USMANU DANFODIYO UNIVERSITY, SOKOTO
(POSTGRADUATE SCHOOL)

GROWTH RESPONSE OF THREE INDIGENOUS TREE SPECIES TO HORMONE AND SALT STRESS IN SOKOTO NIGERIA

A Dissertation

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MASTER OF SCIENCE (FOREST BIOLOGY AND SILVICULTURE)

BY

IGBOKWE OBIKE GODWIN
ADM No. IGBOKWE OBIKE GODWIN

Department of Forestry and Fisheries

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DEDICATION

This work is dedicated to the glory of God the Father, God the Son and God the Holy Spirit and the memory of my late brother Alexander C. Joseph.

CERTIFICATION

This dissertation by Igbokwe, Obike Godwin, has met the requirements for the award of the Degree of Master of Science (Forest Biology and Silviculture) of the Usmanu Danfodiyo University, Sokoto, and is hereby approved for its contribution to knowledge.

_____ _____

Dr. A. G. Bello Date

(Major Supervisor)

_____ _____

Dr. A. D. Isah Date

(Co- Supervisor I)

_____ _____

Dr. M. Audu Date

(Co- Supervisor II)

_____ _____

Date

(External Examiner)

_____ _____

Dr. A. D. Isah Date

(Head of Department)

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ABSTRACT

Seeds of three forest tree species namely *Acacia senegal* (L.) Willd, *Balanites aegyptiaca* (L.) Delile and *Parkia biglobosa* (Jacq.) were used to investigate the effect of different salinity (NaCl) and auxin (IAA) concentrations on germination percentage, stem height growth, collar diameter study and Relative Growth Rate (RGR). A factorial experiment in a completely randomised design was employed. 90 seedlings of the tree species were randomly divided into six treatment groups of 3 seedlings with five replicates. The experimental hormone at three levels of (0.0, 2.77 and 3.62µgg^{-1}) and salt at two levels (2.2 and 2.8dSm^{-1}) concentrations were respectively administered to each treatment for a period of twelve weeks. Result showed that seedlings administered with salt concentrations of 2.2dSm^{-1}

and 2.8dSm^{-1} showed decrease in germination percentage, stem height growth, collar diameter and Relative Growth Rate. Similarly, results showed that increasing concentration of NaCl reduced germination percentage, stem height growth and collar diameter in the species. Auxin (IAA) decreased seed germination percentage in *Acacia senegal* (12%) and Parkia biglobosa (6%) at 2.8dSm^{-1}, but increased seed germination in Balanites aegyptiaca (4%) at both levels tested, just as stem growth and collar diameter of the species were also influenced. *Balanites aegyptiaca* showed high seed germination percentage, stem height growth and collar diameter in comparison to other species studied. Treatment combination 0µgg^{-1}/2.8dSm^{-1} was observed to be best for the growth of *Acacia senegal,* 2.77µgg^{-1}/2.8dSm^{-1} for *Balanites aegyptiaca* and 2.77µgg^{-1}/ 2.2dSm^{-1} for *Parkia biglobosa*. *Parkia biglobosa* was very susceptible to salt stress. These results showed that salinity is a major abiotic factor that influence auxin production and distribution, nutrient assimilation and shoot growth in the species tested. *Parkia biglobosa* should not be used in regeneration on high saline soils.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Marginal lands sometimes called wastelands or idle lands can be defined as lands which are of no importance for biodiversity or carbon sequestration. They play no role in food production and in guaranteeing people's livelihood (Salva,

2008). It has been discovered that they have poor soil containing toxic levels of salt and are deficient in essential plant nutrients. They are generally unsuitable to crops. High concentration of salt particularly in the root zone could cause stress to a plant and eventually damage or kill it. Salt stress often coexist with other abiotic stresses such as drought. Tilman *et. al*. (2006) estimated that developing countries have vast area of marginal lands (at least 500 million hectares). Genetic analysis has shown that tolerance for abiotic stresses such as salinity could be attributed to germplasm – hormones (Mackill, 2004).

Plant growth has been determined at different levels to involve different metabolic processes in cells and there is a link between the cells and some external factors. Philipson (1987) showed how flowering could be induced in potted grafts of Sitka spruce and hybrid larch species by stem injections of a mixture of gibberellic acid ($GA_{4/7}$ – a hormone) in combination with drought and high temperature treatments (external factors). Differentiation processes were not controlled just by a single factor, but by a complex, balanced equilibrium of growth regulators and external factors like light, temperature, nutrients, moisture and soil. Researches have indicated that hormones mediate between an external factor and physiological activities (Benjamins and Scheres, 2008; Zhang *et al*. 2000; Zhu, 2000). The process of tree breeding techniques has advanced and is currently at the phase where certain economic traits such as high wood density,

good stem straightness and disease resistance could be induced using a combination of several factors.

Soil salinity has had an adverse effect since ancient civilization by limiting the available land for cultivation and to this day, it continues to affect agricultural productivity in many parts of the world. Soil salinity has been defined as a soil condition characterized by a high concentration of soluble salts. Soils are classified as saline when the electrical conductivity of the saturated paste extract (ECe) is 4 dS/m or more, which is equivalent to approximately 40mM NaCl and generates an osmotic pressure of approximately 0.2MPa (USDA-ARS, 2008). According to FAO report (2008), soil salinity is one of the major factors of soil degradation. More than 800 million hectares of land throughout the world are salt affected. This amount accounts for more than 6% of the world's total land area. Most of this salt-affected land has arisen from natural causes; the accumulation of salts over long periods of time in arid and semi-arid zones (Rengasamy, 2002). Weathering of parent rocks release soluble salts of various types, mainly chlorides of sodium, calcium, and magnesium, and to a large extent, sulphates and carbonates (Szabolcs, 1989). Other causes of accumulation are the deposition of oceanic salts carried in wind and rain. Apart from natural salinity, a significant proportion of recently cultivated agricultural land has become saline owing to land clearing or irrigation, both of which cause water tables to rise and concentrate the salts in the root zone (Munns and Tester, 2008). Salinity effect is more conspicuous in the arid and semi-

arid areas where 25% of the irrigated land is affected by salt. Salt-tolerant plants (halophytes) have evolved to grow on these soils. Halophytes and less tolerant plants show a wide range of adaptations. Attempts to improve the salt tolerance of plants have given limited success due to the complexity of their trait both genetically and physiologically. The development of salt-tolerant plants is being pursued from many angles (Zhu, 2000).

1.2 Statement of the Problem

Arable crop farmers try to avoid soils with high salt levels. A growing world population and a decline in arable land area have brought an increasing demand / competition for marginal lands which were previously unsuitable for arable crops, hence abandoned and committed to growing woody perennials (trees). Agriculturists and most financial institutions are interested in ventures that will bring maximum returns on investment within a reasonably short period. This results in a short fall on the forestry sub-sector because trees are known to have a long gestation period (A major shortfall of the forestry sector in Nigeria). The forester needs to work at utilizing the rejected and unproductive lands for tree growth and at the same time work at developing tree crops that could adapt to harsh soil and climatic conditions. This in the long run will help in revitalizing the land.

1.3 Justification of the tudy

Success with growing trees on rejected/unproductive lands will ultimately result in utilization of such lands, leading to reclamation. It will reduce land hunger and conflict; promote private / individual forestry practices in Nigeria. Making use of such lands will not only make forestry business attractive.

This will increase the production of the marginal lands, improve the conservation of watershed and ameliorate the hostile micro-climate within the area. It will also provide baseline information for further research.

Perennial trees from the forest could be used to remediate soil salinity since their roots can penetrate deep into the soil to reach low water table and draw up moisture for the plant use.

The society will benefit from the result of this research as more land will be available for other users.

Objectives of the Study

The study examines the response of three tree species (*Acacia senegal*; *Parkia biglobosa* and *Balanites aegyptiaca*) to application of hormone (Indole-3-acetic acid IAA) and salinity caused by salt (NaCl) stress.

Specific Objectives

(i). To determine the salinity and hormonal levels suitable for the germination of the tree species.

(ii). To determine the salinity levels suitable for the early growth of the chosen tree species.

(iii). To determine the effect of hormones on the early growth of these three forest tree species.

(iv). To study the interaction effects of hormone (IAA) and salt stress on shoot elongation of these forest tree species.

(v). To determine which of the species is more tolerant to salt stress.

1.5 Scope of the study

This research will investigate the growth of these three tree species (*Acacia senegal*; *Parkia biglobosa*; *Balanites aegyptiaca*) in salt concentrated soils found around Dabagi Farm of Usmanu Danfodiyo University Sokoto under a growth hormone (Indole-3-Acetic Acid, IAA).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Plant Hormone

Plant hormones (also known as phyto-hormones) are chemicals that regulate plant growth. The word hormone is derived from Greek and means 'set in motion.' They are naturally produced within plants, and occur in extremely low concentrations. Similar chemical compounds are produced by fungi and bacteria that can also effect plant growth. (Srivastava, 2002). A large number of related chemical compounds are synthesized by humans and used to regulate the growth of cultivated plants, weeds, and in vitro grown plants and plant cells; these manmade compounds are called Plant Growth Regulators or PGRs.

According to Helgi Opik (2005), Plant hormones are not nutrients, but chemicals that in small amounts promote and influence the growth, development, and differentiation of cells and tissues. Plant hormones shape the plant, affecting seed growth, time of flowering, the sex of flowers, senescence of leaves and fruits. They affect tissues which grow upward (shoot) and downward (root), leaf formation, fruit development and ripening, plant longevity and even plant death (Dutta, 1997). Hormones are vital to plant growth and lacking them, plants would be mostly a mass of undifferentiated cells. Plants utilize simple chemicals as hormones, which move easily through the plant's tissues. They are often produced and used on a local basis within the plant body; plant cells produce hormones that affect different regions of the cell producing the hormone.

Not all plant cells respond to hormones. The cells that do are programmed to respond at specific points in their growth cycle. The greatest effects of hormone

response occur at specific stages during the cell's life, with diminishing effects occurring before or after this period. Plants need hormones at very specific times and locations during their growth. They also disengage the effects that hormones have when they are no longer needed. The production of hormones occurs very often at sites of active growth within the meristems, before cells have fully differentiated. After production, they are sometimes moved to other parts of the plant where they cause an immediate effect or they can be stored in cells to be released later. Plants can also break down hormones chemically, effectively destroying them. Plants also move hormones around the plant diluting their concentrations.

2.1.2 Auxins

Auxins, according to Vines (1972), can be defined as those substances which in low concentration (< 0.001 mol dm^{-3}) and apparently independently of other growth-promoting substances are known to stimulate an irreversible increase in size of cells of shoots and to inhibit the same in roots. They may be natural or synthetic auxins according to origin. One substance only {β-indolyl acetic acid (IAA)}, has been identified with certainty as a natural auxin by the above definition. Other closely related derivatives with similar properties, β-indolyl acetaldehyde, β-indolyl pyruvic acid, β-indolyl ethanol and β-indolyl acetonitrile, have been isolated, but these may not be free active auxins.

Auxin activity is remarkable from the point of view of the concentrations required for full effect, a few part per million is sufficient. Different parts of plant do not react in the same way to the same concentration; very low concentrations which may elicit maximum response in root cells are virtually ineffective in shoots, while the higher concentrations which give maximum effect in shoots and coleoptiles tend to inhibit the response in roots.

2.2 Nutrient Absorption in Plants:

Plants absorb virtually all of the essential elements through their roots. Essential elements are also called nutrients or fertilizers. Plants need seventeen (17) essential elements, which are:

(i) Three supplied naturally by air and water – these make up the bulk of the plant C,H and O.

(ii) Six macronutrients required at 0.1 to 6% of the dry weight of plants. N, P, K, S, Ca and Mg.

(iii) Eight micronutrients required at 1 to 300ppm of the dry weight of plants Fe, Zn, Cu, Mo, B, Mn, Cl and Ni.

The 14 macronutrients and micronutrients are mainly supplied through water by root absorption (in the soil). Unfortunately, sodium Na+ is not one of the nutrient elements required by plants for growth. Its accumulation in the soil

through parent rock weathering, wind and rain water results in sodium chloride deposits which could be inhibitive to plant growth and development. Sodium salts stresses plants in two ways. A high concentration of salts in the soil makes it harder for roots to extract water and other essential elements, and high concentrations of salts within the plant can be toxic. Salts on the outside of roots have an immediate effect on cell growth and associated metabolism. High concentration of salts in soils account for large decrease in the yield of a wide range of crops all over the world (Tester and Davenport, 2003). The agricultural problem of salinity tolerance could probably be best tackled by either altering farming practices to prevent soil salinization occurring in the first place, or by implementing schemes to try to remediate salinized soils such as by planting perennials (trees) to lower water tables. These approaches can be complemented by programmes to increase the salt tolerance of plants by either traditional breeding or genetic manipulation technologies. In this way, yields can be increased on affected soils whilst they are being remediated, and plants can also maintain increased growth when they encounter saline subsoils, thus enabling them to form part of the remediation process itself (Tester and Davenport, 2003).

2.3.1 Acacia senegal - Gum Tree

Acacia senegal is a multipurpose African tree (subfamily Mimosoideae, family Leguminosae), highly valued for centuries for gum arabic production. Today, *A. senegal* is grown primarily for gum, but plays a secondary role in agricultural systems, restoring soil fertility and providing fuel and fodder.

2.3.2 Botanical description

A deciduous shrub or shrub tree, *Acacia senegal* (L.) Willd grows to 2-6 m (occasionally to 15 m) tall with a flat to rounded crown. The tree has many branches and erect twigs spreading within the upright part. The bark is typically yellow/brown and smooth on younger trees, changing to dark grey, gnarled and cracked on older trees. The branchlets have thorns just below the nodes: either three thorns with the central one hooked downwards and laterals curved upwards, or a single thorn with laterals absent. Leaves are small, grey-green, alternate, and bipinnate. Pinnae occur in (2-) 3-8(-12) pairs, and leaflets in 7-25 pairs. The rachis sometimes have prickles. The white or cream colored flowers occur on 2-12 cm long spikes. Pods are dehiscent (open by splitting at maturity), yellowish to brown, flat papery, and oblong (2-19 cm long by 1-3.4 cm wide). Seeds are nearly round to flat olive brown, and 8-12 mm in diameter. The tree flowers during the rainy season (Cossalter, 1991).

2.3.3 Distribution.

Acacia senegal var. *senegal* is found in Mauritania, Senegal Gambia, Ghana, Burkina Faso, Cote d'lvoire, Mali, Niger, Nigeria, Cameroon, Zaire, Central African Republic, Rwanda, Chad, Sudan, Ethiopia, Somalia, Uganda, Kenya, Tanzania, Mozambique, Oman, Pakistan, and India. It has been introduced into Egypt, Australia, Puerto Rico, and the Virgin Islands. Var. kerensis is found in Ethiopia, Somalia Uganda, Kenya, and Tanzania. Var. *rostrata* occurs in Somalia, Uganda, Kenya, Mozambique, south to Zimbabwe, Botswana, Angola, Namibia, and South Africa. Var. *leiorhachis* occurs in Ethiopia, Somalia, Kenya, Tanzania, southern Zambia, Zimbabwe, Mozambique, Botswana, and South Africa (Wickens *et. al*., 1995).

2.3.4 Ecology.

Acacia senegal is very drought resistant. It grows on sites with annual rainfall between 100-950 mm, mainly between 300-400 mm, and 5-11 month dry periods. It tolerates high daily temperatures (mean maximum temperatures of up to 45^{o}C or more), dry wind, and sandstorms. Generally, it cannot withstand frost. *Acacia senegal* prefers coarse-textured soils such as fossil dunes, but it will also grow on slightly loamy sands and skeletal soils such as Lithosols. Although generally soils are well- drained, there are exceptions: in the Kayers region, South-Kordofan, East Sudan, *A. senegal* grows on heavy clay soils with approximately 800 mm annual precipitation. The best sites have pH of 5 to 8. The tree ranges

from 100-1700 m elevation in the Sudan to 1950 m around Nakuru in Kenya (Wickens *et. al*., 1995).

2.3.5 Uses.

i. Gum: *Acacia senegal* and its close relatives are the defined source of commercial gum arabic for food purposes. *Acacia senegal* produces the only acacia gum evaluated toxicologically as a safe food additive (Anderson, 1989). Gum arabic has been used for at least 4,000 years by local people for preparation in food, in human and veterinary medicine, in crafts, and as a cosmetic.

ii. Wood: *Acacia senegal* wood is locally valued for fuelwood and charcoal, although biomass yield per unit land area is not sufficient to plant.

iii. Food and fodder: Dried and preserved seeds of *Acacia senegal* are used by people as vegetables. The foliage and pods are browsed by sheep, goats, camels, impala, and giraffe.

iv. Dune stabilization: *Acacia senegal* is important for desertification control through sand dune stabilization and wind breaks.

v. Agroforestry :*Acacia senegal* is grown in agroforestry systems especially in the Sudan in "gum gardens' for gum as well as to restore soil fertility.

2.3.6 Propagation.

Seed should be harvested before pods dry for easy collection and to avoid insect attack. Seed is easily extracted by hand. Freshly extracted seed should immediately be dusted with an insecticide. Seed will remain viable for 3-4 years if kept in opaque, airtight containers. There are 10,000-30,000 seeds/kg. Fresh seed requires no pretreatment if sown immediately after harvest. Seed collected in previous seasons, however, requires pretreatment to break seed dormancy. Soaking seed in water for 12-24 hours gives good results and is simple to apply. Seeds can also be nicked (Cossalter, 1991).

2.4.1 *Parkia biglobosa* (Jacq.)

Parkia biglobosa (Jacq.) belongs to the family Fabaceae – Mimosoideae. In (English) it is called African locust bean, monkey cutlass tree, two ball nitta-tree. Robert Brown described the genus Parkia in 1826. He named it after Mungo Park, a Scot who made two remarkable journeys of exploration into the interior of West Africa in 1795-1797 and 1805.

2.4.2 Botanic description

Parkia biglobosa (syn. *clappertoniana*) is a perennial deciduous tree with a height ranging from 7 to 20 m, although it can reach 30 m under exceptional conditions. Crown large, spreads wide with branches low down on a stout bole; amber gum exudes from wounds; bark dark grey brown, thick, fissured. Leaves

alternate, dark green, bipinnate to 30 cm long, pinnate up to 17 pairs with 13-60 pairs of leaflets, 8-30 mm x 1.5-8 mm, of distinctive shape and venation. Leaflets held on a long rachis. Peduncles 10-35 cm long; capitula 4.5-7 cm long and 3.5-6 cm in diameter, biglobose but distal portion much larger. Hermaphrodite flowers orange or red in colour: calyx 10-13 (16 max.) mm; corolla 10-14 (17 max.) mm long, lobes very short 1-3 mm long, connate in the middle and free or connate at base; filaments exerted about 4 mm beyond calyx mouth. Nectar-secreting flowers: calyx about 6-7 mm long. Staminodial flowers: calyx about 5.5-7 mm long, filaments exerted 2-3 mm beyond calyx mouth (Whitmore 1972). Pods, pink brown to dark brown when mature, about 45 cm long and 2 cm wide; may contain up to 30 seeds embedded in a yellow pericarp. Seeds have a hard testa, are large (mean weight 0.26 g/seed) with large cotyledons forming about 70% of their weight (Booths and Wickens, 1988).

2.4.3 Ecology and distribution

P. biglobosa is recorded in early literature from the West Indies where it was apparently introduced in the 18th century from West Africa as a food plant. It occurs on a wide range of natural and semi-natural communities such as open savannah woodlands, but it is most conspicuous and abundant in anthropic communities, principally bush fallow and wooded farmland where cultivation is semi-permanent. The tree can also grow on rocky slopes, stony ridges or sandstone hills. It is a fire-resistant heliophyte. *P. biglobosa* occurs in a diversity of agro-

ecological zones, ranging from tropical forests with high and well-distributed rainfall to arid zones where mean annual rainfall may be less than 400 mm. It has a capacity to withstand drought conditions because of its deep taproot system and an ability to restrict transpiration (Von Maydell, 1986).

2.4.4 Geographic distribution

Native : Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Cote d'Ivoire, Democratic Republic of Congo, Gambia, Ghana, Guinea, Guinea-Bissau, Mali, Niger, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone,Sudan,Togo,Uganda

Exotic : Antigua and Barbuda, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Puerto Rico, St Lucia, St Vincent and the Grenadines, Trinidad and Tobago, Virgin Islands (US) (Booths and Wickens, 1988).

2.4.5 Biophysical limits

Altitude: 0-300 m; Mean annual rainfall: 400-700 mm; Mean annual temperature: 24-28^0 C. Soil type: Prefers well-drained, deep, cultivated soils, but also found on shallow, skeletal soils and thick laterites.

2.4.6 Reproductive Biology

Anthesis is at dusk; large quantities of nectar and pollen are produced, and capitula may smell foetid and fruity like cow manure; pollination is by bats

including Eidolinhelvum, Epomophorusgambianus, Micropteropuspusillus and Nanonycherisveldkampi; seed set can occur in the absence of bats; honeybees, flies, wasps, ants, tenebrionid beetles and tettigometid bugs may be involved; sunbirds also visit the capitula but contribute negligibly in pollination; it is possible that some degree of self-incompatibility may occur. Trees 1st fruit at 5-10 years; they vary in precocity; fruits start to ripen just before the 1st rains and continue over most of the season; each hermaphrodite flower is potentially capable of producing a single pod, but this does not happen; up to 20 pods may develop per head, but there are usually fewer, dispersed by animals and birds eating fruits or seeds, pods are eaten by chimpanzees (which sometimes spit out the seeds), baboons, parrots and possibly hornbills, seeds have a thick, resistant testa that can possibly pass through the animal gut unharmed and dormant (Hopkins H.C, 1983)

2.4.7 Propagation methods

P. biglobosa has 2 types of seed: reddish-dark and dark (black); both occur in every pod, and the ratio of their number varies from 1:20 to 1:5; the reddish-dark seed seems to have a thinner coat, probably a development factor, and germinates earlier than the dark seed if the seeds are not acid treated before sowing. Dark seeds have a hard seed coat and require various pretreatments to ensure good germination rates; acid treatment appears to be the best method; next is by chipping the seeds at 1 end. Germination can also be improved by scalding the seeds for about 7 min and then cooling or soaking them in hot water overnight;

usual the germination rate is 75%. *P. biglobosa* can be established vegetatively in nursery beds by grafting or budding, or by rooting adult cuttings.

2.4.8 Uses

i. Food: According to Booth and Wickens (1988), the seeds are fermented to make dawadawa, a black, strong-smelling, tasty food high in protein. Dawadawa is rich in protein, lipids and vitamin B_2. Seeds are used as a coffee substitute. Seeds are embedded in a mealy pulp sometimes called dozim that is high in energy value. The pulp is eaten raw or made into a refreshing drink and is used as a sweetener. For storage, it is pressed into a cake. The fruit provides emergency food during severe droughts. Young pods are sometimes roasted on embers and eaten. Leaves are edible but not commonly eaten. The leaves are mixed with cereal flour and eaten or fermented into balls and used in sauces.

ii. Fodder: Whole pods are eaten by domestic stock, including cattle. The young seedlings are nutritious and heavily browsed by livestock. An important attribute of *P. biglobosa* trees is that most of their leaves remain green throughout the dry season and branches are lopped and used as fodder. Seeds are rich in calcium, sodium, potassium and phosphorus (Sabiiti*et al.,* 1992).

iii. Apiculture: *P. biglobosa* attracts bees and is a popular tree among beekeepers. Fuel: Branches are sometimes lopped for firewood.

iv. Fibre: Pods and roots are used as sponges and as strings for musical instruments.

v. Timber: Wood is whitish, moderately heavy, 580-640 kg/cubic m when air seasoned, relatively hard and solid; it smells unpleasant when newly felled, but seasoning does not take long and only occasionally causes shape distortion; easily worked by hand or power tools; nails, glues, varnishes and paints well; mainly useful as a light structural timber, for example, for vehicle bodies, agricultural implements, boxes, crates and barrels, furniture, mortars and pestles, bowls, planks and carvings. Twigs are used to clean teeth; bark stains mouth red and contains saponins that clean teeth.

vi. Gum or resin: Mucilage from part of fruit is made into a fluid and used for hardening earth floors and to give a black glaze in pottery; gum exudate is proteinaceous and contains as the constituent sugars, galactose, arabinose, glucuronic and 4-0-methyglucuronic acid. Tannin or dyestuff: Husks of pods mixed with indigo improve the lustre of dye products. Seeds and bark contain tannin, and bark is used in tanning.

vii. Alcohol: Fruit pulp can be fermented into an alcoholic beverage.

viii. Poison: Bark and pods contain pesticides; the alkaloid parkine that occurs in pods and bark may be responsible.

ix. Medicine: Bark is used as a mouthwash, vapour inhalant for toothache, or for ear complaints. It is macerated in baths for leprosy and used for bronchitis, pneumonia, skin infections, sores, ulcers, bilharzia, washes for fever, malaria, diarrhoea, violent colic and vomiting, sterility, venereal diseases, guinea worm, oedema and rickets, and as a poison antidote. Leaves are used in lotions for sore eyes, burns, haemorrhoids and toothache. Seed is taken for tension, and pulp for fevers, as a diuretic and as a mild purgative. Roots are used in a lotion for sore eyes.

x. Other products: Burnt husks are added to tobacco to increase its pungency. Pulp is supposedly a water purifier but possibly just sweetens and disguises taste of foul water.

xi. Shade or shelter: *P. biglobosa* is a useful windbreak and shade tree. Soil improver: Soils under *P. biglobosa* trees are improved by leaf fall.

Intercropping: It is common practice to grow several crops such as maize, cassava, yams, sorghum and millet under *P. biglobosa* canopy.

2.5.1 *Balanites aegyptiaca* (L.) Delile

Balanites aegyptiaca is a species of tree, classified either as a member of the Zygophyllaceae or the Balanitaceae. This tree is native to much of Africa and part

of the Middle East. According to Ndoye, *et al.* (2004), it is one of the most common trees in Senegal.

2.5.2 Description

This tree reaches 10m (33ft) in height with a generally narrow form. The branches are thorny. It bears dark green compound leaves that are made up of two leaflets which are variable in size and shape. The tree produces several forms of inflorescence bearing yellow-green bisexual flowers which exude nectar (Ndoye, *et al*. 2004). They are pollinated by halictid bees and flies. The fruits are yellow and single seeded.

Balanites aegyptiaca can be found in most arid, semi-arid to sub-humid tropical savannas, and hot dry areas in many kinds of habitat (along watercourses and in woodlands). This is because it can tolerate a wide variety of soil types, from sand to heavy clay, and climatic moisture levels, from arid to sub-humid. It is relatively tolerant of flooding, livestock activity and wildfire.

2.5.3 Ecology

Ecologically, it is very flexible with excellent persistence. It withstands occasional flooding and is adaptable to a wide range of sites (Von Maydell, 1986) and climatic conditions. It cannot tolerate prolonged water-logging (Kew, 1984). It has good drought tolerance (Hall, 1991) and is not damaged by grass fires (except

young trees), due to a deep tap root and thick bark. It invades areas having periodic fires with heavy livestock activity. Young plants are fairly termite resistant, but Buneaalcinoe defoliates the tree.

2.5.4 Propagation

When ready to plant, soak the fruit containing the seed overnight in lukewarm water until the pulp is removed. Pre-treatment methods include: internal scarification; boiling for 7 to 10 minutes; soaking 12 to 18 hours in hot water; soaking for 24 hours in warm water; and soaking overnight in warm water (FAO, 1988). The seedlings do not withstand transplanting well because of the deep tap root. For good germination, the seeds were planted in polypots with the seed vertical (Teel, 1984).

2.5.5 Uses

i. Food: The fruit pulp though bitter, is edible. Pounded fruits make a refreshing drink which becomes alcoholic if left to ferment.

ii. The roots are used for abdominal pains and as a purgative. The fruit is known to kill the snails which carry schistosomiasis and bilharzias flukes (Tredgold, 1986).

iii. *Balanites aegyptiaca* is easily worked and takes good polish. It may be twisted and difficult to saw, but the wood is durable and resistant to insects making it good for tool handles and domestic items.

iv. The leaves make very good mulch and the tree is nitrogen fixing, it is also valued as firewood; it produces little or no smoke and has a calorific value of 4600 kcal per kg (Webb, 1984).

2.6. Plant Growth Analysis

Analyzing the mean relative growth rate of seedlings is one method used to compare growth differences that arise from experimental treatments (Hunt 1982; Causton and Venus 1981; Ledig 1974; Evans 1972). This technique is particularly viewed as useful when comparing seedlings that differ in size (van den Driessche 1991; Kozlowski et al. 1991; Kramer and Kozlowski 1979; and Sweet and Wareing, 1966). The main reason for examining relative growth rates is to eliminate growth differences that arise from initial size differences (Wareing, 1966). Another reason for examining relative growth rates is to determine which seedlings are more resistant to treatments (Brand, 1991; Causton, 1983).

CHAPTER THREE

MATERIALS AND METHOD

3.1 Study Area

Dabagi Research Farm of Usmanu Danfodiyo University, Sokoto is geographically located 33km south east of Sokoto town in Sokoto State Nigeria between Latitudes $12^0$30'N and 13^0N and longitudes $5^0$30'E and 6^0'E (United Nations, 2004). Dabagi in Dange-Shuni Local Government Area of Sokoto State shares boundaries with Budude and T. Kowa to the south, Salau to the east and Dabaga and Boda to the west. (MANR, `2009).

The climate of Dabagi which is similar to that of Sokoto, Nigeria is mainly semi-arid characterized by low rainfall usually between 500 – 13,00mm annually occurring between June – October with peak in August. The dry season starts from October and ends in May. According to Nigerian Metrological Services Report (2009), maximum daytime temperature ranges from 25^0C – 46^0C and minimum temperature is between 19^0C – 26^0C relative humidity ranges from 12-17% with highest occurring around August (World Weather Online, (2012). The soil is sedimentary basement complex type and is sandy with little organic matter content. The soil pH ranges from 6 – 7. The vegetation is Sudan savanna type. A relatively sparse savanna vegetation of grasses and shrubs predominates the area.

3.2 METHODOLOGY

3.2.1 Sample collection

(a) Soil sample collection

Soil samples were collected from two locations in Dabagi Research Farm of Usmanu Danfodiyo University, Sokoto (Dabagi Upland well drained soils DUP_2 and Dabagi Lowland soil imperfectly drained DLL) (Figure 1) (Yakubu, 2010). A total area of 1ha was demarcated in each of the locations and 36 soil samples were collected from a net area of 9,900.25m^2 removing boundary effects of 25cm from each side. The soil aurgar was used to collect samples at a depth of 0-30cm from each of the two plots at horizontal interval of 10m and vertical intervals of 20m. The soil samples were bulked and samples taken for physical and chemical analysis at the Faculty of Agricultural Science Laboratory, Usmanu Danfodiyo University Sokoto. Soil sample from each of the two plots were analyzed to determine the salt concentration.

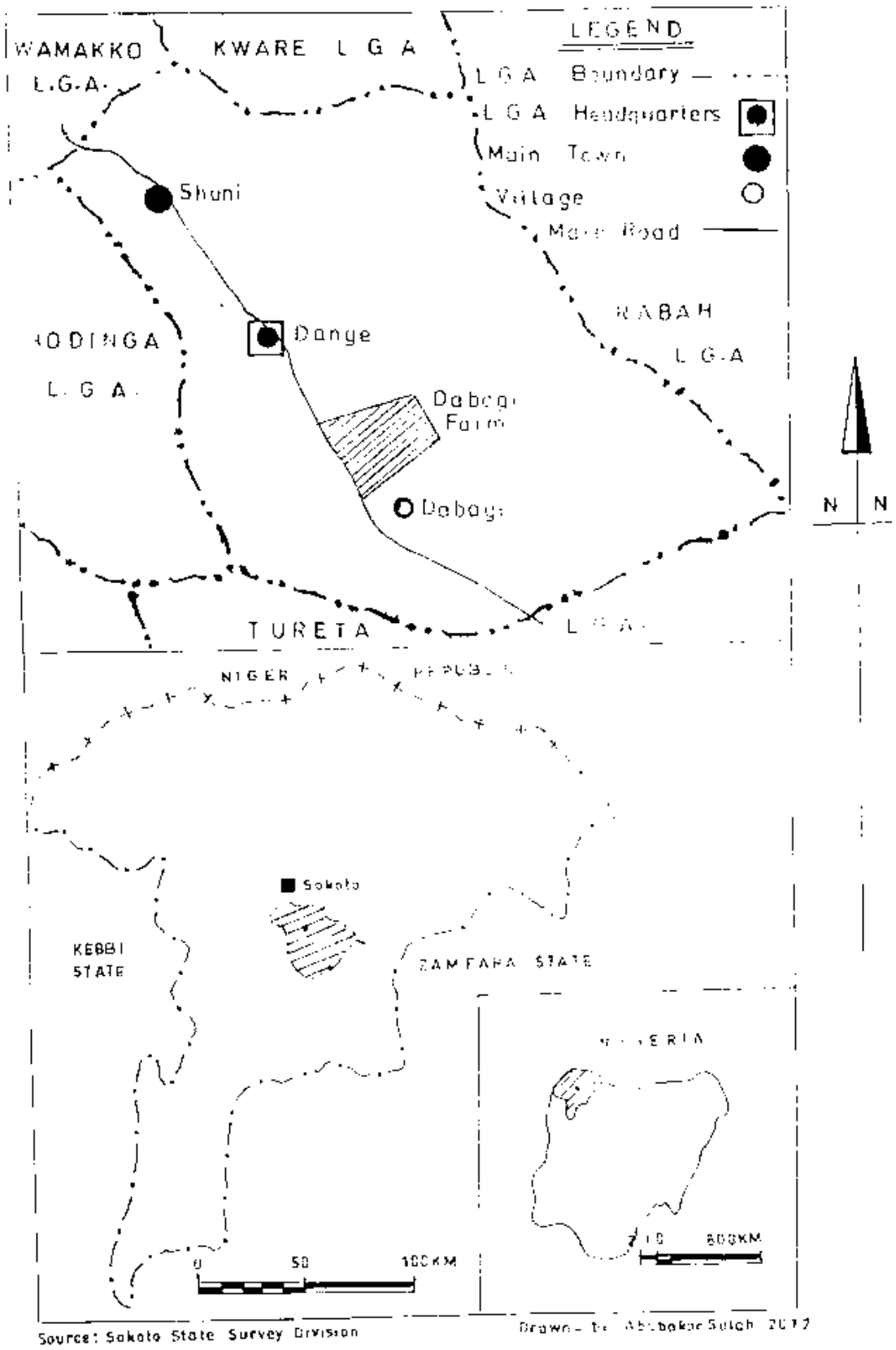

Figure1: Map of Nigeria showing Sokoto State, the State and Dange/Shuni Local Government Area showing Dabagi Farm of Usmanu Danfodiyo University, Sokoto

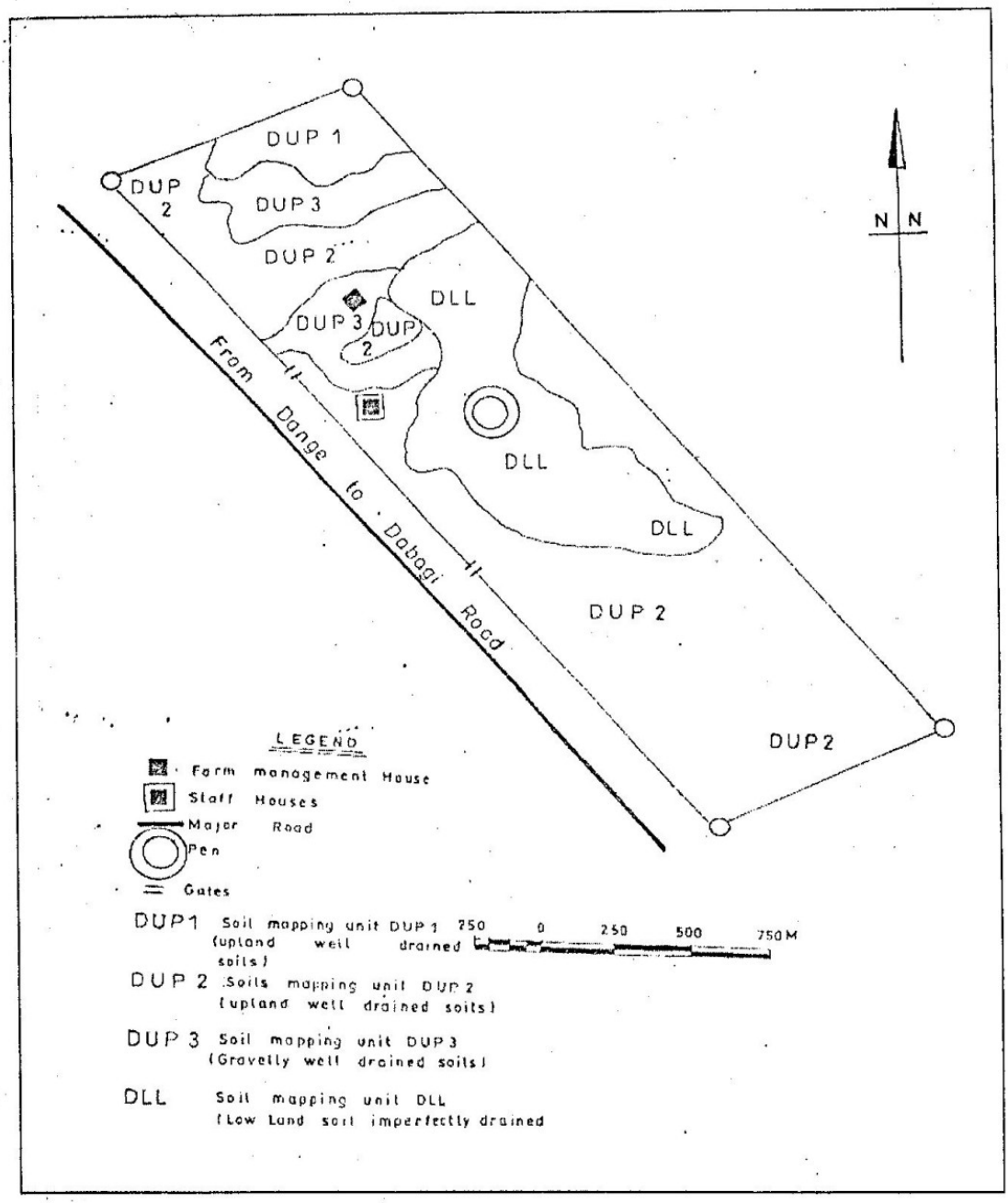

Figure 2: Sketch Soil map of the portion of Dabagi Farm Surveyed

(b) Seed Collection and Germination

Seeds of *Acacia senegal, Balanities aegyptiaca* and *Parkia biglobosa* were sourced from a good mother tree within the study area. Method of collection was by handpicking and plucking. The seeds were sterilized for 15 minutes in 5% NaCl and rinsed for 10 minutes under running tap water to remove the effect of any contaminant (Lyubun, 2009). Bulked soil samples from Dabagi Farm were used for the germination and growth trials. The control experiment for seed germination were sown on germination tray and watered with distilled water. Medium sized polypots (3.5″ x 7″ x 7″) were filled with soil samples from the two sites and used for the experiment. The seeds were sown and watered daily until complete germination was observed.

3.2 Auxin preparation

Different concentration levels of 2.77μgg^{-1} and 3.62μgg^{-1} of indol-3-acetic acid (IAA) were prepared by weighing out 2.77mg and 3.62mg of powdered auxin. The weighed powders were dissolved in a 1:1 concentration of alcohol (ethanol) and make up to the mark in 1 litre volume of distilled water. Each mixture was shaken properly to allow for dissolution of the powdered auxin. The shoots of the seedlings (phloem tissue) were injected with the auxin concentrations using 1ml syringe (Van Adrichmen, 2007).

3.3 Growth trials

A total of 90 seedlings (30 seedlings of each species) were used for the interaction experiment. The treatments applied were hormones at 3 levels: 0, 2.77 and 3.62µgg^{-1} and salt at 2 levels (2.2 and 2.8dSm^{-1}) and were replicated five (5) times. A seedling in a polypot was considered as an experimental unit. 1kg of Urea fertilizer dissolved in 3.3litres of water was applied in order to reduce growth defect due to nutrient deficiencies. A factorial experiment in a completely randomized design was used.

3.3.1 Application of treatments

i. Salt (NaCl)

The seedlings were watered daily throughout the period of the experiment. 0.5dSm^{-1} of sodium chloride (NaCl) solution was applied to soils in polypots under 2.2dSm^{-1} and 2.8dSm^{-1} salinity levels fortnightly to maintain soil salinity due to dilution and leaching.

ii. Hormone

Using a 1ml syringe, 0.1ml solution of prepared hormone (IAA) was administered (injected) into the phloem tissue of the seedlings stem fortnightly (Van Adrichmen, 2007).

3.4 Data collection

Plant growth parameters (stem height and collar diameter) were recorded fortnightly for 12 weeks. Stem height was measured using meter rule, while collar diameter was measured using veneer caliper.

At the end of 12 weeks, the seedlings were harvested for the determination of Relative Growth Rate (RGR) using fresh and dry matter.

Fresh matter of harvested plants was determined by weighing using Muneer electronic balance (DM_1). Dry matter (DM_2) was determined after drying the harvested plants in an oven at 46^0C for 72hours and weighed.

3.5 Plant Growth Analysis

The relative growth rate (RGR) was determined as follows:

$RGR = \{1/DM_2 - 1/DM_1\} \{t_2-t_1\}$ $(g.g^{-1}.d^{-1})$

Where;

DM_1 is the initial total (shoot + root) dry mass, DM_2 is the final total dry mass, and $(t_2 - t_1)$ the difference in time interval between the two samplings (70 days), $(gg^{-1}d^{-1})$ mass increase per above ground biomass per day.

3.6 Statistical Analysis

Objective 1and 5 were achieved using descriptive statistics (Percentage), objective 2, 3 and 4 were analyzed using Analysis of variance. Where differences existed, Duncan Multiple Range Test was used to separate the mean values.

CHAPTER FOUR

RESULTS

4.1 Effect of salinity on seed germination

The results (Table 1) showed that at 2.2dSm^{-1} salinity level, the germination of the *A. senegal* was greater (54%) than at 2.8dSm^{-1} (42%) and control (46%). *B. aegyptiaca* however had greater germination percentage of 94% at 2.8dSm^{-1} compared to 82% at 2.2dSm^{-1} and 86% at 0.0dSm^{-1}. *P. biglobosa* showed a greater germination at 0.0dSm^{-1} and 2.2dSm^{-1} with a percentage of 44% compared to 36% at 2.8dSm^{-1}. Comparing the germination of the species, it was observed that *B. aegyptiaca* showed greater germination percentage at 2.2 and 2.8dSm^{-1}salt levels (94 and 82) followed by *A. senegal* (54) at 2.2dSm^{-1}. The germination percentage of *A. senegal*, at control (46) and 2.8dSm^{-1}(42); *P. biglobosa* at control (44), 2.2dSm^{-1} (44), and 2.8dSm^{-1}(36) respectively were poor since these were less than 50%.

Table 1. Effect of salinity on seed germination

Plant species	*A. senegal*			*B. aegyptiaca*			*P. biglobosa*		
	Salt Conc.			Salt Conc.			Salt Conc.		
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Total (out of 50)	23	27	21	43	41	47	22	22	18
Percentage	46	54	42	86	82	94	44	44	36

Key:

A = 0.0dSm^{-1} B = 2.2dSm^{-1} C = 2.8dSm^{-1}

4.2 Effect of hormone (IAA) on seed germination.

The results (Table 2) showed that at 3.62μgg^{-1} hormonal level, the germination of *B. aegyptiaca* was better (98%) than (94%) at 2.77μgg^{-1} and (86%) at 0.00μgg^{-1}. *A. senegal* also showed a better germination performance at 2.77μgg^{-1} with 62%, followed by control (54%) and 3.62μgg^{-1} (50%). *P. biglobosa* showed a greater germination at 2.77μgg^{-1} with 74% compared with 68% at 3.62μgg^{-1} and 48% at 0.00μgg^{-1}. Comparing the germination of the species, it was observed that *B. aegyptiaca* showed an increasing trend in germination percentage with corresponding increase in the levels of hormones. But for *A. senegal* and *P. biglobosa*, 2.77μgg^{-1}hormonal level favoured better germination.

Table 2. Effect of hormone (IAA) on seed germination

Hormone levels	0.00μgg^{-1}		2.77μgg^{-1}		3.62μgg^{-1}	
Species	No. germ.	(%)	No. germ.	(%)	No. germ.	(%)
A. senegal	27	(54)	31	(62)	25	(50)
B. aegyptiaca	43	(86)	47	(94)	49	(98)
P. biglobosa	29	(48)	37	(74)	39	(68)

4.3 Effect of salinity (NaCl) on the early growth of the tree species.

4.3.1 *Acacia senegal*

The results in table 3 showed that there was variation in height and collar diameter from 2 to 12weeks. Treatment A (2.2dSm^{-1}) showed that there was no significant difference in stem height from 2 to 6WAP and 10 to 12WAP. Stem height at 10 to 12WAP was greater ($p<0.05$) than stem height at 2 to 8WAP. However, stem height at 6WAP and 10WAP were not statistically different but at par with the values obtained at 2 to 4WAP and 12WAP respectively. Stem height of 8.0cm obtained at 2WAP was statistically the lowest. The results indicated that the collar diameter remained unchanged for the first 8weeks, but the values were lower ($p<0.05$) than those obtained at 10 and 12 WAP, and the latter were the same. Treatment B(2.8dSm^{-1})showed that there was no significant difference in stem height between 4 and 6WAP as well as between10 and 12WAP. However, stem height at 10 to 12WAP were greater ($p<0.05$) compared to 4 and 6WAP and but stem height at 8WAP was not different with the stem height at 4, 6, 10 and 12WAP. Stem height of 7.6cm obtained at 2WAP was statistically the lowest. The collar diameter did not show any statistical difference from 2 to 12WAP.

4.3.2 *Balanites aegyptiaca*

The result in table 3 showed that there was variation in height and collar diameter from 2 to 12WAP. Treatment A (2.2dSm^{-1}) showed that there was no significant difference in stem height from 2 to 6WAP. However, significant difference occurred in stem height between 8WAP compared to10and 12WAP and the latter were the same statistically.

Stem height of 9.4cm obtained at 2WAP was the lowest. It was observed that the collar diameter was unchanged from 2 to 10WAP, 12WAP had the highest ($p<0.05$) collar

Table 3: Effect of salinity (NaCl) on early growth of the tree species

Species	A. senegal		B. aegyptiaca		P. biglobosa	
	Height (cm)	C.D (mm)	Height (cm)	C.D (mm)	Height (cm)	C.D (mm)
Treatment						
2.2dSm^{-1}						
2WAP	8.0^{c}	0.6^{b}	9.4^{c}	0.3^{b}	11.8^{b}	0.5^{d}
4WAP	10.1^{c}	0.6^{b}	11.1^{bc}	0.3^{b}	12.3^{b}	0.5^{d}
6WAP	13.5^{bc}	0.6^{b}	15.3^{bc}	0.3^{b}	13.5^{b}	0.6^{c}
8WAP	16.2^{b}	0.6^{b}	18.3^{b}	0.3^{b}	14.9^{ab}	0.7^{b}
10WAP	19.7^{ab}	0.8^{a}	22.8^{a}	0.3^{b}	17.1^{a}	0.8^{a}
12WAP	23.5^{a}	0.9^{a}	27.7^{a}	0.4^{a}	19.3^{a}	0.8^{a}
SE±	2.4	0.05	2.9	0.02	1.2	0.06
2.8dSm^{-1}						
2WAP	7.6^{c}	0.6^{ab}	10.2^{c}	0.3^{c}	8.6^{c}	0.5^{b}
4WAP	8.8^{b}	0.6^{ab}	13.2^{bc}	0.3^{c}	9.8^{bc}	0.5^{b}
6WAP	11.3^{b}	0.7^{a}	16.7^{bc}	0.3^{c}	11.2^{bc}	0.5^{b}
8WAP	14.4^{ab}	0.7^{a}	21.1^{b}	0.3^{c}	13.8^{a}	0.6^{ab}
10WAP	17.5^{a}	0.8^{a}	26.5^{a}	0.4^{b}	16.1^{a}	0.7^{a}
12WAP	20.1^{a}	0.8^{a}	34.0^{a}	0.5^{a}	18.2^{a}	0.8^{a}
SE±	2.0	0.4	3.6	0.3	1.5	0.5
Sig.	S	S	S	S	S	S

Means with the same superscript in a column are not significantly different at P>0.05 according to Duncan's multiple range test (DMRG)

WAP = Weeks after Planting

C.D = Collar Diameter.

diameter of 0.04mm.Treatment B (2.8dSm^{-1}) showed that there was no significant difference in stem height from 2 to 6WAP. However, significant difference occurred in stem height at 8WAP with that of 10 and 12WAP and the latter were the same statistically. Stem height of 10.2cm obtained at 2WAP was the lowest. It was observed that the collar diameter remained unchanged from 2 to 8WAP. The collar diameter at 10WAP was higher ($p<0.05$) compared with the values obtained at 2 to 8WAP but lower statistically than 0.5mm obtained at 12WAP.

4.3.3 *Parkia biglobosa*

The results in table 3 showed that for treatment A (2.2dSm^{-1}), there was no statistical difference in stem height from 2 to 8WAP, and from 8 to 12WAP. Statistical difference occurred in stem height between 10 and 12WAP compared to values obtained from 2 to 6WAP. Stem height of 11.8cm obtained at 2WAP was the lowest. The collar diameter at 10 and 12WAP was the same but higher ($p<0.05$) compared with 4, 6 and 8WAP.Treatment B (2.8dSm^{-1}) showed no statistical difference in stem height from 2 to 6WAP and from 8 to 12WAP. Stem height of 8.6cm obtained at 2WAP was the lowest. The collar diameter showed no statistical difference in growth from 2 to 8WAP and from 10 to 12WAP. Collar

diameter at 8WAP was at par with the values obtained at 2 to 6WAP and 10 to 12WAP.

4.4 Effect of indole-3-acetic acid (IAA) on the early growth of species.

4.4.1 *Acacia senegal*

The results in table 4 showed that there was variation in stem height from 2 to 12weeks. Treatment 0.0μgg^{-1} gave stem height of 11.5 and 13.7cm at 4 and 6WAP which were statistically the same with the value obtained at 2WAP but lower than stem heights at 8, 10 and 12WAP.

Treatment X_1 (2.77μgg^{-1}) showed no statistical difference in stem height values obtained from 2 to 4WAP and from 6 to 12WAP. Stem height at 6 to 12WAP were greater ($p<0.05$) than stem height at 2 to 4WAP. Stem height of 12.1cm was the lowest.

Treatment X_2 (3.62μgg^{-1}) showed that there was no statistical difference in stem height from 2 to 6WAP and from 8 to 12WAP. Stem height at 8 to 12WAP were greater ($p<0.05$) than stem height at 2 to 4WAP. Stem height of 12.4cm was the lowest.

4.4.2 *Balanites aegyptiaca*

The results in table 4 showed that there was variation in stem height from 2 to 12weeks. Treatment Y_0(0.0μgg^{-1}) showed that there was no statistical difference in stem height from 2 to 8WAP and also in stem height from 10and 12WAP. Stem height at 10 to 12WAP were greater ($p<0.05$) compared with stem height at 2 and 4WAP, but was statistically the same with the value obtained at 6 and 8WAP. Stem height of 15.3cm was the lowest.

Treatment Y_1 (2.77μgg^{-1}) showed that there was no statistical difference in stem height from 2 to 6WAP and from 10 to 12WAP. Stem height at 10 to 12WAP were greater ($p<0.05$) than stem height at 2 to 6WAP, but was statistically the same with the value obtained at 8WAP. Stem height of 14.9cm was the lowest.

Treatment Y_2 (3.62μgg^{-1}) showed no statistical difference in stem height from 2 to 4WAP and from 10 to 12WAP. Stem height at 10 to 12WAP were greater ($p<0.05$) than stem height at 2 to 4WAP, but was statistically the same with the values obtained at 6 and 8WAP. Stem height of 15.4cm was statistically the lowest.

4.4.3 *Parkia biglobosa*

The results in table 4 showed that there was variation in stem height from 2 to 12weeks. Treatment Z_0(0.0μgg^{-1}) showed that there was no statistical difference in stem height from 2 to 6WAP and from 8 to 12WAP. Stem height at 8 to 12WAP were greater ($p<0.05$) than stem height at 2WAP, but was statistically the same with the values obtained at 4 and 6WAP. Stem height of 8.9cm was the lowest.

Treatment Z_1 (2.77μgg^{-1}) showed no statistical difference in stem height from 2 to 6WAP and in stem height from 8 to 12WAP. Stem height at 8 to 12WAP were greater ($p<0.05$) than stem height at 2 to 4WAP, but was statistically the same with the value obtained at 6WAP. Stem height of 12.8cm was the lowest.

Treatment Z_2 (3.62μgg^{-1}) showed no statistical difference in stem height from 2 to 6WAP and from 8 to 12WAP. Stem height at 8 to 12WAP were greater ($p<0.05$) than stem height at 2 to 4WAP, but was statistically the same with the value obtained at 6WAP. Stem height of 12.1cm was the lowest.

4.5 Effects of Interaction between Hormone (IAA) and Salinity (NaCl) on Growth.

4.5.1 *Acacia senegal*

Treatment combination 2.77μgg^{-1}/2.2dSm^{-1} showed no significant difference in stem height between 2, 4 and 6WAP and between 6, 8, 10 and 12WAP. The stem heights at 8, 10and 12WAP were greater ($p<0.05$) compared with stem height at 2 and 4WAP. Stem height of 7.2cm obtained at 2WAP was the lowest. The results of collar diameter measured at 8, 10and 12WAP were greater ($p<0.05$) compared with that at 2WAP, but was statistically the same with those at 4 and 6WAP. Treatment combination 2.77μgg^{-1}/2.8dSm^{-1} showed that there was no significant difference in stem height between 2, 4 and 6WAP and between 6, 8, 10 and 12WAP. Stem height between 8, 10and 12WAP were greater ($p<0.05$) compared

with stem height at 2 and 4WAP but were statistically the same with the value obtained at 6WAP. Stem height of 7.5cm obtained at 2WAP was the lowest (Table 5). The collar diameter results showed that the values between 8, 10and 12WAP were greater ($p<0.05$) compared with that at 2WAP but were statistically the same with those between 4 and 6WAP. Treatment combination $3.62\mu gg^{-1}/2.2dSm^{-1}$ showed that there was no significant difference in stem height between 2, 4 and 6WAP and between 6, 8, 10 and 12WAP. Stem heights between 8, 10 and 12WAP were greater ($p<0.05$) compared with stem height at 2 and 4WAP. The results showed that collar diameters between 10 and 12WAP were greater ($p<0.05$) compared with those between 6 and 8WAP, the collar diameter between 6 and 8WAP also differed significantly compared with the values at 2 and 4WAP. Treatment combination $3.62\mu gg^{-1}/2.8dSm^{-1}$ showed that there was no significant difference in stem height of *Acacia senegal* between 2, 4 and 6WAP and between 6, 8, 10 and 12WAP. Stem height between 8, 10 and 12WAP were greater ($p<0.05$) compared with stem height between 2 and 4WAP but were statistically the same with the value obtained at 6WAP. Stem height of 7.7cm obtained at 2WAP was the lowest. The results of collar diameters measured showed that the values between 10 and 12WAP were greater ($p<0.05$) compared with those between 6 and 8WAP which also was greater ($p<0.05$) when compared with 2 and 4WAP.

Table 5: Effect of Interaction between Hormone (IAA) and Salinity (NaCl) on Growth

	A. *senegal*		*B. aegyptiaca*		*P. biglobosa*	
	SH (cm)	CD (mm)	SH (cm)	CD (mm)	SH (cm)	CD (mm)
Treatment						
2.77μgg^{-1}/2.2dSm^{-1}						
2WAP	7.2^{b}	0.5^{b}	10.2^{b}	0.3^{b}	10.3^{b}	0.6^{b}
4WAP	8.3^{b}	0.6^{ab}	13.3^{b}	0.3^{b}	11.9^{ab}	0.6^{b}
6WAP	10.4^{ab}	0.6^{ab}	17.1^{ab}	0.4^{a}	14.8^{ab}	0.7^{ab}
8WAP	14.1^{a}	0.7^{a}	21.9^{a}	0.4^{a}	17.1^{ab}	0.7^{ab}
10WAP	15.7^{a}	0.8^{a}	29.4^{a}	0.4^{a}	20.2^{a}	0.9^{a}
12WAP	18.3^{a}	0.8^{a}	36.2^{a}	0.4^{a}	23.2^{a}	1.0^{a}
SE	1.8	0.04	4.1	0.02	2.0`	0.07
Sig.	S	S	S	S	S	S
2.77μgg^{-1}/2.8dSm^{-1}						
2WAP	7.5^{b}	0.5^{b}	10.8^{b}	0.3^{b}	8.0^{b}	0.4^{b}
4WAP	8.9^{b}	0.6^{ab}	13.0^{b}	0.3^{b}	8.9^{b}	0.4^{b}
6WAP	12.2^{ab}	0.6^{ab}	15.6^{ab}	0.4^{a}	10.1^{ab}	0.5^{ab}
8WAP	14.1^{a}	0.7^{a}	18.8^{a}	0.4^{a}	12.3^{a}	0.6^{a}
10WAP	16.8^{a}	0.8^{a}	24.4^{a}	0.4^{a}	13.6^{a}	0.6^{a}
12WAP	19.1^{a}	0.8^{a}	28.3^{a}	0.4^{a}	14.8^{a}	0.7^{a}
SE	1.8	0.04	2.8	0.02	1.1	0.05
Sig.	S	S	S	S	S	S
3.62μgg^{-1}/2.2dSm^{-1}						
2WAP	7.7^{b}	0.3^{c}	12.4^{b}	0.5^{c}	8.5^{b}	0.4^{d}
4WAP	8.9^{b}	0.3^{c}	15.8^{b}	0.6^{bc}	9.3^{b}	0.5^{c}
6WAP	11.8^{ab}	0.4^{b}	19.7^{ab}	0.7^{ab}	10.5^{ab}	0.5^{c}
8WAP	15.4^{a}	0.4^{b}	24.9^{ab}	0.8^{a}	11.8^{ab}	0.6^{b}
10WAP	17.7^{a}	0.5^{a}	31.8^{a}	0.8^{a}	13.7^{a}	0.6^{b}
12WAP	20.3^{a}	0.5^{a}	39.7^{a}	0.9^{a}	15.7^{a}	0.7^{a}
SE	2.0	0.03	4.2	0.06	1.1	0.03
Sig.	S	S	S	S	S	S
3.62μgg^{-1}/2.8dSm^{-1}						
2WAP	7.3^{b}	0.3^{c}	11.1^{b}	0.5^{c}	7.7^{b}	0.4^{c}
4WAP	8.5^{b}	0.3^{c}	13.2^{b}	0.5^{c}	8.5^{b}	0.4^{c}
6WAP	11.2^{ab}	0.3^{c}	17.2^{ab}	0.6^{bc}	9.3^{ab}	0.4^{c}
8WAP	14.9^{a}	0.4^{b}	21.3^{ab}	0.7^{ab}	10.3^{ab}	0.5^{b}
10WAP	16.6^{a}	0.4^{b}	26.5^{a}	0.8^{a}	11.9^{a}	0.5^{b}

12WAP	19.8[a]	0.5[a]	33.7[a]	0.9[a]	13.4[a]	0.6[a]
SE	2.0	0.03	3.5	0.06	0.9	0.03
Sig.	S	S	S	S	S	S

Means with the same superscript in a column are not significantly different at P>0.05 according to Duncan's multiple range test (DMRG)

Key:
SH = Stem Height
CD = Collar Diameter
WAP = Weeks after Planting

4.5.2 *Balanities aegyptiaca*

The results in table 5 showed that there was variation in height and collar diameter growth from 2 to 12WAP. Treatment combination 2.77μgg^{-1}/2.2dSm^{-1} showed no significant difference in stem height between 2 and 4WAP and between 8, 10 and 12WAP. Stem heights between 8, 10 and 12WAP were greater ($p<0.05$) compared with the heights between 2 and 4WAP but were statistically the same with the value obtained at 6WAP.The stem height of 10.2cm obtained at 2WAP was the lowest. The results of collar diameters measured between 6, 8, 10 and 12WAP were greater ($p<0.05$) compared with those measured between 2 and 4WAP. Treatment combination 2.77μgg^{-1}/2.8dSm^{-1} showed that there was no significant difference in stem heights between 2 and 4WAP and between 8, 10 and 12WAP. Stem heights at 8, 10 and 12WAP were greater ($p<0.05$) compared with those between 2 and 4WAP but were statistically the same with the value obtained at 6WAP.The stem height of 10.2cm obtained at 2WAP was the lowest. The collar diameter results showed that the values between 6, 8, 10 and 12WAP were greater ($p<0.05$) compared with those between 2 and 4WAP. Treatment combination3.62μgg^{-1}/2.2dSm^{-1} showed that there was no significant difference in

stem height between 2 and 4WAP and between 10 and 12WAP. Stem height between 10 and 12WAP were greater ($p<0.05$) compared with those between 2 and 4WAP but were statistically the same with the values obtained between 6 and 8WAP. Stem height of 12.4cm obtained at 2WAP was the lowest. The collar diameter results showed that the values between 6, 8, 10 and 12WAP were greater ($p<0.05$) compared with those between 2 and 4WAP. Treatment combination3.62μgg^{-1}/2.2dSm^{-1} showed that there was no significant difference in stem height between 2 and 4WAP and between 10 and 12WAP. Stem height between 10 and 12WAP were greater ($p<0.05$) compared with those between 2 and 4WAP but were statistically the same with the values obtained between 6 and 8WAP. Stem height of 12.4cm obtained at 2WAP was the lowest. The results showed that collar diameters between 10 and 12WAP were greater ($p<0.05$) compared with those between 6 and 8WAP, the collar diameters between 6 and 8WAP also differed significantly at ($p<0.05$) compared with 2 and 4WAP. Treatment combination3.62μgg^{-1}/2.8dSm^{-1} showed that there was no significant difference in stem height between 2 and 4WAP and between 10 and 12WAP respectively. The stem height between 10 and 12WAP were greater ($p<0.05$) compared with those between 2 and 4WAP but were statistically the same with the values obtained between 6 and 8WAP. Stem height of 12.4cm obtained at 2WAP was the lowest. The results showed that collar diameters between 10 and 12WAP were greater ($p<0.05$) compared with those between 6 and 8WAP, the collar

diameters between 6 and 8WAP also differed significantly at ($p<0.05$) compared with 2 and 4WAP.

4.5.3 *Parkia biglobosa*

The results in table 5 showed that there was variation in height and collar diameter growth from 2 to 12WAP. Treatment combination 2.77μgg^{-1}/2.2dSm^{-1} showed no significant difference in stem height between 10 and 12WAP. The stem height between 10 and 12WAP were greater ($p<0.05$) compared with stem height at 2WAP but were statistically the same with the values obtained between 4, 6 and 8WAP. Stem height of 10.3cm obtained at 2WAP was the lowest. The results of collar diameters measured between 10 and 12WAP were greater ($p<0.05$) compared with those between 2 and 4WAP but were statistically the same with the values obtained between 6 and 8WAP. Treatment combination 2.77μgg^{-1}/2.8dSm^{-1} showed no significant difference in stem height between 2 and 4WAP and between 8, 10 and 12WAP respectively. The stem height between 8, 10 and 12WAP were greater ($p<0.05$) compared with those between 2 and 4WAP but were statistically the same with the value obtained at 6WAP. Stem height of 8.0cm obtained at 2WAP was the lowest. The results of collar diameters obtained between 8, 10 and 12WAP were greater ($p<0.05$) compared with those obtained between 2 and

4WAP but were statistically the same with the value obtained at 6WAP. Treatment combination 3.62μgg^{-1}/2.2dSm^{-1} showed that there were no significant difference in stem height between 2 and 4WAP and between 10 and 12WAP. The stem height between 10 and 12WAP were greater ($p<0.05$) compared with those between 2 and 4WAP but were statistically the same with the values obtained between 6 and 8WAP.Stem height of 8.5cm obtained at 2WAP was the lowest. The results showed that collar diameter obtained at 12WAP was greater ($p<0.05$) compared with those between 8 and 10WAP, these were also higher statistically compared with values obtained between 4 and 6WAP. The result obtained at 2WAP was statistically the lowest. Treatment combination 3.62μgg^{-1}/2.8dSm^{-1}showed that there were no significant difference in stem heights between 2 and 4WAP and between 10 and 12WAP. The stem heights between 10 and 12WAP were greater ($p<0.05$) compared with stem heights between 2 and 4WAP but were statistically the same with the values obtained between 6 and 8WAP.Stem height of 8.5cm obtained at 2WAP was the lowest. The results showed that collar diameter obtained at 12WAP was greater ($p<0.05$) compared with those between 8 and 10WAP, these were also higher statistically compared with values obtained between 2 and 6WAP.

4.6 Determination of salt stress tolerant in species

The Relative Growth Rate (RGR) of the three species period measured as the mass increase per above ground biomass per day (gg^{-1}d^{-1}) were determined at the end of

growth period and used to establish which specie was more tolerant to salt stress and at what treatment combination. Table 6 shows that *B. aegyptiaca* has a better growth at all treatment combinations than *A. senegal* and *P. biglobosa. A. senegal* showed better growth at $0\mu gg^{-1}/2.8dSm^{-1}$, *B. aegyptiaca* at $2.77\mu gg^{-1}/2.8dSm^{-1}$ and *P. biglobosa* at $2.77\mu gg^{-1}/2.2dSm^{-1}$.

Table 6: Relative growth rate (RGR) of the species under different treatment combinations

Treatments	Species	*A. Senegal*	*B. aegyptiaca*	*P. biglobosa*
		$g.g^{-1}.d^{-1}$	$g.g^{-1}.d^{-1}$	$g.g^{-1}.d^{-1}$
	Control			
$0\mu gg^{-1}/2.2dSm^{-1}$		0.42	0.47	0.33
$0\mu gg^{-1}/2.8dSm^{-1}$		0.47	0.52	0.21
	Interactions			
$2.77\mu gg^{-1}/2.2dSm^{-1}$		0.41	0.55	0.35
$2.77\mu gg^{-1}/2.8dSm^{-1}$		0.42	0.58	0.27
$3.62\mu gg^{-1}/2.2dSm^{-1}$		0.41	0.42	0.27
$3.62\mu gg^{-1}/2.8dSm^{-1}$		0.43	0.48	0.24

CHAPTER FIVE

DISCUSSIONS

5.1 Effect of salinity on seed germination

The presence of higher salt concentration lowered germination in the species studied. *A. senegal* and *P. biglobosa* showed better germination at 2.2dSm^{-1}, while *B. aegyptiaca* showed better germination at 2.8dSm^{-1}. This result agrees with Sands (1981) and Totey *et al*. (1987) who reported that germination rates have been used to determine the response of plants to salinity. It also agrees with Estes (2004) who reported that each species has its own level of salt tolerance.

5.2 Effect of hormone (IAA) on seed germination

B. aegyptiaca showed increased germination with corresponding increase in auxin applied and both *A. senegal* and *P. biglobosa* showed increase germination at 2.77µgg^{-1} auxin level when compared with control. This result suggests that seeds treated with IAA favoured higher percentage germination in the species studied and is in agreement with Ali *et. Al.* (2007) who found an increased germination of *Cicer arietium* treated with IAA and in disagreement with Akbari *et. al.* (2007) who working with three cultivars of wheat (*Triticum aestivum*) reported that auxin,

does not stimulate germination of seeds. The increase observed in seed germination of the species tested could be attributed to their individual genetic characteristic and viable seeds used under favourable environmental conditions. The inherent character of auxin in improving water content, protein synthesis (Hopkins, 1995) and promotion of cell division and elongation (Hopkins, 1995) favoured the process of seed germination. It is important to point out that increasing concentration of auxin levels in *Acacia senegal* and *Parkia biglobosa* beyond 2.77μgg^{-1} adversely affected their germination, therefore, growers working with auxin may not expend much on hormone.

5.3 Effect of salinity (NaCl) on early growth of tree species.

Salinity influenced some changes in the growth of the tree species studied. The stem growth of *B. aegyptiaca* and *A. senegal* increased at 2.8dSm^{-1} and 2.2dSm^{-1} respectively which is perhaps the reason for their prevalence and dominance in this region. This result agrees with Li, (2008) investigating the effects of different salinity concentrations on seedling growth of three species found out that the shoot growth of *Limonium sinensis* and *Sorghum sudanense* increased with increasing salt (4dSm^{-1}). Sustained growth under increasing salt suggests that they had appreciable tolerance to salt (NaCl) stress. *P. biglobosa* on the other hand had a decrease in stem growth with corresponding increase in salt suggesting that they had lower tolerance in shoot growth under increased salt (NaCl) and therefore, gives reason for their non prevalence in the region. This result also agrees with

Ghanem *et al*. (2008) who worked with tomato plants (*Solanum lycopersicum*) at 100mM NaCl showed that salinity reduced shoot biomass by 50-60%. Seedling growth, cell division, elongation and primordium formation could all be decreased by salinity; since high levels of salt will cause water to leave the plant cells by osmosis and the plant lose turgor (i.e become limp). Without turgidity, the plant protoplasm cannot push against the cell wall and expand so growth ceases.

5.4 Effects of indole-3-acetic acid (IAA) on early growth of species

Auxin increased seedling growth in all the species studied. It was observed that for *A. senegal*, auxin level of 2.77μgg^{-1} showed a better stem growth, *B. aegyptiaca* and *P. biglobosa* had better stem heights at 3.62μgg^{-1} auxin level. This agrees with Akbari *et. al.* (2007) who worked with three cultivars of wheat (*Triticum aestivum*) and Sally (2012) who tested the effect of auxin (IBA and NAA) on cuttings of *Trecular africana* and reported that the hormones increased rooting of the specie. Benjamins and Scheres, (2008) also reported that auxin is involved in many aspects of plant growth and development. Reinhardt, *et. al*. (2003) suggested that auxin accumulation mechanism could account for organ primordial initiation thereby guaranteeing outgrowth of lateral organs.

5.5 Effects of interaction between hormone (IAA) and salinity (NaCl) on growth

There were some degree of significance observed in the growth parameters measured in this study. These explain the interaction effect of hormone and salinity on the tree seedling as described below.

It was observed that treatment $3.62\mu gg^{-1}/2.2dSm^{-1}$ gave a better growth performance for *Acacia senegal* and *Balanities aegyptiaca* at 12WAP, while *Parkia biglobosa* had the highest growth performance influenced by treatment $2.77\mu gg^{-1}/2.2dSm^{-1}$ at 12WAP. Higher concentration of salt even though in combination with auxin (IAA) resulted in lower growth performance in *Parkia biglobosa* but higher growth performance in the other two species. Considering these results, salinity has played a key role in determining growth performance of the studied species. This is in agreement with the findings of Albacete *et. al*. (2008) who worked on tomato (*Solanum lycopersicum*) plants. He reported that hormonal changes affect the normal growth of harvestable plant organs. Dunlap and Binzel (1996) reported that salinity decreased the auxin (IAA) levels in roots but not in the leaves of tomato plants. Albacete *et. al*. (2008) reported contrarily that salinity induced opposite changes in auxin (IAA) concentrations in leaves and roots. Whichever way, nutrient assimilation through the root and manufacture of food materials in the leaves is necessary for proper shoot growth. It is important to note that reduced levels of IAA in the species as a result of increased salinity could be responsible for retarded shoot elongation particularly in *Parkia biglobosa*. The overall effect of the interaction to a forester is in the development of better shoot growth, 3.62µgg-1/2.2dSm-1 suggested this particularly in *Acacia senegal* and *Balanities aegyptiaca*.

5.6 Determination of the most Tolerant Specie to Salt Stress

The Relative growth rate (RGR) is an indicator of the differences in the ability of the plants to absorb and utilize nutrients at different salinity and hormonal treatment levels. *Balanities aegyptiaca* proved to be the most tolerant with maximum relative growth rate (RGR) at all levels of interactions while *Parkia biglobosa* was most susceptible to salt stress. *Acacia senegal* showed moderate tolerance to salt. This could be due to the adaptation mechanism and the genetic makeup of the tree species. This agrees with Flowers (1988); Silberbush and Ben-Asher (2001) who observed that the most common effects of soil salinity is growth inhibition by Na^+ and Cl^-. Wild (1988) also noted that the growth of soil microorganisms, such as mycorrhizal fungi can be inhibited by high salt concentration. Similar observation was made by Erhenhi *et. al*. (2008) who commented that salinity significantly affected biomass, dry and fresh weight, ash content and ionic concentration at varying degrees depending on salt tolerance level of such plant and its adaptive mechanism.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

Seeds of *Acacia senegal*, *Balanities aegyptiaca* and *Parkia biglobosa* were used to investigate the germination and seedling growth as influenced by different salinity and auxin (IAA) concentrations. Results showed that increased concentration of NaCl reduced germination percentage and seedling growth in *Parkia biglobosa*. Different levels of auxin tested increased germination percentage, stem height and collar diameter of the tree species. *Balanities aegyptiaca* showed high seed germination percentage, stem height and collar diameter growth in comparison to other species at the salinity and hormonal levels considered.

6.2 Conclusion

Soil salinity stress is an abiotic factor responsible for a change in plant growth and when in excess could lead to death of plant. This is evident as observed in this research whereby the growth of plant species used were influenced at varying salt levels compared. Land suitability classification is very important when it comes to

the issue of regeneration of tree species. This is evident from the result that *Parkia biglobosa* must not be regenerated in salt concentrated land, while *Balanities aegyptiaca* has proved to be highly tolerant species and could be used in reclamation of marginal lands.

This is very important to tree growers and it is hoped that this will help land users and managers in Nigeria when planning and allocating land for various uses.

6.3 Recommendation

Research emphasis on the quantitative information on hormonal doses suitable for better growth of indigenous tree species should be made.

More tree species and a wider range of salt stress should be investigated to widen the scope of tree regeneration effort especially on marginal lands.

Availability of hormones can make hormone based researches very interesting.

Research on seasonal hormone levels present in indigenous tree species both at early and mature growing stages should be conducted.

Balanites aegyptiaca could be used in reclamation of marginal lands.

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Plate 1: Hormone, Indole-3-acetic acid used in inducing growth in species.