Sudan University of Science and Technology

College of Graduate Studies

Seed Germination and Early Root and Shoot Growth of *Prosopis juliflora* (mesquite)

انبات البذور ورصد النمو المبكر للمجموع الجزرى والخضرى لشتلات المسكيت نوع (جولفلورا)

The Thesis submitted for fulfillment of the requirements for the Degree of Master of Science in Forestry

By

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Dedication

To my Mother

To my father

To my dear brother and sisters

To my all family

To my teachers, friends and colleagues

To my love, who light my live Alnour

To my supervisor Dr. Ahmed Mohamed Adam Eldoma

For all those;

I gift my research and simple effort

Salma

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I would like to express my deep thanks to Allah for giving me the ability and power to make this work .

Then special thanks to my supervisor Dr. Ahmed Mohamed Adam Eldoma for his help to make this research , sincere thanks to the staff of the college of forestry and range science for their assistance and support, special thanks to the national seed center of trees staff.

My great thanks are also due to dear family; I am grateful to my mother for her support and love.

Also for everyone who assisted, supported and facilitated the study

Abstract

Mesquite has been introduced into Sudan for the purpose of controlling land degradation and sand dune fixation. However, during the past three decades mesquite has naturalized in the country and started to pose some problems by being an alien invasive tree species particularly in irrigated areas in Sudan.

The study aimed at understanding the competitive ability of mesquite through the study of the root and shoot development in three soil types. In present study, an attempt was made to study the growth of both the shoot and root systems to gather basic information about the development of the young seedlings in order to understand the best way to deal with the species distribution and control at its initial stage of growth.

Tow experiments were conducted: The first one was an experiment on germination of seeds and the other dealt with investigations on the growth performance of the seedling in different germination Media and different soil types respectively. Result showed significant differences between germination media as well as between the soil types used. Information obtained was rather preliminary and need to be improved to sufficiently contribute to complete understanding of the species growth behavior and its control.

ملخص الدراسة

شجرة المسكيت استخدمت فى السودان بغرض وقف زحف الرمال ومنع التصحر.علاوة على زلك فى الثلاثة اجيال الماضيه شجرة المسكيت انتشرت انتشارا كبيرا فى القطر مما ادى لظهور مشكله وبالتالى اصبحت شجرة غير مرغوب فيها جزئيا فى المناطق الزراعية فى البلاد.

هدفت الدراسة الى معرفة وفهم مقدرة منافسة المسكيت مع الاشجار الاخرى عن طريق دراسة وتحليل نمو الجذور والمجموع الخضرى فى ثلاث انواع من الترب ، اجريت الدراسة لمعرفة انبات البذور ونمو المجموعين الجذرى والخضرى للحصول على معلومات اساسية عن نمو شتول المسكيت بغرض فهم طرق انتشار شجرة المسكيت واساليب التحكم والتخلص منها فى المراحل الاولى من نمو الشتلات.

اجريت تجربتين: الاولى فى اختبارات انبات البذور ، والثانية فى نمو المجموع الخضرى والمجموع الجزرى باستخدام وسائط مهد مختلفة منها التربة السلتية والرملية وخليط منهما.

اوضحت الدراسة الاتى:

- توجد اختلافات معنوية بين الترب المستخدمة فى نمو الجذور

- توجد فروقات معنوية فى انبات البذوربين التربة الرملية والسلتية واطباق بترى بينما لاتوجد فروقات بين السلتية والبترى .

- توجد فروقات معنوية بين انواع الترب فى نمو المجموع الخضرى.

تم جمع المعلومات الضرورية من النتائج عن النمو وسلوك النباتات والتحكم فى طريقة انتشارها ونموها.

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Chapter one

Introduction

Mesquite Prosopis is a well-known exotic plant species especially in dry land areas of the world. It has been introduced to different parts of the globe for several reasons. However, in the northern drier parts of Sudan it has introduced for the purpose of combating desertification and sand dune stabilization.

Mesquite has contributed to halt desert creep and have also played important ecological and environmental as well as social and economic roles since its introduction in the early twenties of last century. Recently the role of mesquite was seriously questioned in the light of its vigorous invasiveness and wide spreading in vast areas especially in irrigated schemes in the Sudan. Despite the formal banning of planting mesquite trees in the Sudan since 1996 and the governmental several campaigns to eradicate it from the landscape of the country, but, it has flourished and expanded into new areas in the Sudan. The best option seen by scientist working with mesquite in the country has been to manage the tree rather than to eradicate it. Their point of view is that the mesquite tree has already naturalized and become part of the flora of the country in addition to its many uses and values especially to the rural poor people. Management of such tree species necessitates a deep and informative knowledge of all aspects of growth behavior, ecological adaptation and generative mode and capacity. Such information constitutes a vial step in the appropriate future management and silviculture of the tree. The present work is an attempt to contribute to the needed information on the phreatophytism, shoot growth and germination of mesquite seeds. It has been hypothesized that the root system of mesquite grows faster than the aerial parts in the initial stages of growth to establish itself with the least amount of rainfall as a survival strategy.

This characteristic may differ with different soil types and may also vary with varying amount of rainfall or irrigation regime. In addition seed germination behavior may also exhibit different germination capacities according to the type of soil or germination media used.

Justification

Mesquite planting was intended to solve the problem of desertification in the dry-lands of Sudan in the first place. However, recently the debate about the invasive characteristics of mesquite created different ideas about its suitability for afforestation in many areas of the country. One of the suggested limitations of mesquite is its phreatophytism and the consequent drawing of water reserves from underground water. This might have serious consequences on the lowering of the water table and thus affecting other plant communities growing on the same area. Investigating the rate of growth of the root system and its variation with different soil types and final depths that it reaches will pave the way to understanding how mesquite competes and affects other plant species in the ecosystem. Comparing the above ground vegetative growth performance seems to be indispensable to draw necessary information on the behavior of mesquite and how it interacts with its associated plant communities. Since the germination capacity of mesquite seeds of mesquite has a pronounced effect on its spreading and its invasion of new habitats, its becomes important to study the germination of the seeds and know about its characteristics and how fast it can colonize new adjacent areas.

Therefore the main objective of the present work was to investigate the seed germination and compare the rate of shoot and root growth at the nursery level using different growing media and soil types.

The specific objectives were:

1. To study and compare the germination percentage and speed of mesquite seeds using different growing media or soil types.
2. To determine the rate of root growth of mesquite in different types of soils
3. To Study the growth of the above ground parts of mesquite seedling in the nursery stage
4. To compare between the rate of root growth and shoot growth of mesquite seedling grown in the nursery using different soil types.

Chapter two

Literature Review

Mesquite (Prosopis sp), an ever green plant plays an ecological, economical, and hydrological roles in desert environments. The mesquite has been classified as a phreatophyte plant because it has access to constantly saturated water reservoirs. The mesquite has been introduced to several parts of the arid areas in order to rehabilitate the degraded lands and stop the continuous desert creeping. (Babiker, 2006). *Prosopis juliflora* was introduced in1917 to Sudan simultaneously from both Egypt and South Africa by R.E.Massey, who worked at the Egyptian department of agriculture in Giza. The imported seeds were sown at shambat, Khartoum north, from where prospis has later been spread by humans to other places in Sudan. Currently, mesquite has been classified as a major non-indigenous alien species weed in Sudan. It has been proved to have two mechanisms to survive under hard arid conditions viz phreatophytism and drought resistance. These two mechanisms support the mesquite during the prolonged drought conditions, which makes mesquite, compete successfully with the natural indigenous species. Consequently, mesquite displaces indigenous plant communities, affects agricultural practices, and disturbs the eco-hydrological system in the invaded areas. Understanding of the mesquite water uptake mechanism could be important from eco-system and water conservation sides of view. Evaporation from vegetation is generally the second largest component of water balance. Evaporation from phreatophyte plant spices can be directly related to diurnal water table fluctuation and may limit water resources. Mesquite phreatophytic mechanism has been investigated by various researchers. (Eldoma et al, 2011)

Botanical description

Prosopis sp. (mesquite) an ever green tree or shrub. The genus comprises 44 species of which 40 are natives to the Americas .Of the remaining species *p. Africana* in indigenous to africa, *whereas p.kodziana, p.cineraria* are natives to the Middle East and Pakistan. Prosopis species grow in arrays of environments and are not restricted by soil type, ph., salinity or fertility. Prosopis juliflora belong on family leguminosae subfamily mimosoideae, syn. Mimosaceae, latin name *Prosopis juliflora* the name juliflora, comes from julus, meaning whip-like referring to the long inflorescences, and *flora* being the flower.common synonym: English: mesquite, algoroba, Arabic mesquite.(Abdel Nor, 1995)

*Prosopis juliflora*isa fast growing, nitrogen-fixing and tolerant to arid conditions and saline soils. It has a large crown and an open canopy and can grow to a height of 14 m. Its stem is green-brown, sinuous and twisted with axial and strong thorns .Its bark is red-brownish and rough and the root system has a deep taproot that allows the tree to reach deep water tables. The leaves are compound. Dark bluish-green and have high tannin content .The foliage is unpalatable for livestock, except for very tender new shoots. *P. juliflora*flowers throughout the year with yellow flowers hanging from the branches. Its fruits are pods, which are green when immature and turn yellow when they mature. The pods contain a high level of sugar. and are palatable to livestock when ripe .A mature *P. juliflora*tree can produce 40 kg of pods per year, from which 60 000 seeds can be obtained. (Andersson 2005).

Reproductive biology and phenology

P. juliflora inflorescence is small, green-yellowish spikes without any Particular fragrance or attractiveness, though relished by bees. Flowering

Begins at the age of 3-4 years. In India, *P. juliflora* flowers twice a year, in February-March and August-September, and is a prolific seeder. The pods from autumn flowering mature by May or early June and are dispersed before the onset of the monsoon. In drought years, autumn flowering is extremely affected, with trees often failing to flower, but these same trees flower and fruit subsequently when there is adequate rainfall. The bisexual, pea like flowers are cross-pollinated by wind and insects. The seed is disseminated and pretreated by the agency of animals that feed on the pods. (Orwa et al, 2009)

Mesquite and its distribution in Sudan

Mesquite *P. Juliflora* was introduced in to Sudan in 1917 from South Africa and Egypt and planted in Khartoum the success attained in establishment of the tree and its abilities to tolerate drought and fix sand dunes. In 1938 the plant was introduced into Sinar, Fwar, EL Foung (Central Sudan), Elghaba, Lietti basin (northern Sudan), Sinkat, ELgalabat, Port Sudan (eastern Sudan), Kordofan and Darfur (western Sudan) Late in 1947 and subsequently in 1965 mesquite was re-introduced into eastern Sudan, where it was planted in a green belt around Kassala In New Halfa mesquite was introduced to protect the research farm (El Tayeb, et al., 2001). .The prevailing drought in the 1970 s rejuvenated the interest in mesquite and further introductions, into eastern Sudan, were made to protect residential and cultivated areas.

In 1974 mesquite seeds were broadcasted by airplanes in around Kassala and further planted in protected forests. In the period 1978-1981 the tree was planted as shelterbelts at Port Sudan and Tokar. Moreover. Introductions were made into the White Nile province, western and central Sudan. The tree was planted in shelterbelts around farms, irrigated schemes and along the Nile. (A.G.T babiker 2006)

Mesquite root s system

The three years old mesquite plants had well- developed tap roots winch had penetrated to the level of the petro calcic horizon. In every case the lower portions of the tap roots were dead and decayed. The active root systems were composed of a few roots originating from the root crowns and. collectively about 230 adventitious roots ranging in diameter from 0.8 to 34mm arising from the buried branches. Root system of woody perennials tends to be deeper than that of non-woody perennials, with the shallowest rooting system to be observed in annual herbs. Roots of *P.juliflora*can develop rapidly following germination and can reach a depth of 40 cm in eight weeks.); they are widely referred to as tap root system. (Leanz, 1997). The root system of some *Prosopis* species belongs to the deepest documented; a live root of an American *Prosopis* tree was discovered in a copper mine over 50 m below the surface. With a good soil water supply, however, 90% of *Prosopis* roots are in the upper 100 cm of soil. The deep roots presumably enable a *Prosopis* tree to survive severe droughts. Prosopis ssp. can be long-lived, probably a couple of centuries in favorable sites. (Dieter geesing @ prosopis. Net)

Its complex and deep-ranging root system allows it to tap different water tables, both at the surface and deep underground, which makes it a very hardy crop. The roots also act as an energy storage mechanism, because once a tree is cut down, new shoots spring up rapidly from the existing roots. The depth of mesquite taproots and the density and distribution of lateral also vary depending on the vertical and horizontal distribute of available soil water across soil types (Alessandra Fravolini 2006) most notably, mesquites' root systems give the plants a competitive botanical edge in the desert landscape. As hosts to nitrogen-fixing bacteria, they help enrich otherwise impoverished desert soils in which the plants and their progeny grow. In lateral reach, they out compete other plants in the battle for soil moisture. In their taproots' downward reach, they find subsurface water, sometimes 150 m to perhaps 200 m feet below the surface "The mesquite's root system is the deepest documented, a live root was discovered in a copper mine over 160 feet 50 meters below the surface." (Copyright © 1996-2012 DesertUSA.com and Digital West Media, Inc.) There are two distinct root systems which are formed under normal conditions of unim`peded root development. These are characteristically a deep root system, and a superficial root organic organization system, both having different functions during different seasons. The deep root system is made up of one, two or three (rarely more) main tap roots, which may divide at lower depths. They have the function of anchoring the tree but are primarily ground water reserves, whether water table or other subterranean supply. They can become very thick and tens of meters long until a permanent water source are found. *P. pallida*tap roots reach water tables 20-25m deep, while *P. velutina*has roots reaching over 53 m deep Roots extend horizontally once a water source is reached and tend to grow following the direction of water flow Where there is an impermeable sub-surface layer, such as that formed by a an iron pan or hardened calcareous pans, tap root extension is prevented and roots will extend laterally above this layer. Was found to consist of main lateral roots and two types of secondary root. Larger secondary roots (approximately 20 mm in diameter) grew vertically downwards from the laterals, while small, fibrous secondary roots (under 5 mm in diameter) extended and bifurcated vertically upward to within 4 cm of the soil surface. Root colour could be used to distinguish *P. juliflora* roots from other species, the young roots of *P. juliflor a*were cream coloured with a translucent cortex, while old roots were pale brown with a semi-opaque cortex. Root density of *P. juliflora*was 3 cm of root /cm3 of soil in the upper 15 cm of the soil profile, dropping to less than 0.5 cm root/cm3 of soil at below 45 cm depth, and less than 0.2 cm root/cm3 of soil at 1.8 m depth. This was approximately three times the root density found with *A .nilotica*, but *P. juliflora* roots had less effect on crop growth than *A. nilotica*per unit root length .All *Prosopis* species are able to survive in areas with exceptionally low annual rainfall or very lengthy dry periods, but only if roots are able to tap ground water or another permanent water sources within the first few years. Being species adapted to arid and semi-arid climates, germination and establishment generally occurs during the brief rainy season and seedlings must be sufficiently well established to survive the first dry season. The existence of two root systems, a deep tap root to reach ground water and a mat of surface lateral roots to make use of infrequent rainfall events, puts *Prosopis* species firmly in the category of phreatophytes, but showing a variety of mesophytic and xerophytes characteristics depending on water availability. (Harris et al, 2011)

Water requirements

P. juliflora p.tamarugo - P. pallida complex thrives in a wide range of rainfall zones, from 100 mm mean annual rainfall or less in dry coastal zones, to 1500 mm in the Andean region. *Prosopis* species are, however, generally much less common in regions with more than 1000 mm but their ability tolerate very low annual rainfall is well known. *P. juliflora* and are able to survive with under 50 mm and these *Prosopis* species dominate in parts of the Arabian and Atacama deserts, with some of the lowest recorded rainfall in the world.

Species native to very arid zones of the Americas such as p. *chilensis*, *P. glandulosa, P. juliflora and P. pallida* can survive with annual rainfall in the range of 50-250 mm. Many other species are noted as having a rain fall requirements in the range of 300-600 mm/yr. leaves of *Prosopis* show many xerophytic adaptations to drought but the existence of two root systems, a deep tap root to reach ground water and a mat of surface lateral roots to make use of infrequent rainfall events, places *Prosopis* as phreatophytes All Prosopis species are able to survive in areas with exceptionally low annual rainfall or very lengthy dry periods but only if roots are able to tap ground water within the first few years, or if sufficient atmospheric moisture is available, as in many coastal desert areas with persistent trade winds Or seasonal fog. The importance of foliar water uptake is unclear as water tables are present where these two species grow, and mucilaginous cells in the leaves could serve as water reserves research that claimed to prove foliar water uptake is seriously questioned and, if it does occur, it probably plays a significant part in the water balance of these *Prosopis s*pecies in dry coastal regions, *P. juliflora*and *P. pallida*grow well where rainfall is low, often less than 200 mm m.a.r.

Trees are found in higher densities along water courses and, when found in valleys, tend to congregate along the valley bottom where there is likely to be a permanent supply of sub-surface water. In montane areas, species tend to inhabit dry valleys in the rain shadow of large mountains with rainfall up to 1500 mm (Ansley et al 1990).

Temperature

Mean annual air temperature in the shade where the *P.juliflora - P. pallida* complex is generally found above 20°C, with optimum temperatures for growth being in the range 20-30°C. There appears to be no natural upper limit to temperature, with introduced *P. juliflora* known to tolerate day time shade temperatures of over 50°C, and soil temperatures in full sunlight as high as 70°C in Africa and Asia. In its native range in coastal or Montana environments, such high temperatures are rarely recorded. A major limitation to the distribution of *Prosopis* species, and particularly the truly tropical *P. juliflora - P. pallida* complex, is mean minimum temperatures and the frequency and duration of winter frosts. Light frosts cause dieback of branches, with complete stem mortality with harder frosts, and complete death of the plant when frosts are more severe or longer lasting Frost damage is more severe on seedlings and younger trees of *P. juliflora* and on trees in interdunal or other low lying areas p. *juliflora* and *P. pallida* are the most frost sensitive of *Prosopis s*pecies, along with *P. africana*, the latter two tolerated several -1.5°C frosts but died with a frost of -5°C. (FAO 1997).

Environmental effects

Effects on soil fertility

Over time, *P. juliflora* exhibits the ability to improve soils via biological nitrogen fixation, leaf litter addition and incorporation, nutrient pumping, changes in soil structure and in soil fauna and microbial populations. It is generally accepted that *Prosopis* species ameliorate the soils in which they grow. The ability of *Prosopis* to fix nitrogen may be severely reduced in highly saline or alkaline soils. Many studies on *Prosopis* species have shown that the quantities of soil nutrients are greater under the tree crown, with additions to soil fertility from root symbioses and also decomposition of senesced foliage, there is an increase in organic matter content and increases in soil macronutrients and many micronutrients. That island of fertility' exists around trees in nutrient poor areas are accepted, although whether the improved fertility precedes the tree has often been debated. An increase in silt and clay particles was also noted under the canopies of *P. juliflora* with a corresponding decrease in sand particles. This was thought to be due to a reduction in wind and water erosion and/or entrapment of wind-blown dust resulting in surface sealing and an increase in surface runoff and soil cracks. (Harris et al, 2011).

Mesquite as a phreatophyte

Mesquite is a native plant, to USA but it was historically limited to lowland areas. The species is now so dense on millions of acres of both uplands and lowlands that it often considered being a noxious plant. It is a facultative 4 phreatophyte that can grow to heights of 60 m and develop trunks(three M) in diameter it is adaptive to both wet and dry conditions once established. If the canopy is damaged or killed; the tree re-sprouts from the basal bud zone, root collar into multi-trunks that are very resistant to control. Mesquite easily dominates suitable habitat because of its extensive dual root system including both extensive lateral and deep tap roots. Tap roots are known to penetrate at least 60 feet into the ground to reach groundwater, while lateral roots fill the capillary zone above the water table. Reported water losses from individual mature trees have ranged from 7.9 to 19.8 liter per day. Some local organizations and water districts have already established control and management measures as a means of conserving water. Research to improve existing measures to develop new techniques to control undesirable vegetation continues to be a high priority research area for range scientists.

Additional research could determine the potential locations for control programs and could predict the quantities of water savings expected from control. Mesquite growing on dry site, may not consume very much water, therefore control or eradication would not increase soil water significantly. Mesquite eradication in many areas, however, conserves water by holding the water in the soil profile or by making it available for more useful plants. Phreatophyte eradication actually releases water which can be used further downstream. (Abdel basit, et al 1983).

Under such conditions mesquites have been described as phreatophyte or facultative phreatophytes. Mesquite occur throughout the Rolling Plains resource region of mesquite drought to North Central Texas and encounters conditions characterized by limited subsurface water and intermittently available surface moisture. Summer rainfall from convective storms seldom penetrates below 30 cm into the soil profile on medium to heavy textured soils and is rapidly depleted by evapotranspiration. Problems mesquite trees or surrounding vegetation in frequent shallow watering for turf will encourage surface rooting rather than the deep root development that proper irrigation of trees will provide. Mesquite trees can become unstable with excess irrigation, such as in lawns, due to rapid crown growth and limited root system development. (Schuch and Kelly, 2003)

Water relation of mesquite

Differences Between Sites

Ansley and Jacopy (1990) conduct experienced similar ambient conditions during 1985and 1986, responses may be attributed to differences in root/ soil water relations between sites. The observation that virtually all leaf and soil variables measured were affected by root severing to a greater degree at Cottonwood than at Ninemile suggests trees at Cottonwood were more dependent on lateral roots than trees at Ninemile.Trees at the Cottonwood site encountered an extremely dry layer of soil from about 1 to2 m depth. Edaphic conditions for root growth were favorable above this layer, given frequent soil moisture recharge. Results from this study and root distribution data by Heitschmidt et al. (1988) suggest that under natural conditions, these trees preferentially grew extensive, shallow lateral roots instead of tap roots to supply water demands. Since subsurface water was more abundant at Ninemile than at Cottonwood, trees at Ninemile may naturally have had a greater development of a sub canopy roots into deeper soil regions than trees at Cottonwood, and may thus have been able to tolerate pruning of lateral roots more than trees at Cottonwood. A more pronounced difference in predawn leaf between treatments at Cottonwood than Ninemile during 1986, suggests belowground recovery from root severing via new root growth was greater for trees at Cottonwood than at Ninemile. (Ansley et al., 1990)

Mesquite drought tolerance

Mesquite should be grown in full sun on well-drained soil. The tree is very drought tolerate. Young plants can be successfully transplanted while small, but they need irrigation until established. Fire used to limit its invasive habit. It has become an unimaginable weed in Texas due to fire control. Prior to fire control, heat from flames killed many trees and kept the tree from spreading throughout the region. (Edward et al., 1994).

All mesquites are very tolerant of hot south and west-facing walls, are valuable trees in parks or large public areas, and are an asset in low water-use landscapes. They may be planted in groups or as solitary specimens and add a lush appearance to the landscape. Mesquites are well suited to heat, low humidity, alkaline and poor soils. Mesquite trees are not well suited as street trees due to their multi-trunk character. The cold tolerance of many species has been established but this tolerance is quite variable owing to the condition of the plant at the onset of winter. Heavily fertilized and irrigated trees will not tolerate the cold as well as those that have been conditioned with less water and no fertilizer late in the summer. (Schuch and Kelly 2003).

The role of mesquite tree in rural development

Prosopis is now a declared weed over Millions of square kilometers of arid and semiarid lands, although experts usually agree on the invasiveness of the species the global Discussion that has been continuing for some decades focuses foremost on the impact of *Prosopis* has on both the rural livelihoods and the natural environment, and the role it plays within it. The positive role of *P.juliflora* as a useful, multi-purpose shrub or tree has been extensively promoted. This has challenged those reports outlining the downside of *Prosopis*. These are the hazards for example the vast spread of *Prosopis* at the expense of Native range lands - that have occurred in many semi-arid and arid lands as a consequence of intensive planting of the species over the last decades and sometimes centuries, extended by the lack of appropriate management and planning. The reasons for the approval of a “common weed” lay in its utilization *P.juliflora* provides valuable resources to local communities in the form of fuel wood, timber, and fodder for livestock such as goats, sheep, and cattle. It can be used as shade in hot climates, as wind breaks or for the stabilization of sand dunes that threaten to encroach into inhabited land areas. Moreover, *P.juliflora*is extremely tolerant towards a wide range of climatic, soil Physical and chemical factors. As a result of those attributes, *P.juliflora*is widely regarded as a useful resource for rural communities which are facing increased natural resources shortages due to population pressure, drought and other climate hazards, as well as armed conflicts. Particular consideration measured by the many reports of research trials is given to the ability of *Prosopis* as a source for fuel wood of high quality. Due to its high biomass production, high wood density and low ash and moisture content, the species is broadly regarded as an excellent energy source - including the production of charcoal - and usually outperforms other native and alien tree legumes. (Rural communities have to meet their energy needs. In some countries, up to 86% of this comes from cut wood). This has led to serious deforestation and desertification in many parts of the hot dry land regions and leads increasingly to resource-based Conflict. The continuous spread of *Prosopis* provides rural communities with a rare opportunity to unrestricted access to fuel wood. (Harnet bokrezion 2008)**.**

Of economic importance is the use of timber for construction purposes on this basis, many researchers suggest the establishment of *Prosopis* energy plantations to meet the energy shortages of rural communities. Another area that has attracted great interest is the potential ability of *Prosopis* to regenerate sodic waste lands, due to its high survival rate and relatively good tolerance towards soil salinity, low pH and water logging. Which my increase the productivity of these degraded lands Focus has also been given to the research of *P.juliflora* as a browse for livestock and a processed fodder resource. Pastoralists, the poor and those living in hot arid desert zones are believed to benefit the most, particularly during the dry season when feed resources are becoming scarce. In particular, the high protein content of the pods has been referred to the leaves, which are only relatively palatable, are still a potentially valuable browse when everything has dried out. (These are also of importance to animal production). Many Researchers feel that it is foremost the rural poor or landless that profit from *Prosopis*, as it provides "income safety nets for the survival on the contrary, (Harnet bokrezion2008)

Early Uses of Mesquite

Southwestern Indians used all parts of the tree: beans, bean pods, leaves, roots, trunk, limbs, bark and gum. Perhaps the first written description of mesquite's uses among Texas Indians was by Spanish explorer Alvar Nuñez Cabeza de Vaca. Shipwreck and cast up on the Texas Gulf Coast in 1528, Cabeza de Vaca and several companions lived a nomadic life for six years, much of it as Indian captives, before escaping to a Spanish outpost in Mexico. In his journal, he recorded that the natives pounded mesquite-bean pods with a wooden pestle in a dirt hole, mixed the resulting meal with some of the dirt and added water to make a kind of mush. Later European explorers and Anglo settlers reported Southwestern Indians using mesquite in these ways:

A drink called atole was made from a decoction of ground beans and water. Fermenting it produced a mildly intoxicating drink. Trunks and limbs were used for shelters and fencing. (Made a lotion sooth to sore eyes from ground mesquite leaves mixed with water). Yuma Indians treated venereal disease with an infusion of leaves, and Comanche relieved toothaches by chewing the leaves. Yaquis treated headaches with a poultice made from mashing leaves to a pulp, mixing them with water and binding the mixture to the forehead. Gum, or sap, that oozed from mesquite bark was mixed with water to treat sore throats and diarrhea, aid digestion, and help wounds heal. The Yavapai rubbed a mixture of mud and mesquite gum into their hair to simultaneously kill mice and dye their hair.

Fuel wood

Prosopis is used for many purposes, providing a cheap and easily available natural resource for everyone that can be used as fuel or as raw material for many objects. The most common use of Prosopis is as fuel wood. Almost every one of the inter viewees used Prosopis as firewood even if gas facilities are available; it is still common to use firewood now and then. Especially among the landless and poor, *Prosopis* is the only available heating resource to prepare their meals. Hyderabad is a fast expanding city in India with a blossoming building industry Roots provided a reliable source of fuel in the generally treeless desert southwest. (Kurt walter 2011)

The light-amber colored gum that oozes from mesquite bark in the fall was used as a glue to mend pottery. Indian women made cuts in the bark to gather a darker gum, full of tannins, to use as hair dye or to decorate bark clothing. Indian women pounded bark into flat sheets of fiber for clothing.

Recreational Equipment

Papago Indians used a ball made of mesquite wood or gum about the size of a croquet ball in a footrace game. Mesquite sticks and Maricopa used a mesquite ball in games similar to field hockey. (Ramos 2006).

Industrial uses

Turnings and Carvings

Some mesquite crafters use lathes or their own carving skills to create everything from heirloom rocking horses to guitars, plus smaller decorative items: jewelry boxes, desk sets, vases, and bowls and kitchen utensils.

Furniture

Finding mesquite pieces large enough to make into furniture is difficult .However; artisans creating fine furniture sometimes go through many cords of mesquite to find enough usable wood to make a chair, a desk or a table.

Flooring

Mesquite's deep, rich, red-brown wood makes mesquite floors, using either planks, as in a standard hardwood floor, or cross-grain blocks. The cross-grain pieces are more than 50 percent harder than flat-sawn planks, with swirls and radial cracks that make each one unique. The lobby and mezzanine of the Hilton Palacio del Rio in San Antonio are floored with mesquite. (Ramos 2006)

The Socio-economic Benefits of *Prosopis* in Rural Communities

While there has been some research on the health effects of *Prosopis* consumption for livestock, most international attention has focused on possible economic benefits. The utilization of *Prosopis* and its related economic benefits for rural households and communities is one of the key issues in the international discussion over *Prosopis* and its management. According to many researchers and practitioners the potential of *Prosopis* has not been fully realized by rural communities who could benefit economically from it. Therefore, the exploitation of the species is widely propagated among local communities by experts. Areas of utilization include fire wood, charcoal, construction material, animal feed planting within agro-forestry and soil regeneration projects or as a source of gum, wax, honey, human nutrition or medical remedy. Moreover, *Prosopis* wood has been widely praised as being of high density and durability, producing charcoal of good quality. Overall, the exploitation of *Prosopis* to the benefit and development of communities and as a measure of controlling its spread is the main approach that is currently being internationally pursued. (Harnetbokrezion, 2008)

Dispersal and germination

The success of *P. juliflora* is largely attributed to the high number of seeds produced and their efficient dispersal mechanism. Seeds of P. *juliflora* disperse by means of flowing water such as rivers and floods, livestock and wild animals. If the seeds fail to germinate at a particular point in time, they undergo to dormancy and remain in the seed bank. With the destruction of the vegetation cover, the soil will be exposed, that promotes the germination.

The seeds are dispersed mostly by water around wetlands and rivers, pods have high sugar content, are low in anti- feed ants and are widely the sought after by a variety of animals. Birds, bats, reptiles and ants also feed on the fruits and are potential agents of dispersal animals are the primary dispersal agents. (Samuel, 2010)

Wild animals also disperse the seeds of *P. juliflora*by consuming the fruit. after the seed passes through the gut of animals and excreted along with feces, it will germinate. The passage of the seeds through the gut facilitates the germination of the hard coated seeds of *P. juliflora*. After falling, the seed will become a component of the seed bank and remain viable for many years. Seeds set between May and June are likely cached by rodents in July and august. These cached seeds may germinate in response to summer monsoons, and therefore exhibit higher germination rates and over-winter survival than seeds produced in August and September (B.D. Duval et al 2005). Seedlings are rarely observed under the canopy of *P. juliflora*. This is because of shading and allelopathic effects of *Prosopis* and insect attacks. The hard seed coat must be broken or weakened to facilitate germination to occur. Seed germination of *P. juliflora*is usually about 21% and after scarification of the seed coat shows about 100% germination Other factors that affect the germination of seeds include salinity (that decrease germination with its increase alkalinity (that affect germination when above pH 9.0) and temperature with optimum condition for germination at about 30°C, the decrease below 20°C or above 40°C results in reduced germination in general, a number of characteristics foster the invasion of *P. juliflora*. These are the production of many small seeds, attractive and rewarding pods, accumulation of long lived seeds in the soil, production of mixture of seeds, some of which germinate immediately after dispersal and others remain dormant for spreading germination over time and incredible ability of re-sprouting and fast coppice growth from stumped or damaged trees. (Samuel, 2010).

Pre-treatments of *Prosopis* seed before sowing can be classified into the following categories: mechanical treatment, water treatment, dry heat treatment, chemical treatment, and electrical treatment.

Mechanical treatment

Small numbers of seed can be effectively scarified by making a small scratch on each seed with sand paper, by cutting each seed with a knife, or by sand papering the end of each seed that is opposite the radicle until the cotyledon is seen. However, as the seeds have to be individually treated, these treatments may not be practical for large operations.

For large quantities of seed, mechanical treatment can be achieved by pounding the seeds with sand. Both of these techniques are simple and inexpensive, and they have been found successful.

Dry heat treatment

Application of dry heat at 60°C to 80°C for 24 hours has been successful in increasing the imbibition and germination of Prosopis seed. However, when exposed to temperatures of 90°C and higher for periods of three hours or more, the seeds can be seriously damaged.

Chemical treatment

Small samples of Prosopis seed have been successfully scarified by immersion in absolute ethyl alcohol for 12 hours. For large seed lots, a concentrated (98 percent) sulfuric acid treatment is frequently recommended, if the soaking time in the acid is predetermined. Most commonly, soaking times vary from 15 to 30 minutes. The increase in germination due to treatment with sulfuric acid is generally attributed to a softening of the seed coat by oxidation, increasing the permeability of air and water through the seed coat. The seed must be meticulously rinsed several times in large quantities of water after soaking in the acid. (FAO 1986).

The uses of Prosopis juliflora seeds

The ground endosperm of mesquite seed consists mainly of galactomannan type polysaccharides, similar to those in locust bean and guar gums. Mesquite pod is used to produce syrup, flour, and drinks and also used as a coffee substitute. However, the most extended use of this fruit nowadays is as animal forage. Mesquite seed gum is not yet produced on a commercial scale, but p.*juliflora* is widely grown as a source of animal feed, fodder and fuel in some countries, such as Brazil and India, and since some research has been carried out involving pilot-scale processing of the seed with a view to recovering the gum, it is possible that mesquite may be produced commercially in the future. (Edy, Embrabo 2005**)**

Pods and seeds

The pods are usually flattened and straight, but incurved at the apex.

Some pods may be sickle shaped. In general, pods are 6-30 cm long, 5-16 mm wide and 4-9 mm thick. With age, the pods swell and become pulpy and yellowish brown in color. The prominent outline of seeds in immature green pods is no longer discernible in mature pods. The seeds are hard, flattened, 7x 4 mm in size and ovoid, and have shiny yellowish brown color.

Collection of pods from trees

If pods are to be used for planting, they should be collected from trees that have been identified for desirable traits such as erect form, high pod production, spinelessness or very few spines. November to December and March to May are the best times for pod collection.

P. juliflora pods can be collected from trees by;

• Manual shaking (pole and rope method)

• Manual shaking and cutting-sawing method, manual shaking is a useful method as the mature pods are easy to detach. In shrubby forms of the species this method is quite workable. However, branches cannot be shaken directly by hands as they contain numerous spines. Therefore, branches are shaken using a pole or a rope thrown over the branches. *P. juliflora* seed is a combination of manual shaking and cutting-sawing methods.http://www.gardenorganic.org.uk/pdfs/.../ManagingProsopisManual.pdf (Managing *Prosopis juliflora*).

Germination test

A high germination percentage is obviously desirable for the nurseryman; anything other than pure germinable seed is waste. Therefore germination and viability test should indicate the potential germinability which, with proper handling, should reflect expected germination in the nursery. Germination potential is most directly determined in a germination test: under the appropriate conditions. Germination tests are widely used in both standard seed testing and more informal simple nursery tests (Boland et al. 1980). Three situations where germination tests are less applicable :

- Where seeds have a very short viability. Duration of a germination test is typically 3-5 weeks. For short-lived recalcitrant seed significant loss of viability may take place during the test period. Hence, the germination percentage obtained by the test may not be valid for the seed lot from which it was taken because the viability of the seed lot has declined during the test period.
- Where germination is delayed or suppressed by deep dormancy. If pretreatment has been insufficient to overcome dormancy, germination may be low even if seeds are viable.
- Where fast test results are required. Especially for slow germinating species (some species take several months to germinate) the duration of a germination test may be inconvenient. Where a seed lot is to be dispatched soon after collection, there is often not enough time for a germination test. (Lars Schmidt, 2000)

Chapter Three

Material and methods

Seeds and seedlings of *Prosopis juliflora* were utilized as the main experimental materials. Two experiments were carried out. The first experiment investigated the germination of mesquite seeds while the second one constituted nursery pot trial to study the shoot and root growth characteristics of *Prosopis juliflora.* The details of the two experiments are as follow:

Experiment no. 1.

Mesquite seeds germination test,

A germination experiment using a completely randomized design (RCD) was used. In July 2012 Fresh seeds were extracted from pods collected from naturally growing mesquite trees in the vicinity of the College of Forestry and Range Science at Soba. Prior to the imposition of the treatments, the seed consignment was treated with conc. sulphuric acid to remove the seed coat dormancy. They were then thoroughly washed with tap water for several minutes and then dried and made ready for germination. Three treatments were employed viz. seeds were germinated using petri dishes, sandy soil and silty soil. In the Petri dishes treatment no media was used, while in the other two treatments plastic tray containers filled with sandy soil and silt were used respectively. Twenty five healthy sound seeds were germinated in each treatment unit. However, the silt soil germination medium treatments were replicated twice, while the Petri dishes germination treatment and the sandy soil germination treatment media were replicated four times. The experiment was carried out inside a germination room in the National tree seed center of The Forestry Research Center at Soba ARC. All treatments were daily irrigated. The number of germinating seeds was recorded on biweekly basis and was continued for three weeks. The germination speed, parentage and germination time for all treatments were calculated using data thus obtained. Data were analyzed using analysis of variance and means were separated by Duncan New multiple Range Test

Experiment no.2.

Root and shoot growth characteristics of mesquite seedlings:

Seeds extracted from *Prosopis juliflora* pods collected from naturally growing mesquite trees in Soba area were used. The seeds were treated with sulphuric acid to remove the seed coat dormancy, then thoroughly washed with water and dried prior to germination. Primarily seeds were sown in plastic trays containing silt soil. The germinated seeds were grown in germination trays for two weeks and were regularly and adequately irrigated and given necessary care and protection.

The experiment used a completely randomized design with three treatments each replicated four times. The treatments used were sandy soil medium, silt soil and a mixture of sand and silt media. A total of twenty four 1.5 m long x 15 cm diameter polyethylene pipes, eight of each of the respective three above mentioned soil media were filled with the appropriate type. A single seedling was planted in each pipe of each soil media type. These were supported with a metal frame to keep the pipes erect in place. The metal frame was kept in a nursery with a saran shade of about 50% for six weeks. Normal irrigation was maintained all through the duration of the experiment. Measurements on root length, number of root branches, number of leaves and plant height were recorded at two weeks, four weeks and six weeks interval. However, destructive sampling was used during data recording of the root length and number of root branches recording.

Data obtained from the experiment were subjected to analysis of variance. Duncan New Multiple Range test was used to separate means.

Chapter Four

Results and Discussion

Results

Results obtained from the analysis of variance on root and shoot growth characteristics of *Prosopis juliflora* seedlings showed very highly significant differences between the three soil type media tested for total plant height, number of leaves and number of root branches. However, the there was no significant differences between the soil types on root length characteristic (Table 1.).

Table 1. ANOVA summary of mesquite root and shoot growth on three types of soil during six

growth characteristic											
Source of variation	**Number of leaves**			**Plant height**			**Root length**			**Numbe**	
Soil media type	SS	MS	F	SS	MS	F	SS	MS	F	SS	M
	427.14	213.57	51.92***	388.11	149.05	99999.99***	901.72	450.86	3.28ns	8769.0	4384

Number of leaves.

As shown in Table 2. The effect of soil media type on this growth characteristic was very highly significant. The biggest number of leaves (13) was obtained when seedlings were grown in the mixture of silt and sandy soils. On the other hand, the sandy soil recorded a significantly lower number of leaves (6) compared to the silt and sandy – silt soil mixture. The silt soil medium produced (11) leaves ranking in the second place and was significantly different from the other two treatments.

Plant height

The mixed soil media significantly enhanced plant height growth compared the both silt and sandy soil media attaining a total seedling height of (13.48 cm). However, the silt soil on the other hand produced significantly taller seedlings (12.43 cm) than the sandy soil media which recorded the shortest seedlings (7.43 cm).

Table 2. Variation in root and shoot growth characteristic *of Prosopis juliflora* seedlings at six weeks grown in poly ethylene pipes in a nursery.

Soil type	**Growth characteristic**			
	Leaves number	**Plant height (cm)**	**Root length (cm)**	**Number of root branches**
mixed soil	13a	13.48 a	68.10b	125 a
Sandy soil	06 c	07.34 c	43.23c	081 c
Silt soil	11 b	12.43 b	76.73a	117b
Period (weeks)				
2 weeks	6 c	5.52 c	29.13 a	44 c
4 weeks	10 b	12.38 b	39.95 a	65 b
6 weeks	19a	20.26 a		161a

Root length

The three soil types differed significantly on their effect on root length. The silt soil ranked first and had significantly longer root length (76.73 cm) than either of the other two soil media investigated. The sandy soil gave the least effect on root length of the seedling (43.23 cm) which is significantly shorter that the seedling growth in mixture of the silt and sandy soils. However, the mixed silt-sandy soil media was intermediate in ranking with a mean length of (68.10 cm). similar results were obtained by (Yoda et al. 2012) they investigated the root length growth using different soil types including a silty soil, and they also found that the silt soil gave significantly longer root system of mesquite *Prosopis juliflora*. In additional (Kozlowski 1971) pointed that silt and sand soil sometimes modify root growth so much that species characteristic are obscured. According to (Yoda et al. 2012) a single rain fall of more than 12 mm will promote seed germination and consequently long root growth of mesquite. Therefore this finding can be used for controlling mesquite in there early growing stages by uprooting small seedlings in the first week of their growth. As indicated in the present study mesquite cans produce along root system within a very few weeks of about 40.0 cm within one month. Generally soil structure affected root system growth and penetration into the soil perhaps other factors like availability of water are also important.

Number of root branches.

The mixed sand and silt media yielded a significantly bigger number of root branches (125) compared to the silt soil or sand alone. On the other hand the silt soil medium induced the growth of a significantly greater number of root branches (117.81) as compared to the sandy soil medium which effected the growth of the fewest number of root branches (81).

Experiment no 1.

Data obtained from the seed testing experiment were analyzed using analysis of variance. The analysis showed highly significant differences between the three methods of germination tests used viz. petrri dish medium test, sandy soil medium and silt soil medium. (Table 3.)

Table3. Analysis of variance summary of mesquite seed germination on two types of soil and petri dish growing media during three weeks.

Source of variation	**DF**	**SS**	**MS**	**F value**
Treatments	2	1190.00	595.00	8.38 **
Weeks	2	1192.0	596.00	8.39 **
Replication	3	292.72	97.57	1.37ns

Table 4. Variation in germination of *prosopis juliflora* seeds as affected by different soil types and Petri dish germination media during three weeks.

Treatment	**Germination percentage**
Sandy soil	27.27a
Silt soil	18.4ab
Petri dishes	16.57b

Germination percentage of *Prosopis juliflora* seeds

The three media types showed significant differences ($p < 0.5$) between them in their ability to effect in germination percentage of *Prosopis juliflora* seeds. The best germination media was the sandy soil. The sandy soil showed significantly higher germination percentage (27.27). As compared to both the silt soil and the Petri dish growing media. However, the silt soil and the Petri dish growing media showed no significant ($p < 0.5$) differences between them recording (18.4) and (16.57) for silt soil and Petri dish growing media respectively.

Germination speed.

Germination speed was calculated using the Lars Schmidt (2000) formula:

Germination speed = Cumulative daily germination % /Number of test days.

Table 4 below shows the cumulative daily germination percentage of the six test days recorded from the germination test experiment.

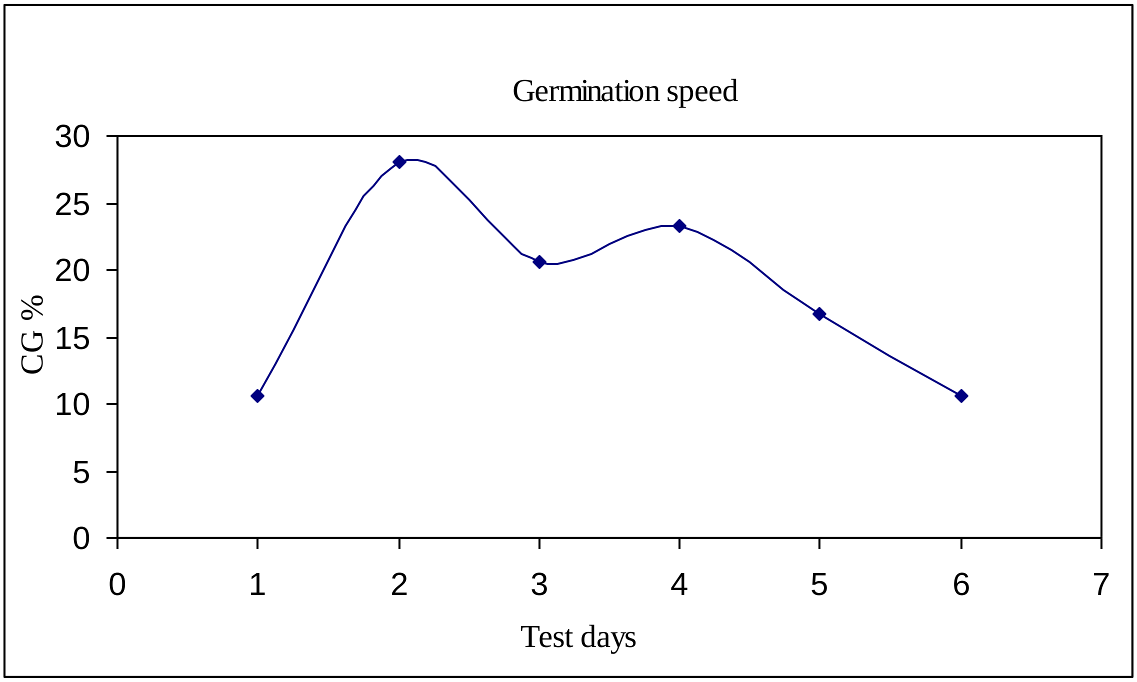

Figure 1. The course of germination speed of *Prosopis juliflora* seeds during three weeks.

Chapter five

. Conclusion and recommendation

Results obtained from the present work were preliminary due to the short time of the study. However, it can be concluded:

1.mesquite, *Prosopis juliflora* seeds germinate easily after treatment to break it dormancy. However significant differences were found between the different germination media used in laboratory. The silt soil media was significantly effective compared to the remainder of media used.

2. Seeds on their natural environment are subject to different ecological and biological factors which affect their dormancy, and hence readily germinate. This is supported by the regeneration of mesquite from its seed bank on the areas where seeds were dispersed. Treated mesquite seeds used in the present work germinated in a very high percentage mitigating these natural conditions.

3. *Prosopis juliflora* seedlings grew fast at their initial stage producing along root system within a very short time compared to other tree species like the acacia species. This gives mesquite comparatively higher chances for competition and dominance in the new habitats that   invade.

4. Seedlings performance on both root and shoot growth differed with the different soil types used. However, the silt soil produced the longest root system during the experimental period of six weeks. This explains the variation in stocking and sizes of mesquite trees growing in different parts of the country with different soil types viz. sandy soil of western Sudan and loamy rich soil of gash and Atbara River bank on eastern Sudan.

Recommendation

1. Since mesquite seedling develop along tap root system soon after germination it seems appropriate to uproot it from the agricultural fields at this time to save time and efforts in the future.

2. Additional work is needed to avail more information on growth and development of mesquite seedling and germination behavior to assist in its sustainable management in different land use system and patterns in the country

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