# EFFECT OF SALINITY ON SEED GERMINATION AND EARLY SEEDLING GROWTH OF *Acacia auriculiformis*

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## *CERTIFICATE*

*This is to certify that thesis entitled, "**EFFECT OF SALINITY ON SEED GERMINATION AND EARLY SEEDLING GROWTH OF Acacia auriculiformis**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGROFORESTRY AND ENVIRONMENTAL SCIENCE**, embodies the result of a piece of bona-fide research work carried out by **MD. SAJADUL ISLAM**, Registration no. **13-05456** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

*I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.*

**Date: JUNE, 2021**
**Place: Dhaka, Bangladesh**

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*May Allah bless and protect them all.*

***The Author***
***June, 2021***

Dedicated

To

My beloved

Parents

**EFFECT OF SALINITY ON SEED GERMINATION AND EARLY SEEDLING GROWTH OF *Acacia auriculiformis***

## ABSTRACT

Seed germination and early seedling growth of different species in saline condition is familiar to all. But effect of salinity on seed germination and early seedling growth of *Acacia auriculiformis* is not well known to all. So, a pot experiment was conducted at the Agroforestry research field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from 02 July, 2020 to 15 February, 2021 to find out the effects of salinity on seed germination and early seedling growth of *Acacia auriculiformis.* The experiment consisted of single factor as salinity. There are eight treatments namely were as follows: $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 Mm NaCl concentration. This experiment was laid out in CRD(completely randomized design) with four replications. Germination (%), plant height, branch length, number of branches plant$^{-1}$ at different data recording intervals gradually decreased with increasing salinity level. The highest value for the growth attributes mentioned above were obtained from control treatment while the lowest values were seen in 200–250 mM concentration of salinity. Leaf length was not affected significantly but the variation among the leaf width value were significantly influenced due to different concentration of salinity with the highest values were recorded from 0–150 mM salinity and the lowest values were recorded around 250 mM concentration. Shoot fresh weight, shoot dry weight, root fresh weight and root dry weight all were varied significantly due to the effect of different level of saline condition.

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# LIST OF ABBREVIATIONS

| ABBREVIATION | ELABORATION |
|---|---|
| AEZ | Agro-Ecological Zone |
| *Agric.* | Agriculture |
| *Agra.* | Agricultural |
| *Annu.* | Annual |
| *Appl.* | Applied |
| *Biol.* | Biology |
| *Chem.* | Chemistry |
| Cm | Centi-meter |
| CV | Coefficient of Variance |
| DAS | Days After Storage |
| DAP | Days After Planting |
| *Dev.* | Development |
| *Ecol.* | Ecology |
| *Environ.* | Environmental |
| *Etci* | and others |
| *Exptl.* | Experimental |
| % | Percentage |
| *J.* | Journal |
| LSD | Least Significant Difference |
| M.S. | Master of Science |
| $m^2$ | Meter squares |
| mg | Milligram |
| *Nutr.* | Nutrition |
| *Physiol.* | Physiological |
| *Progress.* | Progressive |
| *Res.* | Research |
| SAU | Sher-e-Bangla Agricultural University |
| *Sci* | Science |
| T | Tuber size |
| *So* | Society |
| SRDI | Soil Resource Development Institute |
| t $ha^{-1}$ | Ton per hectare |
| UNDP | United Nations Development Programme |
| *Viz* | *videlicet* (L.), Namely |

## LIST OF ABBREVIATIONS (CONT'D)

| | |
|---|---|
| AEZ | Agro-Ecological Zone |
| BBS | Bangladesh Bureau of Statistics |
| CV % | Percent Coefficient of Variance |
| DAS | Days After Sowing |
| eds. | Editors |
| et al. | et alia (and others) |
| etc. | et cetera (and other similar things) |
| FAO | Food and Agricultural Organization |
| L. | Linnaeus |
| LSD | Least Significant Difference |
| MoP | Muriate of Potash |
| SAU | Sher-e-Bangla Agricultural University |
| SRDI | Soil Resources and Development Institute |
| TDM | Total Dry Matter |
| TSP | Triple Super Phosphate |
| UNDP | United Nations Development Programme |
| *viz.* | Namely |

# CHAPTER I

# INTRODUCTION

*Acacia auriculiformis* is a multipurpose leguminous tree of medicinal forestry importance (Girijashankar., 2011). *Acacia auriculiformis* is a tree species and is native to Australia, Indonesia and Papua New Guinea. Plants of this species have been transplanted in coastal area of Arabian Sea in Saurashtra region and at low lands in Bangladesh. The transplanted plants grow successfully in these saline areas and are locally known as Akash moni. This tree species shows a high degree of salt tolerance and is considered to be valuable for utilizing saline soils. Its bark is a valuable material for tannin .

*A. auriculiformis* is one of the most popular species in social forestry and cropland agroforestry, which has the potential to grow and survive in a wide range of territories and environments, and is well acclimatized to salty environments (Chowdhury *et al.*, 2013). However, the salt-tolerant limit and the defense mechanisms underlying salt-tolerant capacity in *A. auriculiformis* are still elusive. Moreover, no study has been conducted at morpho-physiological, biochemical and cellular levels to understand the mechanisms associated with the adaptability of *A. auriculiformis* under salt stress.

Soil salinity has detrimental effects on seed germination and plant growth (Bernstein, 1962; Ramoliya *et al.*, 2005). However, plant species differ in their sensitivity or tolerance to salts (Marschner, 1995). There is evidence that organs, tissues and cells at different developmental stages of plants exhibit varying degrees of tolerance to environmental conditions (Munns, 1993). It is reported that soil salinity suppresses shoot growth more than root growth (Maas and Hoffman, 1977; Munns, 2002; Ramoliya *et al.*, 2006). However, fewer studies on the effect of soil salinity on root growth have been conducted (Munns, 2002). The salt-induced water deficit is one of the major constraints for plant growth in saline soils. In addition, many nutrient interactions in salt-stressed plants can occur that may have important consequences for growth. Internal concentrations of major nutrients and their uptake have been frequently studied (Cramer *et al.*, 1989; Maas and Grieve, 1987, Ramoliya *et al.*, 2006, Patel and Pandey, 2008) but the relationship between micro-nutrient concentrations and soil salinity is rather complex and remains poorly understood (Tozlu *et al.*, 2000).

High salinity causes diverse cooperative events that adversely affect all plant formative stages (Lee *et al.*, 2013); with corresponding pernicious impacts on the plant yield resulting lessening of agricultural outputs by billions of dollars per annum, with remediation activities being troublesome and costly (Nosetto *et al.*, 2013). The rate of plant growth relies upon a couple of principle events, for instance, cell division, cell enlargement and cell differentiation, together with genetic, morphological, physiological, biochemical and ecological activities and their intricate interactions, that are severely overwhelmed by salinity stress (Taiz and Zeiger, 2006 and Islam *et al.*, 2015).

Salinity stress not only threats world agriculture, but also jeopardizes Bangladesh food security (Islam *et al.*, 2016). The sustainable livelihoods of millions of people of Bangladesh hinge on agriculture, which acts as a mainstay of the economy, are severely plagued by salinity stress (Abdullah and Rahman, 2015; Islam *et al.*, 2016). In spite of the yield of the alleged salt tolerant shallow rooted glycophytes is severely reduced under ultra-saline soils, the halophyte species can be efficaciously grown in salty environment where the level of saltiness may stretch around 200 mM and more. There are various species of halophytes suited to grow in saline decumbent area (Hasan *et al.*, 2016). However, the fast-growing nature of *Acacia auriculiformis* and its good adaptability in degraded soil condition, especially in saline soils, it has been considered a priority species in the short-rotation plantations in Bangladesh, such as social forestry and agroforestry projects in the coastal belts (Islam *et al.*, 2007 and Abdullah *et al.*, 2015). It is a fast-growing nitrogen fixing multipurpose tree species which prevents exposure of soils to direct radiation from the sun using its perennial foliage as well as crown cover, and reduce the evaporation rate, resulting in less salt accumulation in the top soils (Tham and Liew, 2012). Furthermore, it is extensively used to provide shade, form windbreaks, and the wood has been used widely for charcoal, fuel, pulp, tool handles, oars, paddles, packing cases, and furniture manufacturing (Shukla *et al.*, 2007 and Chowdhury *et al.*, 2013). Therefore, if *Acacia auriculiformis* can be brought under plantation in the saline prone area, the existing agrarian land will be more productive through minimizing the detrimental effects of salts as well as to sustain crop productivity, which will help to maintain a wide range of ecological security.

Therefore, in the present study, we aimed to examine the effects of salinity on seed germination and early seedling growth of *A. auriculiformis*. The present investigation was carried out-

(i) To investigate the seed germination rate of *Acacia auriculiformis* under different salinity levels

(ii) To determine the growth parameters of *Acacia* seedling under different saline conditions.

# CHAPTER II

# REVIEW OF LITERATURE

Due to fast-growing nature of *Acacia auriculiformis* and its good adaptability in degraded soil condition, especially in saline soils, it has been considered a priority species in the short-rotation plantations in Bangladesh, such as social forestry and agroforestry projects in the coastal belts. Salinity tolerance limit alongside morpho-physiological response of *Acacia auriculiformis* to salinity stress is not well documented in Bangladesh conditions. However, a good number of investigations were done under the agro-climatic situations of Australia, Pakistan, India and elsewhere in the world. Some the relevant research studies performed on salinity stress on *Acacia auriculiformis* and other related species of *Acacia* so far were reviewed and described under the following headings and sub-headings in this chapter.

## 2.1 Effect of salinity on different parameters of *Acacia auriculiformis*

Patel *et al*. (2010) conducted greenhouse experiments to assess the effects of salinization of soil on emergence, growth, water status, proline content, and mineral accumulation of seedlings of Acacia auriculiformis A. Cunn. ex Benth. (Fabaceae). Sodium chloride (NaCl) was added to the soil and salinity was maintained at 0.3, 3.9, 6.0, 7.9, 10.0, 12.1 and 13.9 $dS{\cdot}m^{-1}$. Seedlings began to emerge two days after sowing and 87% seed germination was obtained over a period of 12 days under control (0.3 $dS{\cdot}m^{-1}$ salinity) conditions. Seedling emergence in saline soils was recorded two to four days after sowing. Emergence lasted for 13, 13, 12, 13, 12, and 8 days in soils with 3.9, 6.0, 7.9, 10.0, 12.1, and 13.9 $dS{\cdot}m^{-1}$ salinities, respectively, and corresponding seed germination was 77%, 68%, 55%, 49%, 41%, and 8%. There was a significant reduction in seed germination with increasing salt stress.

Shivanna *et al*. (2015) conducted experiments to induce saline tolerance in callus cultures of A. auriculiformis on Murashige and Skoogs (MS) medium without (control) salts supplemented with different concentrations of NaCl + $CaCl_2$ (2:1; 50, 100, 150, 200, 250 or 300 mM). Calli were trained for eight sub-culture generations. Acacia auriculiformis is saline intolerant and failed to establish. Results indicated that saline training of calli resulted in the expression of tolerance to 100 mM and 150 mM saline concentration after eight sub-cultures. Callus cultures of A. auriculiformis failed to grow at and above 200 mM. The saline concentration of 50 and 100 mM had no visible effect on the color and growth of callus cultures. At 150 mM salt, the callus growth decreased with slight discoloration in all four sub-cultures. Calli at 200 mM were light brown and non-viable from second sub-culture onwards; at 250 and 300 mM, calli turned brown and failed to proliferate even after repeated transfer on fresh MS with same saline condition. Those callus cultures, that sustained salinity at 50, 100 or 150 mM showed near normal growth when transferred to the next high concentration. Calli of fifth sub-culture showed improved growth when subjected to the sixth sub-culture. All the viable callus cultures that sustained salinity stress resumed normal growth in the seventh sub-culture on MS without salt. When transferred back to the previously elevated saline concentration, the calli at eighth sub-culture responded as in the sixth sub-culture. The control culture expressed normal growth all through eight subcultures.

Marcar *et al.* (1991) conducted an experiment to observe the effect of root-zone salinity on growth and chemical composition of *Acacia ampliceps* B. R. Maslin, *Acacia auriculiformis* A. Cunn. Ex Benth. and *Acacia mangium* Willd. at two nitrogen levels. Four-month-old seedlings were treated with 100 (S1), 200 (S2) and 400 (S3) mol $m^{-3}$ NaCl in sand culture. Two months prior to NaCl application the seedlings had been pretreated with either 1 mol $m^{-3}$ N (low N; LN) or 5 mol $m^{-3}$ N (high N; HN) as ammonium nitrate. LN seedlings were inoculated with *a suspension* of *Rhizobium.* HN plants were considerably larger than inoculated plants at each NaCl concentration. Survival, damage symptoms and relative growth reduction under NaCl were generally similar for both N treatments. There was also no effect of N level on shoot water relations and stomatal conductance of youngest expanded phyllodes. Application of NaCl at S1 and S2 (data for S3 not analysed statistically because all *A. mangium* plants died) significantly decreased shoot and root growth, but the magnitude of the response was again markedly species dependent. *A. ampliceps* was the least affected, particularly at S2, and *A. auriculiformis* was the most affected. Species responses to applied NaCl were not significantly altered by N level. Overall, the response of shoot dry weight to NaCl was not affected by N level. However, the relative reduction in shoot growth of plants at S1 compared to control (S0) was greater for HN plants than those grown at LN. *A. ampliceps* was the most tolerant of NaCl with only a 50–60% dry weight decreased at S2 compared with S0, depending on N level. However, at S1 and S2, HN plants had significantly lower concentrations of shoot $Na^+$ and $Cl^-$ concentrations than LN plants. There were differences in nodule number and weight per plant between species receiving the LN treatment. Nodule dry weight and nitrogenase (acetylene reduction) activity was more sensitive than plant dry weight to NaCl imposition. The researchers showed that shoot dry weight of four-month-old seedlings of *A. ampliceps* (Lake Dora, WA) was reduced by about 50% after 30 days at 200 mol $m^{-3}$ NaCl. Ranking of species for salt tolerance, based on relative decline in dry weight of shoot, whole plant and nodules under NaCl addition, *was in* the order *A. ampliceps* > *A. auriculiformis* > *A. mangium*. The greater salt tolerance of *A. ampliceps* was associated with relatively low shoot $Na^+$ and $Cl^-$ concentrations (dry weight basis) and high phyllode succulence. The decrease in phyllode succulence is consistent with that of water content, though the researchers found no effects for *A. ampliceps.*

Rahman *et al.* (2017) elucidated mechanisms regulating the adaptability of the multi-purpose perennial species *Acacia auriculiformis* to salt stress. The growth, ion homeostasis, osmoprotection, tissue tolerance and $Na^+$ exclusion and anatomical adjustments of *A. auriculiformis* grown in varied doses of seawater for 90 and 150 days were assessed. Seawater collected from southern coastal area (Cox's Bazar sea beach) of Bangladesh (electrical conductivity of 49.6 $dS{\cdot}m^{-1}$, and $Na^+$, $K^+$, $Ca^{2+}$ and $Mg^{2+}$ concentrations of 478.70, 10.38, 9.90 and 56.08 $mmol{\cdot}L^{-1}$, respectively) was diluted with tap water to formulate 4, 8 and 12 $dS{\cdot}m^{-1}$ of salinity. For imposing salt stress, the uniformly grown plants were irrigated with the diluted seawater (300 mL) at 3-day interval for a period of 150 days. The control plants were irrigated with tap water devoid of seawater (0 $dS{\cdot}m^{-1}$). Results showed that diluted seawater caused notable reductions in the level of growth-related parameters, relative water content, stomatal conductance, photosynthetic pigments, proteins and carbohydrates in dose- and time-dependent manners. However, the percent reduction of these parameters did not exceed 50% of those of control plants. Salinity had considerable negative effects on the growth of *A. auriculiformis*, and the overall growth performance gradually declined upon increasing the level of salt stress for a period of 150 days. Salt stress caused a significant reduction of plant height by 15%, 25% and 31% at day 90th, and 21%, 30% and 39% at day 150th after exposure of plants to 4, 8 and 12 $dS{\cdot}m^{-1}$ salinity levels, respectively, as compared with the respective control values.

Giri *et al.* (2003) investigated the effect of salinity on the efficacy of two arbuscular mycorrhizal (AM) fungi, *Glomus fasciculatum* and *G. macrocarpum* alone and in combination on growth, development and nutrition of *Acacia auriculiformis*. Plants were grown under different salinity levels imposed by 0.3, 0.5 and 1.0 $S{\cdot}m^{-1}$ solutions of 1 M NaCl. Both mycorrhizal fungi protected the host plant against the detrimental effect of salinity. AM fungal inoculated plants showed significantly higher root and shoot weights.

Mezanur-Rahman *et al.* (2016) evaluated the morpho-physiological changes of *Acacia auriculiformis* in response to seawater induced salinity stress along with its tolerance limit. Three saline treatments (4, 8, 12 $dS \cdot m^{-1}$) were applied to six-month aged *Acacia auriculiformis* seedlings and the tap water was used as control treatment. Diluted seawater caused a notable reduction in plant height, which was found to be decreased to some extent compared to control plants. Salinity stressed plant height and results indicated that the progressive increase in salinity levels triggered an increase in the percent reduction of the plant height over control treatment. This increase reached the severe level after 150 days after treatment. Plant height was reduced by 5.56%, 21.16% and 29.69% at 4, 8, 12 $dS \cdot m^{-1}$ salinity levels, respectively, in relation to the control plants at 150 DAT.

Diouf *et al.* (2005) conducted a research work to assess the growth and mineral nutrition of salt stressed *Acacia auriculiformis* A. Cunn. ex Benth. and *Acacia mangium* Willd. seedlings inoculated with a combination of selected microsymbionts (bradyrhizobia and mycorrhizal fungi). Plants were grown in greenhouse conditions in non-sterile soil, irrigated with a saline nutrient solution (0, 50 and 100 mM NaCl). The inoculation combinations consisted of the *Bradyrhizobium* strain Aust 13c for *A. mangium* and Aust 11c for *A. auriculiformis*, an arbuscular mycorrhizal fungus (*Glomus intraradices*, DAOM 181602) and an ectomycorrhizal fungus (*Pisolithus albus*, strain COI 007). The inoculation treatments were designed to identify the symbionts that might improve the salt tolerance of both *Acacia* species. The main effect of salinity reduced tree growth in both acacias. Salt stress reduced plant growth but the root systems appeared more affected than the shoot systems by salinity in the rooting medium. However, it appeared that, compared with controls, both rhizobial and mycorrhizal inoculation improved the growth of the salt-stressed plants, while inoculation with the ectomycorrhizal fungus strain appeared to have a small effect on their growth and mineral nutrition levels. Endomycorrhizal inoculation combined with rhizobial inoculation usually gave good results. Analysis of foliar proline accumulation confirmed that dual inoculation gave the trees better tolerance to salt stress and suggested that the use of this dual inoculum might be beneficial for inoculation of both *Acacia* species in soils with moderate salt constraints.

## 2.2 Effect of salinity on different species of *Acacia*

### 2.2.1 *Acacia stenophylla, Acacia albida and Acacia mearnsii*

Abbas *et al.* (2017) carried out a hydroponic experiment to study different mechanisms of salinity tolerance in two *Acacia* species, namely *Acacia stenophylla* A. Cunn. ex Benth. and *Acacia albida* Delile. Uniform seedlings of both species were grown for 28 days in half-strength Hoagland's nutrient solution with 0, 100, or 200 mmol·$L^{-1}$ NaCl concentrations. With increasing salinity levels (100 and 200 mM NaCl) in the nutrient solution, shoot and root fresh weights of both the acacia species were decreased. *A. stenophylla* produced more fresh weights of shoot and root than *A. albida* at both salinity levels. Shoot and root dry weights of both the species were also decreased significantly as the salt level was increased in the growth medium. At both salinity levels, *A. stenophylla* produced higher amount of dry biomass of shoot and root than *A. Albida*. The results revealed that shoot biomass decreased by 21% and 29% at the lower salinity level (100 mmol·$L^{-1}$ NaCl) and by 44% and 55% at the higher salinity level (200 mmol·$L^{-1}$ NaCl) in *A. stenophylla* and *A. albida*, respectively. Shoot lengths of both the species were statistically similar at the lower salinity level whereas, at the higher salinity level *A. stenophylla* produced significantly more shoot length than *A. albida*. On the other hand, *A. stenophylla* produced significantly more root length than *A. albida* at both the salinity levels.

Thrall *et al.* (2008) used a range of native Australian shrubby legumes (*Acacia* spp.) and associated root-nodule forming bacteria (rhizobia) in laboratory and glasshouse studies to investigate the ecology of *Acacia*–rhizobial interactions with respect to soil salinity, a major environmental stressor in many parts of the world. The host species chosen were: *A. brachybotrya*, *A. hakeoides*, *A. ligulata*, *A. mearnsii*, *A. pendula*, *A. pycnantha*, *A. rigens*, *A. salicina* and *A. stenophylla*. There were significant differences among *Acacia* spp. In their sensitivity to salt, as well as in their responsiveness to nitrogen addition ($N^+$ controls) and rhizobial inoculation as reflected in the significant interactions between host species, salt and inoculation. Interestingly, salt-tolerance of plant species (in the context of survival time) was negatively correlated with responsiveness to added nitrogen ($r = -0.93$, $P < 0.01$). However, there was not a consistent relationship between plant tolerance of salinity and the responsiveness of the species to rhizobial inoculation.

Hussain *et al*. (1991) conducted an experiment to select suitable tree species for saline and waterlogged areas. They reported that *Acacia stenophylla* survived and grew well as an exotic species planted in the saline soil of Pakistan.

### 2.2.2 *Acacia horrida*, *Acacia raddiana* and *Acacia cyanophylla*

Chérifi *et al.* (2017) assessed and compared the seed germination response of six *Acacia* species under different NaCl concentrations in order to explore opportunities for selection and breeding salt tolerant genotypes. The analysis of the diversity of the tolerance to salinity focused on two native species, represented by *Acacia gummifera* and *Acacia raddiana* and four exotic species, represented by *Acacia eburnean*, *Acacia cyanophylla*, *Acacia cyclops* and *Acacia horrida*. The salinity effect was examined by measuring some agro-morphological parameters in controlled growth environment using five treatment levels: 0, 100, 200, 300 and 400 mM of NaCl. The analysed data revealed significant variability in salt response within and between species. All growth parameters were progressively reduced by increased NaCl concentrations. Growth in height, leaf number and total plant dry weight were considered as the most sensitive parameters. However, the growth reduction varied among species in accordance with their tolerance level. It is important to note that all species survived at the highest salinity (400 mM). Whereas *A. horrida* and *A. raddiana* were proved to be often the best tolerant.

### 2.2.3 *Acacia nilotica*, *Acacia ampliceps* and *Acacia mangium*

Theerawitaya *et al.* (2015) investigated various physio-biochemical and morphological attributes of *Acacia ampliceps* in response to varying levels of salt treatment (200–600 mM NaCl). Seedlings of *A. ampliceps* (25 $\pm$ 2 cm in plant height) raised from seeds were treated with 200 mM (mild stress), 400 and 600 mM (extreme stress) of salt treatment (NaCl) under greenhouse conditions. Leaf color of control (0 mM NaCl) and mild salt-stressed plants (200 mM NaCl) was green. In contrast, phyllodes and the bipinnate leaves (true older leaves) turned yellow in the plants grown under extreme salt stress (400–600 mM NaCl) for 9 days. The overall growth characters declined in plants subjected to extreme salt stress for 9 days. Shoot height (SH), root length (RL), number of phyllodes (NL), number of roots (NR), fresh weight (FW), dry weight (DW) and phyllode leaf area (LA) of salt wattle (*Acacia ampliceps*) grown under 200 mM NaCl stress increased; however, these declined significantly when plants were subjected to 400–600 mM NaCl for 9 days. Shoot height (SH), root length (RL), number of phyllodes (NL), number of roots (NR), shoot fresh weight (SHFW), and root fresh weight (RTFW) in extreme salt-stressed (600 mM NaCl) plants were sharply dropped by 25, 23, 60, 45, 78, and 74%, respectively, compared to plants growing under mild stress (200 mM NaCl).

Marcar and Crawford (2011) investigated the extent of variation amongst provenances and families of *Acacia ampliceps* for seedling response to salt and waterlogging. *Acacia ampliceps* is a highly salt tolerant small tree, naturally-occurring in north-western Australia, which produces abundant biomass with potential for fuelwood and fodder. Seven-week old seedlings from 27 families (seven provenances, grouped into two regions), were treated in sand-filled pots in a glasshouse with either mixed salt (S) solutions (150 $mol \cdot m^{-3}$ for 14 days, 300 $mol \cdot m^{-3}$ for 33 days), waterlogging (W) or combined salt (S) and waterlogging (SW). Only 3% of seedlings died, mostly from the combined salt × waterlogging treatment. Seedlings from the Kimberley region had significantly greater height and shoot biomass than those from the Pilbara. Plant height and growth reduced similarly for S- and W-treated plants, whereas in that of SW-treated plants height and growth reduced much more. Height growth was reduced compared to control plants similarly for S- and W-treated plants from early in the experiment, whereas height of SW-treated plants was reduced much more from day 28 (once 300 $mol \cdot m^{-3}$ had been reached), after which growth ceased.

Yaqoob *et al.* (2009) conducted a study to observe the effect of salinity and water levels on root/shoot development of *Acacia ampliceps* (Maslin). Seedlings were transplanted to plastic pots having soils of 3.61, 11.33, 21.70 and 36.10 $dS \cdot m^{-1}$ salinity separately. Four water levels (50, 75, 100 and 125% water of FC) were applied to each salinity level of each soil type making a total of 16 treatments. Low shoot growth was observed in all irrigation regimes of 50% in all salinity levels. Maximum and minimum root and shoot weight of *Acacia ampliceps* was found in saline soil having ECe 11.33 $dS \cdot m^{-1}$ and highly saline soil having ECe 36.1 $dS \cdot m^{-1}$, respectively. Maximum dry root and shoot weight was found in saline soil having ECe 11.33 $dS \cdot m^{-1}$ while minimum was noted in highly saline soil (ECe 36.1 dS·m.

Yokota (2003) compared five acacia species, viz *A. ampliceps*, *A. salicina*, *A. ligulata*, *A. holosericea* and *A. mangium* in solution culture for their salt tolerance and found that *A. ampliceps* was more tolerant and survived even at 428 mM NaCl where all the other species died. The researcher showed that shoot dry weight of three-week-old seedlings of *A. ampliceps* (De Grey River, WA) treated with 171, 257 and 342 $mol \cdot m^{-3}$ NaCl was reduced by about 50%, 65% and 80%, respectively.

McKinnell (1990) and Thomson (1987) from their separate research studies reported that *Acacia ampliceps* was the most promising species in the hot, dry subtropics and tropics with high salt tolerance and high coppicing ability.

Jain *et al*. (1983) and Tomar and Yadav (1980) mentioned *Acacia nilotica* to be quite tolerant of salts from their separate research works.

### 2.2.4 *Acacia dealbata*, *Acacia ehrenbergiana*, *Acacia tortilis* and *Acacia oerfota*

Kheloufi *et al.* (2016) conducted a study in order to compare the levels of tolerance to salinity in three Acacia species (*Acacia dealbata* Link., *Acacia ehrenbergiana* Hayne and *Acacia tortilis* (Forssk.) Hayne var. *raddiana*) during germination. The researchers were able to determine the optimum conditions for germination to assess suitability for germination of these species under different concentrations of seawater (0: Control, 10, 30, 50 and 100%) in Petri dishes. Preliminary results showed that germination was completely inhibited from 100% of seawater for all studied species.The effect of seawater on the germination and the growth of seedlings differed significantly between the species. *Acacia tortilis* var. *raddiana* was proved to be the most tolerant to salinity with a very high germinability (96% at 50% of seawater concentration). *Acacia tortilis* var. *raddiana* and *Acacia ehrenbergiana* showed great tolerance to 50% of seawater in all studied parameters. It was revealed that the seeds of *A. ehrenbergiana* Hayne collected in Oued Tin Amezzegin (Tamanrasset, Southern of Algeria) gave a final germination rate (GR) of 100% for the first three seawater treatments (0, 10, and 30%) and 78% in the presence of 50% of seawater.

Abari *et al.* (2011) reported an in vitro procedure for studying germination of *Acacia* spp. under salt stress with different NaCl and KCl concentrations. Seeds of *Acacia tortilis* (Forssk.) Hayne and *Acacia oerfota* (Forssk) Schweinf after subjected to sulphuric acid and boiling water, were grown in L2 medium under eight salinity levels (0, 50, 100, 150, 200, 250 and 300 mM) under laboratory conditions. Germination of both species decreased by increasing salinity. Both *Acacia* species showed higher tolerance to increased level of NaCl than to KCl.

Jaouadi *et al.* (2010) suggested that germination of *Acacia tortilis* (Forsk.) Hayne ssp. *raddiana* (Savi) Brenan. was significantly affected by 9 $g \cdot L^{-1}$ of NaCl giving a germination rate of 60%. Furthermore, *Acacia tortilis* continued to germinate even at high concentrations of NaCl reaching 18 $g \cdot L^{-1}$ with a germination rate of 50%.

Elhadi *et al.* (2009) conducted a pot trial to study the effect of irrigation with saline water (NaCl) on three *Acacia* sp. and *Eucalyptus camaldulensis*. Four-week old seedlings of Acacia *seyal* variety Seyal, *A. mellifera, A. tortilis* ssp. *raddiana* and *Eucalyptus camaldulensis* were grown in polyethylene bags filled with a sandy clay loam soil and irrigated with 250, 500, 1000 and 1500 mg/l NaCl for 12 weeks. Plants were monitored for growth (plant height) and symptoms of salt induced stress every 2 weeks. At the end of the experiment root length and root and shoot dry weights were measured. The results showed that seedling growth of all the species decreased significantly with increasing NaCl concentration in the irrigation water.

# CHAPTER III

# MATERIALS AND METHOD

This chapter presents a brief description about experimental period, site, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, intercultural operations, data collection and statistical analysis. The details of experimental materials and methods are described below:

## 3.1 Experimental period and location

The experiment was conducted at the Agroforestry Research Field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from 02 July, 2020 to 15 February, 2021. Location of the site is 23°74'N latitude and 90°35'E longitude with an elevation of 8 meter from sea level (Islam, 2014; Laylin, 2014) .

## 3.2 Agro-Ecological Region

The experimental site belongs to the Agro-ecological zone of "Modhupur Tract", AEZ-28 (Anonymous, 2013). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain . The experimental site is shown in the map of AEZ of Bangladesh in Appendix I.

## 3.3 Climate and soil of the experimental site

Experimental site was located in the sub-tropical monsoon climatic zone, set a parted by winter during the months from July, 2020 to February, 2021. Plenty of sunshine and moderately low temperature prevails during experimental period, which is suitable for potato growing in Bangladesh. The weather data during the study period at the experimental site are shown in Appendix II. Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish-brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood levels. The soli data during the study period at the experimental site are shown in Appendix III.

### 3.4 Experimental treatments

The experiment consisted of single factor as salinity. The treatments were as follows:

1. $S_0$ = 0 mM,
2. $S_1$ = 25 mM,
3. $S_2$ = 50 mM,
4. $S_3$ = 75 mM,
5. $S_4$ = 100 mM,
6. $S_5$ = 150 mM,
7. $S_6$ = 200 mM and
8. $S_7$ = 250 mM.

### 3.5 Experimental design and source of seed

The experiment was laid out in a Completely Randomized Design (C**RD**) with four (4) replications. Total 32 unit-pots were made for the experiment with 8 treatments. Each pot was made of required size.The seed was collected from Seed Bazar, Siddiq Bazar, Fulbaria, Dhaka.

### 3.6 Crop management

#### 3.6.1 Land preparation

The experimental pots (L 10.5 and D 9.5 inch) were first filled at 02 July, 2020 with 10 kg soil. Potted soil was brought into desirable fine tilth by hand mixing. The stubble and weeds were removed from the soil and then vermicompost was mixed. The final pot preparation was done on 10$^{th}$ July, 2020. The soil was treated with insecticides (Bifar 5G @ 4 kg $ha^{-1}$) at the time of final pot preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

#### 3.6.2 Manure application and Seed Sowing

The experimental soil was manured with cow dung.This manure was applied 10 days prior to final land preparation.About 50kg cow dung was used in this experiment and mixed well with soil by hand.The healthy and uniform sized seeds were sowed according to treatment. On an average, seeds were sowed at 4-5 cm depth in soil on 20 July, 2020.

### 3.7 Intercultural operations

#### 3.7.1 Weeding

Weeding was necessary to keep the plant free from weeds. The newly emerged weeds were uprooted carefully from the field after complete emergence of sprouts and afterwards when necessary.

#### 3.7.2 Irrigation

Just after full emergence the crop was irrigated by flooding at 5 days after sowing (DAS) so that uniform growth and development of the crop was occurred and also moisture status of soil retain as per requirement of plants. The second, third and fourth irrigation were done at 30, 50 and 70 DAS, respectively.

### 3.7.3 Plant protection measures

Dithane M-45 was applied at 30 and 60 DAS as a preventive measure for controlling fungal infection.

## 3.8 Treatments preparation

Firstly, saline condition was created with the use of NaCl where 0 mM, 25 mM, 50 mM, 75 mM, 100 mM, 150 mM, 200 mM and 250 mM salinity was applied. To done this work, 1M NaCl solution was prepared. Then, converts to mM solution. In every pot salinity was imposed as required. Finally, 1L solution of different concentration was poured into pot. Before solution preparation, soil was sun dried and soil with water saturation level was finalized. Then, treatment was applied to soil. The seeds were allowed to grow for few days for germination. The control plants were irrigated with tap water devoid of sea water (0 $dSm^{-1}$). Root, stem etc samples were harvested at $90^{th}$ days of salt treatments for determining various physiological and biochemical parameters. The experiment was conducted in Completely Randomized Design (C**RD**) with four replications in each treatment and each replication comprised more than one plant.

## 3.9 Experimental measurements

A brief outline of the data recording procedure followed during the study is given below:

### 3.9.1 Germination

Seed were tested for germination capacity in each month. From each sample, four replications of one hundred seeds were counted at random from well mixed pure seed fraction. Seeds were spaced uniformly and adequately apart on two layers of moist filter paper substrate in 21 cm and 15.5 cm transparent germination trays. Germination trays were kept in a walk-in germinator maintained at 20°C for 16 hours in dark and 30°C for 8 hours with tight, for a total period of 14 days. Then each and every seedling was evaluated separately with reference to evaluation group and general principles laid down. Classification was made as normal seedlings, abnormal seedlings and dead seeds. Germination percentage was calculated as:

$$\text{Germination (\%)} = \frac{\text{No. of seeds germinated}}{\text{No. of seeds placed}} \times 100$$

Maximum tolerated range for four replications was consulted. The experiment was conducted on top of paper for ease so that germinating seeds and seedling structures could be observed easily.

### 3.9.2 Plant height

Plant height refers to the length of the plant from ground level to the tip of the tallest stem. It was measured at an interval of 15 days starting from 30 DAS till 90 DAS.

### 3.9.3 Branch

Branch length refers to the length of the branch from ground level to the tip of the tallest stem. It was measured at an interval of 15 days starting from 45 DAS till 90 DAS.Total number of branches per 10 plants was counted and the average number of branches per plant was recorded. It was measured at an interval of 15 days starting from 30 DAS till 90 DAS.

### 3.9.4 Leaf

Leaf length refers to the length of the leaf from ground level to the tip of the tallest levels. Leaf width refers to the length of the leaf from ground level to the tip of the tallest levels.

### 3.9.5 Shoot

After 90 DAS, leaves of 10 selected plants from each plot were collected and weight of leaves were taken by an ordinary balance in gram (g) and their mean was calculated. The samples of shoot were collected from each treatment. After peel off the samples were dried in an oven at 72°C for 72 hours. It took 72 hrs. and weight by using a digital electric balance and the weight was expressed in gram.

### 3.9.6 Root

After 90 DAS, roots of 10 selected plants from each plot were collected and weight of leaves were taken by an ordinary balance in gram (g) and their mean was calculated. The samples of root were collected from each treatment. After peel off the samples were dried in an oven at $72^0$C for 72 hours. It took 72 hrs. and weight by using a digital electric balance and the weight was expressed in gram.Root length refers to the length of the root from ground level to the tip of the tallest main root. After 90 DAS, total number of roots per 10 plants was counted and the average number of roots per plant was recorded.

### 3.10 Statistical Analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques by using MSTAT-C computer package programme. The significant differences among the treatment means were compared by Least Significant Different (LSD) at 5% levels of probability (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

The experiment was conducted to find out the effects of salinity on seed germination and early seedling growth of *Acacia auriculiformis.* The results obtained from the study have been presented, discussed and compared in this chapter through tables and appendices. The analyses of variance of data in respect of all the parameters have been shown in Appendix IV–IX. The results have been presented and discussed with the help of table 1–8 and possible interpretations given under the following sub-headings.

## 4.1 Effect of different levels of salinity on germination

Different levels of salinity stress showed significant impact on germination (%) of *Acacia auriculiformis* seeds (Table 1). The maximum germination (%) (100%) was observed from the control treatment while the minimum percentage of germination (35.00%) was recorded from treatment $S_7$ (250 ppm). Gradual increase in salinity level showed gradual decrease in germination (%) of *Acacia auriculiformis* seed. The result of this study was supported by the findings of Patel *et al.* (2010), Ben zetta *et al.* (2017), Abari *et al.* (2011), Aref *et al.* (2003), Ramoliya and Pandey (2002), Aziz *et al.* (2001) and Ndour and Danthu (1999) who mentioned that increase in salinity level reduced germination percentage in different *Acacia* species including *Acacia auriculiformis*.

**Table 1:** Effect of different levels of salinity on germination (%) of *Acacia auriculiformis*

| Treatment | Germination (%) |
|---|---|
| $S_0$ | 100.00 a |
| $S_1$ | 95.00 ab |
| $S_2$ | 95.00 ab |
| $S_3$ | 90.00 ab |
| $S_4$ | 80.00 ab |
| $S_5$ | 86.67 ab |
| $S_6$ | 40.00 c |
| $S_7$ | 35.00 c |
| **LSD $_{(.05)}$** | **26.84** |
| **CV (%)** | **23.49** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.Here, $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 mM.

### 4.2 Effect of different levels of salinity on seedling height

Plant height of *Acacia auriculiformis* seedlings was significantly influenced by different levels of imposed salinity at different data recording intervals (Table 2). The tallest plant (7.18 cm, 11.25 cm, 21.62 cm, 33.03 cm and 40.50 cm) at 30 DAS, 45 DAS, 60 DAS, 75 DAS and 90 DAS, respectively was recorded from no salinity treatment ($S_0$). In liew, at 30 DAS, the shortest plant (4.75 cm) was recorded from treatment $S_4$ (100 ppm) and at 45 DAS, the shortest plant (6.60 cm) was observed in treatment $S_6$ (200 ppm). At 60 DAS, 75 DAS and 90 DAS, the shortest plant (9.92 cm, 12.76 cm and 14.54 cm, respectively) was reported from treatment $S_7$ (250 ppm). The results obtained from the present study were in conformity with the findings of Rahman *et al.* (2017), Mezanur-Rahman *et al.* (2016)**,** Abbas *et al.* (2016), who observed reduction in plant height due to increase in salinity level in different *Acacia* species including *Acacia auriculiformis*.

**Table 2:** Effect of different levels of salinity on seedling height (cm) of *Acacia auriculiformis*

| Treatment | Seedling height (cm) at | | | | |
|---|---|---|---|---|---|
| | **30 DAS** | **45 DAS** | **60 DAS** | **75 DAS** | **90 DAS** |
| $S_0$ | 7.18 a | 11.25 a | 21.62 a | 33.03 a | 40.50 a |
| $S_1$ | 7.13 a | 9.43 ab | 21.00 a | 25.38 ab | 36.75 ab |
| $S_2$ | 6.63 ab | 8.13 bc | 17.25 ab | 24.63 b | 34.63 ab |
| $S_3$ | 5.60 ab | 7.80 bc | 14.88 abc | 26.03 ab | 30.66 ab |
| $S_4$ | 4.75 b | 6.28 c | 15.50 abc | 23.06 b | 30.33 ab |
| $S_5$ | 5.10 b | 7.00 bc | 15.56 abc | 28.34 ab | 36.50 ab |
| $S_6$ | 5.08 b | 6.60 c | 11.50 bc | 24.34 b | 27.18 b |
| $S_7$ | 6.00 ab | 8.68 abc | 9.92 c | 12.76 c | 14.54 c |
| **LSD $_{(.05)}$** | **1.96** | **2.67** | **7.17** | **8.10** | **10.93** |
| **CV (%)** | **22.44** | **22.29** | **30.67** | **22.29** | **23.69** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, Salinity**:** $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 mM.

## 4.3 Effect of different levels of salinity on branch length

Different levels of salinity stress showed significant effect on length of branch (cm) of Acacia auriculiformis seedlings (Table 3). The tallest branch (8.58 cm, 9.75 cm, 12.75 cm and 16.30 cm) at 45 DAS, 60 DAS, 75 DAS and 90 DAS, respectively was recorded from no salinity treatment ($S_0$). Whereas, at 45 DAS, 60 DAS, 75 DAS and 90 DAS, the shortest branch (2.87 cm, 4.93 cm, 5.28 cm and 6.19 cm, respectively) was reported from treatment $S_7$ (250 ppm). Gradual increase in salinity level showed gradual decrease in branch length of Acacia auriculiformis seedlings.

**Table 3:** Effect of different levels of salinity on branch length (cm) of *Acacia auriculiformis*

| Treatment | Branch length (cm) at | | | |
|---|---|---|---|---|
| | 45 DAS | 60 DAS | 75 DAS | 90 DAS |
| $S_0$ | 8.58 a | 9.75 a | 12.75 a | 16.30 a |
| $S_1$ | 7.05 ab | 8.63 b | 12.00 a | 15.50 ab |
| $S_2$ | 5.68 bc | 7.50 c | 10.13 b | 13.88 bc |
| $S_3$ | 5.58 bc | 6.93 cd | 9.53 b | 12.33 cd |
| $S_4$ | 5.22 c | 6.67 cd | 7.48 c | 12.06 c |
| $S_5$ | 5.10 c | 6.13 d | 6.74 cd | 10.88 de |
| $S_6$ | 6.01 bc | 6.43 d | 7.01 c | 9.28 e |
| $S_7$ | 2.87 d | 4.93 e | 5.28 d | 6.19 f |
| **$LSD_{(.05)}$** | **1.74** | **0.88** | **1.62** | **2.19** |
| **CV (%)** | **20.58** | **8.41** | **12.46** | **12.37** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. **Here, Salinity:** $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 mM.

### 4.4 Effect of different levels of salinity on number of branches·plant$^{-1}$

Number of branches·plant$^{-1}$ of Acacia auriculiformis seedlings was significantly influenced by different levels of imposed salinity at different data recording intervals (Table 4). The maximum number of branches·plant$^{-1}$ at 30 DAS (4.75) was recoded from control treatment ($S_0$) which was statistically similar to treatment $S_2$ (50 ppm) (4.50). The minimum number of branches·plant$^{-1}$ (3.25) was observed in treatment $S_6$ (200 ppm) which was statistically similar to $S_5$ (3.50) and $S_7$ (3.50). At 45 DAS, the maximum number of branches·plant$^{-1}$ (7.00) was obtained from control treatment ($S_0$) which was statistically similar to treatment $S_2$ (50 ppm) (6.75). The minimum number of branches·plant$^{-1}$ (4.50) was observed in treatment $S_6$ (200 ppm) which was statistically similar to $S_5$ (5.00). The maximum number of branches·plant$^{-1}$ at 60 DAS (9.50) was recoded from control treatment ($S_0$) which was statistically similar to treatment $S_2$ (50 ppm) (9.00) whereas the minimum number of branches·plant$^{-1}$ (5.50) was observed in treatment $S_7$ (250 ppm) which was statistically similar to $S_6$ (6.50). At 75 DAS, the maximum number of branches·plant$^{-1}$ (11.25) was obtained from control treatment ($S_0$) which was statistically similar to treatment $S_2$ (50 ppm) (10.50) while the minimum number of branches·plant$^{-1}$ (6.25) was observed in treatment $S_7$ (250 ppm) which was statistically similar to $S_4$ (8.00). The maximum number of branches·plant$^{-1}$ at 90 DAS (11.50) was recoded from control treatment ($S_0$) which was statistically similar to treatment $S_3$ (11.25) while the minimum number of branches·plant$^{-1}$ (6.50) was observed in treatment $S_7$ (6.50). The results mentioned above are in conformity with the findings of Mahmood et al. (2009) who stated that saline condition reduced number of branches in Acacia plants.

**Table 4:** Effect of different levels of salinity on number of branches·plant$^{-1}$ of *Acacia auriculiformis*

| **Treatment** | **Number of branches·plant$^{-1}$ at** | | | | |
|---|---|---|---|---|---|
| | **30 DAS** | **45 DAS** | **60 DAS** | **75 DAS** | **90 DAS** |
| $S_0$ | 4.75 a | 7.00 a | 9.50 a | 11.25 a | 11.50 a |
| $S_1$ | 4.25 ab | 6.25 ab | 8.50 ab | 10.00 ab | 11.00 a |
| $S_2$ | 4.50 a | 6.75 a | 9.00 ab | 10.50 ab | 11.00 a |
| $S_3$ | 4.25 ab | 6.00 abc | 8.50 ab | 9.75 ab | 11.25 a |
| $S_4$ | 4.25 ab | 5.50 abc | 7.25 abc | 8.00 bc | 9.50 a |
| $S_5$ | 3.50 bc | 5.00 bc | 7.75 abc | 10.00 ab | 11.00 a |
| $S_6$ | 3.25 c | 4.50 c | 6.50 bc | 8.25 bc | 10.25 a |
| $S_7$ | 3.50 bc | 5.50 abc | 5.50 c | 6.25 c | 6.50 b |
| **LSD $_{(.05)}$** | **0.92** | **1.63** | **2.73** | **2.65** | **2.61** |
| **CV (%)** | **15.46** | **19.10** | **23.76** | **19.49** | **17.33** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, Salinity**:** $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 mM.

## 4.5 Effect of different levels of salinity on leaf length and leaf width

Different levels of salinity stress did not show any significant effect on length of leaf (cm) of *Acacia auriculiformis* seedlings (Table 5). The longest leaf (17.25 cm) was recorded from no salinity treatment ($S_0$). But, the shortest leaf (12.56 cm) was reported from treatment $S_7$ (250 ppm). The result of this study was supported by the findings of Patel *et al.* (2010), Theerawitaya *et al.* (2015) and Hardikar and Pandey (2008) who mentioned a negative relationship between leaf area and salt concentration. Width of leaf was significantly influenced by different levels of imposed salinity (Table 5). The widest leaf (5.27 cm) was recorded from treatment $S_3$ (75 ppm), which was statistically similar to $S_0$ (4.73 cm), $S_1$ (4.68 cm) and $S_5$ (5.00 cm). Nevertheless, the narrowest leaf (3.19 cm) was reported from treatment $S_7$ (250 ppm). The result of this study was supported by the findings of Patel *et al*. (2010), Theerawitaya *et al*. (2015) and Hardikar and Pandey (2008) who mentioned a negative relationship between leaf area and salt concentration.

**Table 5:** Effect of different levels of salinity on leaf length and width of *Acacia auriculiformis*

| Treatment | Leaf length (cm) | Leaf width (cm) |
|---|---|---|
| $S_0$ | 17.25 | 4.73 a |
| $S_1$ | 16.90 | 4.68 a |
| $S_2$ | 15.73 | 4.25 ab |
| $S_3$ | 15.67 | 5.27 a |
| $S_4$ | 15.33 | 4.40 ab |
| $S_5$ | 16.22 | 5.00 a |
| $S_6$ | 16.03 | 4.32 ab |
| $S_7$ | 12.56 | 3.19 b |
| **LSD $_{(.05)}$** | **NS** | **1.45** |
| **CV (%)** | **21.90** | **21.96** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, Salinity**:** $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 mM

## 4.6 Effect of different levels of salinity on shoot fresh weight

Different levels of salinity stress showed significant impact on shoot fresh weight of *Acacia auriculiformis* seedlings (Table 6). The maximum fresh weight of shoot (54.50 g) was recorded from no salinity treatment ($S_0$).Moreover, the minimum fresh weight of shoot (11.00 g) was reported from treatment $S_6$ (200 ppm) which was statistically similar to $S_7$ (12.25 g). The results mentioned above are in conformity with the findings of Abbas *et al.* (2015), Theerawitaya *et al.* (2015) and Abbas *et al.* (2013) who stated that increasing levels of salinity resulted in reduction in shoot fresh weight**.**

**Table 6:** Effect of different levels of salinity on shoot fresh and dry weight of *Acacia auriculiformis*

| Treatment | Shoot fresh weight (g) | Shoot dry weight (g) |
|---|---|---|
| $S_0$ | 54.50 a | 30.40 a |
| $S_1$ | 26.00 b | 14.40 b |
| $S_2$ | 19.00 bc | 10.43 bc |
| $S_3$ | 17.33 bc | 10.06 bc |
| $S_4$ | 20.00 bc | 12.07 bc |
| $S_5$ | 16.00 bc | 9.75 bc |
| $S_6$ | 11.00 c | 6.22 c |
| $S_7$ | 12.25 c | 7.06 c |
| **LSD $_{(.05)}$** | **12.92** | **7.24** |
| **CV (%)** | **39.93** | **39.26** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, Salinity**:** $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 mM.

## 4.7 Effect of different levels of salinity on shoot dry weight

Different levels of salinity stress showed significant effect on shoot dry weight of *Acacia auriculiformis* seedlings (Table 6). The maximum dry weight of shoot (30.40 g) was recorded from no salinity treatment ($S_0$). In addition, the minimum dry weight of shoot (6.22 g) was reported from treatment $S_6$ (200 ppm) which was statistically similar to $S_7$ (7.06 g). The results mentioned above are in conformity with the findings of Abbas *et al.* (2015), Theerawitaya *et al.* (2015) and Abbas *et al.* (2013) who stated that increasing levels of salinity resulted in reduction in shoot dry weight.

**Table 7:** Effect of different levels of salinity on root fresh and dry weight of *Acacia auriculiformis*

| Treatment | Root fresh weight (g) | Root dry weight (g) |
|---|---|---|
| $S_0$ | 2.44 a | 1.360 a |
| $S_1$ | 1.46 b | 0.810 b |
| $S_2$ | 1.02 c | 0.560 cd |
| $S_3$ | 1.00 cd | 0.580 c |
| $S_4$ | 0.67 edf | 0.408 cd |
| $S_5$ | 0.69 de | 0.405 de |
| $S_6$ | 0.66 ef | 0.390 de |
| $S_7$ | 0.37 f | 0.233 e |
| **LSD $_{(.05)}$** | **0.32** | **0.17** |
| **CV (%)** | **20.68** | **19.92** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, Salinity**:** $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 mM.

### 4.8 Effect of different levels of salinity on root fresh weight

Root fresh weight was significantly influenced by different levels of imposed salinity (Table 7). The maximum fresh weight of root (2.44 g) was recorded from no salinity treatment ($S_0$). On the flip side, the minimum fresh weight of root (0.37 g) was reported from treatment $S_7$ (250 ppm). The result of this study was supported by the findings of Abbas *et al.* (2017), Abbas *et al.* (2015)**,** Theerawitaya *et al.* (2015) and Abbas *et al.* (2013) who mentioned reduction in root fresh weight under different saline condition among different *Acacia* species.

### 4.9 Effect of different levels of salinity on root dry weight

Different levels of salinity stress showed significant effect on root dry weight of *Acacia auriculiformis* seedlings (Table 7). The maximum dry weight of root (1.360 g) was recorded from no salinity treatment ($S_0$). But, the minimum dry weight of root (0.233 g) was reported from treatment $S_7$ (250 ppm). The results mentioned above are in conformity with the findings of Abbas *et al.* (2015) and Abbas *et al.* (2013) who observed reduction in root dry weight under salinity stressed condition among different *Acacia* species.

**Table 8:** Effect of different levels of salinity on root length and number of roots of *Acacia auriculiformis*

| Treatment | Root length (cm) | Number of roots |
|---|---|---|
| $S_0$ | 20.53 a | 15.75 a |
| $S_1$ | 16.88 ab | 14.00 ab |
| $S_2$ | 15.65 ab | 12.00 ab |
| $S_3$ | 16.26 ab | 13.25 ab |
| $S_4$ | 15.68 ab | 10.75 b |
| $S_5$ | 12.96 ab | 11.50 b |
| $S_6$ | 14.50 ab | 10.75 b |
| $S_7$ | 11.60 b | 6.50 c |
| **LSD $_{(.05)}$** | **7.98** | **3.99** |
| **CV (%)** | **34.98** | **22.99** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, Salinity**:** $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 mM**.**

### 4.10 Effect of different levels of salinity on root length

Length of root of *Acacia auriculiformis* seedlings showed significant differences due to the imposition of different levels of salinity (Table 8). The longest root length (20.53 cm) was observed from no salinity treatment ($S_0$), which was statistically similar to $S_1$ (16.88 cm), $S_2$ (15.65 cm), $S_3$ (16.26 cm), $S_4$ (15.68 cm), $S_5$ (12.96 cm) and $S_6$ (14.50 cm). Whereas, the shortest length of root (11.60 cm) was reported from treatment $S_7$ (250 ppm). The result of this study was supported by the findings of Rahman *et al.* (2017), Patel *et al.* (2010), Abbas *et al.* (2017), Abbas *et al.* (2016), Abbas *et al.* (2015), Theerawitaya *et al.* (2015), Abbas *et al.* (2013), Morais *et al.* (2012), Elhadi *et al.* (2009), Yaqoob *et al.* (2009) and Hardikar and Pandey (2008) who mentioned from their individual studies that root length decreased at different saline levels compared with control.

### 4.11 Effect of different levels of salinity on number of roots

Different levels of salinity stress showed significant effect on number of roots in *Acacia auriculiformis* seedlings (Table 8). The maximum number of roots (15.75) was recorded from treatment $S_0$ (control), which was statistically similar to $S_1$ (14.00), $S_2$ (12.00) and $S_3$ (13.25). Inversely, the minimum value for number of roots (6.50) was observed in $S_7$ (250 ppm) treatment. The results mentioned above are in conformity with the findings of Theerawitaya *et al.* (2015) number of roots decreased sharply in increasing salt-stressed condition.

# CHAPTER V

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### SUMMARY

The experiment was conducted at the Agroforestry Research Field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from 02 July, 2020 to 15 February, 2021 to find out the effects of salinity on seed germination and early seedling growth of *Acacia auriculiformis*. The experiment consisted of single factor as salinity. The treatments were as follows: $S_0$ = 0 mM, $S_1$ = 25 mM, $S_2$ = 50 mM, $S_3$ = 75 mM, $S_4$ = 100 mM, $S_5$ = 150 mM, $S_6$ = 200 mM and $S_7$ = 250 mM

This experiment was laid out in a Completely Randomized Design (CRD) with four replications. Data were collected on different aspects of growth attributes of Acacia auriculiformis.

Significant differences existed among different levels of imposed salinity with respect to growth parameters of *Acacia auriculiformis*. Germination (%), plant height, branch length, number of branches plant$^{-1}$ at different data recording intervals gradually decreased with increasing salinity level. The highest germination (100%), tallest plant at 90 DAS (40.50 cm), maximum branch length at 90 DAS (16.30 cm) and maximum number of branches plant$^{-1}$ at 90 DAS (11.50) were obtained from control treatment while the lowest germination (35%), shortest plant at 90 DAS (14.54 cm), minimum branch length at 90 DAS (6.19 cm) and minimum number of branches plant$^{-1}$ at 90 DAS (6.50) were recorded from 250 ppm ($S_7$) concentration of salinity.

Leaf length was not affected significantly but the variation among the leaf width value were significantly influenced due to different concentration of salinity with the highest values (5.27 cm and 5.00 cm) were recorded from $S_3$(75 ppm) and $S_5$

(150 ppm) treatment and the lowest value (3.19 cm) were recorded around 250 ppm ($S_7$) concentration.

Shoot fresh weight, shoot dry weight, root fresh weight and root dry weight all were varied significantly due to the effect of different level of saline condition. The maximum shoot fresh weight (54.50 g), maximum shoot dry weight (30.40 g), maximum root fresh weight (2.44 g) and the maximum root dry weight (1.36 g) was reported from control treatment $S_0$ (0 ppm). Meanwhile, the minimum shoot fresh weight (11.00 g) and minimum shoot dry weight (6.22 g) were recorded from 200 ppm ($S_6$) salinity while the minimum root fresh weight (0.37 g) and the minimum root dry weight (0.233 g) were observed from $S_7$ (250 ppm) treatment.

Root length and number of roots in Acacia auriculiformis seedlings were also affected significantly which decreased gradually with increasing salinity level. Like the other parameters, the maximum length of root and maximum number of roots 20.53 cm and 15.75 respectively for these parameters were observed in non-saline condition (0 ppm) and the minimum length of root and minimum number of roots 11.60 cm and 6.50 respectively were recorded in 250 ppm ($S_7$) salinity

# CONCLUSIONS

From the above result it was revealed that *Acacia auriculiformis* can tolerate salinity up to 150 mM salinity. The maximum germination (%) (100%) was observed from the control treatment while the minimum percentage of germination (35.00%) was recorded from treatment $S_7$ (250 mM). Gradual increase in salinity level showed gradual decrease in germination (%). In case of $S_7$ treatment , lowest number of roots (6.50) ,shortest length of roots (11.60) cm, shortest leaf (12.56) cm was reported. The result of this experiment allowed us to conclude that germination and seedling growth are salinity specific.

# RECOMMENDATIONS

Considering the results of the present experiment, further studies in the following areas are suggested:

- More species of *Acacia* may be used with different levels of salinity treatment for getting species specific salinity tolerance level at different soil conditions.
- Studies of similar nature could be carried out in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of zonal adaptability.

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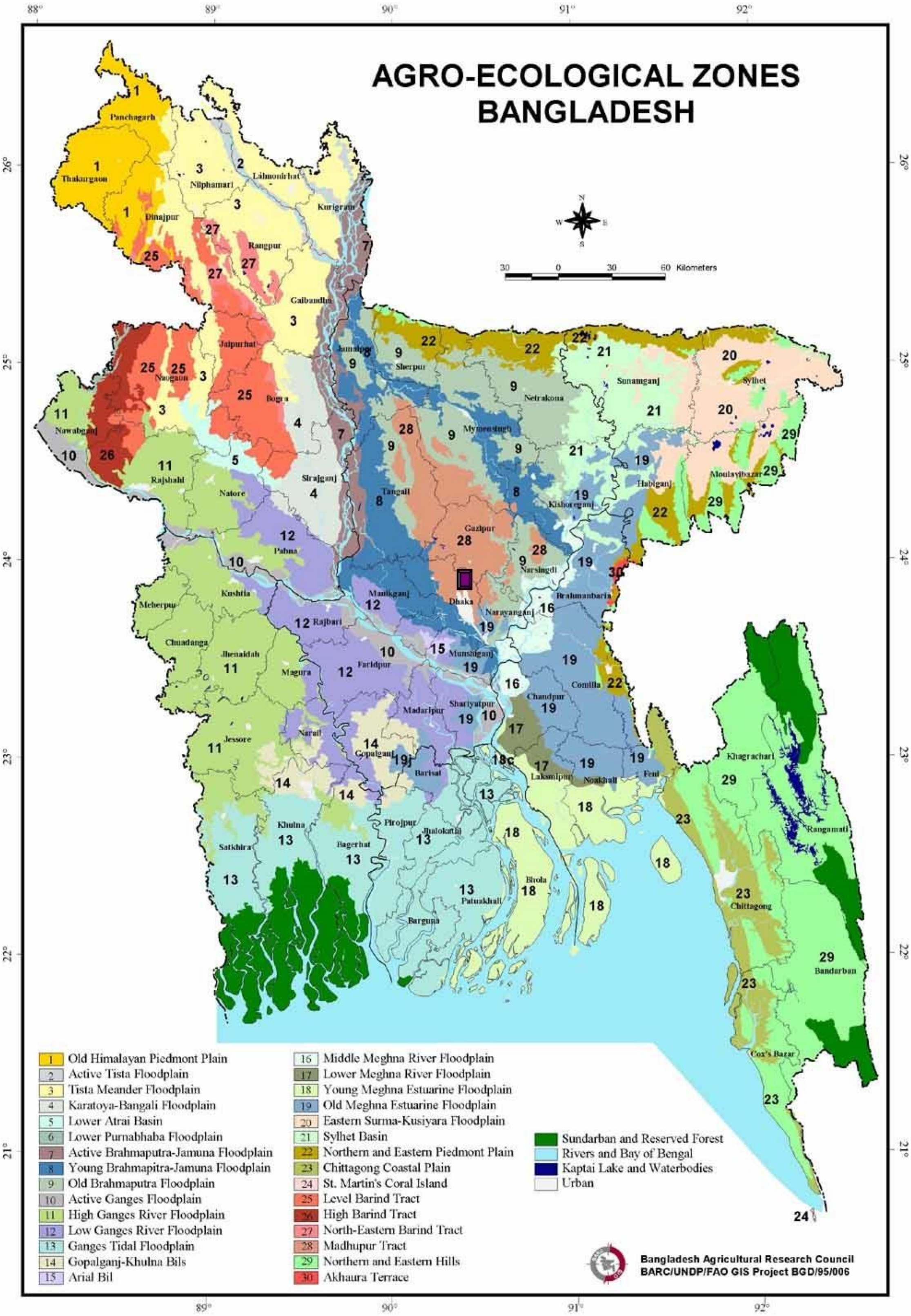
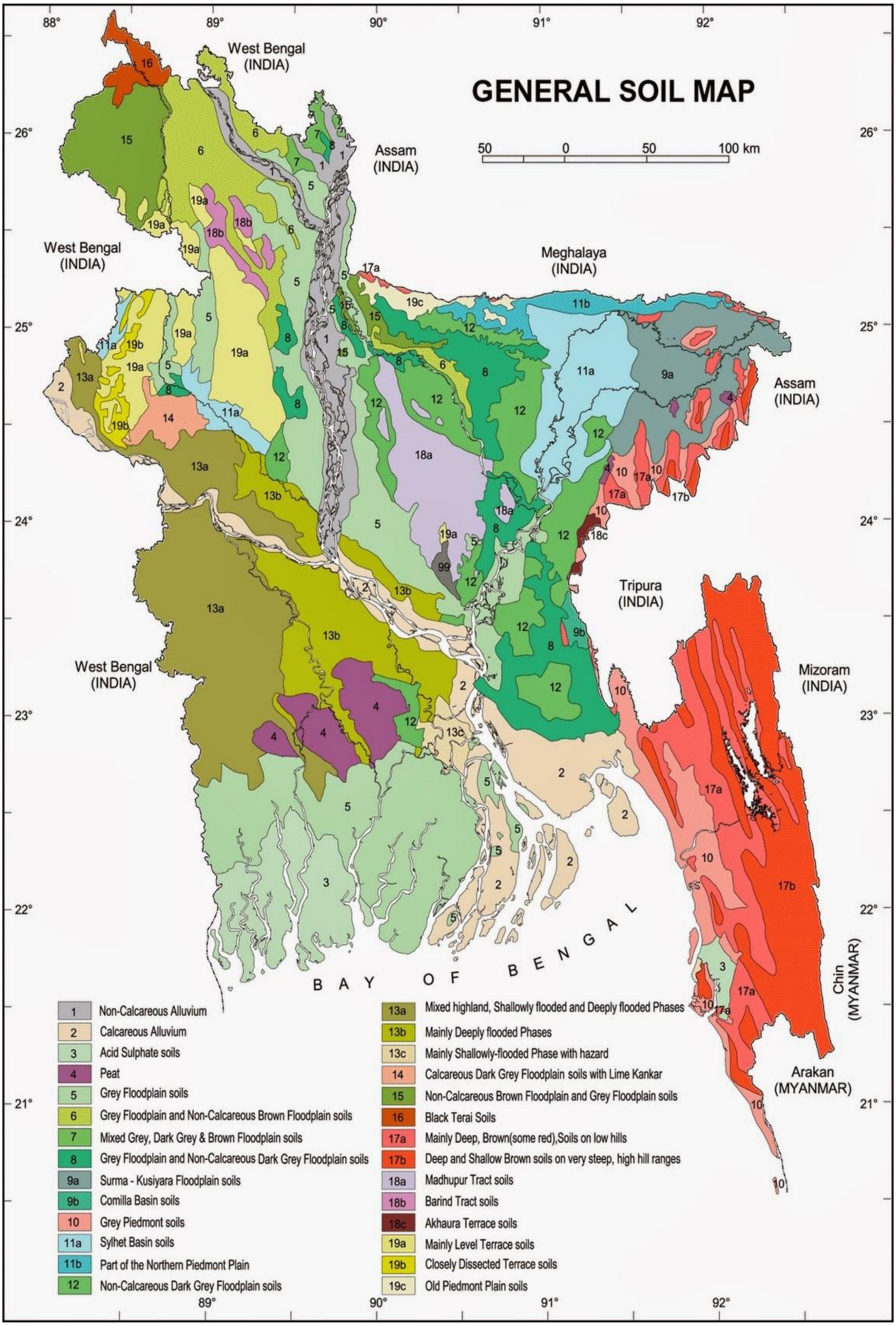
# APPENDICES

## Appendix I (A). Map showing the experimental sites under study




**The experimental site under study**

**Appendix I (B). Map showing the general soil sites under study**



**Appendix II.** Characteristics of soil of experimental site is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Morphological characteristics of the experimental field

| Morphological features | Characteristics |
|---|---|
| Location | Experimental field, SAU, Dhaka |
| AEZ | Madhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |

**B**. Physical and chemical properties of the initial soil

| Characteristics | Value |
|---|---|
| % Sand | 27 |
| % Silt | 43 |
| % clay | 30 |
| Textural class | Silty-clay |
| pH | 5.5 |
| Organic carbon (%) | 0.43 |
| Organic matter (%) | 0.75 |
| Total N (%) | 0.075 |
| Available P (ppm) | 21.00 |
| Exchangeable K (meq/ 100 g soil) | 0.11 |
| Available S (ppm) | 43 |

Source: SRDI, 2019

**Appendix III.** Monthly average of temperature, relative humidity, total rainfall and sunshine hour of the experimental site during the period from July 2020 to February 2021

| Year | Month | Temperature | | | Relative Humidity (%) | Rainfall (mm) | Sunshine (Hour) |
|---|---|---|---|---|---|---|---|
| | | Max (°C) | Min (°C) | Mean (°C) | | | |
| 2020 | July | 33 | 28 | 31 | 76 | 471.20 | 205 |
| | August | 33 | 27 | 31 | 75 | 259.40 | 214 |
| | September | 33 | 27 | 31 | 75 | 461.40 | 236 |
| | October | 33 | 27 | 31 | 71 | 340.30 | 281 |
| | November | 32 | 23 | 28 | 54 | 0.60 | 347 |
| | December | 30 | 21 | 26 | 46 | 0.00 | 372 |
| 2021 | January | 30 | 20 | 26 | 40 | 2.00 | 367 |
| | February | 33 | 20 | 28 | 34 | 0.60 | 329 |

**Appendix IV. Mean square value of germination of *Acacia auriculiformis* from Analysis of variance (ANOVA)**

| Source of variation | Degree of freedom | Mean square value of germination |
|---|---|---|
| Replication | 3 | 56.940 |
| Salinity level | 7 | 2615.683* |
| Error | 21 | 333.135 |

* = Significant at 0.05 level of probability and
NS = Non-significant

**Appendix V. Mean square value of plant height of *Acacia auriculiformis* from Analysis of variance (ANOVA)**

| Source of variation | Degree of freedom | Mean square value of plant height | | | | |
|---|---|---|---|---|---|---|
| | | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 90 DAS |
| Replication | 3 | 1.421 | 3.433 | 12.889* | 4.047 | 50.695 |
| Salinity level | 7 | 3.649* | 10.785* | 66.921 | 131.514* | 258.011* |
| Error | 21 | 1.771 | 3.296 | 23.790 | 30.314 | 55.268 |

* = Significant at 0.05 level of probability and
NS = Non-significant

**Appendix VI. Mean square value of branch length of *Acacia auriculiformis* from Analysis of variance (ANOVA)**

| Source of variation | Degree of freedom | Mean square value of branch length | | | |
|---|---|---|---|---|---|
| | | 45 DAS | 60 DAS | 75 DAS | 90 DAS |
| Replication | 3 | 5.397 | 2.806 | 2.028 | 0.735 |
| Salinity level | 7 | 10.707* | 9.062* | 28.416 | 43.908* |
| Error | 21 | 1.406 | 0.358 | 1.219 | 2.221 |

* = Significant at 0.05 level of probability and
NS = Non-significant

**Appendix VII. Mean square value of number of branches per plant of *Acacia auriculiformis* from Analysis of variance (ANOVA)**

| Source of variation | Degree of freedom | Mean square value of Number of branches per plant | | | | |
|---|---|---|---|---|---|---|
| | | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 90 DAS |
| Replication | 3 | 0.197 | 0.875 | 0.708 | 0.583 | 0.0833 |
| Salinity level | 7 | 1.174* | 2.910* | 7.196* | 10.571* | 10.785* |
| Error | 21 | 0.388 | 1.232 | 3.446 | 3.25 | 3.154 |

* = Significant at 0.05 level of probability and
NS = Non-significant

**Appendix VIII. Mean square value of leaf and shoot parameters of *Acacia auriculiformis* from Analysis of variance (ANOVA)**

| Source of variation | Degree of freedom | Mean square value of | | | |
|---|---|---|---|---|---|
| | | Leaf length | Leaf width | Shoot fresh weight | Shoot dry weight |
| Replication | 3 | 8.903 | 1.382 | 28.696 | 6.620 |
| Salinity level | 7 | 8.125 $^{NS}$ | 1.565* | 776.626* | 234.826* |
| Error | 21 | 11.833 | 0.966 | 77.253 | 24.266 |

* = Significant at 0.05 level of probability and
NS = Non-significant

**Appendix IX. Mean square value of root parameters of *Acacia auriculiformis* from Analysis of variance (ANOVA)**

| Source of variation | Degree of freedom | Mean square value of | | | |
|---|---|---|---|---|---|
| | | Root fresh weight | Root dry weight | Root length | Number of roots |
| Replication | 3 | 0.035 | 0.018 | 23.873 | 5.375 |
| Salinity level | 7 | 1.711* | 0.499* | 28.807* | 30.267* |
| Error | 21 | 0.0459 | 0.013 | 29.428 | 7.375 |

* = Significant at 0.05 level of probability and
NS = Non-significant

# PLATES

**Plate 1.** Overview of the experimental pots

**Plate 2.** Germination rate difference between the pots due to salinity

**Plate 3.** Gradual decrease in shoot length of *Acacia auriculiformis* due to effect of salinity

**Plate 4.** Gradual decrease in root length of *Acacia auriculiformis* due to effect of salinity