CHALLENGES OF PRODUCING QUALITY TREE SEEDS TO SUPPORT AFFORESTATION IN TANZANIA

[1]Msanga, H.P., *[2]Masunga, E.W., [3]Andrew, S.M., and [2]Fandey, F.H.

[1]Sebastian Kolowa Memorial University (SEKOMU), P.O. Box 370, Lushoto
[2]Tanzania Tree Seed Agency, P.O. Box 373, Morogoro
[3]Department of Ecosystems and Conservation, Sokoine University of Agriculture, P.O. Box 3010, Morogoro
*Corresponding author email: masunga@hotmail.com

ABSTRACT

There is an increase of awareness among local communities, NGOs, the private sector and government agencies on the importance of afforestation in fostering the supply of important environmental goods and services. However, in order to sustain the afforestation initiatives and realize the anticipated impacts, quality seed production is critical. The history of tree seed production in Tanzania started as early as the 1902. In the 1970's, the Government launched the national tree planting campaigns which led to the establishment of the National Tree Seed Programme (NTSP) in 1989. Following Government reforms, NTSP was transformed to Tanzania Tree Seed Agency (TTSA) in 2003. TTSA mandate is to produce and market high quality tree seed and other propagating materials. Currently, there is an increasing demand for quality tree seed for afforestation both locally and internationally. This paper identifies the challenges facing the production of quality tree seeds such as seed quality, low investments in tree seed industry, inadequate policy, and specific law to regulate and control tree seed quality, human resource limitations, and inadequate institutional integration with related expertise, research and climate change. Others issues include, problems of seed dormancy for some species, inadequate data on individual seed protocol for storage and germination. In addressing these challenges, the paper recommends investment in establishing as many seed orchards as possible, integrating institutions with related discipline at each node to create a multiplier effect on abundance, quality, and distribution as well as financing the tree seed industry, support training and recognition of the tree seed industry through policy and legal mechanisms.

Keywords: Tanzania Tree Seed Agency, Orchard, Provenance, Policy

INTRODUCTION

The history of tree seed production and the establishment of forest plantations in Tanzania started as early as in 1902, under the German rule at the Biological and Agricultural Research Institute (Das Biologisch Land Wirtschaftlichen Institute) at Amani in Tanga Region. The sole objective of the project was to supplement the dwindling wood supplies from natural forests. This was then subsequently followed by a large scale industrial forest plantation establishment in the 1950s under the British rule.

In 1927 during the British rule in Tanganyika, the Biological and Agricultural Research Institute was renamed the "East African Agricultural Research Station (EAARS). In 1948, the Amani Station was moved to Muguga, Kenya to form the East African Agricultural and Forestry Research Organisation (EAAFRO). Besides research, the organisation catered for tree seed handling activities which were common for the three partner states under the British rule. Problems which were unique to individual countries were addressed on a national basis. This led to the establishment of the Silvicultural Research Station at Lushoto in 1951.

At Lushoto, a sub-section of handling seed activities was formed and whose objective was to supply small quantities of tree seed of mainly Pines, Cypress, and Eucalypts for research purposes and for the establishment of Government plantations.

In 1970s the Government of Tanzania launched national tree planting campaigns to rehabilitate the degraded environments. This created high demand for seed of local and exotic tree species for various end uses. The Silviculture Research Station at Lushoto was not well placed and had no capacity to handle large quantities of tree seed. The Government recognized the seriousness of the situation and this led to the establishment of the National Tree Seed Programme (NTSP) under the Ministry of Natural Resources and Tourism in 1989 to enhance sustainable supply of high quality tree seed and other propagating materials.

Following Government reforms under the Civil Service Programme, NTSP was transformed into the Tanzania Tree Seed Agency (TTSA) in 2004 with the purpose of supplying market high quality tree seed and other propagating materials.

Prevailing Conditions of forestry and tree seed

Commercial forestry is a growing industry in Tanzania. Increased domestic and international demand for wood-based products requires an ever increasing supply of quality tree seed. The demand can be met by either increasing the size of the forest area or increasing productivity of the existing forest area or both. Yields per unit area of forests land can be increased through tree improvement, which involves improving the seed quality.

The tree seed industry in Tanzania has faced many challenges including; lack of financial resources and technical expertise, weak institutional linkages and unclear mandates, inadequate collaboration among participating partners, poor oversight arrangements and inadequate resources to support public servicing agencies dealing with tree seed. The advent of climate change has also brought with it new challenges in seed production.

Quality tree seeds are a prerequisite to successful afforestation programme and constitute a major pathway for the achievement of forest conservation. Therefore, there is a great need of ensuring availability of high quality and diverse genetic material to meet the demand of its end use. Tree seed quality is a measure of potential performance of a seed under optimal conditions. The seed of the highest quality will result in trees of the highest value in the field. A high quality tree seed is a seed which has been produced from the selected good mother tree. A good mother tree is one which has gone through genetic improvement by the selection of good qualities of the desired character. For example, a timber tree should have a straight, cylindrical, non-forking and non- twisting bole, fast growth, narrow crown, thin branches with wide branch angles, high wood density and long fibre, and resistant to pest and diseases. In respect of a fruit tree, the tree should be able to produce many fruits and of the desired taste. A firewood tree should produce high biomass and wood of high calorific value. In all cases, a high quality tree seed should be free of diseases and of high physiological quality with high germination capacity (Msanga, 2007).

SPECIFIC TREE SEED INDUSTRY CHALLENGES IN TANZANIA

Seed Quality

Although TTSA has its own standards on seed sources, the collection, testing and storage to meet specific requirements in the forestry and tree seed production operations, most of the stakeholders to a large extent do not perceive it as important. As a result, common practices result in the collection of poor

quality tree seeds. For instance, seeds are sometimes collected from poor quality fruits as the best fruits are sold fresh. In many cases, farmers do not maintain genetic purity through the isolation procedures and the elimination of unwanted or inferior plants. The collected seeds more often than not are those which are most accessible including those lying on the ground and vulnerable to attacks by seed eating insects and fungal pathogens. The seeds harvested from small trees which are easy to reach may result in a greater frequency of small trees in subsequent populations. It is thought that, about 90% of the non-indigenous trees in southern Tanzania woodlots came from an extremely limited genetic base. The original introduction may not have been selected for any useful characters. For indigenous species may have indeed been selected for ornamental and amenity properties, which may well not be the qualities sought for multipurpose use or timber production.

The prevailing situation calls for the need for provenance tested seed for both timber species and multipurpose trees as a means of doing away with almost exclusively from the wild, `unimproved' populations. Many of the most important species are self-incompatible thus seed characters are inherited from different parent trees, increasing the variation between individual seeds. Trees grown from the seeds collected from many trees within one area, when compared with trees from the seeds of the same species from a different area, often marked differences will be exhibited in growth rates, growth form, pod production, tolerance of environmental stresses, thorniness and the presence of ant nutritional factors. Even the seeds are collected from an individual tree; they will still produce progenies with highly variable characteristics. This variation can be exploited to allow plant breeders to develop varieties with particular desirable characteristics. Such conventional breeding programmes with multipurpose trees are rare, although the techniques have been well established for high value temperate and tropical commercial forestry species such as Eucalyptus and Pine.

A good example of the breeding of an agroforestry species was carried out at the University of Hawaii by Dr. Brewbaker (Harris, 1993). The researcher selected vigorous `giant type' varieties of *Leucaena leucocephala* from the natural population. An alternative method for rapidly isolating and exploiting useful variation between individual trees is to propagate them vegetatively by cutting. This type of work has been carried out to establish high yielding clones of commercial species such as eucalyptus. This is also not a well-developed technique for multipurpose tropical trees and is associated with more problems of storage, quality control, phytosanitary certification, transport and distribution, than is the case with the use of seeds. Hence, when a species has been selected to be tested in a particular locality, it is important to include trees from different populations (provenances) of that species in order to gain the widest genetic range possible and to determine which provenance is most suitable for that area and for the purpose of its selection.

Low Key Investments in the Seed Sector

The report on situational analyses of tree breeding and tree germplasm supply which was conducted in West and Central Africa (Avana-Tientcheu, 2016), Eastern Africa (Msanga, 2016) and Southern Africa (Marunda, 2016) showed that almost all National Tree Seed Centres in Africa are operating below capacity due to decreased levels of investment in equipment and human resource.

Tree Seed industry in Tanzania is not financially sustainable because the Government is not allocating enough funds and the low of ability of tree growers to pay for quality seed and services. TTSA was formerly supported by DANIDA, which terminated her support in 1998. TTSA inherited capital assets such as buildings, climbing gears, laboratory, and a handful of vehicles. For over 15 years, TTSA has been trying to increase its revenue by promoting the sales of seeds, seedlings and other services to make it sustainable. Due to low investment, most of the equipment and laboratory facilities are obsolete. This has resulted to

low capacities in the collection, extraction and storage of seed causing delays in processing and hence resulting to poor quality seed.

Most of the seeds are often sold at cost price, therefore, self-financing through sales of seed is at present an unrealistic approach, and is probably likely to be so for many years until the farmers know the importance of using improved quality seed and seedlings. To ensure good quantity and quality tree seed, the Government support is crucial and almost all successful tree seed centres in the world are partly financed by their governments.

The assumption that trade in tree seed constitutes a viable commercial option is wrong. It is a fatal mistake to assume that seed business can generate income that can cover all the costs and generate revenue to cater for the required investments in conservation and improvement. Tree seed business can only be profitable if it specializes in some few selected species. In short, research institutions and other public sector servicing institutions dealing with tree seed such as TAFORI and TTSA are under-funded and this limits their critical roles of multiplication of quality tree seeds.

Inadequate Policy Support

Overall, policy support is also important in achieving a sustainably quality seed production. The issues of tree seed have never been addressed by the current Forest Policy. There is no law in Tanzania which provides for the promotion, regulation, and control of tree seed variety release, multiplication, conditioning, marketing, importing, quality assurance, and other propagating materials. The Seed Act of 2003 and the Plant Protection Act of 1997 which regulate the production, distribution, and marketing of seeds are categorically for agricultural seeds and are under the Ministry responsible for agriculture.

The National Forest Policy (1998) has 41 policy statements, but none of them on tree seeds. The policy only identifies management and conservation problems and opportunities. The policy states that one of the goals and objectives of the forestry sector is to ensure sustainable supply of forest products and services by maintaining sufficient forest area under effective management. Despite its strategic importance in ensuring sustainable development of forests in Tanzania, the tree seeds issue is not mentioned in the respective Policy.

The Government established Tanzania Tree Seed Agency (TTSA) in 2003 under the Executive Agencies Act, 1997 as a semi-autonomous executive agency within the ambit of the Ministry of Natural Resources and Tourism. TTSA was established for the purpose of enhancing sustainable supply of forest products and environmental conservation by producing, procuring, and marketing of high quality tree seed and other propagating materials. In the Tanzania Tree Seed Establishment Order of 2003 and its Amendment Order, 2016, the Tanzania Tree Seeds Agency is assigned some roles and functions to play through very brief statements without any legal powers.

Conclusively, there is no legal mechanism which makes provisions for the control and regulation of tree seeds and other related matters. This position impacts TTSA negatively against the performance of its roles and attainment of its objectives. It also impacts negatively the national desire and efforts of meeting the challenges in the management of forest resources on an integrated and sustainable basis. It is for this reason that the Management of Tanzania Tree Seed Agency hereby proposes for the enactment of a Tree Seed Act to provide for the promotion, regulation and control of tree seed breeding and release, multiplication, conditioning, marketing, importing, and quality assurance of tree seeds and other propagating materials and for other related matters.

This area needs to be given a national priority requiring the development of specific policies to guide and regulate the use of tree seed. Policy support requires awareness among decision makers. They must realize the important values that can be protected and generated by a specialized and well managed national tree seed programme. Many problems facing TTSA and tree seed industry in Tanzania emanate from the absence of a clear and straight forward policy, Law, and other legal guidelines. The new Forest Policy is required to consider the essence of having a new tree seed act or of having clauses on tree seeds in the legislation.

Human Resource limitations, in terms of Numbers and Skills

We live in a dynamic world where changes appear continuously, where institutions that can continue to adapt and find new ways will survive. These new ways can only be found if the institution trains its staff and motivate them at the same time. Taking on board the objectives and work load of TTSA, the quality and quantity of human resource should be seriously taken into consideration. The present situation does not allow for the maintenance of even few trained and recruited staff. For the past 10 years, TTSA has recruited 40 staff, out of these 15 left the job or asked for transfer to other institutions. The Institution is in a dare need of a Tree breeder, Plant Pathologist, Plant Entomologist and Botanist. This can only be solved through joint efforts with other stakeholders. In order to ensure long term availability of quality seeds and other propagating materials, the existing professional gap cannot be left as it is, investing in human resource in this case is inevitable.

Inadequacy of Integration between Institutions with Related Expertise

The institutional co-operation is very important in technical sustainability, in order to create a multiplier effect in line with seed production value chain. For tree seed industry to achieve this goal, all institutions in the value chain must play their role well at each node starting from the grassroots to the apex, that is, applied research in tree improvement programme, tree breeding, seed production and seed storage technology and then all the findings from each node should be integrated to generate solutions for the seed end users. The possible model for this to work might be promotion of technologies through research Institutions and Universities, while TTSA concentrates on the multiplication of seeds and other propagating materials. TFS and other private companies should finance research and multiplication of seeds and other propagating materials. In reality, the Institutional collaboration is still at a low level.

Inadequate Tree Breeding Research

The establishment of forest plantations in Tanzania started as early as in the 1900s with the objective of supplementing dwindling wood supplies from natural forests. This was then subsequently followed by large scale industrial forest plantation establishment in the 1950s. Tree improvement research is one of the key areas that support productive forest plantations and indeed, this research played a key role in the success of these early industrial plantations. For many years research services were and are being supplied by Tanzania Forestry Research Institute (TAFORI) the Ministry of Natural Resources and Tourism.

However, the level of investment in research and development related to plantation forest productivity is low due to lack of both financial resources and technical expertise. The same problem is facing collaborating institutions such as Sokoine University of Agriculture (SUA). Over time therefore, very little has been done on tree improvement research hence key constraints of the forestry sector including access to improved seed and narrow genetic base of industrial tree species in both public and private plantations could not be addressed . In summary, there is inadequate knowledge and skills among the seed value chain actors.

Climate Change

Climate change brings a change in temperatures which affects flowering phenology abundance, and seed production. Most of the exotic and indigenous tree species have been affected by climate change. Flowering studies need to be conducted and modern technologies such as vegetative propagation need to be adopted to address seeding shyness in certain species. One major seed problem in Tanzania is lack of definitive information on the phenology of flowering and maturation of fruits and seeds. Extensive phenological observations of many species have been recorded, yet predictive models for flowering are lacking (Bawa *et al.,* 1990). Flowering and fruiting of some species seem to be related to wet -dry seasons cycles (Whitmore, 1983; Wright and Cornejo, 1990) and these patterns are very difficult to predict under climate change.

Spatial Distribution

Other problems relate to spatial distribution or sizes of trees in natural stands. Low distribution frequencies of species in tropical forests are common (Gentry, 1988). If only a few fruits are available from individual trees, then the collection costs soar quickly. Plantations and/or seed orchards would have solved this problem, but they are almost non-existent for these species. In moist tropical forests, fruit-bearing limbs of the desirable trees may be as much as 35 meters above the forest floor. Unless seeds can be collected from the ground after natural seed fall, climbing is the only practical option which is very expensive for a tree seed industry.

Predators

Predators present another major problem in Tanzania. Birds, monkeys, and bats eat fruits and seeds before the natural seed fall (Howe, 1990). This problem is observed when collecting seeds of some of the species such as *Milicia excelsa,* which is eaten by bats and birds. In some cases, animals are natural seed dispersal mechanisms in tropical ecosystems, but they complicate things for seed collectors. Moreover, when seeds are dispersed on the ground, numerous birds, rodents, and insects come forth to eat them. Timely collections are needed to avoid losses, but incomplete knowledge about fruiting phenology combined with wide spatial distribution of trees make seed collection more difficult.

Seed Dormancy

In contrast to the common image of rapid germination in tropical forests, there are many species that exhibit seed dormancy. While many species germinate promptly when dispersed, others exhibit long delays in germination. Seed dormancy is most common among leguminous species and species of dry tropical forests. Numerous species (including non-legumes) have seed coats which are hard enough to survive in the litter in moist forests for at least 3 years (Whitmore, 1983). Seed coat dormancy, which is most common in the listed species, is easily overcome with scarification. However, in many cases, other more complex dormancies may be encountered.

Variation of Seed Storage Behaviour

There are three categories of seeds namely; Orthodox, recalcitrant, and intermediate seeds. Orthodox seeds survive the drying of 10 to 15%, increase longevity with drying, have predictable response to moisture and temperature and have predictable storage life. Recalcitrant seeds, on the other hand, do not survive drying to any large degree, and are thus not amenable to long term storage. The critical moisture content (MC) for survival varies among species, depending on the oil content. For example, safe moisture content for Dipterocarps (starchy seeds) is 50% and for cacao (oily) is 20%. Therefore, recalcitrant seeds cannot be dried neither can they be frozen. Intermediate seeds behave like a subset of Orthodox. They can tolerate drying of to around 40 - 50% MC. They are also often sensitive to storage of -20°C. Sugar analysis suggests that some intermediate seeds have orthodox embryos as well as mismatch between development of

the fruit and the seed inside resulting to its behaviour. The well-known tree species as intermediate is Neem (*Azadirachta indica)*. *A. indica* is often classified as intermediate but is fully desiccation tolerant if dried appropriately (remove seeds from fully-ripe fruits and dry slowly under ambient conditions). *A. indica* seeds can be stored at -20°C but are sensitive to chilling damage if imbibed at low temperatures. This can be partially overcome by imbibition at temperatures of >25 - 30°C. In general, desiccation sensitivity is recorded in 65 families with varying frequencies. In this regard, there is a big challenge in screening to determine seed storage category. How do we know if the seeds are orthodox, recalcitrant, or intermediate? Currently, TTSA use methodologies such as taxonomy, literature, laboratory experiments, predicting from seed traits, biochemical traits, ecology, and physical attributes in locating storage category.

Regardless the achievement, conservation (storage) of recalcitrant seeds is still a problem. There are no easy options for the conservation of recalcitrant seeds. Short term moist storage is the most widely used method but it has some disadvantages. The temperature must be low enough to reduce germination but high enough to avoid chilling injury. Seeds may germinate if it is too moist, and die if it is too dry. Fungal contamination is always an issue and fungicides have to be used. Alternatively, recalcitrant seeds can be stored or conserved by cryopreservation of zygotic and somatic embryos whose facilities are expensive and determination for storage needs investment in research to develop protocols. Cryopreservation of embryos rather than whole seeds is possible for some recalcitrant species. Each species requires an individual protocol for dehydration, storage, and regeneration.

CURRENT STATUS OF TREE SEED INDUSTRY

The commercial forestry sector is currently heavily reliant on poor quality planting material from a very narrow range of commercial species. The key species planted are *Pinus patula*, *Eucalyptus grandis*, *Cupressus lusitanica* and *Tectona grandis*. Lack of locally available quality planting stock affects woodlot and plantation productivity and quality, leading to reliance on the imported improved seeds. The limited species diversity in commercial use exposes the country to grave danger of the outbreak of severe pests or diseases.

In 2013 Forestry and Beekeeping Division started to support collaborative work on tree improvement in the Southern Highlands. A public- private Tree Improvement Research Working Group (TIRWG) was formed and developed a Tree Improvement Strategy for the Southern Highlands. This led to the establishment of species trials with public and private partners covering all the ecological zones in the Southern Highlands. Breeding populations have been developed for the two dominant species. The trials will yield valuable information on alternative species to be introduced.

Plans are underway to establish clonal and seed orchards of Eucalyptus and Pines in suitable locations. This year 2018, two clonal seed orchards were established at Rongai by TTSA. In order to make improved seed available on a sustainable basis, TTSA in collaboration with Tanzania Forestry Research Institute (TAFORI), Tanzania Forest Fund (TaFF), Tanzania Forest Service Agency (TFS), Private Forest Programme (PFP), and Tree Growers Associations (TGA's) have established about 50ha of seed orchard in 2018 in the Southern Highlands, Rongai and Shume forests. However, we have a long way to go if Tanzania would is to satisfy the local market and to be the leading exporter in tree seed **(Table 1).**

Table 1: A comparison between Zimbabwe and Tanzania on number of seed orchards, area and level of improvement of seed germplasm available in both countries

Species	Seed orchards in Zimbabwe			Tanzania Area (ha)		
	Number	Generation	Area (ha)	TTSA	TFS	PFP/TTSA
E. grandis	6	2nd and 4th	15	6	10	
E. maidenii				4		
E. saligna				5		5.78
E. camaldulensis	17	1st, 2nd, 3rd and 4th	33	15		
E. tereticornis	9	2nd and 3rd	10	12.5		
E. cloeziana				6.2		
E. citriodora	1	1st	0.6			
P. patula	26	1st and 2nd	46	2	10	
P. taeda	24	1st and 2nd	33			
P. radiata				1.5		
P. elliottii	28	1st and 2nd	61			
P. kesiya	17	1st and 2nd	53			
P. oocarpa	7	1st	22			3.99
P. pseudostrobus	1	1st	0.7			
P. maximinoi	4	1st	19			7.86
P. tecunumanii	14	1st	18			8.72
P. caribaea var hondurensis	1	1st	0.6			0.88
P. caribaea var bahamensis	1	1st	0.6			
P. caribaea var caribaea	1	1st	0.6			
P. palustris	1	1st	0.5			
P. chiapensis	4	1st	6			
Pinus spp hybrids	2		1.4			
Cupressus lusitanica	1		0.6			
Tectona grandis				5	52	
Grevillea robusta				0.5		
Milicia excelsa				5		
Khaya anthotheca						
Afzelia quanzensis						
Total	**165**		**321.6**	**62.5**	**72**	**27.23**

CONCLUSION

Tanzania's Tree Seed Industry has shown remarkable development over the past five years after the establishment of Private Forest Programme and Forest Development Trust. These international Non-Government Organisations (NGO's) have very much stimulated the afforestation programmes in the southern highlands, southern part, and in the Lake Zone. TFS, Local Government, many private companies (e.g. New Forest, TANWAT, Mufindi Paper Mill, Tree Growers Associations - TGA's), and farmers are ordering large quantities of quality seeds from abroad. This is an opportunity for the tree seed industry to excel by establishing seed orchards for the local and export markets. The new draft of Forest Policy for the first time contains policy statement which addresses high production of quality tree seed. There are signs of hope with Public, private companies and NGO's towards the formation of social enterprise for tree improvement programme. If the government properly coordinates tree improvement programmes through TAFORI and TTSA, the tree seed industry will experience a turn around that will make Tanzania among the prominent and leading nations in tree seed production and afforestation programme.

THE WAY FORWARD

- Seed Industry should therefore not necessarily be financially self-reliant, but rather it should obtain funding that reflects their actual contributions to the value of planted trees and environmental sustainability in the short and in the long run. The benefits/essence of TTSA should not only be assessed based on the earnings from the sales of seeds, but on the value added to the sector and to the society. Because of this reason, we recommend that since the objective is to enhance sustainable supply of forest products and carry out environmental conservation by producing, procuring, and marketing high quality tree seeds and other propagating materials, the funding must be guaranteed. Income accrued from the sales of seeds is not enough to sustain seed production due to its high cost. Due to the challenges facing budgetary allocations in the face of competing demands from other development needs, the budget for tree seed production should be met from a certain percentage of every prescribed fee payable under the forest Act.
- The Government should ensure that there is multi–stakeholder research and tree improvement research program and which is sufficiently resourced and coordinated by TAFORI for long -term sustainability. There is also a need of ensuring that there is availability of quality seeds by enabling the private sector participation in seed production and distribution and at the same time encouraging Public, Private Partnership.
- The private sector should be encouraged to invest in the sector to complement in the tree seed production, distribution, and marketing while the government carries out with tree seed production, distribution, and marketing and regulating the tree seed industry. The involvement of the private sector, donor partners, and development organizations will help to reduce the burden on government budget and the government can then channel the savings resulting from such assistance into the development of other sectors for research and development. The resurgence of the private sector and the public- private partnership arrangements will ensure that this infrastructure is used for the benefit of all players in the seed industry.

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