Determination of *Triumfetta tomentosa* B. Growth Parameters and Fibre Properties in Kenya

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Abstract

Triumfetta tomentosa B. (Fam. Tiliaceae) is an indigenous perennial shrub growing naturally in moist habitats. It is a multipurpose plant traditionally used by many communities in Kenya as a source of fodder, fiber for baskets and ropes and wood for winnowing trays. However, as population increases, the suitable habitat for the shrub is being converted into agricultural and settlement sites making *T. tomentosa* an endangered species. Kenya needs a cheap source of vegetable fiber in order to revive its textile industries and make industrialization a reality by the year 2030. Currently Kenya spends about Ksh 20M in imported vegetable fibres. The aim of this study was to investigate methods of cultivating *T. tomentosa* and processing its fibres. Seeds and cuttings were collected from Mt. Kenya and Karura forests. These were raised in nurseries at Muguga (Kenya Forestry Research Institute - KEFRI). The seedlings were transplanted after attaining about 25-40 cm in height. Three experimental sites including Embu, Meru and Muguga were used for cultivation of *T. tomentosa*. Random Block Design method was used at spacing of 30 cm X 30 cm and 45 cm X 45 cm in 3 replicates for each plant material. Growth in height and diameter at breath (dbh) was measured after every month until about 50% of all the plants had formed flowers. Others were subjected to retting at Egerton University to release fibres. Fiber properties were tested at Kenya Bureau of Standards (KEBS) in Nairobi, Kenya. Descriptive statistics, Chi-square test of independence and Mann-Whitney U test of significance models were used. Cuttings from Karura had a higher shooting percentage (70%) than those from Mt. Kenya forest (40%). Plants from Embu plot gave the highest fiber yield among the three plots, while tenacity tests showed significant difference between fibres from cuttings and those from seeds. The results showed that it was easier to cultivate *T. tomentosa* from cuttings. Its fibres were close to those of Jute in tenacity and therefore good for making sacks, ropes and mats.

Key words: *Triumfetta tomentosa* B. Textile, Fiber properties, endangered, vegetable fibres

Introduction

The *Triumfetta* belongs to the family Tiliaceae. Locally the plant is referred to by different names varying from one community to the other. For example, *Majijo* or *mujijo* (Meru), *Mukiswa* or *Muindanguue* (Kamba), *Mughambi* (Kisii), *Shitanda-Nguo* (Luhya), *Ang'orno* (Luo) and *Mugio* (Kikuyu) (Gachathi, 2007).

It is a shrub that grows to 0.6–3 m high and up to 7cm basal diameter. The stems are erect and are thickly covered in a pale brown downy tomentum of largely stellate hairs (easily scraped away by a fingernail). The leaves usually are oblong to ovate with the lowest slightly 3-lobed, 5.5–12.5 cm long, 2.5–9.5 cm wide and apex acute to subacuminate. The length of the central lobe may vary by ± 3 cm, with the length of lateral lobes varying by ± 0.5 cm, if present. The base of the leaf is cordate to obtuse with leaf margin 2-serrate, rarely crenate and densely covered beneath in a soft tomentose down of white stellate hairs (Gachathi, 2007). The hairs are sparse above and with fewer and shorter arms. The petioles are 0.9–4.5 cm long, 1–1.5 mm wide with stipules persistent which are dark brown, narrowly triangular, 6–7 mm long and 0.5–1 mm wide. Inflorescence is terminal with sparse branches that are 10–22 cm long with lower nodes slightly reduced with un-lobed leaves. Nodes 0.7–3.2 cm apart, each with 6–10 leaf-opposed cymes and each cyme with 1–3 florets. The peduncles are 3–4 mm long with narrow ovate bracts which are 1.5–3.5 mm long and 0.25–0.5 mm wide. Sepals are narrowly lanceolate to oblong, slightly pandurate, 5–10 mm long, 1 mm wide with densely grey stellate hairs. The petals are rounded-oblong, 4-8.5 mm long, 0.7–3.0 mm wide with basal 0.75–2 mm claw fringed which is pubescent. The stamens are 9–12 while ovary is subvillose. The fruit is round and brownish in color, often with reddish prickles, measuring 2–7 mm long, that are hooked at the apex.

In general, textile fibres fall under two main categories; man-made and natural fibres. Man-made fibres can either be simple polymers, copolymers or heteropolymers. They fall under two main groups, depending on the origin of the fibre forming material. These are the regenerated fibres that are obtained from materials of natural origin and synthetic fibres that are made purely from chemicals. The regenerated fibres constitute two main types; these are regenerated cellulose fibres such as rayon, viscose cotton and those of regenerated protein fibres such as casein and groundnut fibres. Examples of synthetic fibres include nylon, polyester and acrylics (Collier, *et al.,* 2009; Kroschwitz, 1990).

The natural fibres are divided into three main classes. These are vegetable fibres, animal fibres and mineral fibres. Natural fibres include copolymers obtained either from animal hairs and fruits such as cotton, coir and kapok; from the stem (bast fibres) such as linen, jute and aramina; or from the main vascular system of monocotyledonous plants commonly referred to as leaf fibres. These include sisal, henequen, abaca (manila) and pineapple (Collier, et. al, 2009; Kroschwitz, 1990).

The fibres obtained from *T. tomentosa* resemble jute more closely than other jute substitutes. They are also as fine as jute and can be spun in the same machinery. The fibre is often used in admixture with jute. It is soft, lustrous and pale yellow in color. It is used for making Hessian, ropes and carpets. In Malaysia, the plant is widely used as a source of herbal medicine (Wynne, 2008).

In Kenya, the plants grow naturally at the periphery of the Mt. Kenya Forest, Mau Hills, Kakamega Forest and the Aberdare Ranges. The plant is traditionally used as a livestock fodder (leaves), to make winnowing trays (stem) and the bark (which contains the fibre) is used to make ropes and baskets (Oginasako, *et al.,* 2006). According to Gachathi (2007), the leaves were also used to make the girls' bed among the Kikuyu community. So far no attempt has been made to domesticate the *T. tomentosa* as a crop in Kenya.

Currently, Kenya imports most of the vegetable fibres apart from cotton and sisal. Hence the increase on the production cost that has an influence on consumer prices. According to Kenya Industrial Research and Development Institute (KIRDI) (1981), there is need for research in the development and utilization of other vegetable fibre sources. Though *T. tomentosa* fibre has been used traditionally in Kenya to make ropes, its full potential as a textile fibre and commercialization has not been fully investigated and exploited. Moreover, Kenya aims at being industrialized by the year 2030 with the major objective being to create employment opportunities for the rapidly growing labour-force. This then calls upon the utilization of local materials and services that are less expensive, locally available yet internationally competitive. This paper therefore focuses of the determining the *T. tomentosa* growth parameters, some properties of its fibres and the most efficient mode of propagation.

Materials and methods

Propagation of *Triumfetta tomentosa* B. from Cuttings

The cuttings were obtained from Mt Kenya Forest (Chogoria) and Karura Forest in March 2009. Rooting hormones Rhizopon AA 1% (IBA) and Azatone 'X' were used. Red top soil was sieved to remove any stone and large particles. Potting was done using 15 cm x 10 cm inches black punched polythene papers. Before planting the potted tubes were watered and dredged using fungicide (Milraz) to control fungi. The cuttings were also treated with Milraz before and after planting and then the beds were covered with polythene sheets. The beds were aerated after 8 weeks and left for 1 week when the cutting were divided into three categories depending on their diameter; category A (0.5cm – 0.8cm), category B (0.9cm – 1.2cm) and category C (1.3cm – 1.6cm).

The beds were watered every two weeks and sprayed with the fungicide. When the seedlings were about 25 – 40cm and the cuttings had rooted they were transplanted to the field. The trial plots were divided into different treatment with 3 replicates using RCBD design. The treatments were as follows: Sb (Seed broadcast), S_1 (Seedlings planted 30 cm x 30 cm, S_2 (Seedlings planted 45 cm x 45 cm), C_1 (Cuttings planted 30 cm x 30 cm) and C_2 (Cuttings planted 45 cm x 45 cm). The data was analyzed using chi-square test of independence to test whether there was a variation in the survival rate based on the source of the cuttings and the size of the stems.

Propagation of *Triumfetta tomentosa* B. from Seeds

One kilogram of seeds was broadcasted on a well prepared and aerated seed bed. After germination the seedlings were pricked when they were about 5 cm. The seedlings were watered for four months twice a day until they were about 20-40 cm after which they were transplanted.

Determination of Growth Parameters

The growth parameters were recorded after every four weeks in terms of height (cm) and diameter of seedlings at ground level (cm). This was carried out over a period of four months. The height/diameter measurement analysis was based on spacing and method of propagation. The data was analyzed using Mann-Whitney test. This test was used to compare whether there was a significant difference between the means of the seedlings and the cuttings. The independent variables were spacing and method of propagation.

Analysis of Tenacity and Elongation of the Fibres

The plants were harvested; barks stripped off and steeped in water for 2 weeks to ret. The retted barks were then washed and dried under shade. Samples were taken based on site, method of propagation and spacing. The samples were taken to KEBS to test for tenacity and elongation using established standards (Kenya Bureau of Standards, 1987).

Results and Discussions

Propagation of *Triumfetta tomentosa* B. from Cuttings

The shooting took place between 7 to 12 days and the rate of shooting was determined by destructive random sampling carried out every two weeks. The cuttings from Mt. Kenya Forest recorded a shooting rate of about 60% after 12 days while those from Karura forest recorded a shooting rate of about 90%. After 4 weeks some of the cuttings that had dried, lowering the shooting rate to 40% and 70% for those from Mt. Kenya and Karura Forests respectively. The low shooting rate of cuttings from Mt. Kenya Forest was attributed to the length of time they took before they were planted and the low temperatures (cool box with ice for 2 days). This shows that if they stay longer in the cool box the stems start rotting, interfering with the rooting process. However, those from Karura forest were cut and planted on the same day. This indicates that for better results, cuttings should be obtained and planted on the same day.

Cuttings in category A recorded the lowest survival rate (36%) as compared to categories B and C which had a survival rate of 54% and 80% respectively. Cuttings from Karura Forest recorded a higher survival rate on average as compared to those obtained from Mt. Kenya Forest which was statistically significant ($P<0.05$) (Table 1).

Table 1: The survival rate of *T. tomentosa* B cuttings based on source

Stem size	Survival rate %	
	Mt. Kenya Forest	**Karura Forest**
Category A	207 (38%)	132 (71%)
Category B	562 (54%)	208 (81%)
Category C	134 (80%)	29 (72%)

NB Category A (0.5cm – 0.8cm), category B (0.9cm – 1.2cm) and category C (1.3cm – 1.6cm)

The cuttings that showed higher survival rates were the medium sized (category B) from Karura Forest and the large sized (Category C) from Mt. Kenya Forest. This indicates that cuttings need to be used immediately after

preparing them. It also means the stems that are between 0.9 cm and 1.6 cm thick will root better than the small sized ones. However, if they are not potted immediately, the large stems would be better than the other sizes possibly because they retain moisture longer.

Propagation of *Triumfetta tomentosa* B. from Seeds

The rate of germination was recorded as 90% after eight days. However, the survival rate was about 15%. This was due to an acute shortage of water. The survival rate after pricking was 80% giving a total of 351 seedlings (Table 2). The survival rate for the pricked seedlings was very high. This implies that once the seed have germinated, they are able to grow to maturity as long as there is sufficient water. It was note that at the germination stage, a lot of tendering and watering is required.

Table 2: The survival rate of *T. tomentosa* B seedlings

	Pricked/potted	**survived**	**dried**	**Survival rate %**
Seed broadcast	437	351	86	80

Determination of Growth Parameters

The plants were harvested after flowering (six months after plantings). The mean height for the plants from the cuttings was 70 cm while that from the seeds was 66 cm. There was a statistically significant difference in mean heights of plants from cuttings and those from seeds ($p<0.05$). This implies that on average, the cuttings have the potential of growing into taller plants compared to those from seeds. Therefore, in order to obtain relatively long thin fibres, it would be better to grow *T. tomentosa* B. from cuttings. Based on Mann-Whitney U test, the mean diameter for plants from cuttings was significantly different from those from seed (Tables 3 and 4). This implies that the method of propagation has significant influence on the resulting stems.

Table 3: Mean Height/diameter of *T. tomentosa* B stems as influenced by method of propagation and spacing

Spacing	**Height(cm)**	**DGL(cm)**
Cuttings	69.63	1.0585
Seedlings	66.31	1.0822
S1	68.13	1.0699
S2	62.38	1.1087
C1	65.46	1.2345
C2	58.79	1.1216

Table 4: Significance of Mean Height/diameter based on method of propagation and spacing

Treatment	Height(cm) Mann-Whitney U Asymp. Sig. (2-tailed)	DGL(cm) Mann-Whitney U Asymp. Sig. (2-tailed)
Propagation Method	0.000	0.000
Spacing for Cuttings	0.006	0.000
Spacing for Seedlings	0.007	0.323

The plants that were closely spaced were slightly longer than those that were not while there was no difference with regard to the basal width. As indicated in Table 3, the means for plants from cuttings with 30 cm spacing and 45 cm were significantly different for both diameter and height. This implies that spacing is very crucial in cultivating this plant. Those that were spaced closely tended to be longer as they compete for sunlight as opposed to those that had a wider spacing. The means for plants from seeds with 30 cm and 45 cm spacing were found not to be significantly different with regard to diameter. This implies that as far as seedlings are concerned the spacing is not a parameter to take keen interest on.

Analysis of Tenacity and Elongation of the Fibres

The *T. tomentosa* B fibres are course with tenacity of 2.6g/d for all the fibres tested showing that there was no difference among all the samples tested. This compares with other cellulose fibres such as phineapple (2.6g/d) and agave Americana (2.9 g/d). This implies that *T. tomentosa* B fibres are strong and can be put into textile use. The fibres obtained from plants cultivated from seeds that were closely planted had a better elongation (1.8 % - 2.1 %) (Table 5). This finding concurs with arguments by Msahli, *et al.,* (2006) that most vegetable fibres do not exceed 10%. Based on these results it is clear that for better quality fibres in terms of elongation, the closer the plants are the better. Therefore, in order to obtain fibres from *T. tomentosa* B. with good elongation properties, the plants should be spaced closely (30 cm x 30 cm) when planting.

Table 5: Tenacity (g/d) and Elongation (%) of *T. tomentosa* B. Fiber

Plot	Meru		Embu		Muguga	
	Tenacity	Elongation	Tenacity	Elongation	Tenacity	Elongation
S_2	2.6	1.3	2.6	2.2	2.6	1.6
S_1	2.6	2.1	2.6	2.2	2.6	2.1
C_2	2.6	1.8	2.6	1.8	2.6	1.7
C_1	2.6	2.2	2.6	1.6	2.6	1.6

Conclusion

From the findings it can be concluded that:

i. The best method to cultivate *T. tomentosa* is first to establish the seedlings in the nursery and then transplant them into the field at appropriate height.
ii. Fresh cuttings should be used if plants are to be established from cuttings.
iii. Among the three sites used for trials, Embu proved to be the best site for the cultivation of the *T. tomentosa* plant.
iv. The *T. tomentosa* fibres are strong and with good elongation compared with other natural vegetable fibres and therefore can be used in technical applications as a substitute of jute, sisal and pineapple.

Recommendations

We recommend further research to be done on the germination tests and commercialization of the plant and its products. There is also need to carry out tests on other plant fibre parameters. Research is required to determine its usage in reinforced materials and geotextiles. It is necessary to create awareness about conservation and utilization of this plant species within various communities especially where the plant grows naturally.

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