



بسم الله الرحمن الرحيم

Sudan University of Sciences and Technology

College of Agriculture Studies

Department of Plant Protection

B.Sc. (Honors)

Graduation Research Project

Effect of Herbicide on Mesquite (*Prosopis juliflora*)

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September, 2016

الاية

قال تعالى:

(إِنَّ فِي خَلْقِ السَّمَاوَاتِ وَالْأَرْضِ وَاخْتِلَافِ اللَّيْلِ وَالنَّهَارِ
وَالْفُلْكِ الَّتِي تَجْرِي فِي الْبَحْرِ بِمَا يَنْفَعُ النَّاسَ وَمَا أَنْزَلَ اللَّهُ مِنَ
السَّمَاءِ مِنْ مَّاءٍ فَأَحْيَا بِهِ الْأَرْضَ بَعْدَ مَوْتِهَا وَبَثَّ فِيهَا مِنْ كُلِّ
دَابَّةٍ وَتَصْرِيفِ الرِّيَّاحِ وَالسَّحَابِ الْمُسَخَّرِ بَيْنَ السَّمَاءِ وَالْأَرْضِ
لَايَاتٍ لِقَوْمٍ يَعْقِلُونَ)

سورة البقرة الاية (164)

صدق الله العظيم

Dedication

To my father and mother, to my brothers, sisters

To All My Teachers in Plant Protection, Sudan University
Of Sciences and Technology, College of Agricultural
Studies

To My Class Mate

TO My spouse

To all member which help me to produce this work.

Acknowledgement

Firstly thanks god for every things especially for giving me health and well to finish this research. I am thankful to all my teachers in the department of plant protection Sudan University of Science and Technology. Special thanks are due to Professor: Mukhtar Abdel Aziz Mohamed who supervised this work and to my friends Moeed Ali, Hala Osman and Abdel rahim... Thanks are due to Ream, in the then Striga Research laboratory, who helped a lot during the course of this work.

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ABSTRACT

The experiment was carried out in College of Agricultural Studies, Shambat, Sudan University of Science and Technology during the summer season of the year 2016 to evaluate the efficacy of mesquite control by two post-emergence herbicides: glyphosate applied at and 2, 4-D applied at. Results showed that all herbicides treatments at their different rates significantly reduced Plant height (cm), number of leaves/plant and number of leaflets/plant as compared to the control. The lowest Plant height (cm), number of leaves/plant and number of leaflets/plant was achieved by the highest rate of glyphosate. Within the two herbicides the best mesquite control was achieved with glyphosate at highest rate.

الملخص العربي

أجريت هذه التجربة في جامعة السودان للعلوم والتكنولوجيا كلية الدراسات الزراعية (شحات) خلال صيف عام 2016 لمعرفة فعالية واثربقيات الحشائش علي المسكيت (جالايفوسيت, 2-4-D) بعد الانبات , اثبتت النتائج المتحصل عليها فعالية المبيدات في تقليل طول النبات , عدد الاوراق والوريقات مقارنة بالشاهد, اقل طةل للنبات, عدد الاوراق والوريقات تم الحصول عليه بواسطة اعلي تركيز من الجالايفوسيت, تم الحصول علي اكبر نسبة مكافحة من مبيد الجالايفوسيت عند اعلي تركيز.

□

CHAPTER ONE

INTRODUCTION

Prosopis spp.(mesquite) are multi-purpose evergreen leguminous trees or shrubs. The genus comprises 44 species of which 40 are natives to the Americas (Pasiecznik, 2001).Mesquite grows in arrays of environments and is not restricted by soil type, pH, salinity or fertility. In Sudan flowering is year-round (Babiker, 2006). The fruiting period, which peaks in December to June, coincides with the dry season. Mesquite leaves are unpalatable, while pods, renowned for their high sugar (16%) and protein (12%) contents are attractive to animals. The high degree of self incompatibility promotes hybridization and results in genetic variability, which as noted in similar situations, confers plasticity and allows colonization of a wide range of habitats (Hierro and Callaway, 2003).

Common mesquite(*P. juliflora* Swartz, DC.), often multi-stemmed with a spreading crown of pendulous branches hanging down to the ground, is a copious seed producer (Babiker, 2006). The seeds, characterized by coat imposed dormancy, germinate in flushes and establish a huge persistent seed bank. Long distance transport of seeds is ensured by animals and water (Babiker, 2006).

Following germination mesquite seedlings grow vigorously (Ahmed, 2009). Tap roots reach deep water tables and extensive lateral roots spread well beyond the crown. The rapidly growing root system and un-palatability of foliage increase seedling survival rate and competitiveness particularly in heavy grazed areas and/or on uncultivated fallows. The high coppicing ability of mesquite ensures recovery of the plant when cut and often results in multi-stemmed trees. The trees have many competitive advantages over other plants however, the seedlings are somewhat sensitive (Pasiecznik,

2001). They colonize disturbed, eroded, overgrazed or drought-ridden land associated with unsustainable agronomic practices (Pasiiecznik, 2001). The trees are believed to deplete groundwater reserves and to smother and suppress, through both allelopathic and competitive effects, growth of neighbouring plants (Ahmed, 2009). *Prosopis pollens* are said to be a major cause of allergic reactions and the thorns are poisonous and/or promotive to secondary infections on prickling (Takur and Sharma, 1985).

Mesquite, at its centre of origin, the arid areas in South America, has played an important social role. In addition to its role in combating desertification and supply of high-value mechanical wood products, firewood and charcoal, mesquite provides shelters, animal feed and food for humans in areas where protein intake is very low and under adverse conditions of drought and famines (Ibrahim, 1989). The plant is important for fencing stalks, and as bee forage for honey production. Mesquite pods are a source of good quality flour and syrup which may be utilized in making foodstuffs at household levels (Pasiiecznik, 2001, Felkeret *al.*, 2003). Mesquite species exude a water soluble gum that has been used as a substitute for gum Arabic during periods of restricted trading or international market shortages (Vilela and Ravtta, 2005). Mesquite species have ameliorating effects on soil under canopy. The tree fixes nitrogen and the leaf litter, when incorporated, improves soil physical and chemical properties. Leaves of mesquite are valued as compost (Pasiiecznik, 2001). Foliage of mesquite contains several chemicals which are effective against several weeds; insects, fungi and some are of medical and/or industrial value (Pasiiecznik, 1999). Moreover, mesquite, when properly managed, is a suitable tree for agroforestry in low-input low-rainfall areas (Luukkanen*etal.*, 1983)

Mesquite was introduced into several countries with the primary objective of curbing desertification and providing fire wood and thus preserving indigenous trees (Babiker, 2006, Chog and Chikamai, 2006). However, in most of the countries, where it was introduced, mesquite has spread outside where it was originally planted and has become a serious weed (ElHour, 1986). Ease of spread of mesquite is consistent with its invasive nature, ease of adaptations to novel environments, lack of natural enemies and underutilization and mismanagements (Ali and Labrada, 2006; Babiker, 2006; Kathiresan, 2006). Thus common mesquite has become a formidable weed in several countries. It is noteworthy that exploitation of mesquite for wood and non-wood products in Sayun and Tarim in Yemen, in addition to the benefits realized by the community, curtailed spread of the tree and lessened its importance as a weed (Ali and labrada, 2006).

P. juliflora, was introduced into Sudan in 1917 from South Africa and Egypt and planted in Khartoum (Broun and Massey, 1929). The success attained in establishment and the ability to tolerate drought, fix sand dunes and capacity to furnish shade, fuel, timber, fodder and edible pods provided the impetus for repeated introductions of the tree into various agro ecologies with emphasis on dry areas (Babiker, 2006). In the period 1978-1981 the tree was planted as shelterbelts on premises of major cities in eastern Sudan (Elsidig, Abdelsalam and Abdelmagid, 1998). Moreover, introductions were made into various places in western and central Sudan. The tree was planted in shelterbelts around farms, irrigated schemes and along the Nile.

Repeated introductions of mesquite from unknown sources (Pasiiecznik, 2001), its deliberate distribution within the country, prevailing drought, livestock and feral animal's movement coupled with decreased land-use,

land tenure, under utilization of the plant, mismanagement and over exploitation of natural vegetation have led to spread of mesquite into various locations where it has become a national pest (Elhour, 1986). The plant constitutes a threat to agriculture, biodiversity and may lead to deterioration of natural vegetation and pastures and thus jeopardizes the livelihood of a large proportion of the populace, particularly, where livestock keeping and subsistent farming are the main avenues for income generation.

The bulk of mesquite infestation (>90%) is in eastern Sudan, where livestock keeping and subsistence cultivation constitute the main source of income. Invading mesquite tends to form dense, impenetrable thickets. In pastures it reduces grass cover and stocking density, interferes with mustering of stock and threatens the livelihood of traditional pastoralists. Invasion into agricultural land, along irrigation channels and water courses is also a major problem. (Elsidigetal., 1998).

In Sudan as in most of the countries, where mesquite has been introduced, it is underutilized. Its use, beside sand dune fixation is limited to fuel wood and charcoal production (Babiker, 2006). Animal rearing constitutes the main livelihood of land and resource less farmers in many of the mesquite endemic areas. Unpalatability of *P. juliflora* leaves to livestock limits their use as animal feed. Results from trials on feeding mesquite pods to sheep were also disappointing and over 90% of livestock owners in eastern Sudan regard mesquite as a liability (Elsidiget, al., 1998).

Several efforts were made in Sudan, to eradicate mesquite (Babiker, 2006). However, because of high cost and complexity of the problem, most of the efforts were not successful or sustainable. In 1995 the government approved a bill on mesquite management. The tree is to be eradicated where it

constitutes a threat to agriculture or biodiversity and preserved in areas threatened by desertification. Active eradication programmes, using both mechanical and manual methods for uprooting mesquite, were implemented in various locations in the country, at very high cost, and with variable results (Babiker, 2006). Soil disturbance resulting from uprooting brings mesquite seeds to the surface soil and aids regeneration (Ahmed, 2009).

Global experience showed clearly that eradication of mesquite is neither desirable nor tenable (Pasiiecznik, 1999). The plant is considered by several scientists to be an elemental force comparable to fire too valuable to extinguish completely and too dangerous to trust unwatched and spread and establishment of the plant into new areas should be discouraged (Peattie, 1953). Mesquite, if properly managed, could be a boon to the rural poor. Mesquite, in addition to curtailment of sand dunes, provides several wood and non-wood products which could be of benefits to rural communities in dry areas where no other trees could grow and flourish. However, when not properly managed mesquite proved to be a serious invasive weed.

Spread of the plant could be curtailed by discouraging movement of seeds which constitute the major vehicles for long distance transport. For seed movement animals and water constitute the main vehicles (Babiker, 2006). It is very difficult to control animal's movement in mesquite endemic areas viz in eastern Sudan, where livestock keeping is the mainstay of income. Furthermore, movement of seeds through water, particularly during floods and flow of ephemeral streams and rivers is difficult to restrain. Continuous monitoring and rapid response and development of rapid efficient method(s) for eradication of new infestations are therefore imperative.

Mesquite seeds are the main vehicle for long distance transport. Satellite foci are pivotal for establishment of colonies (Babiker, 2006). Mesquite, as is the case with many invasive alien plants, spreads by seed dispersal and repeated establishment of satellite foci from a founder population (Moody and Mack, 1988). Environments with open niches, abandoned land or over-grazed and drought stricken sites are the most vulnerable to invasion. Mesquite, upstream, on rivers, water courses and irrigation canals or in premises of irrigated schemes displays a high tendency to spread. The huge seed bank and basal buds endow mesquite with a high capacity for regeneration after cutting and/or uprooting. Efforts have to focus on containment and maximum utilization. To curtail mesquite invasion seed movement should be discouraged or the seeds should be devitalized, satellite foci should be denied establishment, over exploitation of natural vegetation and overgrazing of marginal land should be discouraged. Land tenure in mesquite endemic areas should be reviewed. Satellite foci and mesquite infestations on strategic and high risk areas such as irrigation canals, water courses and agricultural land should be eradicated. Ways and means for utilization of the removed mass should be designed to generate income for farmers and pastoralist. Following destruction mesquite has to be replaced by appropriate trees and/or crops. The treated area has to be vigilantly observed and interventions by chemical and/or mechanical mean should be implemented to discourage regeneration.

Mesquite when not a threat to agricultural lands or biodiversity and in areas prone to desertification should be conserved and ways and means for its management and utilization should be developed.

At present a research programme with the prime objective of developing sustainable and economically viable management site specific strategies which offer several options have been proposed. The strategies, based on containment and utilization, are to take into account distribution of mesquite, infested areas, their possible contribution to further spread of the plant, socio-economic aspects of mesquite, its environmental impact, indigenous methods of management and utilization and their possible improvement through research generated technologies.

Thus, this study was conducted to evaluate and compare the effects of two widely used post-emergence herbicides in Sudan, namely, glyphosate and 2, 4-D to determine the most suitable mesquite control treatment.

CHAPTER TWO

LITERATURE REVIEW

2.1 Description:

Common mesquite (*Prosopis juliflora*). aFabaceae, is an evergreen multi-purpose tree or shrub. Pending water availability the plant grows up to 12m high or into a shrub. Mesquite growth is not limited by soil type , pH, salinity and/or soil fertility. The tree is a nitrogen fixer, endowed with an extensive root system. Its tap root grows down to 53m and its lateral roots may extend beyond the crown.

The tree is competitive and allopathic. It is also a prolific seed producer. The seeds, mainly distributed by animals and water, are persistent and a high seed bank often builds up in soil.

2.2 Economic and other uses:

Various *prosopis* species have been introduced to Africa over the past 190 years for their beneficial qualities which include erosion control, shade, fuel wood, building materials, and pods for animal and human consumption in arid and semi-arid regions. The fact that there is clear economic use to this species but severe negative consequences of *P.juliflora* invasion makes this conflict of interest species. Sacrificed

2.3 Mesquite as an alien Plant

Mesquite was introduced into several countries with the primary objective of curbing desertification and providing fire wood and thus preserving indigenous trees (Babiker, 2006; Chog and Chikamai' 2006). However, in most of the countries, where it was introduced, mesquite has spread outside where it was originally planted and has become a serious weed (ElHour, 1986; Babiker, 1976). Ease of spread of mesquite is consistent with its invasive nature, ease of adaptations to novel environments, lack of natural

enemies, underutilization and mismanagements (Ali and Labrada, 2006; Babiker, 2006; Chog and Ngujiri, 2006; Kathiresan, 2006). Exploitation of mesquite in Argentina between 1500 and 1975 reduced the natural coverage of *Prosopis* to between 25 and 50% (Choge and Chikamai, 2003). *P. uliflora*, which is of rampant spread in Yemen, has been reported to constitute a threat to agriculture, pastures and biodiversity when underutilized and mismanaged (Elsiddig, 2004). However, utilization of wood and non-wood products of mesquite in Yemen, Sayun and Tarim areas, in addition to the benefits realized by the community, curtailed spread of the tree and lessened its importance as a weed (Ali and labrada, 2006). However, blockage of natural ephemeral water courses by mesquite often causes serious flood problems in Yemen (Elsidig, 2004).

2.4 Mesquite in Sudan

2.4.1 General

Sudan, the third largest country in Africa with an area of 1.752.187 Km², lies between longitudes 21⁰ 49 E-38⁰-34 E and latitudes 8⁰ 45 N-23⁰ 8 N (Fig. 2). The River Nile and its

Tributaries form the most prominent physiographic feature and they played significant roles in soil and vegetation formation process. The country is characterized by diverse climatic conditions. Rainfall varies between less than 100 mm/annum in the north to about 700-900 mm/annum in the south. More than 50% of the total area of the country is arid or semi-arid. The savanna covers about 40% of the area forming primary forest land, but much of it has been cleared, resulting, approximately, in 6.5 million hectares of bare land (Anonymous, 2011). Total arable land is estimated to be 84 million ha of which only 20% is cultivated (Anonymous, 2011). Irrigated agriculture is about 4.62 million ha, while rainfed agriculture is practiced on

12.18 million ha. Agriculture contributes substantially to the national income (31.6%) and constitutes 9% of the non-petroleum exports (Anonymous, 2011). Animal wealth is a major contributor to the national income (25-30%) (Abdel Noor et al., 2009). Pastoralists, agro-pastoralists and sedentary animal's owners constitute about 60% of the populace and possess about 90% of the total livestock population (Abdel Noor et al., 2009).

Desert encroachment, drought, land degradation, and overexploitation of natural resources including pastures and forests are considered to be major problems in Sudan (Laxen, 2007). These problems are closely related and it would not be realistic to work out a cause and effect relationship. Desertification in Sudan is not a new phenomenon and has been known since time immemorial. However, recently it has been exacerbated by drought, population pressure and associated overgrazing, over-exploitation of natural vegetation for domestic use and wrong agricultural practices which aim at increasing production through horizontal expansion of the cultivated area with complete negligence of the balance between management of natural resources and agricultural development (Laxen, 2007). As a result of these malpractices it was claimed that desertification, in the last decade (2000-2011), proceeded at a rapid rate ($0.504 \text{ ha min}^{-1}$) and that 5.04 million ha of arable land have been lost to the desert (Mrgani, 2014)

2.4.2 Mesquite introduction and distribution in Sudan

Mesquite (*P. juliflora*) was introduced into Sudan from Egypt and South Africa in 1917 and established in a limited area in Shabbat arboretum in Khartoum North (Broun and Massy, 1929, Babiker, 2006). In 1918 it was planted in a plot near where is to-day stands Khartoum airport (Babiker, 2006). In 1937 the plant was introduced into the Grease area in the then White Nile province as a trial for evaluation of efficacy as a shelterbelt for

curtailment of sand encroachment. A mesquite plantation was established at Elshagera, Kilo5, in 1938 and subsequently mesquite was planted on eroded slopes near Sonar, Elfoung, Elgalabat and on sandy soils with high salt contents near Port Sudan with good results (Abdel Bari, 1986). However, plantations at Fawwar, in the Gezira scheme, and on the sandy soils in Cordovan and Darfur were not successful. Mesquite was planted in Taker in 1945, Kassala in 1947, Elghaba in 1958. In 1962-1964 mesquite was further planted in the greenbelt on the suburbs of Khartoum. In 1966 mesquite was introduced into New Halfa to fence the experimental farm. As a result of these experimental plantations *P. juliflora* was proclaimed a hope of afforestation in the arid areas of the Sudan (Abdel Bari, 1986).

The drought which struck the Sudano-Sahelian countries in the 1960s to the early 1970s together with associated desert encroachment rejuvenated interest in mesquite and provided the impetus for further introductions of the plant to protect residential and cultivated areas (Babiker, 2006). In Sudan dry zones variations of rainfall (50-250 mm/annum), high evaporation, associated with high temperature and high wind, increasing animal population, shortage of fodder and firewood, desert encroachment (5 kilometer yr⁻¹) and land degradation together with the associated decrease in productivity provided the impetus for further introductions of mesquite (Laxen, 2007). Mesquite was introduced into the then River Nile province as shelterbelts to protect the agricultural schemes at Kelly, Gandato and Elzeidab by the Sudanese Council of Churches. In 1980 the plant was re-introduced through the Finland

forest programmer and was planted in central (Tendelti) and northern Sudan (Lati basin) (Musnad, 1971). In 1986 the plant was introduced and distributed in several locations into the then Kassala province.

In the 1980s the International Research Centre of Canada (IDRC) and the Faculty of Veterinary Sciences University of Khartoum evaluated about 30 mesquite ecotypes for fodder production in Northern Cordovan in the premises of El-Obeid. Under the same project several species of mesquite including *P. valutina*, *P. chilensis*, and *P. glandulosa* var. *torreyana* were evaluated at El Obeid and further west for establishment, fuel wood and fodder production (Abdel Bari, 1986). Furthermore, mesquite was planted at two sites (Hamarat el-wiz and el Bashri oasis) in a zone where rainfall was 200-320 mm/annum (Elsiddig, 2004). A report made by Abdel Bari in 1986 indicated that mesquite had established satellite foci along the highway from Port Sudan to Khartoum and by 2007 mesquite has spread and established itself in most of the Sudanese States (Laxen, 2007).

The identity of the mesquite species introduced into Sudan, as in elsewhere, has been a source of controversy. The species when introduced was claimed to be *P. juliflora* (Broun and Massy, 1929, Jackson, 1960). However, it was later identified as *P. Chilensis* (Molino) Stuntz (Wunder, 1966). The latter identity was confirmed by Abdel Bari, 1986), but refuted by ElFadl (1997), and Mohamed (2001) who ascertained the species as *P. juliflora*. The considerable taxonomic confusion, often encountered in mesquite, may be due to the renowned genetic and phenotypic variations and hybridization within and between species (Babiker, 2006; Hamza, 2010).

Mesquite was originally appreciated for its plasticity and qualities of survival, sand fixing potential (Plate 2) and not least for the take-off, comprising of fuel wood, charcoal, construction timber and livestock feed, availed to local community. However, the plant has spread into various ecological niches and was recognized as a potential problem late in the 1970s. Mesquite has invaded natural and managed habitats, including

highways, railway lines; floodplains, watercourses, irrigation canals and degraded abandoned land and irrigated areas (Plates 13-18) (Abdel Bari, 1986, Babiker, 2006). Mesquite is a problem within Central, Northern and Eastern Sudan in the sandy soils of Western Sudan, apart from localized foci; no problems of weedy invasions were reported (Elfadl and Luukanen, 2003).

Mesquite tends to establish successfully on clay and alluvial soils which have good water retention (Luukanen et al., 1983). The bulk of mesquite infestation (>90%) is in Eastern Sudan, where livestock keeping and subsistent agriculture, constitute the main sources of income (Babiker, 2006). In most of the infected sites mesquite forms impenetrable thickets that smothered and excludes native vegetation and substantially changes community structure and several indigenous trees were replaced by mesquite (Elsiddig, 1998).

A workshop held on the 26th of November 2007 in the Martyr's hall, Sudan University of Science and Technology, attended by participants and representatives of 7 states, known to be mesquite infested or at risk, and the private sector including contractors engaged in *Prosopis* control, revealed that six States, namely Khartoum, Gezira and the White Nile (central Sudan), River Nile, the Northern State (Northern Sudan), Kassala, and the Red sea States (Eastern Sudan) are infested by *Prosopis*, while 2 States (Gadarief and Sennar) are at risk (Babiker, 2007). The Red sea State was the most infested, while Khartoum State was the least. Infested areas in thousand hectares were 424.2, 224.8, 22.433, 12.036 and 4.569 in Red sea State, Kassala State, White Nile State, the Gezira State and Khartoum State, respectively. The infested areas in Gadarief, Sennar and the Northern States were not reported. It deserves mentioning that the weed was first introduced

into Khartoum in 1917, Kassala in 1947, the Red sea in 1938, Northern state in 1977, the White Nile in 1937, and the Gezira in 1937. In the Gadarief, renowned for rainfed agriculture, mesquite was planted around the refugee's camps in the 1970s to provide shade, shelter and animal feed. In Sennar State, a part from the early introductions made in the 1930s, no data on more recent introductions were available. The discussions revealed localized infestations in Sennar and Gadarief and numerous scattered foci in Darfur and Kordofan (Western Sudan) States. Legislations invoking eradication of the weed were made in some of the States. The main methods of control are hand cutting, using hand tools, and mechanical and manual uprooting. Both methods are costly and very slow and regeneration from seeds or through coppicing was the norm (Plates 19-20). A simple hand equipment for uprooting mesquite was displayed. Chemical control, employing 2,4-D in diesel, to cut stumps, was reported in limited areas. Research on biological control was limited. Some observations were made on efficacy of the bruchid *Algarobius prosopis*, which was involuntary, introduced with the weed seeds

wood and charcoal making. The biomass resulting from mechanical removal of the weed is usually burned. The workshop was informed that land abandonment, failure to replace mesquite or use the land after hand pulling, encourages re-infestation and that mesquite spread and distribution is linked with heavy animal stocking, water courses, irrigation canals and the water table. The banks of the Atbara River, in eastern Sudan, the White Nile, south of Khartoum and north of El Dawium, and the Nile, in the Northern state, are infested to different levels. A part from New Halfa scheme, where a rigorous follow up and strict regulations comprising livestock movement and early detection and quick response are in vogue, most of the *Prosopis* cleared

areas were re-invaded. The re-invasion was attributed to improper planning of the control campaign, improper use of the cleared land and lack of follow up (Babiker, 2006). The role of the seed bank, in regeneration, is yet to be ascertained. Ahmed (2009) in his studies on effects of soil burial on mesquite emergence and establishment reported no seedling emergence from seed buried at or below 2 cm soil depth in eastern Sudan, where mesquite infestation is the highest, the plant showed low spreading rate in 1962-1978. An increase in rate of spread was observed in the 1980s and the plant was recognized as a plausible serious weed (ElHour, 1986). In 1987-1992 the rate of spread was substantial (389.5 ha per annum). A further increase in rate of spread (483.2 ha per annum) was reported in the period 1992-1996 (Elsiddig et al., 1998). An investigation undertaken at Tokar Delta on socio-economic impact of mesquite on local communities showed clearly that invasion by mesquite decreased the cultivated area, increased crop production cost and food prices, decreased job opportunities, led to migration of productive people and concomitantly led to the decline of the social well-being of local communities. Furthermore, a drop in the water table from 10 m to 14 m was reported (SidAhmed, 2005).

In Eastern Sudan the plant is spreading very fast (> 1 ha /day) accordingly cheap, versatile and effective methods of control have to be developed. Research undertaken at the Gezira Research Station showed that glyphosate and 2,4-D applied to 1-4 months seedlings resulted in initial growth suppression, however complete recovery of the seedlings occurred (Ahmed, 2009). Clopyr, triclopyr and their tank mixtures applied to cut stumps, and as basal or foliar treatments effected excellent and lasting suppression of the plant. Furthermore treatments made in June-September were more effective than those made in January to May and that triclopyr performance was less

affected by timing of application (Ahmed, 2009). A collaborative research on chemical control undertaken in Khartoum, Gezira, River Nile and In eastern Sudan, where mesquite infestation is the highest, the plant showed low spreading rate in 1962-1978. An increase in rate of spread was observed in the 1980s and the plant was recognized as a plausible serious weed (ElHour, 1986). In 1987-1992 the rate of spread was substantial (389.5 ha per annum). A further increase in rate of spread (483.2 ha per annum) was reported in the period 1992-1996 (Elsiddig et al., 1998). An investigation undertaken at Tokar Delta on socio-economic impact of mesquite on local communities showed clearly that invasion by mesquite decreased the cultivated area, increased crop production cost and food prices, decreased job opportunities, led to migration of productive people and concomitantly led to the decline of the social well-being of local communities. Furthermore, a drop in the water table from 10 m to 14 m was reported (SidAhmed, 2005).

2.4.3 Prevention and control:

2.4.3.1 Cultural control:

High value, such as for agriculture or where labour is relatively cheap.

Hand clearing can also be used in conjunction with some mechanical or chemical methods, such as chemical stump treatment (khan,1961).

Grubbing was is more cost effective in lighter infestations.

Fire, probably one of the original management tools used in American grassland, has undergone limited assessment for controlling *prosopis*.

Young seedlings are sensitive to fire but older trees become hand clearance is the first but method used to deal with *prosopis* as awed. Work teams are sent into invaded pasture to fell the trees and uproot all stumps. Although very effective, fire can be used successfully as management tool for

preventing the re-establishment of young *prosopis* seedling while also improving forage production. Fire has been used in conjunction with other methods in the development of integrated eradication programmes.

Studies on succession suggest the possibility of ecological control, by leaving succession to take its natural course. The invasion of *prosopis* species into rangeland has been observed and studied for over a century in the USA (e.g. Archer, 1995), and for long periods in South America (e.g. D'Antoni and Solbrig, 1977) and India (e.g. Chinnamani, 1998).

2.4.3.2 Mechanical control:

Mechanical site clearance involves tractor operations developed for removing trees in which the roots are severed below ground level to ensure tree kill. These operations include root plunging and chipping which are often the most effective mechanical means, using moldboard plough pulled behind a caterpillar tractor or a heavy chain pulled between tow machines. For root ploughing, large trees must first be felled by hand, but this treatment has been used to remove stumps up to 50 cm in diameter without difficulty and has a treatment life of 20 years or more (Jacoby and Ansley, 1991). Other advantages are that only a single pass is required, and whole site cultivation is effected leading to improved soil water conservation, and there is a chance to reseed with improved forage species. However, this method is one of the most expensive control treatments and is recommended only on deep soils that have a high potential for subsequent increased forage production (Jacoby and Ansley, 1991).

2.4.3.3 Chemical control

Chemical treatments involve the use of herbicide to kill trees, with the most effective being stem or aerial applications of systemic herbicides. Effectiveness is dependent upon chemical uptake, which in *prosopis* is

limited by the thick bark, woody stems and small leaves with a protective waxy outer layer difficult. Many herbicides and herbicide mixtures have been tested, mostly on *P.glandulosa* until the banning of its use in the 1980s, 2,4,5-T was the herbicide of choice in the USA (Jacoby and Ansley, 1991). And Australia (Csurhes, 1996). Although 2,4-D provided excellent suppression of top growth, few trees were actually killed and such chemical treatments had to be applied periodically to ensure that forage yields were maintained. Infested sites often needed spraying every 5-7 years. The most effective chemical for high tree kill in the USA is clopralid, but dicamba, picloram and triclopyr have also been successfully used, either alone or in combination (Jacoby and Ansley, 1991). In India, ammonium sulfamate was successful in killing *P.juliflora* trees and as a stump treatment (Paschal and Shetty, 1977).

2.4.3.4 Biological control:

Several biological control programmes using species of seed-feeding bruchid beetles have been developed and implemented. The advantages with bruchids is their observed host specificity, with many species found to feed only on *prosopis*, and some only on a single species. Other insect species known to have deleterious effect on native and exotic *prosopis* in the Americas, mainly twig girdlers and psyllids, have also been suggested as possible biological control agents. The same two bruchid species were also introduced to Ascension Island in an attempt to control *p.juliflora* which is present on 80% of the island, often in dense thickets. Two other species, one a psyllid and the other an amirid, were identified as attacking *P.juliflora* on Ascension Island and were thought to have been introduced accidentally from the Caribbean. The mite *Rhizocloa sp.* causes widespread damage and is thought to lead to substantial mortality of trees (Fowler, 1998). In

Australia, prosopis infestation are at a relatively early stage and extreme care is being employed in the selection of suitable biological control agents, following the long history of problems caused there by plant and animal introduction. Insect species continue to be tested for their efficacy and host specificity as possible biological control agents of prosopis species in Australia (e.g. Van klinken, 1999,.van klinken et al.,2009).

Prosopis species continue to spread widely imparts of their native ranges where many insect species including brushed, psyllid and other injurious pests are common components of the ecology. These regularly attack prosopis but the trees have adapted to infestation by these pests and are still able to become invasive weeds over large tracts of land.

2.4.4 Integrated control:

Fire has been used in conjunction with other methods in the development of integrated eradication programmers. For example spraying with herbicides produces dead wood that will ignite and support a sustained fire with more likelihood of killing the remaining trees. Control could also include the use of animals, other than insect ,to eat and kill prosopis seed. The factor common to most prosopis invasions is over –grazing with spreads prosopis seed widely. Prospis seed found in cattle faeces have much improved germination compared with undigested seed(peinetti et al., 1993;Danthu et., 1996). In contrast, the percentage of p.juliflora seed excreted after ingestion by sheep and goats was much lower (10-15) (Harding, 1991; Danthu et al., 1996). Marked difference were noted in the germination of seed following passage through different animals (Moony et al., 1977); germination was 82% with horses, 69% with cattle, but only 25% with sheep .p.flexuosa seed were killed completely followed ingestion by pigs (peinetti et al., 1993). Replacing free-ranging cattle with other livestock, particular sheep and pigs,

possibly in conjunction with other control method, Could drastically reduce the spread of *prosopis* species weedy invasion of *prosopis* can be successfully. Adapted to agroforestry systems by a conversion process developed by felker et al. (1999) and adapted

This conversion requires three main management interventions: thinning, pruning and treatment of understory .weedy thickets with 100-2500 trees/ha and dense infestation with over 2500 trees/ha. This thinning operation is the most problematic and costly aspect of conversion and limits the uptake of such system. The use of a tractor-mounted flail-mower to cut rows through the stand is the most economical means of initial thinning. The harvested biomass is sold to offset some of the cost of the operation.

2.4.5 Herbicides used in this investigation:

2.4.5.1 Glyphosate:

This herbicide is non selective systemic and post emergence herbicide, the results of the application can be seen in two weeks of application. It is a leaf herbicide that gives effective and long lasting control on many grasses, sedges, broad leaf weeds and woody species in crop land, industrial and non-cropped areas. It can be used on fast growing weeds or those weeds which are actively translocating nutrients into the roots, bulbs, thizomes and stolons. Repeated application will be necessary to maintain long lasting weed control, since it has no pre-emergence activity. It will control annual, biennial and perennial weeds.

24.5.2 2,4-D:

This herbicide is a selective post emergence herbicide used for control of broad leaved weeds in sorghum and wheat crops. It is should be applied as post-emergence treatment 3 weeks after sowing sorghum or wheat.

CHAPTER THREE

MATERIAL and METHODS

3.2. *Prosopis juliflora* SeedS:

P. juliflora pods were collected from mesquite growing within the premises of the College of Agricultural Studies at Shmbat Khartoum North (Lat. 32– and Long --15) Babiker, *et al.* (2013).. Seeds were extracted with a home kitchen blender, cleaned and stored at room temperature till used.

3.2 Herbicides Experiment:

Plastic pots perforated at the bottom and were filled with soil and sand mixture, mechanically scarified seeds of *P. juliflora* were sown on the 19 March in pots (5 seeds/pot). The seedlings were later thinned to 2seedlings/pot, 2 weeks after emergence and were allowed to grow for an additional 6 weeks prior to treat with herbicides. Irrigation water was applied at 10-15 days interval according to temperature and other environmental conditions.

In this experiment, the design used was randomized complete block design (RCBD), with three replications.

Two herbicides glyphosate and 2, 4-D were applied as aqueous as post-emergence treatments with a knapsack sprayer at a volume rate of 100 liters per feddan and a pressure of 4 bars with a flood jet nozzle, as follows:

- (i) glyphosate 41% S.L. at 7.90, 9.20 and 10.60 l /fed.
- (ii) 2, 4-D 600 SL at 2.60, 3.90 and 5.20 L. a.i. /fed.

The seedlings were observed for chlorosis, mortality and regeneration over a period of 2 months.

3.3 Statistical Analysis:

Analysis of variance (ANOVA) was carried out on data obtained using the statistical analysis system (SAS) computer package for SAS Institute Inc., 1990, to detect significant effects among the treatments and populations compared. Mean squares for treatments or populations were calculated. Simple statistics including mean, standard deviation, standard error and coefficient of variation (C. V.%) were also calculated.

CHAPTER FOUR

Results and Discussion

4.1 Effect of herbicides treatments on plant height (cm)

after 4weeks from application:

All herbicides treatments significantly reduced Plant height (cm) as compared to the control. The lowest plant height was achieved by the highest rate of glyphosate followed by highest rate of 2, 4-D (Table 1).

Table 1: Effect of herbicides treatments on plant height (cm)

after 4weeks from application

Treatments	Herbicide rate (l/fed.)	Plant height (cm)
Glyphosate R ₁	7.90	12.50 b
Glyphosate R ₂	9.20	10.60 bc
Glyphosate R ₃	10.60	8.60 c
2, 4-D R ₁	2.60	12.00 b
2, 4-D R ₂	3.90	10.60 bc
2, 4-D R ₃	5.20	9.60 c
Control	-	14.50 a
CV%	-	1.89
SE±	-	5.04

* Means followed by the same letter (s) within each do not differ significantly at 5% level of probability according to DMRT.

4.2 Effect of herbicides treatments on number of leaves/plant after 4weeks from application:

All herbicides treatments significantly reduced number of leaves/plant as compared to the control. The lowest number of leaves/plant was achieved by the highest rate of glyphosate followed by the medium rate of glyphosate and the highest rate of 2, 4-D (Table 2).

Table 2: Effect of herbicides treatments on number of leaves/plant after 4weeks from application

Treatments	Herbicide rate (l/fed.)	Number of leaves/plant
Glyphosate R ₁	7.90	6.00 bc
Glyphosate R ₂	9.20	4.00 c
Glyphosate R ₃	10.60	2.00 d
2, 4-D R ₁	2.60	9.00 b
2, 4-D R ₂	3.90	7.00 bc
2, 4-D R ₃	5.20	5.00 c
Control	-	18.00 a
CV%	-	2.21
SE±	-	3.96

* Means followed by the same letter (s) within each do not differ significantly at 5% level of probability according to DMRT.

4.3 Effect of herbicides treatments on number of leaflets/plant after 4weeks from application:

All herbicides treatments significantly reduced number of leaflets/plant as compared to the control. The lowest number of leaflets/plant was achieved by the highest rate of glyphosate followed by medium rate of glyphosate and the highest rate of 2, 4-D (Table 3).

Table 3: Effect of herbicides treatments on number of leaflets/plant after 4weeks from application

Treatments	Herbicide rate (l/fed.)	Number of leaflets/plant
Glyphosate R ₁	7.90	100.00 b
Glyphosate R ₂	9.20	68.00 c
Glyphosate R ₃	10.60	32.00 d
2, 4-D R ₁	2.60	153.00 b
2, 4-D R ₂	3.90	110.00 b
2, 4-D R ₃	5.20	64.00 c
Control	-	306.00 a
CV%	-	2.83
SE±	-	4.01

* Means followed by the same letter (s) within each do not differ significantly at 5% level of probability according to DMRT.

Within the two herbicides the best mesquite control was achieved with glyphosate at highest rate. Similar result was reported by Jacoby and Ansely, (1991).

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