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:Title

A Review of Soil Seed Bank from Studies conducted in Khartoum and White Nile States Areas-Sudan

مراجعه مخزون التربة من البذور من دراسات سابقة في ولايتي الخرطوم والنيل الابيض –السودان

In

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Dedication

To those who ask Allah to educate me,

To my mother,

To my father,

To all my family and friends.

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My thanks and praise to Almighty Allah who gave me the health and strength to accomplish this work. My deep thanks go to my supervisor prof. Ahmed Mohmed Adam Eldoma, for his continuous help and guidance throughout this research work. Thanks to Dr. Mohammed Ibrahim Abdelsalam, for his valuable help during the course and research work. Thanks to all teachers who taught me during the course, and thanks to the library staff. Also my thanks extend to my Dear uncle Ismail Ahmed Gedo who support me, and to my class mate Badawi Ibrahim Elsafi, and loyal friend Hussien Mohammed Adam, and to Bahar Eldeen Abaker Dindi.

English Abstract

The objective of this work was to make a comprehensive review about the soil seed bank studies and researches carried out in the Sudan. It is meant to avail all information about the soil seed bank that can be gathered in one place so that researchers and students can benefit from such a compendium for their future studies and research on the soil seed bank.

The review examined all publications related to the subject and made all necessary comparisons between the various research papers and studies undertaken and captured in the country. Generally, the procedure used was sampling. Soil samples were taken from different depths and the number of seeds were counted, and their type was identified. In all studies it was found that live seeds were found in the upper soil horizons and number decreases towards the lower horizons. The studies almost covered all types of plant in these areas that include mainly grasses, herbs, shrubs and trees. The studies recommended more studies and research in soil seed bank and it must be linked to climate change. New approaches must be introduced and up-to-date equipment and devices should be used to improve the accuracy of results from analysis.

However, because of limitation of logistic and time the review limits all critical examination of information in Khartoum and White Nile States. The review in Khartoum state covered some forest reserves and arable lands in addition to range enclosures. The most important locations covered were the Mogran forest, Al mata, Abu Zaid, Alsalama, and Alhowida reserves in the Eastern Nile area. In the White Nile the work covered the area of El Gaitaina.

Arabic Abstract

الهدف من هذا العمل هو إجراء مراجعة شاملة للدراسات والبحوث الخاصة ببنك بذور التربة التي أجريت في منطقتين في السودان. الغرض الاساسي هو الاستفادة من جميع المعلومات المستخلصة من هذه الدراسات حول بنك بذور التربة التي يمكن جمعها في مكان واحد لإعانة الباحثين والطلاب في دراساتهم وأبحاثهم المستقبلية حول بنك بذور التربة.

فحصت المراجعة المنشورات المتعلقة بالموضوع وأجريت جميع المقارنات اللازمة بين الأوراق البحثية والدراسات المختلفة التي تم إجراؤها في منطقتي الدراسة. بشكل عام، كان الإجراء المستخدم هو أخذ العينات العشوائية. تم أخذ عينات من التربة من أعماق مختلفة وتم تحديد عدد البذور ونوعها. في جميع الدراسات وجد أن البذور الحية وجدت في آفاق التربة العليا وأن عددها يتناقص باتجاه الآفاق السفلية. غطت الدراسات تقريبًا جميع أنواع النباتات في هذه المناطق والتي تشمل بشكل رئيسي الأعشاب والحوليات والشجيرات والأشجار. وأوصت الدراسات بإجراء مزيد من الدراسات والبحوث في بنك بذور التربة وربطها بتغير المناخ. يجب إدخال أساليب جديدة واستخدام المعدات والأجهزة الحديثة لتحسين دقة النتائج من التحليل.

وبسبب محدودية اللوجستيات والوقت، فإن المراجعة اقتصرت على إجراء الدراسة في ولايتي الخرطوم والنيل الأبيض. غطت المراجعة في ولاية الخرطوم بعض المحميات الحراجية والأراضي الصالحة للزراعة بالإضافة إلى محميات المراعي. وكانت أهم المواقع التي تم تغطيتها هي محمية غابة المقرن، والمتمة، وأبو زيد، والسلمة، والهويدا في منطقة شرق النيل. كما غطى العمل في النيل الأبيض منطقة القطينة.

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Chapter One

Introduction

Sudan is a country well known of its wealth and endowment of a variety of natural resources. Rangelands of Sudan were reputed as one the vast and richest in Africa. Generally, Sudan's economy depends largely on its agricultural and animal production. The Country also exhibits a wide range of variation in its topography, climate, soil and hydrology. These variables characteristics are reflected in diversified ecological habitats and vegetation zones. (IFAD, 2006).

Rangelands of Sudan is primarily covered by natural vegetation, provide grazing and forage for livestock and wildlife, land for farming, water for sustainable landscapes, habitat for plants, insects and animals, area for recreational activities, and potential renewable energy. They are described as lands on which the indigenous vegetation in predominately grasses, grass-like plants, forbs, and possibly shrubs or dispersed tree. In addition, Sudan rangelands provide a diversity of ecosystems and provide a diverse and significant production of economic benefits and ecosystem goods and services including animal production as the main activity practiced by pastoralists and farmers alike. The importance of this mini review stems from the fact that it will summarize all information hitherto gathered from studies and research work carried out from some areas of the country in an attempt to collect as much as possible of the fragmented results from studies and research output so far obtained and make it available for application and further investigation and research work.

To best of the knowledge of this review, the intensity of work done is quite substantial. However, it is utterly fragmented. Consequently, making a compendium that avail as much information as possible on soil seed bank issues will help

planners and resource managers to draw effective plans based on good strategies and programs for sustainable management of this valuable natural resources of the country on which the economy may flourish and contribute significantly to rural development and poverty elevation

Literature on the soil seed bank in the Sudan show a multitude of issue related to the topic under investigation. Rangelands of the Sudan were studied since the colonial area in the form of reports by the authorities of the ministry of agriculture. In addition a lot of research have been carried out by none government organizations, and national or international corporations in the Sudan. The most prominent of which is the Western Savannah Development Corporation and Gebel Mara Development Project in western Sudan.

Rangelands of the Sudan have also been considered in context of natural resources management. However, because the soil seed bank is fundamental to the existence and sustainability of range and pastures it had been given the utmost attention and priority in the majority of research and studies reviewed in this work.

The main objective of the study is to review the status of soil seed bank and the causes of soil seed bank depletion in two areas of the country. However, the specific objectives of this review were if possible, to collective all relevant information available on soil seed bank from studies and research work hitherto carried out in some parts of the Sudan and make critical comparisons between them. In addition the review will attempt to summarize the main findings of the researches and studies and the recommendations set forth to make it available for further research and studies in the future. The review will also seek to assess the intensity of research work and studies done on the area of soil seed bank in the country compared to other countries and identify the gaps in the coverage of the various aspects of the soil seed bank.

Despite the fact that the review is originally intended to cover all the country however, because of the limited time and lack of resources the review was limited to the two areas mentioned above.

Official reports from government authorities especially from the department of range and pasture, the ministry of Agriculture were consulted and the practical application techniques in the field of soil seed bank considered.

Chapter Two

Historical background of the soil seed bank in Sudan

The importance of the soil seed bank studies stems from the fact that it is a key element in successful natural regeneration of rangeland plants including trees and shrubs consumed by all types of animal. Plants vary in the seed viability and germination capacity and their likely longevity inside the soil. Seeds of some plant species can stay a life buried down the soil layers for years and can germinate and grow form the natural regeneration when conditions become conducive.

The soil seed bank is defined as the natural storage of seeds in the leaf litter, on the soil surface, or in the deep soil horizons of many ecosystems, which service as a repository for the production of subsequent regeneration plants to enable their survival. Soil seed bank is the storage of seeds from a single species or from all the species in a particular area. Given, the variety of stresses that ecosystems experience such as cold, wild fire, drought, and disturbances, the soil seed bank is often a crucial survival mechanism for many plant species and can maintain the long-term stability of ecosystems.

Among seeds requiring low temperature after ripening an increasing number were found to possess seed coats, which are impermeable to water. After ripening in dry storage some seeds, which fail to germinate, are dormant only in the sense that they require certain specific conditions for sprouting. Seeds of a surprising number of plants are dormant when they are freshly harvested, the dormancy being measured by their requirement of such special conditions and vary according to plant species the type of plant and dormancy is more frequent in some families than in others. Many conifers and rosaceous plants have seeds with a low-temperature after-ripening.

The environment under which a plant grows affects both the quality and quantity of seeds that will be produced. (Scholar.google.com-link.springer.com)

Soil seed bank in rangelands and their role in their sustainability has been the subject of much recent debate. The vegetative spread of plant species and the determining of seedlings from the soil seed bank, are important in determining the species composition of plant community, Dormancy may be induced in non-dormant seeds, or seeds, which have been subjected to an optimal dormancy-breaking treatment, by holding them in an imbibed condition under an environmental regime unfavorable for germination (Peco et al .1998).

The resilience of plant species to grazing is dependent upon environmental factors, animal's behavior and the soil seed bank. The potential for restoring species–rich rangelands and maintaining floristic diversity are the major factors that have motivated researchers to compare the composition of the surface vegetation with seed reserves in the soil, (wilems, 1983; Mc Donald et al. 1996).

Grazing reduces the seed production of perennial species due to the reduction of photosynthetic tissue and the removal of flowers and seed stalks, (Sternberg et al. 2003; Bakoglu et al. 2009). Grazed species generally have less seed production ability because grazing encourages vegetation reproduction over sexual reproduction, (Sternberg et al. 2003). Seed produced by grazed plants have a short-term persistence in the soil, (Champness and Morris, 1948; Peco et al.1998; Sternberg et al, 2003). Annual species are more persistent to extreme climatic conditions and grazing than perennial species, (Erkovan, 2000), because they produce and scatter a high amount of seed under favorable years and the seeds live in the soil for several years. The effect of grazing on seed production change depending on the system and the place of grazing (Hopkins et al. 2003)

Study of changes in the species composition and density of the viable seeds in the soil seed bank (SSB) following deforestation and subsequent cultivation of a tropical dry Afromontane forest were assessed in the southern highlands of Ethiopia. 66 plant species (54 identified and 12 unidentified) after germination. Herbs dominated species representing nearly 78% of the identified species. Composition and density of the SSB varied significantly between sites and the soil depth. However, there was a general tendency of disappearance of native woody species from the SSB with increasing period of soil cultivation as evidenced by the declining contribution of woody species to the soil SSB (Mulugeta and Teketay, 2006).

Study in soil seed bank evaluation and seedling establishment along a degradation in a semi – arid rangeland on the size and species composition of the seed bank and seedling over two years period (2000 – 2001 and 2001 – 2002) growing seasons) was conducted by Snyman, (2004). Sampling was from rangeland artificially maintained in three different rangeland conditions, good, moderate and poor. Rangeland in poor condition was characterized by a significantly higher seed density in seed bank and more seedling establishment than grassland in good condition. A mean seasonal seed bank density of rangeland in good, moderate and poor condition was respectively: 48, 74 and 98 seedlings per m^2 for October, 28, 32 and 40 seedlings m^2 for January, and 58, 172 and 128 seedlings m^2 for April.

The effect of grazing on soil seed bank

Species composition, number of emerging seedlings, species diversity and functional group of the soil seed banks, and the influence of grazing on the similarity between the soil seed banks and aboveground vegetation, the availability of persistent seeds in the soil could drive the transition from a degraded to healthy vegetation. Heavy grazing reduces the number of seed

that can germinate in the seed bank (scholar.google.com) (wily online library).

Studies of soil seed bank carried out in Sudan.

Quite a good number of researches, reports and studies were being published in different publishing sites in the Sudan and abroad. In the following we strived to make a comprehensive review summary to these publications which fragmented in an endeavor to provide in one place all what has been reported about the soil seed bank in some parts of the Sudan. In this regard, Magda, et.al.(2015) conducted a study in an arable land in Khartoum state. The study investigated and analyzed the soil seed bank of cultivated areas and four fallow sites on farmer arable land, Results of the investigation valuable information. Numbers of emergent seedling per one-meter square were counted from the soil borne seed using top soil sample. 60 plant species belonging to 17 families were found in the seed bank, there were considerable differences in number of total germinating seed in each of the 40 trays at greenhouse germination over a 7-month period. The species from which the highest number of germinant were produced were classified into annual, perennial, grasses and broad-leaved herbs. Three sites showed increased number of annual dicots. Density value are highest in site 1 and 2, however, in site 3 the relative abundance showed small deviation from the normal trend.

Furthermore a study in rangeland area in White Nile state was carried out by Elsafori, et al. (2011). Results confirmed that the seed bank density was higher in the upper depths of the soil as compared to the lower ones. The live seed density in the study area which characterized as a semi-arid, ranged between 1015 and 5371 seeds/m^2, while that for the dead seed density ranged between 3215 to 6957 seeds/m^2. The soil seed bank density for both live and dead seed in the study area was in the range 3034 to 8462 seeds/m^2.

In another different area in western Sudan Abdelrahim et al. (2016) studied the seed densities of the soil of Eldebeibat area south Kordofan state. They calculated the average seed densities/m2 of live and dead seeds and percentage of live and dead seed in depth (0- 10 cm). The results showed that the clay site scored the lowest seeds density for both live and dead seeds. They recorded (1460 seeds/m^2) approximating (43%) and (1920 seed/m^2) approximating (57%) respectively.

On the other hand, the sandy site scored the highest seeds density per square meter. Accordingly live seeds represented (57%) amounting to (3320 seeds/m^2) while dead seeds accounted for (7720 seeds/ m^2 approx. (43%) . The Gardud site followed the sandy in seed density live seeds and scored (3540 seeds/m^2) accounting for 54%, compared to dead seeds recorded as (3040 seed/m^2) amounting for 46%.

A similar study was done in the area of Elain Natural Forest Reserve (North kordofan state), (Sulieman, 2008). Unexpectedly In this study area seeds of *Acacia mellifera* were the only detected seeds in the soil bank. Tree seed density ranged from (828) to (1052). Seed/m^2 representing (59.72) to (73.91%) in the top 5 cm soil depth, whereas the highest germinated seeds (trees, shrubs, and herbaceous) were (3540) seed/m^2 of which only 10% were tree seeds. The results of the study showed that tree seed are available up to 10 cm soil depth, and decreasing with increasing in depth, while herbaceous seeds are available up to 20 cm depth.

In another investigation by Abdallah (2008) in ElGtaina locality, White Nile, similar results were obtained. The seed bank density was higher in upper soil depth as compared to the lower levels for both types of soils. It was also found that the seed density decreases with increasing depth. The live seed density ranges from 789-715 seed/m^2 whereas the density of the dead ranges from 12150 seed/m^2 .

A similar trend was as well detected in study in Altadamon locality- South Kordofan state (Abdelsalam et al. 2017). The seed bank density decreased with the increase of soil seed depth and the soil depth had a significant effect on the number of soil seed bank. Mahgoub (2015) linked the issue of soil seed bank to climate change effects and consequently the prevailing environmental conditions. The study focused on Tree soil seed bank and characteristics according to the prevailing environmental conditions in their habitats as a guarantee for the presence and continuity of the parent plants on earth. It showed that successful plants are those, which are adapted to their habitats and encounter even slight changes in their natural homes to arrange their life phases. Adaptations are found in seeds and fruits as well. The seed in the mobile phase of the plant and so it is the most important part of the plant responsible for the distribution and continuity of the plant on earth. Seeds have physical and/or physiological characters that help them to protect itself from being decayed, eaten, or losing viability. Seeds once detached from the parent plant are provided with characters that protect them from external factors harmful to the seed (willan, 1995). Dry seed of desert and semi-desert areas mostly have dehiscent papery thin fruits that are below by wind carrying the seeds and extracted by beating or easy crushing to release the seed, (Mahgoub, 1995 - 2005). The phenomenon of seed dormancy is a direct response to environmental conditions for a seedling to grow but will perish (Harper, 1977). The tree soil seed bank is the future forest through natural regeneration if suitable conditions for seed germination (water, temp, and oxygen) are available in the soil. Seeds of the soil seed bank have a lifetime of seed age that varies between seed of the different species. The tree soil seed bank of seyal (A*cacia tortilis* sub sp-raddiana), were found to have seed age of 2 to 3 years (Mamoun, 2004; Ashria, 2008 and Elmagoul, 2009)

(Ahmed, 2005) carried out a study of forest tree soil seed bank in two different states in central Sudan viz Gizera and Khartoum states. Two dominant *Acacia nilotica* forests were selected. Mattama forest represented Gezira state; located along Blue Nile bank east Elkamlin. Extends from latitudes 15.00N north and langitudes 33.40 east, and tempterature 16-43 ^{0}C rainfall from 75 to 300mm. In Khartoum Mogran forest was selected, located east White Nile bank near the junction of the two Niles, between altitudes 15-80 and 10-45 north, and longitudes 31-36 and 25-34 , temperature 16- 47 ^{0}C, and rainfall 120mm.

The objective of the study was to identify the soil seed bank of *Acacia nilotica* and its potentiality in natural regeneration of sunt forests. The two forests have rich soil seed bank of *Acacia nilotica* in both depths (0- 5, 5- 15 cm). The results also revealed that (0- 5 cm) depths are rich in seeds than the (5- 15 cm) depths. It is expected to have most of the soil seed bank in the top 5 cm, but it's also interesting to know that quite a lot of seeds are buried deep in the soil, because seed longevity increase with depth of burial, (Mamoun, 2004).

The results showed that the soil seed bank is rich in the two forests and in all forest types, Mattama forest have bigger seed bank. Geref soil in the two forests is richer in seeds than Mayaa and Kerib soil. Results also revealed that (0-5cm) depths are far rich in seeds than the (5-15cm) depths. It is expected to have most of the soil seed bank in the top 5cm. Analysis of the collected data from the study showed that germination percentage of seeds that were collected from Mattama forest was higher than those collected from Mogran forest.

Elsafori and Mona (2014) assessed the soil seed bank in a semi-arid area in The White state in Central Sudan. The study was conducted at Getaina locality. It lies between latitudes 13:30 north, and longitudes 32:33 east The objective of the study was to investigate the soil seed bank under different conditions and practices in the study area. The soil seed bank was analyzed for

the number of live and dead seeds at three depths in two types of soils within the study area. The results indicated high significant differences in plant species number within different depths, generally, the upper depths with high plant species than lower depths. Also from the results, the vertical distribution and soil seed density were higher in upper layers and that both vertical distribution and soil seed density decreases with increasing depths

Wad Omer agricultural schemes are known for its good rangelands. Variation of soil seed bank in natural rangeland of Wad Omer that lies in Omdurman locality on the north part at kilo 48, (khartoum- Dongla highway), in Khartoum state was investigated.The investigation was carried to assess the soil seed bank in the rangelands in the scheme. The study was done at the end of two rainy seasons (2017-2018). The goal was to estimated soil seed bank in the natural rangeland, to use them to develop the proper management plans. The concept of the study was to identify the different types of the soil seed bank in two sites in the Wad Omer area. The results showed that, the soil types had no significant effect on seed density in wad omer area, and soil depths had a significant effect on seed density in the soil. Majority of the seeds in the upper layer of the soil makes them able to grow the next growing season. From the results, the seeds in the rocky soil range site were able to regenerate the rangelands in the subsequent years (Samia, 2019).

Chapter Three

Findings and some successful soil seed bank practices from two areas of the Sudan.

Although the research and studies reviewed here could not cover the whole country but the review selected two important areas of the country relatively rich in range lands and pasture .

The reason for the selection of these two areas is solely because of the availability of material as both areas where near the capital of Sudan and consequently a lot of studies and researches were undertaken due to its proximity and easy access and services. The two areas were Khartoum and the White Niles states.

The reviewed literature in this study gave some insides to multitude of work done in soil seed bank in the Sudan. It reflected the variation in intensity of research works and its variation according to the different ecosystems and ecological zonation of Sudan. The studies undertaken covered range land , forested areas and agricultural fields as well.

One of the basic findings is the presence of variation in seed soil banks stocks in the soil depths. Normally seeds were found in the upper soil horizons as compared to low horizons or layers. The actual trend in both sandy and clay soils. Tree seeds seem to be somewhat different from the normal herbs annuals and perennial plant species that constitute the majority of range lands of the country. This may be attributed to nature of trees which produce fruits that contain relatively bigger seeds as compared to seeds of most plants other than trees. Almost all plants of the family geraminae bear very tiny and small seeds as compared to the trees belonging to the family leguminaeace like *Acacia tortilis, Acacia ehrenbergina* and *Acacia mellifera* in addition to trees producing big fruits like *Balanites aegyptiaca, Meaura crassifolia,* and *Ziziphus spina Christi.* Trees were

considered as important as fodder for livestock during the dry season in most of arid and semi-arid areas of the Sudan.

Khartoum State Range and pasture.

Several studies described the natural vegetation cover of Khartoum State with special emphasis on range and pasture. Khartoum state is located in the semi-desert region of the Sudan. According to Harrison and Jackson (1958) there are three dominant plant population groups in the state.

The first group is the *Acacia tortilis* and *Meaura crassifolia*. Group which is considered the dominant trees or shrubs. In addition to short grasses which cover more than 90% of Khartoum state area. *Acacia tortilis, Meaura crassifolia*, and *Acacia ehrenbergiana* in the tree cover and variety group of grass and annuals herbs dominate more than 75% among total vegetation cover of the state. The second group is the herbs and grass on sand semi-desert areas. The third group composed of herbs and grass on clay semi-desert areas. One of the most extensively studied areas in Khartoum State is the Mogran forest. It is Located west of Khartoum city at the eastern side of the White Nile. It was considered a forest natural reserved and was registered as a natural reserve forest by the Forestry department since year 1939. The dominant species is *Acacia nilotica* in addition to grasses and herbs of many plant species.

The Mogran soils were classified as clay sand soil in addition there are river soils, rocks, and sand dune. (Bannaga 2013).

The plant species including trees that form the source of fodder and pastures in Khartoum State include *Acacia nilotica* in the islands and rivers banks, *Acacia seyal* near the Nile bank, and *Feldherbia albida, Ziziphus spina-christi, Balanites aegyptiaca*, and Tamarix spp, inside the islands, *Acacia tortilis* and *Capparis decidua***.** However, in the Eastern Nile area there are many kinds of trees and shrubs like *Acacia tortilis, Acacia tortilis spp-raddiana, Acacia ehrenbergiana, Ziziphus spina-*

christi, Balanites aegyptiaca, Maeura crassifolia, Acacia seyal, Capparis decidua, Calatropis procera, and grass and herbs as *Panicum teurgidum, Cymbopogen proximus, Cassia sanna, Solanum dobium, Aristida mutabilis, Schoenfeldia gtacilis, Tribulis terrestris,* and *Euphorbia aegyptiaca .*

The pasture and fodder plants found in Western Nile area include trees and shrubs like *Acacia mellifera, Acacia tortilis, Balanites aegyptiaca, Ziziphus spina-christi, Acacia nilotica, Acacia ehrenbergiana, Acacia tortilis spp, commiphora africacna, Maeura crassifolia, Salvadora persica*; grasses and shrubs like *panicum turgidum, Aristida pallidae, Cymbopogon proximus, Aristida mutabilis, Dactyloctenium aegyptium, Echinocloa colona, Cenchrus biflorus, Solanum dobium, Ocimum americanum, Tribulis terrestis, Ipomoea spp, Cyperus spp, colosyathus vulgaris, Dicanthium anulatum .* (Ministry of Agriclture Range Department 2012).The most important ongoing activities on range and pasture in Khartoum area include range improvement, rehabilitation and protection. Consequently a lot of studies and research work were being carried out. Soil seed bank studies were the most conspicuous. (Ahmed 2005)

Another area in Khartoum State where the range department carried a lot of range assessment and soil seed bank studies were the Abu Zaid, Salama, and Alhowida reserves in the Eastern Nile area. (2019) and (Ministry of Agriclture Range Department 2012).

However, findings recorded (108900) seeds per feddan at both depths (0-5 and 5-15 cm). These results indicated that the soil seed bank of Mogran Forest is very rich. Saeed et. al, (2010) examined the soil seed bank of Abu Zaid forest in the Eastern Nile locality of the Khartoum state. Three sites were studied within the reserve. The results showed no significant difference between the three sites in the soil seed bank stock. However, the plain site recorded the biggest soil seed bank stock compared to

the other two sites. Generally, the percentage of live seed amounts to 28%, while the dead seeds were approximately 78%.

A very important study of the soil seed banks of Arable land in Khartoum state was carried out by Magda, e.t al., (2015). Data were collect from the fallow sites in four cultivated areas. Findings revealed about 60 plant species belonging to 17 families were present in the soil seed bank. Plants species having seeds in the soil bank were numerous. Germinable seeds were identified and classified into annuals, perennials, grasses and broad leaves herbs. Density value were high in site 1 and site two, however, site 3 showed small deviations in relative abundance (Magda, et al 2015).

White Nile Range and Pasture.

The second area from which some examples were considered is the White Nile state. It lies between latitudes 30:15:15 and longitudes 32:33:00, and with an area of 30, 411 km^2 (ElGetaina province Atlas, 2000) The climate it is a typical continental, characterized by warm dry winters and hot rainy summers. The temperatures is 36 ^{O}C and 22 ^{O}C maximum and minimum The average annual rainfall is 105-204 mm. (Halwagy, 1961). The humidity percentage is lowest in April (10%) and highest in august (67%). The north - east or northerly trade winds prevail during winter, whereas, the south or south – east winds prevail during autumn. Topography is traversed by seasonal water courses, which run along the east – west direction towards the White Nile (Elsafori, 2006). Geology, the whole area is underlain by the (African Basement complex) of Precambrian origin (Elsafori, 2006). The area is generally underlain basement complex rocks Whiteman (1971). The main land use system is agriculture. There are many schemes already functioning and some other irrigated on both side of the Nile (ElGetaina province Atlas (2000). During the rainy season the main activity is sorghum cultivation and millet. (Elsafori, 2006).This practice

helps in making additional fodder available for animals during the dry summer and winter seasons.

One of the remarkable research works done in the area is one carried out in Getaina. Abdallah (2008) investigated the soil seed bank in the area and findings of the study revealed some very important data that can help in the range management, protection and development. It showed that the plant species that dominate the Getaina rangelands were mainly grass species with few acacia species. Analysis of the obtained data showed that the soil seed bank density was higher in upper soil depths as compared to the lower levels for both types of soils viz. clay and sand. It was also found that the seed density decrease with increasing depth. The live seed density ranges from 789-7150 seeds/m^2, whereas, the density of the dead seeds ranges from 2410-12150 seeds/m^2 (Mona, 2008).

In another study of soil seed banks of a rangeland Area in the White Nile state is the one executed by Elsafori (2006). Resulted of the data in three soil depths, after analysis the number of live and dead seeds, revealed that the seed bank density was higher in upper soil depths (0 to 5 and 5 to 10 cm) as compared to the lower one (10 to 15 cm). The live seed density ranged from 1015 to 5371 seeds/m^2, whereas, that of the dead seeds ranged from 3215 to 6957 seeds/m^2. The dominant plant species to which the live seeds belonged were grasses *Schoenefeldia gracilis*, including *Dactyloctenium* spp, *Bracgiaria. Aristida* and *aegyptium* were the dominant species to which the dead seeds belonged whereas the species with live seeds were mixed of species of *Panicum turgidum*, *Euphorbia*, and *Cyperus rotundus* (Elsafori, 2006).

An additional example of successful studies in the White Nile area with the objective to identify the type of vegetation dynamics in three types of land use systems and to compare three species composition above ground with soil seed bank of the communities. The results showed that, the stock of seeds for

Acacia tortilis (seyal) was very rich in each of the three zones. Results obtained give encourages the great opportunities for natural regeneration in these area (Fatima, et. al., 2013). One of the very useful works in this regard is review performed by Sayda Mahgoub (2015). The work covered most of the work carried out on Sudan tree seed characteristic and the impact of climate change on tree soil seed bank and tree seed productivity and natural regeneration. The work showed the adverse impacts of accelerated climate change on the soil seed bank and consequently tree productivity and regeneration expressed in the poor seed quality and quantity.

Chapter Four

Conclusions and recommendations

The findings of accumulated research and studies performed so far in the Khartoum and White Nile areas were very encouraging. It furnished a lot of information needed for range lands management, protection and development through the soil seed bank information which carefully analyzed and genuine results that can readily be used for planning and managing the vast range and pasture endowment resource present in the two areas. Perhaps these results and information from the two areas can be used for range improvement and management in other areas in the Sudan with similar environmental conditions. It is also inevitable to link the issue of soil seed bank as an important tool for rangelands development with the issue of climate change as a new trend. It is obvious that climate change effect is a global phenomenon that affect all form of life

The research undertaken focused on the issue of soil seed bank studies and research work hitherto carried out throughout the Sudan. Due the nature of study and time limits in addition the resources available, the study covered only small area of the country. The information so far obtained can be useful for range management practices in various areas of the country because of the similarities of the soils and environmental conditions in arid and semi-arid conditions across the Sudan.

Generally, the review covered all aspects of the soil seed bank including the methods used and design of the trials undertaken. However the most useful information was the depths in which seeds were found in plenty. The clear trend is that the upper soil horizon contain the biggest amount of seeds.

This is one of the basic findings from the majority of the studies is the presence of variation in seed soil banks stocks in the soil depths. Normally seeds were found in the upper soil horizons as compared to low horizons or layers. The is the actual trend in

both sandy and clay soils. Tree seeds seems to be somewhat different from the normal herbs, annuals and perennial plant spices that constitute the majority of range lands of the country.

Soil seed bank studies covered all types of plant species foraged by animals. Some of studies were carried out in forest reserves indicating the important of trees and shrubs in producing food for animal in addition to the grasses and herbs that constitute the majority of natural pasture on which the bulk of livestock in Sudan depend on.

The most important ongoing activities on range and pasture in Khartoum area include range improvement, rehabilitation and protection. Consequently a lot of studies and research work were being carried out. Soil seed bank studies were the most conspicuous. (Ahmed 2005).Forest reserves seem to be very important in providing forage and there were given more attention in soil seed bank studies.

The Abu Zaid, Salama, Alhowida and mogran reserves were good examples in Khartoum area (Minsistry of Agriclture Range Department (2012).

However, in this connection findings showed that the soil seed bank in Mogran forest was substantial. Ahmed (2005) recorded (108900) seeds per feddan at both depths (0-5 and 5-15 cm). These results indicated that the soil seed bank of Mogran Forest is very rich. Ibtisam, et. al, (2010) examined the soil seed bank of Abu Zaid forest in the Eastern Nile locality of the Khartoum state. Three sites were studied within the reserve. The results showed no significant difference between the three sites in the soil seed bank stock. However, the plain site recorded the biggest soil seed bank stock compared to the other two sites. Generally, the percentage of live seed amounts to 28%, while the dead seeds was approximately 78%

In addition studies covered even some arable lands in the area of Khartoum and results were very promising. This fact indicates

that arable land although used for agricultural products like vegetables and cereals but it is still contained a substantial quantities of live and viable seeds in its lower soil horizons. This was very clear from the results of the very important study of the soil seed banks of Arable land in Khartoum state which has been carried out by Magda, e.t al., (2015). In this work data were collect from the fallow sites of four cultivated areas. Findings revealed about 60 plant species belonging to 17 families were present in the soil seed bank. Plants species having seeds in the soil bank were numerous. Germinable seeds were identified and classified into annuals, perennials, grasses and broad leaves herbs. Density value were high in site 1 and site two, however, site 3 showed small deviation in relative abundance(Magda, et al 2015).

Recommendations

Recommendations that can be drawn from this review is basically stemming from the information furnished by the researches and studies carried out all over the Sudan albeit not all covered herein. These recommendations were summarized in the following:

1. The soil seed bank studies should be extended to cover the major rangelands and pasture across the country.
2. Forest reserves soil seed banks seems to be detrimental as the trees and shrubs provide forage during the long dry season for livestock. Consequently soil seed bank studies in these forest reserves must be considered.
3. Soil seed bank studies should be closely linked to climate change to investigate its adverse effects if any to ovoid them and make necessary precaution
4. New approaches must be introduced and up-to-date equipment and devices should be used
5. Because soil seed bank studies were closely linked to viability in storage, germination and dormancy it is recommended that those who are interested in soil seed

bank studies must fully be acquainted with appropriate procedures of these seed technologies.

6. Seed identification needs a good understanding of plant taxonomy and identification, therefore it is strongly recommended to consult dedicated plant taxonomist to get reliable results from the soil samples obtained.

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