AN EVALUATION OF THE EFFECT OF SALT STRESS ON GERMINATION AND SEEDLING GROWTH OF *Corchorus olitorius* L.

BY

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DEPARTMENT OF PLANT BIOLOGY AND BIOTECHNOLOGY

FACULTY OF LIFE SCIENCES

UNIVERSITY OF BENIN

BENIN CITY

OCTOBER, 2025.

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF PLANT BIOLOGY AND BIOTECHNOLOGY, FACULTY OF LIFE SCIENCES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (HONOURS) DEGREE (BSc.) IN PLANT BIOLOGY AND BIOTECHNOLOGY

OCTOBER, 2025.

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CERTIFICATION

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Signed:———————————— ————————————

Date

Prof. B.O. Edegbai

Supervisor

Signed:———————————— ————————————

Date

Prof. B. Ikhajiagbe

Head of Department

DEDICATION

This project is dedicated to God Almighty for his mercies, unending faithfulness, guidance, knowledge and strength, to my esteemed parents Mr. Edwin and Mrs Joy Ikponmwen Amasowomwan I love you so much and I am forever grateful.

ACKNOWLEDGEMENT

I thank God for his grace, wisdom and strength to complete this work. Special thanks and appreciation goes to my ever loving parents Mr and Mrs. E. Ikponmwen, thank you for all the sacrifices you have made all through from when I existed till now and even in the future, for your immense love, unswerving support, encouragement and assistance during this various stages of my life up till this moment. To my younger sister, Success Amasowomwan, I love and appreciate you for always calling and asking how I have gone with my work and helping out in one or two ways.

My special appreciation goes to my project supervisor, Prof. B. Edegbai, for his guidance, support and patience and calmness throughout the course of this study.

I would also like to appreciate the HOD, Prof. B. Ikhajiagbe, for his fatherly care and assistance towards me and all the students in department.

I want to also thank my co-researchers, Ella and Chexi, Thank you for your support and assistance during the various stages of my work.

Finally I want to thank the one that's most dear to my heart Musa Tijani for assisting in different ways to make sure my project was a success and to everyone who kept me sane in this phase of my life. Thank you all for being part of this beautiful journey.

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ABSTRACT

This study was carried out to examine the effect of salt stress on germination and seedling growth of Jute's mallow (*Corchorus olitorius* L.) between two landraces (Ondo & NIHORT Research Institute). Several parameters were measured, including germination percentage, shoot length, number of branches, leaf area, number of leaves, stem girth, internode length and leaf loss for eight days to day fifty-six. The experimental treatments included various concentrations of Nacl; 10g/L(Z), 5g/L(Y), 2g/L(X), 0.2g/L(W) and the control (V). Germination was observed on the eight day for V,W,X with W having the highest germination percentage (86.6±1.15%), followed by V(70.00±1.00%). Treatment X recorded moderate germination (40.00±1.00%), while treatment Y and Z had no germination. Low concentrations of salt (V,W and X) stimulated germination in *Corchorus olitorius* L.. Shoot length and number of branches were significantly higher in W (6.50±1.00, 2.00±3.46) by day 21, performing better than other treatments. The number of leaves and stem girth were also higher in W (1.67±2.89, 6.33±0.57), while X, Y and Z had no number of leaves and stem girth. W recorded the highest leaf area (9.06±15.68, 30.25±2.36). Analysis of variance (ANOVA) showed that there was no significant difference between W, control and other treatments for all parameters. The results suggest that W (with moderate salinity) enhanced germination and growth, whereas higher salinity (Y and Z) inhibited germination and growth, indicating an adverse effect of salinity stress on *Corchorus olitorius* L. physiology.

CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

Soil salinity is one of the major abiotic stress limiting agricultural productivity worldwide particularly in arid and semi-arid regions. Conducting the required studies on salt stress and soil pollution can alter osmotic balance, reduce water uptake and interfere with nutrient availability, thereby affecting plant growth and development. Interest in ecologically sustainable solutions for salt tolerance in plant comprises the selection of naturally salt tolerant varieties and cross breeding them with high yielding ones, edit crop DNA to improve salt tolerance the use of salt tolerant beneficial bacterial/ fungal to help crops grown in saline soil or the treatment of seeds / plants before planting them.

1.1 Background Information of *Corchorus olitorius* L.

Members of the Malvaceae family (formally Tiliaceae) Ewedu (Yoruba) or Jew's mallow (*Corchorus olitorius* L. L.***)*** is a vital leafy green vegetable in many African and Asian cultures, renowned for its nutritional value, adaptability and each of cultivation. Jute leaf has long been used as a remedy in many cultures. Jute leaf product which include the leaf juice, fried leaf and sometime whole green leaf are used among other reasons, as laxatives, in creams for skin care, and as a treatment for a wide range of diseases respectively.

The heterogeneous nature of jute leaf product may contribute to the diverse biological and therapeutic activities that have been observed. Variations in the composition of jute leaf can result in products with different chemical and physical properties, making the comparison of products difficult. The green leafy vegetable is rich in beta-carotene for good eye site, iron for healthy red blood cells, calcium for strong bones and teeth and vitamin c for smooth, clear skin, strong immune cells and fast wound healing. Jute leaf as vegetable contain an abundance of anti-oxidants that has been associated with protection from chronic diseases such as heart disease, cancer, diabetes and hypertension as well as other medical conditions. Fresh jute leaf has higher demand Ayurvedics use the leaves for ascites, pain, piles (laxatives), and tumours elsewhere the leaves are used for cystitis, dysuria and fever. The cold infusion is said to restore the appetite and strength.

1.2 Scientificc Classification of *Corchorus olitorius* L.

Kingdom: Plantae

Subkingdom: Tracheobionta

Superdivison: Spermatophyta

Division: Magnoliophya

Class: Magnolopsida

Subclass: Dilleniidae

Order: Malvales

Family: Malvaceae

Tribe: Corchoreae

Genus: Corchorus

Species: *Corchorus olitorius* L.

Stem: The stem of *Corchorus olitorius* L. is erect, cylindrical and typically grown with a reddish-brown hue, sometimes becoming woody at the base. It is generally 1.5 meters tall but can reach up to 4 meters. A singular leaf is produced per node and the stalks may possess 20 or more nodes.

Leaves: Each leave is alternate along the stem, long and narrow tapering at both ends finely serrated often with two to three small forward pointing teeth near the base. The leaf surface is smooth, brightly coloured and typically 4 to 10cm long depending on age and environment.

Fruits: Dry dehiscent capsule, long, slender or slightly ribbed. Typically 3-10cm, usually 10 ribs along the length of the capsule. It contains many small seeds arranged in rows. It splits longitudinally when dry to release seeds.

Propagation, Germination and Development: *Corchorus olitorius* L. is typically propagated from seeds, which require dormancy-beating treatments like brief immersion in boiling water or scarification with sand before sowing. Germination takes place about 5-8 days and the seedling stage last about 3-4 weeks after germination.

Nutritional Benefits: *Corchorus olitorius* L. offers numerous health advantages. It is mainly composed of Vitamin A (β-carotene) which supports vision, immunity and skin health.

Additionally, it contains Vitamin C, E and B9 which supports wound healing, protects cells from oxidative stress and blood formation. *Corchorus olitorius* L. is rich in minerals like irons and calcium that prevents anaemia and gives strength to the bones.

1.3 Geographical Distribution and Climatic Requirements

Jute mallow is an important crop produced for its leaves and fibre. In Africa, it is mostly produced and consumed as a leafy green vegetable. *Corchorus olitorius* L. is indigenous to tropical Africa and South Asia and is now widely cultivated or naturalized across the humid lowland tropics of Africa, Asia, and the middle East, as well as in parts of Latin America and the Caribbean (Mguis *et al*., 2014; Rahman, 2021). In Africa, it is grown both as a leafy vegetable and fibre crop in West, East and North African countries, including Nigeria, Sudan and Egypt, whereas in South and Southeast Asia especially Bangladesh, Myanmar and Thailand- it is an important fibre crop with secondary use as a vegetable (Mukul *et al*., 2021; Rahman 2021). Its eastward spread into the Levant and Arabian Peninsula has established C. *olitorius* as the culinary leaf for "molokhia" in Egypt, Lebanon and surrounding countries. Introductions into the Americas (e.g., Brazil, Cuba and Caribbean) have supported niche vegetable cultivation, typically in peri-urban gardens (Mguis *et al*., 2014). Climatically, C. *olitorius* is a heat- demanding tropical annuals that establishes best under mean temperatures of approximately 25-35℃ growth rate and biomass accumulation decline below 20℃ and plants are rapidly damaged by frost (Mukul *et al.*, 2021; Rahman, 2021). The crop performs optimally under well-distributed rainfall or irrigation totally about 600-2000mm per growing season, and requires full sun exposure for optimal leaf and fibre yield (Rahman, 2021). Although it tolerates a range of soil textures, highest performance is obtained on fertile, well drained alluvial loams with pH 5-7.8, and elevations below approximately 1200m (Mguis *et al*., 2014). Germination and early seedling development are particularly sensitive to osmotic and ionic stress; even moderate salinity depresses germination percentage, rate and early vigour (Mukul *et al*., 2014).

1.4 Definition and Causes of Salt Stress

Salt stress is a form of abiotic stress that arises when soluble salts in the soil solution elevate the osmotic potential and/or accumulate to toxic concentrations around plant roots, thereby impairing water uptake and metabolic function (Munns and Tester, 2008). In agricultural systems, salinity typically develops either from natural pedogenic processes or from anthropogenic drivers. Primary (natural) salinity originates from weathering of parent rock,

capillary rise of saline ground water in arid basins and long-term marine aerosol deposition (FAO, 2015). Secondary (human-induced) salinity is commonly generated by poor irrigation management, shallow water tables, inadequate drainage use of saline irrigation water and evaporation concentration of salts under high evaporative demand (FAO, 2015; Qadir *et al*., 2014). At the plant level, salt stress exerts two coupled constraints: an osmotic phase, which rapidly restricts leaf expansion and germination by lowering external water potential, and an ionic phase where Na^+ and Cl^- accumulate in tissues to toxic levels over time, disrupting photosynthesis, membrane stability and enzyme systems (Munns and Tester, 2008). In addition, soil salinity can be influenced by changes in land utilization including deforestation, mining activities, and urban expansion. Urbanization may further aggravate soil salinity by promoting runoff while simultaneously diminishing infiltration, thereby eliminating salt concentrations (Amini *et al*., 2016).

1.5 Soil stress as a major abiotic stress affecting plant growth, productivity and agricultural sustainability

Salinity is regarded as one of the most severe environmental stresses, significantly reduces crop productivity and quality worldwide. Over 20% of the planet's arable land faces challenges from salt stress, with these affected areas steadily expanding due to both natural processes and human activities (Arora, N.K. 2019). Salt stress is widely recognized as one of the most consequential abiotic constraints limiting plant growth, agricultural productivity and long-term land sustainability in arid, semi-arid and irrigated environments (Munns and Tester, 2008; FAO, 2015). Estimates indicate that more than 20% of irrigated land and roughly 7–8% of total cultivated land worldwide are salt-affected, with a continuing upward trend driven by climate drying, poor drainage, and inappropriate irrigation practices (Qadir *et al*., 2014; FAO, 2015). The burden of salinization is disproportionally concentrated in the Indo-Gangetic plains, the Nile basin, Central Asian irrigation schemes and dryland river basins of Africa and the Middle East — areas which collectively underpin major shares of global food supply (Qadir *et al*., 2014).

At the plant scale, salt stress exerts growth limitation through two coupled biophysical phases: a rapid osmotic phase that lowers external water potential and restricts cell expansion, germination and leaf growth, and a slower ionic phase in which Na^+ and Cl^- accumulate in photosynthetic and meristematic tissues to toxic concentrations, triggering metabolic inhibition, membrane destabilization and premature senescence (Munns and Tester, 2008).

These primary constraints cascade into secondary stresses including oxidative stress, nutrient imbalance (e.g., K^+/Na^+ antagonism), impaired carbohydrate partitioning and suppression of hormonal signalling linked to growth and reproductive competency (Munns and Tester, 2008; Rahman, 2021).

Beyond individual plant injury, the agronomic consequences of salt stress manifest across temporal and spatial scales as depressed germination and stand establishment, curtailed vegetative vigour, reduced leaf area duration, impaired reproductive development and ultimately yield penalties that rise quasi-exponentially with electrical conductivity beyond crop-specific thresholds (Munns and Tester, 2008; FAO, 2015). Salinity also alters soil–plant feedbacks through structural dispersion of clays, reduction of hydraulic conductivity, and collapse of biological functions such as N fixation, organic matter turnover and rhizosphere microbial activity, thereby embedding a self-reinforcing degradation loop that impairs recovery (Qadir *et al*., 2014). At landscape and system level, these mechanisms converge into two strategic sustainability liabilities: (i) irreversible productivity loss on once-productive irrigated lands, and (ii) increased pressure to convert new land to agriculture — accelerating deforestation, biodiversity loss and greenhouse-gas externalities (FAO, 2015; Qadir *et al*., 2014).

At mechanistic resolution, the osmotic–ionic duality of salinity translates to a multi-layered stress cascade: the immediate osmotic shock suppresses turgor-driven cell expansion and delays or aborts germination, while progressive Na^+/Cl^- ingress displaces K^+ at enzyme active sites, perturbs stomatal control, and disrupts thylakoid membranes, driving photosynthetic depression and premature oxidative load (Munns and Tester, 2008). Excess salts intensify reactive oxygen species (ROS) generation in chloroplasts, mitochondria and apoplasts; when antioxidant capacity (SOD, CAT, APX, GSH pool) is exceeded, membrane lipid peroxidation, protein carboxylation and nucleic acid lesions ensue, accelerating senescence and reproductive failure (Rahman, 2021). In parallel, salinity recasts ionic homeostasis, hormone equilibria (ABA-GA crosstalk in germination; ethylene-cytokinin antagonism in leaf ageing) and source–sink partitioning, such that assimilate supply and reproductive execution are jointly constricted, making salt stress not only an environmental constraint but a systems-level metabolic re-programming that lowers the ceiling of attainable yield (Munns and Tester, 2008).

1.6 LITERATURE REVIEW

1.6.1 Effect of salt stress on plant metabolism and physiological processes

Salt stress perturbs plant metabolism through an integrated set of osmotic, ionic and oxidative disruptions that jointly re-programme physiological functioning. The initial osmotic constraint lowers external water potential and reduces turgor-driven processes such as cell expansion, seed germination and leaf elongation (Munns and Tester, 2008). As Na^+ and Cl^- accumulate over time, ionic toxicity displaces essential cations especially K^+ at enzyme active sites thereby inhibiting protein synthesis, stomatal regulation and enzyme-coupled metabolic pathways (Munns and Tester, 2008). Salinity also depresses photosynthesis by damaging thylakoid membranes, reducing chlorophyll integrity, and constraining CO_2 assimilation through stomatal and non-stomatal limitations (Rahman, 2021). Metabolically, excess salts intensify reactive oxygen species (ROS) production in chloroplasts, mitochondria and the apoplast; when antioxidant buffers (SOD, CAT, APX, GSH) are insufficient, oxidative injury causes lipid peroxidation, protein carboxylation and nucleic acid damage (Rahman, 2021). These biochemical derangements alter hormone equilibria elevating ABA and disturbing GA/ABA and cytokinin/ethylene crosstalk which suppresses growth, delays reproductive transitions and accelerates senescence (Munns and Tester, 2008). Collectively, these shifts redirect carbon and nitrogen partitioning away from growth and reproduction toward stress defence, reducing growth efficiency and yield potential even before visible injury is expressed.

Salt stress perturbs plant metabolism at multiple, mutually reinforcing tiers carbon, nitrogen, energy, and secondary metabolism thereby constraining growth efficiency and biomass accrual even before visible injury appears. On the carbon axis, stomatal closure and chloroplast ionic disequilibrium suppress CO_2 assimilation, depressing Rubisco activation, Calvin-cycle flux and triose-phosphate export. Photo assimilate scarcity pushes plants to catabolize structural and storage carbohydrates to fuel respiration under stress. Concurrently, excess reducing power and impaired electron sinks provoke photo respiratory up-shift and ROS leakage, further consuming energy and carbon skeletons.

Nitrogen metabolism is likewise destabilized: salinity inhibits nitrate uptake and xylem loading, down-regulates nitrate reductase activity, and diverts assimilatory power and C-skeletons away from amino acid biosynthesis. Under persistent stress, plants substitute growth-supportive amino acids with compatible osmolytes (e.g. proline, glycine betaine), reallocating nitrogen from protein anabolism toward osmotic protection. This defensive

re-allocation manifests metabolically as lower protein content, higher free amino acid pools, and altered C/N ratios.

At the level of energy metabolism, mitochondrial respiration is re-programmed; ATP demand for ion pumping (Na^+ exclusion, K^+ retention, vascular sequestration) increases substantially, while ATP supply is constrained by impaired photosynthesis. Salinity also remodels the TCA cycle and anaplerotic flux to sustain redox balance and precursor supply under constrained carbon entry. Secondary metabolism is non-inert: phenylpropanoid, flavonoid, and lignin biosynthesis are often induced, reinforcing cell walls and antioxidant capacity but at a growth cost. The global picture is not a simple "metabolic decline" but a strategic re-budgeting from growth-centric metabolism toward survival-centric metabolism with yield loss as a systemic emergent outcome.

In plant physiological processes, salt stress first disturbs plant water relations, creating an external osmotic potential lower than that of root tissues and thereby reducing the soil–plant water gradient. Roots experience immediate "physiological drought," lowering cell turgor, inhibiting cell expansion and constraining leaf elongation. Prolonged osmotic strain triggers sustained abscisic acid (ABA) biosynthesis in roots and leaves, promoting stomatal closure to limit transpirational water loss. This hydraulic-hormonal coupling conserves water but simultaneously restricts CO_2 uptake and suppresses photosynthetic rate, establishing a trade-off between water saving and carbon gain.

Ion toxicity constitutes the second major physiological axis. Excess Na^+ and Cl^- entering roots displace K^+ at transporters and binding sites, destabilizing enzyme activation, ribosomal function and guard-cell ion homeostasis. Plants deploy multiple tiers of ion homeostasis — Na^+ extrusion (SOS1), retrieval from xylem, and vascular sequestration — to insulate the cytosol, but these processes are energetically expensive and rarely fully compensatory under chronic stress. Ion imbalance further feeds forward to metabolic down-regulation and premature senescence.

Oxidative stress is a parallel and integrated physiological consequence. Salinity elevates ROS formation in chloroplasts, mitochondria and peroxisomes due to disrupted electron transport and metabolic bottlenecks. ROS attack lipids, proteins and nucleic acids, impairing membrane integrity and enzymatic function. Plants counter with enzymatic (SOD, CAT, APX, GR) and non-enzymatic (ascorbate, glutathione, phenolics, flavonoids) antioxidants, but the balance

between ROS generation and scavenging often leans toward molecular injury under sustained stress.

Additional layers of physiological re-programming involve altered nutrient transport (reduction in NO_3^-, P, Ca^{2+} acquisition), hormonal cross-talk (ABA–GA–ethylene–cytokinin rebalancing), and mechanical outcomes such as reduced cell wall extensibility due to lowered expansion activity and re-partitioning toward lignification. Collectively, these shifts reflect not random impairment but a coordinated physiological pivot from growth optimization to stress survival, with yield loss emerging as the systemic cost of maintaining viability under salinity.

Salinity is one of the major abiotic constraints that restricts plant establishment and early growth. When plants are grown under non-saline conditions, germination and seedling development proceed without osmotic constraints, allowing seeds to imbibe water readily and metabolic enzymes to activate efficiently. In an environment free of excess soluble salts, plants maintain stable internal ion homeostasis, normal photosynthesis, and continuous cell expansion, resulting in healthy and vigorous seedlings.

In contrast, saline conditions impose both osmotic stress and specific ion toxicity, primarily from sodium and chloride ions. The high salt concentration lowers the soil water potential, making water physiologically less available even when moisture is present. This inhibits imbibition during germination and slows cell elongation in seedlings. As salt accumulates in plant tissues, it interferes with metabolic enzymes, disrupts membrane integrity, and inhibits chlorophyll synthesis. Consequently, plants under salt stress often display delayed germination, reduced radicle and plumule elongation, leaf chlorosis, necrotic lesions, and overall lower biomass.

Beyond the immediate effects on early growth, salinity also alters stomatal behaviour and reduces photosynthetic efficiency. Plants frequently close stomata to limit further water loss under osmotic stress, but this also restricts carbon dioxide uptake, lowering carbon assimilation and plant productivity. Additionally, ionic imbalance triggers the generation of reactive oxygen species, which further damages cellular components unless detoxified by antioxidant systems. These combined effects mean that even mild salinity can translate into significant reductions in early vigour and subsequent yield.

Therefore, comparison of plant growth under saline and non-saline conditions consistently shows that the absence of salinity promotes rapid germination, robust seedling establishment, efficient metabolism, and sustained physiological performance, whereas the presence of

salinity imposes multiple layers of stress that cumulatively depress plant growth and productivity.

1.6.2 Responses, Salt tolerance and adaptation of plant salinity

Plants exposed to salinity deploy a combination of physiological, biochemical and morphological strategies to survive. A central component of salt tolerance is the ability to exclude, compartmentalize, or detoxify excess Na^+ and Cl^- ions while maintaining cellular homeostasis. Salt-tolerant plants (halophytes) often achieve ion homeostasis by reducing Na^+ uptake at the root surface, sequestering absorbed Na^+ into root vacuoles, or translocating it to older leaves for safe storage. In addition, they sustain osmotic balance by accumulating compatible solutes such as proline, glycine betaine and soluble sugars, which stabilize proteins and membranes without interfering with metabolism.

Another key adaptive mechanism is the activation of antioxidant defence systems (e.g. SOD, CAT, APX), which mitigate oxidative stress caused by salt-induced ROS accumulation. Morphological adaptations, including succulence, reduced leaf area, salt glands, and deeper root systems, also contribute to lowering salt injury and maintaining water uptake. At the cellular level, stress-responsive genes, ion transporters (e.g. NHX, HKT), and signaling molecules (Ca^{2+}, ABA, NO) modulate metabolic pathways to reprogram growth under saline conditions. Through this integrated suite of exclusion, tolerance, and repair mechanisms, salt-adapted plants preserve growth and metabolic function even under high external salinity, allowing survival and productivity in salt-affected environments.

Plants adapt to salt stress through a multi-faceted response that includes ion homeostasis (like excluding sodium and using transporters), osmotic adjustment (accumulating compatible solutes like proline and trehalose), and antioxidant defence (scavenging reactive oxygen species). These mechanisms, regulated by complex signaling pathways involving hormones and other molecules, allow plants to survive by managing ion toxicity, maintaining water potential, and repairing cellular damage caused by high salt concentrations.

Ion Homeostasis and Salt Tolerance

Maintaining ion homeostasis by ion uptake and compartmentalization is not only crucial for normal plant growth but is also an essential process for growth during salt stress. Irrespective of their nature, both glycophytes and halophytes cannot tolerate high salt concentration in their cytoplasm. Hence, the excess salt is either transported to the vacuole or sequestered in older tissues which eventually are sacrificed, thereby protecting the plant from salinity stress.

Major form of salt present in the soil is NaCl, so the main focus of research is the study about the transport mechanism of Na+ ion and its compartmentalization. The Na+ ion that enters the cytoplasm is then transported to the vacuole via Na+/H+ antiporter. Two types of H+ pumps are present in the vacuolar membrane: vacuolar type H+-ATPase (V-ATPase) and the vacuolar pyrophosphatase (V-PPase). Of these, V-ATPase is the most dominant H+ pump present within the plant cell. During nonstress conditions it plays an important role in maintaining solute homeostasis, energizing secondary transport and facilitating vesicle fusion. Under stressed condition the survivability of the plant depends upon the activity of V-ATPase.

1.6.3 Role of plant hormones in modulating stress response

Plant hormones (phytohormones) act as chemical signals that integrate perception of stress with physiological responses. Under abiotic stresses (salinity, drought, heat, cold, oxidative stress) and biotic stresses (pathogen/herbivore attack), they reprogram growth, metabolism, and gene expression to improve survival. These hormones interact with each other in complex, often antagonistic or synergistic ways, and also with other hormones like auxins and cytokinins, to fine-tune the plant's overall stress tolerance.

Role of Specific Plant Hormones in Stress Responses

1) Abscisic Acid (ABA) — Core stress hormone

Rapidly accumulates under drought/salinity. Induces stomatal closure to reduce transpiration. Activates ABA-responsive genes (e.g. LEA proteins, osmoprotectants).

It also regulates root hydraulic conductivity and ion transport.

2) Salicylic Acid (SA) — Immunity & defense priming

Central in systemic acquired resistance (SAR) to biotrophic pathogens. Induces pathogenesis-related (PR) proteins. Crosstalks with ROS and redox signaling.

3) Jasmonic Acid (JA) — Wounding & herbivory stress

Activated by chewing insects, wounding, necrotrophs. Promotes defence proteins (protease inhibitors, secondary metabolites). Interacts antagonistically with SA.

4) Ethylene — Stress signaling & growth adjustment

Induced by mechanical, flooding, temperature, biotic stress. It modulates cell expansion, senescence, and defence gene networks. Synergizes with JA in necrotroph resistance.

5) Auxin — Growth reallocation under stress

Stress often suppresses auxin transport to shoots. It promotes root plasticity (lateral roots, aerenchyma under flooding). Crosstalks with ABA in drought-induced root architecture.

6) Cytokinins — Growth vs. survival balance

Usually decrease under stress to suppress growth. Exogenous CKs can delay senescence and enhance stress tolerance by maintaining chlorophyll.

7) Gibberellins (GAs) — Growth restraint during stress. Stress reduces GA levels/signaling to conserve energy. DELLA proteins accumulate, enhancing stress tolerance genes.

1.7 AIMS AND OBJECTIVES OF THE RESEARCH

AIMS: The study was carried at investigating the effect of salinity on germination and seedling growth of *Corchorus olitorius* L.

OBJECTIVES

The objectives of the study are to:

1. Evaluate the impact of different salt concentration (e.g, Nacl solutions) on the germination rate and percentage of jute seeds.
2. Understand how different levels of salt stress affects various parameters such as germination percentage, germination rate, seedling length, stem girth, internode length.
3. Determine the salt concentration levels that significantly inhibits *Corchorus olitorius* L. germination and seedling growth.

CHAPTER TWO

MATERIALS AND METHODS

2.1 Materials and equipment

The following materials were used for the purpose of the study.

They include loamy soil, polythene bags, bamboo sticks, sodium chloride (NaCl), distilled water, and laboratory grade glassware.

2.2 Methodology

2.2.1 Study Area

The experiment was conducted at the Department of Plant Biology and Biotechnology, Faculty of Life Sciences, University of Benin, Edo State Nigeria.

2.2.2 Collection of Samples

Source of Seed

The seeds of *Corchorus olitorius* L. were gotten from Ondo State, Edo State (Benin), Delta State and NIHORT Research Institute.

Source of Treatment

Sodium Chloride used for this experiment was gotten from Prof. Edegbai's Laboratory.

2.2.3 Treatment Preparation

Treatment V = 20 litres of water diluted with 0.1g of Nacl

Treatment W = 20 litres of water diluted with 0.4g of Nacl

Treatment X = 20 litres of water diluted with 40g of Nacl

Treatment Y = 20 litres of water diluted with 100g of Nacl

Treatment Z = 20 litres of water diluted with 200g of Nacl

2.2.4 Seed Planting

After collection, seeds from the various landraces were sorted. 10 seeds were planted in each polythene bags. These polythene bags were filled with dry loamy soil and observed for 8 days before germination started.

2.2.5 Experimental Set Up

This study was carried out using 5 treatments and control identified as follows:

Category 0 (control); 5ppm (Not Saline)

Category 1 (non-saline sodic); 200ppm

Category 2 (Slightly sodic-saline); 2000ppm

Category 3 (Medium); 5000ppm

Category 4 (Highly sodic-saline); 10,000ppm

The experiment will be conducted in a completely randomized design (CRD) with 5 salinity levels as stated above. Salinity treatments will be applied to the plants every two days.

All treatments were in five replicates and 10 seeds per polythene bags were planted.

2.2.6 Germination Study

Germination percentage is the estimate of the viability of the seed

Represented mathematically,

$$GP = \frac{\text{Number of seed germinated}}{\text{Total number of seeds planted}} \times 100$$

2.2.7 Other Parameters of the Study

Shoot Length

The height of the plant was measured from the base of the plant to its terminal bud. It was taken with a ruler (cm) and was taken weekly.

Stem Girth

The stem girth was measured 1cm from the point of emergence with a pair of dividers and placed on the ruler (cm) on the 21st day and was done weekly.

Number of Leaves

The number of leaves were counted and recorded for each plants on the 21st day and was taken weekly.

Number of Branches

The number of branches were counted and recorded on the 21st day and was taken weekly.

Internode Length

This is the length between two successive nodes of the plants to its terminal bud. The internode length was taken on the 21st day and afterwards taken weekly.

Leaf Loss

The leaf loss was counted and recorded on the 21st day and taken weekly.

Leaf Area

Leaf area was determined by measuring the length and breadth of the leaf from the point of emergence on the 21st day multiplied by the plant's leaf area constant.

$A = L \times B \times 0.65$

Where A is the leaf area

L is the length of leaf

B is the breadth of leaf

Statistical Analysis

The readings from initial germination were calculated, results were given in percentage germination and sample standard deviation also in percentage. Conversely, mean and sample standard deviation were calculated to determine if there was any significant difference between the physiological characters observed in the various landraces of *Corchorus olitorius* L. being studied.

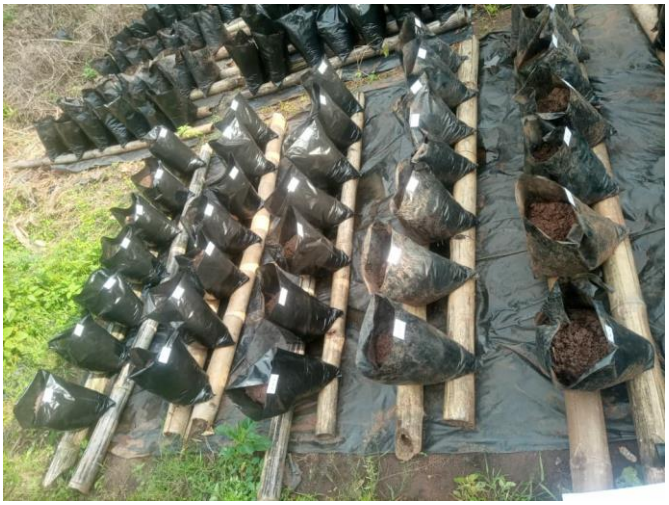

Plate 2.1: Experimental setup

Plate 2.2: Growth stage

Plate 2.3: Maturation stage

CHAPTER THREE

RESULTS

The results of the effect of salinity stress on the germination and seedling growth of *Corchorus olitorius* L. are interpreted below;

Table 3.1 shows the effect of salt stress on the germination of *Corchorus olitorius* L. seeds from Ondo (A) from the eighth day of planting to fifteenth day of planting. It shows the percentage mean and sample standard deviation value of germination of *Corchorus olitorius* L. seeds from the land race A (Ondo). The seeds the received 5ppm NaCl solution (control / treatment V), 2000ppm NaCl solution (treatment X) started germination on the eighth day. Higher germination rate (26.67 ± 2.31) was recorded on treatment W than treatment Y and Z (3.33 ± 0.58) on the eighth day. The record also showed treatment W had higher germination rate (30.00 ± 3.00) than other treatments, but treatment Y and Z had lower germination records (3.33 ± 0.58). Therefore, this indicated that treatment W improved germination compared to control (V) and other treatments (W, X, Y, Z). Treatment X, Y and Z had the least records of germination (10.00 ± 1.00, 3.33 ± 0.58).

Table 3.2 shows the percentage mean and the standard deviation value of *Corchorus olitorius* L. seeds from the landrace E (NIHORT). The seeds that received 5ppm Nacl solution (control / treatment V), 200ppm (treatment W) 2000ppm (treatment X), 5000ppm (treatment Y) and 10,000ppm (treatment Z) germinated on the eighth day. The highest germination rate was recorded on treatment W from day 8 to day 15 (86.67 ± 1.15, 96.67 ± 0.58) on germination. The lowest germination rate was recorded on treatment Z from day 8 to day 15 (16.67 ± 2.08, 40.00 ± 4.58). This shows that treatment W is considered the best treatment when compared to other treatments.

Table 3.3 shows the effect of salt stress on the shoot height of *Corchorus olitorius* L. seeds from Ondo (Landrace A) from day 21 to day 56. Treatment W recorded the highest sooth height (15.33 ± 26.58) throughout the study, Treatment V (control) recorded no shoot height due to the death of seedlings once grown. Treatment X, Y and Z recorded no shoot height due to high salt concentrations.

Table 3.1: Effect of treatment with NaCl on the germination (%) of *Corchorus olitorius* L. from landrace A (Ondo)

Treatments	Time (Days)							
	8	**9**	**10**	**11**	**12**	**13**	**14**	**15**
V	16.67 ± 1.53^{b}	20.00 ± 2.00^{b}	20.00 ± 2.00^{b}	16.67 ± 1.53^{b}	16.67 ± 1.53^{b}	16.67 ± 1.53^{b}	16.67 ± 1.53^{b}	16.67 ± 1.53^{b}
W	26.67 ± 2.31^{a}	26.67 ± 2.31^{a}	26.67 ± 2.31^{a}	30.00 ± 3.00^{a}	30.00 ± 3.00^{a}	30.00 ± 3.00^{a}	30.00 ± 3.00^{a}	30.00 ± 3.00^{a}
X	10.00 ± 1.00^{b}	10.00 ± 1.00^{b}	10.00 ± 1.00^{b}	13.33 ± 1.15^{b}	13.33 ± 1.15^{b}	13.33 ± 1.15^{b}	13.33 ± 1.15^{b}	13.33 ± 1.15^{b}
Y	3.33 ± 0.58^{c}	3.33 ± 0.58^{c}	3.33 ± 0.58^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}
Z	3.33 ± 0.58^{c}	3.33 ± 0.58^{c}	3.33 ± 0.58^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}

Means with the same letters along each column are not significantly different at p=0.05

Results on each column represents percentage mean and sample standard deviation

Table 3.2: Effect of treatment with NaCl on the germination (percentage) of *Corchorus olitorius* L. from landrace E (NIHORT)

Treatments	Time (Days)							
	8	**9**	**10**	**11**	**12**	**13**	**14**	**15**
V	70.00 ± 1.00[b]	70.00 ± 1.00[b]	70.00 ± 1.00[b]	50.00 ± 4.00[b]	50.00 ± 4.00[b]	50.00 ± 4.00[b]	50.00 ± 4.00[b]	50.00 ± 4.00[b]
W	86.67 ± 1.15[a]	86.67 ± 1.15[a]	86.67 ± 1.15[a]	86.67 ± 1.15[a]	96.67 ± 0.58[a]	96.67 ± 0.58[a]	96.67 ± 0.58[a]	96.67 ± 0.58[a]
X	40.00 ± 1.00[b]	40.00 ± 1.00[b]	40.00 ± 1.00[b]	36.67 ± 1.15[b]	36.67 ± 1.15[b]	36.67 ± 1.15[b]	36.67 ± 1.15[b]	36.67 ± 1.15[b]
Y	3.33 ± 1.15[d]	3.33 ± 1.15[d]	3.33 ± 1.15[d]	10.00 ± 1.00[d]	10.00 ± 1.00[d]	10.00 ± 1.00[d]	10.00 ± 1.00[d]	10.00 ± 1.00[d]
Z	16.67 ± 2.08[c]	16.67 ± 2.08[c]	16.67 ± 2.08[c]	40.00 ± 4.58[c]	40.00 ± 4.58[c]	40.00 ± 4.58[c]	40.00 ± 4.58[c]	40.00 ± 4.58[c]

Means with the same letters along each column are not significantly different at p=0.05

Results on each column represents percentage mean and sample standard deviation

Table 3.3: Effect of treatment with NaCl on the shoot height (cm) of *Corchorus olitorius* L. from landrace A (Ondo)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
W	1.67 ± 2.89^{a}	2.50 ± 4.33^{a}	4.83 ± 8.37^{a}	8.33 ± 14.43^{a}	12.83 ± 22.23^{a}	15.33 ± 26.58^{a}
X	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Y	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Z	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}

Results on each column represents mean and sample standard deviation

Table 3.4 shows the effect of salt stress on the shoot height of *Corchorus olitorius* L. seeds from (NIHORT) Research Institute (E). Treatment W recorded the highest number of shoot height (56.17 ± 17.87) followed by treatment V and X (38.83 ± 33.67, 33.23 ± 12.08). Then treatment Y and Z recorded no shoot height due to extremely high salt concentration.

Table 3.5 shows the effect of salt stress on the number of branches on *Corchorus olitorius* L. seedlings gotten from Ondo (Landrace A). Treatment V (control) recorded no number of branches due to the death of seedlings once germinated. Treatment W recorded the highest number of branches (8.33 ± 14.44) Treatment X, Y and Z recorded no number of branches as a result of high salt concentrations.

Table 3.6 shows the effect of salt stress on the number of branches of *Corchorus olitorius* L. seedlings from (NIHORT) Research Institute (E). Treatment V (control) W, X, Y and Z recorded no value for number of branches on day 21. Treatment V, W and X had recorded values on the number of branches from day 28 (3.33 ± 3.06, 7.33 ± 2.89, 6.67 ± 1.53). Treatment W had the highest number of branches recorded (26.33 ± 3.06) but treatment Y and Z had none due to extremely high salt concentrations.

Table 3.7 shows the effect of salt stress on the leaf area of *Corchorus olitorius* L. seedlings gotten from Ondo (Landrace A).Treatment V (control) had no record on leaf area due to the death of seedlings once grown. Treatment W had the highest and only record on leaf area throughout the study (9.06 ± 15.68), Treatment X, Y and Z had no record on leaf area due to extremely high salt concentrations.

Table 3.8 shows the effect of salt stress on the leaf area of *Corchorus olitorius* L. seedlings from (NIHORT) Research Institute (E). Treatment V (control) recorded data on the leaf area from day 21 to day 56 (1.95 ± 1.76, 15.23 ± 13.82). Treatment W has the highest record on the leaf area (30.25 ± 2.36), followed by treatment X (29.02 ± 9.94). Treatment Y and Z had no record on leaf area due to high salt concentrations

Table 3.4: Effect of treatment of NaCl on the shoot height (cm) of *Corchorus olitorius* L. from landrace E (NIHORT)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	7.50 ± 8.35^{b}	6.07 ± 5.29^{b}	13.23 ± 11.48^{b}	24.23 ± 21.02^{b}	32.73 ± 28.36^{b}	38.83 ± 33.67^{b}
W	6.50 ± 1.00^{a}	9.23 ± 2.20^{a}	19.17 ± 7.70^{a}	32.17 ± 12.95^{a}	44.00 ± 15.21^{a}	56.17 ± 17.87^{a}
X	5.07 ± 1.79^{b}	7.47 ± 0.47^{b}	12.93 ± 0.12^{b}	19.00 ± 3.28^{b}	24.67 ± 5.39^{b}	33.23 ± 12.08^{b}
Y	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}
Z	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}

Means with the same letters along each column are not significantly different at p=0.05

Results on each column represents mean and sample standard deviation

Tables 3.5: Effect of treatment with NaCl on the number of branches of *Corchorus olitorius* L. from landrace A (Ondo)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
W	2.00 ± 3.46^{a}	2.00 ± 3.46^{a}	4.00 ± 6.93^{a}	5.00 ± 8.66^{a}	6.33 ± 10.97^{a}	8.33 ± 14.44^{a}
X	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Y	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Z	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}

Results on each column represents mean and sample standard deviation

Table 3.6: Effect of treatment of NaCl on the number of branches of *Corchorus olitorius* L. from landrace E (NIHORT)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0^{b}	3.33 ± 3.06^{b}	6.00 ± 5.29^{b}	8.67 ± 7.57^{b}	12.67 ± 10.96^{b}	13.67 ± 11.84^{b}
W	0^{a}	7.33 ± 2.89^{a}	11.33 ± 2.89^{a}	15.00 ± 2.65^{a}	20.00 ± 2.65^{a}	26.33 ± 3.06^{a}
X	0^{b}	6.67 ± 1.53^{b}	9.67 ± 2.08^{b}	11.67 ± 3.22^{b}	14.00 ± 3.61^{b}	20.00 ± 4.58^{b}
Y	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}
Z	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}

Means with the same letters along each column are not significantly different at p=0.05

Results on each column represents mean and sample standard deviation

Table 3.7: Effect of treatment with NaCl on the Leaf area of *Corchorus olitorius* L. from landrace A (Ondo).

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
W	0.26 ± 0.45^{a}	2.33 ± 4.04^{a}	6.20 ± 10.74^{a}	7.50 ± 12.99^{a}	8.34 ± 14.45^{a}	9.06 ± 15.68^{a}
X	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Y	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Z	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}

Results on each column represents mean and sample standard deviation

Table 3.8: Effect of treatment of NaCl on the leaf area of *Corchorus olitorius* L. from landrace E (NIHORT)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	1.95 ± 1.76^{b}	6.31 ± 5.61^{b}	9.62 ± 8.47^{b}	11.02 ± 9.92^{b}	14.13 ± 13.46^{b}	15.23 ± 13.82^{b}
W	5.49 ± 2.08^{a}	12.70 ± 4.55^{a}	19.18 ± 3.10^{a}	23.26 ± 2.88^{a}	26.50 ± 1.58^{a}	30.25 ± 2.36^{a}
X	4.07 ± 1.09^{b}	8.41 ± 3.56^{b}	17.57 ± 5.93^{b}	21.21 ± 7.00^{b}	25.69 ± 9.48^{b}	29.02 ± 9.94^{b}
Y	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}
Z	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}

Means with the same letters along each column are not significantly different at p=0.05

Results on each column represents mean and sample standard deviation

Table 3.9 shows the effect of salt stress on number of leaves of *Corchorus olitorius* L. seedlings gotten from Ondo (Landrace A). Treatment V (control) had no record of number of leaves from day 21 to day 56. Treatment W had the highest record on number of leaves (23.33 ± 40.43). Treatment X, Y and Z had no record as a result of extremely high salt concentrations.

Table 3.10 shows the effect of salt stress on the number of leaves of *Corchorus olitorius* L. seedlings from (NIHORT) Research Institute (E). Treatment V (control) has the least record on number of leaves (45.00 ± 39.51), while treatment W had the highest record on the number of leaves (91.33 ± 18.57), followed by treatment X (46.33 ± 26.51). Treatment Y and Z had no records due to high salt concentrations.

Table 3.11 shows the effect of salt stress on the stem girth of *Corchorus olitorius* L. seedlings gotten from Ondo (Landrace A). From day 21 to day 56 treatment V (control) had no record of stem girth due to the death of seedlings once grown. Treatment W had the highest and only record on stem girth from day 21 to day 56 (0.13 ± 0.23, 0.27 ± 0.46). Treatment X, Y and Z had no record due to extremely high salt concentrations.

Table 3.12 shows the effect of salt stress on steam girth of *Corchorus olitorius* L. seedlings from (NIHORT) Research Institute (E). Treatment W had the highest record of stem girth (0.90 ± 0.10), Followed by treatment X (0.87 ± 0.15) and Treatment V (control) had the least record on stem girth (0.67 ± 0.57). Treatment Y and Z had no record due to high salt concentrations.

Table 3.13 shows the effect of salt stress of internode length of *Corchorus olitorius* L. seedlings gotten from Ondo (Landrace A). Treatment W had the only and highest record on internode length from day 21 to day 56 (0.00 ± 0.56, 2.00 ± 2.46). Treatment V (control), X, Y and Z had no record due to the death of seedlings once grown and extremely high salt concentrations.

Table 3.14 shows the effect of salt stress of internode length of *Corchorus olitorius* L. seedlings from (NIHORT) Research Institute (E). Treatment V (control), W and X had records on internode lengths from day 21 to day 56 (0.83 ± 1.44, 1.90 ± 3.29, 1.13 ± 0.40, 7.23 ± 0.55, 0.50 ± 0.17, 5.50 ± 0.50). Treatment W had the highest record (1.13 ± 0.40, 7.23 ± 0.55). Treatment Y and Z had no record due to high salt concentrations.

Table 3.9: Effect of treatment with NaCl on the number of leaves of *Corchorus olitorius* L. from landrace A (Ondo).

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
W	1.67 ± 2.89^{a}	2.33 ± 4.04^{a}	7.67 ± 13.28^{a}	13.33 ± 29.09^{a}	17.33 ± 30.02^{a}	23.33 ± 40.43^{a}
X	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Y	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Z	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}

Results on each column represents mean and sample standard deviation

Table 3.10: Effect of treatment of NaCl on the number of leaves of *Corchorus olitorius* L. from landrace E (NIHORT)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	3.33 ± 3.06^{b}	4.67 ± 4.04^{b}	17.33 ± 15.31^{b}	27.33 ± 24.00^{b}	37.33 ± 32.58^{b}	45.00 ± 39.51^{b}
W	6.33 ± 0.57^{a}	13.00 ± 5.20^{a}	31.33 ± 16.26^{a}	46.33 ± 12.01^{a}	63.67 ± 11.06^{a}	91.33 ± 18.57^{a}
X	6.00 ± 0.00^{b}	8.00 ± 2.64^{b}	14.00 ± 3.46^{b}	23.00 ± 11.14^{b}	34.67 ± 18.58^{b}	46.33 ± 26.51^{b}
Y	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}
Z	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}

Means with the same letters along each column are not significantly different at p=0.05

Results on each column represents mean and sample standard deviation

Table 3.11: Effect of treatment with NaCl on the stem girth of *Corchorus olitorius* L. from landrace A (Ondo)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
W	0.13 ± 0.23^{a}	0.13 ± 0.23^{a}	0.17 ± 0.28^{a}	0.20 ± 0.34^{a}	0.27 ± 0.46^{a}	0.27 ± 0.46^{a}
X	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Y	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Z	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}

Results on each column represents mean and sample standard deviation

Table 3.12: Effect of treatment of NaCl on the stem girth of *Corchorus olitorius* L. from landrace E (NIHORT)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0.17 ± 0.15^{b}	0.17 ± 0.15^{b}	0.37 ± 0.32^{b}	0.50 ± 0.43^{b}	0.60 ± 0.52^{b}	0.67 ± 0.57^{b}
W	0.33 ± 0.05^{a}	0.33 ± 0.05^{a}	0.57 ± 0.15^{a}	0.67 ± 0.15^{a}	0.87 ± 0.15^{a}	0.90 ± 0.10^{a}
X	0.33 ± 0.11^{b}	0.33 ± 0.11^{b}	0.50 ± 0.00^{b}	0.53 ± 0.05^{b}	0.67 ± 0.05^{b}	0.87 ± 0.15^{b}
Y	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}
Z	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}

Means with the same letters along each column are not significantly different at p=0.05

Results on each column represents mean and sample standard deviation

Table 3.13: Effect of treatment with NaCl on the internode length of *Corchorus olitorius* L. from landrace A (Ondo)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
W	0.00 ± 0.57^{a}	0.40 ± 0.69^{a}	1.00 ± 1.73^{a}	1.27 ± 2.19^{a}	1.83 ± 3.18^{a}	2.00 ± 3.46^{a}
X	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Y	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Z	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}

Results on each column represents mean and sample standard deviation

Table 3.14: Effect of treatment of NaCl on the internode length of *Corchorus olitorius* L. from landrace E (NIHORT).

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0.83 ± 1.44^{b}	0.83 ± 1.44^{b}	1.67 ± 2.88^{b}	1.73 ± 3.00^{b}	1.83 ± 3.18^{b}	1.90 ± 3.29^{b}
W	1.33 ± 0.40^{a}	1.27 ± 0.49^{a}	3.20 ± 1.10^{a}	5.07 ± 0.40^{a}	6.76 ± 0.40^{a}	7.23 ± 0.55^{a}
X	0.50 ± 0.17^{b}	0.47 ± 0.31^{b}	2.47 ± 0.46^{b}	3.40 ± 0.36^{b}	4.33 ± 1.25^{b}	5.50 ± 0.50^{b}
Y	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}
Z	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}

Means with the same letters along each column are not significantly different at p=0.05

Results on each column represents mean and sample standard deviation

Table 3.15 shows the effect on salt stress on the loss of leaves of *Corchorus olitorius* L. seedlings gotten from Ondo (Landrace A) from day 21 to day 56. Treatment W had the highest record on the loss of leaves from day 21 to day 56 (0.33 ± 0.57, 5.67 ± 9.81). Treatment V (control) X, Y and Z had no record due to death of plants and high salt concentrations.

Table 3.16 shows the effect of salt stress on loss of leaves of of *Corchorus olitorius* L. seedlings from (NIHORT) Research Institute (E) from day 21 to day 56. Treatment W and X had the highest records on the loss of leaves from day 21 to day 56 (1.67 ± 0.57, 11.67 ± 3.21, 1.33 ±0.57, 11.67 ± 1.52). Treatment V (control) had the least record (0.67 ± 1.15, 5.00 ± 8.66). Treatment Y and Z had no record due to extremely high salt concentrations.

Table 3.15 Effect of treatment with NaCl on the loss of leaves of *Corchorus olitorius* L. from landrace A (Ondo)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
W	0.33 ± 0.57^{a}	0.67 ± 1.41^{a}	1.33 ± 2.31^{a}	2.33 ± 4.04^{a}	4.00 ± 6.93^{a}	5.67 ± 9.81^{a}
X	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Y	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}
Z	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}

Results on each column represents mean and sample standard deviation

Table 3.16 Effect of treatment of NaCl on the loss of leaves of *Corchorus olitorius* L. from landrace E (NIHORT)

Treatments	Time (Days)					
	21	**28**	**35**	**42**	**49**	**56**
V	0.67 ± 1.15^{b}	0.67 ± 1.15^{b}	1.67 ± 2.89^{b}	2.33 ± 4.04^{b}	4.00 ± 6.93^{b}	5.00 ± 8.66^{b}
W	1.67 ± 0.57^{a}	2.33 ± 0.57^{a}	5.00 ± 1.00^{a}	5.67 ± 0.57^{a}	7.67 ± 1.53^{a}	11.67 ± 3.21^{a}
X	1.33 ± 0.57^{b}	2.00 ± 0.00^{b}	4.33 ± 1.52^{b}	6.67 ± 1.52^{b}	9.00 ± 1.00^{b}	11.67 ± 1.52^{b}
Y	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}
Z	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}

Means with the same letters along each column are not significantly different at p=0.05

Results on each column represents mean and sample standard deviation

CHAPTER FOUR

DISSCUSSION

Salinity is one of the major abiotic stresses that adversely affect crop production by disrupting plant physiological and biochemical processes. This research was carried out to evaluate the effect of salinity on germination and seedling growth of *Corchorus olitorius* L. and to determine the salt concentration levels that can inhibit or promote germination and seedling growth of *Corchorus olitorius* L.

In the study, the result for germination percentage in Ondo landmark A shows that there was significant difference between Treatment W, control and other treatments. Data record for W showed a great effect on enhancing the effect of salt on germination. There was no significant difference between V (control) and X. Treatment Y and Z showed no germination with no significant difference between them. This shows that the high salinity levels (Y and Z) inhibits germination. This conforms the findings of Munns and Testers (2008), who demonstrated that salinity delays germination by limiting water absorption and disrupting activities essential for seed metabolism. The result for germination percentage in NIHORT Research institute (Landrace E) shows that the treatment V (control) supports the growth of plants with little amount of salts that is not shown. Treatment W recorded the highest value and germination was significantly enhanced followed by treatments X, Y and Z significantly reduced germination due to high salt concentrations.

Shoot Length in Ondo (Landmark A) was significantly reduced under high salinity levels. Treatment W recorded the highest height and it significantly enhanced growth in shoot length compared to control and other treatments. For seeds from NIHORT research institute (Landrace E), Treatment V (control), W and X enhanced growth in shoot length compared to Y and Z which showed minimal or no growth at all. The result from the number of branches in Ondo (landrace A) shows there was no significant difference between treatment V (control), X, Y and Z due to no growth of plant as a result of the death of seedlings. Treatment W had the highest and only record for the number of branches this shows that W enhanced the growth of plant with moderate amount of salt concentrations. In Landrace E, Treatment V (control), W and X significantly enhanced the growth of plants but Y and Z inhibited the growth of plants.

Leaf area, number of leaves and stem girth were also significantly influenced by salinity. Treatment W recorded the highest in all parameters ranging from Landrace A and E (Ondo and

NIHORT Research institute) with leaf area of 15.8cm^3, 30.25cm^3, 2.33 leaves, 6.33 leaves and a stem girth of 0.46 and 0.90cm. Data for V (control) showed moderate performance with a leaf area of 6.31cm^3 and 5.61cm^3, 3.33 leaves and a stem girth of 0.67. Treatment X recorded the leaf area of 4.07cm, 6.00 leaves and stem girth 0.87. Treatment X and Y showed no growth. These observations confirmed the studies of Flowers *et al*. (2010), who showed that the high salt concentrations reduced chlorophyll content, leaf expansion and stem development by disrupting metabolic processes.

CONCLUSION

The findings of this study showed that higher salinity levels inhibited and negatively affected *Corchorus olitorius* L. germination and seedlings growth with reductions in all the measured parameters from the two different landraces: Ondo (A) and NIHORT Research Institute(E). The treatment W with moderate salinity was the most effective treatment, showing the highest performance in all measured parameters, followed by treatment X and V (control). Treatment Y and Z showed no growth due to high salt concentrations which led to the death of plants once grown.

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