Growth performance of Shea nut tree (*Vitellaria paradoxa*) collections in an *ex-situ* trial plot in Lira District, Uganda.

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Abstract

Shea nut tree (Vitellaria paradoxa) is one of the most important indigenous trees growing in sub-Saharan Africa. Its primary product, Shea butter is used to make vital ingredients in confectionary, cosmetic and pharmaceutical industries. Despite its significance, little is known about its progression in growth from germination to maturity. To close this knowledge gap, a study to assess the growth performance was conducted on Shea tree collections from four provenances of Northern Uganda. The objectives of the study were to; establish a collection of V. paradoxa trees from the different major growing areas in Lango sub-region to serve as a genebank for future improvement programmes; compare the growth performance of the different accessions and to bring V. paradoxa into domestication to avoid depletion of those in the wild. The study was designed in a systematic plot design at a spacing of 4 m x 8 m in August, 2011. Minimal growth for all accessions was observed in the first 24 months followed by an abrupt but steady height gain thereafter for 20 months. Accessions from Palabek recorded the greatest height and number of branches; whereas Adwari had the lowest branch recruitment. Significant variations in growth demands for studies to correlate traits investigated with fruit nut yield of the parent trees.

Key words: *Vitellaria paradoxa*, provenances, domestication, accessions, Shea tree genebank.

1. Introduction

Shea nut tree (*Vitellaria paradoxa* C.F.Gaertn.) also known as Karité (in French) is an indigenous fruit tree of Sudano-Sahelian Africa. There are two subspecies of V. paradoxa, (sub species Paradoxa and sub species. nilotica), whereby nilotica is prevalent in Sudan, Ethiopia, Uganda and Democratic Republic of Congo (Boffa, 1999). Shea trees commonly occur in a region of 600–1400 mm of annual rainfall (http://sl.ku.dk/rapporter/seed-leaflets/filer/vitellaria-paradoxa-50.pdf). It is an important indigenous tree species which has undergone domestication in the savannah parklands of Africa for over 1000 years. The tree provides fruits, oils, income, cosmetic and medicinal ointments, hair cream, soaps illuminant and water proofing materials, fuels. This tree is therefore important for both community and household livelihoods in Uganda. However, there is no definite source of shea tree germplasm in the country given that seed from wild tree is collected for consumption. There is a lack of

apparent or deliberate conservation of shea tree genetic diversity in the country. Farmers are discouraged from planting the shea tree for its long juvenile period. There have been no shea tree genebanks in the country where consolidated research studies can be done.

Since 2011, the National Agricultural Research Organization (NARO) in collaboration with the World Agroforestry Centre (ICRAF) has been managing a 1-acre shea tree genebank in Uganda. This is the first genebank of its kind in the country specifically holding shea tree accessions from the entire range of the species in Uganda. The genebank has not only been used to study nursery tree generation but has also been utilized as a research platform by National Research Institutes, Makerere University and international agencies (ICRAF).

The Shea nut tree is one of the most important indigenous trees in sub-Saharan Africa largely due to the economic and ecological roles it plays to the communities where it grows (Jasaw *et al.,* 2015). Shea butter which is extracted from the kernel is used to produce a number of useful products. These include; cooking oil, cosmetic and medicinal ointments, chocolates, hair creams and soap among others. It also plays a major role in nutrient recycling when the leaves and fine roots decompose (Bayala *et al.,* 2006) although the leaves decompose at a low rate (Bayala *et al.,* 2005). The nutritious fruit makes it a good source of food during the hunger season. In Uganda, Shea tree grows mainly in the northern, eastern and west Nile regions of the country where it is known by various names.

Despite its great contribution to the local economies mostly women (Pauliot *et al*., 2012), shea nut tree remains undomesticated probably because of lack of tradition to plant local tree species (Asante *et. al*., 2012). Indeed, shea tree parklands result from naturally occurring individual trees that are protected by farmers when clearing their fields, thus creating parkland systems (Boffa *et al*., 1996). Shea is also known to be slow growing taking over a full decade to start bearing fruits. Worse still, because it is an excellent source of fuelwood, many mature trees are harvested to produce charcoal to meet the energy demands of the growing urban areas.

Although Shea nut tree is slow growing, knowledge about its growth performance from germination to maturity is scarce. Nevertheless, such information is useful in tree improvement where trees/plants with good growth habits can be selected for breeding programs. For this reason, an experimental plot was established at Ngetta ZARDI in 2011 to monitor the performance of *V. paradoxa* collections from different sites in northern Uganda.

The rationale for establishing the experimental plot is to establish a collection of *V. paradoxa* trees from major growing areas in northern Uganda to serve as a genebank for future improvement programmes; and to bring *V. paradoxa* into domestication to avoid depletion of those in the wild. Meanwhile this current study compared the growth performance of the different accessions.

2. Materials and Methods

2.1 Study area

A study to evaluate the performance of nursery propagated *Vitellaria paradoxa* planting materials was established at Ngetta Zonal Agricultural Research and Development Institute (Ngetta ZARDI) situated in Lira district, Northern Uganda at 2˚17'N, 32˚55'E and is 1,100m above sea level. Ngetta is located in the mid-northern agro-ecological zone which has an average rainfall of 1,197mm and temperatures ranging from 15 to 32.5^{o}C (UBOS, 2009). The study commenced in July, 2010.

2.2 Selection and collection of planting materials

Fresh shea fruits were collected from four provenances in July, 2010. A total of 125 trees were selected for seed collection from four provenances/accessions including Adwari (33), Atiak (32) Palabek (32), and Kilak (28) trees. The provenances represent sub-counties in respective districts of Otuke, Amuru, Lamwo and Pader respectively. Shea trees with high yielding records (those that give more shea butter) were identified by the farmers for seed collection. The selected mother trees were also known by the farmers for their nice taste and bigger seeds yield.

Fruits were collected from individual shea trees located either near homesteads or located within farmlands. Only fallen fruits were collected early in the mornings between June and July, 2010. Fruits still attached to the trees were considered unripe. Fruits from selected trees were separated while those collected from other trees were bulked together. All fruits were placed in gunny bags (read sacks) and transported to Ngetta ZARDI where they were processed and sowed.

2.3 Seed extraction and germination

Seeds were de-pulped by hand, rinsed with cold water and immediately sowed by placing in propagation beds made out of perforated black polythene and the seeds covered with a blanket. The seeds were watered slightly only to keep the blankets moist to avoid seed rot and kept under a shade net that provided 70 % light intensity. Within one to two weeks, the germinating seeds were sorted as soon as the radicles broke through the kernels (sprouted). Germination percentage ranged from 50 to 95% depending on the handling i.e. 50-70% for seeds partially de-pulped by the farmers in the field and 80-95% for seeds extracted on station. The germinating shea seeds were sorted and pricked out into 5 x 8 inch potting polythene bags for a period of five weeks. The germinating seeds developed shoots between two to three months from the date of sowing.

2.4 Seedling management

The seedlings were managed for 13 months (July 2010 to August, 2011) within a nursery under a shade net providing 70 % light intensity prior to planting out when they were grown to average of 15 cm tall.

2.5 Experimental design

Seedlings were collected from four provenances namely; Adwari, Palabek, Attiak and Kilak. The seedlings (198 in total) were established in a 0.63 ha plot using systematic plot design at a spacing of 4 x 8 m in August, 2011. Each accession was replicated three times within the plot to cater for internal differences within the experimental plots.

2.6 Data collection and analysis

Data collection was conducted after every 3 months on plant growth parameters such as leaf number, plant height, root collar diameter and branching. Non-parametric tests were used to ascertain the differences in the growth parameters of the different accessions. Relationships among the various growth parameters tested within the trials plots was tested using chi square. Generalized Linear Model was run to check the interactions among the various growth parameters of *Vitellaria paradoxa* within the trial plots.

3. Results

There was a very minimal seedlings height growth registered from all the accessions within the first two years from August 2011 when planting out was done to April 2013 (Fig.1). The seedlings made an abrupt height gain from April 2013 increasing steadily till December 2014 (after four years) when all the accessions again made another abrupt height growth (Fig.1). Palabek seedlings picked off in April 2013 from 50 cm to 301 cm in December 2015 and recorded the greatest height followed by Kilak with an average of 185 cm in December 2015. Atiak and Adwari had uniform height growth performance over the past four years.

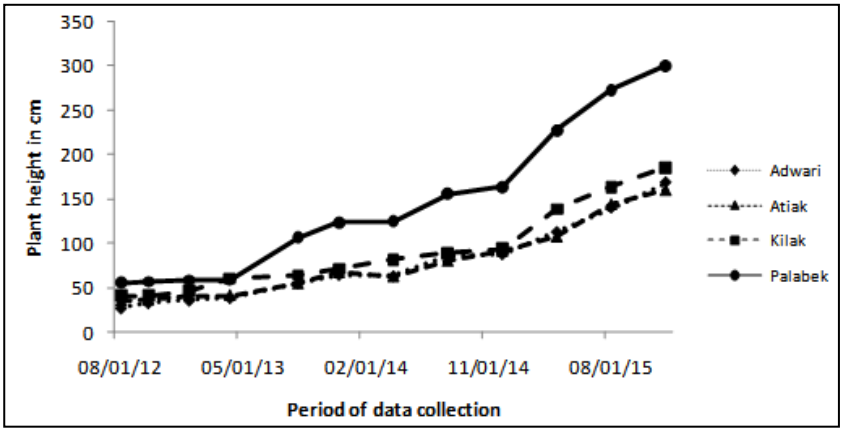

Figure 1 Height growth performance of *V. paradoxa* accessions at Ngetta ZARDI

Plant shoot development is closely related to height and crown width development (Olusegun *et al*. 2007). Kilak and Palabek had the highest average number of newly developed shoots (2) per assessment period (every 3 months in a year). Atiak and Adwari accessions had a similar growth pattern where one new shoot developed every three months (Fig.2).

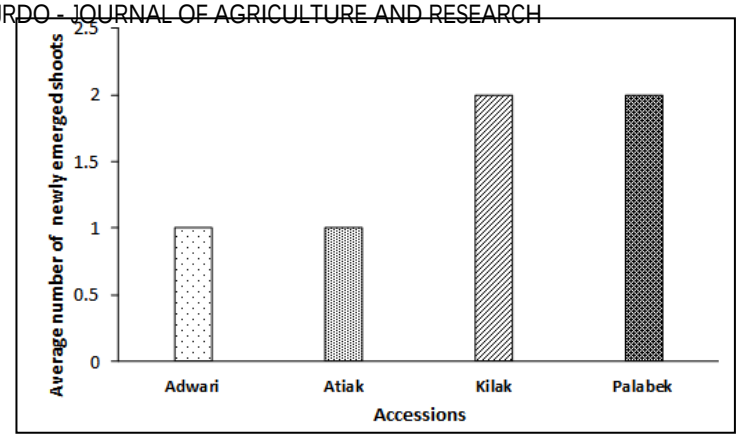

Figure 2 Shoot development by accession

Although branch recruitment was observed to be steady in all the accessions, Palabek rapidly recruited more branches in April 2014 from 10 branches to over 30 branches from where it continued increasing progressively (Fig.3). The other accessions had successive branch recruitment with Adwari having the lowest number of branches (Figure 3). Adwari only recruited one branch from one to two over the four years' study (August 2011 to December 2015).

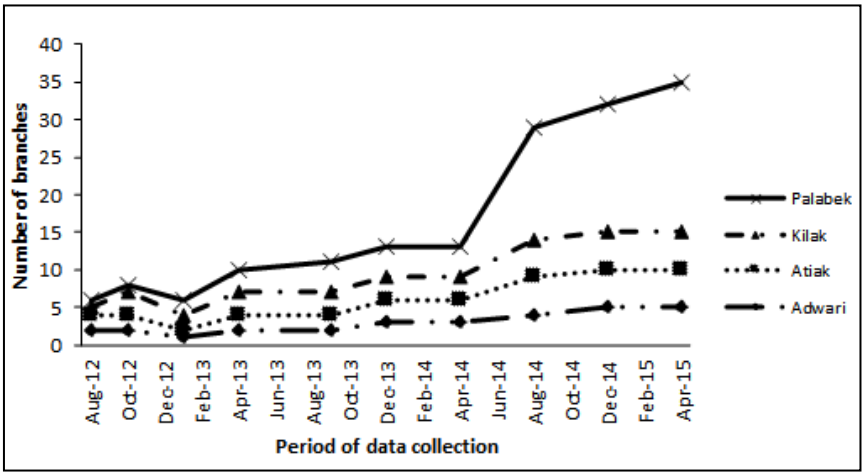

Figure 3 Branch recruitment

Palabek accession had the largest number of leaves (104) as compared with the other three accessions which ranged between 30 and 50 large leaves. This was followed by Kilak with 46 leaves and the least number of leaves (37) was recorded for accessions from Adwari (Fig.4).

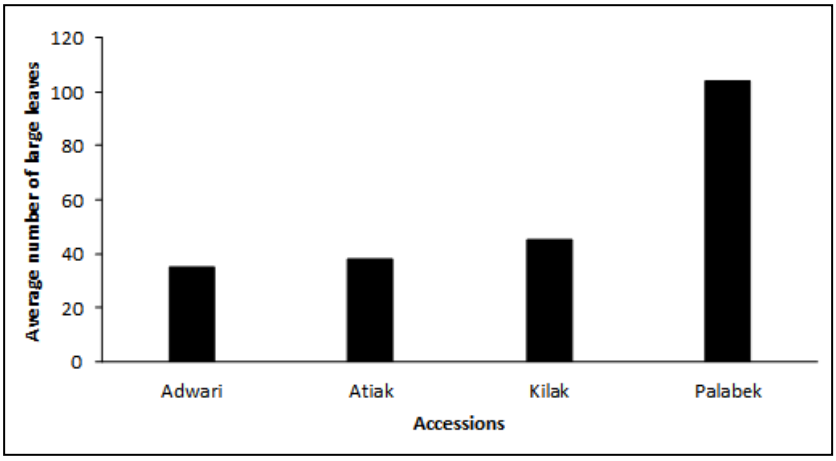

Figure 4 Average number of large Shea leaves

4. Discussions

Tree vertical growth is an indicative factor of plant establishment, performance and suitability for the site (Ayari *et al.,* 2012). During the first two years, all the accessions grew at the same rate for the first two years before each one of them changed height rate (Fig.1). This was establishment period for the seedlings while getting used to the field conditions and also spreading the root system from the nursery ball into the natural field soil.

In this investigation, considerable variations in growth parameters were observed for trees from the different accessions. These variations could have accrued from genetic differences shaped by environmental factors in these localities (Hoffmann *et al.,* 2005).
Palabek as an accession produced the best results as far as canopy development is concerned.

According to Ayari *et al.,* (2012) tree crown size correlates positively with fruit yield. This means that a tree having more branches or greater crown diameter has the potential to produce more fruits compared to others with less. Therefore, such trees could be used as parents for selecting desired traits if there is a positive correlation between canopy development and fruit yield.

On the other hand, shea tree growth throughout sub-saharan Africa is greatly affected by bush fires and browsing animals (Augusseau *et al.,* 2006). Therefore, it could be argued that faster growing Shea trees have a better chance of outgrowing setbacks accruing from these threats. In this study however, significant variations in tree height were observed between the different accessions where Palabek showed the highest vigor. Nevertheless, it is of great interest in any tree improvement program to promote fast growing trees. Thus, identification and selection of such trees could play a significant role in producing early maturing Shea trees.

Shea tree crown width increased with increasing tree height, relative crown depth (RCD) and relative crown width (RCW) because the RCD increased as the tree height increased. Taller trees allocate less energy for crown expansion but more for height gain before becoming reproductive (Olusegun et al. 2007).

5. Conclusion

The study revealed that Shea nut trees from Palabek showed superior growth in terms of plant height, leaf number and canopy development in comparison to others. The various accessions showed significant variation in growth performance. This means that there is a need to correlate the tree traits investigated with fruit yield of the parent trees. Lastly, further studies on tree phenology are required to follow on how the accessions perform within the experimental plot.

6. References

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