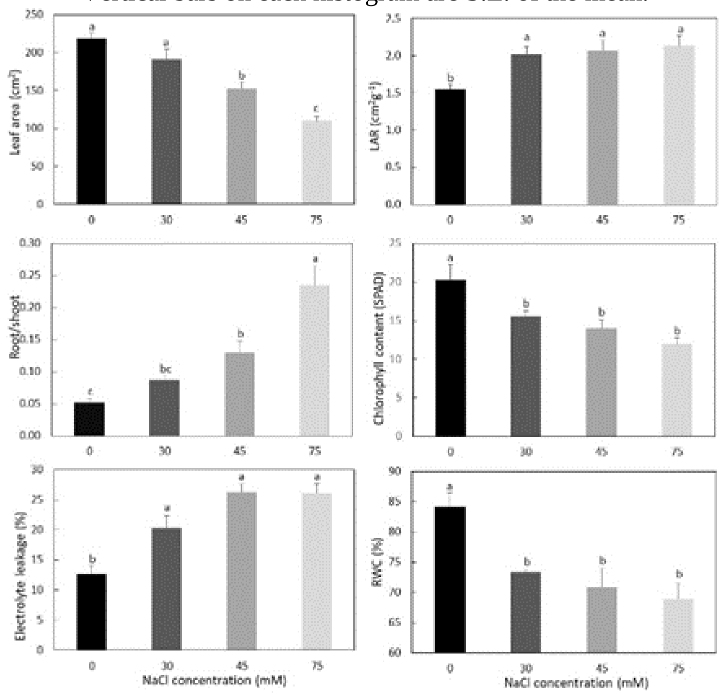


Figure 2. Leaf area, relative water content, LAR, root/shoot, chlorophyll content, electrolyte leakage and RWC of taro plants grown for five weeks with five different concentrations of sodium chloride. Each histogram is the mean of ten measurements. Values with the same letter are not significantly different by Tukey HSD 0.05 test. Vertical bars on each histogram are S.E. of the mean.



IV. Discussion

Salinity is one of the most significant abiotic stressors limiting plant productivity globally. This study aimed to evaluate the impact of salinity on taro by subjecting plants to varying concentrations of NaCl (0, 30, 45, and 75 mM) over 12 weeks. The results highlight substantial morphological and physiological responses, providing insights into the mechanisms of salinity tolerance and limitations in this species. The findings also contribute to the understanding of how local taro landraces from Colombia's Pacific region may have evolved partial tolerance to saline conditions.

Biomass and Growth Responses

The decline in total plant biomass with increasing NaCl concentrations highlights the severe impact of salinity on taro, these results are consistent previous studies that reported significant reductions in growth and biomass of taro when plantlets were grown under NaCl treatments[15,19]. The reduction in biomass is a common response in plants exposed to high salinity, as osmotic stress and ion toxicity can disrupt cellular processes and nutrient uptake[20,21]. Additionally, the accumulation of Na^+ ions within plant tissues can interfere with essential metabolic processes and enzyme activities, further exacerbating growth retardation[22]. The disproportionate reduction in shoot biomass compared to root biomass suggests that taro may prioritize root growth under saline conditions, possibly as a strategy to enhance water and nutrient uptake. Interestingly, while root dry weight did not differ significantly among the salinity treatments, plants under saline conditions had lighter roots compared to the control. This suggests that while root growth is somewhat resilient to salinity, it is still negatively affected, potentially due to the high energy cost of maintaining ion homeostasis and osmotic balance in the roots[23]. The substantial reductions in corm mass observed in this study is accord with those reported by Lloyd et al.19, and for other plants with underground storage organs, such as potato and cassava[24,25]. The significant reduction in corm mass is of particular concern as the corm is the primary economic product of taro[26] and highlight the potential for significant yield losses in saline environments.

Leaf Morphology and Photosynthetic Traits

The number of leaves per plantlet decreased significantly under saline treatments compared to controls. This reduction can be attributed to impaired leaf initiation or expansion due to osmotic stress and ion toxicity[27]. The reduction in leaf area, particularly at higher salinity levels, is consistent with the overall growth inhibition and is typical response to salt stress described by different authors[9]. Smaller leaf area implies reduced photosynthetic capacity, which can further contribute to decreased biomass accumulation[21]. The reduction in LA at elevated salinity levels is a response considered an avoidance mechanism, which minimizes water losses when the stomata are closed, which happens to many species under osmotic stress[28]. The lack of significant difference in LA between the control and the 30 mM treatment suggests a threshold below which taro's leaf development is not substantially affected. While no significant differences were observed in LAR among the salinity treatments, the higher LAR values in stressed plants (except for 30 mM NaCl) compared to the control suggest shifts in biomass allocation favoring leaves over other tissues. The LAR is an important metric as it reflects the amount of leaf area available for photosynthesis relative to the plant's biomass. This increase in LAR indicates an attempt by taro plants to maximize photosynthetic surface area under stress. However, the lack of significant differences among treatments suggests that this strategy may be less effective at higher salinity levels where other physiological constraints, such as reduced chlorophyll content and impaired water relations, dominate[29].

Physiological Responses

The reduction in chlorophyll content observed in salinity treatments aligns with previous findings that salinity induces oxidative stress, damages chloroplast structures, and disrupts chlorophyll synthesis[30,31]. It is known that salt-sensitive species show decreased chlorophyll content under salinity conditions suggesting that this parameter can be considered a biochemical marker of salt tolerance in plants[9]. Chlorophyll degradation directly affects photosynthetic efficiency, leading to reduced carbohydrate production and limited energy availability for growth[32]. These physiological impairments are consistent with earlier reports of reduced carbon assimilation rates in taro under NaCl stress[19].

Electrolyte leakage, a marker of membrane damage, was significantly elevated in plants exposed to salinity. This indicates disrupted membrane integrity caused by osmotic stress and ion toxicity, which leads to ion imbalance and impaired nutrient transport[33]. Maintaining membrane integrity is crucial for the survival of plants under stress conditions, as it ensures proper cellular function and stability. Damaged cell membranes impair the transport of water and nutrients across cells, further exacerbating the negative effects of salinity stress. The loss of membrane integrity can disrupt the uptake and distribution of essential nutrients, leading to deficiencies that affect growth and development[34].

A decrease in RWC under salinity stress is a common and expected response in plants, it indicates that plants are experiencing osmotic stress, leading to a reduced ability to take up water from the soil[35]. This reduction in water uptake results in lower turgor pressure, which is essential for cell expansion and growth; without adequate turgor pressure, plants cannot maintain the rigidity of their cells, leading to wilting and stunted growth[36]. This explains the observed reductions in biomass and leaf area in the salinity treatments. Lower RWC is often associated with increased electrolyte leakage, as observed in this study.

Salinity Tolerance and Adaptive Mechanisms

The results support the hypothesis that local landraces of taro from Colombia's Pacific region may possess a degree of salinity tolerance, as evidenced by the partial performance of plants under moderate salinity (30 and 45 mM NaCl). These landraces likely evolved adaptive mechanisms, including increased root-to-shoot ratios, and adjustments in LAR, in response to the saline or brackish environments characteristic of the region. However, the severe reductions in growth and physiological performance at 75 mM NaCl suggest that their tolerance is limited and that high salinity significantly exceeds their adaptive capacity.

Implications for Crop Management and Breeding

The findings emphasize the need to develop salt-tolerant taro cultivars to mitigate yield losses in saline environments. Breeding programs should focus on leveraging the genetic diversity of local landraces, selecting for traits such as improved ion homeostasis, higher chlorophyll retention, and enhanced water use efficiency. Agronomic strategies, including soil amendments, controlled irrigation, and nutrient supplementation, can further support taro cultivation in salt-affected areas.

V. Conclusion

This study demonstrates that salinity stress significantly affects 'Maruja'taro growth and physiology, with severe impacts at higher NaCl concentrations. The partial tolerance observed at moderate salinity suggests that local landraces from Colombia's Pacific region have evolved adaptive traits to cope with saline conditions, though their capacity is limited under high salinity. These findings contribute to understanding taro's response to salinity and highlight the importance of integrating breeding and agronomic approaches to enhance its resilience in saline environments.

References

[1]. Ubalua, A. O., Ewa, F., &Okeagu, O. D. (2016). Potentials And Challenges Of Sustainable Taro (*Colocasia esculenta*) Production In Nigeria. J Appl BiolBiotechnol, 4(1), 53-59 (8)

[2]. Singh, D., Jackson, G., Hunter, D., Fullerton, R., Lebot, V., Taylor, M., ... &Tyson, J. (2012). Taro Leaf Blight—A Threat To Food Security. Agriculture, 2(3), 182-203.

[3]. Lasso-Rivas, N. L., &Cundumí-Jori, I. (2016). Efecto De Abono Orgánico Y Densidad De Siembra En Crecimiento Y Producción De Papa China (*Colocasia esculenta*L.). RIAA, 7(1), 139-146.

[4]. Aguilar, P. V. &Villalobos, D. H. (2013). Harinas Y Almidones De Yuca, Ñame, Camote Y Ñampí: Propiedades Funcionales Y Posibles Aplicaciones En La Industria Alimentaria. RevistaTecnologíaEn Marcha, 26(1), 37-45.

[5]. Munns, R., &Gilliham, M. (2015). Salinity Tolerance Of Crops–What Is The Cost?.New Phytologist, 208(3), 668-673..

[6]. Hagemann, M. And Erdmann, N. (1997) Environmental Stresses. In: Rai, A.K., Ed., Cyanobacterial Nitrogen Metabolism And Environmental Biotechnology, Springer, Heidelberg, Narosa Publishing House, New Delhi, 156-221..

[7]. Yadav, S., &Atri, N. (2020). Impact Of Salinity Stress In Crop Plants And Mitigation Strategies. New Frontiers InStress Management For Durable Agriculture, 49-63.

[8]. Hayashi, H., &Murata, N. (1998). Genetically Engineered Enhancement Of Salt Tolerance In Higher Plants. Stress Response Of Photosynthetic Organisms: Molecular Mechanisms And Molecular Regulation, 133-148.

[9]. Acosta-Motos, J. R., Ortuño, M. F., Bernal-Vicente, A., Diaz-Vivancos, P., Sanchez-Blanco, M. J., &Hernandez, J. A. (2017). Plant Responses To Salt Stress: Adaptive Mechanisms. Agronomy, 7(1), 18.

[10]. Desingh, R., &Kanagaraj, G. (2007). Influence Of Salinity Stress on Photosynthesis And Antioxidative Systems In Two Cotton Varieties. Gen. Appl. Plant Physiol, 33(3-4), 221-234..

[11]. González-Pedraza, A. F., Barrios, Y. A. C., &Escalante, J. C. (2022). Soil Salinization In Agricultural Areas Of The Caribbean Region And Agroecological Recovery Strategies. Review. Inge Cuc, 18(1), 14-26.

[12]. Quintero-Angel, M., &Ospina-Salazar, D. I. (2022). Agricultural Soil Degradation InColombia. In Impact OfAgriculture On Soil Degradation I: Perspectives From Africa, Asia, America And Oceania (Pp. 177-218). Cham: Springer International Publishing..

[13]. IDEAM, U. (2015). Síntesis Del Estudio Nacional De La Degradación De Suelos Por Erosión En Colombia. Bogotá DC, Colombia: Instituto De Hidrología Y MeterologíaDe Estudios Ambientales–Ministerio De Ambiente Y Desarrollo Sostenible–Universidad De Ciencias Aplicadas Y Ambientales. Recuperado De: Http://Documentacion. Ideam. Gov. Co/Openbiblio/Bvirtual/023648/Sintesis. Pdf.

[14]. Shannon, M. C., &Grieve, C. M. (1998). Tolerance Of Vegetable Crops To Salinity. ScientiaHorticulturae, 78(1-4), 5-38

[15]. Hill, S., Abaidoo, R., &Miyasaka, S. (1998). Sodium Chloride Concentration Affects Early Growth AndNutrient Accumulation In Taro. Hortscience, 33, 1153–1156.

[16]. Vaurasi, V., &Kant, R. (2016). Effects Of Salinity And Plant Growth Media On In Vitro Growth And Development Of Taro (*Colocasia esculenta*L.) Varieties. Acta HorticulturaeEt Regiotecturae, 19(1), 17-20

[17]. Whitlow T. H., Bassuk N. L., Ranney T. G. And Reichert D. L. (1992). An Improved Method For Using Electrolyte Leakage To Assess Membrane Competence In Plant Tissues. PlantPhysiol98(1): 198-205.

[18]. Turner N.C. (1981). Techniques And Experimental Approaches For The Measurement Of Plant Water Status. PlantSoil, 58, 339.

[19]. Lloyd, G. R., Uesugi, A., &Gleadow, R. M. (2021). Effects Of Salinity On The Growth And Nutrition Of Taro (*Colocasia esculenta*): Implications For Food Security. Plants, 10(11), 2319.

[20]. Munns, R. &Tester, M. (2008). Mechanisms Of Salinity Tolerance. Ann. Rev. Plant Biol., 59, 651–681.

[21]. Abdel-Farid, I. B., Marghany, M. R., Rowezek, M. M., &Sheded, M. G. (2020). Effect Of Salinity Stress OnGrowth And Metabolomicprofiling Of Cucumis Sativus And Solanum lycopersicum. Plants, 9(11), 1626.

[22]. Kamran, M., Parveen, A., Ahmar, S., Malik, Z., Hussain, S., Chattha, M.S., Saleem, M.H., Adil, M., Heidari, P. &Chen, J.T. (2019). An Overview Of Hazardous Impacts Of Soil Salinity In Crops, Tolerance Mechanisms, And Amelioration Through Selenium Supplementation. International JournalOf Molecular Sciences, 21(1), 148.

[23]. Negrão, S., Schmöckel, S. M., &Tester, M. J. A. O. B. (2017). Evaluating Physiological Responses Of Plants To Salinity Stress. AnnalsOfBotany, 119(1), 1-11.

[24]. Levy, D. (1992). The Response Of Potatoes (*Solunumtuberosum*L.) To Salinity: Plant Growth And Tuber Yields In The Arid Desert Of Israel. Ann. Appl. Biol., 120, 547–555

[25]. Gleadow, R., Pegg, A., &Blomstedt, C. K. (2016). Resilience Of Cassava (*Manihot esculenta*Crantz) To Salinity: Implications For Food Security In Low-Lying Regions. Journal Of Experimental Botany, 67(18), 5403-5413

[26]. Kaushal, P., Kumar, V., &Sharma, H. K. (2015). Utilization Of Taro (*Colocasia esculenta*): A Review. Journal Of Food Science AndTechnology, 52, 27-40.

[27]. Taleisnik, E., Rodríguez, A. A., Bustos, D., Erdei, L., Ortega, L., &Senn, M. E. (2009). Leaf Expansion In Grasses Under Salt Stress. Journal Of Plant Physiology, 166(11), 1123-1140.

[28]. Rodrıguez, P., Torrecillas, A., Morales, M. A., Ortuno, M. F., &Sánchez-Blanco, M. J. (2005). Effects Of Nacl Salinity And Water Stress On Growth And Leaf Water Relations Of *Asteriscusmaritimus* Plants. Environmental And Experimental Botany, 53(2), 113-123.

[29]. Ashraf, M. H. P. J. C., &Harris, P. J. (2013). Photosynthesis Under Stressful Environments: An Overview. Photosynthetica, 51, 163-190.

[30]. Taïbi, K., Taïbi, F., Abderrahim, L. A., Ennajah, A., Belkhodja, M., &Mulet, J. M. (2016). Effect Of Salt Stress On Growth, Chlorophyll Content, Lipid Peroxidation And Antioxidant Defence Systems In *Phaseolus vulgaris*L. South African Journal Of Botany, 105, 306-312.

[31]. Balasubramaniam, T., Shen, G., Esmaeili, N., &Zhang, H. (2023). Plants' Response Mechanisms To Salinity Stress. Plants, 12(12), 2253.

[32]. Hameed, A., Ahmed, M. Z., Hussain, T., Aziz, I., Ahmad, N., Gul, B., &Nielsen, B. L. (2021). Effects Of Salinity Stress On Chloroplast Structure And Function. Cells, 10(8), 2023.

[33]. Mansour M.M.F., Salama K.H.A. (2004): Cellular Basis Of Salinity Tolerance In Plants. Environmental And Experimental Botany, 52: 113–122.

[34]. Parida, A. K., &Das, A. B. (2005). Salt Tolerance And Salinity Effects On Plants: A Review. Ecotoxicology And Environmental Safety, 60(3), 324-349.

[35]. Chakraborty, K., Singh, A. L., Bhaduri, D., &Sairam, R. K. (2013). Mechanism Of Salinity Stress Tolerance In Crop Plants And Recent Developments. Advances In Plant Physiology, 14, 466-496.

[36]. Flowers, T.J. (2004). Improving Crop Salt Tolerance. J.Exp.Bot., 55: 307–319.