TREE ATTRIBUTE RANKING AND PHENOLOGY STUDY: FARMERS' KNOWLEDGE OF TREES COMMONLY FOUND ON COFFEE FARMS BORDERING MABIRA FOREST RESERVE IN MUKONO DISTRICT, UGANDA

BY

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Declaration

This dissertation is my original work and has not been presented for a degree in any other University

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Dedication

This dissertation is dedicated to my sisters;

Rachel and Sylvia

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Acronyms and abbreviations

This section presents acronyms and abbreviations used

ICRAF: International Centre for Research in Agroforestry

AP: Activity package

CAFNET: Coffee Agroforestry Network

CATIE: Centro Agronomico Tropical de Investigacion y Ensenanza

CGIAR: Consultative Group on International Agricultural Research

CIRAD: Centre de Coopération Internationale en Recherche Agronomique pour le Développement (French Agricultural Research Centre for International Development)

EDA: Exploratory Data Analysis

JKUAT: Jomo Kenyatta University of Agriculture and Technology

NAFORI: National Forestry Research Institute

PH: Potential hydrogen (the degree of acidity or alkalinity of the substance)

PRA: Participatory Rural Appraisal

RUFORUM: Regional Universities' Forum

SOM: Soil organic matter

Abbreviations

SE: Standard error

Definition of terms

Agroforestry: Agroforestry has been defined as a dynamic and ecological based natural resources management systems that through integration of trees on farms and in the agricultural landscape diversifies and sustains production for increased social, environmental and economic benefits for land use at all levels

Fruit trees: trees whose fruits are edible

Local knowledge: is defined as the general explanatory ecological knowledge encompassing all the practical skills, know-how and wisdom developed through the understanding of observations, experience and experimentation held by a person or a community in a particular environment.

Non-fruit trees: trees whose fruits are not edible

Phenology: is the annual cycle of growth events of trees.

Ranking of trees: Ordering of tree species above or below the other based on a particular attribute.

ABSTRACT

The potential of trees in agroforestry coffee systems to provide goods and services is increasingly recognized as important in improving local livelihoods and reducing the pressure on existing forest resources. There is a lack of information about how different trees interact with coffee systems and it is important to consider farmers' knowledge of tree physical attributes to understand how these affect coffee production and influence the selection of trees and management practices. The research was carried out in the selected five Sub-counties of Mukono district in South-central Uganda during February – May 2010. The purpose of the study was to assess the local knowledge about 18 tree species common in coffee farms for a selection of twelve tree attributes and to evaluate the consistency of farmers' knowledge and identify whether there were major differences amongst tree species.

Phenology information collection exercises, followed by an attribute ranking survey, were conducted with a random sample of 210 farmers. Farmers used visual tree cards in identifying trees they had direct experience and 10 tree species were selected by each participant. Farmers were able to rank these trees for the twelve attributes implying they had knowledge about these trees. More farmers had phenology knowledge of fruit than no-fruit trees.The level of consistency in the ranking survey suggested local knowledge about these tree attributes was important in the management practices of coffee agroforestry systems. However, the level of consistency varied from attribute to attribute and from species to species. Regarding species, African teak, banana and pawpaw seemed to have been ranked consistently indicating that farmers had a widespread and homogenous knowledge of these species because they were either superior on inferior for the particular attrributes. Despite the knowledge of attributes known to be negatively affecting coffee production, farmers' decision to plant or retain trees in coffee plot was influenced by the perception of utility. This is notably the case for fruit trees which appeared most commonly across all farms in both exercises, suggesting their contribution to nutrition and income was important and justified their presence in coffee plots despite their negative effect on coffee production. The study recommends planting for Fig natal and *A. coriaria* for soil improvement and African teak for timber should not be planted together with coffee. Further research on the other tree species not included here like Grevillea is highly recommended.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Foster (1976) reported that the soils to the north of Lake Victoria, where Mukono district, the area where research was conducted is located, are found on the rolling relief of the Buganda surface. This is the oldest surface within the East African Plateau whose soils are believed to have been formed during the Precambrian era (Yost and Eswaran, 1990). The implication is that these soils are extremely old, with very low weatherable nutrients (Yost and Eswaran, 1990). Thus, intensive management is required to maintain the productivity of the soil. The trees in savanna forests or the agroforestry fields play an important role in satisfaction of people's needs including improving the soil fertility (Maydell, 1986). However, maximum benefit from agroforestry is only possible if farmers' knowledge is put into consideration for proper management. Coffee quality is reported to be higher when grown together with trees than when exposed to direct sun shine, (Boffa, 1999).

1.2 Coffee Agroforestry

Agroforestry has been defined as a dynamic and ecological based natural resources management system that through integration of trees on farms and in the agricultural landscape diversifies and sustains production for increased social, environmental and economic benefits for land use at all levels (ICRAF, 1997).

Growing trees with crops in Agroforestry systems can increase total productivity, reduce land degradation and improve recycling of nutrients, while producing fuelwood, fodder, fruits and timber in addition to products from annual crops (Sanchez 1995).

Rural people in developing countries often depend on access to trees for a multitude of purposes. Trees provide important products such as fuel wood, construction material, fodder, medicine, and domestic utensils (Iben, *et al*. 2007). Trees provide important services such as shade and wind protection, and many woody species contribute to sustainability and improved productivity in agriculture by protecting watersheds, and by stabilising and enriching the soil (Iben *et al*., 2007). Trees on farms can also provide key habitats, resources and corridors for forest plant and animal species, thereby increasing both local and regional biodiversity (Pimentel *et al*., 1992).

Coffee is the world's second most traded commodity in terms of value after petroleum (Maina *et al*., 2010). The coffee yields are affected with the interactions with the trees, particularly the size of coffee beans is bigger under Agroforestry than under direct sun light
In rain-fed agriculture systems, the biophysical interactions between trees and crops strongly influences tree management practices and their structural and spatial assemblage (Boffa, 1999). Farmers maintain and plant trees in farming landscapes that enhance food, fuel and medical security, especially for low-income rural people and during hungry periods, diversify income, lower production risk and optimize the management of their resources (Arnold and Dewees, 1995).

The potential benefits of higher productivity, improved sustainability and reduced risk of such simultaneous Agroforestry systems in comparison with monocultures are the outcome of a complex set of spatial and temporal interactions between the different components of the system (Ong *et al*., 2004). The Savanna trees are responsible for more nutrient enrichment and addition of organic carbon, nitrogen, potassium and phosphorus in the sub-crown environment compared with the open land (Belsky, 1994).

1.3 Indigenous knowledge

Local knowledge in Agroforestry research is defined as the general explanatory ecological knowledge encompassing all the practical skills, know-how and wisdom developed through the understanding of observations, experience and experimentation held by a person or a community in a particular environment (Walker and Sinclair, 1998). Through daily observations, experimentation, experience and perceptions, farmers build an understanding of ecological processes and change (Brook and McLachlan 2008). Local knowledge is constantly evolving and relies on three stages of development, Observation, experimentation and validation (Kolawole, 2001).

It is also important to distinguish the present interest in local ecological knowledge from what has been referred to as indigenous technical knowledge (IDS, 1979; Sinclair and Laxman, 2003). Much of what has been written about technical knowledge has actually referred to practice rather than knowledge, but what people *do* and what they *know* are rather different (Sinclair and Walker, 1999). Interactions between farmers and scientific information can be classified in four main types (Ortiz, 1999, Claudia, 2010): Formative, when new knowledge is formed; Modifying, when knowledge is adjusted; Reinforcing, when scientific information confirms farmers' knowledge; and Confusing, when there is a conflict with the knowledge and the new information. In view of the fact that previous top down approaches have proven to be unsuccessful (Kolawole, 2001), these interactions together with the cultural and socioeconomic background should be taken into consideration when working on rural development.

1.4 Institution of Attachment

1.4.1 Introduction to ICRAF Projects

ICRAF (International Centre for Research in Agroforestry) was established in 1978 to promote Agroforestry research in developing countries, and joined the Consultative Group on International Agricultural Research (CGIAR) in 1991 to conduct strategic research on Agroforestry at a global scale, and explicitly linked its work to the goals of reducing poverty, increasing food security and improving the environment. In the mid-90s,the Centre formally adopted an integrated natural resource management framework for all of its work, and institutionalized its commitment to impact, and acquired the brand name the 'World Agroforestry Centre' in 2002 reflecting its recognition as the international leader in Agroforestry research and development.

With over three decades of work with smallholder farmers in Africa, Asia and Latin America, and strategic alliances with advanced laboratories, national research institutions, universities and non-government organizations, ICRAF is uniquely positioned to address global challenges To improve the livelihoods of poor smallholders and improve the sustainability and productivity of agricultural landscapes, ICRAF focuses on;

Broadening the range and diversity of trees that can be integrated into farming systems, especially as many produce higher income per unit of area than annual crops, require less labour and are more resilient to drought;

Maximizing the productivity of Agroforestry systems through improved tree germplasm, integrated soil fertility and the enhanced supply of high-quality tree fodder resources;

Improving the income of poor households by facilitating their access to markets, (This is also important in stabilizing land-use change in some areas as well as increasing farmers' investment in Agroforestry trees and systems); Working in agricultural landscapes that experience the greatest environmental stress to balance improved productivity with the sustainable management of natural resources. (For example: stabilizing forest margins in Southeast Asia; and rehabilitating degraded agricultural land throughout Africa);

Managing trees in agricultural landscapes to ensure the health of river and groundwater systems; and Examining reward systems or other types of institutional and policy innovations (such as for carbon or water) to sustain biodiversity at the interface between smallholder agricultural landscapes and conservation areas.

ICRAF has active Agroforestry programme activity throughout the East and Southern African regions with a focus on the use of trees in rainwater harvesting, maintaining soil fertility and improving farm income through product development and marketing.

Thus a lot of research activities are taking place at ICRAF and so many experiences have been gained in terms of research methods, being attached at ICRAF will offer me an opportunity to learn from the experienced staff as well as offering my contribution towards ensuring quality research through enhancing the research methods (Agroforestry, 2011).

1.4.2. Introduction to CAFNET Project

Coffee Agroforestry Network(CAFNET) is a participatory rural research and development project that brings together pilot projects in Central America, East Africa and India, in collaboration with coffee producers and stakeholders in the sector, including NGOs (Rainforest Alliance, etc.) and the big buyers in the sector (Starbucks, Nespresso, Utz Kapeh, 4C, etc.). The four-year project started in 2007, coordinated by CIRAD with regional partners CATIE in Central America, ICRAF in East Africa and Bangalore University/Coffee Board in India

In the three East African countries (Kenya, Uganda and Rwanda), CAFNET focuses in watersheds that have a major national importance in terms of area and volume of coffee

grown in the country, where coffee growing is mostly a smallholder enterprise, and which have a marked potential to respond to market demand for high quality, sustainable coffee.
The CAFNET project is organized into five Activity Packages (APs). The activities are listed under each AP including their justification, the partners and the local groups involved, and the deliverables to be produced. However, attachment was particularly geared towards achieved AP2: Participatory assessment of socio-economic and environmental impacts of coffee Agroforestry practices and definition of guidelines for sustainable coffee practices (CAFNET, 2011).

1.5 Research Objectives

General objective

The purpose of the study was to assess the local knowledge about 18 tree species common in coffee farms to improve tree farm diversity and management

Specific objectives

- To compare farmers' phenology information for fruit and non-fruit trees found in coffee farm in five selected sub-counties of Mukono district
- To compare tree species for physical attributes based on farmers' knowledge trees found in coffee farms in Mukono district
- To determine the consistency of farmers' ranking of tree species for each attribute in five sub-countries of Mukono district

1.6 Hypotheses

i. Farmers have equal phenology knowledge for fruit and non-fruit trees in their locality
ii. Farmers consider all the tree species in their coffee farms as having similar physical in Mukono district
iii. Farmers have consistent knowledge about the physical attributes of trees across the research area for all the attributes.

1.7 Statement of the problem

Increasing land degradation exacerbated by the increasing population from 23.3 million in 2001 to 32.9 million in 2011 that depend on this fixed yet important natural resource (UBoS,2011). Robusta coffee annual production has dropped from 2.7 million bags in 2007/08 to 1.9 million bags in 2009/10 (UCDA, 2010). This decline in coffee production has been attributed to decline in soil fertility, it therefore important for the community to embrace agroforestry to increase tree diversity for provision of tree products as well as improve soil fertility and coffee quality which is linked to tree shade, (Boffa, 1999).

Over one billion People in developing countries use trees on farms to generate food and cash (ILO, 2002).According to NatureUganda (n.d), Mabira forest is source of livelihood for over 200,000 forest adjust communities. The livelihood of the communities living inside and around the forests depends, in various ways, on the products and services provided by a diversity of trees. There has been increasing encroachment on the Mabira forest reserve due to this high demand and the forest is threatened due to unsustainable harvesting of these forest products.

Farmers through their experiences with their local environments have gained great knowledge which has not been adequately documented and utilized and thus there is need to gather the local knowledge and compare it with the scientific knowledge to improve the management of trees grown on farms.

1.8 Justification of the study

In most instances, the knowledge systems of these farmers have never been recorded systematically in written form; hence they are not easily accessible to agricultural researchers, extension workers, and development practitioners (Warren et al., 1995). Farmers need to be guided on how to plant trees in the right positions in order to harness maximum benefits. Rao *et al*., (2004) and Schroth, (1995) noted that Reducing below-ground competition may be achieved by selecting trees with less competitive root architecture, i.e. deep rooted trees with few roots in the upper soil layers, or by controlling tree roots in these upper layers by management. The guidelines for farmers on the tree species selection can be successful only when their knowledge about the trees is put into consideration.

On the other hand, Mabira forest has greatly reduced in size; this has been so because of the continued encroachment by the locals to get wood and land for agriculture, this research will therefore empower farmers living close to the Forest reverse to plant trees on their farms and management them sustainable based on their local and scientific knowledge this research is set to cover. This will also save the forest which is the major water catchment in the area.

It is therefore important to assess the consistence of the farmers' knowledge and whether there are major differences in this consistence between locations or among the tree species. The purpose of the whole research was to get farmers knowledge and compare it with science, and then use this information to advise farmers on which trees to plant in order to increase diversity on farms.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Coffee Agroforestry

Numerous factors have been believed to have both negative and positive effect on the growth and bean quality in coffee Agroecosystems, these include; climatic conditions, shade management, fertilization regimes, and adequate pruning (Wintgens, 2004; Steiman, 2008; Bosselmann et al., 2009; Valos-Sartorio and Blackman, 2010). Research has proven that the weight of coffee beans increases when coffee is grown together with tree as the trees provide shade (Youkhana and Idol, 2010).

Soto-Pinto, (2000) carried out a study in Mexico and found out that shade had a positive effect between 23 and 38%, and yield was maintained up to 48%. However, Beer et al., (1998) and Perefecto et al., (2005) noted that shaded coffee can produce lower, higher or equal yields relative to comparable sun systems. Somarriba *et al.*, (2001) and later Claudia, (2010) attributed the lowering of yields due to competition which is inevitable when more than one species are sharing the same resources, but they believed that the system as a whole can benefit from their interactions. This implies that proper tree species selection is important if the maximum benefits are to be realized. Therefore the farmers needed to be guided on how much shade the coffee trees will be able to produce higher yields and this implies tree species selection is very important.

By regulating microclimatic conditions, shade trees are known to stabilize the yields throughout the seasons, making planning and harvesting more efficient for the farmer and prolonging the life span of the crop (Claudia, 2010). As a result of the reduced stress, crops can withstand physical conditions of lower quality or lower external inputs, such as fertilizer, and become a more suitable option for small scale farmers in tropical countries (Beer, 1987).

2.2 Local knowledge in Agroforestry management

The knowledge that native or local people have acquired of their environment with generations living in direct contact with nature is referred to as local knowledge (Inglis, 1993; Rajasekaran *et al.*, 1991; Kolawole, 2001). Farmers in developing countries have quite a sophisticated knowledge of agriculture and natural resources management, which are recognized to be more eco-friendly and sustainable. This knowledge is based on many generations of insights gained through close interaction within natural and physical microenvironments (Rajasekaran et al., 1991 and Kolawole, 2001).

The important contribution local knowledge can make to scientific knowledge has been increasingly recognised as useful in provision of a deeper insight into the interdisciplinary and site-specific characteristics of land use and natural resource management and the understanding of the interaction between agro-ecological systems and humans (Warburton and Martin, 1999).

Local knowledge can be useful in providing valuable information that can feed back synergistically to channel the direction of conventional science to meet the needs of local people (Sinclair and Joshi, 2001). In many circumstances, interventions that build on local practice to improve land management practices will be more readily accepted by farmers than new technology (Smith, 2010). Indigenous knowledge (IK) is dynamic, changing through indigenous mechanisms of creativity and innovativeness and contact with other local and international knowledge systems (Warren, 1991).

2.3 Ranking of the tree attributes by farmers based on indigenous Knowledge

Preference ranking has been a popular tool in PRA activities for a long time (Bayer, 1988; Chambers, 1988). The aim is to identify farmers' assessment of the "best" or "most important" item from a list of items. But for this study it was not about the best or worst scenario but it was about which tree species was ranked above the other based on various attributes. This is so because most trees are grown for different purposes and no particular tree species can be regarded as being best. Trees that produce good timber may not necessarily be good at improving soil fertility and a farmer who is interested in soil fertility improvement will regard it as being the worst while the other Farmer who is interested in timber considers it as the best. The lack of a standard scale for ranks makes the task of combining ranks over several farmers difficult unless effort is made to ask supplementary questions to elicit farmers' absolute views on the "best" and "worst" ranked items, (Abeyasekera, 2001).

An alternative to scoring is to conduct a ranking exercise. Here researchers request only that each farmer place the items in rank order. In either case, the number of items presented to the farmer (or farmer group) may be a fixed number (Abeyasekera, 2001).

2.4 Ranking and rating studies

Ranking enables a participant to compare the items they are presented to before plancing them in order. The options available are placed in order without any attempt to describe how much one differs from another or whether any of the alternatives are, for example, good or acceptable (Coe, 2002).

Ranking is common in the preference surveys: A number of subjects are asked to rank list of items or concepts according to their person order of preference (Ludwig, et al., 2007). Partial rankings require some refinements of models designed for complete rankings, since two arbitray partial ranking will in general contain different subset of the items(Ludwig, et al., 2007).An extensive review of rank comparisons can be found in (Critchlow, 1985). Clustering of rank data aims at the identification of groups of rankers with common, typical preference behavior (Marden, 1995). An unsupervised clustering method for complete rankings has been proposed in (Murphy and Martin, 2003)

When analyzing ranking data, consistent results across different forms of enquiry can provide greater reliance on the findings, while contradictory evidence can give useful insights concerning the issue under consideration (Moris and Copestake, 1993). Means, standard deviations and summary charts (e.g. histograms) all have potential to provide insight into ranked data, Poole, (1997). Tables for testing multiple comparisons for ranked data are given in Hollander and Wolfe, (1973). The Friedman test (*Friedman, 1937*) is the nonparametric equivalent of the two-way analysis of variance, used in situations where observations on the different treatments are not independent.

2.5 Phenology of tree in the tropics

Phenology patterns of tropical trees are expected to be sensitive to short-term fluctuations in typical rainfall and temperature (Aderson *et al*., 2005). Rain and high humidity during flowering and fruit development reduces fruit yields in mango tree (Bally, 2006). The tree generally flowers in mid- to late winter, with fruit maturing in the early to mid-summer months.

Flowering is usually seasonal, from 1–2 months in duration, but it varies widely from place to place and even from year to year. In some areas, black plum flowers two or three times per year (Whistler and Elevetch, 2006).Flowering for most of the tree species occur more than once in a year, Whistler and Elevetch (2006) reported that area close to the equator in Hawaii, black plum flowers from March–April, flowering apparently occurs twice a year, in November–December, and again in April–May. Trees begin flowering at an age of 7–8 years.

Elevetch and Manner (2006) observed that Fruits of Jack fruit trees take 3–8 months from flower to mature fruit, depending on the individual tree, growing conditions, and weather; therefore, time from flowering alone is not a good indicator of maturity. It takes some experience to gauge maturity. Thomson and Evans, (2006) observed that flowering for Canarium spp appear to be initiated by changes in day length. Accordingly, the onset of flowering depends on latitude and under good conditions flowering trees start flowering at about 5 to 7 years after flowering. Flowering and fruiting of bananas occur year-round but often fluctuates seasonally, with maximum production during summer and fall (Scot *et al*, 2006).

2.6 Tree attributes important for crop growth in agroforestry

2.6.1 Root architecture of some of the tree species

Coder, (1996) argues that the ability of the tree to resist strong winds, ice storms, and major losses of woody materials, while remaining alive and erect, is a direct consequence of annual diameter growth. Chaplin, (1988) and Thomson and Evans, (2006) also stated that *C.*

schweinfurthii tree has a deep taproot. Coit, (1940) who conducted research on this tree species and discussed that Ovacado is naturally a surface rooting tree. He attributed this to the fact that fine fibrous rootlets, which absorb water, food and air, develop in greatest abundance at or near the surface of the soil.

Mango tree has a long taproot that often branches just below ground level, forming between two and four major anchoring taproots that can reach 6 m (20 ft) down to the water table (Bally,2006). The thought that Tree roots mirror the size and spread of the crown was rejected by Harmony, (n.d) as a common misconception, rather root size and spread is often defined by the ground conditions the tree is growing in.

2.6.2 Crown architecture of different tree species

Bally, (2006) also noted that mango do not make a good overstory tree for cropping shade-tolerant species because their dense canopy produces100% shade.

Elevitch and Manner, (2006) also noted that jackfruit is used as a shade tree for coffee. Because the tree casts a deep shade, wide spacing such as 15 x 15 m (50 x 50 ft) is recommended unless the intercrop is considered short-term. Bally (2006) who stated that Mango trees typically branch 0.6–2 m (2–6.5 ft) above the ground and develop an evergreen, dome-shaped canopy. Similarly, Bally (2006) reported that variability in canopy shape and openness occurs among varieties

2.6.3 Growth rate of different tree species

Trees grow in diameter every year (Coder, 1996). From the farthest reach of the woody roots to the tips of the twigs, trees expand in girth. This annual growth increment allows trees to respond to changing environmental conditions and react to injuries. The ability of the tree to resist strong winds, ice storms, and major losses of woody materials, while remaining alive and erect, is a direct consequence of annual diameter growth (Coder, 1996). Tree height may not necessarily be an indication of growth rate due to differences in physiology of trees.

Thomson and Evans, (2006) stated that trees closely related to African elemi grow slowly and begin to flower and fruit more heavily and regularly from about age 7–8 years. This implies it takes long to bear fruits.Wood, (2010), stated that growth rate for trees typically are classified based on individual observation or experience and thus different people may make varied observations. Scot *et al*., (2006) observed that the growth rate of banana is rapid until flowering; after the flower bud shoots, vertical growth of the pseudostem ceases and no additional leaves are added. Elevitch and Manner, (2006) also noted that jackfruit is a fast growing tree that reaches maturity within two years. Bally, (2006) noted that mango trees are fast-growing trees, often growing in excess of 1.5 m (5 ft) per year when well tended in urban conditions. Whereas black plum is considered to be moderate growing even in early years, likely less than 75 cm (30 in) per year, (Whistler and Elevitch, 2006).

2.6.4 Leaf decomposition rate and soil benefit of different tree species

When plant residues are returned to the soil, various organic compounds undergo decomposition (Bot and Benites, 2005). Decomposition is a biological process that includes the physical breakdown and biochemical transformation of complex organic molecules of dead material into simpler organic and inorganic molecules (Juma, 1998).

In forest ecosystems, more than 90 % of net aboveground primary production returns to the forest floor as litter fall which constitutes the major substrate for plant species and soil decomposers (Swift *et al.*, 1979). Litter decomposition includes leaching, breakdown by soil fauna, and transformation of organic matter by microorganisms and transfer of organic compounds and nutrients to the soil (Ibrahima *et al*., 2010). This process is mostly biological, but is influenced by abiotic factors through their effects on soil fauna. Climate, soil characteristics, resource quality, and soil organisms are the most important factors regulating litter decomposition (Ibrahima *et al*., 2010; Swift *et al.*, 1979).

Montan˜ez (1998) as reported by Xuluc-Tolos *et al*.,(2003) found out that leaf litter decomposition of tree species in home gardens depended on season and species, where a slow decomposition occurred during the dry season and fast during the rainy season. Ibrahima *et al*., (2011) also stated that resource quality is an important factor regulating litter decomposition in Cameroon. Some leaves are considered to decompose slowly as to them those leaves are not preferred by termites which do most of the leaf decomposition. However, a similar and clearer explanation is given by Xuluc-Tolos *et al*., (2003) who stated that leaf quality, especially the C/N ratio, is a sound predictor of decomposition rate. This thus implies that termites prefer certain leaves to other could be due to differences in C/N ratio where the leaves with lower C/N ratio are selected. Swift *et al., (*1979) included other factors like climate and soil microorganisms as being most important in regulating leaf decomposition which the farmer did not seem to have this considered possibly because climate has been relatively uniform that farmers were not able to recognise its impact. Leaves from certain tree species like fig natal are more preferred by microorganisms and to them that could have been the contributing factor to their faster decomposition rate, this seems not to differ much from Swift *et al*., (1979) that soil microorganisms are one of the most important factors influencing leaf decomposition although termites are not part of the microorganisms. Brouwer, (1996) argues that impact of plant species on litter decomposition and nutrient availability depend on the chemical composition of their litter fall, tree species and species groups such as climax and pioneers.

2.6.5 Timber quality for each tree species

Elevitch and Manner, (2006) classified jackfruit wood as a medium hardwood (specific gravity 0.6–0.7) and is highly valued for building material, furniture and cabinet making, and even for musical instruments. It is highly durable, resisting termites and decay, seasons easily, resembles mahogany in appearance, and takes a beautiful polish. As the wood ages, it turns from yellow or orange to red or brown, although not as strong as teak (*Tectona grandis*) which could be related to African teak in this case. Jackfruit wood is considered superior for many purposes including furniture, construction, turnery, masts, oars, implements, and musical instruments. Thomson and Evans, (2006) noted that the wood of trees closely related to African elemi is suitable for light construction (in low-decay situations), moldings, veneer, and numerous interior purposes as it has a medium density of 430–560 kg/m3 (27–35 lb/ft3) and is non-durable when exposed to weather.

Bosu and Krampah, (2007) reported that bark cloth tree is most important on the international market for its veneer and plywood. Bosu and Krampah, (2007) also noted that the wood of bark cloth tree is often traded in mixed consignments of lightweight hardwood. Bally, (2005) reported that mango timber when properly seasoned has been used in furniture, for carving, as wall and floor paneling, and utensil manufacture. The timber is gray-brown, often with a pink tinge. It is coarse-textured hardwood that is easy to work and finishes well. The timber breaks down rapidly if exposed to the elements without preservation treatment. Thomson and Evans, (2005), noted that African elemi wood is suitable for light construction (in low-decay situations). Orwa *et al*., (2009) found out that sapwood for *Albizia coriaria* is soft but the heartwood hard and durable and its timber is used for boat building, utensils and furniture.

2.2.6 Pruning of trees as both a management practice and means of obtaining fuel-wood for rural communities

Most trees are pruned as a management practices to improve their growth but signifant cases indicate that pruning can be of other reasons like obtaining fuel-wood. Occasionally fruit trees are used for firewood, the fruit trees are not usually so utilized, especially if the trees are still producing fruits (Whistler and Elevitch, 2006) but increasing population have forced people to use them for Fuelwood (UNDP, 2000) .African elemi is also suitable for fuel wood and sometimes is burned (Thomson and Evans, 2006). Bosu and Krampah, (2007) reported that the wood of bark cloth tree is lightweight and its wood works easily with hand and machine saws. Bosu and Krampah, (2007) reported that bark cloth tree has a good self-pruning ability. Whistler and Elevitch, (2005) found out that pruning of black plum controls the tree’s size. Orwa *et al*., (2009) reported that *A.coriaria* is a slow growing tree and recommended management practices are lopping and pollarding. However, heavy pruning can kill the tree especially black plum (Whistler and Elevitch, 2005). Black plum grows slowly after pruning due to slow re-growth after pruning (Whistler and Elevitch, 2005).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

This study was conducted in five Sub-counties of Mukono district, south-central Uganda approximately 30 km east of Kampala. Rainfall in Mukono is bimodal, with a mean annual rainfall of about 1240 mm. Mean minimum and maximum annual temperatures are 21 and 25.3 °C respectively (Okorio, 2000; Wajja-Musukwe, *et al*.,n.d). Rainfall occurs with highest frequency from March – May and October – November. The monthly rainfall is fairly evenly distributed throughout the year (NEMA 1996). The soil, a ferralsol (FAO-UNESCO 1974), is a sandy loam, which averages 14% clay, 30% silt and 57% sand, with a pH 6.2 and 1.13% organic matter in the top 0 – 0.45 m (Okorio, 2000).

3.1.1 Location and Climate of Mukono district

Mukono District is located in Central Uganda lies between longitudes 320 35"E and 330 05 "E and latitudes 000 and 10 30" N It borders the districts of Jinja and Kamuli to the east, Mpigi and Luwero to the west, Apac to the north and Tanzania to the south **.**The district covers an area of 14,241 Km 2 of which 9,648 Km 2 is open water and swamps, DSE report, (1997). The climate of Mukono district is influenced by Mabira Forest Reserve and Lakes Kyoga and Victoria. The District experiences two rainy seasons (March - May and September to December) with a mean annual rainfall of 1400- 1600 mm but much higher as 1600 -2000 mm in areas close to the lakes and forest reserve. The mean annual maximum temperatures of Mukono District is 25 - 27.5 C and mean annual minimum is 15 - 17.5 C. Evaporation of 1472 mm is much lower than rainfall received (1610 mm) rendering the district a rain fall surplus zone. The prevailing wind (south easterly direction) diurnal variation is influenced by the L. Victoria water body. Generally, the vegetation cover is of the forest/ Savannah mosaic characterised by patches of dense forest in the south and scattered trees in shrubs and grassland of the north. Natural forests on private land and government controlled forests are a characteristic of this region

Figure 3.1: Location of the study area, Mukono district, south-central Uganda.
Source: http://www.sacuganda.net/02_2010.php[accessed on 9th/09/2011]

3.2 Collection of Phenology and Ranking data in Mukono district, Uganda

The survey consisted of two exercises, that is collection of tree phenology data which took about two weeks and ranking of those tree species based on the twelve pre-selected attributes took close to seven weeks. Data collection team comprised of four people who were divided in two groups. The collected data were on phenology and ranking of the tree species based on the twelve attributes, data also included the sex of the respondent, the location of the farm where the GPS readings were taken. The ranking data later during the exercise was decided that age of the respondent be recorded since the exercise revealed that the responses from the elderly were quite different from those of the youth, however further data analysis is required to prove that.

3.2.1 Training a research Team on data collection methods

The training was conducted to field data collection team on the methodology for data collection (Plate 3.1). This involved the tree cards which were to be given to farmers for the phenology and tree ranking exercises. Further training was conducted on data entry and this was purposed to ensure that the data entry process minimized errors as much as possible.

Plate 3.1: Training of a research team in data collection methods at NaFoRI at Kabembe, Mukono

3.2.3 Farmer Selection

Farmers were selected randomly from the coffee farmers list achieved at NAFORI, Kifu. The names were assigned by numbers which were written on the small pieces of paper folded and picked randomly. This was done separately for the five sub-counties that ensure participants from each of the selected sub-counties.

Although random selection of the farmers was a good practice to eliminate bias and improve the representation of the selected farmers to the whole district population, this had its own setbacks. For example, several farmers raised complaints as to why they were not selected to participate in the exercise, given that the study commenced just barely a week after presidential elections, several farmers who were not picked due to random selection thought it was deliberate because they voted for a particular candidate. This forced the research team to clearly explain the purpose of the study and held informal meetings with the locals (Plate 3.2) to rule out their fears of being left out, this was cleared when we explained to them how random selection was done and an example was demonstrated to them.

Plate 3.2: Community members listening to the how the random selection of the participants was conducted in Kasawo Sub-county, Mukono district

This cleared the issue of some farmers thinking they were left out deliberately.

3.2.4 Phenology data collection

Data collection process for Phenology exercise took 2 weeks. The data collection tools had been designed previously. Data collected for phenology included; the timing for flowering, fruiting and leaf fall. The farmers indetified the tree they had direct experience which were marked by the interviewer, from the indetified trees, the farmers selected at most ten (10) species which he of she had pheniology information.

After selection of the trees, information on the timing of flowering, fruiting and leaf fall were recorded. During data collection, farmers need to be interviewed where they are working so that the exercise does not interfere with their activities. In addition each farmer was interviewed indivually to get their own views without being influenced by other people's opinions.

Collected data were entered in excel files and frequencies were determined for each tree species. The frequencies for fruit and non-fruit trees were compared

Plate 3.3: A farmer being interviewed for phenology information in Kimenyedde Sub-county, Mukono district

3.2.5 Tree attributes ranking data collection

Data collection process which took up to 6 weeks and this was achieved by interviewing the randomly selected farmers on the ranking of the tree attributes.

To ensure high data quality during the data collection process, the check list at the farm involved;

i. The research team prepared well beforehand with the correct recording sheets, notebooks, information sheet for farmers. Also, decided who was going to do what during the exercise.

ii. Introduction of data collection work to farmer and who each of the research team members was – there was an emphasis on making the participant farmer happy to participate.

iii. Ensured that anyone else there understood that it was only a ONE person exercise. They were welcomed to listen but not to contribute at that stage.

iv. The GPS were taken and recorded after close to 5 minutes to locate satellites for more accuracy.

v. The required information on the ‘tree list’ was filled on the sheet of paper.

vi. The ranking exercise was carried out and questions to clarify anything were asked accordingly, any important comments were written on the data sheets.

vii. Notes of what was said were kept in notebooks.

viii. The data sheets were kept together neatly in the folders which were given and checked over what had been recorded at the end of each day by all the team members. Then EXCEL sheets were filled out on the computer.

3.4 Conference/seminar Presentation

The CAFNET e-conference was concurrently held in Kampala and Nairobi where several papers were presented this was the held to mark the end of CAFNET project which had been in operation in the past three years (Plate 3.4). In that conference the paper tree ranking was jointly presented with ICRAF supervisor, involvement was majorly during discuss period where the observations experienced in the field were shared especially during answering some the questions particularly those which were concerning Tree ranking exercises in Uganda, being a principal researcher this was a great experience gained.

Plate 3.4: The Ugandan team that attended the conference, in which research papers on CAFNET 3 year project were presented, Kampala-Uganda

The active participation during the seminar presentation was mainly during the discussions session on the field experiences on the Uganda CAFNET survey was

3.5 Data management

Data from Uganda site was entered on daily basis and this ensured that all the errors were corrected immediately to improve on the quality of data. Since the data collected were collected from five sub-counties, the first step in data management involved putting the data in a single file, the data collected were 'cleaned' though basic checks and be organized in the format ready for analysis. This was done after checking the data consistencies and quality in the original data set in excel files. Some of the errors noted were repeating of certain tree species and omission of others, this indicated that data management is very critical process that needs more than two people to cross-check the entries to ascertain its accuracy, errors due to omission and commission are very common if the whole process of data entry is left to one individual.

3.5.1 Data formats

Both data from the phenology exercise and the ranking exercise were prepared and put in two forms one which was similar to the data collection sheet and one in the format for analysis. For phenology exercise, one file was an electronic form phenology data sheets which contained data for each farm visited and how each farmer responded to the questions: and the other was phenology information with each excel sheet containing responses by all the farmers on a single tree species. This depicted how consistent farmer knowledge for the particular species across Mukono district, and also partly revealed the gaps in the knowledge held by farmers.

3.5.2 Data storage

Data were stored in several different files in the computer and had a well protected back-up on the flash disk, which was so to ensure that in case of loss of data or damage there was an alternative file. However, there was no case of data loss or damage possibly because of high level of organisation.

3.6 Data analysis

Data were analysed to determine the consistence of the tree ranking for a particular attribute by farmers across the study area. The R add-on package Bradley Terry2, which facilitates the specification and fitting of Bradley-Terry logit, probit or cauchit models to pair-comparison data (Turner and Firth, 2011) was use determine the consistence of farmers' knowledge among the tree species. Multivariate hierarchical cluster analysis was done in Genstat 12th Edition to draw Dendrograms Payne, *et al*., (2009). Frequencies were summarised in Microsoft excel links been the species ranked and the region tree species selection.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Results

In the graphs, the tree species were abbreviated for easy presentation. They stands as follows; Ach-Albizia chinensis, Aco- *Albizia coriaria*, Art- *Artocarpus heterophyllus*(jackfruit), Azy- *Albizia zygia*(red nongo), Ant- *Antarias toxicaria*(bark cloth tree), Can- *Canarium schweinfurthii*,(African elemi), Car-*Carica papaya* (Pawpaw) Fna- *Ficus natalensis*(natal fig), Fov- *Ficus ovata*(Fig tree), Mae- *Maesopsis eminii*,(umbrella tree) Man- *Mangifera indica*,(Mango) Mar- *Markhamia lutea*(Markhamia), Mil- *Milicia excelsa*(African teak), Mus-Musa spp(banana), Per- *Persea americana*(Ovocado), Sen- *Senna spectabilis*(Cassia), Spa- *Spathodea campanulata* (Nandi flame) and Syz- *Syzygium cuminii*(black plum). The results have been presented using figures, tables and plates to summaries the findings.

4.1.1 Data Collection from five sub-counties in Mukono district Uganda

Fieldworkers were trained to carry out the work effectively or whether the methods needed to be altered and/or more training given. The methods were understood well by the fieldworkers and they were able to carry out the work with limited supervision very quickly, after training had been given. The data collected was meaningful for achieving our objectives.The data show which trees were ranked more consistently than others by farmers and factors for this may be due to different tree growth rate in different areas of the landscape, as well as knowledge levels of the farmers. During data collection, farmers were allowed to view all the tree cards (Appendix 4a and 4b), identified those they use/have used in the past and then the selected 10 out of those they have identified OR the tree cards were held in a pack and gone through until 10 species were selected by the farmer (with rarer species on the top of the pack). It was decided to allow farmers to view all the trees and then pick out those that they had had direct experience with.

Plate 4.1 a farmer observing the tree cards and selecting the trees has direct experience in Najjembe Sub-county, Mukono district

4.1.1 Phenology of the tree species

4.1.1.1 Farmers' phenology knowledge for different tree species

Exploratory data analysis was conducted to summarise the data and gave some meaningful output. Data summaries included frequencies since the data that was collected were qualitative in nature. Data analysis was conducted for both phenology exercise and ranking exercise. The phenology exercise involved 3 timing (periodic lifecycle events in trees) namely; flowering, fruiting and leaf fall (Table 4.1).

Table 4.1: The number of farmers with phenology information for deciduous and ever green tree species on coffee farms in Mukono district

Scientific Name	**Number of farmers with Phenology information out of 76 visited**				
	Tree type	**Behaviour**	**Flowering**	**Fruiting**	**Leaf fall**
Albizia chinensis	Non-fruit	Deciduous	6	7	7
Albizia coriaria	Non-fruit	Deciduous	14	14	15
Red nongo	Non-fruit	Deciduous	3	2	2
Bark cloth tree	Non-fruit	Deciduous	4	6	5
(jackfruit)	Fruit	Evergreen	61	66	28
African elemi	Fruit	Deciduous	18	19	13
Pawpaw	Fruit	Evergreen	47	50	18
Natal fig	Non-fruit	Deciduous	8	23	22
Fig tree	Non-fruit	Deciduous	18	23	23
Umbrella tree	Non-fruit	Deciduous	10	13	7
Mango	Fruit	Evergreen	69	69	27
Markhamia	Non-fruit	Evergreen	19	16	13
African teak	Non-fruit	Deciduous	11	17	23
Banana	Fruit	Evergreen	62	61	29
Ovocada	Fruit	Evergreen	49	51	19
Cassia	Non-fruit	Evergreen	11	10	7
Nandi flame	Non-fruit	Deciduous	10	9	6
Black plum	Fruit	Evergreen	25	29	19

The Table 4.1 and Figure 4.1 show that more farmers had phenology information on *Mangifera indica*,(manogo) *Musa spp*,(banana) *Artocarpus heterophyllus*,(jackfruit) *Persea americana*(Ovocado)and *Carica papaya*(pawpaw). On the other hand, *Albizia zygia*,(red nongo) *Antiaris toxicaria* (bark cloth tree) and *Albizia chinensis* (A.chinensis)had less number of farmers with phenology knowledge.

More farmers also had knowledge on flowering and fruiting than the leaf fall for most of the trees and the reverse was true for non-fruit trees where more farmers had leaf fall knowledge than flowering and fruiting. *Milicia excelsa* (African teak) and *Albizia coriaria* (A.coriaria) had more farmers with leaf fall knowledge than flowering and fruiting. Fruiting also was slightly higher than flowering for *A.chinensis*, bark cloth tree, jackfruit *Canarium schweinfurthii* (African elemi), pawpaw, natal fig, fig tree, umbrella tree, African teak, ovocado and black plum. Species which had equal number of farmers for fruiting and flowering knowledge included *A. coriaria* and mango. Flowering had more farmers than fruiting for red nongo, markhamia, banana, cassia and nandi flame.

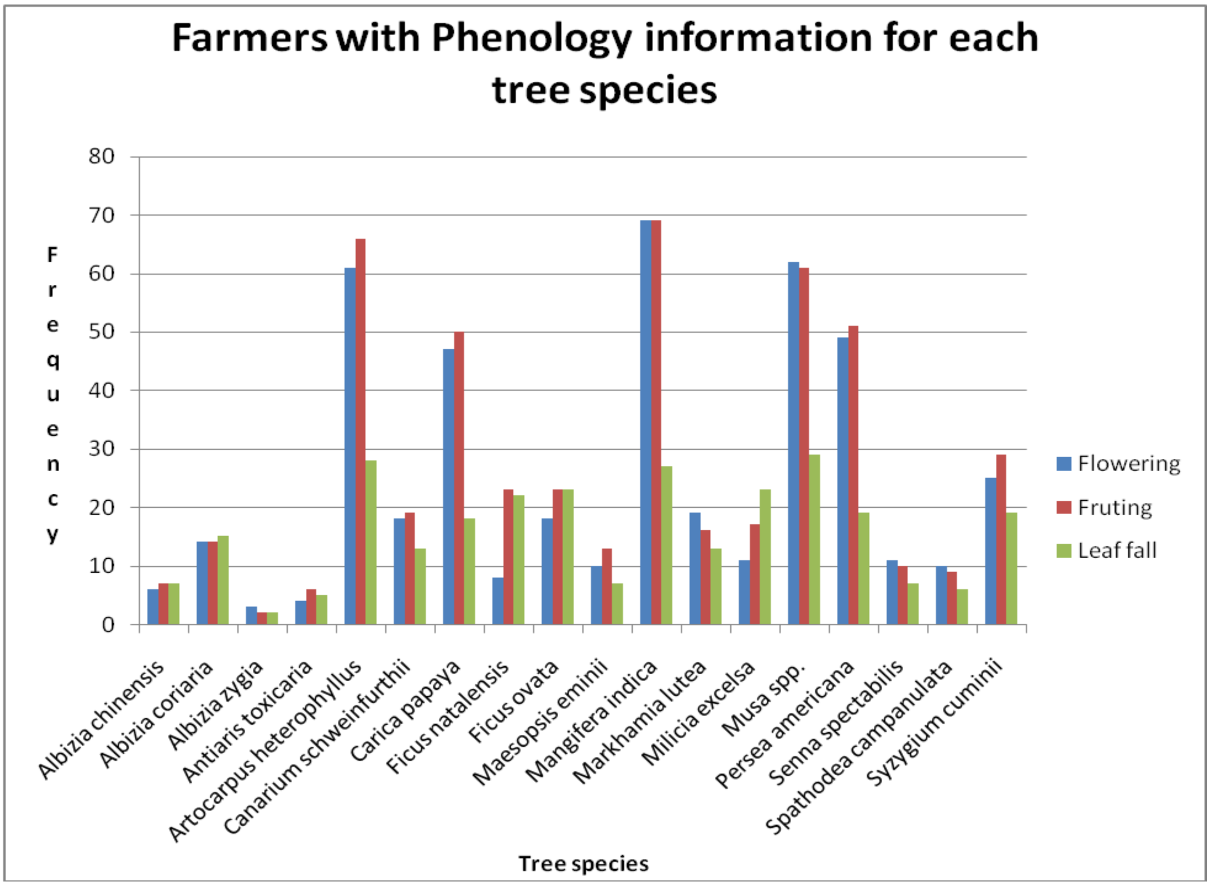

Figure 4.1 Frequencies of farmers with phenology information for each tree species, in Mukono district between February and March, 2011

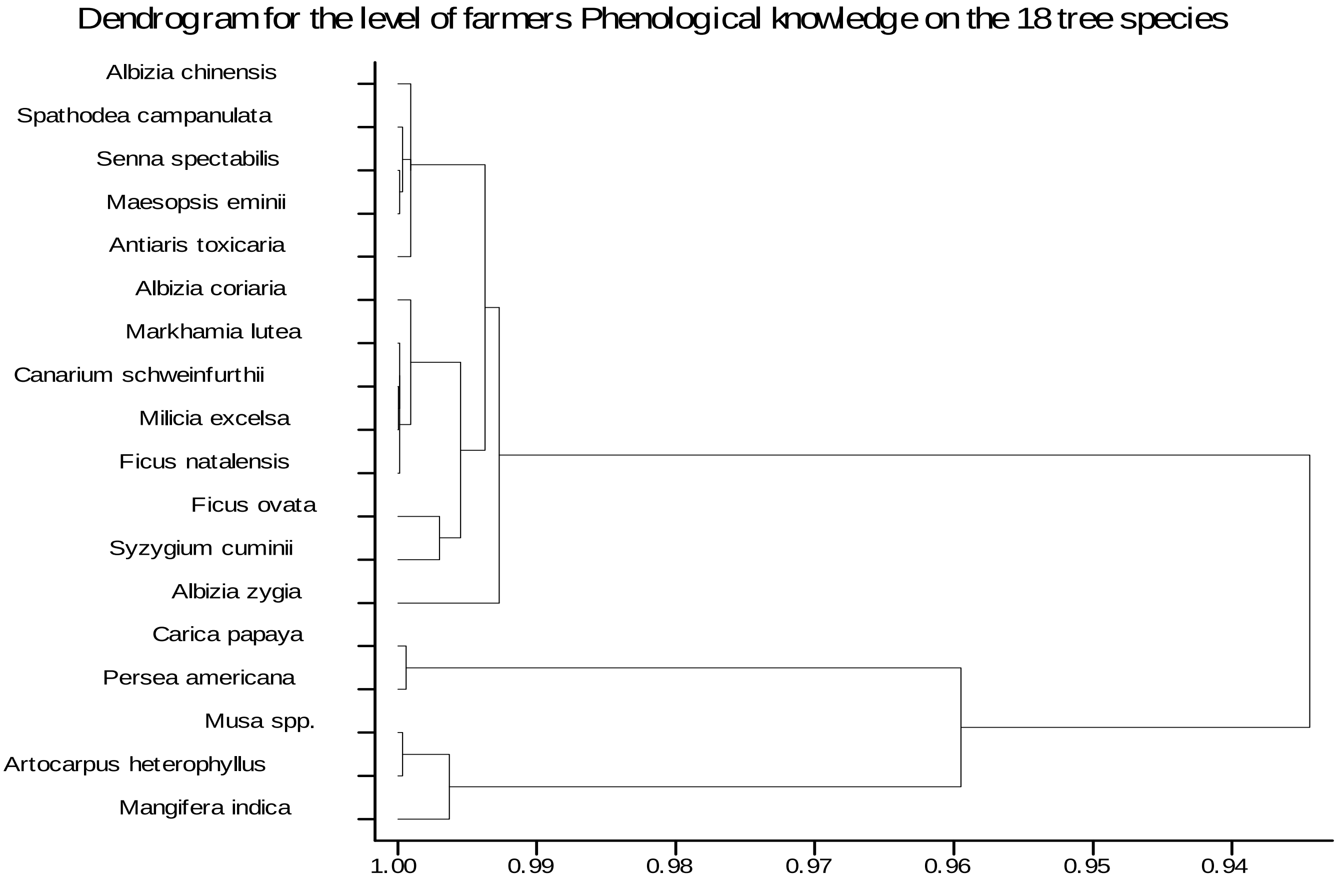

Figure 4.2 Dendrogram clustering tree species based on phenology information

There were two main clusters; cluster 1 had *C.papaya*, *P.americana*, *Musa spp*, *A.heterophyllus* and *M. indica* while cluster 2 had *A. coriaria*, *A.zygia*, *A.chinensis*, *A.toxicaria*, *C.schweinfurthii*, *F.natalensis*, *F.ovata*, *M.lutea,S.cuminii*, *M.excelsa*, *S.campanulata*, *S.specatbilis* and *M.eminii*. These two major clusters were further sub-clustered (Figure 4.2). It can be observed in Figure 4.2, that cluster 1 comprised of fruit trees; appeared in the same major cluster as far as phenology information was concerned. This indicated that farmers had different level of knowledge of phenology for fruit and non fruit trees. Amongst fruit trees still *M. indica* was exceptionally selected by the farmers, this could be so because of the way farmers link the fruiting habit of this tree to crop harvest. Most farmers explained that when this particular tree species put on many fruits it is an indication the crops yield in that same year would be poor.

4.1.1.2 Phenology information for fruit and non-fruit trees

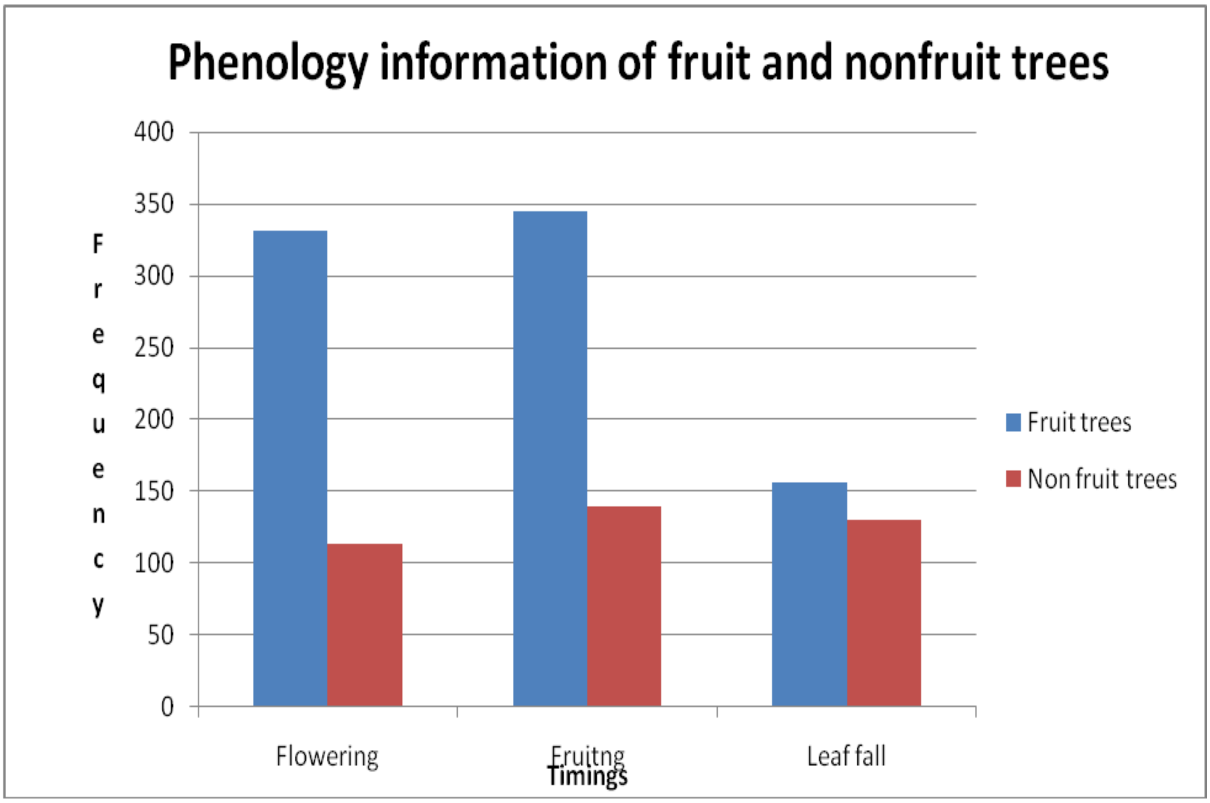

Figure 4.3 Farmers with phenology information on fruit trees versus non-fruit trees in Five Sub-counties of Mukono district, between February and March, 2011

Fruit trees included; pawpaw, ovocado, banana, jackfruit, Afican elemi and mango while non-fruit trees were; *A. coriaria*, red nongo, *A.chinensis*, bark cloth tree,fig natal, fig tree, markhamia, black plum, African teak, nandi flame, cassia and umbrella tree.

Figure4.3 indicates that farmers were more knowledgeable about the phenology of fruit trees than non-fruit trees for all the three events. Fruiting period was generally more known to farmers followed by flowering and lastly leaf fall for fruit trees. There was a very small difference between the leaf and for both fruiting and non-fruiting trees. There was a great difference in tree flowering knowledge by farmers for fruit and non-fruit trees. Flowering for fruit trees was almost three times higher for fruit trees compared to non-fruit trees. Knowledge on fruiting for fruit trees was more than twice for non-fruit trees.

Plate 4.2: Jackfruit tree with fruits in Kimenyedde sub-county Mukono district was the most common tree species farmers had phenology information

Table 4.1 and Figure 4.1 indicated that was the one of most selected tree species for phenology. The tree has bears larger quantities of fruits

4.1.2 Ranking for the tree species for the twelve attributes

4.1.2.1 Species ranking by the farmers

4.1.2.2 Cluster analysis of the ranking by tree species

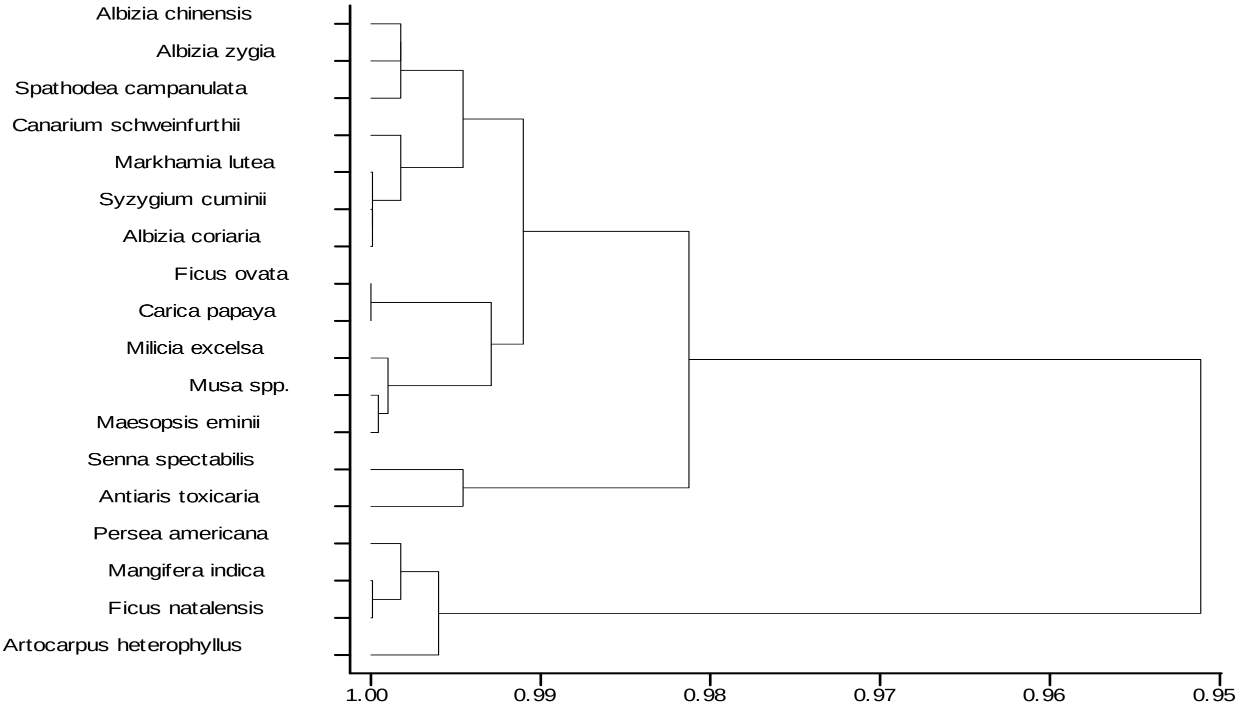

Figure 4.4 Clustering tree species according to frequency of their selection for ranking

There appears to be five close clusters in Figure 4.4, cluster 1 consisted *A.chinensis*, *A. zygia*, and *S.campanulata*. Cluster 2 consisted of *C.schweinfurthii*, *M. lutea*, *S.cuminii* and *A. coriaria*. Cluster 3 comprised of *F. ovata*, *C.papaya*, *M.excelsa*, *Musa spp*, and *M. eminii*. Cluster 4 consisted of *S.spectabilis* and *A. toxicaria*. Cluster 5 included *P.americana*, *M. indica*, *F.natalensis* and *A.heterophyllus*. Cluster 5 had the most popular tree species in the area.

4.1.2.3 Clustering by tree attribute

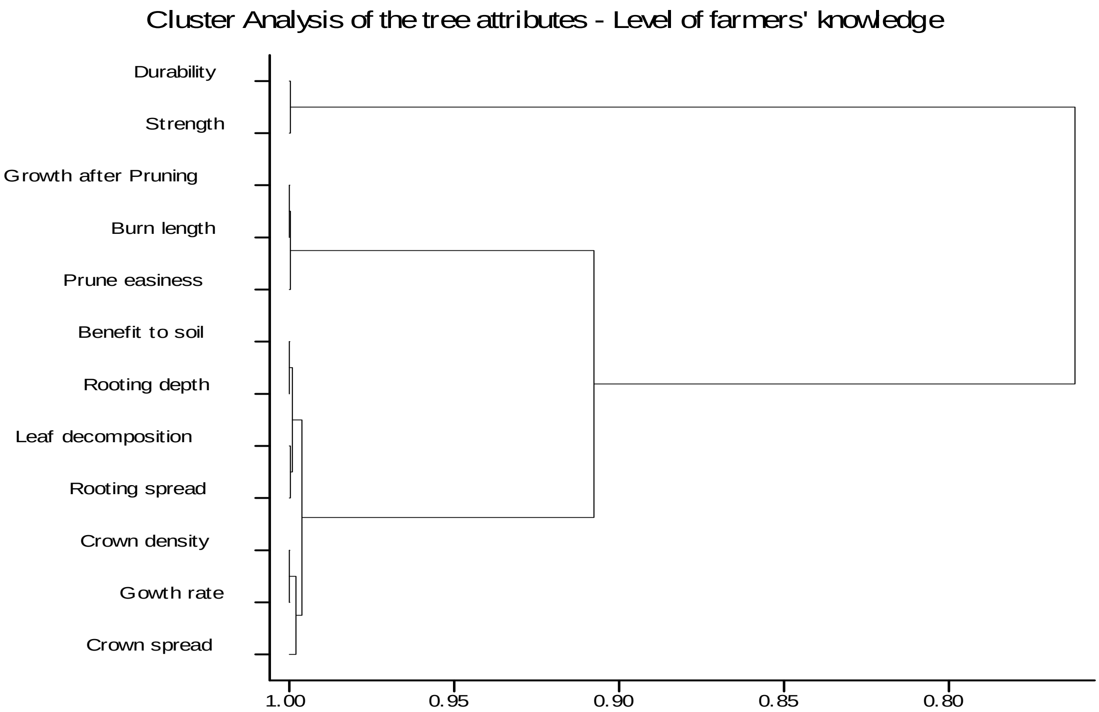

Figure 4.5 clustering of tree attributes according to level of farmers knowledge on each

The two main clusters can be observed. Cluster 1 had timber durability and timber strength. Cluster 2 comprised of prune easiness, growth after pruning, fuel wood burn length, mulch benefit to the soil, rooting depth, leaf decomposition rate, root spread, crown density, growth rate and crown spread. Cluster 2 was sub-clustered into 2 sub clusters 2a comprising of growth after pruning, fuel wood burn length and prune easiness. Cluster 2b had mulch benefit to the soil, rooting depth, leaf decomposition rate, rooting spread, crown density, growth rate and crown spread. The further clustering of 2b into 2b(i) which included, mulch benefit to the soil, rooting depth, leaf decomposition rate, rooting spread and 2b(ii) having crown density, growth rate and crown spread cluster appeared to have separated attributes which are observed above the ground 2b(i) from those on the ground and below ground 2b(ii).

4.1.3 Ranking for specific attribute s

4.1.3.1 Timber quality for each tree species

The farmers ranked timber for strength which was based on how hard the timber was to breaking and durability which was based on the resistance to decomposition and insect attack. Most farmers said they gained experiences on these two timber attributes mainly through observation of the home furniture and building materials. The exercise also revealed that farmers had limited experiences with timber from fruit trees, this was attributed to the fact that these trees are rarely cut down due to their functions the performance. In fact some farmers confessed that that they had never imagined fruit trees like ovocado can produce timber. Two tree species banana and pawpaw were not ranked for timber as they were not considered non-timber producing by majority of the farmers.

4.1.3.1.1 Timber – durability of wood and vulnerability to rotting and insect attack

This attribute was less ranked as some farmers had experience with just few tree species, this registered one of the highest gap in knowledge, the experiences were mainly from the home furniture and doors which most respondents said were made from timber, however, the home furniture also seemed to have been made from just few popular tree species. The fruit trees were also less ranked as far as timber was concerned possibly because most fruit trees are rarely cut down given their high value to the livelihood of the farmers.

Table 4.2 Comparison of trees species for timber- durability

Species	**Timber Durability**				
	Estimate	SE	Z-value	P-value	% consistence
Albizia chinensis	0.000	0.000	0.000	0.000	27
Albizia coriaria	3.65747	0.22384	16.340	< 2e-16 ***	83
Red nongo	1.93738	0.19079	10.154	< 2e-16 ***	25
Bark cloth tree	-0.14751	0.23487	-0.628	0.52996	60
Jackfruit	1.06497	0.15604	6.825	8.80e-12 ***	45
African elemi	1.71088	0.18623	9.187	< 2e-16 ***	56
Natal fig	0.27724	0.15701	1.766	0.07743	32
Fig tree	0.63838	0.16836	3.792	0.00015 ***	38
Umbrella tree	2.44761	0.17612	13.898	< 2e-16 ***	69
Mango	0.42571	0.15802	2.694	0.00706 **	35
Markhamia	2.81796	0.19963	14.116	< 2e-16 ***	75
African teak	6.16410	0.39380	15.653	< 2e-16 ***	99
Ovocada	-0.85013	0.18596	-4.572	4.84e-06 ***	17
Cassia	0.09151	0.22342	0.410	0.68211	33
Nandi flame	-1.61996	0.28763	-5.632	1.78e-08 ***	10
Black plum	1.51293	0.17740	8.529	< 2e-16 ***	56

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1($p \leq 0.05$)

The Table 4.2 indicates that with reference to *A. chinensis*, ten tree species; African teak, *A.coriaria*, markhamia, umbrella tree, red nongo,African elemi, black plum, jackfruit, fig tree and mango were significantly ranked ($p \leq 0.05$) above *A. chinensis* for timber durability. The tree species that were significantly ranked below *A.chinensis* for this attribute were nandi flame and ovocado. However, there was no significant difference in timber durability between *A.chinensis* and cassia, fig natal & bark cloth tree at ($p \leq 0.05$). On species level, African teak was ranked 6 six times higher than *A.chinensis* for timber durability. This was followed by *A.coriaria* which was ranked 3 times higher than *A.chinensis* for this attribute. Those that were ranked twice above *A.chinensis* included markhamia and umbrella tree. In terms of consistence, African teak was ranked above the other tree species for timber durability 99 times for every 100 times it was selected for ranking. *A. coriaria*, markhamia and umbrella tree had 83%, 75%, and 69% respectively ranking above the other trees they were compared with for every 100 times they were selected. Nandi flame, ovocado, red nongo and *A .chinesis* were ranked above the others 10, 17, 25 and 27 times for every 100 times they were selected for timber durability.

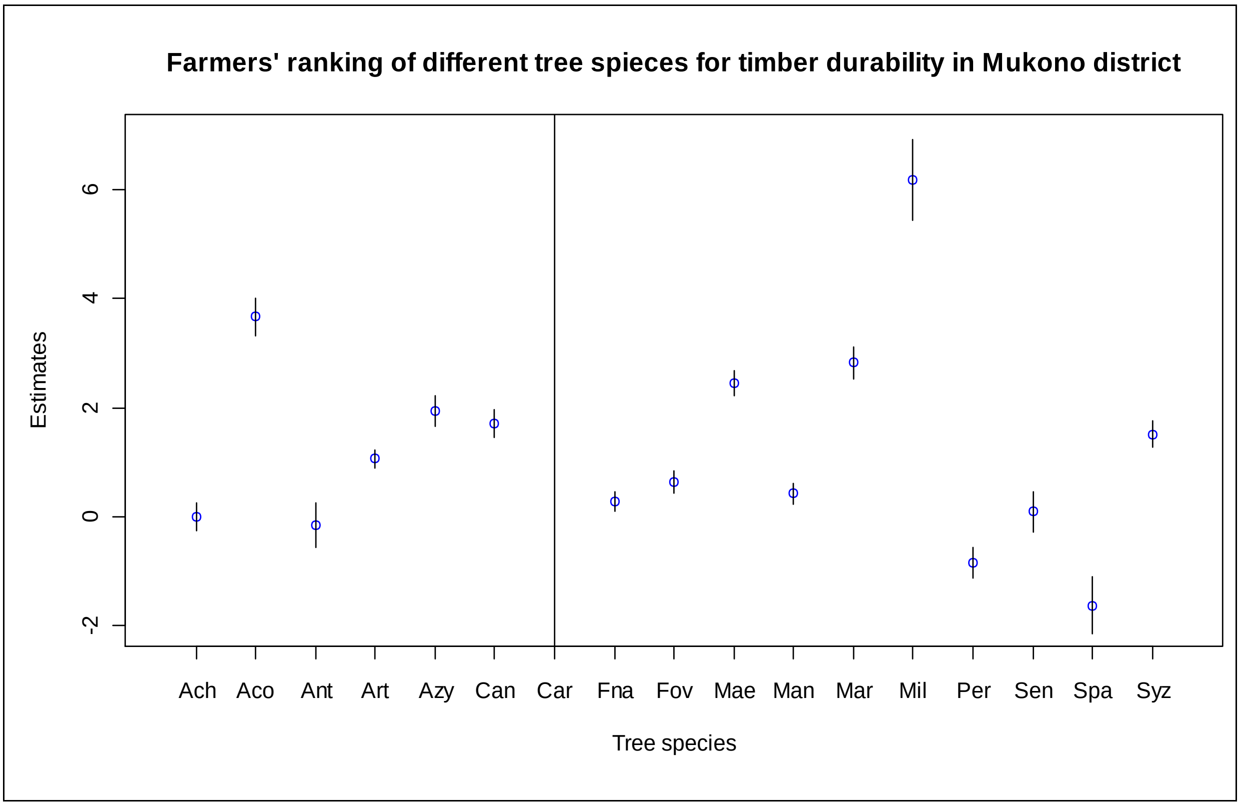

Figure 4.6 Mean and SE for trees ranked for timber durability in Mukono district, Uganda from Least to most susceptible to insect attack and rotting

Aco- *Albizia coriaria*, Art- *Artocarpus heterophyllus*, Azy- *Albizia zygia*, Ant- *Antarias toxicaria*, Can- *Canarium schweinfurthii*, Fna- *Ficus natalensis*, Fov- *Ficus ovata*, Mae- *Maesopsis eminii*, Man- *Mangifera indica*, Mar- *Markhamia lutea*, Mil- *Milicia excelsa*, Per- *Persea americana*, Sen- *Senna spectabilis*, Spa- *Spathodea campanulata*, Syz- *Syzygium cuminii*

M.excelsa was consistently ranked above the other tree species for timber durability; this was followed by *Albizia coriaria*, *M. lutea*, *M.eminii*, *A.zygia*, *C.schweinfurthii*, *Syzygium cuminii*, *A. heterophyllus*, *F.ovata*, *M.indica*, *F. natalensis*, *S.spectabilis*, *A.toxicaria*, *P.americana* and *S.campanulata* respectively. The error bars were small for all the tree species indicating each species was ranked considerable number of times for this timber attribute.

4.1.3.1.2 Timber – strength

This attribute appeared to be correlated with growth rate as the participants noted that the trees which are slow growing produce harder timber than those that are fast growing; to them this attribute has an inverse relationship with the growth rate.

Table 4.3 Comparison of trees species for timber- Strength

Species	Timber Strength				
	Estimate	SE	Z-value	P-value	% consistence
Albizia chinensis	0.0000	0.0000	0.0000	0.0000	27
Albizia coriaria	3.7462	0.2290	16.360	< 2e-16 ***	83
Red nongo	2.7281	0.2067	13.201	< 2e-16 ***	30
Bark cloth tree	0.1565	0.2296	0.682	0.495545	71
Jackfruit	0.9796	0.1563	6.265	3.72e-10 ***	43
African elemi	1.7906	0.1873	9.559	< 2e-16 ***	57
Natal fig	0.2390	0.1582	01.511	0.130833	31
Fig tree	0.5698	0.1695	3.362	0.000775 ***	37
Umbrella tree	2.1929	0.1727	12.696	< 2e-16 ***	64
Mango	0.5225	0.1583	3.301	0.000963 ***	37
Markhamia	2.6648	0.1970	13.525	< 2e-16 ***	72
African teak	6.9310	0.5306	13.063	< 2e-16 ***	99
Ovocada	-1.0110	0.1889	-5.352	8.69e-08 ***	15
Cassia	0.0909	0.2249	0.404	0.686075	34
Nandi flame	-1.9429	0.3094	-6.281	3.37e-10 ***	8
Black plum	1.6628	0.1799	9.245	< 2e-16 ***	58

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1(p≤0.05)

The Table 4.3 indicates that with reference to *A. chinensis*, tree species; African teak, *A.coriaria*, markhamia, umbrella tree, red nongo, African elemi, jackfruit, fig tree and mango were significantly ranked (p≤0.05) above *A.chinensis* for timber strength. The trees that were significantly ranked below *A.chinensis* for this attribute were nandi flame and ovocado. However, there was no significant difference in timber durability between *A.chinensis* and cassia, fig natal & bark cloth tree (p≤0.05). African teak was ranked 7 times above *A. chinensis* whereas *A.coriaria* was ranked 4 times above *A.chinensis*, this shows that there was significant difference in ranking African teak from other trees. African teak, A. coriaria, markhamia and bark cloth tree had 99, 83, 72 and 71 above the other trees they were compared with for timber strength respectively for every 100 farmers who selected them for ranking.On the other hand nandi flame and ovocado had only 8 and 15 respectively ranked above others for every 100 farmers who selected them.

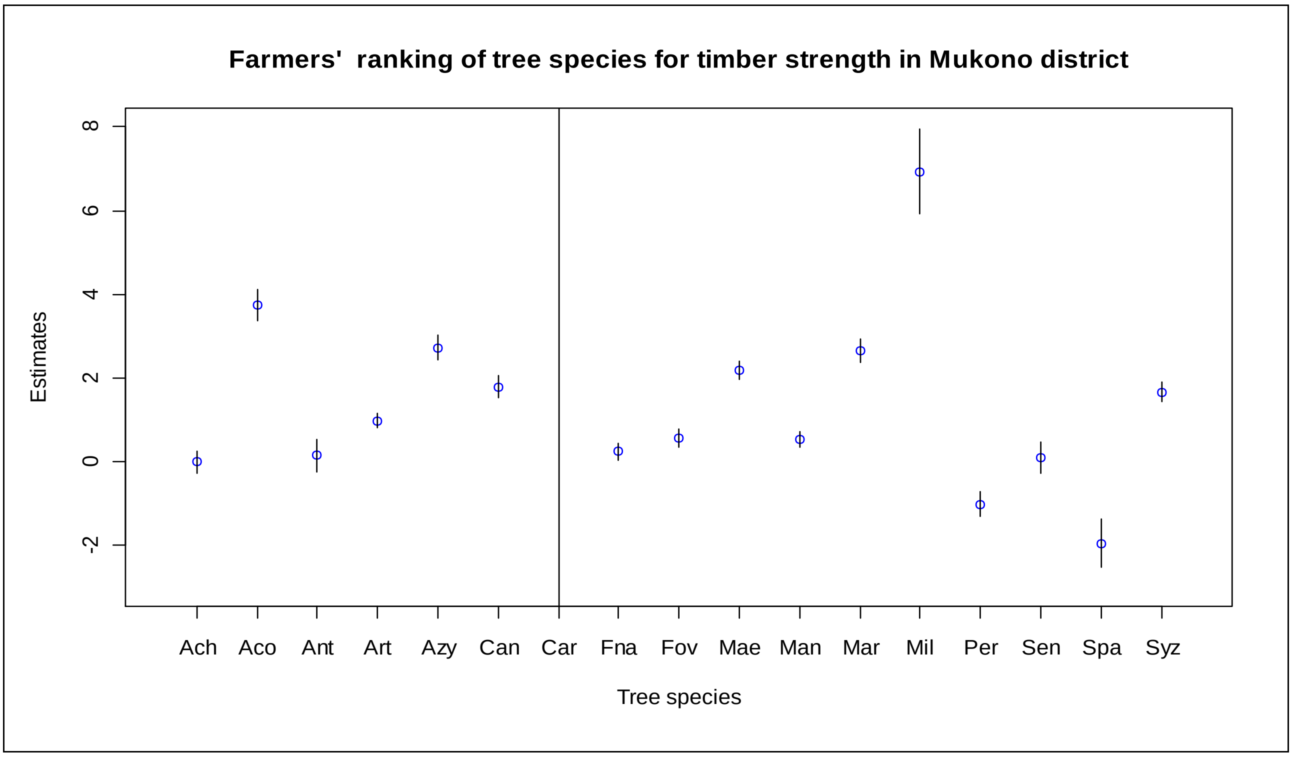

Figure 4.7 Mean and SE for trees ranked for timber strength in Mukono, Uganda displayed from strongest to weakest

M. excelsa was consistently ranked as the tree with the strongest timber. This was followed by *A.coriaria*. *A. zygia* and *M. lutea* were not distinguished for timber strength. *M. eminii*, *C.schweinfurthii* and *S.cuminii* appeared in a cluster. There were little differences in timber strength for *A. heterophyllus*, *F.ovata*, *M.indica*, *F.natalensis*, *A.toxicaria* and *S.spectabilis*. *P. americana* and *S.campanulata* were the trees with weakest timber.

4.1.3.2 Ranking of specific attribute – fuel-wood burn Length

This attribute was ranked with ease as most farmers seemed to have great knowledge about the fuel wood. The men also found it easy ranking this attribute as most of them said they also cook and have had extra experiences during burning bricks and charcoal. Two species; pawpaw and banana farmers said they do not use them for fuel-wood. It was only one village in Kyampsisi where some farmers reported not using *A. coriaria* for fuel wood as it is a taboo in fact the village was named after this tree species. The research team did not seek further explanation on why this tree species was highly respected in this area as this was considered out of the scope of this study.

Table 4.4 Comparison of trees species for Fuel wood- burn length

Species	Burn Length				
	Estimate	SE	Z-value	P-Value	% Consistence
Albizia chinensis	0.000	0.000	0.000	0.000	28
Albizia coriaria	3.5460	0.2020	17.556	< 2e-16 ***	84
Red nongo	3.5179	0.2146	16.392	< 2e-16 ***	33
Bark cloth tree	0.1723	0.2048	0.842	0.400031	82
Jackfruit	0.9671	0.1392	6.949	3.68e-12 ***	46
African elemi	1.2926	0.1610	8.030	9.77e-16 ***	53
Pawpaw	-16.2868	211.1484	-0.077	0.938517	9
Natal fig	0.9010	0.1398	6.444	1.17e-10 ***	44
Fig tree	0.4713	0.1519	3.102	0.001925 **	37
Umbrella tree	0.7807	0.1453	5.372	7.79e-08 ***	42
Mango	1.5909	0.1434	11.091	< 2e-16 ***	58
Markhamia	3.0435	0.1862	16.348	< 2e-16 ***	79
African teak	5.4260	0.2785	19.482	< 2e-16 ***	97
Banana	-17.3854	211.1487	-0.082	0.934379	8
Ovocada	-0.5646	0.1475	-3.828	0.000129 ***	20
Cassia	1.1850	0.1917	6.181	6.38e-10 ***	51
Nandi flame	-1.4775	0.2266	-6.520	7.02e-11 ***	14
Black plum	1.5620	0.1582	9.871	< 2e-16 ***	57

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1($p \leq 0.05$)

African teak, A.coriaria, red nongo, markhamia, mango,black plum, African elemi, cassia, fig natal, umbrella tree and fig tree were significantly ranked ($p \leq 0.05$) above *A. chinensis* for fuel-wood burn length. This implies they were considered to take long burn length than *A. chinensis*. Nandi flame and ovocado were significantly ranked below *A.chinensis* for fuel wood burn length. However, bark cloth tree was not significantly different from *A. chinensis*. Banana and pawpaw although the P-value indicates they were not significantly different from *A.chinensis* for fuel-wood burn length ($p > 0.05$), the larger standard error indicates less times these were compared with other species that indicate their results are not valid.

African teak, *A. coriaria*, bark cloth tree and markhamia had 97, 84, 82 and 79 above the other trees they were compared with for wood burn length respectively for every 100 farmers who selected them for ranking.On the other hand banana, pawpaw, nandi flame and ovocado had only 8, 9,14 and 20 respectively ranked above others for every 100 farmers who selected them.

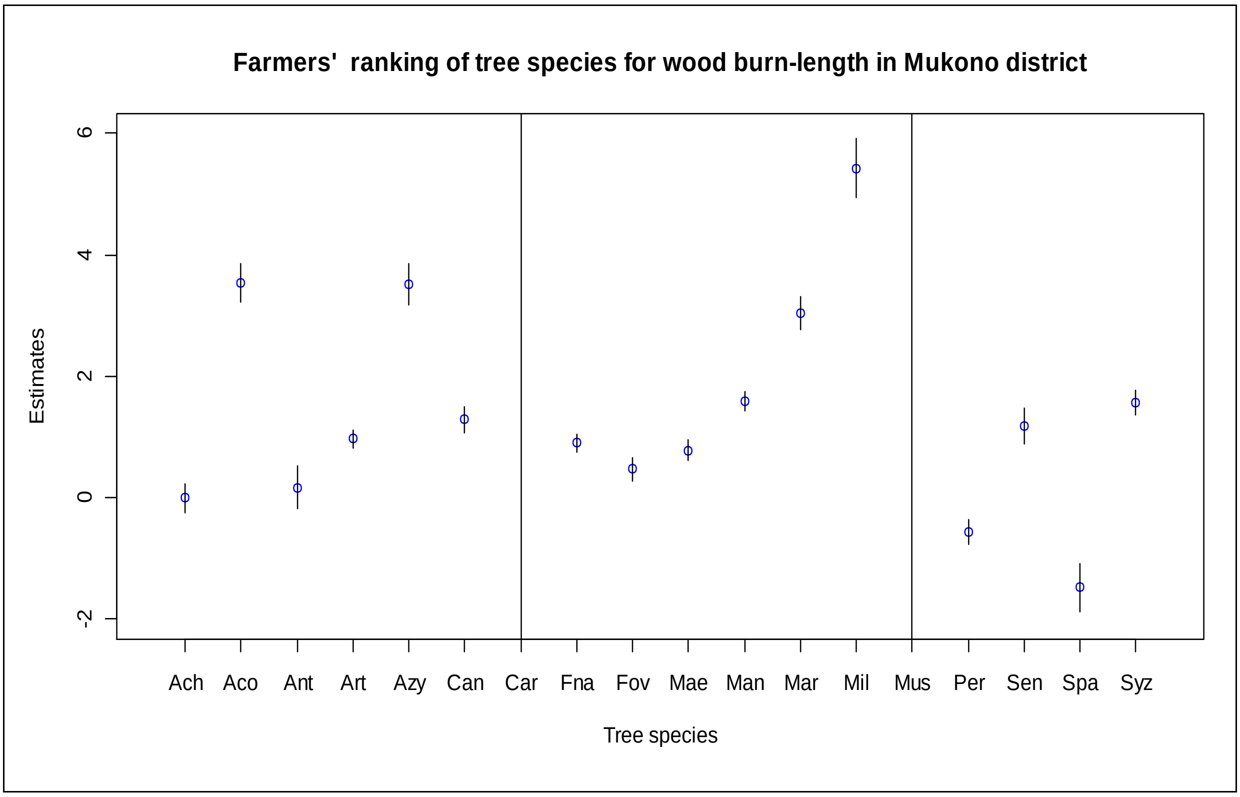

Figure 4.8 Mean and SE for trees ranked for burning length in Mukono, Uganda displayed from longest to shortest

African teak was ranked consistently above the other for longest wood burn length (Figure 4.8). This was followed by *A.coriaria*, *A. zygia*, and *M. lutea* which seemed not distinguished by the farmers for this attribute. The next cluster comprised of *M. indica*, *S.cuminii*, *C.schweinfurthii*, *S.spectabilis*, *A.heterophyllus*, *F.natalensis*, *M. eminii*, *F.ovata* and *A. toxicaria* were not distinguished for this attribute that means farmers did not have consistent knowledge about burn length for this trees that appeared in a cluster. With the exception of *C. papaya* and *Musa spp* which were considered taking the shortest burn length, *P. americana* and *S.campanulata* were also consistently ranked as having a short wood burn length. *C. papaya* and *Musa spp* had bigger error bar because they were ranked less number of times for this attribute this is so because most participant considered these two species as not used as fuel wood.

4.1.3.3Ranking of general attributes – Crown architecture

This attribute was easily ranked by the farmers and all the farms visited they were no missing data for this attribute, even farmers who were not very sure opted to simply observe their trees as they did the ranking. This was however, linked with how easily the sun rays go through, trees which had cool shade were considered having high crown density than the others.

Table 4.5 Comparison of trees species for Crown density

Species	**Comparison of tree species for crown density**				
	Estimate	25	Z-value	P-Value	% consistence
Albizia chinensis	0.000	0.000	0.000	0.000	25
Albizia coriaria	-2.2781	0.1660	-13.726	< 2e-16 ***	63
Red nongo	-1.4792	0.1712	-8.638	< 2e-16 ***	38
Bark cloth tree	-0.9640	0.2070	-4.658	3.20e-06 ***	47
Jackfruit	-2.5716	0.1532	-16.785	< 2e-16 ***	68
African elemi	-1.8021	0.1666	-10.816	< 2e-16 ***	53
Pawpaw	2.3900	0.2350	10.170	< 2e-16 ***	5
Natal fig	-3.1523	0.1584	-19.895	< 2e-16 ***	78
Fig tree	-2.5916	0.1634	-15.860	< 2e-16 ***	67
Umbrella tree	-0.1515	0.1567	-0.967	0.3337	26
Mango	-3.8600	0.1687	-22.879	< 2e-16 ***	88
Markhamia	0.4168	0.1776	2.347	0.0189 *	20
African teak	-2.3651	0.1597	-14.813	< 2e-16 ***	63
Banana	1.7132	0.2002	8.558	< 2e-16 ***	10
Ovocada	-1.1480	0.1490	-7.704	1.32e-14 ***	42
Cassia	-1.9940	0.1938	-10.288	< 2e-16 ***	56
Nandi flame	-1.5984	0.1781	-8.974	< 2e-16 ***	50
Black plum	-1.9127	0.1635	-11.700	< 2e-16 ***	55

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1(p≤0.05)

The crown density ranked from least to most dense. Pawpaw, banana and markhamia were significantly at ($p \leq 0.05$) ranked as having least crown density than *A.chinensis*. Although umbrella tree was ranked slightly higher than *A. chinensis* for crown density, there was no significant difference in crown density ($p<0.05$). Mango, fig natal, jackfruit and fig tree had 88, 78, 68 and 67 above the other trees they were compared with for crown density respectively for every 100 farmers who selected them for ranking.On the other hand pawpaw, banana, markhamia, A. chinensis had 5, 10, 20 and 25 respectively ranked above others for every 100 farmers who selected them.

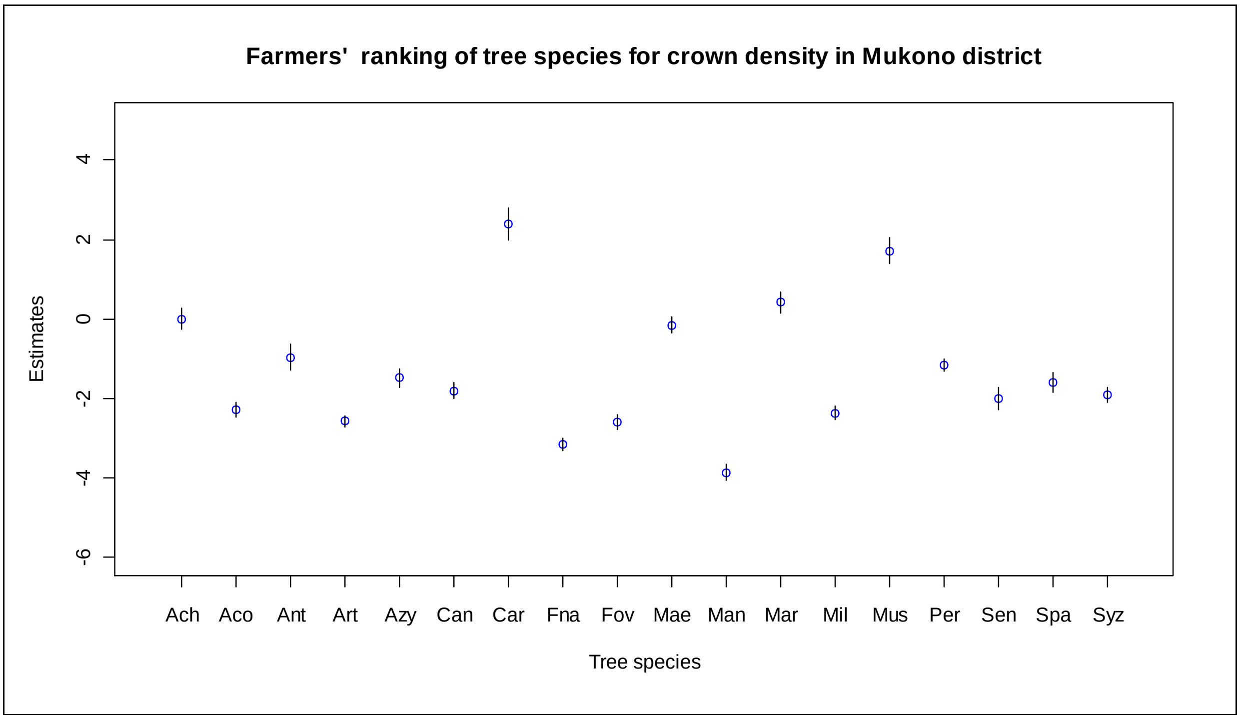

Figure 4.9 Mean and SE for trees ranked for crown density in Mukono, Uganda from least to most dense

C. papaya was clearly distinguished as having the least crown density. This was clearly followed by *Musa spp*, *M. lutea*, *M. eminii* were all clearly distinguished from each other for crown density. *Antiaris toxicaria* and *P.americana* were not clearly distinguished for crown density. Also *A.zygia*, *S.campanulata* were not distinguished. *C.schweinfurthii*, *S. cuminii* and *S.spectabilis* appeared in the same cluster indicating farmers did not consistently distinguish them for crown density. *A.coriaria*, *M.excelsa*, *A. heterophyllus* and *F.ovata* were also not distinguishable for crown density. *M. indica* was clearly ranked as having the densest crown which was followed clearly by *F.natalensis* and also clearly distinguished from the other.

4.1.3.4 Ranking trees for general attribute – Pruning by farmers in Mukono district

4.1.3.4.1 Trees species Easiness to Pruning

Prune easiness was considered in terms of the height of the tree, trees that grow very tall were considered to be difficult to prune, some farmers also noted that trees that have hard wood are more difficult to prune than those with relatively soft wood. Other considerations in ranking this attribute was the age of the tree, farmers highlighted that most tree species when at a young stage, they are almost equally easy to prune but the easiness changes as they grow, this still concurred with the issue of height and hardness which come into play as the tree matures. The challenge with this attribute was that some trees farmers considered them self-pruning like umbrella tree while others had pruning experience (Plate 4.3).

Table 4.6 Comparison of trees species for Easiness to pruning

Species	**Comparison of tree species for prune easiness**				
	Estimate	SE	Z-value	P-Value	% consistence
A. chinensis	0.000	0.000	0.000	0.000	50
A. coriaria	-1.1078	0.1547	-7.163	7.92e-13 ***	29
Red nongo	-1.8427	0.1850	-9.960	< 2e-16 ***	26
Bark cloth tree	-1.4607	0.2256	-6.475	9.48e-11 ***	59
Jackfruit	0.5004	0.1310	3.819	0.000134 ***	22
African elemi	-1.5347	0.1856	-8.267	< 2e-16 ***	25
Pawpaw	2.0699	0.1890	10.951	< 2e-16 ***	80
Natal fig	0.9770	0.1348	7.251	4.15e-13 ***	68
Fig tree	-0.1635	0.1419	-1.152	0.249337	45
Umbrella tree	-0.9427	0.1495	-6.305	2.88e-10 ***	34
Mango	0.3287	0.1310	2.510	0.012083 *	55
Markhamia	-0.6796	0.1536	-4.426	9.62e-06 ***	35
African teak	-3.5774	0.2645	-13.523	< 2e-16 ***	11
Banana	4.8857	0.3777	12.935	< 2e-16 ***	99
Ovocada	0.5200	0.1323	3.930	8.48e-05 ***	58
Cassia	-0.1542	0.1836	-0.840	0.401030	45
Nandi flame	-0.2652	0.1703	-1.557	0.119477	43
Black plum	-0.6514	0.1479	-4.403	1.07e-05 ***	37

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1($p \leq 0.05$)

The Table 4.6 shows that banana, pawpaw, fig natal, ovocado, jackfruit and mango were significantly ($p<0.05$) ranked above *A.chinensis* as easier to prune. African teak, red nongo, *A.coriaria*, African elemi, bark cloth tree, black plum, umbrella tree and *markhamia* were significantly ranked below *A.chinensis* as harder to prune. While cassia, nandi flame and fig tree were not significantly ($p>0.05$) distinguished from *A.chinensis* for prune easiness. Banana, pawpaw and fig natal had 99, 80 and 68 were consistently above the other trees they were compared with for prune easiness respectively for every 100 farmers who selected them for ranking.On the other hand African teak, bark cloth tree, red nongo and *A. coriaria* had 11, 22, 26 and 29 respectively ranked above others for every 100 farmers who selected them.

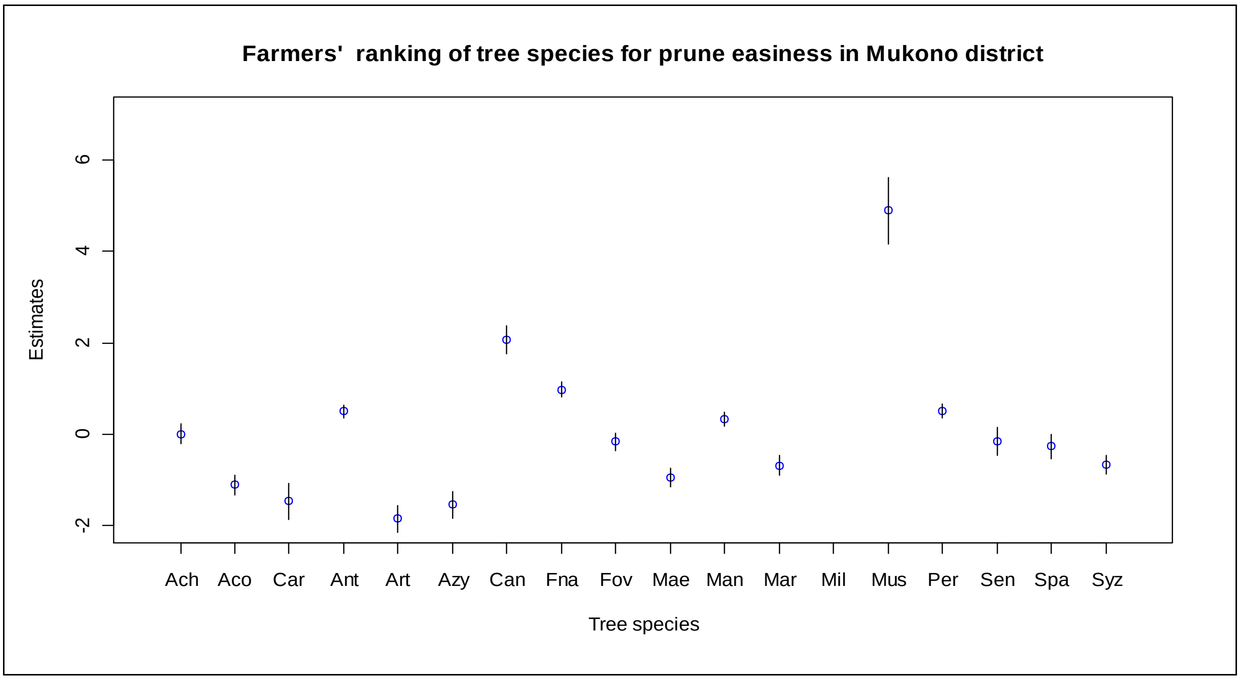

Figure 4.10 Mean and SE for trees ranked for Easiness to pruning in Mukono, Uganda displayed from easiest to hardest

Musa spp was clearly distinguished from other species as the easiest to prune, this was followed by *Carica papaya* and *Ficus natalensis* consistently ranked in the second and third easiest to prune respectively. There were distinct clusters of the tree species suggesting farmer were not consistent in ranking this attribute. The first cluster consisted of *Persea americana*, *Artocarpus heterophyllus*, and *Mangifera indica* which were not distinguished for prune easiness. The second cluster consisted of *Senna spectabilis, Ficus ovata and Spathodea campanulata* these were also not distinguished for this attribute. The fourth cluster consisted of *Syzygium cuminii*, *Maesopsis eminii*, *Markhamia lutea* and *Albizia coriaria*. While

Antarias toxicaria, *Canarium schweinfurthii* and *Albizia zygia* were not also distinguished for prune easiness. However, *Milicia excelsa* was clearly distinguished as the hardest tree species to prune.

Plate 4.3: Pruned *umbrella* tree in Kasawo Subcounty, Mukono district

The pruning for some species was not common as they were considered self, for instance umbrella tree. But some farmers still pruned these self pruning species purposely for fuel wood (Plate 4.3).

4.1.3.4.2 Tree species growth rate after Pruning

A significant number of farmers said they had not been keen at observing the growth rate after pruning but argued that all trees grow faster once pruned.

Table 4.7 Comparison of trees species for growth after pruning

Species	**Growth After Pruning**				
	Estimate	SE	Z-value	P-Value	% consistence
Albizia chinensis	0.000	0.000	0.000	0.000	55
Albizia coriaria	-0.81546	0.14066	-5.797	6.73e-09 ***	37
Red nongo	-1.28946	0.16029	-8.044	8.67e-16 ***	32
Bark cloth tree	-1.16813	0.20798	-5.617	1.95e-08 ***	30
Jackfruit	0.27579	0.12357	2.232	0.0256 *	61
African elemi	-1.50835	0.17245	-8.746	< 2e-16 ***	27
Pawpaw	-0.08818	0.14401	0.612	-0.5403	52
Natal fig	0.96627	0.12960	7.456	8.94e-14 ***	76
Fig tree	0.10381	0.13491	0.769	0.4416	57
Umbrella tree	-0.86577	0.13865	-6.244	4.26e-10 ***	38
Mango	-0.30773	0.12425	-2.477	0.0133 *	48
Markhamia	-0.94838	0.14645	-6.476	9.44e-11 ***	35
African teak	-2.30483	0.17714	-13.012	< 2e-16 ***	17
Banana	1.52904	0.14875	10.279	< 2e-16 ***	84
Ovocada	0.05233	0.12476	0.419	0.6749	56
Cassia	-0.28253	0.17370	-1.627	0.1038	48
Nandi flame	-0.76051	0.16245	-4.681	2.85e-06 ***	38
Black plum	-0.97594	0.14303	-6.823	8.91e-12 ***	34

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1($p \leq 0.05$)

The Table 4.7 shows that banana, fig natal, jackfruit were significantly ranked ($p \leq 0.05$) above *A.chinensis* as having the faster growth rate.African teak, African elemi, red nongo, barkcloth tree, black plum, markhamia, *A.coriaria*, umbrella tree, nandi flame and mango were significantly ranked below *A. chinensis* for growth rate after pruning. However, there was no significant difference ($p>0.05$) in growth rate between *A. chinensis* and ovocado, cassia, fig tree and pawpaw for growth rate after pruning. Banana, fig natal, jackfruit and fig tree had 84, 76, 61 and 57 above the other trees they were compared with for growth rate after pruning respectively for every 100 farmers who selected them for ranking.On the other hand African teak, African elemi and bark cloth tree had 17, 27 and 30 respectively ranked above others for every 100 farmers who selected them.

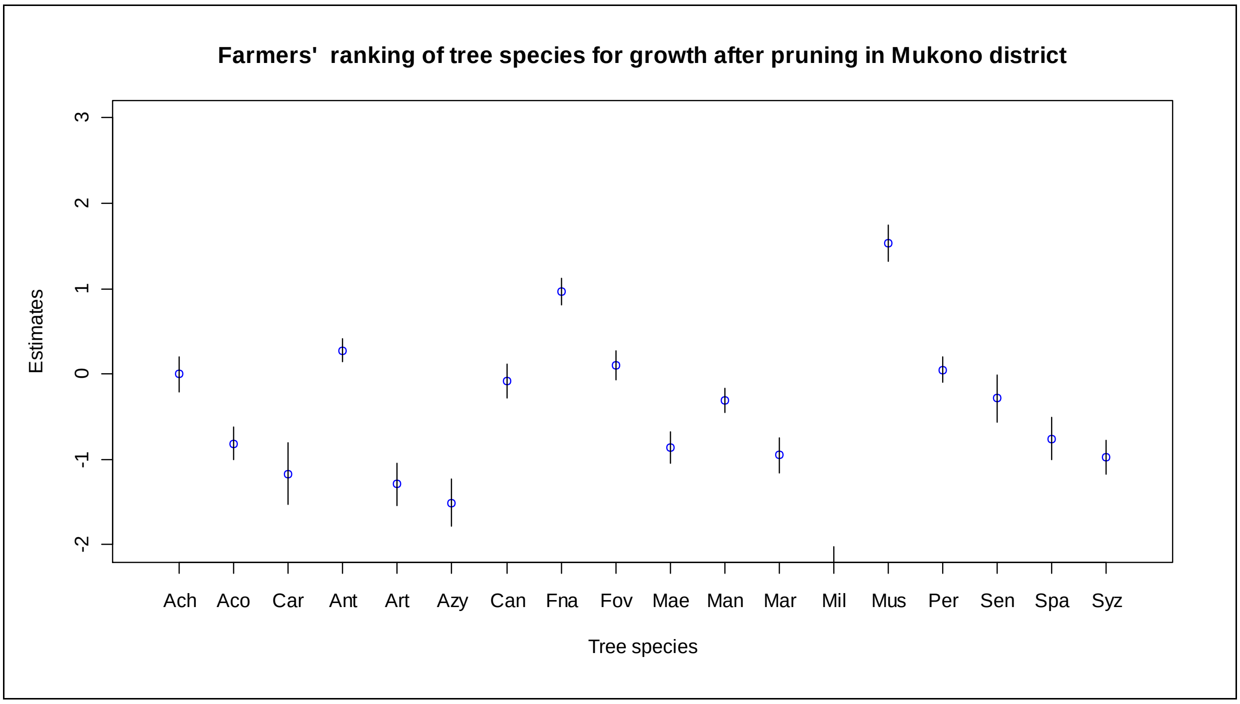

Figure 4.11 Mean and SE for trees ranked for growth after pruning in Mukono, Uganda displayed from fastest to slowest

Growth after pruning ranking by farmers shows that *Musa spp* was clearly distinguished as the having the fastest growth after pruning, this was distinctly followed by *F. natalensis*. There first cluster consisted of *A. heterophyllus*, *P.americana*, and *C. papaya* which were not distinguished for growth after pruning. *S. spectabilis* and *M.indica* were also not distinguished for growth after pruning. The next tree species appeared in cluster which consisted of *S.campanulata*, *A.coriaria*, *M.eminii*, *M. lutea* and *S. cuminii*; these were not differentiated as far as growth after pruning was concerned. *A.toxicaria* and *A.zygia* were not distinguished for growth after pruning but were among species with the slowest growth after pruning. *C. schweinfurthii* was the second last species for this attribute. *M. excelsa* was clearly distinguished as the slowest tree species to growth after pruning. *S.spectabilis* and *A. toxicaria* had the lager error bars due to less number times they were compared with other tree species for growth after pruning.

4.1.3.5 Ranking for general attribute – root architecture

4.1.3.5.1 Root depth of the different tree species

This had a lot of gaps in knowledge as some farmers said they were not able to rank all the trees based on this attribute, however, most of those who ranked trees based on this attribute were considering resistance to strong winds. Other said they observed rooting depth during road constructions where several trees were uprooted by tractors. However, some noted that the rooting depth of the trees can be determined from the height of the trees; tall trees were considered to have deeper roots than shorter tress.

Table 4.8 Comparison of trees species for root depth

Species	**Comparison for tree species for root depth**				
	Estimate	SE	Z-value	P-Value	% consistence
Albizia chinensis	0.000	0.000	0.000	0.000	41
Albizia coriaria	1.5926	0.1551	10.270	< 2e-16 ***	71
Red nongo	1.9202	0.1716	11.190	< 2e-16 ***	65
Bark cloth tree	1.2890	0.1930	6.677	2.44e-11 ***	75
Jackfruit	0.6301	0.1307	4.821	1.43e-06 ***	54
African elemi	1.9463	0.1658	11.736	< 2e-16 ***	76
Pawpaw	-2.6104	0.2156	-12.105	< 2e-16 ***	14
Natal fig	-0.9295	0.1391	-6.681	2.38e-11 ***	27
Fig tree	0.1514	0.1428	1.060	0.289010	45
Umbrella tree	1.2027	0.1406	8.552	< 2e-16 ***	64
Mango	0.7060	0.1320	5.348	8.88e-08 ***	56
Markhamia	0.6286	0.1468	4.282	1.85e-05 ***	55
African teak	4.9391	0.3264	15.132	< 2e-16 ***	98
Banana	-5.2193	0.4155	-12.562	< 2e-16 ***	1
Ovocada	-0.4639	0.1348	-3.441	0.000579 ***	34
Cassia	0.2662	0.1808	1.473	0.140856	49
Nandi flame	0.1549	0.1663	-0.932	0.351583	41
Black plum	1.1616	0.1495	7.771	7.78e-15 ***	64

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1(p≤0.05)

The root depth ranking shows that ten species were significantly ranked ($p \leq 0.05$) above *A.chinensis* as having the deeper root depth. These included; African teak, African elemi, red nongo, *A.coriaria*, bark cloth tree, umbrella tree, black plum, mango, jackfruit and markhamia. Four species were significantly ranked below *A.chinensis* for root depth, these included; banana, pawpaw, fig natal and ovocado. However, cassia, nandi flame and fig tree were not significantly ($p>0.05$) different from *A. chinensis*. African teak was ranked above the other trees it was compared with 98 for every 100 farmers who ranked it for root depth. African elemi, bark cloth tree and *A.coriaria* had 76, 75 and 71 respectively above the others for every 100 times they were compared with other tree species. Ovocado, fig natal, pawpaw and banana had 34, 27, 14 and 1 above the other trees they were compared with respectively for every 100 farmers who selected them for ranking.

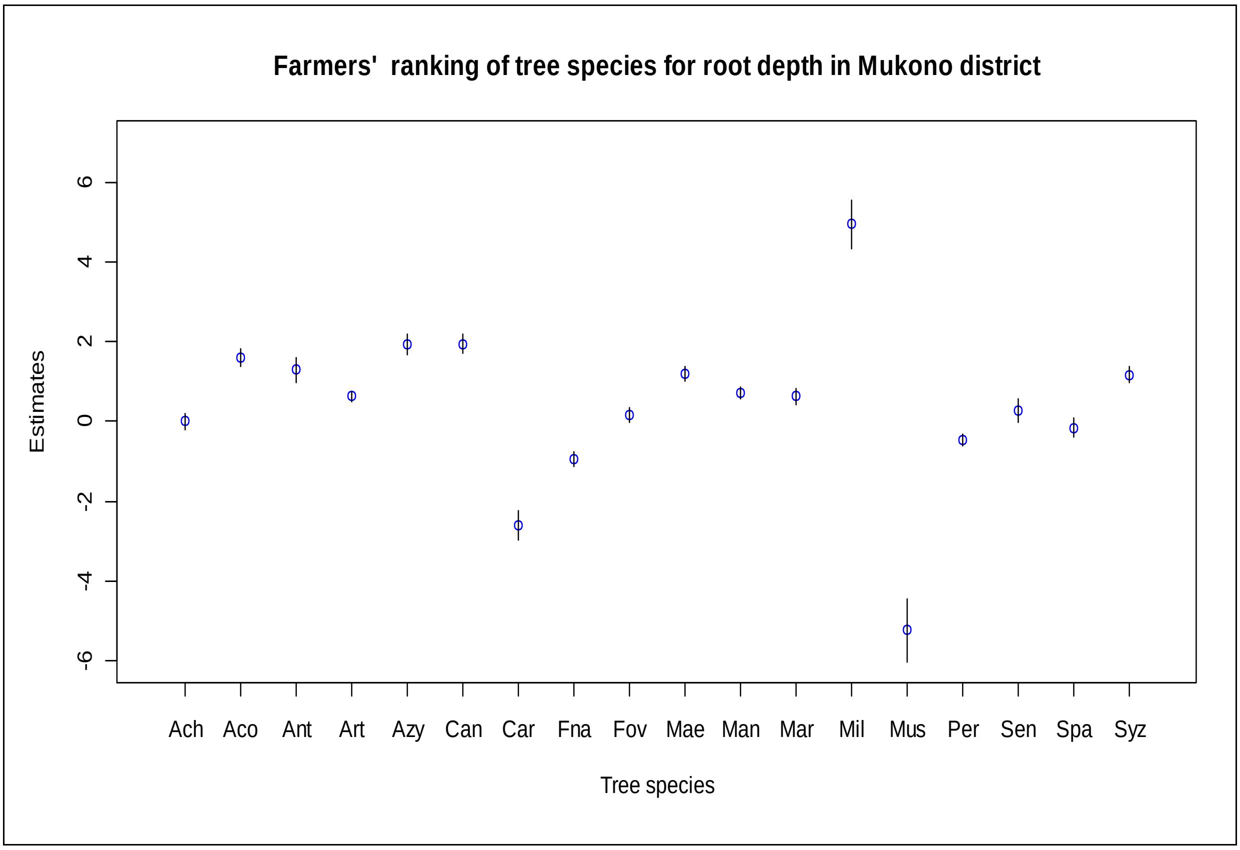

Figure 4.12 Mean and SE for trees ranked for rooting depth, in Mukono, Uganda displayed from the deepest to the least deep

The root depth results from figure 4.13 show that only *Milicia excelsa*, *Ficus natalensis*, *Carica papaya* and *Musa spp* were clearly distinguished for root depth. The other species were not consistently ranked for root depth as they appeared form a large cluster with small differences between the tree species. *Milicia excelsa* was clearly distinguished as having the deepest root depth. Similarly *Musa spp* was clearly distinguished itself as the species with the shallowest root depth. *Carica papaya* was the second shallowest species for root depth.

4.1.3.5.2 Root spread of the different tree species

This attribute was ranked on the basis that farmers observe this during weeding of their gardens in which they were able to see the roots several metres away from the tree. Very few farmers said they were not sure of the rooting spread. Some farmers used the tree size at maturity as the basis for determining the rooting spread, trees which grow big spread roots more than the others.

Table 4.9 Comparison of trees species for root spread

Species	**Comparison of tree species for root spread**				
	Estimate	SE	Z-value	P-Value	% consistence
Albizia chinensis	0.000	0.000	0.000	0.000	50
Albizia coriaria	1.71474	0.16148	10.619	< 2e-16 ***	79
Red nongo	1.11368	0.16108	6.914	4.72e-12 ***	60
Bark cloth tree	0.55606	0.18929	2.938	0.00331 **	69
Jackfruit	0.19973	0.12924	1.545	0.12224	55
African elemi	1.21675	0.15672	7.764	8.24e-15 ***	73
Pawpaw	-5.10884	0.36366	-14.048	< 2e-16 ***	10
Natal fig	0.51241	0.13062	3.923	8.75e-05 ***	61
Fig tree	0.71656	0.14288	5.015	5.30e-07 ***	64
Umbrella tree	-0.13771	0.13562	-1.015	0.30991	47
Mango	0.04522	0.13007	0.348	0.72807	53
Markhamia	-0.87665	0.15351	-5.711	1.12e-08 ***	37
African teak	3.77557	0.24568	15.368	< 2e-16 ***	97
Banana	-5.04989	0.35420	-14.257	< 2e-16 ***	11
Ovocada	-1.54580	0.14523	-10.644	< 2e-16 ***	27
Cassia	-0.50542	0.18481	-2.735	0.00624 **	44
Nandi flame	-1.24051	0.18046	-6.874	6.23e-12 ***	32
Black plum	-0.06277	0.14380	-0.436	0.66248	50

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 ($p \leq 0.05$)

Table 4.9 shows that with reference to *A.chinensis*, African teak, *A. coriaria*,African elemi, red nongo, fig tree, bark cloth tree and fi natal were significantly($p<0.05$) ranked as having wider root spread than *A.chinensis*. Pawpaw, banana, ovocado, nandi flame, markhamia and cassia were significantly ($p<0.05$) ranked below *A. chinensis* for root spread. However, umbrella tree, mango, jackfruit and black plum had $p>0.05$ implying they were not significantly different from *A.chinensis*. For every 100 farmers who selected African teak for ranking, 97 considered it as having widest root spread.While A.coriaria, Africam elemi ,bark cloth tree had 79, 73,69 respectively considering them having wider root spread than those which were compared with them. Pawpaw, banana and ovocado had 10, 11 and 27 for every 100 farmers respectively ranking them above those they were compared with.

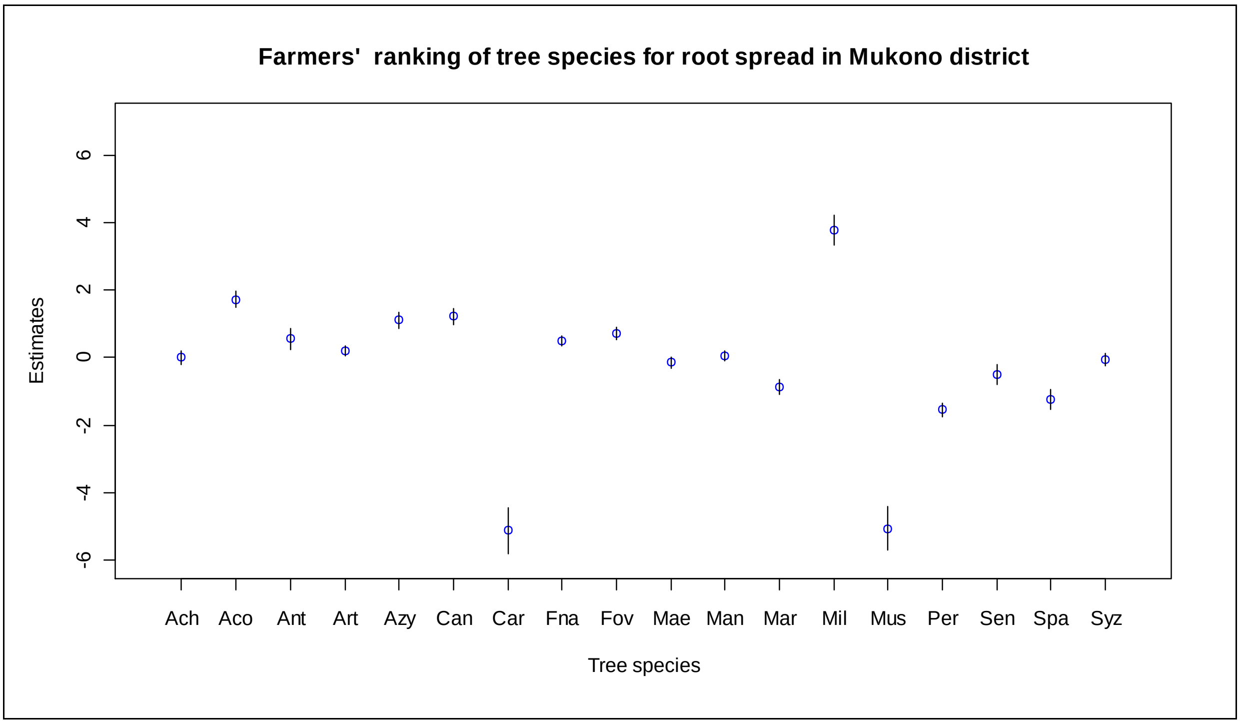

Figure 4.13 Mean and SE for trees ranked for rooting spread in Mukono, Uganda displayed from widest to narrowest

M.excelsa stands out as the tree with the widest spreading roots, with a marked a difference from *A.coriaria* which comes in second. These were followed *C.schweinfurthii* and *A. zygia* which appeared very similar. A relatively line followed composed of seven species with little difference between the trees for root spread. *M. lutea*, *S.campanulata* and *P.americana* were the trees with narrowest root spreading with exception of *Musa spp* and *C. papaya* but had little differences between each other. *Musa spp* and *C.papaya* were clearly distinguished as the species with the narrowest root spread but they were not differentiated for this attribute.

4.1.3.6. Ranking for general attribute – growth rate

Table 4.10 Comparison of trees species for growth rate

Species	**Comparison of tree species for growth Rate**				
	Estimate	SE	Z-value	P-Value	% consistence
Albizia chinensis	0.000000	0.000000	0.000	0.000	69
Albizia coriaria	-3.297200	0.189581	-17.392	< 2e-16 ***	19
Red nongo	-3.432605	0.206343	-16.635	< 2e-16 ***	30
Bark cloth tree	-2.366781	0.219342	-10.790	< 2e-16 ***	19
Jackfruit	-0.296553	0.135291	-2.192	0.028382 *	63
African elemi	-3.368962	0.193439	-17.416	< 2e-16 ***	19
Pawpaw	2.676748	0.229885	11.644	< 2e-16 ***	93
Natal fig	-0.455451	0.135490	-3.362	0.000775 ***	60
Fig tree	-1.208985	0.148401	-8.147	3.74e-16 ***	47
Umbrella tree	-1.055376	0.142405	-7.411	1.25e-13 ***	50
Mango	-0.860823	0.136149	-6.323	2.57e-10 ***	53
Markhamia	-2.221335	0.164609	-13.495	< 2e-16 ***	30
African teak	-6.050162	0.337166	-17.944	< 2e-16 ***	9
Banana	2.660314	0.220897	12.043	< 2e-16 ***	93
Ovocada	0.004023	0.137542	0.029	0.976667	68
Cassia	-1.519865	0.190839	-7.964	1.66e-15 ***	41
Nandi flame	-1.321727	0.169025	-7.820	5.29e-15 ***	45
Black plum	-1.811806	0.157888	-11.475	< 2e-16 ***	37

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1($p \leq 0.05$)

Pawpaw and banana were ranked significantly ($p<0.05$) above *A.chinensis* as having faster growth rate. There was no significant difference ($p>0.05$) between *A. chinensis* and ovocado for growth rate. The rest of the tree species were ranked below *A. chinensis* for growth rate attribute, these have negative estimates. This implies thirteen tree species were considered having growth rate slower than *A. chinensis*. Based on consistence, for every 100 farmers that ranked each tree species, 93 ranked banana above others, also 93 ranked pawpaws above other. Ovocado had 68 and fig natal 60. African teak was only ranked 9% above the other trees for growth rate. *A.coriaria*, bark cloth tree and African elemi each was ranked 19% times for being faster growing than the other trees they were compared with.That means out of 100 farmers only 19 ranked them above any of the other trees and 81 farmers ranked them below other for growth rate.

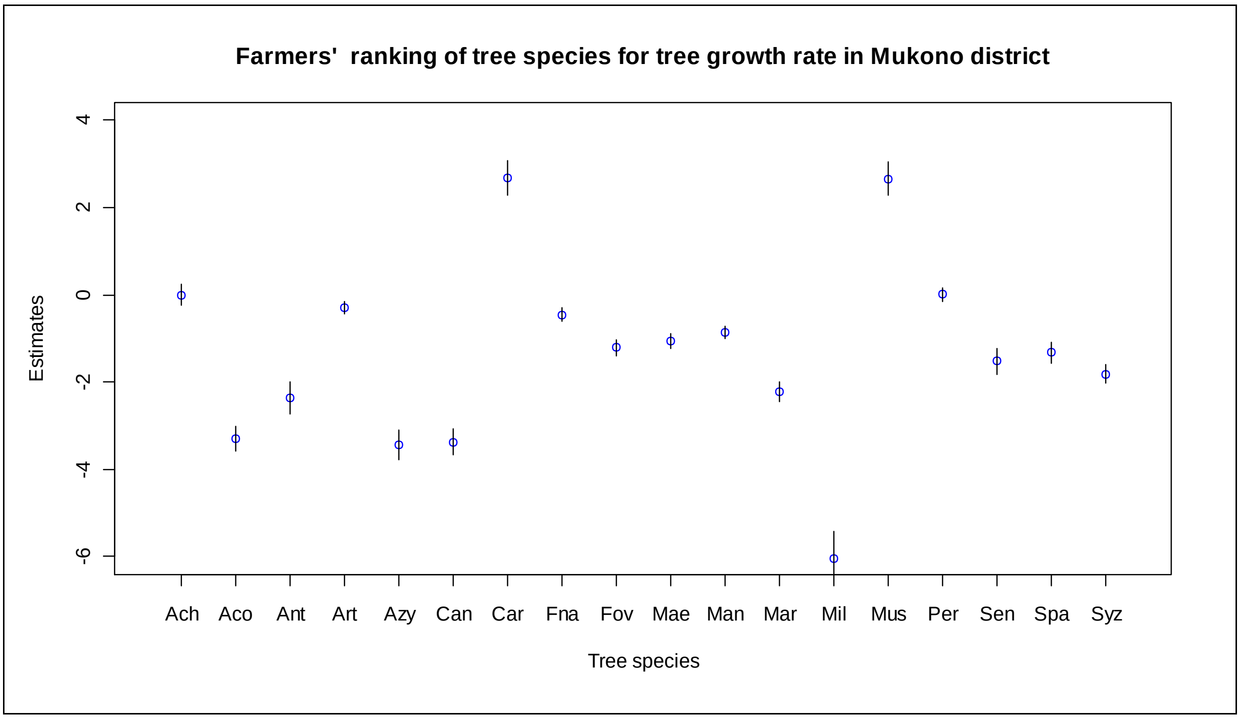

Figure 4.14 Mean SE for trees ranked for growth rate in Mukono, Uganda displayed from fastest to slowest

There appear four clearly distinct groupings of the trees for growth rate. Pawpaw (*C.papaya*) and banana (*Musa spp*) were the fastest growing species but they were not distinguished for this attribute. Eleven species appeared on relatively gentle slope followed with little differences between each other. *A.coriaria*, African elemi (*C. schweinfurthii*) and red nongo (*A.zygia*) followed and were not differentiated for growth rate.African teak (*M.excelsa*) stood out as the slowest tree as far as growth rate was concerned.

4.1. 3.7 Ranking for specific attribute – mulch

4.1.3.7.1 Mulch – Leaf decomposition rate

This attribute was ranked by quite a number of farmers, they noted that decomposition rate depends on the leaf size, the smaller the leaf size the faster the decomposition rate and vice versa. Some farmers noted that succulent leaves decompose faster than less succulent ones even if they are bigger in size. Others however had observed that some leaves are "liked" by termites and these decompose faster.

Table 4.11 Comparison of trees species for leaf decomposition rate by farmers in Mukono district

Species	**Comparison of tree species for leaf decomposition**				
	Estimate	SE	Z-value	P-Value	% Consistence
Albizia chinensis	0.000	0.000	0.000	0.000	85
Albizia coriaria	-0.8908	0.1656	-5.379	7.50e-08 ***	71
Red nongo	-1.3284	0.1720	-7.723	1.14e-14 ***	50
Bark cloth tree	-1.9892	0.2050	-9.704	< 2e-16 ***	62
Jackfruit	-3.5601	0.1623	-21.929	< 2e-16 ***	22
African elemi	-2.6047	0.1705	-15.273	< 2e-16 ***	39
Pawpaw	-0.8616	0.1631	-5.282	1.28e-07 ***	74
Natal fig	-0.3930	0.1529	-2.571	0.0101 *	82
Fig tree	-2.1165	0.1614	-13.115	< 2e-16 ***	48
Umbrella tree	-1.3991	0.1562	-8.958	< 2e-16 ***	62
Mango	-2.8975	0.1574	-18.413	< 2e-16 ***	32
Markhamia	-2.7350	0.1679	-16.294	< 2e-16 ***	37
African teak	-3.4161	0.1693	-20.176	< 2e-16 ***	24
Banana	-1.7032	0.1572	-10.837	< 2e-16 ***	56
Ovocada	-2.3840	0.1546	-15.423	< 2e-16 ***	42
Cassia	-1.6332	0.1929	-8.465	< 2e-16 ***	60
Nandi flame	-1.9526	0.1757	-11.116	< 2e-16 ***	52
Black plum	-3.0926	0.1719	-17.989	< 2e-16 ***	29

The Table 4.11 shows that all the tree species were significantly ranked as having slower leaf decomposition rate with reference to *A. chinensis*. The closest tree species to *A. chinensis* was fig tree. In terms of consistence, *A.chinensis* was ranked 85% times above the other tree species which were compared by it for leaf decomposition rate. This was followed by fig natal and *A.coriaria* with 82% and 71% repectively. On the other hand, jackfruit, African teak and black plum had 22%, 24% and 29% times above the other trees which were compared by them for leaf decomposition rate respectively.

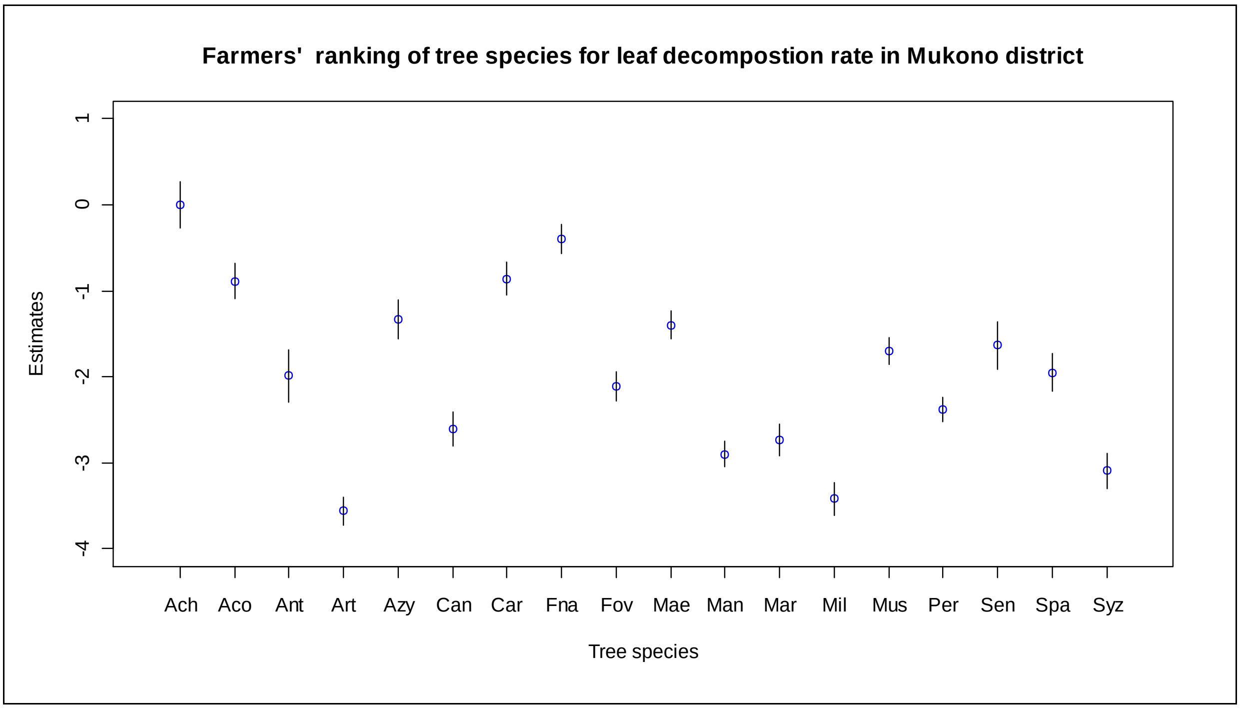

Figure 4.15 Mean SE for trees ranked for leaf decomposition rate in Mukono, Uganda displayed from fastest to slowest

The trees whose leaves were soft were also considered to be fast decomposing than those with hard leaves. Jackfruit (*A. heterophyllus*) and African teak (*M.excelsa)* were clearly distinguished for being the slowest in decomposition as they were considered hard. The analysis shows that trees are plotted diagonally with marked difference between them. The farmers ranked *F. natalensis* as decomposing fastest this was followed by several trees which appeared in pairs; *C.papaya* & *A. coriaria*, *A.zygia* & *M. eminii*, *S.spectabilis & Musa spp* and *S.campanulata* & *A. toxicaria* respectively. The way these trees appeared in pair is not clear but probably *A.zygia* & *M. emini* and *S. campanulata* & *A.toxicaria* appeared in pairs on the basis of their similar leaf size while *C. papaya* & *A.coriaria*, *S.spectabilis* &*Musa spp* could have appeared in pairs due to their similar leaf texture. The error bars could have occurred because several missing comparisons as quite a number of farmers confessed that they had not been keen on observing this attribute rather were more interested in observing the benefits to the soil.

4.1.3.7.2 Mulch – benefits to the soil of the leaves of the selected tree species

The benefit to the soil was closely linked to decomposition rate; the faster the decomposition rate the more benefit to the soil, but most farmers noted that the quantity of the leaves shed by the tree also influenced this attribute. Some trees shed large quantities of leaves and these directly benefit the soil on decomposition.

Table 4.12 Comparison of trees species for Soil benefit in Mukono district

Species	**Comparison of tree species for soil benefit**				
	Estimate	SE	Z-value	P-Value	% consistence
Albizia chinensis	0.000	0.000	0.000	0.000	76
Albizia coriaria	0.1328	0.1587	0.837	0.403	77
Red nongo	-1.2408	0.1595	-7.781	7.18e-15 ***	45
Bark cloth tree	-1.6051	0.1916	-8.376	< 2e-16 ***	51
Jackfruit	-2.3453	0.1418	-16.545	< 2e-16 ***	30
African elemi	-1.8482	0.1551	-11.912	< 2e-16 ***	41
Pawpaw	-2.0404	0.1504	-13.565	< 2e-16 ***	36
Natal fig	1.0558	0.1575	6.704	2.02e-11 ***	91
Fig tree	-0.6171	0.1486	-4.153	3.29e-05 ***	65
Umbrella tree	-1.3846	0.1426	-9.707	< 2e-16 ***	49
Mango	-2.0733	0.1410	-14.709	< 2e-16 ***	35
Markhamia	-2.7337	0.1627	-16.800	< 2e-16 ***	25
African teak	-1.8721	0.1458	-12.841	< 2e-16 ***	40
Banana	-0.7863	0.1438	-5.468	4.56e-08 ***	63
Ovocada	-1.6689	0.1393	-11.983	< 2e-16 ***	44
Cassia	-2.0192	0.1794	-11.253	< 2e-16 ***	39
Nandi flame	-1.3507	0.1645	-8.212	< 2e-16 ***	51
Black plum	-2.1449	0.1541	-13.919	< 2e-16 ***	34

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 ($p \leq 0.05$)

The soil benefit attribute (Table 4.12) shows that only fig natal was significantly ($p<0.05$) ranked above *A.chinensis* for soil benefit. There was no significant difference in soil benefit between *A.chinensis* and *A.coriaria*. There rest of the trees were significantly ranked below *A. chinensis* for soil benefit. Fig natal had 91% times ranked above others for benefit to the soil, this was followed by *A.coriaria*, 77% and *A.chinensis* which was ranked 76% times above the other tree which were compared by them. Fig tree and banana followed with 65% and 63% respectively. Markhamia was on the other side ranked higher than the other species only 25% times for soil benefit. Jackfruit had 30%, black plum 34%, mango 35% and pawpaw 36% times above the other tree species they were compared with for soil benefit.

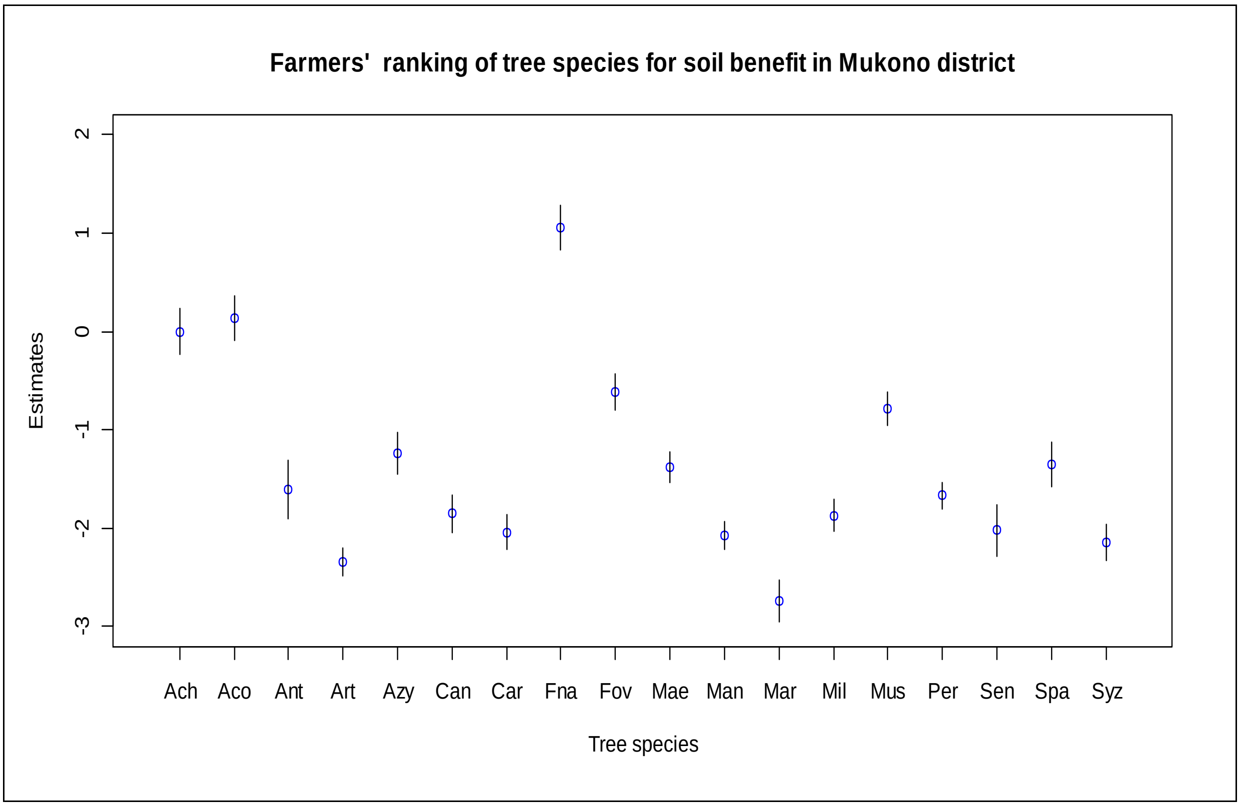

Figure 4.16 Mean and SE data for trees ranked for soil benefit in Mukono, Uganda displayed from most to least benefit

F.natalensis was clearly distinguished as the tree which benefits soil most; this was followed clearly by *A.coriaria* in the second position. *F.ovata* and *Musa spp* were not clearly distinguished from each other for soil benefit. *A.zygia*, *S.campanulata* and *M.eminii* appeared in a cluster for this attributing implying they were not consistently differentiated by the farmers for this attribute. The next cluster comprised of *A. toxicaria*, *P.americana*, *C.schweinfurthii,* and *M. excelsa. S. specatabilis, C. papaya, M. indica* and *S.cuminii. A. heterophyllus* and *M. lutea* were distinguished as the least benefit to the soil.

4.2 Discussion of Results

4.2.1 Phenology of the tree species

The farmers were more conversant with flowering and fruiting (Figure 4.1) as far as fruit trees were concerned and few had knowledge on the leaf fall. However, the reverse was true for most of the other trees. This could be because of the fact that farmers are interested in a particular use of the tree and tend to know more based on the purpose for which they were planted. Tropical tree communities demonstrate substantial seasonality in flowering, fruiting, and leaf flushing events (Anderson *et al*., 2005). This is so clearly distinct in fruit trees.

Farmers had more phenology information on fruit trees than the other trees as far as flowering and fruiting was concerned, but there was no significant differences between fruit trees and non-trees for leaf fall. This could have been so probably due the same function the leaf fall performs. The fruit trees have consistently higher number of farmers with phenology information than other trees for all the timings. The results also indicate that some farmers may have partial information as far as phenology is concerned, that is a farmer may have information on one or two of the timings flowering, leaf fall and fruiting. This was depicted from the above preliminary analysis which showed that no single tree species had same number of farmers with flowering, fruiting and leaf fall information. Least number of farmers had knowledge on the leaf fall than flowering and fruiting indication farmers were much less interested in noting the timing for leaf than the other two. The less knowledge of the phenology of trees could be attributed to the deviations in the flowering period in some trees (Anderson *et al*., 2005). Chapman *et al. (*2004) explained that the deviation from a typical phenology cycle for a community or population of trees are commonly observed, but are not well understood. Fruiting was also slightly higher than flowering due to the fact and several farmers reported to remember the timings when the fruits ripen for obvious reasons.

However, Anderson *et al*., (2005), reported that Phenological patterns may be influenced by the temporal abundance of pollinators, seed dispersers, seed predators, or herbivores.

Artocarpus heterophyllus was one of the most common tree species the farmers had phenology information (Table 4.1). In a 1985 survey, jackfruit was present on 10–24% of Indo- Fijian sugarcane farms in western Viti Levu, Fiji (Elevitch and Manner, 2006). In comparison, mango (*Mangifera indica*), papaya (*Carica papaya*) were found on 75–100% of the farms. However in Mukono district, the reverse is true as the highest number of farms had *Artocarpus heterophyllus* tree. It was closely followed by *Mangifera indica*. This indicates that different areas have different distribution of this tree species thus in the management of agroforestry it is important to be location specific as several factors influence the growth and development of each tree species

The limited knowledge about the Phenology of non-fruit trees could be due to the tendency of some trees having male and female flowers on the different trees this is the case of *Milicia excelsa* (Orwa *et al*., 2009). Some tree of the same species flower at different times of the year this lead to confusion for the farmers to clearly specify the exact time of flowering. This is seen in *Milicia excelsa* which is known to flower at slightly different times of the year depending on the area (Orwa *et al*., 2009). The less knowledge of some tree species could also be possibly because some tree species take a short flowering period to the extent that this event goes unnoticed. The fruit trees have higher chances of being recognised because of the interests farmers have in their fruits. Milicia excelsa is also known to flowers a few weeks after the partial or complete shedding of leaves or with the new leaves. After pollination, the female flower ripens to a fruit within a month. Birds, bats and squirrels readily eat the fruit and probably disperse the seeds (Orwa *et al*., 2009).

4.2.2 Ranking for the tree species for the twelve attributes

4.2.2.1 Species ranking by the farmers in Mukono district

Like in phenology, ranking data indicated that jackfruit, mango and ovocado are the tree species farmer have more information on, where as for phenology information majorly only fruit trees dominated, in the ranking exercise trees like fig natal appeared more times than any other trees except jackfruit. This was attributed to its function in improving soil fertility. Most farmers ranked it higher in terms of benefit to the soil; the farmers noted that coffee and banana do well when planted close with this tree species. It was also credited for the fast rate of leaf decomposition, an attribute which probably makes it more beneficial to the soil. The least ranked tree species was bark cloth tree, the farmers attributed this to the fact that they considered it a forest tree and it was of late that they started planting this tree species on their farms.

4.2.2.2 Cluster analysis of the ranking by tree species

The multivariate hierarchical cluster analysis depicted in Figure 4.4, indicated there were several clusters but the major ones start by separating the most ranked tree species, these were placed in two clusters, one cluster comprised jackfruit, mango, ovocado and fig natal this can be noted that this cluster had mainly fruit trees which indicates the popularity of the fruit trees in this area, fig natal a non-fruit tree appeared in this cluster solely on the basis of its contribution to soil fertility improvement and its fast growth. The second big cluster was sub-clustered with one cluster having trees which were outstandingly less ranked which comprised of cassia and bark cloth tree, these tree species where regarded as forest trees by the farmers although they are now planting them, this could have been the reasons behind their fewer appearance as far as ranking was concerned.

4.2.2.3 Clustering by tree attribute

The clustering (Figure 4.5) placed timber durability and strength as the attributes that famers had least knowledge; this reveals the gap in knowledge by the farmers about these two attributes. This could be attributed to their limited interaction with most trees especially fruit trees for timber. Majority of the farmers noted that they think about timber during construction which is occasional. On the other hand farmers had more knowledge on the crown spread, growth rate and crown density this probably was due to the daily observations they noted while on their farms, rooting spread, leaf decomposition, rooting depth were in one cluster given possibly because these attributes receive less attention. Farmers are keener at observing the outcome of leaf decomposition than the process itself.

4.2.3 Ranking for specific attributes

4.2.3.1 Timber quality for each tree species

4.2.3.1.1 Timber – durability of wood and vulnerability to rotting and insect attack

Milicia excelsa was clearly distinguished as having the most durable timber, this was the reality in the field as there was consistence in the way the farmers ranked this species majority of them attributed its excellent timber quality to the fact that it takes long to grow. They also mentioned that they clearly understand the tree because most of them plant it or leave it to grow on their farm for timber. This means the farmers had consistent because they plant this species for the same purpose. This was followed by *Albizia coriaria* which was also noted to be slow growing. In fact some farmers deduced the timber durability to the slowness to growth of the tree. The farmers also mentioned boat building as one of the uses of its timber. Similarly, Orwa *et al*., (2009) found out that sapwood for *Albizia coriaria* is soft but the heartwood hard and durable. Timber used for boat building, utensils and furniture.

Ovocado and nandi flame were considered the trees with most susceptible timber to insect attack. The ranking for tree attribute timber durability indicates that farmers placed jackfruit in the middle of the other species (Figure 4.6). This could be equated to Elevitch and Manner, (2006) who classified jackfruit wood as a medium hardwood (specific gravity 0.6–0.7) and is highly valued for building material, furniture and cabinet making, and even for musical instruments. It is highly durable, resisting termites and decay, seasons easily, resembles mahogany in appearance, and takes a beautiful polish (Elevitch and Manner, 2006). As the wood ages, it turns from yellow or orange to red or brown, although not as strong as teak (*Tectona grandis*) which could be related to African teak in this case. Jackfruit wood is considered superior for many purposes including furniture, construction, turnery, masts, oars, implements, and musical instruments. The farmers ranking of African elemi above Jackfruit contradicts with Thomson and Evans, (2006) who noted that the wood of trees closely related to African elemi is suitable for light construction (in low-decay situations), moldings, veneer, and numerous interior purposes as it has a medium density of 430–560 kg/m3 (27–35 lb/ft3) and is non-durable when exposed to weather. Whether the farmers were right or Thomson and Evans are right is beyond the scope of this study.

4.2.3.1.2 Timber – strength

There was consistent knowledge on African teak for timber strength as depicted in Figure 4.8, most farmers said they had had experience with this tree species, this was followed by *A. coriaria* which farmers branded as the “second in command” as far as timber is concerned. *Albizia zygia* also although most recognized its strength they said it is not durable because it succumbs to insect attack and therefore Markhamia and umbrella tree which were regarded as less strong but were better in durability. In general the farmers had consistent knowledge of non fruit trees as far as timber strength was concerned and fruit trees the knowledge was not consistent. The fruit trees therefore appeared in the same group comprising of black plum, jackfruit, mango where the knowledge was not consistent, in the same group there were fig tree and fig natal this was so possible because of the fact that these two closely related tree species were grown purposely for other uses like soil improvement and not timber so their timber quality is not understood by the farmers hence the inconsistence in the ranking. Nandi flame was consistently ranked weakest and least durable, most farmers attributed this to its nature of being soft, in fact majority of the farmers still ranked it last for wood burn length(Figure 4.8) with the exception of banana and pawpaw which most farmers considered “unsuitable for cooking” because they do not produce wood. Whereas ovocado was ranked second weakest and second least durable, most farmers confessed having never had experience with the timber from this tree species and thus just deductively placed it in that position although some insisted that much as they have little experience about its timber quality, they ranked it based on the fact that it grows fast and thus to them the tree that grows fast (Figure 4.15) is poor in timber strength (Figure 4.7) and durability (4.6). The consistence in the ranking by the farmers could confirm that they actually had a common understanding. Bosu and Krampah, (2007) reported that bark cloth tree is most important on the international market for its veneer and plywood. Bosu and Krampah, (2007) also noted that the wood of bark cloth tree is often traded in mixed consignments of lightweight hardwood. Bally, (2005) reported that mango timber when properly seasoned has been used in furniture, for carving, as wall and floor paneling, and utensil manufacture. The timber is gray-brown, often with a pink tinge. It is coarse-textured hardwood that is easy to work and finishes well. The timber breaks down rapidly if exposed to the elements without preservation treatment.

Thomson and Evans, (2005), noted that African elemi wood is suitable for light construction (in low-decay situations)

4.2.3.2 Ranking of specific attribute – fuel-wood burn Length

Banana and pawpaw were generally considered not used as fuelwoold by most farmers although a very small number of farmers ranked them on the basis that if burnt it would take a short time, some argued that dry banana leaves are used for starting fire and take short time to burn this is depicted by the large error bars which indicated lack of comparable data. But most farmers did not agree with this reasoning as they said they were ranking for wood which these two species do not produce and thus could not rank them for fuelwood burn length. The big standard error must have occurred because very few farmers ranked these two species for this attribute, statistically the less the sample size the higher the standard error.Africa teak was clearly distinguished as taking the longest fuelwood burn length, this was attributed to its wood hardness and its ability to leave big clods of charcoal, In fact most farmers especially men pointed out that it produces best charcoal and also women concurred with their male counter parts, this can be observed from the standard error which almost not there indicating consensus in the ranking of this attribute. The next group was *A.coriaria* , red nongo and markhamia which were considered the next to Africa teak were also recognized for producing good charcoal and taking longer burn length but the analysis however, indicated that the farmers could not clearly differentiate the three species in terms of fuelwood burn length. These were followed by mango which farmers also considered to have a long burn length, this related to Bally, (2006) that Mango wood makes excellent charcoal. The next eight species; black plum, African elemi, cassia, jackfruit, fig natal, umbrella tree, fig tree and bark cloth tree could not also be distinguished by the farmers. Ovocado and nandi flame were clearly distinguished as having the shortest burn length, the former, the farmers still attributed this to that fact that it grows fast and the latter they attributed it to its soft wood which turns into ash easily and most men pointed out the issue of making charcoal that nandi flame cannot be used for charcoal burning. Occasionally fruit trees are used for firewood, the fruit trees are not usually so utilized, especially if the trees are still producing fruits (Whistler and Elevitch, 2006) but farmers' consistent ranking of these fruit trees actually indicate that they use them frequently for fuelwood, this could be due to increased in population in Uganda (UNDP, 2000) coupled with reduction in tree diversity which forces farmers to use fruit trees for fuelwood. African elemi is also suitable for fuel wood and sometimes is burned (Thomson and Evans, 2006). Bosu and Krampah, (2007) reported that the wood of bark cloth tree is lightweight and its wood works easily with hand and machine saws.

4.2.3.3 Ranking of general attributes – Crown architecture

The annual increment produced throughout the tree is a result of crown production – crown production is a direct result of annual increment transport efficiency and volume. The growth increment also mechanically supports the crown against dynamic forces of gravity, wind, precipitation and the tree's own size, shape and mass (Coder, 1996). Because the crown is provided with raw materials and growth substances collected and generated by the roots, and the roots are provided with food and growth substances generated by the crown, the physical distance and biological health between living crown and absorbing root are critical.

A. coriaria, African teak, jackfruit and fig tree were considered most dense after mango and fig natal which were clearly distinguished. Bally, (2006) also noted that mango do not make a good overstory tree for cropping shade-tolerant species because their dense canopy produces100% shade. The farmers' ranking of mango tree as having the densest crown is in agreement with Bally's argument.

Elevitch and Manner, (2006) also noted that jackfruit is used as a shade tree for coffee. Because the tree casts a deep shade, wide spacing such as 15 x 15 m (50 x 50 ft) is recommended unless the intercrop is considered short-term. This attribute was generally restricted to the period when the tree had not shed off leaves for those trees which shed off leaves completely as this was confusing to some farmers who had preferred to place those trees which do not shed off leaves completely first because they attributed this attribute to shade and so they were tempted to select the trees which was ever green first.

All farmers ranked for this attribute on the basis of when the species are all mature but still noted that for mango, there was also variation within the species itself as different varieties had different crown spread on maturity this was in line with Bally (2006) who stated that Mango trees typically branch 0.6–2 m (2–6.5 ft) above the ground and develop an evergreen, dome-shaped canopy. Similarly, Bally (2006) reported that variability in canopy shape and openness occurs among varieties but he included competition from other trees as another factor which could influence the crown spread of mango as he noted that Mangos grown in heavily forested areas branch much higher than solitary trees and have an umbrella-like form.

4.2.3.4 Ranking trees for general attribute – Pruning

4.2.3.4.1 Trees species Easiness to Pruning

This attribute was ranked on the basis of the tree of the same age and the farmer using the same pruning tool, this was so because trees at different age could have lead to invalid ranking as the age of the tree influences the easiness to pruning. It was also agreed that the farmers consider using the same pruning tool of which most of them agreed they mainly use machetes. This eliminated the scenarios were a farmer uses better tools on some trees and poor one on other tree and could not give comparable results. Generally all farmers with the exception of those who did not select banana for ranking for this attribute considered it the easiest to prune. They based this on its stature, and softness, for the same reasons pawpaw was ranked second easiest. The farmers also explained that easiness prune is closely related to the growth rate, the trees that grow fast are also easy to prune but those that grow slowly are relatively hard to prune. Prune easiness also was challenging to most farmers who noted that almost all the trees are easy to prune when still young but differences in prune easiness come in as the trees mature. African teak was clearly distinguished as being the hardest to prune owing to its height and wood hardness, the farmers explained that easiness to prune is inversely related to timber strength (Figure 4.7). Quite a number of farmers also insisted some tree species like umbrella tree is self pruning and therefore do not prune it so they did not prune them but others emphasized that at times they prune them for the purpose of getting fuelwood. Pawpaw was also considered by farmers as not pruned as they noted that once pruned they rot ant the tree dies, others said it does not produce branches so need for pruning this was also observed that some varieties actually do produce branches so there were differences within the species. With the exception of the easiest three and the hardest on the other side, there appear to be four groups with the first group consisting of ovocado, jackfruit and mango which did not differ significantly for this attribute, the second group consisted of cassia, fig tree and nandi flame did not differ. The third group consisted of black plum,, markhamia, umbrella tree, and *A.coriaria* and the fourth group comprised bark cloth tree, African elemi and red nongo the species which were considered hardest after African teak in terms of prune easiness. However, Bosu and Krampah, (2007) reported that bark cloth tree has a good self-pruning ability. Whistler and Elevitch, (2005) found out that pruning of black plum controls the tree's size.

Whereas *A. coriaria* was referred to as being second in command to African teak for most attributes which involve hardness, for this attribute, farmers argued that it is easier to prune than red nongo and bark cloth tree which grow taller than it. This explanation indicated that farmers considered the height of the tree when ranking for this attribute more than the hardness of the wood. Orwa *et al*., (2009) reported that *A.coriaria* is a slow growing tree and recommended management practices are lopping and pollarding.

4.2.3.4.2 Tree species growth rate after Pruning

Banana, fig natal and jackfruit were clearly distinguished as having the fastest growth after pruning. On the opposite side, African teak was also clearly distinguished for having the slowest growth after pruning (Figure 4.12).African teak appeared to error bar because several farmers distanced themselves from ranking it for this attribute arguing that they had not been bothered to observe its growth after pruning as it was generally believed to be slow growing as shown in (Figure 4.15). A big group of farmers ranked for this attribute based on the sap content of the tree, they reasoned that tree species with much sap content generally grew faster after pruning than others with less water content; they attributed this to reduction in competition for water by the tree branches. Several trees species were not actually pruned by the farmers but farmers based their ranking on the experiences they gained when cutting off branches for fuel-wood and other uses so that implied some trees were pruned with other intensions other than growth and so in such instances farmers were reluctant to observe growth after pruning. Generally four clusters can be observed with fig tree, ovocado and pawpaw appeared in the same cluster indicating that farmers could not distinguish them for this attribute, Although cassia had an error bar due to fewer number of farmers who ranked it for this attribute, it did not differ from mango, the other cluster nandi flame, *A. coriaria*, markhamia,umbrella tree and black plum did not differ significantly for this attribute. Bark cloth tree a*nd red nongo* also appeared in the same cluster. Heavy pruning can kill the tree especially black plum (Whistler and Elevitch, 2005). Black plum grows slowly after pruning due to slow re-growth after pruning (Whistler and Elevitch, 2005).

4.2.3.5 Ranking for general attribute – root architecture

4.2.3.5.1 Root depth of the different tree species

The root depth was ranked by most farmers on the basis of resistance to strong winds, trees which rarely fell down due to strong winds were considered to have deeper roots, the farmers argued that strong winds were the common measure for this attribute because they were able to observe that the tree species which fall frequently had less deep roots. They thus deduced that those that did not fall have deeper roots. However, Coder, (1996) argues that the ability of the tree to resist strong winds, ice storms, and major losses of woody materials, while remaining alive and erect, is a direct consequence of annual diameter growth.

They also mentioned that this attribute influence the position of planting some species close to their houses. The noted that trees with less deep root easily fall and so they avoid as much as possible to plant them close to their houses.Afican teak, was clearly distinguished from the others as having the deepest root depth, some farmers based on direct experience where they observed the trees uprooted during road construction while several of them explained that root depth could be deduced from tree height as it was believed that trees which grow very tall had deeper root depth.African elemi was ranked second most deep rooting tree by the farmers, Chaplin, (1988) and Thomson and Evans, (2006) also stated that this tree has a deep taproot. This confirms that actually farmers have a lot of information that needs to be compared to science which could be helpful for proper management of the trees under agroforestry.

This reasoning was in line with the farmers' consistently placing banana as having the least root depth although they all mentioned having had direct observation through uprooting. The other species were not significantly different but since there were no error bars indicted that several farmers could not differentiate them in ranking for this attribute. Pawpaw was also clearly distinguished from the main group and banana as the second least in root depth which still concurred with the explanation of a link between the root depth and the tree height. Among big trees fig natal was singled out for having less deep root depth owing to its tendency to fall easily due to storms. The tendency for the farmers to place fig natal among the least root depth was attributed to the fact that farmers plant this tree species through vegetative propagation and noted that the fig natal tree that grows from a seed had deeper root depth.

Ovocado was ranked among the last 4 as least rooting depth among the 18 tree species, the farmers' knowledge about this tree was in line with Coit, (1940) who conducted research on this tree species and discussed that Ovocado is naturally a surface rooting tree. Coit, (1940) further explained that the fine fibrous rootlets, which absorb water, food and air, develop in greatest abundance at or near the surface of the soil. Where mats of these fibrous feeders are permitted to develop normally near and at the surface, they function best when protected by a heavy undisturbed mulch of leaves and are kept reasonably moist. This implies that the farmers needed to understand that in the management of the tree mulch plays an important role. Much as mango only appeared in the top ten most deep rooting trees, Bally, (2006) noted that the mango has a long taproot that often branches just below ground level, forming between two and four major anchoring taproots that can reach 6 m (20 ft) down to the water table. However, the farmers' ranking of this tree cannot be contested because the trees that were ranked above it for instance black plum have no available information on their rooting systems (Whistler and Elevitch, 2006).

4.2.3.5.2 Root spread of the different tree species

The ranking for this attribute was based on the farmers' experiences when digging/ cultivating their land but others further mentioned that the rooting spread could be deduced from the tree size. The farmers explained that rooting spread was closely linked to crown spread. They further reasoned that trees with wider crown density need much more water and soil nutrients which meant they meet this high demand through root spreading. The trees with wider canopy were thus considered to have wider root spread than those with the narrow canopy. This could be an explanation for farmers' consistently ranked pawpaw and banana as the species with narrowest root spread were also considered in the same order as having the narrowest crown spread. Generally the narrowest eight species for rooting spread paqwpaw, banana, ovocado, nandi flame,markhamia, cassia, umbrealla tree and black plum were the same trees ranked narrowest for crown spread (Figure 4.10). However, Harmony, (n.d), does not agree with this knowledge as he stated that sometimes it is thought that tree roots mirror the size and spread of the crown. However, this is a common misconception, as root size and spread is often defined by the ground conditions the tree is growing in. For instance; a tree growing in well drained, soft brown earth will have a well developed root system, whereas a tree growing on a hard, shale bank may have a stunted root system (Harmany, n.d). In most cases tree roots are comparatively shallow and spread far beyond the crown of the tree. Roots will spread out in order to locate water, and if the only source of water is located ten metres beyond the tree in one direction then that is where the roots will head. Based on Harmon(n.d) argument, it can be deduced that trees that spread their root more than the other need more water thus the much spread is due to search for water.

African teak was clearly distinguished as the tree with the widest rooting spread from others but slightly less distinct than the case for root depth (Figure 4.13). This was clearly followed by *A. coriaria* while Afican elemi and red nongo appeared not to differ for this attribute. Clustering occurred for fig tree, bark cloth tree, and fig natal which could not be differentiated for this attribute. Jackfruit, mango, black plum and umbrella tree also appeared in the same cluster indicating they did not differ significantly for this attribute. The trees with narrowest root spread were also outstandingly distinguished as pawpaw and banana and these two species did not differ for this attribute.

4.2.3.6. Ranking for general attribute – growth rate

Trees grow in diameter every year (Coder, 1996). From the farthest reach of the woody roots to the tips of the twigs, trees expand in girth. This annual growth increment allows trees to respond to changing environmental conditions and react to injuries. The ability of the tree to resist strong winds, ice storms, and major losses of woody materials, while remaining alive and erect, is a direct consequence of annual diameter growth (Coder, 1996). Growth rate was ranked by most farmers on the basis of how fast the trees grow from planting to bearing fruits. Tree height was not considered much a measure of fast growth rather the period a tree takes to bear fruits or reach maturity for those that are not fruiting. This generally meant the period it takes for the tree to provide a farmer with what he planted it for.

The farmers ranked trees for this attribute based on the period it takes for the tree to produce what it was planted for, none of the respondents considered the tree stature in ranking for this attribute. They highlighted that most trees have specific purposes and the faster the tree produces the product for which it was planted for, it was considered fastest growing. This could probably explain why the first four fastest growing trees were fruit trees as these produce fruits before trees planted for timber. However, African elemi was ranked among the last three slowest growing trees by the farmer although it is considered a fruit tree. This could match what was explained by Thomson and Evans,(2006) who stated that trees closely related to African elemi grow slowly and begin to flower and fruit more heavily and regularly from about age 7–8 years. This could confirm that the farmers actually rate it among the last although it is a fruit tree, it takes long to bear fruits.

Fig natal appeared next because it was considered to be planted purposely for soil fertility improvement which is achieved from it leaf fall attribute which starts fast. However, Wood, (2010), stated that growth rate for trees typically are classified based on individual observation or experience and thus farmers' knowledge is not surprising.

The farmers consistently ranked pawpaw and banana as being the fastest growing owing to their ability to flower and produce fruits within a short time compared to the other tree species. This confirms Scot *et al*., (2006) that the growth rate of banana is rapid until flowering; after the flower bud shoots, vertical growth of the pseudostem ceases and no additional leaves are added. Markhamia and bark cloth tree were not distinguished for this attribute, also A. coriaria, African elemi and red nongo were clustered possible because they perform similar functions but some farmers pointed out that African elemi takes long to mature even when its fruits are edible. African teak was clearly distinguished from the other as being slowest in growth rate as most farmers mentioned that it takes long to produce good timber which is its main purpose. There was a direct link between this tree attribute and the timber strength (Figure 4.7).

The ranking of the tree species for growth rate placed jackfruit the fourth fastest growing trees after banana, pawpaw and ovocado this was in line with what was reported by Elevitch and Manner, (2006) who noted that jackfruit is a fast growing tree that reaches maturity within two years. Bally, (2006) also noted that mango trees are fast-growing trees, often growing in excess of 1.5 m (5 ft) per year when well tended in urban conditions. Farmers also it placed among the fastest growing trees clearly above black plum whose growth rate is moderate even in early years, likely less than 75 cm (30 in) per year, (Whistler and Elevitch, 2006). This indicates that farmers' knowledge on this tree attribute is generally in line with scientific findings.

4.2. 3.7 Mulch – Leaf decomposition rate and soil benefit

This attribute was ranked based on the period it takes for the leaves to decompose; farmers mentioned that this attribute was influenced by leaf qualities like moisture content and leaf size, they noted that small leaves decompose faster than broad ones and the more moist the leaf was the faster the decomposition rate this could have been the major basis for placing *Ficus natalensis* in the first position for this attribute. This is similar to what Montan˜ez (1998) as reported by Xuluc-Tolos *et al*.,(2003) found out that leaf litter decomposition of tree species in home gardens depended on season and species, where a slow decomposition occurred during the dry season and fast during the rainy season. Ibrahima *et al*., (2011) also stated that resource quality is an important factor regulating litter decomposition in Cameroon. Farmers in addition, noted that some leaves were considered to decompose slowly as to them those leaves are not preferred by termites which do most of the leaf decomposition. However, a similar and clearer explanation is given by Xuluc-Tolos *et al*., (2003) who stated that leaf quality, especially the C/N ratio, is a sound predictor of decomposition rate. This thus implies that farmers' observation that termites prefer certain leaves to other could be due to differences in C/N ratio where the leaves with lower C/N ratio are selected. Swift *et al., (*1979) included other factors like climate and soil microorganisms as being most important in regulating leaf decomposition which the farmer did not seem to have this considered possibly because climate has been relatively uniform that farmers were not able to recognise its impact. Interestingly, small group farmers pointed out that leaves from certain tree species like fig natal were more preferred by termites and to them that could have been the contributing factor to their faster decomposition rate, this seems not to differ much from Swift *et al*., (1979) that soil microorganisms are one of the most important factors influencing leaf decomposition although termites are not part of the microorganisms. Brouwer, (1996) argues that impact of plant species on litter decomposition and nutrient availability depend on the chemical composition of their litter fall, tree species and species groups such as climax and pioneers.

The fig natal, *A. coriaria*, fig tree and banana species were ranked as having the most benefit to the soil respectively clearly distinguished from each other.Red nongo, nandi flame and umbrella tree appeared in the same cluster thus they did not differ with each other for this attribute. The next trees appeared in pairs; barkcloth tree & ovocado and African elemi & African teak. The next was a cluster comprising of cassia, pawpaw, mango and black plum.

The last two trees were clearly distinguished as having the least benefit to the soil. The soil benefit for different tree species depends on several factors. Thomson and Evans, (2005) noted that trees in the group of African elemi are likely to have some potential for growing in silvopastoral systems, providing shade for livestock, and recycling nutrients from deeper soil layers, but advised that trees would need to be grown at wide spacing, e.g., 10–25 per ha (4–10 trees/ac) to allow enough light for pasture to grow beyond the edge of the canopy

5.0 Conclusion, Recommendations and Further Research

5.1 Conclusion

This study showed that farmers have different level of knowledge about the trees located on their farms.The study also indicated that farmers had more phenology knowledge about the fruit trees than the non-fruit trees this suggested that local knowledge was linked to the value farmers attached to a particular tree. The leaf fall timing was least understood by the farmers as most of them considered leaf fall as a continuously event except for the deciduous trees. The growth rate of trees was a single attribute that most farmers pointed out they consider in tree selection and thus emphasised that before they plant a particular tree they consider how long it will take to give them the purpose for which they planted. Growth rate also appeared to be negatively correlated with timber strength and durability. The ranking of the tree attributes indicated that farmers had more knowledge on some tree attributes mainly those that were observed easily like crown spread, crown density, growth rate compared to attributes like leaf decomposition rate and benefit to the soil. Particularly growth rate was ranked consistently for all the trees possibly because farmers considered this an important tree attribute that influences their selection of trees for planting.

Comparison of tree species for different attributes reaveled that best performing tree species for each attribute for instance African teak was considered superior for timber attributes while inferior for benetit to soil and growth rate. This also revealed that timber quality is inversely realted to growth rate. Banana was also consistently ranked are the fastest growing species and also grows fastest after pruning. Information was however, for the average performing trees for each attribute.

There were varied levels in consistence of farmers' knowledge of various trees, the level of consistence varied from tree to tree and from for each attribute. The superior and inferior tree for each attribute was ranked consistently but the average trees were inconstiistat. Despite the knowledge of attributes known to be negatively affecting coffee production, farmers' decision to plant or retain trees in coffee plot was influenced by the perception of utility. This is notably the case for fruit trees like jackfruit which appeared most commonly across all farms in both exercises, suggesting their contribution to nutrition and income was important and justified their presence in coffee plots despite their negative effect on coffee production. It is hoped that this study will contribute to improvement of tree diversity on the farms through proper species selection and management.

5.2 Recommendation

The trees with deep rooting system should be planted on soil with deeper soil rooting depth among these crops African teak, *A. coriaria* need deep soils for good growth.

The trees which have little benefit to soil for example jackfruit should be planted on home compounds and where possible on the separate land from coffee farm and those that benefit the soil like, fig natal should be included in coffee agroforestry.

Fig tree, *A.coriaria* and *A.chinensis* attributing to there superior influence to soil fertility should be interplanted with coffee.

5.3 Suggestions for further Research

The work narrowed to Multivariate Analysis. Other statistical methods like non-linear regression may be employed; there is also need to explore the Bayesian approach.

Further research on the other trees species in the area is highly recommended to get a clear picture of tree diversity in the area.

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Appendix 1: Tree list for ranking exercise

Farm number:	
Factory:	
Location:	
Date:	
Name of fieldworker:	
Name of person(s) who took part in the exercise:	
Number of men: Number of women:	
GPS of farm:	
Mark with a * the trees that the farmer has had direct experience with and circle the trees selected for ranking (no more than 10)	
Scientific Name	**Local Name**
Albizia chinensis	albizia
Albizia coriaria	mugavu/musisiya
Albizia zygia	nnongo
Antiaris toxicaria	kirundu
Artocarpus heterophyllus	ffene/kifenensi/yakobo
Canarium schweinfurthii	muwafu
Carica papaya	papaali
Ficus natalensis	mutuba
Ficus ovata	mukookowe
Maesopsis eminii	musizi/musinde/muside
Mangifera indica	muyembe
Markhamia lutea	nsambya/lusambya
Milicia excelsa	muvule
Musa spp.	banana
Persea americana	ovocedo
Senna spectabilis	gasiya
Spathodea campanulata	kifabakazi
Syzygium cuminii	jambula
Any comments:	

Appendix 2: Example data sheet for recording phenology calendar of tree species

Farm number:																								
Location:																								
Date:																								
Name of fieldworker:																								
Name of person(s) who took part in the exercise:																								
GPS of farm:																								
Tree species																								
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Flowering																								
Fruiting																								
Leaf fall																								
Record here any conditions that influence flowering/fruiting/leaf fall to happen at specific times of the year:																								

Appendix 3a: Data sheet for recording trees ranked for general attributes

Farm number:						
Factory:						
Date:						
Trees ranked in order for each general attribute						
Crown spread	Crown density	Easiness to prune	Growth after pruning	Rooting depth	Rooting spread	Growth rate
Widest	Least dense	Easiest	Fastest	Deepest	Widest	Fastest
Narrowest	Most dense	Hardest	Slowest	Least deep	Narrowest	Slowest
Comments and farmers' answers to questions to be recorded here:						

Appendix 3b: Data sheet for recording trees ranked for general attributes

Farm number:				
Factory:				
Date:				
Trees ranked in order for each general attribute				
Firewood	Timber		Mulch	
Burn length	Strength	Durability	Leaf decomposition	Benefit to soil
Longest	Strongest	Least susceptible to insect attack and rotting	Fastest	Highest
Shortest	Weakest	Most susceptible to insect attack and rotting	Slowest	Lowest
Comments and farmers' answers to questions to be recorded here:				

Appendix 4a: Example of a tree card used in the data collection (*Albizia chinensis*)

Albizia chinensis

albizia

Scientific name: Albizia chinensis

Luganda common name: albizia

English common name: Chinese albizia

Primary uses:
Timber, firewood, shade, mulch

Appendix 4b: Example of a tree card used in the data collection (Jackfruit)

Scientific name: Artocarpus heterophyllus

Luganda common name: ffene/kifenensi/yakobo

English common name: jackfruit

Primary uses:
Fruits, fodder, firewood

Appedix 5: Complete List of tree species studied containing their scientific, English and local names

Albizia chinensis

albizia

Scientific name: Albizia chinensis

Luganda common name: albizia

English common name: Chinese albizia

Primary uses:
Timber, firewood, shade, mulch

Albizia coriaria

mugavu/musisiya

Scientific name: Albizia coriaria

Luganda common name: mugavu/musisiya

English common name:

Primary uses:
Timber, firewood, shade, mulch, fodder, medicinal

Albizia zygia

nnongo

Scientific name: Albizia zygia

Luganda common name: nnongo

English common name: red nongo

Primary uses:
Timber, firewood, shade, mulch, fodder

Antiaris toxicaria

kirundu

Scientific name: Antiaris toxicaria

Luganda common name: kirundu

English common name: bark cloth tree

Primary uses:
Timber, firewood, shade, mulch, fibre

Artocarpus heterophyllus

ffene/kifenensi/yakobo

Scientific name: Artocarpus heterophyllus

Luganda common name: ffene/kifenensi/yakobo

English common name: jackfruit

Primary uses:
Fruits, fodder, firewood

Canarium schweinfurthii

muwafu

Scientific name: Canarium schweinfurthii

Luganda common name: muwafu

English common name: African elemi

Primary uses:
Sap, timber, fruits, medicinal

Carica papaya

papaali

Scientific name: Carica papaya

Luganda common name:
papaali

English common name:
papaya/paw-paw

Primary uses:
Fruits, leaves used as soap

Ficus natalensis

Scientific name: Ficus natalensis

Luganda common name: mutuba

English common name: natal fig

Primary uses:
Mulch, firewood, fodder, shade

Ficus ovata

mukookowe

Scientific name: Ficus ovata

Luganda common name: mukookowe

English common name: fig tree

Primary uses: Shade, boundary marker, fibre, fruit, fodder

Maesopsis eminii

musizi/musinde/muside

Scientific name: Maesopsis eminii

Luganda common name: musizi/musinde/muside

English common name: umbrella tree

Primary uses:
Timber, firewood, poles, shade, mulch

Mangifera indica

muyembe

Scientific name: Mangifera indica

Luganda common name: muyembe

English common name: mango

Primary uses:
Fruits, shade, firewood, medicinal

Markhamia lutea

nsambya/lusambya

Scientific name:
Markhamia lutea

Luganda common name:
nsambya/lusambya

English common name:
markhamia

Primary uses:
Poles, timber, firewood, medicinal

Milicia excelsa

muvule

Scientific name: Milicia excelsa

Luganda common name: muvule

English common name: iroko, African teak

Primary uses:
Timber, firewood, mulch

Musa spp

banana

Scientific name: Musa spp.

Luganda common name: banana (there are local names for the different varieties of banana in Uganda)

English common name: banana

Primary uses:
Fruits, shade

Persea americana

Scientific name: Persea americana

Luganda common name: ovocedo

English common name: avocado

Primary uses:
Fruits, firewood, medicinal, shade, mulch

Senna spectabilis

gasiya

Scientific name: Senna spectabilis

Luganda common name: gasiya

English common name: calceolaria shower, cassia, pisabed, yellow shower

Primary uses:
Boundary marker

Spathodea campanulata  **kifabakazi**	Scientific name: Spathodea campanulata Luganda common name: kifabakazi English common name: African tulip tree, nandi flame, flame-of-the-forest, Uganda flame Primary uses: Leaves used for bathing children

Syzygium cuminii

jambula

Scientific name: Syzygium cuminii

Luganda common name: jambula

English common name: black plum, black plum tree, java plum, jambolan

Primary uses:
Fruits, firewood