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SCHOOL OF GRADUATE STUDIES

WOODY SPECIES DIVERSITY AND SOIL NUTIRENTS IN RELATION TO FIRE INCEDENCE IN SELECTED SITES OF AWASH NATIONAL PARK, EASTERN ETHIOPIA

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Summary

The effect of fire on woody species diversity and soil nutrients was investigated in Awash National Park. Sites with fire history from years 2000, 2002, 2004 and unburned plot were selected within three vegetation types (woodland, grassland and doum palm forest). A total of six sites namely, grassland burned during 2000, grassland burned during 2002, woodland burned during 2002, unburned woodland, palm forest burned during 2004 and unburned palm forest were identified. Three random square plots with size of 20 x 20 m were selected within each site. To collect above ground vegetation data three concentric rings were laid within the 20 x 20 m plot. DBH (Diameter at Breast Height), height, frequency and density of woody species were recorded .To collect soil seed bank five random sampling spots were selected within the 20 x 20 m plot and samples were taken at four depths (0 - 0.5 cm, 2.5 - 3 cm, 5.5 – 6 cm and 8.5 -9 cm) from each spot. For study of soil nutrients soil samples were taken from the 4 corners and middle of the square plot and mixed. To study response of seeds of woody species to heating effect of fire seeds were collected and subjected to temperature levels of 20^0C, 60^0C, 90^0C, 120^0C, 150^0C and 200^0C for 1 minute and 5 minutes duration. Shannon-Wiener index, richness index and similarity index were calculated for the above ground vegetation. ANOVA and independent t-test was used to analyze the data. The result showed less species diversity in the recently burned areas than unburned and old burned areas. Species density was observed to be high for two species (*Acacia senegal and Haphaene thebaica*) following fire. The soil seed bank was poor in density and species richness for woody species. Most of the woody species subjected to heat shock trial were responded positively at temperature levels of 60^0C, 90^0C, and 120^0C. The result from soil nutrient study showed high values for soil pH, available phosphorus, organic matter, exchangeable calcium and sodium at the burned sites than unburned and old burned sites.

Fire appears to contribute to loss in woody species diversity. Even though the heat from the fire can stimulate germination the poor soil seed bank strategy may not allow fire stimulated germinations. Therefore if the fire regime becomes more frequent woody species could be at a risk of local extinction while fire incidence could contribute to the maintenance of the grasslands against woody species invasion. The increase in soil pH and organic matter values can increase nutrient availability following fire which can favor germination and seedling establishment. The release of phosphorus, calcium and other nutrients can contribute to post fire regeneration and forage quality.

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1. INTRODUCTION

Ecosystems are large geographic areas containing similar biological communities and abiotic conditions, such as temperature, rainfall, and seasons. They are tied through flows of energy and often identified by the dominant plant communities found in the region (Kimmins, 1997). The plant species found in these biological regions are a function of many factors, including climate, interactions among species, and disturbance regimes such as fire. Thus different fire regimes interact with various forms of biotic and abiotic components of ecosystems to result in either negative or positive impacts (Whelan, 1995).

Fire has long been part of the natural environment of people. Lightning-started fire has been a common occurrence in many of the ecosystems of the world. People became increasingly adept from the mid-Pleistocene period onwards at using fire to manipulate ecosystems to obtain desired benefits. As a consequence, anthropogenic fire overtook lightning as the leading ignition mechanism for biomass combustion worldwide (George and Mucth, 2001).

Fire is a natural and vital component of most tropical forest ecosystems. In the dry forest types, such as African Savannas, fire was historically present as a frequent, low-intensity disturbance. Natural fire is necessary for the health of some of the dry forests, which have evolved to depend on fires to clean out underbrush and maintain biological diversity (Kimmins, 1997). Fire is an important natural phenomenon that encourages the regrowth and diversity of vegetation in the many forests, deserts, and grasslands that are found in different regions of the earth's continents. Much of the plant and tree life in fire prone regions depend on fire to create a domain mechanism for growth or, in fact, use fire as strategy for germination (DeBano *et.al.*, 1998).

Fire has an irregular incidence. Fire varies in how often it occurs (frequency), when it occurs (season), and how fiercely it burns (intensity). Combinations of these three factors are what largely determine a fire regime (DeBano *et.al.,* 1998)

There are different causes for forest fires. Humans have also been causes for forest fires for thousands of years as they use it for hunting and land clearing. The difference now is the scale of the activity.

Historical evidence indicates that high forests of Ethiopia remain victims of war, conflict and wild fires. Yodit/Gudit (849-897 A.C.) ordered her army and the local people to set fire to forests stretching from Tigray to Gonder and Wello in suspected hiding grounds for the soldiers of Emperor Dilnaad. Similarly, Gragn Mohamed (1527-1542 A.C.) ordered his troops to clear and burn all the forests stretching from the eastern lowlands to the central highlands to make access to battlefields easier and to destroy strategic hiding grounds of the soldiers of Emperor L/Dingil and clergies (Wolde Selassie, 1998). Prior to the forest fires in 2000, the last major outbreak was in 1984 when fires damaged approximately 308,200 ha of forests (George and Mutch, 2001).

Recently Ethiopia had encountered large-scale fire incidence during February, 2000 as a consequence of the delayed onset of the rainy season and increased land use pressure. The montane forests in the southern part of the country led to large-scale wildfires and, by the end of the dry season in April 2000, more than 300,000ha of these forests had been severely affected or destroyed by fire (George and Mutch, 2001). The forest fires that broke out in 2000 are certainly different from previous fires and constituted a serious disaster due to both the scale and type of land they affected.

Moreover, fire incidences are much common in the lowland woodland areas of the country such as in the Somali-Masai biome, Sudan-Guinea and Shael-transtional biome. In these biomes extensive ecosystems such as Combretum-Terminalia and Acacia-Commiphora woodlands are largely susceptible to fire (George and Mutch, 2001). Frequent and intensive fire is observed to affect biodiversity resources in form of timber and non-timber products. In some of these regions like in the western lowlands (e.g. in Gambella) fire regularly occurs, at least once in a year (Minassie Gashaw, 2000).

As stated above, fires in different parts of Ethiopia damage every year large areas of forests. The fires also affect many of the National Priority Forest Areas (NFPAs) and National Parks, designated by the Ethiopian Government as especially important to Ethiopia national economy and environment (George and Mutch, 2001).

Fire can affect wood cover of an area which can bring both economic and ecological losses. Wood cover plays an important role in ecosystem functions like in nutrient cycling (Kellman, 1979; Belsky *et al.*, 1989; Archer, 1995), in soil carbon storage (Belsky *et al.*, 1989; Dunham, 1991; Scholes and Archer, 1997), in seedling establishment (Hoffmann,1996), and the distribution of animals. Therefore changes in woody plant diversity can have widespread effects on woodland ecology.

Species composition of the savanna ecosystems at any given site is responses to available moisture, available soil nutrient, grazing and fire, which mold the diversity, structure, and ecological processes in the systems (Braithwaite, 1995). Many plant species in fire prone environments have important adaptations that allow them to survive, thrive, and even require fire for survival. However, over time the impacts of human generated fire can have major consequences on plant communities which could bring significant impacts on the overall ecosystem functioning (Whelan, 1995). Hence the effect of fire on species diversity and population growth is particularly important, as this will determine how well a species can cope with long-term changes in fire frequency.

The relationship between fire and species diversity will determine whether a species will decline toward extinction or become abundant under a particular fire regime. If each species is sensitive to a given fire incidence, we would expect large shifts in species diversity following fire. Hence it is essential to generate information on how plant species respond to fire stress and to investigate the importance of fire on the ecosystem health, in order to design appropriate wild fire management plan. Although, fire has high occurrences in most of the country's woodlands and grasslands, very little attention has been given to investigate and understand the impacts of fire in such ecosystems. Therefore a study on role of fire in such environments can have significance contribution for overall ecosystem study. Moreover conducting this study in Awash National Park can help the park managers on planning fire management system.

The present work has been undertaken investigate if there is any relationship between woody species diversity and fire incidence and whether there is change in soil nutrients in relation to the fire which may affect productivity of the vegetation of Awash National Park. It is envisaged that the work will contribute towards planning fire management Awash National Park.

2. OBJECTIVE OF THE STUDY

2.1. General Objectives

To study the influence of fire incidence on diversity of woody species and soil nutrients in selected sites of Awash National Park.

2.2 Specific Objectives

To asses species diversity for sites with different fire histories
To study age structure in relation to fire incidence
To study soil seed bank in relation to fire
To asses the effect of heat shock on germination of seeds of woody spices
To investigate the change on basic soil nutrients in relation to fire incidence, and
To determine the extent to which fire can be used as a management tool in the Park

3. LITRATURE REVIEW

3.1. Effect of Fire on Diversity and Structure of Woody Species

According to UNEP (1995) biodiversity is the variability among living organisms from all sources and the ecological systems of which they are apart; this includes diversity within species, between species and of ecosystem. Based on this context biodiversity within an area can be characterized by measures of species diversity, species richness, functional diversity and habitat diversity.

According to Solbrig (1991) fire is major determinant of species diversity together with plant available moisture (PAM), available nutrient (AN) and herbivory. Fire has a significant role on diversity and has been important selective force in evolution of plant form and life history (DeBano *et al.*, 1998).

The initial postfire plant community is primarily composed of surviving individuals. Then new species appear progressively on the micro sites opened by the fire and gradually increase the species diversity and richness. Appearance of new species could be from the seeds in the ground seed bank or from the surrounding areas. Here one worth point is that the regular progressive succession event will be interfered by the fire (Kimmins, 1997). This eliminates dominance as a result of open areas, which favors diversity of species.

According to Cerement (1996) observation done for 15-years revealed high flora diversity in areas with frequent fire than controlled plots in Latin America Savannas (Serrado). Grass species are often favored by occurrence of fire; as it removes dead tissues and stimulates re-sprout. However, occurrence at the early stage of their life may adversely affect them (DeBano *et.al.*, 1998).

Fire is one cause of disturbance in ecosystems. The levels of diversity are likely to be higher in areas that contain burned sections than in long unburned areas (Fox, 1998).

The result from Serengeti National Park of Tanzania on early dry season burning showed greatest effect of fire on mid- sized grass community by allowing regeneration of some woody species (Blesky, 1992). On other study done in Queen Elizabeth National Park of Uganda burning favored practically all the main species in the grassland with the exception of a single species. Most regeneration following burns is vegetative or from a prefire seed pool. It may well be that fire and the resulting ash prepares favorable seed beds to allow better chance for germination. Generally the conclusion of the study was that species composition, seed germination, plants density and productivity are better under late burning regime than early burning and much better than unburned plots (Edroma, 1984).

Increase in diversity following fire is seasonal in some cases. Study done in Gambella Region of Western Ethiopia (Minassie Gashaw, 2000) showed increase in plant species richness following fire. This is could be due to reduced competition, increased available plant nutrients or increased light intensity following fire. However, the tendency to increase in plant species was not seen after 210 days, which might indicate, competition intolerants species are eliminated during the post fire succession when the transient improvement in soil nutrient and light availability diminish and competition for resource get more severe.

Fire also affects diversity by altering habitats. Habitat diversity is recognized as an important component of biodiversity. Fire promotes species diversity by creating habitat diversity (DeBano *et. al.*, 1998). When a given area burned it is common that some patches left unburned for various reasons. This alteration of burned and unburned areas creates mosaic of vegetation and provides a wider niche for biotic communities.

Many authors agree that fire can increase over all plant diversity. But for woody species this doesn't hold true in most cases. Rather woody cover shows higher diversity under absence of fire (Blesky, 1992; Braithwaite, 1996; DeBano *et al.,* 1998). As an example absence of fire can cause a change of state from Savanna to rain forest conversely, fire can erode the edges of rain forest and other habitat types converting them to Savanna (Braithwaite, 1996). Most woody species respond negatively probably due to the loss of their aerial parenting buds, which other wise would have given those plants height advantages when they resume growth after dormancy (Blesky, 1992).

While plant species of fire prone ecosystem are highly dependent on fire on other hand any fire dependent species may lose vigor and can die out by fire. This statement holds true when time of occurrence, intensity and frequency exist in active growth season. According to Moreno and Oechel (1994) fire may increase or reduce plant diversity. Reduction is to be expected if fires are too frequent and do not allow enough time for seedlings to reach sexual maturity or for re-sprouters to recover the lost resources during the canopy build-up high- frequency fires are thus expected to select for species capable of tolerating them and there fore to reduce local species diversity.

3.2. Effect of Fire on Seed Germination

Burning is necessary to maintain species diversity in fire prone ecosystems as fire stimulates regeneration by breaking seed dormancies. Most of the ground seedbed seeds become germinating following fire as it removes shading effect of big canopy trees. As a result new seedlings are abundant following fire (Christensen, 1977). In addition heating effects of the fire stimulates dormant seeds to regenerate; thereby contributing to floral diversity.

Germination of new seedlings highly depends on occurrence of fire in fire prone environments. Fire stimulates germination by removing hard coats of seeds and breaking seed dormancy. The hard coats of seeds of species in fire prone areas could be break down by fire heat (Demel Teketay, 1998). According to Luke and Mcarthur (1977) large masses of germinated seedling are observed following fire as a result of removal of hard seeds coats. In the absence of fire germination rate of such species is significantly reduces. Germination is promoted in legumes because crack induced by dry heat make the strophiole permeable in impermeable seeds and thus may promote the germination of such seeds (Baskin and Baskin, 1993; Hanley and Fenner, 1998). In addition seeds of some plants are enclosed within pods, which provide much more heat resistance than provided by the seed coats alone and fire may be a pre requisite for the release of seeds from such fruits.

Gonzalez-Rabanal and Casal (1995) noted increase in post fire germination; this was attributed to waxy or petic material associated with palisade cells in the seed coat. These waxy materials are impermeable to water but the effects become reduced when seeds are exposed to moist or dry heat. Similarly Martin *et al.* (1975) noted dry heat treatment that is analogous to the heat from forest fire contributes to removal of waxy or petic materials associated with palisade cells, which makes the seeds permeable to water.

Minassie Gashaw (2000) noted significance influence of heat on the frequency of germination of seeds of most of the species in regularly burned areas of western Ethiopia irrespective of their life form. According to this study at temperature levels of 60^0C and 90^0C higher germination rate was observed for most of the species. Hence these plant species in this particular area seem to benefit from light burning in Savannas. But higher temperatures (120, 150 and 200^0c) seem to decrease germination rate. He noted that combination of medium intensities and brief exposure may result in high germination frequency.

3.3. Soil Seed Bank Dynamics

Vegetations have different adaptive traits, which can help in lessening the damage caused by fire hazard. Evolutionary traits such as soil seed banks and canopy seed bank, thick barks, hard seed coat are some among these traits. Soil seed banks as defined by Simpson *et .al.* (1989), are viable seeds present in soils or in association with the litter layers. Seeds buried in the soil are well protected from the direct effect of fire as the soil provides insulation from high surface temperatures during the course of burning (Lock, 1998). Therefore soil seed bank is considered as one of the survival strategies of plants, which reduces mortality of seeds by fire. Fire also affects plant species diversity by affecting the soil seed bank

Gaps formed after fire favor pioneer species to colonize the bare area by allowing sun light. This is entirely depending on soil seed banks, which have crucial role in determining plant composition after disturbances (Whitemore, 1998; Keely and Keely, 1987; Thompson, 1992;

Dalling *et al.*, 1997). Composition of the soil seed bank and its contribution to post fire regeneration depends on capacity of seed dormancy and potential of seed dispersal (Dalling *et al.*, 1997). These two reproductive traits allow pioneers to colonize epiphermal gaps. However many studies conducted in dry tropical ecosystems showed that seed bank strategy is less common. According to these studies sprouting is the common pathway followed by most species of these ecosystems than soil seed bank strategy. (Skoglund, 1992; Demel Teketay, 1997; Morgan, 1998; Minassie Gashaw, 2000). This could be due to seed losses through high mortality risks such as fire, predation and pathogens.

Intense fire may reduce belowground diversity by destroying the majority of seeds in the soil seed bank (Demel Teketay, 1997). Predation is also the major threat to the soil seed banks for dry forest of tropical Africa. Tybrik *et.al* (1994) noted that beetles have been found to destroy large quantity of seeds in soil seed banks (up to 100%) of many African species. These authors observed that there is relatively high number of seeds / m^2 for Australian species where there is no attack by bruchid beetles. Further more germination in response to ephemeral favorable conditions (e.g. rains during the dry season) also contributes for seed loss from the soil seed bank. Skoglund (1992) noted that germination of fresh seeds of wind-dispersed seeds after the first rain, which is usually not adequate for the growth of germinated seedlings, destroys much seed from the seed bank. If seeds are kept dry they remain dormant for several years. Other factors such as human interference and climatic conditions have also an impact on the soil seed bank.

Seed size has its own impact on the composition of soil seed banks. Smaller seeds are relatively abundant in soil seed bank than larger seeds (Thompson 1992; Loony and Gibson, 1995; Minassie Gashaw, 2000). According to Thompson and Grime (1979) most of the seeds, which were represented in the soil seed bank, are those having seed size ranging between 0.5-2 mm in length. The seed banks of low disturbance less succession vegetation types exhibit high species richness better emergent speed and high percentage of annual species (Looney and Gibson, 1995).

According to Dalling *et al.* (1997) not all viable seeds in the soil can be included in germinable seed bank because some species might have seeds that remain innately dormant or unable to respond to environmental conditions to germinate. Wind dispersed seeds with hard seed coats and unscarified animal dispersed seeds may remain in the soil for several years before they can respond to gap formation. Therefore recruitment from the seed banks is restricted to periods with favorable conditions of the soil parameters that may control seed germination (Skoglund, 1992).

Some studies show that there is little or no resemblance between the above ground vegetation and the soil seed bank in the dry forest types (Thompson, 1992; Morgan, 1998). Most of The species, which have been buried seeds in the soil, are gap colonizers and usually not observed in the forests before occurrences of disturbance (Thompson and Grime, 1979; Demel Teketay, 1997).

3.4. Effect of Fire on Soil Nutrients

The stimulation of nutrients like P, K and Mg play an important role for plant species diversity maintenance (Cerement, 1996). Fire indirectly affects species diversity by affecting soil nutrients. The intensity of fire for instance varies enormously from one ecosystem to another or from one vegetation type to another, thus brings about variable fire effects on the soil nutrient dynamics.

The major effect of fire on soil nutrient is countered by ash deposit after the fire (West, 1965; Cass *et al.*, 1984; Frost and Robertson 1987). Much of the nutrient capital stored in the aboveground living and dead plant biomass will be deposited as ash immediately after fire. The ash from most of the burned plant material is rich in basic ions such as calcium, potassium, and magnesium. This often tends to raise the pH of acid soils, especially sandy soils that are poorly buffered. Raison (1971) reported that the change in soil properties induced by ash depends on the properties and amount of the ash, and the nature of the soil. However Christensen (1977) noted ash deposits generally do not increase the alkalinity of alkaline soils since the soil is already rich in the released elements and they tend to leach out rather than to become bound to the soil minerals.

The degree to which pH is shifted and the length of time it remains higher than under pre-fire conditions are a function of the original soil pH, organic matter content, the amount of ash produced (Wells, 1971). Menaut *et al.* (1993) observed an increase in soil pH by 0.5-pH unit for a few weeks after fire as a result of the input of base-rich ashes into soil surfaces. Such low variations in soil pH according to Menaut *et al.* (1993) are unlikely to affect greatly the nutrient status of the soil, but might bring significant effects on micro site or trace gases.

The fate of nitrogen and organic matter are of major interest because of their importance to soil physical properties and nutrient release. DeBano and Conrad (1978) reported the loss of 10 percent of the total nitrogen from plant, litter, and upper soil layer in a prescribed Chaparral burn. In a similar study with Chaparral soils and litter layers alone, DeBano *et al.* (1979) found that about 67 percent of the total nitrogen was lost during intense burns over dry soil, but less than 25 percent was lost when the soil and litter were moist. Despite major losses of nitrogen through volatilization in fires, Christensen and Muller (1975) noted that as a result of the rapid liberalization of litter and associated enrichment of the soil, the available forms of nitrogen are commonly higher on burned than unburned site. In addition nitrogen-fixing bacteria positively respond to fire occurrence. Therefore they are expected to compensate nitrogen loss through volatilization.

Soil properties are strongly influenced by living vegetation and accumulation of organic matter. According to Kimmins (1997), loss of organic matter is one important effect of fire as it speeds up normal process of mineralization. As a result it provides necessary minerals to new germinating seedlings. Kimmins (1987) noted if combustion of organic matter is complete, all the nitrogen content could be lost to the atmosphere. In the study of the effects of burning on nutrient availability, Wells (1971) explained the effects of prescribed burning, which reduces the amounts of organic matter on the surface, but the organic matter content of the upper layers of soil (0 to 5 cm depth) increase by up to 30 percent. Wells (1971) further discussed the principal effect of burning, which is more often redistribution of nutrients, not the reduction of organic matter in the soil profile. Neal *et al.* (1965) remarked that the higher the temperature induced by the burn and the greater the frequency of fire, the greater is the change in organic matter than can be expected.

Phosphorus cycles are also affected by fire. As a result of the incorporation of ash and plant particles in the soil, Menaut *et al.* (1993) noted that the level of both total and extractable P increases few days after fire. Snigh *et al.* (1991) reported an increase in the concentration of P after one year, i.e. and increment of extractable inorganic P by 35% in burnt plots. In the long term, P tends to be higher in burnt plots than in protected ones, without any clear effect of the date of burning. Further, Frost and Robertson (1987) explained that a more rapid cycling of P through the vegetation and soil is promoted by fire than in unburned areas where P is retained or locked for longer in the vegetation. Available forms of phosphorus in soil generally increase following fires. An increase in available soil phosphorus was reported by Wagle and Kitchen (1972) by 32 fold after a prescribed burn in pinus ponderosa stands. Christensen (1977) also found larger increases in available phosphorus in burned chaparral soils.

Fire ash is high in basic ions such as calcium; potassium and magnesium (Braithwaite, 1995) Christensen (1977) compared nutrient content of shoots of the same age after burning and clipping. He found higher concentration of calcium and magnesium in plant tissues from the burned areas than in clipped plants while concentration of potassium is the same. Since cations (Na, K, Ca, Mg, Fe, Mn and Zn) are linked to soil organic matter than to clay mineralogy, they usually follow comparable trends similar to carbon and nitrogen dynamics. DeBano and Conrad (1978) for instance reported that a small decrease in total potassium following fire. Calcium and magnesium are also commonly behaving quiet similarly under fire conditions. There are also various studies, which have reported increases in calcium and magnesium concentration following fire. However, Christensen (1977) and Trabaud (1994) have found no change or an actual decrease in soil concentration of these cations. The decrease, according to DeBano and Conrad (1978) might be attributed to changes in the cation exchange capacity that is commonly decreased by fires as the organic matter content of soil is reduced.

4. METHODOLOGY AND DATA ANALYSIS

4.1. Study Area

4.1.1. Location

The study was conducted Awash National Park. Awash National Park is the oldest national park in Ethiopia. It is one of the two gazetted parks being established in 1969 under the legal order (order NO.54); to be "administered in accordance with all applicable laws and regulations by the department of the Government" for the "preservation of Ethiopia's Wildlife".

The park is located on semiarid land approximately 200km southeast of Addis Ababa. It is about 752 km^2 in area and found along the Addis Ababa _ Djibouti highway between Metahara and Awash-Sebat towns (Figure 1).

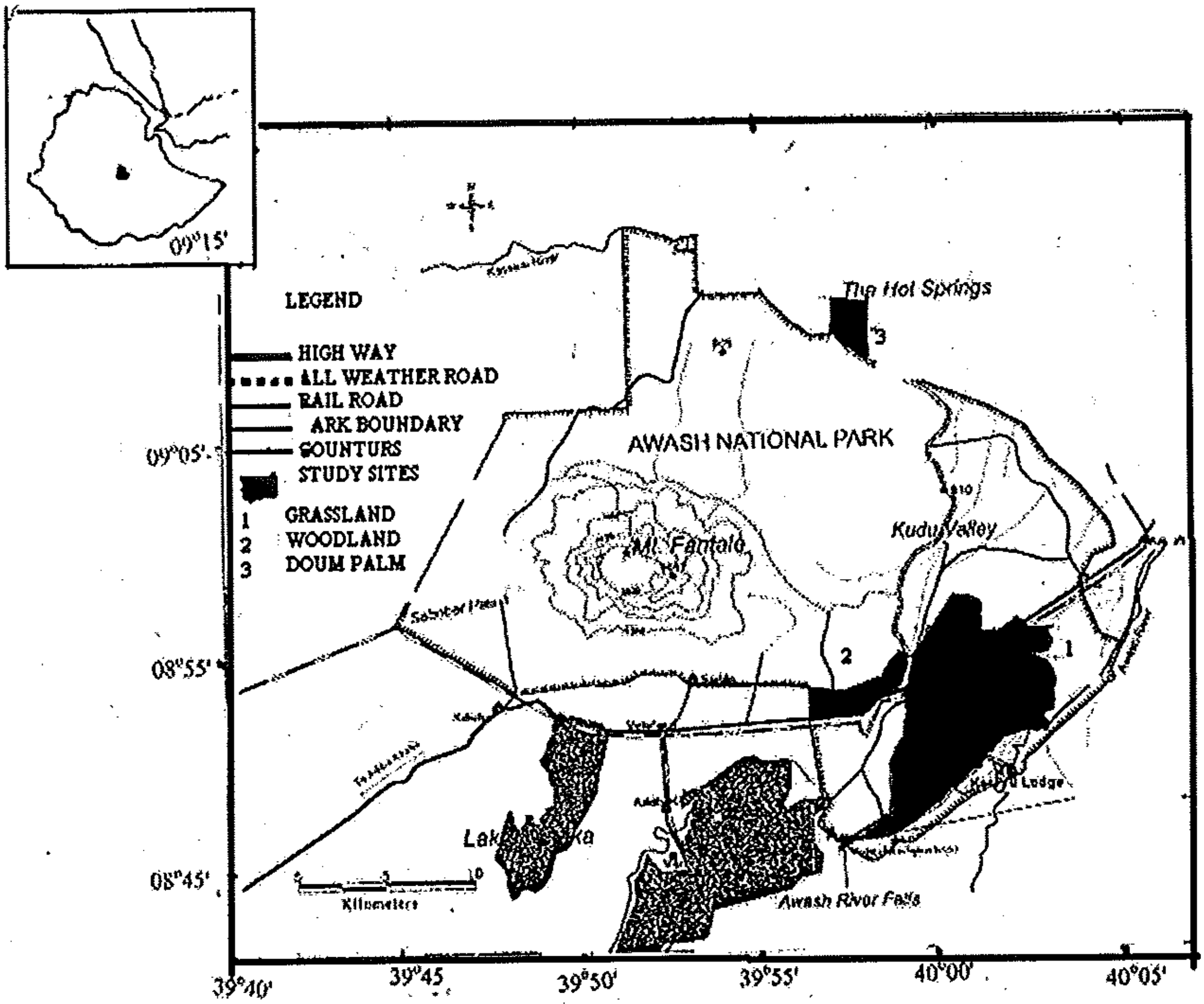


Fig.1-.Map of the study areas

Source: Ministry of Agriculture, Wildlife Conservation Department

4.1.2. Soils

According to FAO (1965) the soil of the park area was classified into three namely, volcanic materials, ancient alluvia and colluvia sols and recent alluvia sols.

1. Volcanic materials

Regosols-parent material is derived from basalt gravel of coluvial origin type of soil is found at the base of Fantalle mountain and around Metehara town.

Andosols-soils which are the result of the eruptive nature of the parent rock; these are basic volcanic ash and very broken pumice known for their low phosphorus and high potassium content.

2. Ancient alluvia and coluvia

Solonchaks-occur on alluvial and coluvial and exclusive of those formed during ancient alluvial deposits. These types of soils are found around Filwuha area and have high concentration of sodium.

Histosols-these are soils having organic horizon of 40 cm or more extending down from the surface. Soils found in the Ilala sala plain and the surrounding are grouped under this category.

3. Recent alluvial sols-These types are developed from recent alluvial deposits. Soils along river Awash those are cultivated as irrigated lands belong to this group.

4.1.3. Climate

The National Park is located within the Great Rift Valley system of east Africa. The area is characterized under semiarid climatic condition (Daniel Gemechu, 1977).

Temperature

Temperatures during the daytime can reach as high as 42^0C (107^0F). Nights are cooler, with temperatures between 10 and 22^0C (50 and 72^0F). The minimum monthly daytime and nighttime temperatures occur between October and January whereas the maximum temperature occur between May and June. The maximum and minimum temperatures vary from 36.9°c in June to 30.6°c in December and from 21.3°c in June to 16.9°c in December, respectively.

Rainfall

The annual rainfall ranges between 400 and 700 mm (Daniel Gemechu, 1977). Rainfall is bimodal with two distinct seasons: the small rain which usually begins in February and extends to the end of April and the big rains, which extends from July to September. Since the area is located within the Inter Tropical Convergence Zone (ITCZ), there is temporal and spatial variability in rainfall, humidity and temperatures (Daniel Gemechu, 1977). Data collected at Metahara Sugar Plantation between 1995 and 2005 showed that the mean annual rainfall is 503.6 mm. The minimum rainfall occurs during October, November, December and February whereas the maximum rainfall occurs during the months of July and August. There is only one distinct dry season in which there is usually no or little rain fall recording. This extends from late October to January.

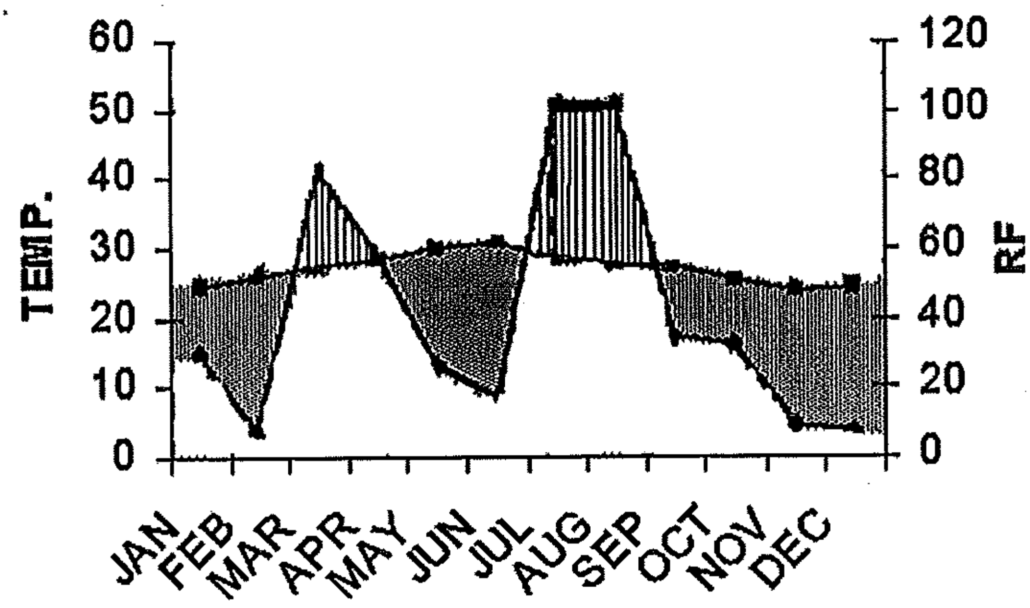


Figure.2-Climatic diagram of Awash National Park based on data of ten years (1995-2005).
Source: Metahara Sugar Factory

4.1.4. Flora and fauna

Floral composition

Awash National Park is considered to be semi-arid due to the high temperatures in the awash area, which result in a large number of deciduous and annual plants of arid and semi-arid woodland savannah, and also riverine forests. The plains are covered by grass species, with scattered small tree species. Areas of shallow soil over rock are covered in dense thickets of acacia species. Acacia woodlands and grasslands mainly cover the terrain. The rocky valleys to the north of the park are heavily bushed. Along the river is a thin belt of dense riverine forest, including acacia and fig species.

Jacobs and Schloeder (1993) identified eight types of vegetation more or less corresponding to the different soil types of the park. These include *grassland, open grassland, low vegetation cover, shrub grassland, shrubland, bush land/woodland, dense tree canopy and wooded grassland*. However, the percentage of each vegetation type in the park is not known.

The grassland plains are of greatest social and economic value in the ANP and serve as a vital wildlife and livestock habitat and food source. The park's grasslands are found within the crater and slope of Mt. Fentalle, as well as along the Addis Ababa-Djibouti road (the Ilala sala plain). Wolde-Yohannis (1996) indicated that the area is rich in graminal family diversity, containing over 90 species, with *Chloris cybidob, Digitaria, Eragrostis, Panicum* and *Adropogon* dominating. The most dominant species are *Chrysopogon plumulosus*, *Bothriochola radicans* and *Ischaemum afrum* in the lower elevations (Illala sala) and *Hypharrhenia hirta* and *Themeda triandra* at higher elevations (on the slopes of Mt. Fantalle). The perennial tussock, *Chrysopogon plumulosus* is the most dominant highly palatable, not only to cattle, but also to Beisa oryx and Soemmering's gazelle. The best grazing field found on the llala sala plains is the core area of the park. To the north and west, heavy grazing by cattle has reduced grass cover such that as much as 50 per cent of the grassland is bare land (Tilahun *et al.*, 1996).

The shrub land type occurs in areas where there is moderate to heavy grazing pressure. It is dominated by *Acacia tortilis* and *A. senegal species*. The bush land and woodland types are also dominated by *Acacia tortilis* and *A. senegal.* However, in some places *Balanites aegyptiaca* becomes dominant in the woodland vegetation type. The dense tree canopy is dominated by Ficus and Acacia trees. Acacia woodlands serve as wildlife and livestock habitat and food sources, source of pollen and nectar for bees and input for charcoal making (Jacobs and Shloder, 1993). According to these authors there are seven Acacia species in the ANP, which provide a valuable browse for game as well as being a fodder for livestock. Acacias are also an important habitat for many of the ANP's wildlife. Depending on the species, a flush of growth is often available at the end of the dry season before the grasses have begun to grow following the first rains. This woody vegetation provides a high quality food source at a critical period in the late pregnancy of most ungulates. Browse is essential to all herbivores in arid and semi-arid environments since grasses alone are unable protein content of most browse is generally considerably higher than that for grasses except during the early growing season.

Doum palm forest stands to the north of the ANP surrounding the Filwuha springs. They are tourist attraction as well an important income source to afar women. The leaves are gathered and then typically sold to buyers in Awash and Metehara towns.

Fauna

The most common mammals include Beisa Oryx, Soemmerring's Gazelle, Warthogs, Anubis and Hamadryas baboons. The tiny salt's Dikdik and both greater and lesser Kudus are present. Cheetah, Serval and Leopard are also there but it is not easy to spot them. The Giant Tortoise, Reedbuck, Aardvark, Caracal are also represented. In the bottom of the gorge, the black and white colored monkey can be seen. The wildlife of Awash reflects its dry nature. It supports 85 species of mammals and 453 species of Birds (Jacobs and Schloeder, 1993).

4.1.5. Study site

The experimental sites for the project were selected based on type of vegetation (grassland, woodland and revirine palm vegetation). Fire histories of 2000, 2002 and 2004 were identified with unburned site as a control and were combined with the three vegetation types. Based on vegetation types and existing fire histories, six sites were identified. These are; unburned woodland (A), grassland burned during 2000 (B), grassland burned during 2002 (C), wood land burned during 2002 (D), palm forest burned during 2004 (E) and unburned palm forest (F). The first four sites (A, B, C, D) were located in the Ilala-sala and Amareti areas around the, main gate of the Park. These four sites are adjacent to each other and located at the core area of the park. The other two sites (E and F) are found around the hot springs, which is 30 km away. There is single palm species; *Hypaene thebaica* Mart is dominating the forest.

4.2. Methods

4.2.1. Vegetation sampling

In order to study the vegetation structure of the woody species stands in the study area, three replicate plots were placed in each selected sites. Therefore totally 18 plots were identified from the six sites. Plots with three concentric rings of different radii were laid within square plot of 20 x 20m to census the vegetation as follows:

1. Within the innermost 2 m radius (12.56m^2 area) all trees/shrubs with diameter < 1 cm

2. Within a 5 m radius (78.5 m^2) all trees/shrubs with diameter 1-10 cm were identified.

3. Within a 10 m radius (314m^2) all trees/shrubs of diameter ≥ 10cm were identified.

Specimens of unidentified woody species were collected and identified in National Herbarium at Addis Ababa University. Within the plots, DBH (Diameter at Breast Height), height, density, frequency, for all individuals of the study species were recorded.

4.2.2. Soil sampling for soil nutrient study

In each sample plot soil sample was taken at the four corners and from the mid point of the square plot and was mixed. Soil sample was taken from the upper 5cm depth. Soil collected from the field was analyzed for pH, available phosphorus, total phosphorus, nitrogen, exchangeable bases, cation exchange capacity (CEC) and organic matter.

4.2.3. Soil sampling for soil seed bank study

Soil samples were taken from each site for the purpose of soil seed bank study. Five random spots within the 20 x 20 m plot were selected. Wooden frame of 15x15cm was placed on the selected spots and soil samples were taken at four depths: 0-0.5 cm, 2.5-3 cm, 5.5-6cm and 8.5-9 cm within the wooden frame. The soil samples were taken to the greenhouse at Addis Ababa University. Each soil sample was placed in a pot of 12cm diameter and 6cm depth over sterilized river sand. The pots were incubated to a natural photoperiod and watered as required. Air temperature during the incubation period ranged between 20^0C and 35^0 C. The seed banks from the different sites were studied following the seed emergence method (Kropac, 1966; Roberts, 1981). Germination was completed within the first 6 weeks while samples were kept in the greenhouse for 12 weeks to monitor late emergence of seedlings. Emerging seedlings were identified, recorded and removed, or replanted for later identification. All seedlings were identified at species level.

4.2.4. Heat shock trial for the seeds of woody species

To study effect of fires on seed germination seeds of ten woody species, which are available at the data collection time, were collected for heat shock trial. One of the ten species (*Cordia sinesis*) was not recorded in the sampling plots but it is abundant in the surrounding along roadsides.

The collected seeds were checked for damage and insect attacks before being subjected to the experiment. The size and weight of each seed was measured prior to the heat shock experiment. The seed of each species was subjected to five temperature levels; 60^0C, 90^0C, 120^0C, 150^0C and 200^0C for 1 minute and 5 minute each in oven at eco-physiology laboratory of Addis Ababa

University. Stopwatch was used to record the time. For each treatment 20 seeds were used and untreated seeds were used as control for all species. After the heat shock treatment the seeds were socked in water for an hour and then sown in a pot with sterilized soil. Germination defined as emergence of radicle from the seed coat was recorded weekly. The experiment was completed within three months.

The mean seed size and the weight of 20 seeds per species was measured in order to relate to the maximal treatment temperatures which was followed by germination to the average seed size and seed weight of the species.

4.3. Data Analysis

The data were analyzed using analysis of variance (ANOVA) in the SPSS statistical procedure. For both above ground and below ground vegetation data one-way ANOVA was used to show variation between sites and between depths (for the seed bank). Species diversity, species evenness and species richness were calculated using Shannon-Wiener index, richness index and Sorensen's similarity index ***for*** the above ground vegetation data. Sorensen's similarity index was also used to relate above ground and soil seed bank data for the woody species.

For soil nutrient analysis one-way ANOVA was used together with independent t-test to compare means of sites with similar vegetation types.

The heat shock trial was analyzed by two way ANOVA taking temperature and time as main factors. Spearman rank correlation was used also to study whether there is relationship between seed size, seed weight and seed heat resistance. Tables', graphs and charts were used to summarize the result.

5. RESULT

5.1. Above Ground Vegetation

In the above ground vegetation 13 woody species were recorded from the six sites. Seven of the 13 species were represented in diameter class1 while all the 13 species were recorded for diameter class 2. In diameter class three except for the three Grewia species and *Acacia oerfota* (Forssk) Schweinf all other species were represented (see Table 2). Regarding study sites for site A 4 species were represented in diameter class1 while there were only 2 species for site B. The rest sites were represented by only one species each in diameter class1.

Even though the vegetation of the first four sites (A, B, C, D) was more or less similar, there was a variation in species diversity (table 3). Based on Shannon-Wiener index the highest species diversity was recorded in A (H': 1.8085), which was unburned woodland. Totally 10 of the thirteen species were recorded here. The burned woodland has only six species and had a diversity index of 1.601(H').

The old burned grassland (B) was more diverse than the recently burned grassland (C). These two adjacent sites were less in diversity (Table 3) than the woodlands. The sites from the palm forest were the least in diversity values.

The result from species richness index showed that the unburned woodland (A) and the lately burned grassland (C) had more richness than others (Table 2).

Species similarity index showed higher values for A and B, A and C, A and D (0.625, 0.47 and 0.625, respectively). Site C had lower value of similarity index with the rest three sites.

The burned palm vegetation (E) had the highest plant density followed by sites A and F respectively. There was significance deference in means of plant density between burned and unburned woodlands (A and B), burned and unburned palm vegetation (E and F) and the old burned and the recently burned grass lands (B and C) based on F-test.

Regarding individual species *Acacia senegal* (L) willd, *Grewia.schweinfurthi* Burret and *Grewia villosa* Willd were more abundant and recorded from the four adjacent blocks (A, B, C and D). *Acacia tortlis* (Forssk) Heyne was represented in A, B, and C while *Acacia mellifera* (Vatke) Benth and *Grewia erythraea* Shwenif were restricted to the two woodland sites (A and D).*Balanites aegyptiaca* (L.) Del was recorded in unburned woodland and old burned grassland (A and B). Three species (*Acacia sieberina* DC, *Cadaba farinosa* Forrsk and *Zizipus abyssinica* Hochst. ex Rich were recorded only in the unburned site (A). Similarly *Dichrostacys cinerea* (L) Wight and Arn and *A. oerfota* were unique to sites A and D respectively. The palm forest was represented with single palm species, *Hypaene thebaica.*

Table.1- Species recorded within the six study sites density of each species (NO/hectare) per diameter class

A-unburned woodland, B-old burned grassland, C-recently burned grassland, D-burned woodland, E-burned palm, F-unburned palm.D1-dimeter class1, D2-dimeter class2, D3-diameter class3.

SPECIES	A			B			C			D			E			F		
	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
Acacia mellifera (Vahl) Benth	5625	267	57.5	0	0	0	0	0	0	0	182	0	0	0	0	0	0	0
Acacia oerfota(Forssk) Schwenfurthi	0	0	0	0	0	0	0	0	0	0	200	0	0	0	0	0	0	0
Acacia senegal Wild	0	257	16.75	432	167.5	7.5	17	150	8	1040	150	0	0	0	0	0	0	0
Acacia sieberina DC.	417	82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia tortilis (Forrsk)	1040	200	250	25	297.5	25	0	0	25	0	0	0	0	0	0		0	0
Balanites aegyptiaca (L.) Del	0	100	16.75	0	33.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Cadaba farinosa Forssk	417	225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dichrostacys cinerea (L) Wight and Arn	0	0	0	425	1000	0	0	0	0	0	0	0	0	0	0	0	0	0
Grewia erythraea Schwenf	0	1165	0	0	0	0	0	0	0	0	1040	0	0	0	0	0	0	0
Grewia sheweinfurthii Burret	0	332	0	0	232.5	0	0	267	0	0	433	0	0	0	0	0	0	0
Grewia villosa Willd.	0	332	0	0	332.5	0	0	0	0	0	633	0	0	0	0	0	0	0
Hypaene thebaica Mart	0	0	0	0	0	0	0	0	0	0	0	0	1457	1300	300	5200	2167	250
Zizipus Abyssinica Hochst,ex.Rich	0	137.5	42.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table.2-The presence or absence of species in each diameter class. D1, D2, D3 are representing Diameter class1, Diameter class2, Diameter class 3 respectively.

(+) for species presence and (-) for species absence in particular diameter class

NO	species	D1 (<1cm)	D2 (1-10 cm)	D3 (>10 cm)
1	*Acacia mellifera*	+	+	+
2	*Acacia oerfota*	–	+	–
3	*Acacia Senegal*	+	+	+
4	*Acacia sieberina*	+	+	+
5	*Acacia tortilis*	+	+	+
6	*Balanites aegyptiaca*	+	+	+
7	*Cadaba farinosa*	–	+	+
8	*Dichrostacys cinerea*	+	+	+
9	*Grewia erythraea*	–	+	–
10	*Grewia sheweinfurthi*	–	+	–
11	*Grewia villosa*	+	+	–
12	*Hypaene thebaica*	+	+	+
13	*Zizipus Abyssinica*	–	+	+

Table.3- the type of vegetation, fire history, number of species per block, species diversity values (H' and mean species richness index) and plant density (based on f-test) and probability values (superscript)

H'-Shannon Wiener diversity index,

BLOCKS	VEGTATION TYPE	FIRE HISTORY	NUMBER OF SPECIES				H'	SPECIES RICHNESS INDEX	DENSITY
			Dbh1	Dbh2	Dbh3	Tot			F
A	Woodland	Unburned	**4**	**10**	**4**	**10**	**1.8085**	**1.345**	**$17.668^{0.001}$**
B	Grassland	Burned before 5 years	**3**	**6**	**2**	**6**	**1.4254**	**0.948**	**$2.818^{0.107}$**
C	Grassland	Burned before 2 years	**1**	**2**	**1**	**3**	**1.2202**	**0.326**	**$4.193^{0.047}$**
D	Woodland	Burned before 2 years	**1**	**6**	**0**	**6**	**1.6010**	**0.820**	**$0.968^{0.457}$**
E	Palm forest	Burned before a year	**1**	**1**	**1**	**1**	**0**	**0**	**$78.992^{0.000}$**
F	Palm forest	Unburned	**1**	**1**	**1**	**1**	**0**	**0**	**$0.580^{0.644}$**

5.2. Heat shock Trial

5.2.1. Germination of seeds

All of the 10 species in the experiment were germinated (Table 4). The result from F-test (at α = 0.05) showed significance values for either temperature level or duration except for seeds of *Balanites aegyptiaca*. For some species temperature levels were highly affect germination while for others germination was more affected by duration of the experiment than the level of the temperatures (Table 4).

Table.4-Maximum germination (%) for 1 and 5 minute duration and analysis of variance F values and probability values (super script) for the effect of duration and temperature levels. Degree of freedom is 1 for duration, 5 for temperature levels.

Species name	Max germination (%)		Duration	Temperature
	1min	5min		
Acacia oerfota	32	19	$.045^{.836}$	$58.722^{.000}$
Acacia senegal	73	83	$.123^{.733}$	$15.259^{.002}$
Acaciia sieberina	53	59	$.442^{.521}$	$7.722^{.014}$
Acacia tortilis	46	57	$.276^{.611}$	$6.769^{.019}$
Balanites aegyptiaca	81	85	$1.460^{.255}$	$.845^{.564}$
Cadaba farinosa	62	4	$4.59^{.058}$	$6.249^{.031}$
Cordia sinensis	78	74	$10.237^{.009}$	$1.022^{.480}$
Grewia erythraea	27	65	$7.357^{.022}$	$.471^{.787}$
Grewia villosa	4	77	$5.724^{.038}$	$.564^{.727}$
Zizpus americana	78	41	$7.463^{.021}$	1 $.346^{.360}$

Seeds of *Acacia oerfota* were negatively responded to the heat shock treatment. As temperature went up germination percentage was reduced. No single seedling germinated above 90^0C both for 1minute and 5 minutes (Fig 3).

Responses in *Acacia senegal* were completely different from *A.oerfota*. Heat shocks increased germination frequency for *A. senegal*. Seeds treated at 60^0C for 5 minute had high germination followed by 60^0 C and 90^0C for 1 minute respectively. Germination at these temperature levels was significantly higher than temperatures at higher levels and the control. There was no significant difference between germination at 120^0C for 5 minutes and the control. No germination was recorded above 120^0C for *A. senegal* (Fig 3).

Response in *Acacia sieberina* was more or less similar to *A. senegal*. High germination was recorded at 60^0 C and 90^0C for 1 minute and 60^0 C for 5 minutes, respectively. There was no significant difference at 120 for 5 minutes and the control; whereas at temperature of 150^0 C germination was significantly reduced (Fig 3).

Similarly *Acacia tortilis* showed higher germination at 60^0C and 90^0C for 1 and 5 minutes. There was no significance difference between temperature at 120^0C for 1 minutes and the control (Fig 4).

Response in *Balanites aegyptiaca* was a bit different. No significant difference was observed for all temperature levels and durations (Fig 4).

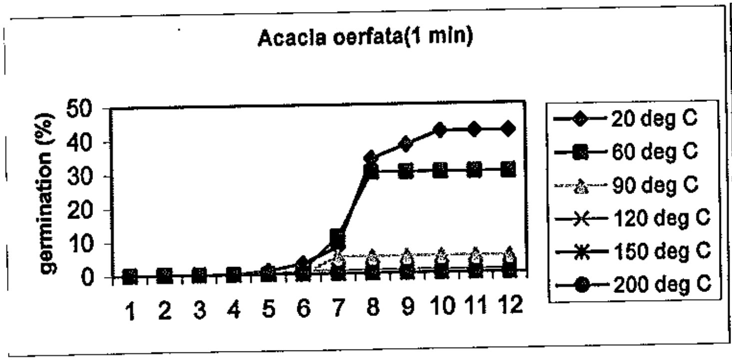
Cadaba farinosa germinated higher at temperature levels 60^0C and 20^0C. Germination was much reduced for higher temperatures and 5-minute duration (Fig 4).

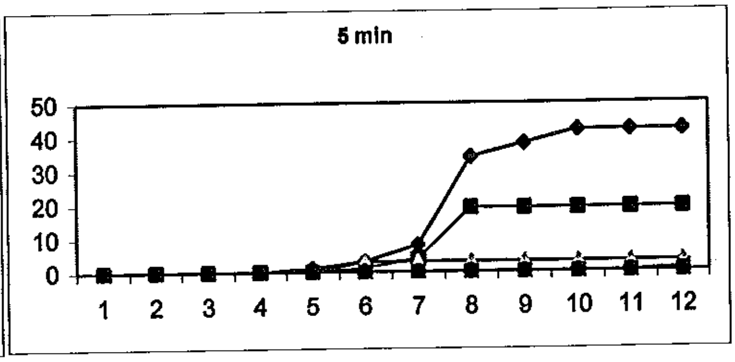
Seeds of *Cordia sinensis* germinate higher at 60^0C. Above 90^0C germination for *C. sinensis* was significantly reduced even though it resisted temperature of 200°C (Fig 5).

No germination was recorded for *Grewia erythraea* at room temperature. Higher germination was recorded at 120°C at one minute followed by 150^{0}C at 1 minute and 90^{0}C at 5 and 1 minute, respectively. No germination was recorded for temperature of 200^{0}C at 5-minute duration. Similarly *G. villosa* did not germinate at room temperature. For this species treatment at 1 minute duration resulted in significantly lower germination than the 5 minute duration. This species resisted temperature level of 200^{0}C; however germination was much reduced (Fig 5).

Zizipus abyssinica germinated higher at 60 °C and 90 °C for 1 minute. No significance difference was observed for the 5-minute duration. This species restricted temperature of 200^{0}C at duration of 5 minutes. However germination was much reduced at this temperature level (Fig 6).

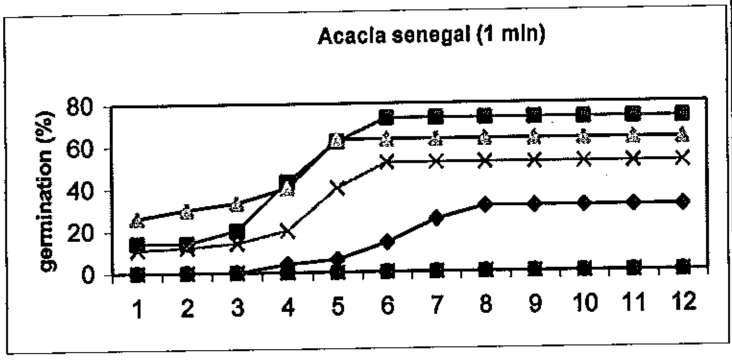
When comparing temperature levels the highest significant value was recorded for 60^{0}C followed by 90^{0}C and 120^{0}C. There was no significance difference for the control and temperatures of the higher levels (150^0 and 200^{0}C). There was a significant difference between duration of 1minute and 5 minutes for most of the species. Regarding species *B. aegyptiaca* and *C. sinesis* attained higher germination frequency than the rest species (Table 5).

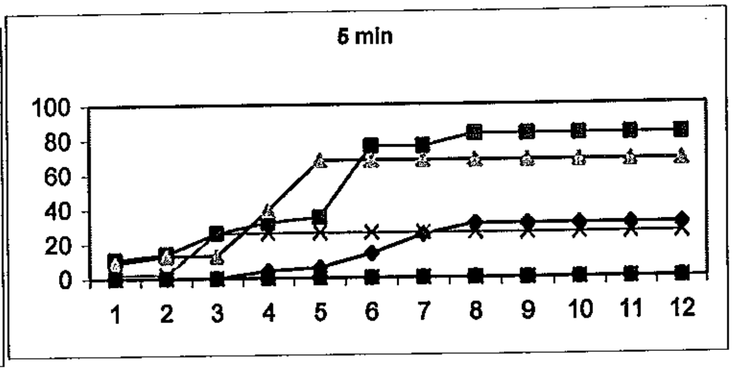




Germination: 20- 90^{0}C

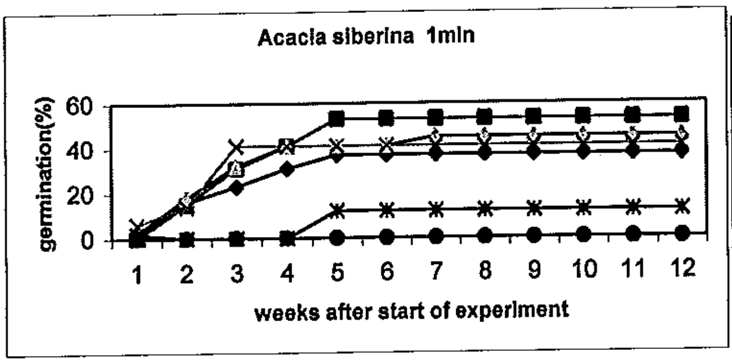
Germination: 20-90^{0}C

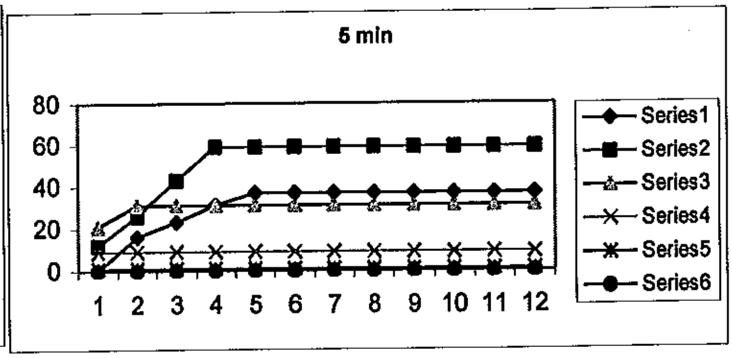




Germination:20-120^{0}C

Germination:20-120^{0}C

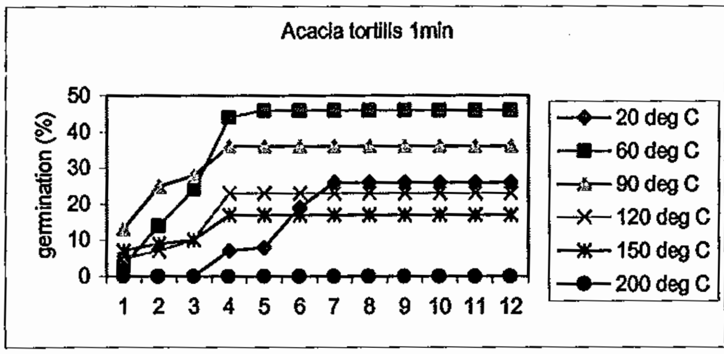




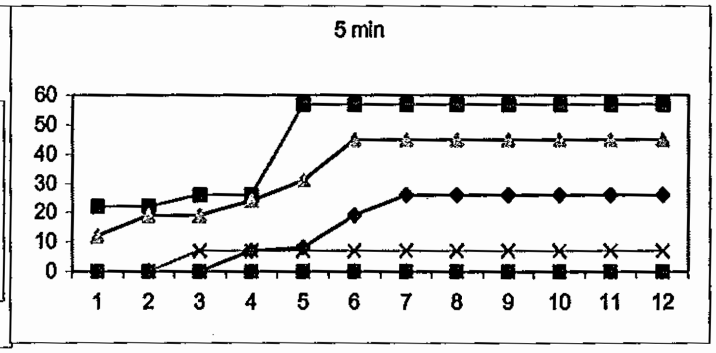
Germination:20-150^{0}C

Germination:20-120^{0}C

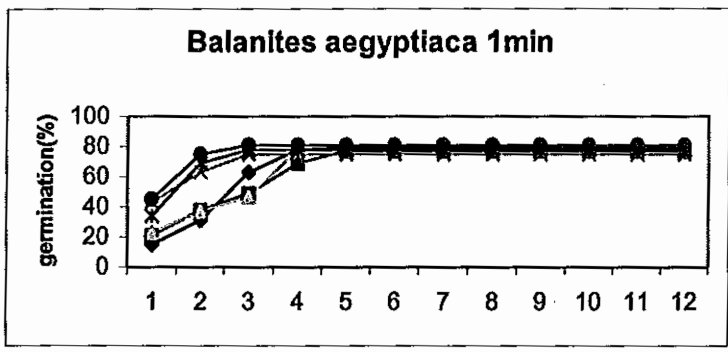
Fig.3-Germination responses of seeds of Acacia species at temperature levels of 20,60,90,120,150 and 200^{0}C at 1 and 5 minute durations.



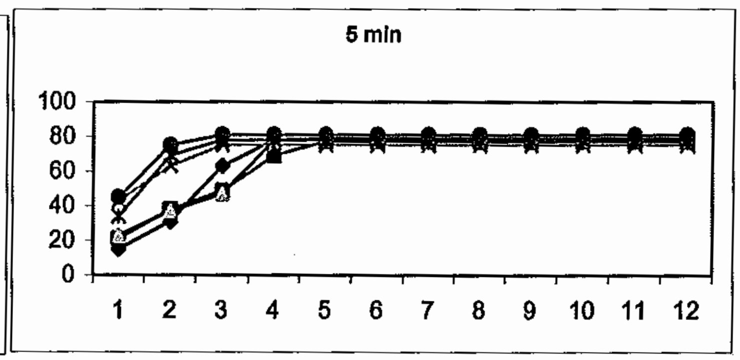
Germination:20-150^{0}C



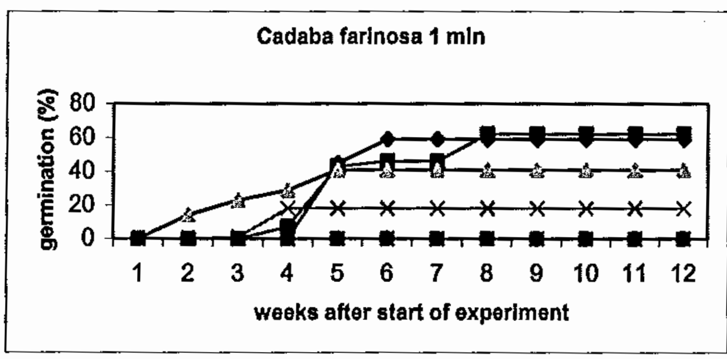
Germination:20-150^{0}C



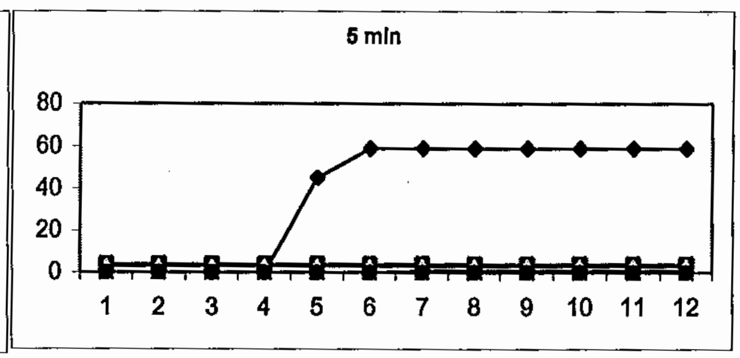
Germination:20-200^{0}C



Germination:20-200^{0}C

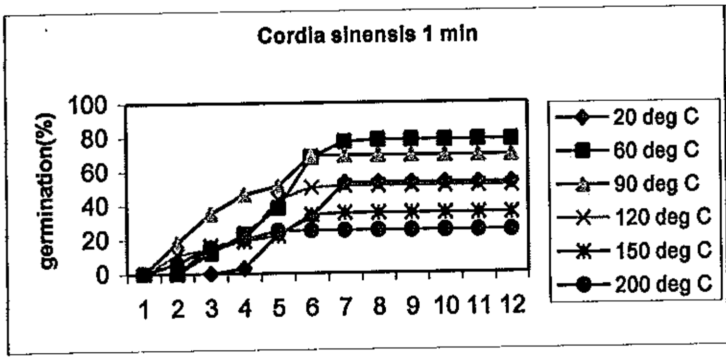


Germination:20-120^{0}C

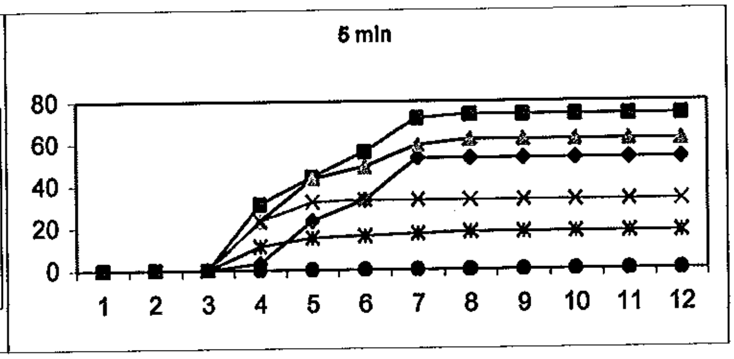


Germination:20^{0}C

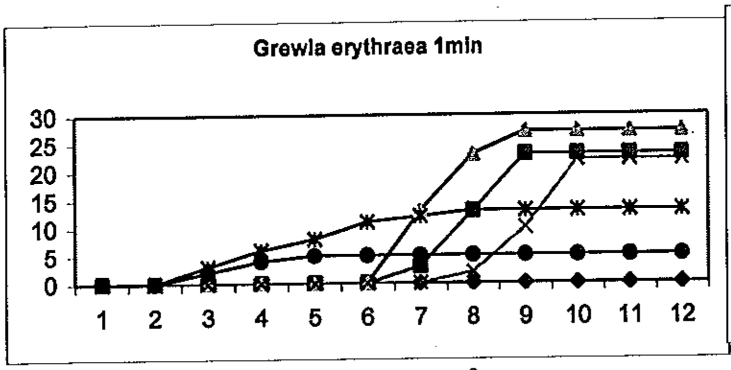
Fig.4-Germination response in seeds of woody species at temperature levels of 20, 60, 90, 120, 150, and 200^{0}C.



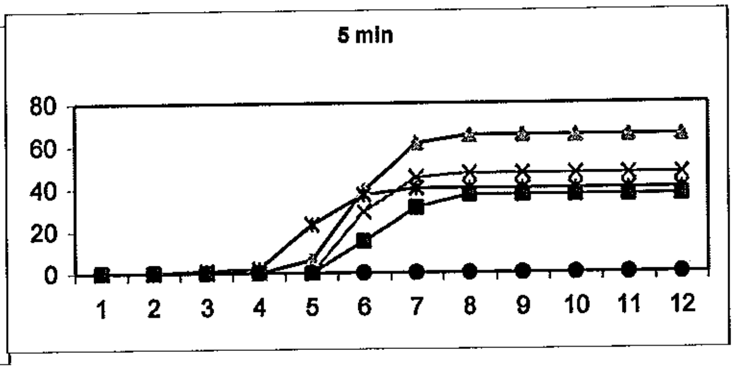
Germination:20-200⁰C



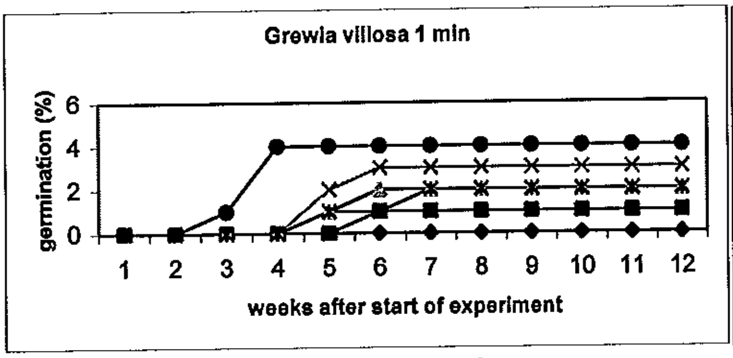
Germination:20-200⁰C



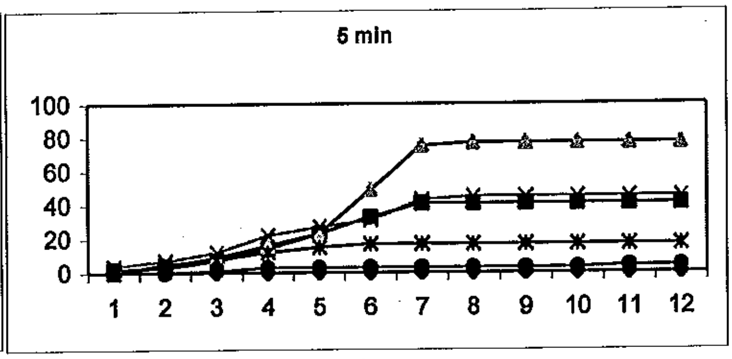
Germination:60-200⁰C



Germination:60-150⁰C

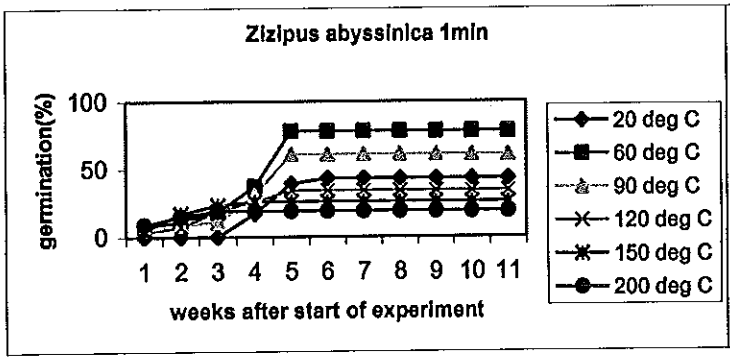


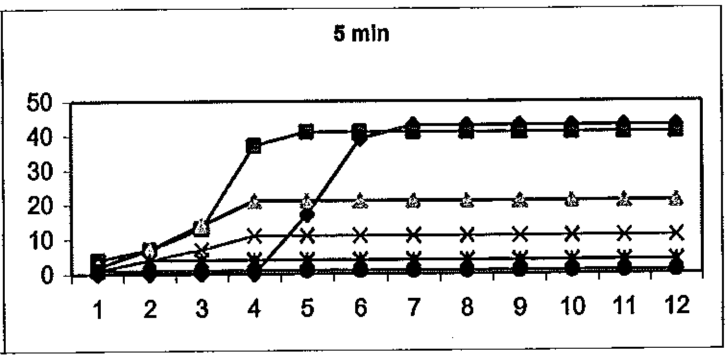
Germination:60-200⁰C



Germination:60-200⁰C

Fig.5-Germination response in seeds of woody species at temperature levels of 20, 60, 90, 120, 150, and 200⁰C.





Germination:20-200^{0}C **Germination:20-200^{0}C**

Fig.6-Germination response in seeds of *Zizipus abyssinica* at temperature levels of 20, 60, 90, 120, 150, and 200^{0}C.

5.2.2. Seed size, seed weight and maximum temperature for germination

Seeds from the different plant species varied greatly in terms of size and weight, in presence of protective tissues (pods or fruits) and in time required to attain maximum germination frequency (Table 5). Most species require six weeks or more to reach their maximal germination frequency. However seeds of *A. sieberina* and *B.aegyptiaca* reached full germination within 5 and 4 weeks, respectively. In all species the relative rate of germination was unaffected by treatment.

There was a positive correlation between seed weight or size of the species and the maximum, temperature level after seed germination could take place except for Grewia species (*G. erythraea* and *G. villosa*).

Table. 5- Description of seeds of germinated plant species the diaspores, size and weight (means and± standard error) and maximum germination weeks for seeds treated by the heat shock

Species	Description of diaspores	Seed Weight (mg)	Seed size (mm)	Max. germ. (Weeks)
A .oerfota	Seeds in pods	750±6.5	3.0 ± 0.1	8
A. senegal	Seeds in pods	1368±9.5	7.5± 0.3	8
A. sieberina	Seeds in pods	1216±5.5	7.5±0.2	5
A. tortilis	Seeds in pods	772±4.3	5.0± 0.2	7
B. aegyptiaca	Seeds in fruits	52310±11.2	41.2±1.2	4
C. farinosa	Seeds in pods	987±4.1	7.5± 0.3	6
C. sinensis	Seeds in fruits	2634±6.3	7.0± 0.2	6
G. erythraea	Seeds in fruits	687±5.5	4.0± 0.1	8
G .villosa	Seeds in fruits	614±4.5	3.0± 0.1	7
Z. abyssinica	Seeds in fruits	4494±5.4	6.0± 0.3	7

5.3. Soil Seed Banks of the Study Sites

A total of 19 plant species representing grass, herbs and woody life forms were recorded from all soil depths and sites in the study area. Out of these 42.1% were herbs 31.6% grasses, and 26.3% were trees and shrubs.

Most of the seeds in the seed bank were concentrated in the upper 0.5 cm depth (73.7%). The two upper depths (0.5 and 2.5 cm) together accounted for 94 % of the total soil seed bank of the study. No seeds from woody spices were detected at the depth of 8.5 cm. Seeds of *A. mellifera* was recorded at 5.5 cm depth (Table 6).

Totally 5 woody species were recorded from the soil seed banks. This includes *A. mellifera*, A. *tortilis, C. farinosa, D. cinerea and G. villoa.* All woody species were having less density of seeds in the soil seed bank when compared with the grass and herb species (Table 7). *A. mellifera* was recorded from the upper three depths and was relatively higher in density than *A. tortilis* (Table 6). *D. cinerea* and *G. villosa* were recorded at the upper two sampling depths (0-0.5cm and 2.5 -3 cm) while *A. tortilis* was restricted to the upper (0.5cm) soil depth. *G. villosa* was more abundant at 2.5cm than *D. cinerea.*

Herbs dominate the soil seed bank of the study area. From the total 19 species 8 of them were herbs. The herb species exploited the upper two depths (0.5 and 2.5cm) except for Commelina species which were recorded at depth of 5.5 cm.

Grass species were more abundant than the woody species in the soil seed bank when compared to woody species. *Chrysopogon plumulosus* Hochst; the dominant grass species in the Ilala-sala plain, (Almaz Tadesse and Masresha Fetene, 1999) had the same abundance in the soil seed bank as well. It was recorded at all the four depths, accounted for the highest seed density (364/m^2) and it was the only species to be recorded at all sites (Table 7). No germination was recorded for grass species at depth of 5.5 cm except for *C. plumulosus (*Table 6). There was no significant difference observed regarding species composition and life forms of the soil seed banks among the sites (Table 8). Similarly no significance difference was observed for the different soil depths. The difference was only for the total seed density for each site.

Table. 6- Species identified from the soil seed bank, their life forms and the number of seedlings at the 4 soil depths (0.5 cm, 2.5 cm, 5.5 cm, and 8.5 cm)

Plant Species		Life form	0.5 cm	2.5 cm	5.5 cm	8.5 cm	Tot
1	*Acacia mellifera (*Vatke) Benth	Shrub	26	7	3	0	36
2	*Acacia tortilis* (Forssk) Heyne	Tree	5	0	0	0	5
3	*Acalypha fructicosa* Forssk	Herb	59	25	11	0	95
4	*Acalypha indica* L	Herb	32	26	0	0	58
5	*Achyranthes* aspera L.det.L.Bouls	Herb	58	17	3	0	78
6	*Amaranthus angustifolius* Lam	Herb	49	0	0	0	49
7	*Botheriochloa radicans* (Lehm)A.Camus	Grass	23	13	6	0	42
8	*Cadaba farinosa* Forssk	Shrub	23	0	0	0	23
9	*Chrysopogon plumulosus* Hochst	Grass	200	23	12	8	243
10	*Commelina albecens* Harsk	Herb	88	35	10	0	133
11	*Commelina imberbis* Harsk	Herb	21	3	4	0	28
12	*Corochorus fascicularis* Lam	Herb	23	0	0	0	23
13	*Corochorus oliturius* Lam	Herb	28	0	0	0	28
14	*Cymbopogon puspichilii* (K. Schum.) C. E. Hubb	Grass	13	0	0	0	13
16	*Digitaria veluntina* (Fossk) P. Beav	Grass	12	12	0	0	24
15	*Dichrostachys cinerea* (L)Wight & Arn	Shrub	57	21	0	0	78
16	*Grewia villosa* Wild	Shrub	28	24	10	0	74
17	*Lintona nutans* Stapf	Grass	32	0	0	0	32
18	*Ischacmum afrum* (J. F. Gemel) Dandy	Grass	90	9	0	0	99

Table. 7- Species recorded in the soil seed bank at the 4 study sites (A, B, C, D) and density of each species per m^2.

No	Plant Species	Life form	A	B	C	D	Tot
1	*Acacia mellifera*	Shrub	206	0	0	12	54.5
2	*Acacia tortilis*	Tree	30	0	0	0	7.5
3	*Acalypha fructicosa*	Herb	462	72	0	96	157.5
4	*Acalypha indica*	Herb	132	72	0	72	69
5	*Achyranthes aspera*	Herb	318	0	54	150	130.5
6	*Amaranthus angustifolius*	Herb	138	30	0	126	73.5
7	*Bathriocla radicans*	Grass	30	90	66	66	38
8	*Cadaba farinosa*	Shrub	138	0	0	0	34.5
9	*Chrysopogon plumulosus*	Grass	522	612	192	132	364.5
10	*Commelina albecens*	Herb	366	126	0	306	199.5
11	*Commelina imberbis*	Herb	132	18	18	0	42
12	*Corochorus fascicularis*	Herb	138	0	0	0	34.5
13	*Corochorus oliturius*	Herb	78	0	0	90	42
14	*Cymbopogon puspichilii*	Grass	30	36	0	12	19.5
15	*Dichrostachis cinerea*	Shrub	0	468	0	0	135
16	*Digitaria veluntina*	Grass	72	72	0	0	36
17	*Grewia villosa*	Shrub	72	30	0	342	111
18	*Lintona nutans*	Grass	0	90	78	18	46.5
19	*Ischacmum afrum*	Grass	72	168	174	150	141

Table. 8- ANOVA table for species, life form and soil sample depths for the four study sites (A, B, C, D), F values and probability values (superscript). Degree of freedom is 3 for variables, and 72 for error.

Variables	F.
species	$.000^{1.000}$
life form	$.000^{1.000}$
0.5cm	$2.530^{.064}$
2.5cm	$1.508^{.220}$
5.5cm	$1.788^{.157}$
8.5cm	$.963^{.415}$
TOTAL	$3.182^{.029}$

Table. 9- The result from Sorensen's similarity coefficients for presence of species in the standing vegetation and soil seed bank based on the 12 sampling plots from the 4 sites.

STUDY SITES	NO OF SPECIES		SIMILARITY COFFICIENT
	ABOVE GROUND	BELOW GROUND	
A	**10**	**4**	**0.57±0.02**
B	**6**	**2**	**0.50±0.01**
C	**5**	**1**	**0.33±0.00**
D	**3**	**0**	**0.00±0.00**

5.4 Soil Nutrient

The result from soil nutrient showed significant values based on independent t-test for some of the nutrients at α= 0.5 confidence level.

5.4.1. pH value

The result from soil pH determination showed high values for blocks from palm forest (E and F) and burned old grassland (B). Site B had a significant difference with the other three adjacent blocks (A, C, and D). Significance differences were observed from independent test between burned and unburned woodland and between the old and recently burned grasslands (Table 10).

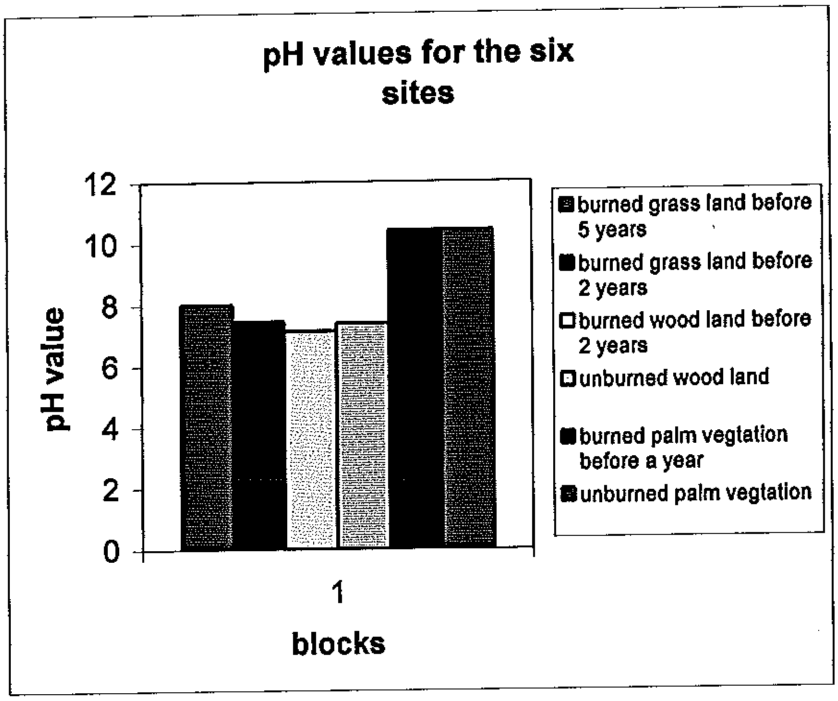
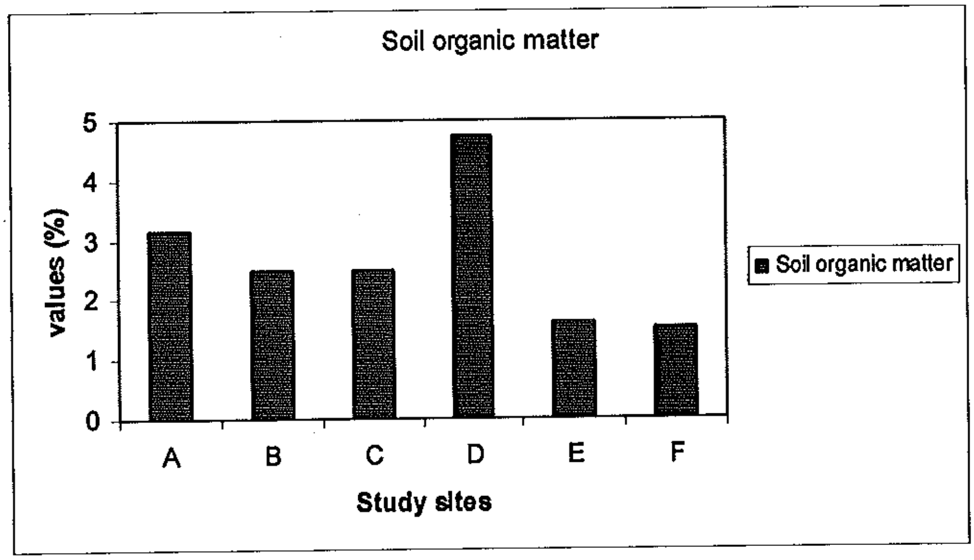


Fig.7- Soil pH values for all the study sites

5.4.2. Soil organic matter content and total nitrogen

For soil organic matter highest value was recorded for the burned woodland (D). The value for burned woodland was significantly higher than the rest blocks. However no significant difference was observed between burned and unburned palm vegetation from the independent T-test (Table 10).

Similarly highest value for the total nitrogen was recorded from the burned woodland (0.213%), while blocks from the palm vegetation (both burned and unburned) were accounted for the least value (0.073%); see (Fig 8). Significance difference was observed between the burned woodland and the rest of the blocks. However there was no significant difference observed by pairing block with the same vegetation types.



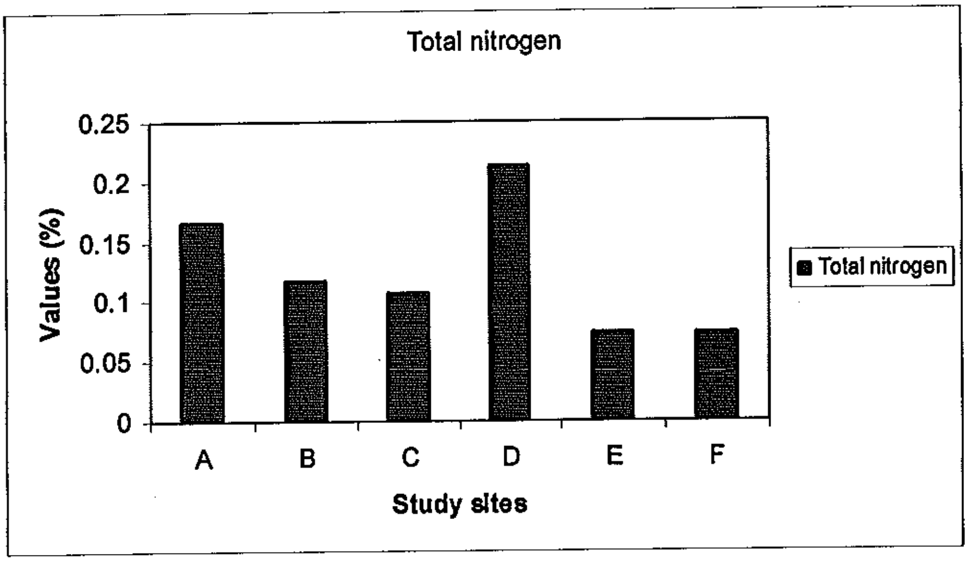


Fig .8- soil of organic matter and total nitrogen in percentage for the six study sites

5.4.3. Total and available phosphorus

Available phosphorus was significantly higher at the burned palm vegetation and in the old burned grassland when compared with the rest of the sites. The burned palm accounted for highest value (13,1ppm) while the least value was from the unburned palm (0.93 ppm). In line with this the independent t-test showed high significant values for the palm blocks while no difference was observed for the means of the rest (Table 10). On the other hand, there was no significance difference for the total phosphorus by pairing the block based on vegetation types. Highest value was recorded for unburned palm vegetation (427.3 ppm) while the least value was for grassland burned before two years (201.85 ppm), see (Fig 9).

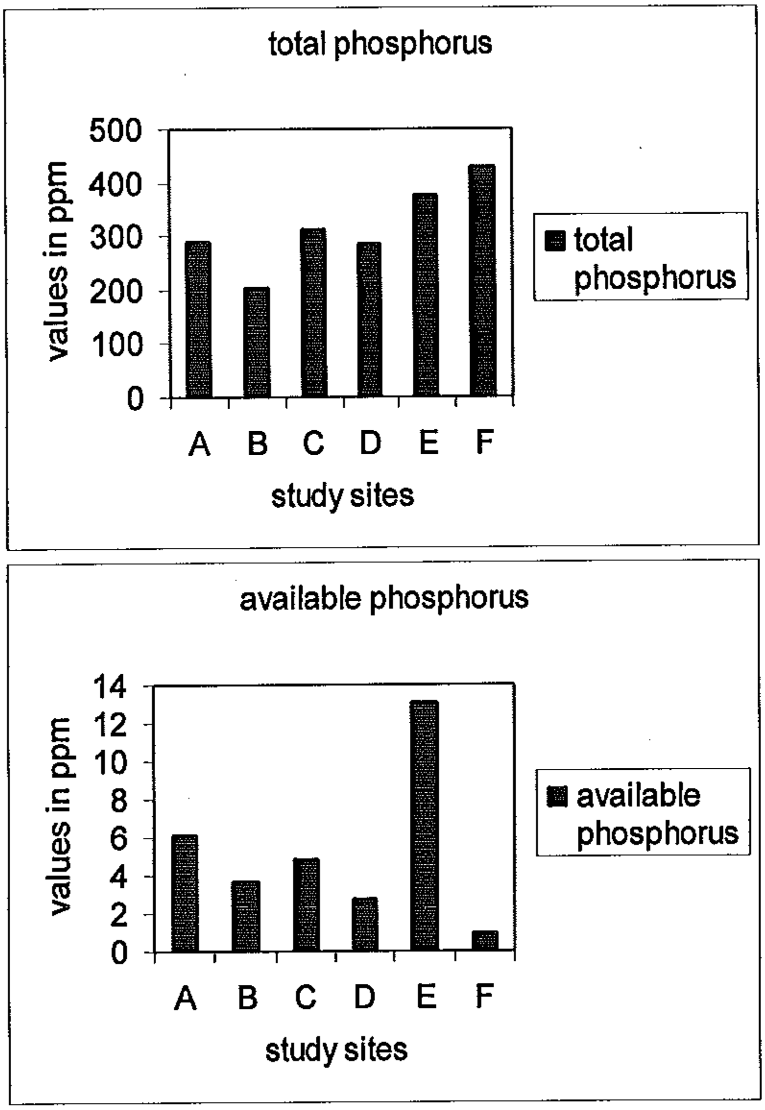


Fig.9-Total and available phosphorus for each site in ppm

5.4.4. Soil exchangeable bases

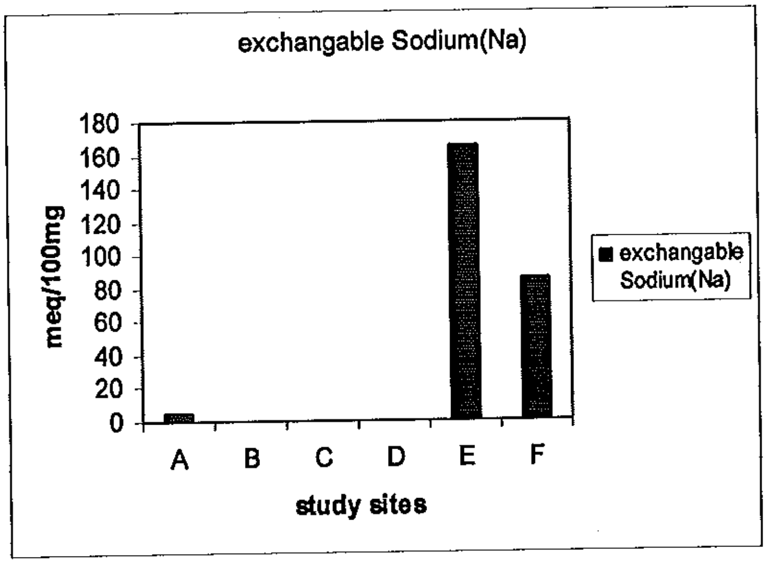
Regarding exchangeable sodium (Na) significance values were observed from independent t-test for the woodland and the grassland. The concentration of exchangeable sodium was significantly higher for the palm blocks than the woodlands and the grasslands (Table 10).

For potassium (K) no significant result was observed from independent-test. (Table 6) However the result from the palm blocks was higher than the rest four blocks (Fig 10).

No significance difference was observed for values of exchangeable calcium (Ca) for the grassland sites and the palm forest. However for the woodlands highly significant values were observed (Table 10). The values from the palm vegetation (both burned and unburned) were significantly lower than the rest blocks by F –test.

For exchangeable magnesium (Mg) no significance value was observed from independent t-test. However values of palm blocks were lower than the grasslands and burned woodland (Fig 11). The woodland bocks showed significantly lower values than the grasslands.

Regarding cation exchange capacity (CEC) high values were recorded for old burned grassland and burned woodland (Fig 12) . Significance differences were observed between woodland blocks based on independent t-test. Accordingly the burned woodland was showed higher value than the unburned woodland (Table 10). The result from the grassland blocks (both old and recently burned) and the burned woodland were significantly higher than the rest blocks by F – test.



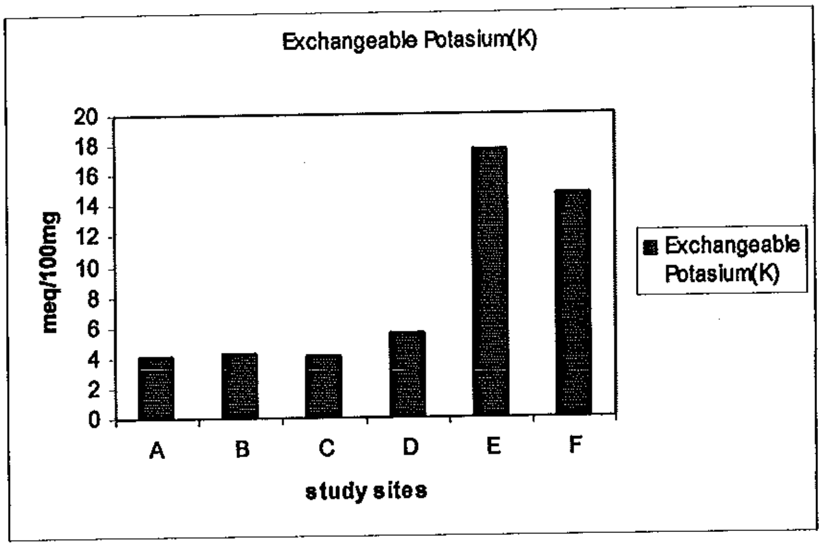


Fig.10-Exchangable potassium and exchangeable sodium for the six study sites

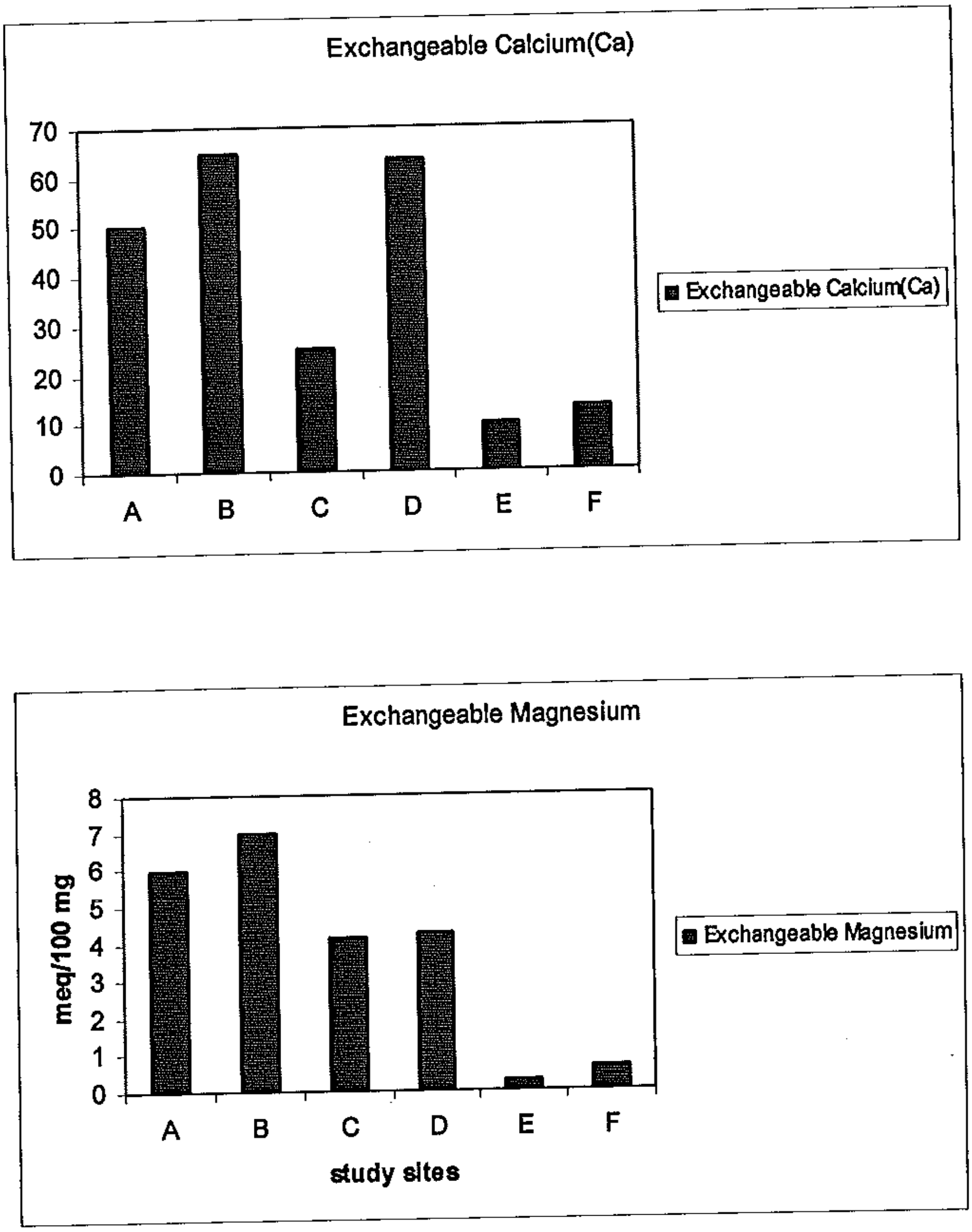


Fig.11- Exchangeable Calcium and exchangeable Magnesium for the six study sites

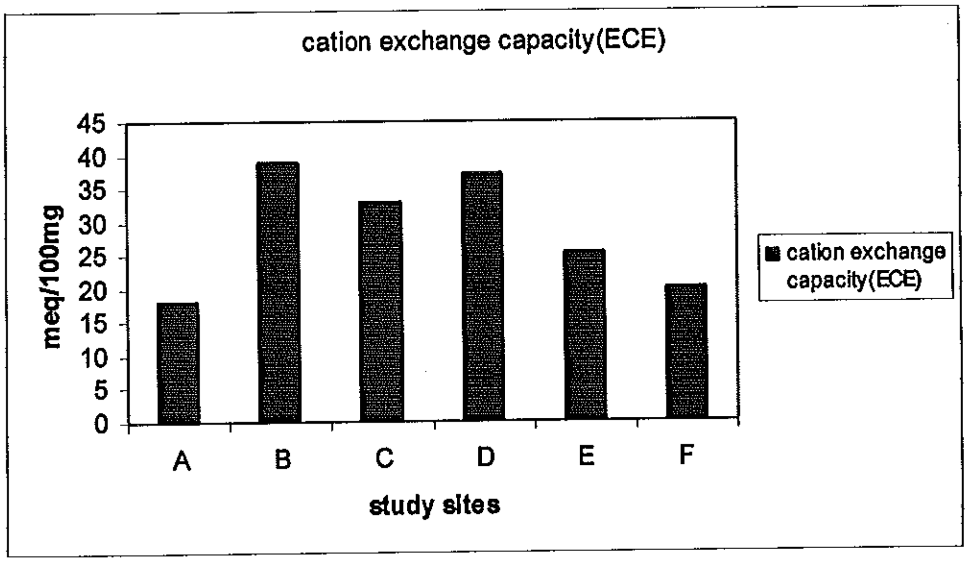


Fig.12- Cat ion exchange capacity for the six study sites

Table10. The result from independent t-test (mean and P-value) for soil chemical properties at α 0.05.

Sites with the same vegetation type (A and D, B and C and E and F) were grouped together.

Groups 1	Groups 2	Variable	Mean (1)	Mean (2)	p
B	**C**	pH	8.0	7.5	**0.0336**
		OM	2.49	2.48	0.9639
		Total N	0.11	0.12	0.6072
		Available P	6.13	3.71	0.4461
		Total P	290.71	201.66	0.2131
		Na	5.04	0.12	**0.0009**
		K	4.16	4.18	0.9787
		Ca	64.57	49.98	0.5750
		Mg	7.00	5.95	0.4621
		ECE	38.84	32.81	0.0985
A	**D**	pH	7.15	7.39	**0.0142**
		OM	3.14	4.74	**0.0316**
		Total N	0.17	0.21	0.1160
		Available P	4.83	2.71	0.3171
		Total P	312.17	284.67	0.6480
		Na	0.03	0.07	**0.0381**
		K	4.08	5.61	0.6700
		Ca	25.21	63.39	**0.0001**
		Mg	4.13	4.26	0.7030
		ECE	18.07	37.20	**0.0001**
E	**F**	pH	10.42	10.41	0.9831
		OM	1.500	1.617	0.8789
		Total N	0.0733	0.733	0.9999
		Available P	13.09	0.99	**0.0016**
		Total P	376.39	427.34	0.1621
		Na	165.65	85.50	0.1621
		K	17.65	14.70	0.2501
		Ca	9.60	12.94	0.4043
		Mg	0.25	0.65	0.4956
		ECE	25.35	19.81	0.1330

6. DISCUSSION

The result from Shannon Wiener index showed less diversity for burned woodland (D) than the unburned woodland (A). Fire might contribute for the reduction in species diversity and for the loss of the five species from the burned woodland which were recorded in the unburned site. Similarly the old burned grassland (B) was less diverse than the newly burned (C) depending on Shannon- Weiner index. These two adjacent sites having the same vegetation type differed on their fire history. The relatively high diversity index value for the old burned site (B) might show the contribution of fire to diversity reduction. Site B seems to be in a transitional state between grassland and woodland. This result is in line with findings of Breman (1995). In the study of fire effects along the Sahelian countries, he explained that absence of fire leads to increased woody plant diversity. Similarly Frost and Robertson (1987) noted that exclusion of fire leads to an increase in woody vegetation while fire incidences have a tendency to reduce woody diversity.

The result from species richens index revealed that unburned woodland (A) higher values than the rest. This result is inline with the result obtained from species diversity index.

Regarding species similarity index, site A had higher values with the rest as the highest species number was found here. The three sites (B, C and D) had less values of similarity index with one another than with A. This could show that these sites lost some species probably due to fire hazard.

Plant density values were significantly high in the burned doum palm vegetation (E) than the unburned plot (F). The difference was observed on the diameter class1 and 2. Here fire seems to stimulate germination of the palm seed. Similarly high number of seedlings for *Acacia senegal* was observed in the burned site D and no seedling of this species was observed at the unburned site. Burning seems to increase germination of the two species.

On other hand the woodland in the unburned block (A) had more plant density than the burned (D) one. Similarly the old burned grassland had more density than the recently burned grassland. This could be related to the poor soil seed bank in burned woodland and lately burned grassland Fire kills some of the mature trees, which can bear seeds. Therefore even though fire stimulates seed germination very few or no individuals may remain to bear seed following the fire event. So these species need more time to re-establish them selves after fire. The presence of the seedlings and saplings of *A. tortilis* and *B. aegyptiaca* in the old burned grassland is in line with this explanation.

A tortilis was absent from the burned woodland while it existed in burned grassland. This could be related to fire severity. This species seems to be susceptible to fire. The appearance of few mature trees of this species in the recently burned grassland (C) could be due to the less severity of grassland fire than the woodland fire.

Similarly the absence of *B. aegyptiaca* from the recently burned areas could be related to fire hazard. Because the species seems to regenerate in the old burned grassland. There fore there is a probability for this species to survive fire hazard when the fire is infrequent as in Awash.

The absence of plant individuals of diameter class 3 within the burned woodland (D) might indicate the extent to which the site was affected by fire. The absence of mature plants might have contribution to the poor soil seed bank as well as the poor germination.

The fact that *A. oerfota* is not represented in diameter class three indicate that individuals of this species are not mature enough to bear seeds and at the same time the species seem to be gap colonizer following disturbances. This could be a reason for being absent from diameter class one regardless of its presence in diameter class 2.

D. cinerea appeared only on the old burned grassland. According to Jacobs and Schloeder (1993) the abundance of the species in this site was related to activities of ungulates. The seed of this species breaks its dormancy after passing through the guts of ungulates i.e. ungulate dispersed.

On other hand *A. sieberina, B. aegyptiaca* and *Z. abyssinica* were not abundant in the standing vegetation. Therefore they could not produce large number of seeds to secure regeneration. This might also contribute for being susceptible to fire hazard.

Temperature had a significant influence on the germination of all seeds of species encountered in the experiment except for *B. aegyptiaca*. The species were differed in the way they responded to the heat shock.

Two species responded negatively (*A. oerfota and C. farinosa*) to the heat shock. Heat shock treatments seem to reduce germination of *A. oerfota*. The fact that no germination was recorded above 90^0 C could show the sensitiveness of the species even to light burning. Therefore elimination of viable seeds from the soil seed bank could be expected even after a light burning. This might reduce the potential of the species to resist fire hazard. On other hand *A. oerfota* seems to colonize the burned woodland (D). This could not be from the soil seed bank as there was no single seedling observed from the seed bank. Therefore the presence of this species in the burned woodland could be related neither to seed heat resistance nor to soil seed bank strategy. It could be due to dispersed seed from the surrounding vegetation. If fire out break covers the whole area of the park including the surrounding the species could be in danger.

Similarly *C. farinosa* seems to be highly fire sensitive. The small seeds of this species could be easily damaged by heat and fire incidence might adversely affect the species. This could be the reason for its absence from the burned areas.

In some species low and medium temperature seems to favor germination. Seeds of Acacia species (*A. senegal, A. sieberina, and A. tortilis*) showed good germination responses at 60^0C and 90^0 C. These temperature levels seem optimum to increase germination of the three species. Generally the extension of the time to 5 minutes might have value only for this temperature levels. The result for *A. senegal* agrees with the findings of Minassie Gashaw (2000). He noted high germination at 60 and 90^0C for this species. The two species (*A. Senegal* and *A. tortilis*) did not germinate at temperatures of above 120^0c. This may show that germination may not be secured when fire intensity become increased above this level. How ever these species could be benefited from the light burning. The result for above ground vegetation show that there was no individual of this species (in the burned areas) belonging to diameter class three, which could be related, to fire kill. On the other hand it was abundant in diameter class1 and class2. Therefore abundance of seedlings and saplings for this species in the burned site could be related to increased germination following light burning together with the reduced competition for resource and space following fire.

For *C. sinensis* and *Zizipus abyssinica* untreated seeds seem to have good germination frequency. At medium temperature levels (60 and 90^0C) germination frequency was slightly. As temperature went up germination decreases even though they can resist and can survive at temperature level of 200^0C. Duration of the experiment seems to affect these species more than temperature levels. How ever the level of damage seems to be tolerable. The fleshy covers, the hard seed coats and the relatively larger size of their seeds might contribute to high fire resistance. Generally fire is not necessarily needed for germination of this species even though it is favorable at low and medium intensity, as the species could perform well even in the luck of heat shock. On the other hand their high resistance against fire damage can contribute for survival of these species after fire hazard.

Grewia species (*Grewia erythraea and Grewia villosa*) seem to be more fire resistant than other species in the study area. Temperature below 60^0c might not able to break seed dormancies in these species. The four lobed seeds covered by fleshy fruit and strong seed coats seem to give these species high fire resistance. Duration of the fire could have advantage for these species as high germination percentage was observed at 5 minutes duration. The resistance of these species for temperature level of 200^0C might contribute to their being abundant in the burned sites.

The larger size, fleshy cover and hard seed coat might contribute for the high heat resistance of seeds of *B. aegyptiaca*. This species could survive after intense fire if the fire occurred after seed dispersal even if the standing plant dies out.

Temperatures of 60, 90 and 120^0C seemed to be stimulating germination for most of the experimental species. The extension of the duration from 1 minute to 5 increased germination while for higher temperature levels (150^0 C, 200^0 C) germination decreased significantly at 5 minute duration. Therefore, a combination of optimum fire intensity (90 and 120^0 C) with 1 minute duration seems to result in high germination frequency. However, a combination of low intensity fire (60^0 C) and extended duration may also lead to high germination frequency in some species, as in *A. senegal* and *A. siberina*.

Those species having higher seed size (*B. aegyptiaca and Zizpus abyssinica*) seem to resist temperature level of 200^{0}C at 5 minute duration while the one with smaller seed size (*A. oerfata, C. farinosa*) could not germinate above 90^{0}C. This could be related to surface area to volume ratio. Keely (1977) noted high heat resistance in seeds having relatively bigger size and this result seems to support his observation.

The soil seed banks of the study area were dominated by herb species. The density of seeds of herbs and grasses in the soil were much higher than the woody species. This could affect the seedlings of woody species as the herbs and grass species might highly compete for nutrient flushes following fire. This event could reduce the role of the seed banks in post fire survival of woody species.

No seed of the woody species was recorded at 8.5 cm while at 5.5 cm only seedlings of *A. mellifera* were recorded. Most of the seeds of the seed banks (95%) are exposed to the heating effect of fire, which may result in high seed mortality following fire. Infrequently occurrences of fires make the damage more severe as infrequent fires are more intense.

In general the abundance of soil seed bank of woody species in the study area was so small even in the unburned plots. Loss of seeds to insect attack could contribute to the low abundance of woody plant seeds in the soil. An additional explanation for the low species abundance of the seed bank could be unexpected rain in the dry season, which makes the seeds to germinate and die out soon. The other point is that seeds remain in the soil seed bank only for a short period of time as noted by many authors. The formation of such a transient seed bank is common in woodland and primary forest species (Enright, 1985; Young *et al.*, 1987; Demel Teketay and Granstrom, 1995; Dalling *et al.*, 1997). The input of seeds, their capacity for dormancy and the loss from the seed pool determines the density of seeds and the seasonal changes in the abundance of viable seeds in the soil (Demel Teketay and Granstrom, 1995; Dalling *et al.,* 1997).

Correspondence between species number and floristic composition of the seed banks and the standing vegetation was low, only 5 of the 13 species were found in the soil seed bank. Study from the degraded land in south Wello, Ethiopia showed similar results (Kebrom Tesfaye, 2000) Other studies in woodlands also indicate poor correlations for the seed banks and standing vegetation (Thompson and Grime, 1979; Demel Teketay and Granstrom, 1995). This could show that there is a great risk of local extinction following intense fire for most of the species. On the other hand less correspondence between above ground vegetation and soil seed bank of woody species might indicate that the woody species in the study area might not use soil seed bank as a major strategy for regeneration after fire. Similar studies showed soil seed bank strategy as the least preferable in African woodlands (Skoglund, 1992; Demel Teketay and Granstrom, 1995; Dalling *et al.,* 1997; Minassie Gashaw, 2000).

After a fire incidence plants regenerate to recolonize a burned site either by germination or sprouting. The availability of soil nutrient at regeneration time following fire is very crucial for the seedlings establishment. Fire seems to influence soil chemical properties in one way or another. The pH value which affects nutrient availability seems to increase after burning. Values from the burned plots were higher than the unburned correspondents. This result is in line with findings of Cass *et al* (1971) where he noted the release of basic cat ions as a result of burning to increase pH values. Braithwaite (1996) also noted that the fire as rich in basic cation tends to raise the pH of a soil after burning.

The increase in organic matter content in the burned woodland could be related to fire incidence. Burning might contribute to increase in organic matter. Burned plots had higher soil biomass C than unburned plots. This result is in line with the conclusion of Wells (1971) in which he noted increase in organic matter of up to 30% for the upper 5 cm soil depth. The relatively higher value of burned palm vegetation was not significant when compared with the unburned palm. This might show that the intensity of fire and the composition of the organic matter can determine the degree to which fire affects soil organic matter contents (Knight, 1966).

Unlike the organic matter the content of total nitrogen doesn't show significant differences. Total nitrogen is expected to be low after burning due to volatile loss. However, the higher values for burned woodland could be due to nitrogen fixing bacteria (Braithwaite, 1996). They bacteria are expected to compensate the volatile loss. Further more savanna fires are not strong enough to completely decompose the organic matter in which high loss is expected. In some cases nitrogen loss up to 63% is expected mostly when the intensity exceeds 200^0 C (Knight, 1966). The grassland, having the same fire history with the burned woodland showed less value than the woodland. This might be due to the relatively less density and diversity of legume woody species in the grassland (which can harbor nitrogen-fixing bacteria). Intense grazing could also affect the total nitrogen content in the grassland sites when compared with the wood lands where grazing is less intense (Frost and Robertson, 1987).

The highly significant value for amount of available phosphorus in the burned palm vegetation could be related to fire incidence. However there was no difference for the means of total phosphorus between burned and unburned palm. Therefore, burning might contributed for the high value of available phosphorus in the burned palm. For the other pairs the luck of significance value may show that the release of the element is temporal. The fact that the value recorded from the recently burned block (E) was significantly higher than the rest may also strengthen this statement. Similarly Kellman *et.al* (1985) reported large flushes of phosphorus appeared following fire was deposited only in the surface soil and this sediment was immobilized rapidly probably by adsorption on the exchange complex and by fixation in combination with Fe and Al. According to Menaut *et al* (1993) the low solubility of phosphorus and its tendency to form complexes with Al and Fe (for acid soil) or Ca and Mg (for alkaline soil) protect it from leaching. This conclusion was supported by this result, as there was no significance difference in amount of total phosphorus among the six sites.

According to many authors concentration of cat ion is expected after burning as the residual ash is full of cat ions (Trabud, 1994; Braithwaite, 1996; Frost and Robertson, 1887; Kauffman, 1980). In this study this statement holds true for Sodium and Calcium. The mean deference based on independent t-test for Sodium and Calcium showed highly significant values.

Unlike Na and K, Ca and Mg showed very low concentrations in the palm than in the woodlands and grasslands. DeBano and Conrad (1978) for instance reported that a small decrease in Potassium and Magnesium following fire. Similarly, Christensen (1977) and Trabaud (1994) have found no change or an actual decrease in soil concentration of these cat ions.

Fire incidence seems to have an effect on the cat ion exchange capacity of the soil as significantly high values were recorded for the burned sites than the unburned. According to DeBano and Conrad (1978), clear effect of the change in cat ion exchange capacity was observed following fire. These authors noted that cat ion exchange capacity follows organic matter content and our result show that the sites with higher organic matter content have higher cation exchange capacity.

7. CONCLUSION AND RECOMENDATIONS

The local fire regime at a specific site, play an important role in determining the composition of the plant community. The immediate impact of wild land fire on woody species is considerable. Following fire major change in the woody plant communities could occur and this was observed in Awash National Park. The burned site was relatively poor in species diversity and density in grassland and woodland vegetation types. For the doum-palm, density was highly increased following fire while there was no change in species diversity. The decrease in diversity of woody species in the study areas could bring local extinction to some of these species in the long term. This could be more pronounced if the fire incidence becomes more frequent. On other hand loss of diversity of woody species following fire can make the fire important tool to protect the grassland against woody encroachment. Especially the Ilala Sala plain, which is the main feeding ground for the Beysa Oryx and other ungulates, is being evaded by woody species in the sites, burned 5 years back. Therefore well-planned prescribed fire can contribute for maintenance of the grassland.

Most of the study species showed increase in seed germination following fire. Most species showed better germination at 60^0 and 90^0 C even when the time was extended to 5 minutes. Germination was observed to decrease at higher temperatures (150^0 and 200^0C) even though some can survive after being exposed to temperature of 200^0 C for 5 minute. Seeds with higher seed size showed high resistance to fire. However, seed resistance to fire alone may not enough for a species to survive and being abundant under a given fire regime. *Acacia totilis* and *Balanites aegyptiaca* could be an example. These species were abundant in unburned area and infrequently observed in the old burned site but not observed in the recently burned areas. So other fire resistance mechanisms like soil seed bank and bark resistance to heat may contribute for better species survival following fire.

The amount of seeds in the soil seed bank varies spatially. Most of the seeds in the soil seed bank were concentrated in the upper 0.5 cm depth. This could expose the seeds to fire damage and most of the seeds could be destroyed after fire incidence. Herbaceous plants followed by grass species dominate the soil seed bank, which could affect the seeds of woody species. Woody species are poorly represented in the soil. Only 5 of the 13 species were observed in the seed bank. Even those observed have very low density, which is not enough for insuring survival after disturbance. There fore, soil seed bank strategy could not be reliable to secure species survival for the study sites.

The effect of fire on nutrient cycling is one of the most important facets of fire ecology. Due to the various interactive and non-interactive environmental factors operating under a given ecosystem, it is still not possible to predict whether burning has a beneficial or adverse effect on the overall nutrient status of a particular ecosystem. However in this study pH value, available phosphorus, calcium and cat ion exchange capacity were observed to be higher for the recently burned sites than the unburned and late burned sites.

Based on these results the following recommendations are made:
The less diversity of burned areas and the poor soil seed bank of woody species predict that if the frequency of current fire regime becomes changed these species will be at great risk of extinction. Therefore it is necessary to control woodland fire.

If burning is needed it should be after seed dispersal as most of the seeds of the woody species seem to be fire resistant. Moreover better soil seed bank could be expected after dispersal. Therefore there is better chance of survival for the woody species after late season fires.

To have better understanding on performance of the woody species under current fire regime the potential of each species to resist fire hazard and the survival strategies after a fire should be studied.

To use fire as a management tool in the national park the effect of fire on the other plant life forms should also be studied.

Forest fires vary on their intensity; frequency and duration .In order to have better understanding of fire effects these three aspects should be studied as well.

Fire policy formulation is needed at national and regional levels to use fire for management purposes and to conserve biodiversity from fire hazard.

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