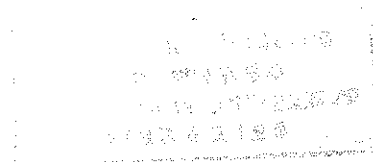


**SOME KENYAN MEDICINAL PLANTS USED IN  
TREATING JOINT DISEASES: ETHNOBOTANY, SEED  
CHARACTERISTICS, GERMINATION PHYSIOLOGY AND  
THE POTENTIALS FOR GERMINANTS TO ESTABLISH**

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**A THESIS SUBMITTED IN PARTIAL FULFILLMENT FOR THE  
DEGREE OF MASTERS OF SCIENCE IN BIOLOGY.  
ADDIS ABABA UNIVERSITY**



**DECEMBER 1998**

## DEDICATION

*This thesis is dedicated to my daughter, SHARON NYAWIRA (Wiri).*

*“You patiently waited for mummy to put down her pen”*

AND

*To the memory of my mother, the late MRS NYAWIRA MATU.*

*“Thanks so much mum, for you never stopped at anything to ensure that I had acquired higher education.”*

## ACKNOWLEDGEMENTS

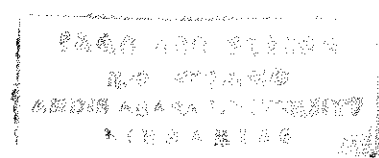
I would like to sincerely thank my advisor, Dr. Legesse Negash for his advice and patience in the course of this study. Dr. J. Odera, the coordinator, EWEMP is acknowledged for his input on the ethnobotanical part of this study. The financial support provided by DAAD through NAPRECA is greatly acknowledged. I would like to thank my employer, KEMRI for granting me study leave. The Rapid Propagation of Trees Project is acknowledged for the provision of a computer facility and the chemicals. I wish to thank the Department of Biology for providing the facilities.

I am grateful to the local people of Elang'ata Wuas for their hospitality and kind response to my inquiries on information about the medicinal plants. Surely, they gave this thesis its direction. Thanks to the EWEMP team for the friendship and patience during the course of the fieldwork. A special note of thanks goes to David Sirim, my research assistant for not tiring as we trekked from one ridge to another.

I am indebted to the following members of staff, AAU who made a contribution to the completion of this study: Prof. Sebsebe Demissew, Dr. Zemedu Asfaw, Dr Solomon Yirga, Dr. Yalemtehay Mekkonen, Dr. Ermias Dagne and W/t Elizabeth Yohannes. Prof. Johnson is sincerely thanked for providing some literature on Ethnobotany. W/t Mammi Asrat, W/t Bungule, Ato Antene Tesfaye and Ato Getachew not only provided technical assistance in the laboratory and in the glasshouse but were also great companions, to whom I am very grateful. Members of staff, the National Herbarium are sincerely thanked for their unfailing support any time I needed some assistance. I thank my colleagues in the department especially Ato Yonas Feleke, Daniel Elias, Berhane Haile and Pascale Nauche for assisting with statistical analysis and being there whenever I needed to consult.

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Lastly but not least, I would like to thank my family especially my dad, mzee Matu, for their prayers, material and moral support. A very special note of thanks goes to my sister, Mrs Lucy Muthoni for taking care of my daughter Wiri during my absence.

I give all the glory and honor unto God, the Almighty. Great has been your faithfulness, oh Lord!

## ABSTRACT

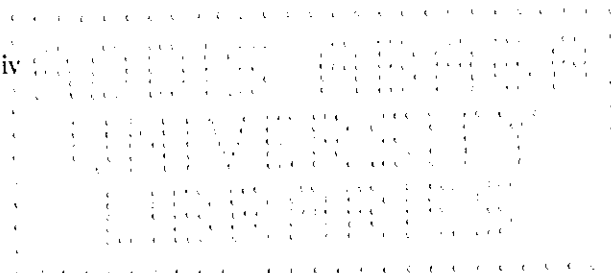
This thesis presents a documentation of indigenous knowledge on plants used in treating joint diseases followed by investigation on some seed characteristics, germination physiology and potentials for germinants to establish of three of the plant species.

In a participatory approach, indigenous knowledge was documented from the local people living in the area under the mandate of Elang'ata Wuas Ecosystem Management Program, (EWEMP), Kajiado District, Kenya. Semi-structured interviews and guided field walks were used in collecting the information. The study on the seed characteristics and germination physiology focused on three plant species namely: *Strychnos henningsii* Gilg., *Myrsine africana* L. and *Ziziphus mucronata* Willd. ssp *mucronata*. One hundred seeds were taken randomly and their size (length and width) and weight measured. The seeds external characteristics including the shape, color, seed-coat features were noted. The seeds were also incubated in distilled water and the embryo examined microscopically twenty-four hours and ten days after sowing. For germination physiology studies, different concentrations ( $10^{-3}$ - $10^{-7}$  M) of three plant growth regulators namely Gibberellic-3-acid ( $GA_3$ ),  $\alpha$ Naphthleneacetic acid (NAA) and Benzyl-aminopurine (BAP) were investigated for their influence on the seed germination.

Investigations on the potentials for germinants to establish were carried out on *Strychnos henningsii* Gilg and *Myrsine africana* L. germinants. One hundred *Strychnos henningsii* germinants (all from distilled water treatment) and one hundred and twenty *Myrsine africana* germinants (thirty each from  $GA_3$   $10^{-4}$ , NAA  $10^{-7}$ , BAP  $10^{-6}$  M and distilled water) treatments were investigated for their potential to establish over a period of eight weeks.

The findings from this study revealed that twenty-one plant species, all of which are harvested from the wild, are used in treating joint diseases. The roots are the parts mostly used in treatment of joint diseases followed by the stem barks. Use of plant species in combination with others (concoctions) was widely reported. Traditional conservation practices applicable to trees and shrubs were reported. Two plant species namely: *Ruellia patula* Jacq. and *Heliotropium rariflorum* Stocks ssp *hereroense* (Shinz.) Verdc. were reported not to be as readily available as they were in the past.

The seeds of *Strychnos henningsii* and *Myrsine africana* showed no conspicuous changes (size and appearance) after soaking in water for twenty-four hours or ten days. Almost all the seeds of *Ziziphus mucronata* Willd. ssp *mucronata* were dead. On the influence of plant growth regulators on seed germination,  $GA_3$  and NAA showed significant differences with the control in *Strychnos henningsii*. Higher concentrations of NAA ( $NAA10^{-3}$  and  $10^{-4}$  M) delayed germination for twenty-one and seventeen days respectively. In *Myrsine africana*, all the treatments showed significant differences with the control. Germination was poor (less than 20%) in all the treatments in *Ziziphus mucronata* ssp *mucronata* seeds. Ninety-nine percent of *Strychnos henningsii* germinants survived for eight weeks. In *Myrsine africana*,  $GA_3$   $10^{-4}$  M treated germinants showed the highest mortality (31%).



From the results of this study, it could be concluded that (i) treatment of joint diseases using medicinal plants mostly utilizes the roots and the stem-barks, parts if excessively removed could lead to the death of the plant. (ii) No efforts have specifically targeted the propagation of the medicinal plants and hence there is need to in-corporate medicinal plants in plant propagation programs. (iii) *Myrsine africana* seeds seemed to be under germination inhibition and hence would require pre-treatment before sowing. Further studies to identify the appropriate pre-treatment techniques are recommended.

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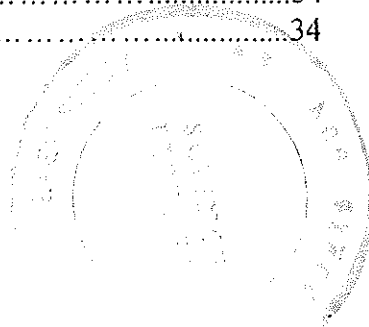
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## 1. INTRODUCTION

The major role of medicinal plants in health care is for instance demonstrated in the developing countries, where it is estimated that about 80% of the people rely on traditional medicine for their primary health care (WHO, 1978). Besides, many modern day drugs owe their origin to plants (Bell, 1993; Farnsworth, 1996). Although traditional medicine involves the use of other substances other than plants, plants form the backbone of this healthcare system (Farnsworth, 1988; Dawit Abebe and Ahadu Ayehu, 1993). However, information on the number of plants employed in traditional medicine and how they are used in traditional therapy is not exhaustively documented.

Many countries lack complete inventories of their medicinal plant species (WHO/IUCN/WWF, 1993; Cunningham, 1997) yet such inventories are important in surveys to identify unique and valuable components. Such inventories coupled with information from knowledgeable rural people, who have learnt through resource use, rather than formal training can be an invaluable source of information for plant utilization and conservation practices (Cunningham, 1997).

In Africa, the traditional knowledge on utilization of plants was an unwritten science. Most of the knowledge acquired by the local people has been passed onto them by a word of mouth from one generation to another (Nyamwaya, 1992; Kokwaro, 1983). Such orally preserved information is liable to loss if left undocumented.

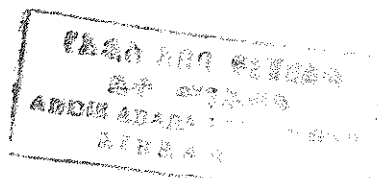
According to Whistler (1988), such kind of information is already threatened with loss due to influence by modern or westernized ways of life. In a rural coastal community in Kenya, it was observed that only the elderly persons were conversant with traditional uses of plants while the young people were disinterested or were busy pursuing modern education (Omino, 1990).

Joint diseases such as rheumatoid arthritis, osteoarthritis and gout afflict many people throughout the world (Mijiyawa, 1995), yet satisfactory cures still remain to be developed (Tyler, 1986). There is need therefore to find drugs in nature for treatment of such diseases. The relevance of ethnobotanical studies on plants used in traditional medicine is that, documentation of the traditional knowledge form a basis for discovery of new plant derived drugs (Cotton, 1996; Heinrich, 1997). Ethnobotany in this case refers to any study that encompasses the mutual relationship between plants and traditional peoples (Cotton, 1996).

Various plant species are used in treatment of joint diseases, such as arthritis, rheumatism and gout (Watt and Breyer-Brandwijk, 1962; Kokwaro 1976; Jansen, 1981; Mesfin Tadesse and Sebsebe Demissew, 1992). According to Sindiga (1994), the Maasai of Narok District make use of medicinal plant species to treat painful joints. There is need therefore to document the ethnobotanical information on plants used in treating joint diseases as a basis for recommendation on their sustainable utilization, pharmaceutical research and overall preservation of the information.

The recent past has witnessed an increased upsurge in public interest on traditional medicine. This is evidenced by, increased activities of Traditional Medical Practitioners (TMPs) (Oketch, 1992), increase in local trade on medicinal plants (Marshall, 1997), increase on international trade on medicinal plants (Xiaroui, 1996; Robbins, 1997; Lange, 1997). As a result, there are reports that some medicinal plants have been over-exploited and are thus becoming scarce (Cunningham, 1994).

Medicinal plants are also threatened as a result of habitat destruction due to inappropriate land use practises (Mburathi, 1984; Cunningham, 1994), timber production (Legesse Negash, 1995; Leakey, 1997), fuelwood production (Kokwaro, 1988) and invasion by foreign species (Quansah, 1988).



The threat on traditional medical knowledge and the medicinal plants calls for urgent need to document the knowledge and to initiate measures to ensure a continuous supply of medicinal plants (Quansah, 1988). According to Kokwaro (1995), there is need for development of improved techniques of propagation of medicinal plants especially the scarce, slow-growing and those vulnerable to over exploitation due to their popularity.

However, information on the seed biology, germination physiology and potentials for germinants to establish is lacking as far as most of the medicinal plants are concerned (WHO/IUCN/ WWF 1993). This is because not many countries have been actively involved in conservation of medicinal plants in the past (Mbenkum 1988; WHO/IUCN/ WWF 1993).

Many indigenous plant species have germination problems due to factors such as possession of hard seed coats (Legesse Negash 1992; 1993; 1995), possession of recalcitrant seeds (Scheafer *et al.*, 1994; Normah *et. al.*, 1997) and embryo dormancy (Wang *et al.*, 1982) among other factors. Such seed characters result in low and sporadic germination thus posing problems to foresters and the local people who may wish to propagate the medicinal plants (Prins and Maghembe, 1994). Verinube (1991) reports that many indigenous plant species exhibit poor germination and poor seedling survival.

In a bid to ensure a continuous supply of medicinal plants as well as arresting land degradation processes, massive propagation of plants should be initiated. Information on potentials for rapid propagation and field performance of the seedlings is a crucial step towards ensuring a continued supply, domestication, conservation of valuable resources and a reverse in degradation of natural forests (Michelsen, 1992; Maghembe *et al.*, 1994).

Detailed information on the seed, germination physiology and potentials for germinants to establish is a prerequisite if such an endeavor is to succeed.

The objective of this study was therefore to document and evaluate indigenous knowledge on medicinal plants used in treating joint diseases and investigate the potentials of some of some of the plants for their (i) rapid seed germination and (ii) germinants and seedlings establishment in the glasshouse.

## 2. LITERATURE REVIEW

### 2.1. Joint diseases: A health problem

Joint diseases are usually discussed under the terms rheumatism and arthritis (Wilson *et al.*, 1976). According to Lewis and Elvis-Lewis (1976), rheumatism describes many conditions associated with the diseases of the joints, tendon, muscles or bones while arthritis refers to inflammation of a joint.

However, depending on the causative factors, there are various diseases that afflict joints. Examples include Rheumatoid arthritis (RA), Osteoarthritis (OA), gout, psoriatic arthritis, hypothyroid arthropathy and systematic lupus erythematosus among others (Grady *et al.*, 1998). Rheumatoid arthritis and Osteoarthritis are the most common types of arthritis managed in health care (Ross, 1997; Grady *et al.*, 1998). They are reported to be the major contributors of disability in older people, particularly females (Hughes and Dunlop, 1995; Kvien *et al.*, 1997).

In Britain alone, it is estimated that one and a half million people have some form of arthritis (Wilson *et al.*, 1976). Gout is reported to be on the increase in Europe (Harris *et al.*, 1995) and in urban areas in Africa (Darmawan and Lutalo, 1995). In Kenya, for instance, 11% of patients attending a traditional medicine clinic in 1989 had joint diseases complaints such as gout and arthritis (Githae, 1995).

### 2.1.1 Rheumatoid Arthritis

Rheumatoid arthritis (RA) is an inflammatory condition caused by an abnormal immunological reaction such that the body attacks itself, eventually destroying the internal structure of the joint and tissues around them (Rogers, 1995). Hands and feet are mostly the affected parts but the knees, shoulders and spine can also be hit (Robbins 1995).

The symptoms of Rheumatoid arthritis include joint stiffness in the morning followed by aching, swollen hot joints, fatigue and depression (Ross 1997; Robbins 1995). A pair of joints is affected at a time (Robbins 1995; Ross 1997). In severe cases, deformation of knuckles occurs (Wilson *et al.*, 1976; Rogers, 1995).

The underlying mechanisms of RA are not understood. There are indications that genetic (Alarcon, 1995; Moroldo *et al.*, 1997; Koumantaki *et al.*, 1997) and environmental factors such as cold weather (Hameed and Gibson 1997), smoking, obesity and blood transfusion (Symmons *et al.* 1997) are involved. However, there is no full proof evidence that environmental factors are involved (Weyand and Goronzy, 1995).

Palaeopathological evidence shows that RA has existed in the New world (now USA) since 400 BC. However, there is no evidence that it existed in Europe or Africa before the 17<sup>th</sup> and 20<sup>th</sup> century respectively (Abdel-Nasser *et al.*, 1997). Although, RA is usually associated with modern industrial societies (Wilson *et al.*, 1976), epidemiological data indicate that RA occurs throughout the world (Mijiyawa 1995). However, the prevalence is higher in Europe and the United States of America compared to Asian and African countries. Jamaica has the highest prevalence in the world with about 2% of the adult population affected (Mijiyawa, 1995).

Rheumatoid arthritis is said to be rare in Africa (Mijiyawa, 1995). This could be due to claims of too little information on rheumatic diseases (Adebajo, 1995) or reduction in severity of the disease (Mody, 1995). However, according to Mody (1995), the existence of RA cannot be ignored as new cases are being reported in large numbers in many parts of Africa. There is no cure for rheumatoid arthritis (Wilson *et al.*, 1976; Robbins 1995). However, various drugs are used in treatment/management of RA, for instance phenylbutazone, indomethacine which are used to relieve inflammation and salicyclates used in mild cases to relieve pain (Wilson *et al.*, 1976).

### **2.1.2 Osteoarthritis**

Osteoarthritis is the most common form of arthritis and typically occurs in people more than 60 years of age (Lewis and Elvin-Lewis, 1976; Ross, 1997; Hughes and Dunlop, 1995). It involves cartilage destruction (Ross, 1997) due to wear and tear of the joint surfaces where they articulate (Rogers, 1995). Osteoarthritis usually affects the hips and the knees but the vertebrae can also be affected. Unlike Rheumatoid arthritis, one joint is affected at a time (Robbins, 1995). The symptoms include pain and aching in the affected joint later in the day, followed by inflammation (Robbins, 1995) and development bony joints and arthralgia that worsens with weight bearing (Ross, 1997).

Treatment includes use of drugs such as acetaminophens, non-steroidal anti-inflammatory drugs (NSAIDS), exercise and surgery in severe cases (Rogers, 1995; Ross, 1997). Like Rheumatoid arthritis, there is no orthodox cure for osteoarthritis (Robbins, 1995).

### **2.1.3 Gout**

Gout is a metabolic disorder that is caused by derailment of purine metabolism hence accumulation of uric acid (waste product of nucleoprotein metabolism) in the body particularly the joints (Robbins, 1995). Accumulation of uric acid in the joints gives rise to acute attacks of arthritis and finally to a chronic form of gouty arthritis in which the uric acid level in the plasma becomes chronically elevated (Wilson *et al.*, 1976).

Epidemiological studies indicate that gout is a common disease with a worldwide distribution (Peichl, 1997). Recent studies in England indicate that gout is on the increase having doubled in the 1970s to about 3 per 1000 (Harris *et al.*, 1995). The increased prevalence can be attributed to alcohol abuse (Fam *et al.*, 1997). In Africa, there are reports that gout is increasingly getting recognized especially in the urban centers (Darmawan and Lutalo, 1995).

Drugs such as colchicin are used for treatment of acute form of gout whereas probenecid and allopurinal are used for chronic forms of gout (Wilson *et al.*, 1976). However, a change in lifestyle and especially cutting down on purine rich foods, for instance, red meat, alcohol and caffeine drinks is recommended (Robbins 1995).

## **2.2. Significance of medicinal plants: a historical perspective**

After food and shelter, the medicinal uses of plants are probably one of the earliest of humans discoveries (Trease and Evans, 1983). According to Sofowora (1982), as early as 5000-4000 BC, the Chinese were already making use of medicinal plants while in Egypt, as early as 1600 BC, the use of medicinal plants such as myrrh, cannabis, opium, aloes, hemlock and cassia have been recorded.

In Assyria for instance, a herbal had been compiled by about 660 BC, two hundred and fifty vegetable drugs were then known and gardens in which medicinal plants were cultivated were in existence (Mbenkum, 1988). In most of the African countries, lack of written literature makes it difficult to trace the history of utilization of medicinal plants (Sofowora, 1982) but the use of medicinal plants and other substances perceived to be therapeutic, was the only means of health care before the introduction of modern medicine.

### **2.3. Medicinal plants in traditional therapy**

The number of plants used in traditional medicine is not clear. Estimates range from 35,000-70,000 species of higher plants (Bronner, 1990) although lower plants are also used in traditional medicine (Kokwaro, 1995).

Economic limitations coupled with cultural attachment to traditional medicine have led to the persistence of utilization of medicinal plants especially in the developing countries (Good and Kimani, 1980; Nyamwaya, 1992; Sindiga, 1995). Precise statistics of the people utilizing traditional medicine remains unclear (Good and Kimani, 1980). However, it is estimated that a large proportion of people either totally or partially make use of medicinal plants at one time or another for therapeutic purposes (Obado and Odera, 1995).

Although traditional medicine employs the use of other substances, for instance, animal parts and mineral substances, medicinal plants form the bulk. A report on enigmatic health practices as practiced in northern Ethiopia revealed that 87% involved the use of plants, while animal parts and mineral substances accounted for 11 and 3% respectively (Dawit Abebe and Ahadu Ayehu, 1993).

According to Berne *et al.*, (1988), an ethnobotanical study among the Samburu, a pastoral community in Kenya revealed that the use of plants as medicine was only second to fodder. A similar survey among the Maasai of Loita in Narok District, Kenya, showed that 60 out 136 (44%) plants were of medicinal application (Karehed and Odhult, 1996).

According to Nyamwaya (1992), the use of plants as medicines among the pastoral communities is generally higher in comparison to non-pastoral communities. He reports that the practice has mostly persisted due to the people's ways of life. They largely interact with nature and their movement from one place to another makes access to modern health care facilities difficult. Besides, pastoralists are very conservative of their traditions and traditional medicine is considered as one of the traditions.

The use of plants in traditional health care is widespread. For instance, according to Odera (1997), it is estimated that, 70-90% of the Kenyan population totally or partially makes use of traditional medicine. In Cameroon, a survey revealed that 88% of the households made use of medicines obtained from wild plants (Jeanrenaud 1991, cited in Leakey, 1997). Even in a relatively more developed country like Swaziland, 85% of the population was reported to have been making use of traditional health services by 1983 (Green and Makhubu 1983, cited in Dlamini, 1997).

### 2.3.1 Medicinal plants and joint diseases

Various accounts of plant uses as medicine indicate that plant species have been traditionally used in treating joints related diseases. Examples of such plants include *Warbugia ugandensis* Sprague, *Ziziphus mucronata* Willd. (Kokwaro 1976), *Zanthoxylum gillettii* (Abbiw 1990), *Cissus bachelianii* Pax. and *Olea chrysophylla* Lam. (Williamson, 1956). For treatment of gout roots from *Landolphia bachelianii* (Hall f.) Staph. (Mesfin Tadesse and Sebsebe Demissew, 1992) and *Clematis simensis* Fres. are used (Jansen 1981).

In Madagascar, a concoction prepared from *Jatropha* spp and other plants is used to massage joints affected by rheumatism and arthritis (Quansah 1988). Willow bark (obtained from *Salix alba*), ginger (*Zingiber officinale*) and Devils claw herbal preparations are used in treatment of arthritis related conditions (Wilson *et al.*, 1976; Rogers 1995).

## 2.4 Role of medicinal plants in pharmaceutical industries

For many years, plants have been sources of compounds used in treating many diseases (Trease and Evans, 1983). The bioactivity in plants is due to the presence of secondary metabolites such as alkaloids, flavonoids, saponins, terpenoids, sterols and other compounds such as fatty acids among others (Kokwaro, 1976).

Plants continue to offer lead compounds in drugs development, despite advents of new technologies in synthetic chemistry (Leakey, 1997). Examples of modern day drugs that owe their origin to plants include; reserpine from *Rauvolfia serpentina* (L.) Benth, artemisinin from *Artemisia annua* L., vincristine and vinblastine from *Catharanthus roseus* (L.) G. Don., digitoxin from *Digitaris purpurea* L., quinine from *Cinchona* spp (Bell, 1993; Farnsworth, 1996). *Prunus africana*, which is widespread in the tropics, is used as a source of a sitosterol glycoside, which is used in managing urinary track disorders (Leakey 1997).

It is estimated that 50-100 million US Dollars are required for every new product that is developed from plants (Tyler, 1986). This means that the economically limited African countries, should aim at standardizing crude extracts rather than synthesizing pure drugs (Farnsworth, 1996).

## 2.5 Trade in medicinal plants

The recent past has witnessed an increase in the volume of traded medicinal plants at local and international markets (Cunningham, 1990; Marshall, 1997; World Bank, 1997). In the developed countries, the increase in trade and utilization of medicinal plants has been enormous. This is accounted for by an awareness of the negative side effects of conventional/modern drugs thus the notion "return to nature" (FAO, 1983). An increase in health care costs has also led to the tendency of self medication using minimally processed medicinal plants (Ayensu, 1978; Robbins, 1997).

According to Bannerman *et al.* (1983), the volume of traded medicinal plants, for instance, aloes, belladonna, cinchona, foxglove and senna was noted to have increased in the order of 5-7%. In Japan, there was a 15% increase in sales of medicinal plants compared to that of conventional pharmaceuticals which only increased by a value of 2.6 in 1988 (Xiaroui, 1996). A global trade valued at more than USD 800 million was recorded annually both in 1995 and 1996 (Lange and Schippmann, 1997). Germany is reported to be the world's number one importer of medicinal plants (Lange, 1997).

In most African countries, the statistics on the volume of medicinal plants traded locally and internationally is lacking. However, crude data from the customs officials indicate that some form of trade takes place (Marshall, 1997). Casual observations in the local markets also reveal the existence of some form of trade. However, it is reported that over four hundred indigenous species and twenty alien species are commercially sold as herbal medicines in South Africa (Cunningham, 1990).

## **2.6 Conservation of medicinal plants**

In various parts of the world, medicinal plants are mostly harvested from the wild sources either for local use (Omino, 1990; Obado and Odera, 1995; Ochieng 1997) or trade purposes (Lange, 1997). However, there were checks and balances in the past that made the use of such plants sustainable. Examples of such practises included, taboos on felling certain plants, seasonal and social restrictions on gathering and the nature of the gathering equipment (Odera, 1997). As a result of a breakdown in many traditions, such customary conservation practices are no longer in place.

With the increasing use of medicinal plants in many countries, it has become clear that their exploitation must be accompanied by conservation if they are to be preserved from depletion or even extinction.

Various reports indicate that several medicinal plants are threatened due to practices such as overcollection (Mbenkum, 1988), harmful collection techniques, for example, "ring barking" (debarking all around the tree trunk), excessive digging of roots (Cunningham, 1990) and "selective destruction" (collection of some plant species in large quantities for research in search for cures for incurable diseases e.g. HIV/AIDS and hypertension among others) (Tesda, 1991).

Examples of some of the medicinal plants reportedly threatened include *Warbugia salutaris*, *Dalbergia melanoxylon* and *Zanthoxylum chalybeum* in Kenya (Oketch, 1992). *Maytenus senegalensis* and *Strophanthus kombe* in the Usambara mountains, Tanzania (Tesda, 1991). In South Africa, some plants are almost extinct for instance *Ocotea bullata*, leading to their collection being controlled by the government (Cunningham, 1994).

According to Marshall *et al.*, (1996), about 19,000 ha of forest cover is felled or converted each year in Kenya, compared to afforestation efforts at 10,000 ha. per year. This implies that some medicinal plants could be getting lost already. There are also reports that over the estimated 6,500 plant species in Kenya, 1000 are of conservation interest, and over 100 are already threatened with extinction (IUCN, 1990).

In the past, medicinal plants have not been of major concern to conservationists (Kokwaro, 1988; Given, 1994). As a result, only a few countries have taken action to ensure their sustainable utilization and propagation.

On the global scene, the IUCN-WWF Plants Advisory Group reports that as many as 60,000 plant species could become extinct by the year 2050 if the present rate of forest destruction continues unabated. Great losses would be felt in the tropics where 60% of the worlds flowering plants occur (Farnsworth, 1996).

## **2.7 Plant propagation**

Plant propagation (multiplication of plants) can be achieved through asexual or sexual means. Asexual means of propagation is achieved through techniques such as, the use of cuttings, grafting, layering, budding and micropropagation. Asexual mode of plant propagation is advantageous in that, it facilitates preservation of the parents unique characteristics as the genotype of the parent plant is intact in the offspring plant (Hartmann *et al.*, 1990). It is however limiting in that deleterious characters in the parent plant are passed onto the offspring as well.

Sexual means of plant propagation is achieved through the use of seeds, as propagules. This mode of plant propagation is advantageous in that the seed contains a new genetic combination from the parent plants.

### 2.7.1 The seed and its role

The seed is the mature product of the fertilized ovule, which becomes separated from the parent plant upon reaching maturity. Such a seed may eventually germinate to give rise to a new individual. At maturity, a seed comprises of an embryo, storage tissues and the seed coverings (Bradbeer, 1988).

By producing seeds, plants aim at achieving the following objectives:

- Gene segregation and recombination;
- Multiplication mechanism;
- Dispersal mechanism;
- Survival mechanism.

Seeds are variable from one species to another and in some instances, variations can be expressed in different populations of the same plant (Ngulube *et al.*, 1997) or even in seeds produced by the same mother plant.

Seeds vary in shape, size, color, seed-coat characters, embryo shape, size, color, the amount of endosperm and the type of nutritive tissues. Such variations have been shown to influence germination.

In *Salsoa* seeds, for instance, the color of the seed depicts the degree of dormancy in such a way that the chlorophyllous seeds have a higher degree of dormancy than the achlorophyllous seeds (Bewley and Black, 1985). Many members of the compositae exhibit seed polymorphism. For instance, in *Tagetes minuta*, the shorter achenes have a deeper dormancy than the longer achenes (Ngugi, Pers. comm.).

According to Ngulube *et. al.*, (1997) the existence of variations in seeds of different populations of *Uapaca kirkii* led to different germination capacities, a phenomenon which has also been reported in *Dalbergia sissoo* provenances (Vakshasya *et. al.*, 1992). In *Acacia* seeds, larger seeds have been shown to have more sensitive seed coats than the smaller seeds thus affecting germination (Cavanagh, 1980 cited in Cervantes *et. al.*, 1996).

## 2.8 Seed germination and its requirements

Seed germination is defined as the consecutive number of steps through which a quiescent seed with a low water content undergoes, exhibiting an increase/activation in its metabolic activity and thereby initiating the formation of a seedling from the embryo (Mayer and Shain 1974; Mayer and Poljakoff-Mayber, 1975). In many instances, the index for germination is the protrusion of the radicle through the seed coat, which scientifically depicts the completion of germination (Bewley and Black, 1985).

Seed germination is the eventual function of a viable seed. It is an orderly, complex process that involves imbibition of water, activation of pre-existing forms of enzymes, mRNA, DNA, hydrolysis and mobilization of food reserves, protein synthesis, cell elongation and synthesis of new enzymes (Palmiano and Juliano 1972; Mayer and Shain 1974; Bray and Dasgupta 1976; Goodwin and Mercer, 1983; Berrie, 1984; Mikkonen, 1986).

In a viable non-dormant seed, external factors that prevailed during seed development as well as hereditary factors (Mayer and Poljakoff-Mayber, 1975) largely determine the requirements of seed germination. Water is required by all seeds and is taken up by the seed in the process of imbibition. The water requirement should be optimal as excessive moisture may reduce permeability to oxygen and hence inhibit germination (Bradbeer, 1988).

Optimal temperature requirements vary from species to species, for instance, 30°C was found to be optimal for *Erythrina brucei* while for *Erythrina burana*, 25°C was the optimal temperature as it gave the highest percentage germination (Demel Teketay, 1994).

Oxygen is required for oxidation purposes in the process of respiration. Most seeds germinate at oxygen tension equivalent to atmospheric oxygen (21.4%) although some seeds e.g. *Xanthium* spp have been shown not to be inhibited by high oxygen tensions (Mayer and Poljakoff-Mayber, 1975).

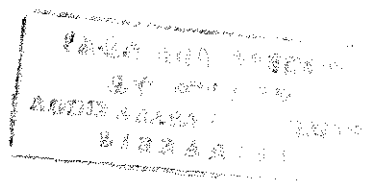
Light is not mandatory for germination e.g. in *Vernonia galamensis* var *ethiopica* (Demel Teketay, 1993b) but its inadequacy can be inhibitory in positively photoblastic seeds e.g. *Apium graveolens* (Mayer and Poljakoff-Mayber, 1975). Other seeds have their germination inhibited by light for instance, *Catharanthus roseus* cv *alba* (Choudhury and Gupta, 1995).

Overall, seed germination is influenced by a species-specific requirement within the environmental complex (Durrani *et al.*, 1997). If one or more of the germination requirements is not favorable, then the seed enters into a state of secondary dormancy (Purohit *et al.*, 1997).

## 2.9 Significance of plant hormones in seed germination

The role of plant hormones in seed germination ranges from inhibitory effects of abscisic acid to stimulatory effects of gibberellins and cytokinins (Mayer and Poljakoff-Mayber, 1975; Bewley and Black, 1985, 1994; Lewak, 1985).

Pea seed, for instance, depicts the importance of plant hormones. The metabolic activities are triggered and controlled by signals from the growing axis in the absence of which, respiratory and enzymatic activities fail (Mayer and Shain, 1974).



Plant hormones interact in their influences on germination. For instance, gibberellic acids and cytokinins (Heydecker and Coolbear, 1977) in counteracting the effects of abscisic acid which inhibits germination in many seeds. Plant hormones have also been shown to interact with environmental factors for instance light, oxygen and carbon dioxide levels in their activities (Taylorson and Hendricks, 1977).

### 2.9.1 Gibberellins

Gibberellins belong to a large family of diterpenes, are widespread and almost of universal occurrence in higher plants (Jones and Macmillan, 1984). They are widely accepted to play a major role in seed germination (Berrie, 1984; Lewak, 1985). It has been shown in some seeds that, failure to accumulate gibberellic acids inhibits seed germination. For instance, in celery (*Apium graveolens*), biennial celery which do not accumulate gibberellic acids during seed maturity had their germination inhibited unlike in annual celery seeds which have the ability to accumulate gibberellic acids (Pressman *et al.*, 1988).

According to Berrie (1984), gibberellins at high concentrations break the dormancy of positively photoblastic seeds, negatively photoblastic seeds and non-photoblastic seeds. Gibberellins alleviate dormancy in chilling and dry storage after-ripening requiring seeds (Mayer and Poljakoff-Mayber, 1975; Pitel and Wang, 1988) and reverses the germination inhibitory effects of high osmotic pressure (Biddington and Thomas, 1978).

Gibberellic acids have been found to alleviate seed dormancy attributed to the presence of germination inhibitors. For instance, gibberellic acids reverse dormancy due to presence of abscisic acid in *Onopordum nervosum* (Perez-Garcia and Duran, 1990) and tannins in *Meconopsis* species (Sulaiman, 1993). Gibberellins induce the synthesis of cell wall hydrolyzing enzymes (Mayer and Poljakoff-Mayber 1975). In tomato seeds, the cell wall hydrolyzing enzymes (Groot *et al.*, 1988) weaken the endosperm that inhibits germination by exerting mechanical restriction on the embryo.

According to Bewley and Black (1985), the mechanism of action of gibberellic acids includes:

- Protein and RNA synthesis in fruits and seeds.
- Activation and stimulation of food reserve mobilizing enzymes. In cereal grains for instance, gibberellic acids are involved in stimulation of synthesis of  $\alpha$ -amylase in the aleurone cells (Mayer and Shain 1974; Mayer and Poljakoff-Mayber 1975; Goodwin and Mercer 1983; Maya *et al.*, 1996).

Gibberellic acids are involved in the repair and development of cell membranes (Berrie, 1984; Ojeda and Trione 1990). This is a crucial role since the success of seed germination depends on the restoration of the integrity of cell membranes that are otherwise disintegrated in a dormant seed. Gibberellic acids also affect seed germination and seedling development by affecting the elongation of the embryonic axis, although it leads to spindly growth (Heydecker and Coolbear, 1977).

### 2.9.2 Cytokinins

Cytokinins affect seed germination (Mayer and Poljakoff-Mayber, 1975; Goodwin and Mercer, 1983) and they are actively metabolized in a germinating seed. Cytokinins at high concentrations induce germination in photosensitive lettuce seeds (Berrie, 1984). They have also been shown to sensitize light requiring seeds such that they respond to low light levels (Mayer and Poljakoff Mayber, 1975). Cytokinins overcome the inhibitory effects of abscisic acid and allow gibberellic acids to function (Khan, 1971 cited in Heydecker and Coolbear 1977).

Cytokinins have been shown to relieve thermodormancy in celery and lettuce seeds (Taylorson and Hendricks, 1977; Biddington *et al.* 1980). Taylorson and Hendricks (1977) in their review on seed dormancy, reported that cytokinins are less effective in alleviating seed dormancy than gibberellic acids. Their effects are more pronounced in the presence of other factors for instance, light, high levels of oxygen and gibberellic acids.

High concentrations of cytokinins have been shown to induce abnormal germination (Bewely and Black, 1985). The effects of cytokinins vary from one plant species to another. For instance, cytokinins were found to be ineffective in stimulating the germination of *Striga asiatica* (Hsiao *et. al.*, 1988), *Podocarpus falcatus* (Legesse Negash, 1992) and *Catharanthus roseus* cv. *alba* (Chodhury and Gupta, 1995).

Cytokinins like gibberellic acids stimulate protein and RNA synthesis (Leopold and Kriedemann, 1975; Berrie, 1984). The stimulation of cytokinins on cell elongation and cell division seems to be related to their effectiveness in promoting germination (Bewley and Black, 1985, 1994).

### **2.9.3 Auxins**

The role of auxins for instance, Indole-acetic acid (IAA) and  $\alpha$ Naphthleneaceatic acid in seed germination is not clear-cut (Mayer and Poljakoff-Mayber, 1975). However, auxins are associated with extension growth in the embryonic axis (Berrie, 1984; Bandurski and Nonhedel, 1984). They stimulate germination in some instances depending on the concentration and the type of seed used (Mayer and Poljakoff-Mayber, 1975).

### 3.0 MATERIALS AND METHODS

#### 3.1 Ethnobotanical study

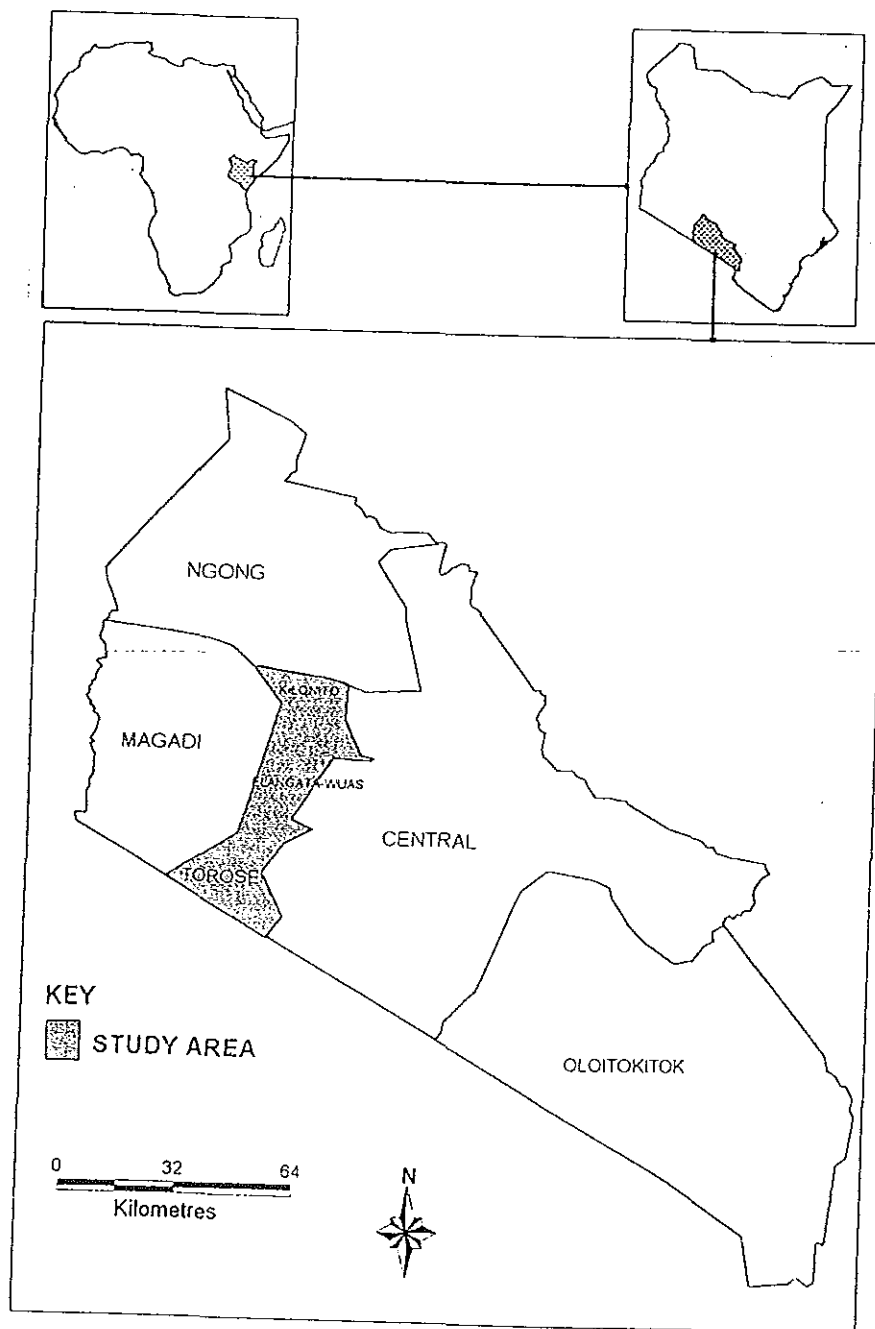
##### 3.1.1 Area of Study

The ethnobotanical study was conducted in the area under the mandate of Elangata Wuas Ecosystem Management Programme (EWEMP) between January and March 1998. The program area covers three locations namely: Torsei, Elang'ata Wuas and Kilonito in Central Division, Kajiado District, Kenya (Figure 1). The area measures about 160, 000 hectares.

The average annual precipitation in the area amounts to 500 mm while the average monthly temperatures ranges between 28-30°C. The area can hence be described as semi-arid. The altitude varies from 1100 to 2100 m above sea level. Most of the land is plain with scattered hills. Three prominent seasonal lakes namely: Lake Kwenia, Loonkujit and Kabongo and one large seasonal river, River Toroka are found in the area.

The geology of the area is mainly quaternary and tertiary volcanic with quaternary sediment and basement rock. The main soil types are calcareous clay loams, lava boulder interspersed with areas of black cotton soils around the flood plains. The main vegetation types include woodland and bushlands that have an *Acacia-Themeda* and *Commiphora-Acacia* combination.

Figure 1. Location of the area covered by Elang'ata Wuas Ecosystem Management Programme, Kajiado District, Kenya.



The main economic mainstay of an estimated 10,000 persons is pastoral livestock production. The livestock reared comprises of cattle, sheep and goats. The dominant community is the Maasai community but members of other communities especially, the Somali and the Kikuyu are found particularly in the trading centers.

### **3.1.2 Collection of ethnobotanical information**

With the help of a research assistant, an employee in Elang'ata Wuas Ecosystem Management Program (EWEMP) and a resident in the study area, contacts were made with the local administrators and community elders to whom the purpose of the study was explained.

The local administrators and the elders assisted in identifying people knowledgeable on traditional medicine. This was done because the study aimed at documenting traditional knowledge that is usually held by specialists (Martin, 1995; Barker and Cross, 1992 cited in Cotton, 1996). Forty elderly people were identified as interviewees. Eleven out of forty interviewees (27.5%) were female whereas the rest were male. Ten out of forty (25%) were Traditional Medical Practitioners (TMPs), who practice traditional medicine to earn a living. The other thirty interviewees (75%) were not TMPs but are reputed to be knowledgeable on medicinal plants.

Appointments were made with the respective interviewees to either meet with them at their homes, market place or at Elang'ata Wuas Ecosystem Management Program (EWEMP) campsite at Isinya Omerok. To collect the ethnobotanical information, semi-structured interviews were conducted with the interviewees (Martin 1995; Cotton 1996). The semi-structured interviews were based on questions that were to be covered (Appendix 1).

Although the questions asked were decided before hand, no sequence was followed and a question was omitted if the interviewees addressed it indirectly. The interviewees were also free to add any information which they thought was relevant to the subject under discussion (Koul, 1988).

The interviews aimed at finding out the following:

- Whether there are medicinal plants that are traditionally used in treating joint diseases in the study area,
- The parts used,
- Mode of preparation, administration and dosage,
- Difficulties experienced in obtaining the plants if any,
- Conservation measures employed on these plants.

Guided field walks (Maundu, 1995) were used to supplement the information collected during the semi-structured interviews. The researcher in the company of some interviewees visited the sources of the plants. As the interviewees identified the plant, they explained how it is harvested and eventually prepared. Information was considered authentic if three or more interviewees at different fora gave the same information.

During the guided field walks plant specimens were collected, pressed and later on dried in a drier. These specimens were later used for botanical authentication at the East-African Herbarium, Nairobi.

### **3.2 Description of some seed characteristics**

This part of the study focused on three plant species namely, *Myrsine africana* L. *Strychnos henningsii* Gilg. and *Ziziphus mucronata* Willd. ssp *mucronata*. The criterion for the selection of the species was based on seed availability at the time.

#### **3.2.1 Seed collection**

##### **1. *Strychnos henningsii* Gilg.**

Ripe fruits (orange to red in color) were collected on the 13<sup>th</sup> of March 1998 from Karura forest, Nairobi (Altitude: 1646 m). They were depulped and washed in running tap water to remove the mucilage.

The seeds were then dried at room temperature for a period of seven days and then packed in a clean, dry cotton cloth and stored at room temperature until used for the experiments.

## **2. *Myrsine africana* L.**

The seeds were collected on the 28<sup>th</sup> of March 1998 from Rowallan Scouts camp forest, an extension of Lang'ata forest in Nairobi (Altitude: 1700 m). The purple fruits were depulped and washed in tap water. The seeds were then dried at room temperature for seven days and then packed in a clean, dry cotton cloth and stored at room temperature until used for the experiments.

## **3. *Ziziphus mucronata* Willd. ssp *mucronata***

Dried fruits were purchased from the Kenya Forestry Seed Center. The information provided on purchasing was that the seeds were collected on the 21<sup>st</sup> of September 1994 from Taita-Taveta District (Altitude: 730 m) and stored at  $\pm 1-3^{\circ}\text{C}$ .

### 3.2.2 Seed description (external)

This part of the study involved compilation of the external characteristics of the seed and a conduction of a series of measurements. The measurements conducted included:

- Seed size

One hundred seeds were taken at random and the size of each seed (length x width) measured to the nearest mm using a ruler. The length referred to the longer side of the seed while the width referred to the shorter side of the seed.

- Seed weight

One hundred seeds were taken at random and the weight of each seed measured (in grams) using an analytic weighing balance.

In addition to the seed size and weight, a description of the seed color was made. The seed coat structure and any conspicuous features on the seed surface were noted and photographs of the seeds taken.

### **3.2.3 Seed description (internal).**

The seeds were incubated in distilled water and dissected at intervals of 24 hr. and 10 days. The location and color of the embryo were observed under Leica MZ8 stereo microscope and noted in a notebook. The embryo was extracted and measured to the nearest mm using a ruler. An illustration depicting the location of the embryo in the seed was made after the seeds had been incubated for 24 hrs. The excised embryo was photographed using a microphotographic system 28/32 photoautomatic.

## **3.3 Germination experiments**

### **3.3.1 Initial tests**

Through unreplicated trials, the capacity for immediate germination was tested on the seeds. Ten unsterilized seeds were placed on ordinary soft paper in a Petri dish. The soft paper was then moistened with distilled water and the Petri dishes placed in a tissue culture room kept at 25-27° C. The room was lit with fluorescent lamps at a quantum flux density of about  $40 \mu \text{ mol. m}^{-2} \text{ S}^{-1}$  for 9 hr. per day. Periodic addition of distilled water was made as the seeds depleted it through imbibition. Each Petri dish was inspected daily. In all the experiments, seeds were considered to have germinated when the radicle length measured about 2 mm (Demel Teketay, 1994).

### 3.3.2 Dormancy breakage

In the initial tests, *Myrsine africana* and *Ziziphus mucronata* ssp *mucronata* seeds failed to germinate even after two months of incubation. Further seeds were then subjected to various additional treatments in an attempt to facilitate germination. The treatments eventually chosen were to remove the seed coats with the hands (for *Myrsine africana*) and to crack the hard seed coat using a clean basalt rock on a clean concrete surface (for *Ziziphus mucronata* ssp *mucronata*). It should be noted that these treatments were not designed to provide an exhaustive study of dormancy.

### 3.3.3 Influence of plant growth regulators

#### 3.3.3.1 Preparation of plant growth regulators

Three plant growth regulators namely; Gibberellic acid ( $GA_3$ ), Naphthaleneacetic acid (NAA) and Benzyl-aminopurine (BAP) were tested for their effects on the rate and percentage germination of *Strychnos henningsii*, *Myrsine africana* and *Ziziphus mucronata* ssp *mucronata* seeds. NAA and BAP had been purchased in powder form from Sigma chemical company (St. Louis, MO, USA).  $GA_3$  was purchased from BDH Chemicals LTD (Pool, England). The chemicals were of "tissue culture" tested quality. Each respective chemical was dissolved in 1N NaOH and diluted with distilled water to prepare a  $10^{-3}$  M stock solution. The pH of the stock solutions was adjusted to  $7.0 \pm 0.1$  using 1N HCl. Using the proper dilution factor, solutions of  $10^{-4}$  M to  $10^{-7}$  M were prepared from the stock solution

### 3.3.3.2 Seed germination response

To determine the influence of different concentrations of NAA, GA<sub>3</sub> and BAP on the germination response of *Strychnos henningsii*, *Myrsine africana*, and *Ziziphus mucronata* ssp *mucronata* seeds, one hundred seeds in ten replicates of ten seeds each were used for each concentration of the respective plant growth regulator. The control was to provide one hundred seeds, replicated in the same way with distilled water.

The seeds were washed with a detergent and rinsed three times. They were then surface sterilized by soaking them in calcium hypochlorite for ten minutes after which they were thoroughly rinsed with distilled water.

Ten seeds were placed on Whatman No. 1 filter paper in each Petri dish (9.0 x 1.5 cm). The filter paper was moistened with 3 ml of the corresponding concentration of a given test solution. The Petri dishes were then randomly placed on shelves in a tissue culture room, lit with fluorescent lamps at a flux density of about 40  $\mu\text{mol m}^{-2} \text{S}^{-1}$  for 9 hr. day<sup>-1</sup> at 27<sup>0</sup> C and night temperature of 25<sup>0</sup> C. The Petri dishes were inspected daily and any germinated seeds were recorded. The experiments were run until no more seeds germinated for three consecutive days.

### 3.4 Post-germination development of the seedlings

Due to differences in germination response in *Strychnos henningsii*, *Myrsine africana* and *Ziziphus mucronata* ssp *mucronata* seeds to the various concentration of plant growth regulators, the criteria for selection of the germinants to be assessed was based on the concentrations that gave the highest germination percentage (for *Myrsine africana*). In *Strychnos henningsii*, only the seeds that were treated with distilled water were used as it gave the highest overall germination percentage. *Ziziphus mucronata* germinants were not assessed, as the germination in all the treatments was poor.

After the termination of the germination response experiments (4 weeks for *Strychnos henningsii* and 7 weeks for *Myrsine africana*), thirty germinants each from GA<sub>3</sub> 10<sup>-4</sup> M, NAA 10<sup>-7</sup> M and BAP 10<sup>-6</sup> M treatments and the control were transplanted for *Myrsine africana*. One hundred germinants were transplanted for *Strychnos henningsii*.

The germinants were planted out in plastic bags (diameter, 80 mm; length, 200 mm) filled with sand, manure and red soil at a ratio of 1:2:2 respectively. The plastic bags were then randomly arranged on rows on a concrete floor in the glasshouse. The transferred germinants were in turn covered with thin polythene sheets (supported by wooden scaffolding, about 50 cm from the surface of the pots) so as to protect them from desiccation. The thin polythene sheets also provided a warm and moist environment for the speedy development of the cotyledons (Legesse Negash, 1993).

Small openings using a pin were made on the polythene sheet to allow for the exchange of air with the external environment. The polythene sheets were removed once the seed coats were shed off. Tap water was added to the seedlings initially, twice a day and later on once a day.

The survival capacity of the germinants was assessed every week for a period of eight weeks. The experiment was carried out from June to August 1998 (for *Strychnos henningsii*) and July to September 1998 (for *Myrsine africana*).

### 3.5 Statistical analyses

Statistical analysis was carried out using the software package, Statistica for Windows, Release, 4.0 (Statsoft INC., 1993). The significance of the means of the different concentrations of plant growth regulators and the control were subjected to analysis of variance (ANOVA). Significant differences were accepted at  $P < 0.05$ . Newman Keuls test was run to compare the differences in means within the treatments.

## **4. RESULTS**

### **4.1 Ethnobotanical study**

#### **4.1.1 Plants used, parts used and method of preparation**

From the ethnobotanical information collected, twenty-one plant species are reportedly used in treatment of joint diseases. On the basis of their habits, trees accounted for 10 species (47.6%) while shrubs and herbs accounted for eight (38.1%) and three (14.3%) plant species respectively (Table 1). The classification on the basis of habits followed that of Beentje (1994). (Note: Some of the trees can fall in the shrubs as well as the tree category depending on the habitat and climatic conditions under which they have grown).

The plants species used in treatment of joint diseases (Table 1) are distributed in seventeen families (Appendix 2). The plant families Rhamnaceae and Leguminosae (Fabaceae) had three species each while the rest of the families had one species each. Details on their botanical descriptions, habitat, altitudinal range, occurrence in the taxonomic regions of Kenya and elsewhere are provided in Appendix 2. A map showing the geographical divisions of the flora as used in the Flora of Tropical East-Africa is shown in Appendix 3.

On the basis of the information provided, roots were the most frequently used accounting for 85.7%, followed by the stem-bark (47.5%). Leaves, pieces of the stem and dried fruits are only used in two out of twenty-one (9.52%) plant species.

Preparation of the medicine in the form of decoction and concoctions tallied at ten plant species each. A decoction is prepared by boiling plant parts of single plant species in water. To prepare a concoction, plant parts are obtained from more than one plant species. Once the decoction or concoction is prepared bone broth, tea or milk is added as the case may be and then taken orally (Table 1).

The decoction prepared from *Heliotropium rariflorum* ssp *hereroense* is taken with tea while that prepared from *Ruellia patulla* is taken with tea or milk. The rest of the preparations are added to bone broth, thoroughly whisked and then taken orally. Only one (4.76%) plant specie is used prepared in form of an infusion and it is used externally, i.e. to massage the aching joints. The use of plant species in the form of concoctions was reported by over 40% of the interviewees in all cases (Table1).

However, the concoction prepared from *Turraea mombassana*, *Rhamnus prinoides* and/or *Rhamnus staddo* and *Acacia nilotica* was the most popular as it was reported by twenty-nine out of forty interviewees (72.5%). Of the plant species used in form of a decoction, *Strychnos henningsii* was the most popular, reported by thirty-one out of forty interviewees (77.5%) (Table 1).

Table 1. A summary of the ethnobotanical information on plants used in treating joint diseases

Key: R-roots: S-Pieces of the stem: SB-Stem-bark: L-leaves: DF-dried fruits

| Plant Species                                  | Local name (Maa) | Habit | Part(s) Used | Form of use | Substance added | No. of interviewees who gave the information (out of 40) |
|------------------------------------------------|------------------|-------|--------------|-------------|-----------------|----------------------------------------------------------|
| <i>Achyranthes aspera</i> L.                   | Oloribat         | Herb  | R            | Decoction   | Bone broth      | 3                                                        |
| <i>Aspilia pluriseta</i> Schweinf.             | Olsinoni         | Shrub | R            | Decoction   | Bone broth      | 4                                                        |
| <i>Cissus quadrangularis</i> L.                | Sukurtuti        | Shrub | R            | Infusion    | -               | 12                                                       |
| <i>Clerodendrum myricoides</i> (Hochst.) Vatke | Olmakutkut       | Shrub | R            | Decoction   | Bone broth      | 3                                                        |
| <i>Croton dichogamus</i> Pax.                  | Enkitaru         | Shrub | R            | Decoction   | Bone broth      | 7                                                        |
| <i>Heliotropium rariflorum</i> Stock.          | Olkikareta       | Herb  | R            | Decoction   | Tea             | 8                                                        |
| <i>Myrsine africana</i> L.                     | Olsegeteti       | Shrub | R/DF         | Decoction   | Bone broth      | 11                                                       |
| <i>Pappea capensis</i> Eckl. and Zehl.         | Oltimigomi       | Tree  | SB           | Decoction   | Bone broth      | 4                                                        |
| <i>Ruellia patula</i> Jacq.                    | Olsupeni         | Herb  | R            | Decoction   | Tea/milk        | 17                                                       |
| <i>Strychnos henningsii</i> Gilg.              | Engilai          | Trees | R/S/SB/L     | Decoction   | Bone broth      | 31                                                       |
| <i>Ziziphus mucronata</i> Willd.               | Ol-ilale         | Tree  | R/SB         | Decoction   | Bone broth      | 7                                                        |
| <i>Acacia nubica</i> Benth.                    | Oidebe           | Tree  | SB           | Concoction  | Bone broth      | 21                                                       |
| <i>Albizia amara</i> (Roxb.) Boiv.             | Olperelongo      | Tree  | R/SB         |             |                 |                                                          |
| <i>Euclea divinorum</i> Hiern.                 | Olenaraan        | Tree  | SB           |             |                 |                                                          |
| <i>Salvadora persica</i> L.                    | Olremi           | Shrub | R            |             |                 |                                                          |
| <i>Acacia nilotica</i> (L.) Del.               | Olkiloriti       | Shrub | R/SB         | Concoction  | Bone broth      | 29                                                       |
| <i>Rhamnus prinoides</i> L. Herit.             | Olkonyil         | Shrub | R/SB         |             |                 |                                                          |
| <i>Rhamnus staddo</i> A. Rich.                 | Olkokola         | Tree  | R/SB         |             |                 |                                                          |
| <i>Turraea mombassana</i> C. DC.               | Olmyirman        | Shrub | R            |             |                 |                                                          |
| <i>Olea europaea</i> L. ssp <i>cuspidata</i>   | Ol-irien         | Tree  | R/SB         | Concoction  | Bone broth      | 18                                                       |
| <i>Teclea simplicifolia</i> (Engl.) Verdoon    | Olgilai          | Tree  | R            |             |                 |                                                          |

Nineteen out of forty (47.5 %) interviewees reported that, half a cupful to one cupful of the preparation is taken until one feels well while seven out of forty (17.5 %) interviewees reported that the preparation is taken until the preparation gets finished. Thirty-one interviewees (77.5 %) said that since the preparations are very bitter, they advise their patients to discontinue taking the preparation after seven days. Efforts to ascertain the size of the cup were met with difficulties because twenty-eight (70 %) interviewees were interviewed away from their homesteads. However, of the twelve interviewees who were interviewed within their homesteads, three of them (25%) showed a cup that could hold about 250 ml while the other nine (74.9 %) showed a cup that could hold more than 250 ml of a substance.

#### **4.1.2 Conservation measures applied on the plant species**

Thirty-five out of forty interviewees (87.5 %) said that they returned the soil after digging out the roots whereas twenty-one interviewees (52.5%) reported that they avoided the main taproot and only removed the lateral roots. Thirteen interviewees (32.5%) said that they removed a few roots per plant.

Four interviewees (10%) said that they removed the stem-bark from the young twigs and not from the main tree trunk. During the guided field walks, it was observed that several plant species had their main trunks stripped off, the stem-bark.

All the twenty-one plant species are harvested from the wild sources. However two interviewees out of forty (5%) had planted some seedlings in their farms which were provided by the Elang'ata Wuas Ecosystem Management Program (EWEMP project although none was used in treating joint diseases. The rest of the interviewees had made no effort to grow any of the plants in their homesteads.

Twenty-five interviewees (62.5%) cited the likelihood of browsing of the seedlings by livestock as one of the reasons why they had not made an effort to grow the plants. Twelve interviewees (30%) felt that lack of enough water as the area is semi-arid would deter the growth of the seedlings. The two interviewees who had planted some seedlings in their farms confirmed that most of the seedlings had died in the past due to lack of water. Seven interviewees (17.5%) claimed that the plants were still available in the wild and hence did not find it necessary to grow the plants.

Thirteen interviewees out of forty (32.5%) reported that *Ruellia patula* was not as frequent as it used to be in the past. *Heliotropium rariflorum* ssp *hereroense* was reported to be less abundant comparative to the past by five out of forty interviewees (12.5%). It was observed that *Heliotropium rariflorum* ssp *hereroense* was only found in one place whereas *Ruellia patula* was available in various places but it was difficult to find.

#### 4.1.3 Problems experienced in obtaining the medicinal plants

All the eleven female interviewees (27.5%) and twenty four males (60%) reported that the long distances that are covered in a bid to collect some of the plant species is a major problem pertaining to the use of the medicinal plants. The female interviewees reported that, traditionally, they are not supposed to go to the forests to collect medicinal plant parts. They hence use the plants near their homesteads and have to send young men to collect the plants found from far places. They however did not cite the tradition banning them from collecting plants from the forests as a problem.

Five out of forty interviewees (12.5%) who did not feel that long distances was a problem however, reported that they always collect large bulks of plant parts to avoid making frequent trips. Various dried plant parts were observed in interviewees' houses. Eleven interviewees (27.5%) said that they once in a while purchase plant parts from Kajiado town or Nairobi. The plant species usually purchased include *Rhamnus staddo*, *Rhamnus prinoides* and *Myrsine africana*.

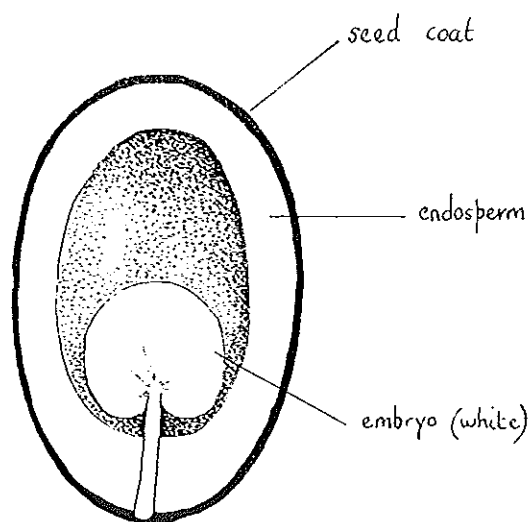
## 4.2 Description of some seed characters

### 4.2.1 *Strychnos henningsii*.

The seeds of *Strychnos henningsii* are off-white in color, coffee bean like and have a groove on one side. The seed size ranges from 6-11 mm (length) and 5-8 mm (width). The weight of the seeds ranged from 0.0185 - 0.29149 g with a mean of  $0.1722 \pm 0.00349$  g.

The embryo is white, has 2 cotyledons with an obscure mid-rib and lateral veins. The embryo is located in a groove (Figure 2) and measures about 6.5 mm in length.

Figure 2. A longitudinal section of the seed of *Strychnos henningsii* showing the location of the embryo after incubation in water for 24 hours (Magnification: X10)



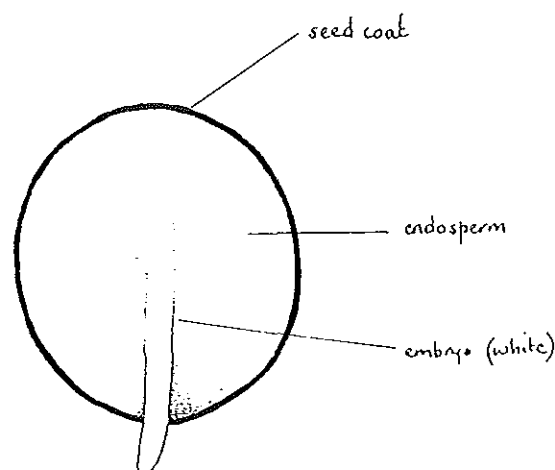
No conspicuous change in color or the appearance of the seed or the embryo was evident after incubation in water for 24 hr. or 10 days in distilled water. However, the seed was mucilaginous on the surface after 48 hr. of incubation.

#### 4.2.2 *Myrsine africana* L.

The seeds of *Myrsine africana* are globose shaped, whitish with purple streaks. The seed size ranged from 2-5 mm (length) and 2-4 mm (width). The weight of the seeds ranged from 0.0092-0.02449 g with a mean of  $0.0167 \pm 0.00409$  g. The seeds have an inner seed coat (tegument) which is leathery in texture and brown in color.

The embryo is white, straight or curved and is found embedded in the white endosperm (Figure 3).

Figure 3; A longitudinal section of the seed of *Myrsine africana* showing the location of the embryo after incubation in water for 24 hours (Magnification: X20)



The plumule or the radicle ends were not evident. The embryo measures about 2mm in length. No conspicuous change (size and appearance) was evident on the seed or the embryo after 24 hr. or 10 days of incubation in distilled water.

#### **4.2.3 *Ziziphus mucronata* Willd. ssp *mucronata***

The seeds are brown in colour, flattened and enclosed in a stony endocarp. The seeds are as long as they are wide and measures 5-6 mm. The weight of the seeds range from 0.0204-0.0637 with a mean of  $0.0426 \pm 0.009$  g. Examination of the embryo after incubation of the seed in distilled water for 24 hours revealed that it was dead and rotten in almost all the seeds.

#### **4.3 Effects of plant growth regulators**

Three plant growth regulators namely: Gibberellic-3-acid ( $GA_3$ ), Benzyl-aminopurine (BAP) and Naphthaleneacetic acid (NAA) were tested for their effects on the germination of *Strychnos henningsii* Gilg., *Myrsine africana* L. and *Ziziphus mucronata* Willd. ssp *mucronata* seeds.

#### 4.3.1 *Strychnos henningsii*

The effects of the different concentrations of the Plant Growth Regulators (PGRs) are shown in Table 2 and Figure 4. GA<sub>3</sub> and NAA showed significant differences with the control ( $p=0.000019$  and  $0.0000$  respectively). BAP treatments showed no significant difference with the control ( $P=0.0534$ ).

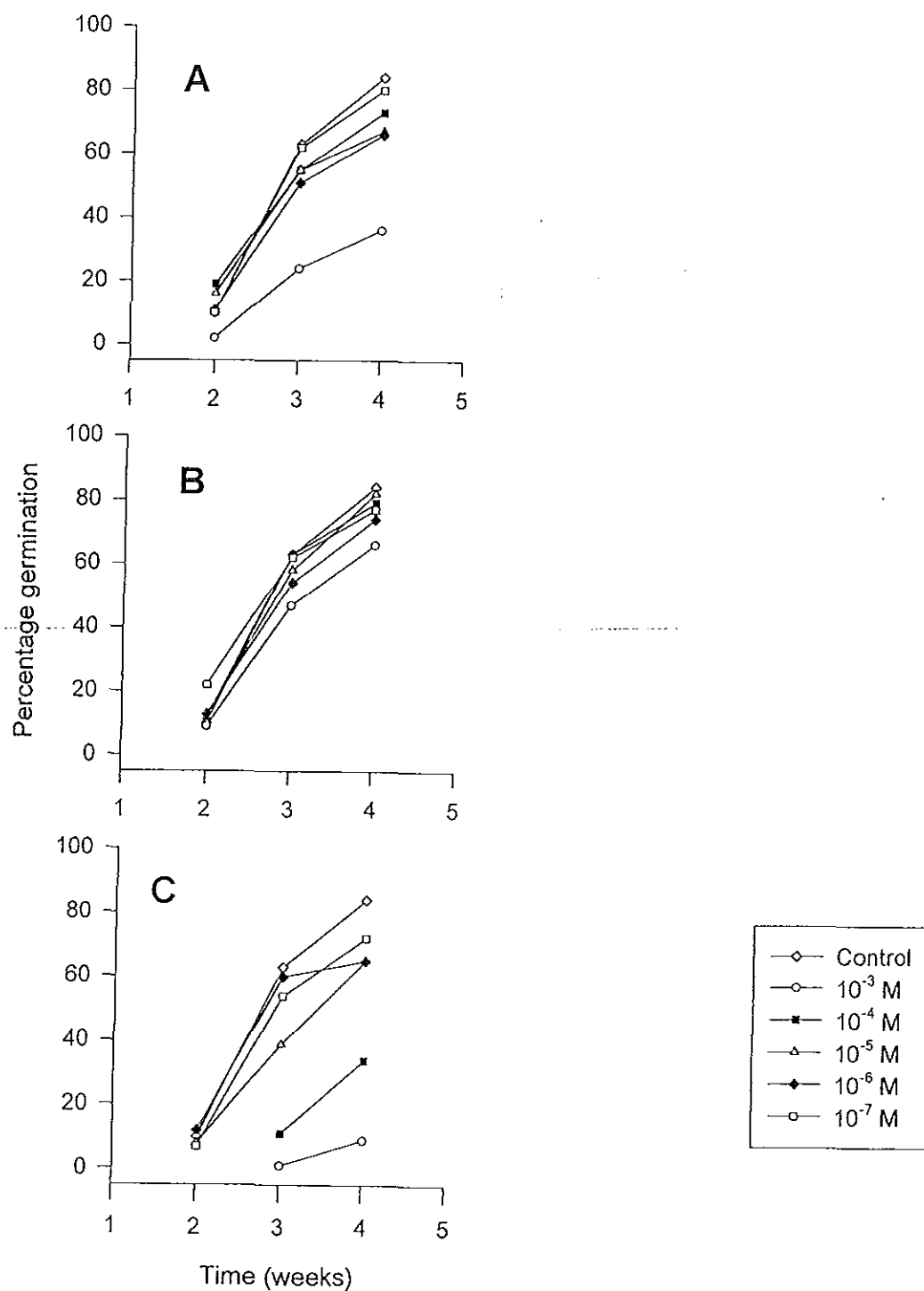
Table 2. Mean percentage germination ( $\pm$ SE) of *Strychnos henningsii* seeds treated with different concentration of GA<sub>3</sub>, BAP, NAA and the control. "Percentage germination  $\pm$ SE" refers to the percentage of seeds that germinated 4 weeks after sowing.

| Concentration (M)                | GA <sub>3</sub> | BAP            | NAA             |
|----------------------------------|-----------------|----------------|-----------------|
| Control (Dist. H <sub>2</sub> O) | 84 $\pm$ 4.27b  | 84 $\pm$ 4.27a | 84 $\pm$ 4.27d  |
| 10 <sup>-7</sup>                 | 80 $\pm$ 4.47b  | 77 $\pm$ 5.39a | 72 $\pm$ 5.33cd |
| 10 <sup>-6</sup>                 | 66 $\pm$ 5.62b  | 74 $\pm$ 5.42a | 65 $\pm$ 4.01c  |
| 10 <sup>-5</sup>                 | 67 $\pm$ 7.16b  | 82 $\pm$ 3.59a | 65 $\pm$ 5.00c  |
| 10 <sup>-4</sup>                 | 73 $\pm$ 5.18b  | 79 $\pm$ 3.16a | 34 $\pm$ 6.86b  |
| 10 <sup>-3</sup>                 | 36 $\pm$ 9.09a  | 66 $\pm$ 2.68a | 9 $\pm$ 2.33a   |

Entries within the same column followed by different letters are significantly different ( $p<0.05$ )

GA<sub>3</sub> at 10<sup>-3</sup> M decreased the percentage germination compared to the other GA<sub>3</sub> treatments and the control. The rest of the GA<sub>3</sub> treatments showed no significant difference from the control (Table 2).

Figure 4. Mean germination percentage as a function of time of *Strychnos henningsii* in different concentrations of GA<sub>3</sub> (A), BAP (B) and NAA (C).



NAA at  $10^{-3}$ - $10^{-6}$  M lowered the percentage germination compared to the control. However, higher concentrations of NAA ( $10^{-3}$  and  $10^{-4}$  M) were more inhibitive giving  $9 \pm 2.33$  and  $34 \pm 6.86$  germination percentage respectively as compared to the control at  $84 \pm 4.27$ .

There was no significant difference between the NAA at  $10^{-7}$  M and the control. NAA at  $10^{-3}$  and  $10^{-4}$  M delayed germination for 21 and 17 days respectively while germination in all the other treatments started between the 10<sup>th</sup> and 13<sup>th</sup> day after sowing (Figure 4). NAA at  $10^{-5}$  M resulted in deformed radicles which were swollen at the tips and coiled backwards towards the seed coat (data not shown). None of the hormones stimulated percentage germination higher than the control.

#### 4.3.2 *Myrsine africana* L.

The effects of different concentrations of the plant growth regulators on the percentage germination of *Myrsine africana* seeds are shown in Table 3 and Figure 5. All the hormones showed significant differences from the control.

GA<sub>3</sub> at  $10^{-4}$  M stimulated percentage germination highly significantly from the control while the other GA<sub>3</sub> treatments (GA<sub>3</sub>  $10^{-3}$ ,  $10^{-5}$ ,  $10^{-6}$  and  $10^{-7}$  M) showed no significant difference from the control. Higher concentrations of BAP ( $10^{-3}$ - $10^{-5}$  M) highly inhibited the percentage germination significantly different from the control.

**Table 3** Mean percentage germination ( $\pm$ SE) of *Myrsine africana* seeds treated with different concentrations of GA<sub>3</sub>, 6-BAP, NAA and the control (distilled water).

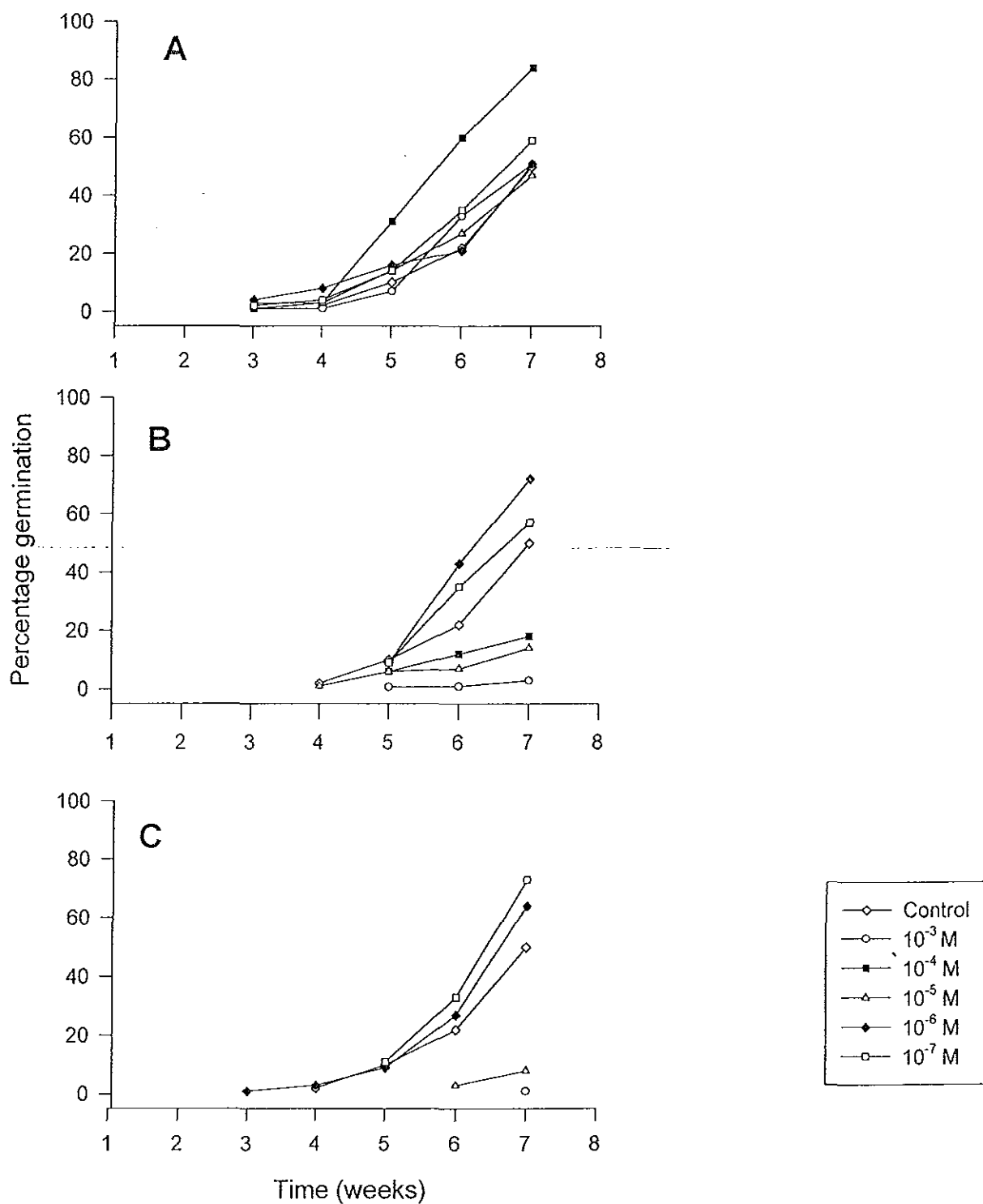
| Concentration (M)                | GA <sub>3</sub> | BAP            | NAA            |
|----------------------------------|-----------------|----------------|----------------|
| Control (Dist. H <sub>2</sub> O) | 50 $\pm$ 5.16a  | 50 $\pm$ 5.16c | 50 $\pm$ 5.16c |
| 10 <sup>-7</sup>                 | 59 $\pm$ 8.23a  | 57 $\pm$ 4.96c | 73 $\pm$ 5.17b |
| 10 <sup>-6</sup>                 | 51 $\pm$ 5.86a  | 72 $\pm$ 5.33b | 64 $\pm$ 6b    |
| 10 <sup>-5</sup>                 | 47 $\pm$ 6.16a  | 14 $\pm$ 3.40a | 8 $\pm$ 2a     |
| 10 <sup>-4</sup>                 | 84 $\pm$ 3.71b  | 18 $\pm$ 5.54a | 0 $\pm$ 0a     |
| 10 <sup>-3</sup>                 | 51 $\pm$ 5.04a  | 3 $\pm$ 1.53a  | 1 $\pm$ 1a     |

Entries within the same column followed by different letters are significantly different (p=0.05)

BAP at 10<sup>-7</sup> M showed no significant difference from the control but BAP at 10<sup>-6</sup> M stimulated percentage germination highly significantly compared to the control (Table 3). NAA at higher concentrations (10<sup>-3</sup>-10<sup>-5</sup> M) inhibited percentage germination highly significantly compared to the control. However, lower concentrations of NAA (10<sup>-6</sup>-10<sup>-7</sup> M) stimulated the percentage germination highly significantly from the control. Overall, GA<sub>3</sub> at 10<sup>-4</sup> M exhibited the highest percentage germination at 84 $\pm$ 3.71.

In all the GA<sub>3</sub> treatments, germination started in the third week while in the control treatment, germination was inhibited until the forth week. In the BAP treatments, germination was inhibited until the fifth week with the exception of the treatment at BAP 10<sup>-5</sup> M. No seed germinated in the NAA at 10<sup>-4</sup> M treatment whereas only one seed germinated in the NAA at 10<sup>-3</sup> M treatment in the seventh week.

Figure 5. Mean germination percentage as a function of time of *Myrsine africana* seeds in different concentrations of GA<sub>3</sub> (A), BAP (B) and NAA (C).



Germination started in the third week in NAA at  $10^{-6}$  M treatment while in the NAA  $10^{-7}$  and NAA  $10^{-5}$  M treatments, germination started in the fifth and sixth week respectively.

#### **4.3.3 *Ziziphus mucronata* ssp *mucronata***

There was poor germination response (less than 20%) in all treatments (data not shown). An examination of the embryo indicated that the embryo was dead in almost all the seeds.

#### **4.4 Post-germination development of the seedlings**

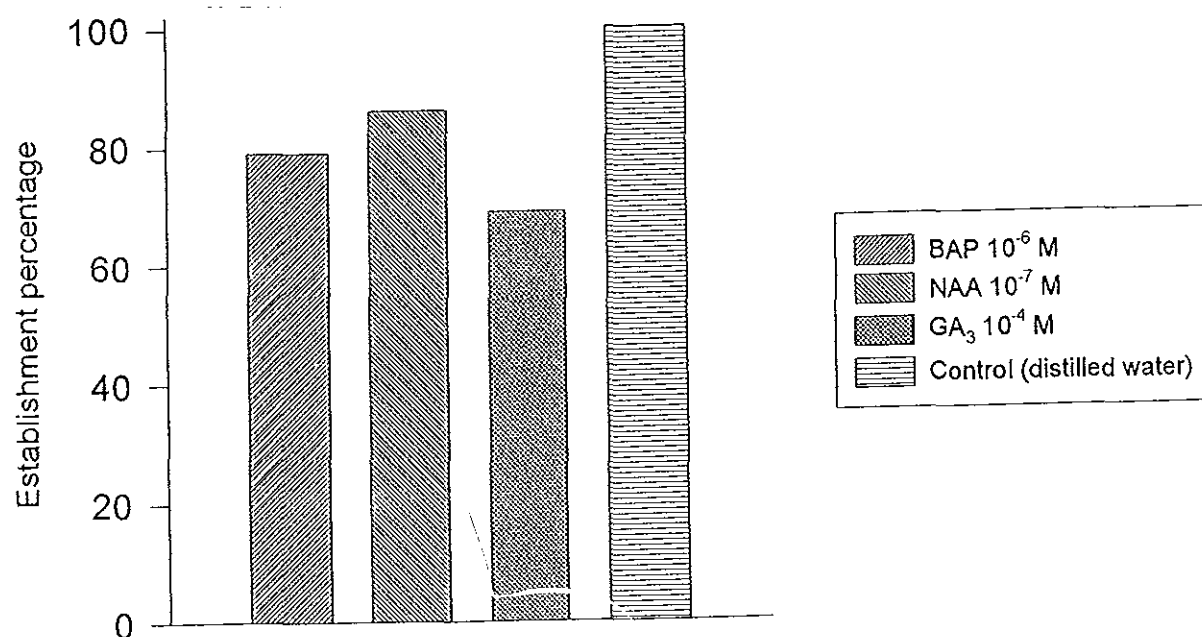
##### **4.4.1 *Strychnos henningsii* Gilg.**

Only one (1%) out of the one hundred seedlings transplanted died within the duration of the experiment. The germinants started to shed off the seed coat by the third week and only six (6%) had not shed off the seed-coat by the eighth week. Two seedlings (2%) of the germinants had four leaves whereas the rest had only two opposite leaves at the end of the experiment.

#### 4.4.2 *Myrsine africana* L.

The percentage establishment potential of *M. africana* seedlings is shown in Figure 6. None of the seedlings from the control treatment died. All the germinants survived and had all shed off their seed coats by the end of the experiment. The highest mortality was obtained from GA<sub>3</sub> at 10<sup>-4</sup> M (31%) while BAP at 10<sup>-6</sup> M and NAA at 10<sup>-7</sup> M treatments had an establishment potential of 86 and 79%, respectively. Most of the deaths occurred during the fourth week of the experiment.

Figure 6. Percentage establishment of *Myrsine africana* seedlings obtained from GA<sub>3</sub> 10<sup>-4</sup>M, NAA 10<sup>-7</sup>M, BAP 10<sup>-6</sup> M and distilled water (control) for a period of eight weeks.



While seedlings from the GA<sub>3</sub> at 10<sup>-4</sup> M treatment started to shed off their seed coats two weeks after transplanting, seedlings from BAP at 10<sup>-6</sup> M treatments did not start to shed off the seed coat until the fifth week. Seedlings from NAA at 10<sup>-7</sup> M treatment and the distilled water treatments started to shed off their seed coats by the fourth week after transplanting.

All the germinants from the distilled water (control) and NAA 10<sup>-7</sup> M treatment had shed off their seed coats by the end of the experiment. However, 3.3% and 10% of the germinants from BAP 10<sup>-6</sup> M and GA<sub>3</sub> 10<sup>-4</sup> M treatments respectively had not shed off the seed coats by the end of the experiment.

## 5.0 DISCUSSION

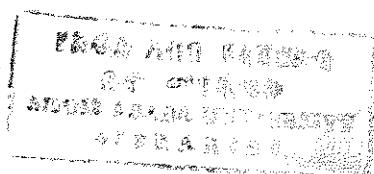
### 5.1 Ethnobotanical Studies

The results of the ethnobotanical studies indicated that all the plants used in treating joint diseases are harvested from the wild. Various ethnobotanical studies have shown that medicinal plant resources are harvested from the wild (FAO, 1983; Omino, 1990; Cunningham, 1996; Ochieng, 1997).

The roots, followed by the stem-bark are the parts, mostly used in preparing traditional medicine in treatment of joint diseases (Table 1). According to Kokwaro (1976), most of the plants used in treating joint diseases involve the use of the stem-bark and the roots. It has been shown that the roots and the stem-bark are the major sources of traditional medicine (involving the use of plants) preparations (Bronner, 1990; Githae, 1995; Maundu and Mungai, 1996).

The bark is rich in secondary metabolites hence its popularity as a source of traditional (Watt and Breyer-Brandwijk, 1962; Cunningham, 1990). The rationale of employing the roots and the stem-bark can for instance, be supported by phytochemical studies carried out on the South-American *Strychnos* species which showed that, the root and the stem-barks were double in alkaloids comparative to the leaves (Quetin-Leclercq *et. al.*, 1990).

It is possible that the local people have through continued use learnt that the roots and the stem-bark are more potent in treating joint diseases.



With the exception of one plant (*Cissus quadrangularis*) (Table 1), in which the root infusion is used to massage the aching joints, the rest of the plant species are either boiled in water alone (decoction) or in combination with other plants (concoctions) and taken orally. The usage of decoctions or concoctions ensures that the ingredients that are extracted through boiling get extracted but it is disadvantageous in that, boiling may result in alteration of many active ingredients for instance, glycosides which readily degrade upon boiling (Sofowora, 1982). The use of concoctions is rational in that some of the plants may act synergistically (Kofi-Tsekpo, 1997) and/or play a role of counteracting the poisonous ingredients of the other plants.

The preparations that are taken orally are either taken with bone broth, milk or tea although most of the preparations are taken with bone broth (Table 1). Karehed and Odhult (1996) reported that the Maasai of Loita in Narok District, Kenya, consume their medicinal preparations with milk or bone broth. The Maasai are mainly pastoralists and their diet largely consists of animal products, thus the use of the same in the medicinal plant preparations. Animal fat may be useful in extracting the fat-soluble substances and or may act as vehicle for more rapid absorption of the active substances (Kofi-Tsekpo, 1997).

Lack of precise dosage of the preparations was evident. The detractors of traditional medicine have stressed that this phenomenon is one of the major demerits of traditional medicine (Sofowora, 1982; Kokwaro, 1995; Sindiga, 1995)

## 5.2. Effects of plant growth regulators

Plant Growth Regulators (PGRs) are known to play a major role in seed germination (Mayer and Poljakoff-Mayber, 1975; Wang *et. al.*, 1982; Lewak, 1985). However, responses to the application of (PGRs) vary from species to species, one provenance to another and even from one individual seed to another (Bewley and Black, 1985, 1994). The results of this study revealed that, the seeds of *Strychnos henningsii* Gilg. and *Myrsine africana* L. responded differently to the application of the different concentrations of GA<sub>3</sub>, NAA, BAP and distilled water (control).

GA<sub>3</sub> at 10<sup>-4</sup> M was the optimal concentration in *Myrsine africana* giving the highest percentage germination of 84±3.71. GA<sub>3</sub> at 10<sup>-4</sup> M was found to be the optimal concentration, for instance, in *Podocarpus falcatus* (Legesse Negash, 1992), *Olea europaea* ssp *cuspidata* (Legesse Negash, 1993) and lettuce seeds (Bewley and Black, 1985). A study on the influence of different concentrations of GA<sub>3</sub> on three *Meconopsis* species also indicated the existence of an optimum dose of GA<sub>3</sub>, below or above which, germination declined (Sulaiman, 1993). Sulaiman (1993) concluded that a critical level of GA<sub>3</sub> (corresponding to the optimal concentration) might be essential to counteract the inhibitory factors.

Stimulation of percentage germination by GA<sub>3</sub> in *Myrsine africana* seeds is in agreement with the consensus, that gibberellins stimulate germination (Mayer and Poljakoff-Mayber, 1975). Gibberellins have been reported to promote germination in seeds with rudimentary embryos (Mayer and Poljakoff-Mayber, 1975; Wang *et.al.*, 1982), permeability barriers (Bewley and Black, 1985, 1994; Demel Teketay, 1993b) those with germination inhibitors (Sulaiman, 1993; Perez-Garcia and Duran, 1990; Bewley and Black, 1985, 1994), those seeds under phytochrome control (Choudhury and Gupta, 1995) and those exhibiting thermodormancy (Taylorson and Hendricks, 1977).

Karssen *et al.* (1989) demonstrated that gibberellins have at least two separate promotive actions on seed germination; (i) reserve food mobilization and (ii) on embryo growth. The two mechanisms might have been involved in the germination of *Myrsine africana* seeds.

GA<sub>3</sub> at 10<sup>-3</sup> M inhibited germination in *Strychnos henningsii* (Figure 4). Heydecker and Coolbear (1977) reported that higher concentrations of gibberellins impose dormancy. Inhibition of germination by higher concentrations of GA<sub>3</sub> was also observed in some weed species (Corn, 1960 cited in Choudhury and Gupta, 1995).

Different concentrations of BAP, exhibited different germination responses between *Strychnos henningsii* (Figure 4) and *Myrsine africana* seeds (Figure 5). Cytokinins have been shown to stimulate seed germination (Mayer and Poljakoff-Mayber, 1975; Wang *et. al.*, 1982).

Stimulation of percentage germination by lower BAP concentrations in *Myrsine africana* is in line with reports of stimulation of germination by members of cytokinins.

Cytokinins play a “permissive” role to gibberellic acids in counteracting the effects of abscisic acid (Khan, 1971 cited in Heydecker and Coolbear, 1977; Bewley and Black, 1985, 1994), relieve therm dormancy (Taylorson and Hendricks, 1977; Lewak, 1985) and have been shown to sensitize light requiring seeds so that they respond to low levels of light (Mayer and Poljakoff-Mayber, 1975).

BAP at  $10^{-6}$  M was found to be the optimal concentration in *Myrsine africana*. Plant growth regulators are considered to penetrate the seed coat at their optimal concentration and may enhance the rate of metabolism during germination (Upreti and Dhar, 1997).

Inhibition of percentage germination in *Myrsine africana* seeds by higher concentrations of BAP (Figure 5) could be due to their altering the threshold level of a critical ratio of promoters to inhibitors needed for induction of germination (Hsiao *et. al.*, 1988).

According to Berrie (1984), synthetic cytokinins are inhibitive to germination compared to natural cytokinins, which could explain the germination inhibition, by higher concentrations of BAP in *Myrsine africana* seeds. BAP at  $10^{-4}$  M was found to be ineffective in stimulating seed germination in *Podocarpus falcatus* seeds stored for five months (Leggese Negash, 1992). Cytokinins were also found to be ineffective in celery seeds (Thomas *et. al.*, 1975) and three *Meconopsis* species (Sulaiman, 1993).

The absence of any significant difference between the different BAP concentrations and the control in *Strychnos henningsii* could be an indication that *Strychnos henningsii* seeds might not be under any germination inhibition.

NAA, an auxin exhibited both germination inhibition (at higher concentrations) and germination stimulation (at lower concentrations) in both *Strychnos henningsii* (Figure 4) and *Myrsine africana* (Figure 5). Mayer and Poljakoff-Mayber (1975) report that the influences of auxins on seed germination have in most cases produced conflicting results, inhibition or stimulation being observed depending on the auxin concentration and the type of seed used.

However, higher concentrations in most cases exhibit inhibition responses (Copeland, 1976; Nikolaeva, 1967 cited in Lewak, 1985). Inhibition of percentage germination by lower concentrations of NAA was reported in *Acacia abyssinica* (Berhane Haile, 1998) and *Catharanthus roseus* cv. alba (Choudhury and Gupta, 1995).

In *Podocarpus falcatus*, NAA at  $10^{-4}$  M stimulated germination (Leggesse Negash, 1992). The effects of auxins on cell membranes and protein synthesis and hence overall growth of tissues could explain stimulation of percentage germination by lower concentrations of NAA.

### 5.3 Post-germination development of the seedlings

*Myrsine africana* seedlings obtained from the GA<sub>3</sub> at 10<sup>-4</sup> M treatment exhibited the least percentage establishment potential in comparison to the other treatments (Figure 6). Although gibberellins play a major role in seed germination (Mayer and Poljakoff-Mayber, 1975; Lewak, 1985), it was observed in *Acacia abyssinica* that gibberellins treated seedlings initially grew at higher rate compared to distilled water treated seedlings. They were however overtaken later on by distilled water treated seedlings (Berhane Haile, 1998).

According to Grime *et al.* (1981), a study on the local flora in Sheffield, England showed that the speed of germination and the rate of seedling development strongly affected the prospects of survival and reproduction. In the case of *Myrsine africana*, although GA<sub>3</sub> 10<sup>-4</sup> M treated seeds exhibited a higher percentage germination compared to the control (distilled water) (Figure 5), the accrued germinants showed a lower establishment percentage (Figure 6).

Lack of any significant seedling mortality in *Strychnos henningsii* exhibited the potential for *Strychnos henningsii* to establish. However, the production of only two leaves within a period of eight weeks could be an indication of a slow growth rate

## 6.0 Conclusions and Recommendations

### 6.1 Conclusions

From the results obtained from this study, the following conclusions have been made;

- Traditional medicine using medicinal plants is still widely used in the study area, as evidenced by ethnobotanical information collected and observation of various plant parts in people's houses.
- No efforts are being made to propagate the medicinal plants in the study area although there are claims that some of the plants are already becoming scarce.
- The seeds of *Strychnos henningsii* exhibited no germination inhibition and hence no germination promoters are required to boost their germination. The germinants exhibited a high establishment potential.
- *Myrsine africana* seeds exhibited germination inhibition, which could be seed coat imposed and hence would require pre-treatments before sowing to boost the germination.
- *Ziziphus mucronata* ssp *mucronata* seeds seemed to have lost their viability after storage for three years, or they may not have been viable in the first place.

## 6.2 Recommendations

- There is need to initiate conservation measures on plants used in treating joint diseases as the parts used (stem-barks and the roots) could lead to the death of the plants if excessively removed. The conservation measures could be in-situ (through sensitizing the foresters on the need to incorporate the indigenous trees in the afforestation and re-afforestation programmes) and/or ex-situ (by encouraging the local people to grow the plants within the vicinity of their homes).
- The most popular plant species such as *Strychnos henningsii* should be included in the department of forestry propagation programs.
- Indigenous knowledge on traditional uses of plants should be incorporated in the school curricula so that the younger people appreciate the value of such plants and thus use them sustainably.
- The claim by the local people that *Ruellia patula* and *Heliotropium rariflorum* spp *hereroense* are becoming rare in the study area should be backed up by ecological studies. Conservation measures on the species should then be initiated accordingly.
- The reasons advanced for failure to make any efforts to propagate the plants should be evaluated with the view of coming up with recommendations as to how the local people can be assisted to propagate the plants.
- Further studies should be carried out on *Myrsine africana* seeds to establish the type of dormancy, the most effective pre-treatment(s) and the optimal germination requirements.
- Studies to establish the growth rates and seedling biomass of *Strychnos henningsii* should be done.

- Further seed and germination physiological studies should be carried out on fresh *Ziziphus mucronata* spp *mucronata* seeds.
- Pharmaceutical studies should be carried out on these plants to establish their potency and explore the possibilities of integrating them in healthcare at a wider scale.

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## **Appendix 1. A list of the interview-guide questions**

- Is traditional medicine used in treatment of joint diseases?
- What materials are used?
- When plants are used, which ones are used?
- What part(s) are used?
- How is the medicine prepared?
- How much does the patient take at a given time?
- For how long does the patient take the medicine?
- Do you employ any measures to ensure that the plants are available at all times?
- Do you experience any problems in as far as the medicinal plants are concerned?

**Appendix 2. Botanical description of the plants used in treating joint diseases.** (NB: The plant are arranged by family in alphabetical order followed by the scientific name, local name brief description of the species, habit and/or plant communities in which the species occurs in Kenya, altitudinal range, geographical distribution in the taxonomic regions of Kenya (Appendix 3) and elsewhere.

#### ACANTHACEAE

1) *Ruellia patula* Jacq. Olesupeni (Maa)

A much branched erect or sub-erect herb. Stem greyish. Leaves ovate to spatulate, stalked. Corolla, pale blue or pink lilac in an almost stalkless axially clusters. Capsule ovoid, pointed, 13-14mm. Occurs in bushland, grassland and open places in forests. Altitude: 0-2300 m. Found in K1-7, Sierra-Leone, Eritrea, Somali land, Ethiopia, Uganda, Angola, Tanzania and Malawi.

#### AMARANTHACEAE

1. *Achyranthes aspera* L. Olorrbat (Maa)

A perennial herb with opposite leaves and long spikes of reddish flowers. Fruits deflected parallel to the stem, adhesive to clothing and animal skins. A common plant of waste places and roadsides. Altitude: 0-3080M. Found in K1-7 and all over the world.

## BORAGINACEAE

### 1) *Heliotropium rariflorum* Stocks ssp *hereroense* (Shinz) Verdc. Olekikareta (Maa)

Much branched woody subshrub or subshrubby herb, 20-80 cm tall. The young branches appear densely white, older branches with a silvery peeling epidermis. Leaves blades, linear to linear elliptic. Inflorescence spike like with leaves reduced to bracts or absent. Corolla white, fruit an ovoid, segment shaped nutlet. Occurs in grassland and bushlands in dry areas mainly with *Combretum-Commiphora-Lannea*, *Commiphora-Dobea* and *Commiphora-Acacia* associations. Altitude: 100-1890m. Found in K1,2,4,6 and 7, Tanzania, Ethiopia, Somalia, Angola and Namibia.

## COMPOSITAE (ASTERACEAE)

### 1) *Aspilia pluriseta* Schweinf. Olsinoni/Olyapasei (Maa)

A woody herb or shrub usually much branched. With stalked rough-hairy elliptic-lanceolate to ovate leaves. Yellow heads in loose terminal cymes or solitary phyllaries to 15mm long.. Abundant in black cotton soils and dry bushed grassland. Altitude: 1050-2400 m. Found in K1-7, Uganda, Tanzania, Sudan, Ethiopia and Somalia south to Zimbabwe and Mozambique.

## EBENACEAE

### 1 *Euclea divinorum* Hiern. Olenaraan/ Olkinyei (Maa)

An evergreen shrub or tree 1-9 (15) m with yellowish green leaves.

Flowers fragrant, creamish. Common in margins of dry forests, riverline bushland or forests. Altitude: 1-2400 m. Found in K1-7, throughout tropical East and Southern Africa.

## EUPHORBIACEAE

### 1. *Croton dichogamus* Pax. Enkitaru (Maa)

Shrub or small tree, 1-7 m. Leaves silvery beneath, turning orange before they fall. Flowers monoecious. Corolla yellowish. Fruit golden brown, three-locular. Found in dry forests, bushland especially on rocky soils or slopes, thickets, *Acacia-Euphorbia* woodland and disturbed sites. Altitude: 550-2000 m. Occurs in K1-7, Uganda, Tanzania, Ethiopia and Rwanda.

## LOGANIACEAE

### 1) *Strychnos henningsii* Gilg. Engilai (Maa): Muteta (Kikuyu)

Shrub or tree, 2-10 m tall. Bark pale grey, rough. Leaves sub-sessile, glossy, apex acute or rounded, glabrous. Corolla white or yellow, 3-4 mm long. Fruit, a berry, orange or red in color. Seed with a groove, coffee bean like. Found in upland and lowland forest, semi-evergreen bushland, lowland dry evergreen forest and riverline forest.

Altitude: 340-2000 m. Occurs in K1,2,4,5,6 and 7, Congo, the Sudan, Somaliland, southwards to Southern Africa.

#### MELIACEAE

1. *Turraea mombassana* C. Dc. Olnyirman (Maa)

Shrub 0.5-3 m (rarely scrambling). Leaves in fascicles, shiny on the upper surface. Corolla white to yellow, 25-45 mm long. Seeds red with white aril. Found in margins of dry forests bushland or thicket especially on rocky slopes, sometimes in grasslands. Altitude: 1-2200m. Occurs in K1,3,4,6 and 7, Tanzania and Ethiopia.

#### MIMOSACEAE

1. *Acacia nilotica* (L.) Del. ssp *subalata* (Vatke.) Brenan. Ol-kiloriti (Maa)

Tree, 1.5-12 m high. Bark rough, fissured, blackish, grey or brownwn. Young branchlets and pods densely pubescent. Fruit black or grey, straight or curved, often nearly cylindrical.. Found in wooded grassland, open bushland, deciduous bushland and clump bushland. Altitude: 15-1830 m. Occurs in K1,2,3,4 and 6, common in arid and semi-arid areas in Africa.

2. *Acacia nubica* Benth. Oidebe (Maa)

Shrub or small tree 1-4.5(6) m, often much spreading from the base. Branches emit a powerful smell when cut, with straight spines. Corolla, red. Pod, pale yellow pod, straight, margin wing like. Found in dry Acacia bushland (often common where overgrazing has occurred). Altitude: 600-1370 m. Occurs in K1,2,3,4,6 and 7, Egypt, Sudan, Ethiopia, Uganda, Tanzania and Arabia.

3. *Albizia amara* (Roxb.) Boiv. ssp *sericocephala* (Benth) Brenan Olperelongo (Maa)

A deciduous tree 2-13 m high. Leaflets symmetrical, straight. Corolla white or flushed pink. Found in bushland (*Acacia* or *Tarchonanthus* type), woodland or bushed grassland. Altitude: 800-1800 m. Occurs in K2,3,4,5,6 and 7, tropical East-Africa, Sudan, Eritrea, South to Malawi and South- Africa.

MYRSINACEAE

1) *Myrsine africana* L. Osegeteti (Maa)

An evergreen undershrub, 1-6 m, often sub-dioecious. Twigs variably pubescent. Bark gray or white with lighter streaks. Leaves alternate, crowded, blades ovate to lanceolate, with a dentate margin. Corolla, greenish, white or pink. Fruit, a berry, green, red, purple finally turning black, with a persistent style and calyx. Seed, one, globose shaped.

Occurs in upland forest edges, open wooded grasslands and stony hillsides in grasslands and pastures. Altitude: 1200-3600. Found in K1-7. Elsewhere occurs in mountains of Eastern Africa, Ethiopia to Zambia, Angola and South Africa. Cultivated in Europe and South Africa as an ornamental.

#### OLEACEAE

1. *Olea europaea* L. ssp *cuspidata* (Wall. Ex DC. ) Cifferi. Ol-irien (Maa)

An evergreen tree or shrub, 3-24m high with a rough dark brown bole and spreading grey branches with lenticels. Leaves glossy, dark above. Corolla, cream yellow. Fruit purple or black. Occurs in dry upland evergreen forest, often associated with *Juniperus*. Altitude: 950-2400m. Found in K1,2,3,4,5,6 and 7, also widely distributed from southern Africa through East Africa to Arabia, Mascarena islands and Madagascar.

#### RHAMNACEAE

1. *Rhamnus prinoides* L'. Herit . Olkonyil (Maa)

An understorey forest shrub or small tree to 8 metres high. Leaves dark green, shiny above. Fruits, globose shaped, red. Occurs in forest edges and less often in secondary bushland or bamboo heath zone. Altitude: 1500-3150 m. Found in K1,3,4,5 and 6. Also found in Uganda, Tanzania, Ethiopia to South Africa and west to Cameroon.

2. *Rhamus staddo* A. Rich. Olkokola (Maa)

Shrub or tree, 1-7.5 m high with twigs occasionally thorn-tipped. Flowers greenish to yellow. Fruit red turning black. Occurs in edges of dry upland forests, upland evergreen bushland. Altitude: 1000-3000 m. Widespread in K13,4,5 and 6. Also found in Uganda, Tanzania, Ethiopia and Yemen.

3. *Ziziphus mucronata* Willd. ssp *mucronata*. Ol-ilale (Maa).

Shrub or tree, 2-15 m young branches with a pair of thorns pointing in different directions. Leaves glabrous or slightly hairy. Flowers yellowish-green. Fruits yellow or red, globose in shape. Occurs along rivers and luggas, bushland, woodland or wooded grassland. Altitude: 1-1950 m. Widespread in K1-7, Tanzania, Uganda, Senegal to Arabia, south to South Africa and Madagascar.

RUTACEAE

1. *Teclea simplicifolia* (Engl.) Verdoon Olgelai (Maa)

Much branched small to medium tree, 2-9 m high. Leaves one-foliate, glabrous with a jointed petiole. Corolla, yellow green. Occurs in dry forests, riverline thicket or woodland or evergreen rocky bushland. Altitude: 850-2300 m. Occurs in K1,3,4,5 and 6, Ethiopia and Tanzania.

## SALVADORACEAE

### 1. *Salvadora persica* L. Olremit (Maa)

An evergreen shrub or tree (occasionally semi-scandent), 1-9 m high. Leaves yellowish green, appear fleshy, glabrous. Corolla, greenish-cream. Fruit, a drupe, translucent white, reddish or purple. Occurs along rivers, in dry Acacia bushland and wooded grassland. Altitude: 1-1500 (1800) m. Found in K1-7, Somali republic, Sudan, Ethiopia, Mozambique, Malawi, Zambia and Namibia.

## SAPINDACEAE

### 1. *Pappea capensis* Eckl. and Zeyhl. Oltimigomi (Maa).

Shrub or tree, 2-9 m high. Leaves papery with prominent lateral nerves and crowded at the edge of the twigs. Corolla, yellowish green. Fruit, a three-locular capsule, pink in colour. Seeds, black and shiny. Usually found in rocky sites in bushed or wooded grassland or semi-evergreen bushland or woodland. Altitude: 1050-2300 m. Occurs in K1-7, Tanzania, Uganda, South- Africa, Ethiopia and Eritrea.

## VERBENACEAE

### 1) *Clerodendrum myricoides* (Hochst) Vatke. Olmakutkut (Maa)

A weak shrub that grows to about 2 m tall. Stems slightly angular. Leaves arranged in twos or four, deeply toothed. Corolla blue, corolla limb glabrous. Occurs in grassland, scrubland, thicket, open woodland on black cotton soils and rocky outcrops. Altitude: 900-2250 (-2400) m. Found in K1-7, Zaire, Rwanda, Ethiopia, Sudan and Somalia.

## VITACEAE

### 1) *Cissus quandrangularis* L. Sukurtuti (Maa)

Climbing succulent, 2-4 m, with four-angled stems. Angles of stem winged, with simple tendrils. Leaves when present fleshy, entire or deeply 3-lobed, margin dentate. Corolla, white or yellow-green. Fruit, red. Found in dry bushland or wooded grassland, often in rocky sites or along luggas and rivers. Along the coast, occasionally found in dry forest margins. Altitude: 1-1700 m. Occurs in K1,2,3,4,6 and 7. Widespread in tropical Africa from Ethiopia, Somalia, Angola and South Africa.

**Appendix 3 A map of Kenya showing the Kenyan geographical divisions of the flora as used in the Flora of Tropical East-Africa (FTEA).**

