

**AN INVESTIGATION OF THE EFFECT OF SALT STRESS ON
GERMINATION AND SEEDLING GROWTH OF *Corchorus olitorius***

L. FROM BENIN CITY AND NIHORT



BY

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SR/2306/RPR/25/48

DEPARTMENT OF PLANT BIOLOGY AND BIOTECHNOLOGY

FACULTY OF LIFE SCIENCES

UNIVERSITY OF BENIN

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**A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF
PLANT BIOLOGY AND BIOTECHNOLOGY, IN THE FACULTY OF
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OCTOBER, 2025

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CERTIFICATION

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DATE

EXTERNAL EXAMINER

DATE

DEDICATION

I dedicate this project to God almighty, to my lovely parents, Mr. and Mrs. J. Ehigiator, my siblings, and also to my esteemed supervisor, Prof. B. O. Edegbai.

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ABSTRACT

Salt stress is an abiotic factor which poses significant threat to plant growth and productivity. A variety of plants are sensitive to salinity, one of which, is *Corchorus olitorius*. This study investigated the effect of salt stress on the germination, seedling growth, and physiological responses of *Corchorus olitorius* seeds collected from Benin (Landrace B) and National Horticultural Research Institute (NIHORT) designated as Landraces C. This experiment was conducted to determine how different concentrations of sodium chloride (NaCl) influenced germination percentage and the various growth parameters namely shoot height, number of leaves, leaf area, stem girth, number of branches, internode length, and leaf loss. The seeds were subjected to five treatments including control (5 ppm NaCl solution) and other varying salt concentrations (200 ppm, 2000 ppm, 5000 ppm, and 10000 ppm). Data collected were subjected to Analysis of Variance (ANOVA) to determine the level significance of the treatments. The results revealed significant differences in the parameters investigated. Increasing salinity levels significantly reduced germination rate, shoot elongation, and overall seedling establishment. The treatments with concentrations below 2000ppm recorded the highest mean values for germination percentage and growth parameters, while the treatments with the highest concentration of salt exhibited severe inhibitory effects leading to reduced germination rate, stunted growth, and poor seedling development. These findings demonstrated that *C. olitorius* is sensitive to high salinity levels, and salt stress adversely affects its early growth stages. It also reveals that *C. olitorius* seeds from Benin city were

more sensitive to salt stress compared to *C. olitorius* seeds from NIHORT as higher germination percentage and growth were observed in landrace C.

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.1. INTRODUCTION

1.1.1. BACKGROUND OF STUDY

Salt stress is known as the most harmful abiotic stress factor that affects the agricultural productivity of many crops, with deleterious effect on seed germination, plant growth, physiological and biochemical characteristics, vigor and crop yield (Zeenat *et al.*, 2020). It is an environmental condition where high concentrations of soluble salts (especially NaCl) in the soil negatively affect plant growth and productivity. This abiotic stress occurs as a result of excessive salt accumulation, thereby, leading to osmotic stress, ionic toxicity (especially from sodium), nutritional imbalances, and oxidative damage. In plants, it results in the disruption of the biochemical and physiological processes, water uptake from the soil, which eventually leads to a detrimental effect on the growth and development of plants.

Plants that are affected by salt stress undergo inhibited growth, reduced leaf expansion, low photosynthetic rate, impaired metabolism, which often result in reduced crop yield and may eventually lead to the death of the affected plant. Salt stress is one of the major abiotic stresses limiting crop production especially in arid and semi-arid regions. It is reported that about 7% of the total Earth's land and 20% of the total arable area are affected by high salt contents (Saiema *et al.*, 2013).

Salt stress results from increased salt concentration in soil. And the process of increasing the salt concentration in the soil is what we refer to as soil salinization. It can either be

caused naturally or anthropogenically (by human activities). The former includes mineral weathering, gradual withdrawal of an ocean and the latter includes irrigation with salt-rich water, and practice of water logging without adequate drainage. Soil salinization has posed a large threat to agriculture and global food security. Therefore, the comprehensive understanding of how various plants respond to different levels of salt stress and adopting strategies to reduce its detrimental effect is necessary.

One of the economically significant crops sensitive to salt stress is *Corchorus olitorius* (Jute or Jews mallow), a popular annual leafy vegetable which grows primarily in the seasonally dry tropical biome. *Corchorus olitorius* is a tropical, fast growing, annual herb, up to 4m tall, with a fibrous stem and yellow flowers in one to two month from the time of germination. It is of great economic value as it possesses significant nutritional and medicinal properties. It is consumed in most part of Africa (e.g Nigeria, South Africa) as vegetable. All the part of the plant has always been used as medicine to treat sicknesses in many parts of the world. The leaves are used to treat ailments like; gonorrhoea, tumors, malaria, typhoid fever, etc. However, despite being of great economic value, jute mallow is highly affected by salt stress, which impair its germination, growth, and productivity. Several studies have examined how *C. olitorius* responds to salinity at different developmental stage and under varying salt concentrations. These responses includes; germination response, morphological, biochemical, and physiological responses.

Salt stress is a major abiotic factor limiting the germination and early seedling development of *C. olitorius* . Exposure of the seeds to high salinity in the soil disrupts water uptake by seeds, causes ion imbalance, and disrupts cellular processes critical for

early plant growth. Germination is particularly sensitive to salinity, which reduces both the rate and final percentage of germinated seeds. At the seedling development stage, salt stress further affect the growth of *C. olitorius* by reducing root and shoot elongation, fresh and dry biomass, and overall seedling vigor. The osmotic effect of salt stress limit water absorption from the soil, while ionic toxicity- primarily due to excessive Na⁺ and Cl⁻-disrupts metabolic activity and cellular integrity. Studies have shown significant reduction in seedling height, root length, and biomass under salt concentrations above 100mM NaCl (Kouadio *et al.*, 2021).

Salinity imposes significant morphological alterations in *C. olitorius* , starting from germination to maturity. The major responses are; stunted shoot, smaller and discolored leaves, restricted root growth, delayed flowering, and reduced seed yield. These morphological traits can be used as a diagnostic markers for salinity stress and may serve as useful selection criteria in breeding programs aimed at improving salt tolerance In *C. olitorius*.

The biochemical responses of *Corchorus olitorius* to salt stress involve osmolyte accumulation, pigment degradation, enhanced antioxidant defenses, and altered ion homeostasis. These responses collectively function to minimize osmotic imbalance, protect cellular structures, and detoxify ROS (Reactive oxygen species). However, prolonged or severe salinity overwhelms these mechanisms, leading to chlorophyll loss, oxidative damage, and reduced productivity. Biochemical markers such as proline content, antioxidant enzyme activities, and K⁺/Na⁺ ratio can serve as reliable indicators for screening tolerance in *Corchorus olitorius* breeding programs (Flowers & Colmer, 2008).

The physiology of *Corchorus olitorius* is greatly affected by salt stress. It impairs photosynthesis, reduces stomatal conductance, disrupt water balance, and causes ion toxicity through Na⁺ and Cl⁻ accumulation. These disturbances lead to pigment degradation, oxidative stress, and reduced membrane stability. The decline in K⁺/Na⁺ ratio and chlorophyll fluorescence efficiency are key physiological markers of salt sensitivity in *Corchorus olitorius*.

Understanding these responses provides a basis for screening and breeding salt tolerant varieties, thereby enhancing *Corchorus olitorius* growth in saline prone environment.

1.1.2. SIGNIFICANCE OF STUDY

The investigation of the effect of salt stress on the germination and seedling development of *Corchorus olitorius* (jute or Jews mallow) is of high significance as it addresses both scientific and practical concerns regarding the cultivation of *C. olitorius*, an important leafy vegetable and fiber crop widely grown in tropical and sub-tropical regions. Soil salinity is a growing problem worldwide due to climate change, poor irrigation practices, and rising sea levels which directly threatens the productivity of salt-sensitive crops such as *C. olitorius* (Mukhopadhyay *et al.*, 2021). The significance of this study lies in its potential to enhance food and nutritional security, promote sustainable agriculture, sustain economic value, and broaden scientific understanding of *C. olitorius* adaptation to salt stress.

SCIENTIFIC AND BIOLOGICAL SIGNIFICANCE

1. Understanding the physiological and morphological response of *Corchorus olitorius*: Studying how *C. olitorius* responds to salt stress provides insight into the complex physiological, morphological, and biochemical changes that occur under adverse environmental conditions. This includes; understanding processes like osmotic adjustment (eg accumulation of proline), ion regulation, and the activation of antioxidant defense systems.
2. Broader application of findings: Because many of the defense strategies plants employ against salt stress are conserved across species, the findings from this study can be applied to other salt-sensitive crops. This can advance the broader field of plant science and help develop resilience in other important food crops.

AGRICULTURAL AND ENVIRONMENTAL SIGNIFICANCE

1. Enhancement of *Corchorus olitorius* productivity in saline prone areas: Salinity severely limits plant productivity by creating osmotic stress and ionic toxicity, which in turn reduces growth, vigor, and overall crop yield. Therefore, studying these effects on a commercially important plant like; *C. olitorius* can lead to ways to mitigate these damages, enhance productivity and secure its production.
2. Developing salt-tolerant varieties: Research has shown genetic variation in salt tolerance, even among different cultivars of *C. olitorius*. Investigating these differences allows for the identification of resilient genotypes that can be used in breeding programs to develop new, salt-tolerant varieties of this crop.

3. Optimizing agricultural practices: This research can inform the development of specific agricultural management practices such as; the use of soil amendments like calcium and potassium, that can help alleviate salt stress and improve the productivity of *C. olerius* in saline soils (Belvida Loko, 2023).

ECONOMIC SIGNIFICANCE

1. Protects farmers livelihood: *C. olerius* is a key cash crop and vegetable in many parts of Africa and Asia. Reduction in yield due to salt stress directly impact the income and food security of farmers and rural populations. Therefore, research that helps sustain or improve yields is crucial for protecting these livelihoods.
2. Food source / nutritional value: The leaves of *Corchorus olerius* are a nutritious vegetable, highly rich in minerals like iron, potassium, and calcium, as well as vitamins and antioxidants. Protecting its production is important for maintaining local diets and nutritional health.
3. Source of natural fiber: In many countries, particularly in South Asia, *C. olerius* is a major source of jute fiber, used for manufacturing textiles, ropes, and other products. Salt stress can negatively affect both the quality and quantity of this fiber, so mitigating these effects has significant industrial implications.

1.1.3. NEED FOR THE STUDY

Studying the effect of salt stress on the germination and growth of *Corchorus olerius* is needed for several reasons. They include the following;

FOOD SECURITY AND NUTRITION

Since *C. olerarius* is a vital source of food in many regions prone to soil salinization, studying its tolerance level can help ensure steady production of this nutrient rich crop under variable environmental conditions.

SUSTAINABLE AGRICULTURE

As salinity threatens arable land, crops that can adapt and perform well under stress will play a major role in sustaining agricultural productivity. A study on *C. olerarius* will provide insights into its potential as a resilient crop in saline-prone areas.

ADAPTATION AND BREEDING PROGRAMS

Identifying the physiological, morphological, and biochemical responses of *C. olerarius* to salt stress will provide a foundation for developing salt-tolerant varieties. This is essential for breeding programs aimed at climate-smart agriculture.

ECONOMIC VALUE

Beyond its nutritional value, *C. olerarius* contributes to local economies through its use as a leafy vegetable and fiber crop. Salt-induced yield reduction can directly affect farmers' income. Research findings could guide management practices that minimize yield loss.

SCIENTIFIC GAP

While extensive studies exist on the impact of salinity on major cereal and legume crops, research on leafy vegetables such as *C. olerarius* remains limited. Addressing this gap will help expand scientific knowledge and promote diversification of stress-tolerant food crops.

1.1.4. AIMS/ OBJECTIVES OF STUDY

The main aim of this study is to investigate the effect of salt stress on the germination and early seedling growth of *Corchorus olitorius* (Jute mallow) between two different landraces.

The objectives are as follows;

1. To evaluate the effect of varying salt concentrations on the growth and yield parameters of *C. olitorius* and assessing variations in tolerance among two different landraces (Benin and research institute).
2. To investigate the physiological, morphological and biochemical responses of *C. olitorius* to varying salt stress conditions.
3. To estimate the impact of salt stress on the germination rate and percentage of *C. olitorius* compared between two landraces (Benin and NIHOR).
4. To highlight sustainable strategies for mitigating the effects of salinity in agriculture.
5. To emphasize the global significance of addressing salinity for food security.

1.2. LITERATURE REVIEW

1.2.1. *Corchorus olitorius* AND ITS IMPORTANCE

Corchorus olitorius L. which belongs to the family, Malvaceae and commonly called jute mallow, ewedu, Egypt spinach is a fast-growing annual leafy vegetable widely consumed

across Africa, the middle east and parts of Asia. It is valued both as a nutritious food (i.e leaves are eaten fresh or as a viscous soup), and oil(seed). Its stem contributes to the jute industry (Biswas, Abdel-Razek, *et al.*, 2022). Nutritionally, the leaves are rich in protein, dietary fiber, essential vitamins (vit A , C, E), and minerals such as calcium, potassium, and iron (Biswas *et al.*, 2022). Beyond their dietary role, phytochemical investigations have revealed diverse secondary metabolites (eg polyphenols, flavonoids, saponins, tannins, and glycosides) that underpin a range of biological activities.

Interest in *C. olitorius* has grown in nutritional science, pharmacology, and sustainable agriculture because its leaves are rich in proteins, vitamins, and minerals and its extracts show multiple bioactivities.

TAXONOMY

Kingdom: plantae

Division: Tracheophyta

Class: Magnoliopsida

Order: Malvales

Family: Malvaceae

Genus: Corchorus

Species: *Corchorus olitorius* .

MORPHOLOGICAL DESCRIPTION

Root system: *C. olitorius* possesses a tap root that supports a sturdy plant structure

Leaves: The leaves are simple, alternate and stalked. They are ovate-lanceolate or lanceolate, measuring 6 -10cm long and 2 to 4cm wide. The leaf margins are serrated (toothed). The leaves possess a distinguishing feature known as the auricles. This occurs from the prolongation of the two lowest serration on the leaf into pointed, hair-like appendages. Stem: The stem is herbaceous, erect, and cylindrical, often with a faint reddish-brown hue and a mucilaginous, smooth, or slightly rough texture.

Flowers: Flowers are complete, bisexual, and solitary or borne in two flowered cymes opposite the upper leaves. They are distinctly yellow in colour. They consist of five free sepals, five free petals, and numerous, long, free stamens. The ovary is superior.

Fruits and seeds: The fruit is a spindle-shaped or cylindrical capsule. This capsule is dehiscent, therefore it opens into five sections via five valves. Each valve contains 25-40 small, black seeds. The fruit can contain a total number of 125-200 seeds.

IMPORTANCE

Corchorus olitorius plays a significant role in nutrition, medicine, agriculture, and the economy. The importance are highlighted as follows;

NUTRITIONAL IMPORTANCE

1. *C. olitorius* contains essential minerals such as calcium, iron, magnesium, and potassium.
2. It is rich in vitamin A, C, and E.
3. It is a good source of protein and dietary fiber.

4. It provides antioxidants that boost the immune system.
5. It is low in calories, making it ideal for a healthy diet

MEDICINAL IMPORTANCE

1. *Corchorus olitorius* contains bioactive substance, therefore it can be traditionally used for treating fever, pain, and inflammation.
2. It contains antimicrobial and antioxidant properties.
3. Its mucilaginous leaves soothe the digestive system, helping in treatment of ulcers and gastritis.
4. It helps promote lactation in nursing mothers
5. Research has shown that *C. olitorius* has a high potential in lowering cholesterol and fighting cancer (Tostoc *et al.*, 2021).

AGRICULTURAL IMPORTANCE

1. *Corchorus olitorius* stem is capable of producing strong jute fiber for making ropes, mats, sacks, and other materials.
2. It can be used as green manure to improve soil fertility.
3. It serves as livestock feed in some regions.

ECONOMIC AND CULTURAL IMPORTANCE

1. *C. olitorius* is a major source of income for farmers.
2. It is a popular vegetable in Africa, Asian and middle eastern cuisines (eg molokhia soup in Egypt, Ewedu soup in Nigeria, saluyot in the Philippines).

3. It plays a role in cultural traditions and local herbal medicine.

1.2.2. SALT STRESS IN PLANTS: A GLOBAL CHALLENGE

Soil salinization is a global problem, with more than 20% of irrigated lands and 7% of total land area affected by salinity (FAO, 2021). Irrigated lands which provide about one-third of global food production, are particularly vulnerable due to inefficient irrigation practice, poor drainage, and rising groundwater tables (Shrivastava & Kumar, 2025). Coastal regions are also at high risk because of sea water intrusion resulting from climate change and sea-level rise (Hossain, 2019).

This challenge threatens global food security, as salinity severely reduces yields of staple crops such as rice, wheat, and maize (Ray *et al.*, 2024). Economically, billions of dollars are lost annually due to reduced productivity and the abandonment of salt-affected lands (Qadir *et al.*, 2014).

Salinity imposes both osmotic stress and ionic toxicity, limiting water uptake, disrupting photosynthesis, and impairing metabolic activities. As a result, crop yield and quality are significantly reduced, making salinity a global agricultural challenge.

The increasing prevalence of salt affected soils poses a serious threat to global food security. Salinity reduces crop productivity, restricts the range of cultivable crops, and forces farmers to abandon fertile lands. This is especially critical in arid and semi-arid regions where irrigation is indispensable (Machado and Serralheiro., 2017). Despite the natural ability of some plant species to tolerate salinity, many staple crops remain highly sensitive. Therefore, there is an urgent need to understand the mechanisms of salt

tolerance in plants and develop strategies to enhance agricultural resilience to salinity stress.

Research shows that plants adopt multiple tolerance mechanisms under salt stress, such as osmotic adjustment, ion homeostasis, antioxidant defense and hormonal regulation (Munns and Tester., 2008; Isayenkov and Maathuis., 2019). Breeding programs and modern biotechnological tools, including genome editing (eg CRISPR- Cas9), transcriptomics, and marker-assisted selection, have shown potential in improving salinity tolerance on crops (Zhao, *et al.*, 2020). However, the complexity of plant responses and the diverse nature of saline environments make this a continuous global challenge requiring interdisciplinary approaches.

1.2.3. EFFECTS OF SALT STRESS ON GERMINATION AND SEEDLING DEVELOPMENT IN PLANTS

Seed germination and seedling establishment are the most critical phases in plants life cycle, as they determine subsequent growth and productivity. However, these early stages are highly sensitive to abiotic stress, particularly salt stress (salinity).

EFFECT ON SEED GERMINATION

Salt stress significantly impair seed germination by creating both osmotic and ionic stresses.

- I. Osmotic stress: Reduces the water potential around the seed, making water uptake difficult, which delays or prevent germination (Munns and Tester, 2008).

- II. Ionic stress: Results from the accumulation of sodium (Na⁺) and chloride(Cl⁻) ions, which may become toxic to the embryo and interfere with metabolic processes (Farooq *et al.*, 2015).

High salt levels also inhibit the activity of enzymes essential for starch hydrolysis, reducing energy availability for seedling emergence (Kaya *et al.*, 2006). Consequently, salinity leads to reduced germination percentage, delayed germination rate, and lower seedling vigor.

EFFECT ON SEEDLING GROWTH

The seedling stage is equally sensitive to salinity stress. The effects include;

1. Reduced root and shoot growth: Salt stress limits cell expansion and division, leading to shorter shoots and roots (Jamil *et al.*, 2011).
2. Nutrient imbalance: Excess sodium competes with essential nutrients such as potassium(K⁺) and calcium(Ca²⁺) disturbing nutrient uptake and metabolic processes(Zhu, 2017).
3. Oxidative stress: Accumulation of reactive oxygen species (ROS) damages membranes, proteins, and nucleic acid, further impairing seedling establishment (Isayenkov and Maathuis , 2019).
4. Photosynthesis inhibition: Salinity reduces chlorophyll content and stomatal conductance, thereby decreasing photosynthesis efficiency in seedlings (AcostaMotos , *et al.*, 2017).

Consequently, seedlings exposed to salt stress exhibit stunted growth, leaf chlorosis, wilting, and reduced biomass accumulation, often leading to low yield potential.

1.2.4. SENSITIVITY OF *Corchorus olitorius* TO SALINITY

Corchorus olitorius (commonly known as jute mallow or jews mallow) is a leafy vegetable of great nutritional and economic importance in many parts of Africa and Asia. However, its productivity is severely limited under saline conditions as the species is generally considered salt sensitive.

During germination and early seedling growth, *C. olitorius* exhibit significant reductions in germination percentage, root and shoot elongation, and seedling vigor when exposed to high salinity levels. This sensitivity is mainly attributed to osmotic stress that restricts water uptake and ionic stress from excessive sodium and chloride ions, which disrupt nutrient balance and impair metabolic functions (Islam *et al.*, 2018).

At later growth stages, salinity reduces leaf expansion, chlorophyll content, and photosynthetic efficiency, leading to stunted growth and reduced biomass(Sani *et al.*, 2020). Salt stress also induces oxidative stress In *C. olitorius*, therefore resulting in membrane damage impaired physiological performance (AbdElgawad *et al.*, 2016).

Although some genotypic variability in salinity tolerance has been reported, most cultivars of *C. olitorius* remain highly sensitive to salinity levels above 50-100 mM NaCl (Sani *et al.*, 2020). This sensitivity highlights the urgent need for screening salt-tolerant accessions, as well as developing effective management strategies such as soil amendments, seed priming, and breeding programs aimed at improving tolerance.

1.2.5. EFFECT OF SALT STRESS ON THE GERMINATION AND SEEDLING DEVELOPMENT OF *Corchorus olitorius*

The germination and seedling stages of *C. olitorius* are highly vulnerable to salt stress.

EFFECT ON GERMINATION

The germination stage is highly sensitive to salt stress. Elevated salinity leads to a decline in germination percentage, delayed germination rate, and reduced seedling vigor index. This occurs due to the osmotic stress that limits water uptake by seeds, thereby inhibiting metabolic activities necessary for germination (Almodares *et al.*, 2014).

In *C. olitorius*, studies have shown that increasing salt concentrations causes a progressive decline in seed germination, suggesting that the species is moderately sensitive to salinity during the early growth phase (Hossain *et al.*, 2019).

EFFECT ON SEEDLING DEVELOPMENT

Salt stress adversely affects seedling growth parameters which include; root length, shoot length, leaf area, internode length, and biomass accumulation. Seedlings under high salinity often exhibit stunted growth, chlorosis, and reduced fresh and dry weight due to impaired photosynthetic efficiency and nutrients uptake (Parida and Das., 2005). In *C. olitorius*, salinity stress has been reported to inhibit both root and shoot elongation, which compromises the plants ability to establish itself successfully in saline soils (Kumar *et al.*, 2020). The accumulation of toxic ions such as Na⁺ and Cl⁻ further disrupts cellular homeostasis, leading to oxidative stress and membrane damage.

Reduced germination rates and impaired seedling development under saline conditions not only limit crop establishment but also have long-term effects on yield and quality. Therefore, understanding these effects is crucial for developing salt-tolerant varieties and implementing soil management practices to mitigate salinity impacts in *C. olitorius* cultivation.

1.2.6. PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES OF *Corchorus olitorius* TO SALT STRESS

Exposure of *C. olitorius* to high salinity levels result in significant physiological and biochemical modification as part of its survival strategy.

PHYSIOLOGICAL RESPONSES

- I. Photosynthesis and chlorophyll content: Salinity decreases chlorophyll content and photosynthetic efficiency due to stomatal closure and impaired photosystem II activity. Declines in leaf area and biomass further contribute to reduced carbon assimilation (Ibrahim *et al.*, 2021).
- II. Water relations: Relative water content (RWC) of leaves decreases under salt stress due to reduced water uptake and osmotic imbalance. Plants exhibit wilting and leaf rolling at higher salinity levels. Foliar application of proline, however, has been shown to maintain RWC more effectively (El-sayed *et al.*, 2020).
- III. Ion homeostasis: Excess Na⁺ accumulation disrupts ionic balance, particularly lowering the K⁺/Na⁺ ratio, which is crucial for enzymatic functions and metabolic activities. In *C. olitorius*, Na⁺ content may increase by over 80%,

while K⁺ content decreases by nearly 70% under high salinity (Islam *et al.*, 2021).

- IV. Leaf senescence and yield reduction: prolonged stress accelerates leaf senescence and significantly reduces leaf biomass and fiber quality.

BIOCHEMICAL RESPONSES

- I. Osmolyte accumulation: Salt stress conditions induce the synthesis of osmoprotectants such as proline, glycine betaine, and soluble sugars, which help maintain cell turgor and protect proteins and membranes (El-Sayed *et al.*, 2020).
- II. Reactive oxygen species (ROS) and lipid peroxidation: Salt stress triggers ROS overproduction, leading to membrane damage, lipid peroxidation (measured as malondialdehyde, MDA) and increased electrolyte leakage. In jute, MDA levels and lipoxygenase activity are strongly elevated under salt exposure (Rahman *et al.*, 2021).
- III. Antioxidant defense: To counter oxidative stress, *C. olitorius* upregulates both enzymatic antioxidants such as superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), and peroxidase (POD) and non enzymatic antioxidants including ascorbate, glutathione, phenolics, and flavonoids (Mia *et al.*, 2022). Application of biochar and chitosan further enhances these antioxidants responses under saline conditions (Haque *et al.*, 2022).
- IV. Stress-related proteins and gene expression: Transcriptome analyses have identified upregulation of abscisic acid – dependents transcription factors,

AREB/ABF genes, and stress responsive proteins such as LEA and heat shock proteins under salt stress(Zhoe *et al.*, 2023). These genes are associated with osmotic adjustment, ROS detoxification and ion transport.

1.2.7. RESEARCH GAP IN THE SALT TOLERANCE OF *C. olitorius*

A major research gap in the salt tolerance of *Corchorus olitorius* is the limited understanding of the genetic and molecular mechanisms that differentiate salt-tolerant from salt-sensitive cultivars. Although preliminary studies have identified some stress-responsive genes and potential quantitative trait loci (QTLs), further work is needed to validate these findings and translate them into practical breeding applications.

MOLECULAR AND GENETIC MECHANISMS

While some research has explored the general physiological responses of *C. olitorius* to salt stress, deeper molecular and genetic research is needed. Specific research gaps include:

- **Gene function validation:** Although transcriptomic studies have identified candidate genes and transcription factors like the SnRK2 family, their precise roles and regulatory networks in conferring salt tolerance need functional validation.
- **QTL mapping and marker-assisted breeding:** While initial QTL mapping for salt tolerance has been conducted, more comprehensive studies are required to identify the specific genes and markers associated with salt tolerance traits across diverse germplasm. This would enable efficient marker-assisted selection programs to develop superior salt-tolerant varieties.

- **Root-level mechanisms:** While some studies have examined the effects of salt on root growth, the specific mechanisms governing ion transport, exclusion, and compartmentalization in the roots of *C. olitorius* have not been thoroughly Investigated (Adekiogun *et al.*, 2023).

CULTIVAR – SPECIFIC RESPONSES AND SCREENING

Significant variations in salt tolerance exist among different *C. olitorius* cultivars. However, extensive screening and characterization are lacking. Research gaps include:

- **Comprehensive germplasm screening:** The salt tolerance of many local and exotic *C. olitorius* cultivars remains uncharacterized. A systematic evaluation is needed to identify a wider range of salt-tolerant accessions that could be used in breeding programs.
- **Ontogenetic variation:** Tolerance to salt stress can change depending on the plant's growth stage. More research is needed to understand how different cultivars respond to salinity at various developmental stages, from germination to maturity, as a cultivar's tolerance at one stage may not be consistent at another.

MITIGATION STRATEGIES

Studies have explored using supplements like calcium and potassium to mitigate the negative effects of salinity. Biosimulants, seed-priming techniques and microbial inoculant are also recognized, sustainable approaches for improving salinity tolerance in *Corchorus*

olitorius and other crops. However, more research is needed to optimize these strategies and develop practical field applications. Specific gaps include:

- Interaction with soil amendments: While studies have tested a few soil amendments like banana peel and inorganic nutrients, the interactive effects of various organic and inorganic amendments on salt tolerance need more research.
- Impact on nutritional quality: Salinity is known to affect the nutritional composition of plants. A research gap exists in understanding how different mitigation strategies, such as adding specific mineral or organic supplements, affect the yield and the overall nutritional quality of *C. olitorius* grown under saline conditions.
- Long-term field trials: Most studies are conducted in controlled pot or greenhouse settings. Research is needed to conduct long-term field trials in naturally salt-affected areas to validate findings and determine the most effective and sustainable mitigation strategies for local farmers.

SYSTEMS – LEVEL AND MULTI – STRESS INTERACTION

Salinity often co-occurs with other abiotic stresses, but research on these combined effects is limited.

- Combined stress response: How *C. olitorius* responds to the combined effects of salinity and other stresses, such as drought, heat, or heavy metals, is not well understood. This knowledge is crucial for developing robust, climate-resilient cultivars.

- Multi-omics integration: The integration of genomic, transcriptomic, and proteomic data is a powerful tool for understanding complex stress tolerance mechanisms.

However, this systems-level approach is still lacking for *C. olearius* salt tolerance research.

CHAPTER TWO

MATERIALS AND METHODS

2.1 STUDY LOCATION

This study was conducted in a field adjacent to the Life Science Complex, Faculty of Life Science, University of Benin, Benin City, Edo State.

2.2 SOURCE OF TREATMENT

The salt (NaCl) used for this experiment was purchased from sales hostel, NDDC hostel, University of Benin, Benin City, Edo State.

2.3 SAMPLE COLLECTION

SOURCE OF *Corchorus olitorius* SEED

The various seeds of *Corchorus olitorius* were gotten from two landraces. They include; Benin City and National Horticultural Research Institute (NIHORT)

2.4 MATERIALS

The materials used in this experiment are; Petri dishes, tissues sheets, measuring tape, pair of divider, field note, weighing balance, electric scale, planting bags, water, underlay, bucket, gallons, masking tape, NaCl (Common salt), measuring rule

2.5 EXPERIMENTAL DESIGN

This experiment was carried out using five levels of salinity treatment which are outlined below;

V – Control (5 ppm i.e. 0.00 5g/L of NaCl Solution)

W – Non-Saline Sodic (200 ppm i.e. 0.2 g/L of NaCl solution)

X – Slightly Sodic-Saline (2000 ppm i.e. 2 g/L of NaCl Solution).

Y – Medium (5000 ppm i.e. 5 g/L of NaCl solution)

Z – Highly sodic-saline (10,000 ppm i.e. 10 g/L of NaCl solution).

8 kg of soil were measured into planting bags. All the treatments were in three replicates. Salinity treatments were applied daily on all the replicates, beginning from the day of planting to the 15th day, then from day 15, salinity treatments were applied every three days. Germination studies were carried out from the 7th day of planting, on a daily basis for one week. Then data on the various parameters (shoot height, number of leaves, number of branches, leaf area, stem girth, internode length, leaf loss) were taken from the second week of planting. The data was record on a weekly basis. This experiment was conducted in a completely randomized design (CRD) with two factors: landrace (2 levels) and salinity (5 levels) replicated three times.

2.6 GERMINATION STUDY

Germination was recorded daily for seven days. Germination Percentage (GP) is a measure of the number of seeds sown, usually expressed as a percentage. It is a key parameter in seed viability and vigor studies, especially when evaluating plant responses to environmental stresses e.g. salinity (salt stress).

It is mathematically expressed as;

$$\text{Germination Percentage (GP)} = \frac{\text{Number of Germinated Seeds}}{\text{Total Number of Seeds Sown}} \times 100$$

2.7 PARAMETERS

The parameters that were taken include; shoot height, number of leaves, leaf area, number of branches, stem girth, internode length, and leaf loss.

2.7.1 SHOOT HEIGHT MEASUREMENT

The shoot height was measured from the base of the stem at the soil to the terminal bud using a measuring tape and it was recorded on a weekly basis, from day 21 to day 56

2.7.2 NUMBER OF LEAVES

The number of leaves on each plant was counted and recorded weekly, from day 21 to day 56.

2.7.3 LEAF AREA

The leaf area of a particular leaf (fourth leaf from the stem base) in each plant was calculated and recorded weekly, starting from day 21 to day 56.

It is expressed mathematically as; Leaf Area = Length x breadth x 0.65

2.7.4. NUMBER OF BRANCHES

The number of branches on each plant was counted and recorded starting from day 21 to day 56, on a weekly basis

2.7.5 MEASUREMENT OF STEM GIRTH

The stem girth of each plants were measured at a distance of 3cm from the base using a pair of divider and measuring rule and it was recorded weekly, starting from day 21 to day 56.

2.7.6 INTERNODE LENGTH

The length of the first internode (i.e. between node 1 and node 2) was measured using a measuring rule. It was recorded weekly, starting from day 21 to day 56.

2.7.7 LEAF LOSS

The number of leaves that fell off from the stem were counted by identifying and counting the leaf scar on the nodes of the stem.

2.8 STATISTICAL ANALYSIS

The results were subjected to a mean, standard deviation, standard error and ANOVA (SPSS) to determine if there was any statistical significance between physiological parameters observed in *C. olitorius*. Significance was determined at $p < 0.0$

CHAPTER THREE

RESULTS

The effect of salt stress on the germination percentage of *Corchorus olitorius* seeds collected from Benin City (Landrace B), recorded from day 8 to day 15 is presented in Table 3.1. Germination was recorded in treatments V, W, and X on the 8th day. The highest germination percentage was recorded in treatment W (23.33 ± 2.08 %) on day 8. However, on day 15 the highest germination percentage was recorded on treatment V (Control), which is 43.33 ± 4.16 %. This indicated that treatment V and W enhanced germination compared to other higher treatments (X, Y, Z). Therefore, the adverse effect of salinity increased with increasing concentration and there was significant difference between all the treatments. There was no germination recorded on treatments Y and Z apparently due to the extremely high salt concentration.

Table 3.1: Effect of Salt Stress on the Germination Percentage (%) of *Corchorus olitorius* (Landrace B)

Treatment	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
V	10.00±1.00 ^C	10.00±1.00 ^C	13.33±1.53 ^C	20.00±2.00 ^a	36.00±3.05 ^a	40.00±3.61 ^a	40.00±3.61 ^a	43.33±4.16 ^d
W	23.33±2.08 ^b	23.33±2.08 ^b	23.33±2.08 ^b	23.33±2.08 ^b	23.33±2.08 ^b	26.67±2.31 ^b	26.67±1.15 ^b	26.67±1.16 ^b
X	13.33±0.58 ^c	13.33±0.58 ^c	13.33±0.58 ^c	10.00±1.00 ^c	10.00±1.00 ^c	13.33±1.53 ^c	13.33±1.53 ^c	13.33±1.53 ^c
Y	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d
Z	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d	0.00±0.00 ^d

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.2 shows the effect of salt stress on the germination percentage of *C. olitorius* seeds from NIHORT (Landrace C), recorded in treatment V (control) on day 8 to day 15. This indicated that treatment V enhanced germination compared to other higher treatments, the lethal effect of salt stress increased along the concentration gradient, with significant difference between the treatments. No germination was recorded on treatment Z due to its extremely high salt concentration.

By comparing the germination percentage of the two landraces (landrace B and C), It is seen that the germination percentage recorded on treatment V, W, X, and Y of landrace C is higher than that of landrace B. In landrace B, there was no germination recorded on treatment Y and no germination was recorded on treatment Z. This therefore shows that the germination rate of seeds from landrace C (NIHORT) is higher than that of landrace B (Benin-City).

Table 3.3 shows the effect of salt stress on the shoot height of the seedling of *Corchorus olitorius*, collected from Benin City (landrace B), recorded from day 21 to day 56. Treatment W recorded the highest shoot height throughout the investigation, with significant difference from treatment V (control) and other higher treatment. The adverse effect of salt stress increased along the concentration gradient. Treatment Y, and Z recorded no shoot height as a result of no germination due to its extreme salt concentration

Table 3.2: Effect of Salt Stress on the Germination Percentage (%) of *Corchorus olitorius* (Landrace C)

Treatment	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
V	80.00±1.73 ^a	80.00±1.73 ^a	80.00±1.73 ^a	80.00±1.73 ^a	86.67±1.16 ^a	86.67±1.16 ^a	86.67±1.16 ^a	90.00±1.00 ^d
W	73.33±2.52 ^a	76.67±2.52 ^a	76.67±2.52 ^a	80.00±2.65 ^a	83.33±2.89 ^a	83.33±2.89 ^a	83.33±2.89 ^a	83.33±2.89 ^a
X	46.67±3.22 ^b	46.67±3.22 ^b	50.00±2.65 ^b	53.33±2.08 ^b	53.33±2.08 ^c	50.00±2.65 ^b	50.00±6.65 ^b	53.33±3.06 ^{cb}
Y	43.33±1.16 ^d	46.67±1.53 ^b	36.67±1.53 ^b	36.67±1.53 ^b	33.33±1.53 ^b	30.00±1.73 ^b	26.67±2.08 ^b	23.33±2.52 ^b
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.3: Effect of Salt Stress on the Shoot Height (cm) of (Landrace B)

olitorius

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.20±0.35 ^b	0.60±0.53 ^b	0.90±1.56 ^b	2.00±3.46 ^b	3.67±6.35 ^b	7.33±12.67 ^b
W	2.00±1.80 ^a	5.50±5.27 ^a	9.67±10.30 ^a	16.67±17.56 ^a	29.00±28.52 ^a	43.33±40.41 ^a
X	0.67±1.16 ^b	1.07±1.55 ^b	2.17±3.75 ^b	4.67±17.56 ^a	29.00±28.52 ^a	15.67±27.10 ^b
Y	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
 Mean sharing the same letters are not significantly different at p=0.05

Table 3.4 shows the effect of salt stress on the shoot height of the seedling of *Corchorus olitorius*, collected from NIHORT research institute (landrace C), recorded from day 21 to day 56. Treatment V and W recorded the highest shoot throughout the study with shoot height of 49.33 ± 5.03 cm and 47.00 ± 9.64 cm respectively. Also treatment X and Y recorded 37.00 ± 34.39 cm and 17.67 ± 30.72 cm respectively. treatment Z recorded no shoot height, as no germination occurred in treatment Z. There was therefore significant difference between the treatments and the adverse effect of salt stress on the shoot height increased along the concentration gradient.

By relating the shoot height of the seedlings of *Corchorus olitorius* between the two landraces (landrace B and C), it is observed that the shoot height recorded on treatment V, W, X, and Y of landrace C is greater than the shoot heights on the respective treatment of landrace B. In landrace B, there was no shoot height recorded on treatment Y and Z as a result of no germination because of the high salt concentration while in landrace C shoot height was recorded on treatment Y and none was recorded on treatment Z.

Table 3.5 shows the effect of salinity stress on the number of leaves of the seedling of *C. olitorius*, collected from Benin (Landrace B), recorded from day 21 to day 56. Treatment W recorded the highest number of leaves (52.67 ± 47.69) all through the investigation. There was significant difference between all the treatments as the adverse effect of salt stress increased along the concentration gradient. There was no number of leaves recorded on treatment Y and Z as there was no germination due to increased salt concentration.

Table 3.4: Effect of Salt Stress on the Shoot Height (cm) of *Corchorus olitorius* (Landrace C)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	3.53±0.92 ^a	6.27±1.91 ^a	11.33±2.02 ^a	21.00±1.00 ^a	35.33±3.06^a	49.33±5.03 ^a
W	4.40±0.10 ^a	7.23±0.45 ^a	11.00±2.18 ^a	18.50±6.73 ^a	31.5±9.18 ^a	47.00±9.64 ^a
X	3.37±2.05 ^b	6.47±3.95 ^b	11.83±6.33 ^b	20.83±10.50 ^b	26.67±25.16 ^b	37.00±34.39 ^b
Y	1.40±2.43 ^c	2.43±4.22 ^c	4.17±7.22 ^c	8.67±15.01	13.00±22.51 ^c	17.67±30.72 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.5: Effect of Salt Stress on the Number of Leaves of , *Corchorus olitorius* (Landrace B)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.67±1.16 ^b	2.00±2.00 ^b	2.00±3.46 ^b	1.33±2.31 ^b	2.67±4.62^b	7.00±12.12 ^b
W	3.33±2.89 ^a	4.33±4.04 ^a	10.00±11.14 ^a	22.67±23.55 ^a	39.00±35.68 ^a	52.67±47.69 ^a
X	1.33±2.31 ^b	1.67±2.89 ^b	2.33±4.04	8.33±14.44 ^b	14.00±24.25 ^b	17.33±30.05 ^b
Y	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.6 shows the effect of salt stress on the number of leaves of the seedling of *C. olitorius*, collected from NIHORT research institute (landrace C), recorded from day 21 to day 56. Treatment V had the highest number of leaves (57.00 ± 19.16) all throughout the investigation. There was significant difference between all the treatments as the adverse effect of salt stress increased along the concentration gradient. Treatment Z, which is the highest salt treatment, recorded no leaves as germination did not occur due to its extremely high salt content.

By comparing between the number of leaves produced by the seedlings of *Corchorus olitorius* of the two land races (B and C) it is observed that the number of leaves produced on each treatment of landrace C is greater than the number of leaves produced on the respective treatment of landrace B.

Table 3.7 indicates the effect of salt stress on the leaf area of the seedling of *C. olitorius* collected from Benin (Landrace B), and recorded from day 21 to day 26. Treatment W recorded the highest leaf area ($4.94 \pm 6.71\text{cm}^2$) throughout the study. There was significant difference between all the treatments as the adverse effect of salt stress increased along the concentration gradient. Treatment Y and Z recorded zero leaf area as there was no germination due to increased salt concentration.

Table 3.6: Effect of Salt Stress on the Number of Leaves of , *Corchorus olitorius* (Landrace C)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	5.33±0.58 ^a	7.33±1.16 ^a	18.67±2.08 ^a	34.67±2.08 ^a	46.33±8.75^a	57.00±19.16 ^a
W	5.00±0.00 ^a	7.00±2.65 ^a	13.67±0.03 ^a	25.67±11.02 ^a	37.67±11.59 ^a	47.33±13.58 ^a
X	5.00±0.00 ^b	6.67±0.58 ^b	1300±3.61 ^b	21.33±5.51 ^b	20.33±17.78 ^b	25.67±22.27 ^b
Y	1.67±2.89 ^c	3.00±5.20 ^b	8.67±15.01	13.33±23.10 ^b	16.00±27.71 ^b	20.67±35.81 ^b
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.7: Effect of Salt Stress on the Leaf Area (cm²) of *Corchorus olitorius* (Landrace B)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.00±0.00 ^c	0.09±0.15 ^c	0.33±0.57 ^c	0.52±0.91 ^b	0.70±1.22^b	3.31±3.15 ^a 0.70±1.22 ^b
W	1.14±1.06 ^a	2.10±2.05 ^a	2.84±3.00 ^a	3.76±3.43 ^a		4.94±6.71 ^a
X	0.12±0.21 ^b	0.18±0.32 ^b	0.35±0.60 ^b	0.65±1.12 ^b	0.76±1.32 ^b	1.17±2.03 ^b
Y	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.8 shows the effect of salt stress on the leaf area of the seedling of *C. olitorius*, collected from NIHORT research institute (landrace C) recorded from day 21 to day 56. Treatment W recorded the highest leaf area ($11.59 \pm 4.29 \text{ cm}^2$) throughout the study. There was significant difference between all the treatments and the adverse effect of salt stress on the leaf area increased along the concentration gradient.

By comparing the leaf area of the seedling between the two landraces (landrace B and C), it is observed that the leaf area recorded on treatment V, W, X, and Y of landrace C is higher than the leaf area on the respective treatment of landrace B. This shows that the leaves of the seedlings of landrace C (NIHORT) grew bigger than the leaves of the seedlings of landrace B (Benin City). This is due to the higher salt tolerance of the NIHORT seedling compared to that of Benin City.

Table 3.9 Indicates the effect of salt stress on the stem girth of the seedling of *C. olitorius*, which was collected from Benin City (landrace B) and recorded from day 21 to day 56. Treatment W recorded the highest stem girth ($0.53 \pm 0.47 \text{ cm}$) throughout the study. There was significant difference between all the treatments and the adverse effect of salt stress increased along the concentration – gradient. Treatment Z recorded no stem girth as a result no germination due to its overly increased salt concentration.

Table 3.8: Effect of Salt Stress on the Leaf Area (cm²) of *Corchorus olitorius* (Landrace C)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	2.36±1.80 ^a	5.87±2.29 ^a	6.64±2.26 ^a	6.92±2.36 ^a	8.74±4.52^a	10.29±4.74 ^a
W	2.00±0.37 ^a	5.01±1.52 ^a	9.36±3.32 ^a	11.06±3.88 ^a	11.59±6.98 ^a	11.59±4.29 ^a
X	2.18±1.70 ^b	7.07±5.11 ^b	5.24±4.77 ^b	8.78±4.88	7.47±6.98 ^b	9.10±9.38 ^b
Y	0.48±0.83 ^c	1.52±2.64 ^c	1.65±2.85 ^c	1.86±3.23 ^c	1.86±3.23 ^c	1.91±3.30 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

3.9: Effect of Salt Stress on the Stem girth (cm) of *Corchorus olitories* (Landrace B)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.00±0.00 ^c	0.07±0.12 ^b	0.07±0.12 ^b	0.07±0.12 ^b	0.10±0.17^b	0.13±0.23 ^b
W	0.20±0.17 ^a	0.20±0.17 ^a	0.30±0.27 ^a	0.33±0.31 ^a	0.43±0.37 ^a	0.53±0.47 ^a
X	0.07±0.12 ^b	0.07±0.12 ^b	0.10±0.17 ^b	0.13±0.31 ^a	0.17±0.29 ^b	0.23±0.40^b
Y	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.10 indicates the effect of salt stress on the stem girth of the seedling of *C. olitorius* which was collected from NIHORT research institute (landrace C), and recorded from day 21 to day 56. Treatment V recorded the highest stem girth (0.67 ± 0.06 cm) throughout the study. There was significant difference between the treatments. The adverse effect of salt stress increased along the concentration gradient. Treatment Z recorded no stem girth as there was no germination due to its overly high salt concentration.

By comparing between the stem girth of the two landraces (Landrace B and C), it is observed that the stem girth recorded on treatment V, W, X, and Y of landrace C is greater than the stem girth recorded on the respective treatment of landrace B. This therefore shows that the growth in the girth of the seedling from NIHORT (landrace C) is higher than the growth in the girth of the seedling from Benin city (landrace B) due to the higher salt tolerance of the seedling from NIHORT compared to the seedling from Benin City.

Table 3.11 indicates the effect of salt stress on the number branches on the seedling of *C. olitorius*, collected from Benin (landrace B), recorded from day 21 to day 56. The highest number of branches was recorded in treatment W (12.00 ± 11.14) throughout the study. there was significant difference between all the treatments. The adverse effect of stress increased along the concentration gradient. Treatment Y and Z recorded no branches due to its highly increased salt concentration.

3.10: Effect of Salt Stress on the Stem girth (cm) of *Corchorus olitorius* (Landrace C)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.30±0.00 ^a	0.30±0.00 ^a	0.37±0.06 ^a	0.43±0.06 ^a	0.57±0.06 ^a	0.67±0.06 ^a
W	0.30±0.00 ^a	0.30±0.00 ^a	0.33±0.06 ^a	0.040±0.60 ^a	0.50±.10 ^a	0.53±0.06 ^a
X	0.27±0.06 ^b	0.30±0.10 ^b	0.33±0.06 ^b	0.30±0.27 ^b	0.30±0.27 ^b	0.30±0.27 ^b
Y	0.10±0.17 ^c	0.10±0.17 ^c	0.13±0.23 ^b	0.17±0.29 ^b	0.17±0.29 ^b	0.20±0.35 ^b
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
 Mean sharing the same letters are not significantly different at p=0.05

Table 3.11: Effect of Salt Stress on the Number of Branches of *Corchorus olitorius* (Landrace B)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.67±1.16 ^b	2.35±4.04
W	0.00±0.00 ^a	1.00±1.73 ^a	3.33±4.16 ^a	5.67±5.51^a	9.33±8.32 ^a	2.00±11.14 ^a
X	0.00±0.00	0.00±0.00 ^c	1.00±1.73 ^b	2.67±4.62 ^b	4.00±6.93 ^b	4.33±7.50^b
Y	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.12 indicates the effect of salt stress on the number of branches on the seedling of *C. olitorius* from NIHORT research institute (landrace C), recorded from day 21 to day 56. Treatment V recorded the highest number of branches (17.33 ± 4.04) throughout the study. There was significant difference between all the treatments. The adverse effect of salt stress increased along the concentration gradient. Treatment Z recorded no branches due to no germination caused by very high salt concentration.

By comparing between the number of branches of the two landraces (B and C), it is seen that the number of branches recorded on the treatment V, W, X, Y, of landrace C is greater than the number of branches recorded on the respective treatment of landrace B. This therefore shows that the growth of branches on the seedling from NIHORT research institute (Landrace C) is greater than that of Benin. This is due to the NIHORT seedling being more able to withstand the effect of salt stress compared to the seedling from Benin City.

Table 3.13 shows the effect of salt stress on the internode length of the seedling of *C. olitorius*, which was collected from Benin City (landrace B), and recorded from day 21 to day 56. Treatment W recorded the highest internode length (1.93 ± 1.72 cm) all throughout the investigation. There was significant difference between all the treatments and the adverse effect of salt stress increased along the concentration gradient. Treatment Y and Z recorded no internode length as a result of its extreme salt concentration which resulted in no germination.

Table 3:12: Effect of Salt Stress on the number of branches of *Corchorus Olitorius* (Landrace C)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.00±0.00 ^c	1.67±1.53 ^a	5.67±0.58 ^a	9.33±1.16 ^a	13.00±1.73^a	17.33±4.04 ^a
W	0.00±0.00 ^c	1.33±2.31 ^a	4.33±2.52 ^a	6.67±2.52 ^a	11.33±4.93 ^a	13.67±4.73 ^a
X	0.00±0.00 ^c	0.67±0.58 ^b	4.67±1.53 ^b	8.00±2.00 ^b	6.67±5.86 ^b	8.67±7.57^b
Y	0.00±0.00 ^c	1.00±1.73 ^c	2.33±4.04 ^c	3.67±6.35 ^c	4.33±7.51	5.33±9.24 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 13: Effect of Salt Stress on the Internode Length (cm) of *Corchorus olitorius* (Landrace B)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.00±0.00 ^c	0.00±0.00 ^c	0.17±0.29 ^b	0.17±0.29 ^b	0.47±0.81^b	0.53±0.92 ^b
W	0.33±0.58 ^a	0.93±0.83 ^a	1.50±1.50 ^a	1.60±1.51 ^a	2.55±0.92 ^a	1.03±1.72 ^a
X	0.00±0.00 ^c	0.17±0.29 ^b	0.43±0.75 ^b	0.47±0.81 ^b	0.50±0.87 ^b	0.55±0.92^b
Y	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.14 show the effect of salt stress on the internode length of the seedling of *C. olitorius* which was collected from landrace C and was recorded from day 21 to day 56. Treatment X recorded the highest internode length (1.93 ± 2.18 cm) throughout the study. There was significant difference between the treatments and the lethal effect of salt stress increased along the concentration gradient. Treatment Z recorded no internode length as there was no germination due to its extremely high salt concentration.

By comparing the effect of salt stress on internode length between the two landraces (B and C) it is seen that the internode length of the seedling from NIHORT (landrace C) is greater than that of landrace B (Benin). And this is due to the higher salt tolerance of the seedling from NIHORT (C) compared to the seedling from Benin City (B).

Table 3.15 indicates the effect of salt stress on the amount of leaf loss by the seedling of *C. olitorius*, collected from landrace B, recorded from day 21 to day 56. Treatment V and W recorded the highest from day 21 to day 56. Treatment V and W recorded the highest leaf loss. There was significant difference between the treatments. The adverse effect of salt stress was along the concentration gradient. There was no leaf loss recorded on treatment Y and Z because there was no germination due to increased salt concentration.

Table 14: Effect of Salt Stress on the Internode Length (cm) of *Corchorus olitorius* (Landrace C)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.00±0.00 ^c	0.83±0.29 ^b	1.17±0.21 ^b	1.47±0.06 ^b	1.53±0.06^b	1.63±0.06 ^b
W	0.27±0.46 ^b	0.87±0.32 ^b	1.13±0.31 ^b	1.33±0.29 ^b	1.53±0.50 ^b	1.73±0.55 ^b
X	0.47±0.45 ^a	1.23±1.25 ^a	2.07±1.51 ^a	2.20±1.57 ^a	1.90±2.13 ^a	1.93±2.18^a
Y	0.17±0.29 ^c	0.40±0.69 ^c	0.50±0.87 ^c	0.53±0.92 ^c	0.53±0.92 ^c	0.57±0.98 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.
Mean sharing the same letters are not significantly different at p=0.05

Table 3.15: Effect of salt Stress on the Leaf Loss of *Corchorus olitorius* (Landrace B)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	1.33±2.31 ^a	1.33±2.31^a	1.33±2.31 ^a
W	0.00±0.00 ^c	1.00±1.00 ^a	1.33±1.16 ^a	1.33±1.16^a	1.33±1.16 ^a	1.33±1.16 ^a
X	0.00±0.00 ^c	0.67±1.16 ^b	0.67±1.16 ^b	0.67±1.16 ^b	0.67±1.16 ^b	0.67±1.16^b
Y	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.

Mean sharing the same letters are not significantly different at p=0.05

Table 3.16 indicates the effect of salt stress on the amount of leaf loss by the seedling of *C. olitorius*, collected from landrace C, and recorded from day 21 to day 56. Treatment V recorded the highest number of leaf loss. There was significant difference and the impact of salt stress was along the concentration gradient. Treatment Z recorded no leaf loss because there was no germination as a result of its high salt content.

By comparing between the number of leaf loss of the two landraces (B and C), more leaves lost in the seedling from landrace C, compared to the seedling from landrace B.

Table 3.16 Effect of Salt Stress on the Leaf Loss of *Corchorus olitorius* (Landrace C)

Treatment	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56
V	0.00±0.00 ^c	0.67±0.58 ^a	1.00±0.00 ^a	1.67±0.58 ^a	2.33±0.58^a	2.33±0.58 ^a
W	0.00±0.00 ^c	1.00±1.00 ^a	1.00±1.00 ^a	1.33±1.16^a	2.67±0.58 ^a	2.67±0.58 ^a
X	0.00±0.00 ^c	1.00±1.00 ^b	1.00±1.00 ^b	1.33±1.16 ^b	1.33±1.16 ^b	1.33±1.16 ^b
Y	0.00±0.00 ^c	0.33±0.58 ^b	0.33±0.58 ^b	0.67±1.16 ^b	0.67±1.16 ^b	0.67±1.16 ^b
Z	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c

The value in each column indicates the mean and standard error.

Mean sharing the same letters are not significantly different at p=0.05



Plate 1: :Experimental layout



Plate 2: Flowering in *Corchorus olitorius*

CHAPTER FOUR

DISCUSSION AND CONCLUSION

4.1 DISCUSSION

Table 3.1 demonstrates how the germination of *Corchorus olitorius* seeds from Benin City (landrace B) responded to varying levels of salt stress. The control (V) recorded 10.00 ± 1.00 by day 8 which eventually increased to 43.33 ± 4.16 % by day 15, thereby indicating normal conditions. W recorded 26.6 ± 1.15 % germination at the end of the study, indicating moderate salinity condition did not significantly affect the seeds germination, as the seeds of *C. olitorius* are tolerant to salt stress to some extent (Mguis *et al.*, 2014) Treatment X recorded reduced germination (13.3 ± 1.53 % at the end of the study due to increasing salinity level. Treatment Y and Z recorded no germination (0.00 ± 0.00 %), indicating the adverse effect of salt stress which causes osmotic and ionic stress leading to metabolism and water uptake impairment (Muuns *et al.*, 2008). These findings highlight the ability of *Corchorus olitorius* to withstand moderately saline environments and higher concentration will significantly impair seed germination.

Table 3.2 demonstrates how the germination of *Corchorus olitorius* seeds from NIHORT (C) responded to varying levels of salt stress. Treatment V recorded 80.00 ± 1.73 % by day 8 which eventually increased to 90.00 ± 1.00 % by day 15, indicating optimal conditions for germination. W recorded 83.33 ± 2.89 % germination at the end of the study, indicating moderate salt level did not severely affect the seed germination. Treatment X and Y recorded more reduced germination as a result of increasing salinity level (Abbass *et al.*, 2010). Treatment Z recorded no germination (0.00 ± 0.00), indicating the lethal effect of increased salt concentration. These findings shows the potential of *Corchorus olitorius* to germinate in moderately saline soil but higher concentration levels will severely hinder seen germination.

By comparing germination percentage between the two landraces, (B and C), it is seen that the seeds from landrace C have a higher potential of withstanding varying levels of salt stress compared to the seeds of landrace B.

Table 3.3 demonstrates how the elongation of the shoot of *Corchorus olitorius* from Benin City responded to varying levels of salt concentration. Treatment W recorded 43.33 ± 40.41 at the end of the study, indicating moderate salt concentration did not significantly reduce the shoot height. Treatment X recorded reduced shoot height (15.67 ± 27.10 cm) at the end of the study as a result of increasing salinity levels (Bimurzayev *et al.*, 2021). Treatment Y and Z recorded no shoot height (0.00 ± 0.00 cm), indicating the lethal effect of increased salt concentration as there was no germination. These findings highlight the potential of *c. olitorius* to grow in mildly concentrated soil but higher concentration levels will severely affect the elongation of the shoot of *Corchorus olitorius* (Shrivastava *et al.*, 2015), thereby reducing crop production.

Table 3.4 demonstrates how the elongation of the shoot of *Corchorus olitorius* from NIHORT (c) responded to increasing levels of salt concentration. Treatment V recorded the highest shoot at the end of the study (49.33 ± 5.03 cm), indicating an optimal condition. Treatment W recorded 47.00 ± 9.64 cm at the end of the study, indicating moderate salt concentration did not severely affect the shoot height. Treatment X and Y recorded more reduce shoot height (37.00 ± 34.39 cm and 17.67 ± 30.72 cm respectively) at the end of the study as a result of increasing salinity levels (Bimurzayev *et al.*, 2021). Treatment Z recorded no shoot height (0.00 ± 0.00 cm), which indicate the lethal effect of increased salt concentration as there was no germination (Mguis *et al.* 2014). These findings highlight the potential of *c. olitorius* to grow in mildly concentrated soil but higher concentration level of salt will severely affect the elongation of the shoot. Thereby reducing crop production.

By comparing between the shoot height of these two landraces (B and C), is observed that the *Corchorus olitorius* seedlings of landrace B are more susceptible to increased salt concentrations compared to the seedlings of landrace C.

Table 3.5 describes how the production of leaves by the *Corchorus olitorius*_seedlings of landrace B responded to the varying salt concentration levels. Treatment W recorded 52.67 ± 47.69 at the end of the investigation, therefore indicating that moderate salt levels did not significantly reduce the production of leaves. Treatment x recorded reduced number of leaves (17.33 ± 30.05) at the end of the study due to the increasing salt concentration (Shrivastava *et al.*, 2015). Treatment Y and Z recorded no leaves, indicating the lethal effect of overly increased salt concentration as there was no germination. These findings shows the potential of *C. olitorius* to produce more leaves in mildly saline soil but higher saline soil will significantly hinder the production of leaves.

Table 3.6 describes how the production of leaves by the *C. olitoirus*_seedlings of landrace C responded to the vary salt concentration levels. Treatment V recorded the highest number of leaves (57.00 ± 19.16), indicating an optimal condition. Treatment W recorded 47.33 ± 13.58 at the end of the study, indicating that moderate salt concentration level did not significantly reduce the production of leaves. Treatment X and Y recorded more reduced number of leaves (25.67 ± 22.27 and 20.67 ± 35.81 respectively) at the end of the investigation as a result of increasing concentration levels (Shrivastava *et al.*, 2015). Treatment Z recorded no leaves, indicating the lethal effect of extremely high salt concentration, as there was no germination of the *Corchorus olitorius* seeds (mguis *et al.*, 2014). These findings shows the ability of *C. olitorius* to produce more leaves in mildly saline soil but higher saline soil will significantly hinder the production of leaves, which will eventually lead to reduce crop yield. By comparing the number of leaves between landrace B and C, it is observed that the seedling of landrace B is more susceptible to salt stress compared to that of landrace C.

Table 3.7 describes how the area of leaves of the *Corchorus olitorius* seedling of landrace B responded to varying levels of salt concentration. Treatment W recorded $4.94 \pm 6.71 \text{ cm}^2$ at the end of the investigation, indicating moderate salt levels did not significantly affect the leaf area. Treatment X recorded more reduced area ($1.17 \pm 2.03 \text{ cm}^2$) at the end of the investigation due to the increasing salt concentration as salt stress decreases photosynthetic efficiency (Ibrahim *et al* 2021). Treatment Y and Z recorded no leaf area, indicating the lethal effect of overly increased salt concentration on the leaf of *C. olitorius* (El-sayed *et al.*, 2020) as there was no germination. These findings shows the potential of *C. Olitorius* to survive in moderately saline soil but highly saline soil will severely affect the leaf area.

Table 3.8 describes how the area of leaves of the *Corchorus olitorius_* seedlings of landrace C responded to varying salt concentration levels. Treatment V recorded $10.29 \pm 4.29 \text{ cm}^2$ at the end of the study, indicating moderate salt level did not significantly reduce the leaf area. Treatment X and Y recorded more reduced leaf area ($9.10 \pm 9.38 \text{ cm}^2$ and $1.91 \pm 3.30 \text{ cm}^2$ respectively) at the end of the study as a result of increasing concentration levels (Ibrahim *et al.*, 2021). Treatment Z recorded no leaf area, indicating the lethal effect of extremely high salt concentration on the leaf of *C. olitorius* (El-Sayed *et al.*, 2020) as there was no germination. These findings therefore highlight the potential of *C. olitorius* to survive in moderately saline soil but highly saline soil will severely affect the leaf area.

By comparing the leaf area response to salt stress between landrace B and C, it is observed that the leaves of the seedling from landrace B is more susceptible to salt stress compared to that of landrace C.

Table 3.9 demonstrates how the growth in the stem girth of the *Corchorus olitorius* seedling of landrace B responded to varying salt concentration. Treatment W recorded $0.53 \pm 0.47 \text{ cm}$ at the end of the investigation, indicating moderate salt concentration levels did not significantly affect the stem girth. Treatment X recorded reduced stem girth ($0.23 \pm 0.40 \text{ cm}$)

at the end of the study due to the increasing salt concentration. Treatment Y and Z recorded no stem girth as there was no germination, indicating the lethal effect of increased salt concentration on the stem girth of *C. olitorius*. These findings highlights the potential of *C. olitorius* to survive moderately saline soil but highly saline soil will severely affect the the stem girth. Thereby, compromising the plants ability to establish itself successfully in saline soils (Kumar *et al.*, 2020).

Table 3.10 demonstrates how the growth in the stem girth of the *Corchorus olitorius* seedling of landrace C responded to vary amount of salt concentration. Treatment V recorded the highest stem girth (0.67 ± 0.06 cm), indicating optimal condition. Treatment W recorded 0.53 ± 0.06 cm at the end of the study, indicating moderate salt level did not significantly reduce the stem girth. Treatment X and Y recorded more reduced area (0.20 ± 0.27 cm and 0.20 ± 0.35 cm respectively) at the end of the investigation as a result of the increasing concentration level compromising the plants ability to establish itself successfully (Kumar *et al.*, 2020). Treatment Z recorded no stem girth, indicating the adverse effect of extremely high salt levels on the growth in the stem girth of *C. olitorius* as there was no germination. These findings indicate the potential of *C. olitorius* to survive and become established in mildly saline soil but highly saline soil will severely reduce the stem girth.

By comparing the stem girth response to salt stress between landrace B and C, it is observed that the growth in stem girth of the *Corchorus olitorius* seedling from landrace B is more susceptible to salinity stress compared the *Corchorus olitorius* seedling of landrace C. Table 3.11 demonstrates how the development of branches by the *Corchorus olitorius* seedling from landrace B responded to varying levels of salt concentration. Treatment W recorded 12.00 ± 11.14 at the end of the study, indicating that moderate salt concentration did not significantly reduce the number of branches produced. Treatment X recorded reduced number of branches (4.33 ± 7.50) at the end of the investigation due to increased salt levels.

Treatment Y and Z recorded no branches, indicating the adverse effect of increased salt concentration as there was no germination recorded. These findings highlights the potential of *C. olitorius* to grow in mildly concentrated soil and produce branches. But higher concentration levels will severely reduce the number of branches produced by *Corchorus olitories*, thereby compromising the plants ability to establish itself successfully in saline soils. (Kuma *et al*, 2020).

Table 3.12 demonstrates how the development of branches by the *Corchorus olitorius* seedling from landrace C responded to varying salt concentration levels. Treatment V recorded the highest number of branches at the end of the study (17.33 ± 4.04) indicating an optimal condition. Treatment W recorded 13.67 ± 4.73 , indicating moderate salt concentration did not severely affect the production of branches (Rahman *et al.* 2021) Treatment X and Y recorded more reduced branches (8.67 ± 7.57) and 5.33 ± 9.24 respectively) at the end of the study as a result of increasing salinity levels (Bimurzayev *et al*, 2021). Growth was completely inhibited on treatment Z, which indicate the lethal effect of extremely high salt concentration. These findings indicate the ability of *C. olitorius* to grow in mildly saline soil but higher levels of salt will significantly hinder the production of branches of *C. olitorius*. Resulting in decrease in crop production.

By comparing the production of branches by the seedling of *C. olitorius* between the two landraces (B and C), it is seen that the *Corchorus olitorius* seedlings of the landrace C are more resistant to salt stress compared to the seedlings of landrace B.

Table 3.13 demonstrates the response of the internode length of the seedling of *Corchorus olitorius* from landrace is to varying salt concentration. Treatment W recorded 1.93 ± 1.72 at the end of the study, indicating moderate salt concentration did not severely affect the internode length. Treatment X recorded reduced internode length. Treatment X recorded reduced internode length (0.53 ± 0.92) as a result of the increasing salt level (Bmurzayev *et.*

al. 2021) Growth was completely inhibited on treatment Y and Z, indicating the adverse effect of increased salt concentration (Munns et. al., 2008). These findings shows the potential of *C. olitorius* to grow and become established in mildly concentrated soil. But extremely high salt concentration will significantly hinder the elongation of the internode length of *C. olitorius* seedling.

Table 3.14 demonstrates the response of the internode length of the seedling of *C. olitorius* from landrace C to increasing salt concentration levels. Treatment V, W, X recorded 1.63 ± 0.06 , 1.73 ± 0.55 , and 1.93 ± 2.18 respectively, indicating moderate salt concentration did not severely affect the internode length. Treatment Y recorded more reduced internode length (0.57 ± 0.98) at the end of the study as a result of increasing salinity levels. Growth was completely inhibited in treatment Z, indicating the lethal effect of increased salt concentration. These findings therefore indicate the potential of *C. olitorius* to grow and become established in moderately saline soil. But the extremely high salt concentration will significantly hinder the elongation of the internode length of *C. olitorius* seedling. Thereby leading to the reduction in crop yield.

By comparing the internode length response between landrace B and C, it is seen that the *C. olitorius* seedling of landrace is more sensitive to increase in salt concentration compared to the *C. olitorius* seedling of landrace C.

Table 3.15 demonstrates how the number of leaf loss from the seedling of *Corchorus olitorius* of landrace B responded to varying concentration levels of salt. Treatment V, W, and X recorded moderate leaf loss. Growth was completely inhibited on treatment Y and Z, indicating the lethal effect of increased salt concentration.

Table 3.16 demonstrates how the number of leaf loss from the seedling of *C. olitorius* of landrace C responded to increasing amount of salt stress. Treatment V and W recorded higher

leaf loss. Treatment X and Y recorded moderate leaf loss. Growth was completely inhibited on treatment Z, indicating the lethal effect of extremely high salt concentrations.

By comparing the number of leaf lost between the two landraces (B and C), it is seen that there was more leaves lost in landrace C compared to that of landrace B

Overall, findings revealed there were significant reduction in the growth parameters across the treatments as the concentration increased. *Corchorus olitorius* seeds from landrace B (Benin City) had a higher sensitivity to salinity stress than the *Corchorus olitorius* seeds from landrace C (NIHORT). Seeds from NIHORT consistently performed better than those from Benin City under all salinity levels, suggesting genetic variability and a possible breeding advantage for salt-tolerant cultivar.

4.2 CONCLUSION

This study shows that *Corchorus olitorius* exhibit tolerance to mildly saline soil but it is significantly affected by higher salt concentration level. At concentrations lower than 200 ppm (0.2 g/L of NaCl), the germination rate, shoot height, number of leaves, leaf area, number of branches, internode length were either unaffected or only slightly reduced, indicating tolerance to mild salinity. At moderate concentrations 2000 ppm (2 g/L of NaCl), there was reduction in all the growth parameters, indicating a higher effect on the physiological parameters.

At higher salinity levels (5 g/L NaCl), growth was markedly inhibited across all measured parameters. Extremely high concentration of salt (10 g/L of NaCl) resulted in complete inhibition of germination and growth, thus indicating the adverse effect of highly saline soil on the growth of *Corchorus olitorius*. These findings therefore, demonstrated that increasing levels of salinity adversely affect both the germination and early seedling development of *Corchorus olitorius*

4.3 RECOMMENDATIONS

Soil salinity levels should be carefully managed to remain below 2 g/L NaCl concentration in order to optimize the growth and productivity of *Corchorus olitorius* in saline-prone soils. Higher concentrations of salt significantly hinder germination and seedling development. It is therefore advisable to use fresh or only slightly saline water for irrigation in order to prevent excessive salt build up, which can obstruct and ad compromise normal plant growth. Also, improving the salt tolerance of *Corchorus olitorius* should be prioritized in breeding programs to enhance crop performance on marginal or degraded soils. Further research on salinity is also recommended to identify effective mitigation strategies and to gain deeper insight into the physiological and molecular mechanisms that enable plants to adapt to salt stress. Additionally, educating farmers on sustainable agricultural practices such as crop rotation can help reduce the adverse impacts of salinity.

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