*Kenya Journal of Sciences (B) (1987) 8 (1-2): 5—13*

# Studies in propagation and establishment of *Oxytenanthera abyssinica, Bambusa vulgaris* and *Arundinaria alpina* in medium altitude site in Kenya

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SUMMARY

Results of propagation, establishment and early development and growth of three bamboo species *Oxytenanthera abyssinica* (A. Rich) Munro, *Bambusa vulgaris* Schrad ex Wendl, and *Arundinaria alpina* K. Schum studies at Muguga are described. It was found possible and easier to propagate the three bamboo species vegetatively through off-sets or rooted rhizomed culms than through unculmed rhizomes. Propagation by culm cuttings was difficult with *B. vulgaris* and impossible with the other two bamboo. Sexual propagation is possible but seed is difficult to obtain and more time is needed before seedlings are ready for planting out. In the field, the three bamboo showed promise for domestic planting and conservation uses.

## INTRODUCTION

Bamboo belongs to the Bambusoideae of the Gramineae or grass family. Only one bamboo species, *Arundinaria alpina* K. Schum is indigenous to Kenya (Dale and Greenway 1961). This bamboo thrives well between 2,400 and 3,350 metres above mean sea level. Its favourable ecological range includes the Aberdares and Mau ranges and Mountains Kenya and Elgon. The lower zone of these ranges carried this bamboo until the 1950s but have now been converted to plantations of fast growing exotic conifers. Bamboo is now confined to patches at higher altitudes of these mountains and ranges.

The restricted ecological range of *A. alpina* and its narrow use supports the need for its management, expansion and the concomitant introduction of exotic bamboos. By contrast, the oriental bamboos are more versatile in their utility and can provide materials for high quality furniture, decorative articles, various household articles including basketry, mat and other products such as pulp and paper (Rao 1960; 1963; 1966; Widjaja 1980; Tamolong and Lopez 1980; Varma and Bahadur 1980; Wimbush 1945).

The extension of the range of local bamboo species to the people and the introduction and cultivation of exotic bamboos will expand and diversify the needful soil conservation materials and the increasing and widespread basketry and handicraft industry. This will go far toward enhancing environmental protection and creating employment. The present studies attempt to answer some of the questions regarding the feasibility of extending the range of the local high altitude bamboo *(A. alpina)* into the medium altitude and more populated areas. The other objective is to test possibilities of introducing exotic bamboos, *Bambusa vulgaris* and *Oxytenanthera abyssinica* to these areas.

In the cultivation of bamboo, the source of planting material is critical to the establishment, early growth and even the eventual plantation management (Banik 1980; Uchimura 1980). Propagation is mainly through rhizome-cuttings (off-set planting), culm cuttings or sexually by use of seed. The present paper summarises results of

experiments carried out to test possible and suitable material sources of the three bamboo species and their establishment and early growth at Muguga.

## STUDY SITE

Propagation and establishment investigations were carried out at Muguga. The station lies about latitude $1^0$ 13′ south and longitude $36^0$ 38′ east and is 2050 metres above mean sea level.

Mean annual rainfall is 970 mm and mean minimum and maximum temperature is $10.8^0$C and $20.0^0$C respectively.

Over most of the area there is a deep (up to 5 metres) layer of dark, red, well drained, fertile, volcanic loam, derived *in situ* from the parent rock (Temperly 1951). The pH of top-soil is about 6.0.

## MATERIALS AND METHODS

Studies on propagation of *O. abyssinica* by seed and vegetative materials in the nursery and field establishment and growth trials of the three bamboo species were carried out in Muguga. Study procedures are described below.

### Propagation of *O. abyssinica* by seed in nursery

Seed of *O. abyssinica* was obtained from the Zimbabwe Forest Department. The seed was stored in tied up khaki papers in the laboratory for one year, and then sown in an open bed. After four months seedlings were pricked out in the nursery. Transplanted seedlings were kept in the nursery for two years and records of germination, growth and health was made during this period.

### Vegetative propagation of *O. abyssinica* in nursery

This investigation was carried out in Muguga nursery under 75% shade structure. The effect of three propagation soil media (sand, forest soil, and "Muguga soil mixture" (Griffith, May and Howland 1962) on rooting, shooting, and establishment of four vegetative material sources (rhizome, first year young culm, lower portion of old culm and upper portion of old culm) was tested. Rhizomes and cuttings of this species were collected from clumps growing in the Muguga Arboretum.

The culm cuttings comprised two nodes each with notable bud(s). One node and its bud(s) was buried in the soil media in a slanting position, while the other node was left above the ground surface. Short rhizomes averaging 12 cm in length and carrying live buds were carefully removed from the mother clumps and buried horizontally in the different propagation media at depths of 3 to 8 cm. The experiment layout was complete randomised block design of three replicates. Soil treatments were randomised among replicates and the four material sources within each soil.

The dates of first leaf appearance in cuttings and rhizome shoots, number and survival were recorded for 11 months from August 1985 to July 1986. At the end of this period shoot heights were measured and all rhizomes were lifted and the conditions on shooting (state of the buds), rooting, and the rhizome itself noted.

### Field establishment and growth trials of *O. abyssinica, A. alpina* and *B. vulgaris*

Seedlings of *O. abyssinica* ranging between 30.5 - 61.0 cm in height where planted out in the Arboretum at a spacing of 5.0 x 5.0 m. Observations on survival, general health, and measurements of height were made over the next 16 years.

Rooted rhizomes of *B. vulgaris* ex Indian source were obtained from Entebbe Botanical garden and planted in Muguga nursery. Three clumps developed and after three years cuttings were collected. Twenty two cuttings of 1.5 metre average length were planted horizontally at depths of 10-15 cm at a spacing of 2.4 x 2.4 m in the Muguga Arboretum. Observations and records of shooting behaviour, health, and survival of

the cuttings were made to the end of the first year. After one year, dead cuttings were replaced with rooted cuttings. Further observations and records of health and growth in height of the surviving culm were made to age 16.

Rooted culms (short culms of 60 cm carrying a short rhizome and its roots) and unrooted culm cuttings of *A. alpina* were obtained from Kerita and Uplands forest stations, both some 25-30 km away from Muguga. These were planted in Muguga Arboretum one day after collection. Thirty rooted culms were planted at 2.4 x 2.4 m spacing and at a 10 cm average depth. Eight unrooted culm cuttings of average 1.2 metre length were planted slanting at the same spacing and with the lower internodes buried. Twelve unrooted culm cuttings were planted horizontally and completely buried. Over the first year, detailed observations on root development and survival were made. Further growth measurements in height and observations of general health were made over the next 16 years.

## RESULTS AND DISCUSSION

### Propagation of *O. abyssinica* by seed

Sexual propagation by seed was carried out in an open bed in the nursery. Table 1 gives a summary of germination, seedling development, and growth for two years in the nursery. Germination was good at 70% after one year of seed storage. After transplanting seedlings on to the open seed bed, only 6% was lost by the sixth month due to wilting. On realising the need for timely watering, no further losses were recorded. By the end of one year seedlings were averaging 25 cm in height. After two years in the nursery, seedling survival and health was good. Healthy 0.5 metre transplants were obtained at the end of the second year, at which time they were planted out in the field.

These initial observations indicate that where seed is available, it is possible to propagate *O. abyssinica* successfully. It is possible that at 25 cm height, seedlings of one year may be planted out if care is taken to avoid disturbance of root ball and availability of adequate moisture in the field. This practice would reduce the cost of retaining the seedlings in the nursery for two years as well as avoiding possible loss of the drought sensitive transplants during planting out.

Direct sowing into polyethylene containers may also reduce cost. The main problem of raising bamboo plantation from seed lies on its limited availability. Many bamboos produce seeds once in a lifetime or at long intervals and the possibilities are limited worldwide.

### Vegetative propagation of *O. abyssinica*

Figure 1 shows results of survival trend of the different vegetative propagation materials over a period of 11 months. All the first year culm cuttings produced shoots within the first month but these died within the second month. Shooting in the old lower portion culm cuttings was 100%, but by the end of four months all these cuttings were dead. All the upper portion of old culm cuttings died by the fifth month. Rhizomes buried in the ground started producing shoots from the third month onwards and by the end of the eleventh month there was 64% survival of the planted rhizomes.

**Table 1. Summary of survival and growth in height in seedlings of *O. abyssinica*.**

| Age (years) | Survival (%) | Mean height (m) | Remarks |
|---|---|---|---|
| 0.17 | 70 | — | Total germination per cent at end of two months |
| 0.5 | 94 | 0.08 | Two months after pricking out into open bed |
| 1 | 92 | 0.25 | Seedlings were noted to be critically sensitive to shortage of moisture |
| 2 | 92 | 0.46 | The range of seedling height was 0.35-0.61m |

These observations suggest that while young culms had the highest potential to shoot they were unable to maintain themselves possibly due to lack of food reserves and failure to root early enough to start tapping nutrients from the rooting media. Although older culm cuttings had more woody material and possibly more food reserves than the young cuttings, these also died later, possibly when the stored food was depleted and again as a result of failure to root within the four-five months period. The rhizomes which had both living buds and roots and accumulated food produced fresh roots to the eleventh month and beyond. It is speculated that the 64% survival in rhizomes could possibly have been higher if lengths longer than 12 cm had been used. Larger rhizomes would hold more food reserves and therefore have higher shooting, rooting, and survival potential.

The ability of meristematic node buds to shoot, root and accumulate food reserves in the form of rhizome is essential if initial propagation and establishment of a bamboo cutting is to be successful. The wide variation in survival of different propagation materials over time is clearly indicated by the survival trend values of the material sources in figure 1.

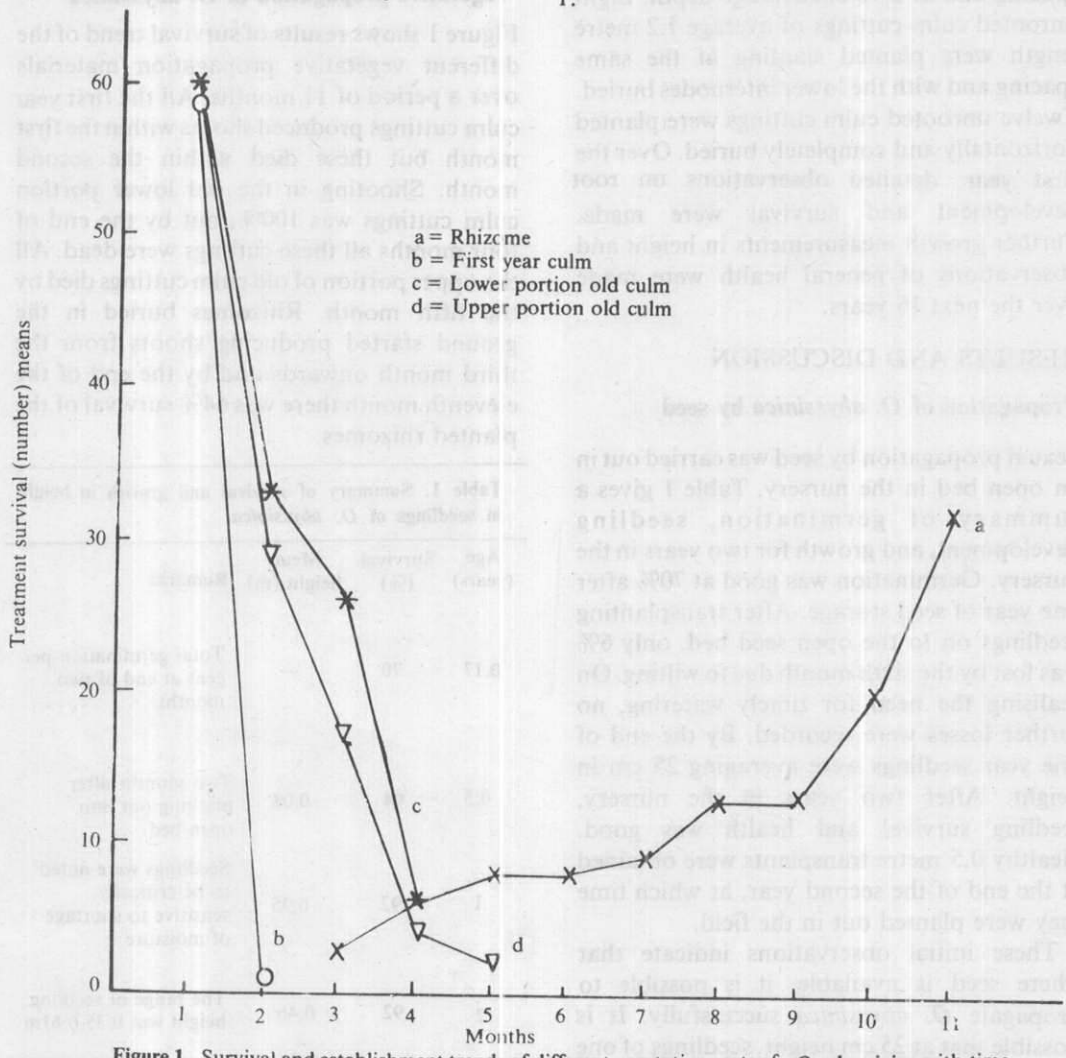


**Figure 1.** Survival and establishment trends of different vegetative parts of *O. abyssinica* with time

Initial shooting of bamboo cuttings followed by similar failures as observed in this study have been reported by among others, Hasan (1977), Banik (1980), Uchimura (1980), McClure and Durand (1951), and Troup (1921). Earlier reports that bamboos are easy to propagate from culm segments (Pathak 1899; Chinte 1965) were limited to a short period of observation. Bamboo cuttings need to develop shoots, roots, and rhizomes in order to sustain further development. Young and old culm cuttings of *O. abyssinica* were slow in forming roots and all died during the process. Survival rates in the rhizome method of propagation were higher since the planting material already possessed the food storing rhizome, active buds, and root initials.

It is likely that the age of culm is an important factor in the propagation of *O. abyssinica* since young culm cuttings produced shoots faster than older culm cuttings.

It would be interesting to test the effect of root-promoting substances on rooting rates with the aim of improving survival rates in cuttings that have already produced shoots. Studies by Bumarlong (1977), Suzuki and Ordinario (1975), and Uchimura (1980) on *Bambusa vulgaris* and other *Bambusa* species showed the importance of culm age and root regulators in propagation. Younger culms tended to have higher survival rates, while use of root promoting substances such as indole-butyric acid (IBA) and alpha-naphthalene acetic acid (NAA) tended to achieve better rooting rates with all species, especially *B. vulgaris.*

Soil media had little influence on survival rates or shoot formation (figure 2). Ignoring effect of time, analysis of variance on square root transformed final count data of rhizomes showed no statistically significant influence (at 0.01 probability level) of soil media on survival and establishment of rhizome. The effect of soil on establishment of the four propagation material is graphically shown (figure 3). The influence of soil media on propagation may be realised only when well established roots are able to tap nutrients advantageously.

**Field establishment and growth trials of *O. abyssinica, B. vulgaris* and *A. alpina***

Two year old seedlings of *O. abyssinica* transplanted into the field were observed to wither easily with drop of field soil moisture. No deaths were recorded after transplanting in the first year. After one month new growth appeared and towards the end of the first year some clumps had started producing new culms. Only 12% of the clumps showed poor health at the end of the first year and average culm height was 3 metres.

A summary of survival and establishment of various propagation materials of *B. vulgaris* and *A. alpina* over three years is given in table 2. Survival rates with vegetative material were relatively high and were better with *B. vulgaris.* The first three years showed good establishment and growth in height for both species. Propagation by rhizome in *B. vulgaris* was better than with *O. abyssinica* discussed in the above section. Propagation by rhizome was not tested with *A. alpina.* As reported above culm cuttings of different ages of *O. abyssinica* produced shoots but all died gradually and by the fifth month no cuttings were surviving. Similar observations were made with *A. alpina.* Some 60% of the cuttings produced shoots but from the seventh month the shoots started withering.

It is of interest that survival of *B. vulgaris* cuttings though low, was observed to beyond the establishment phase. These cuttings survived and successfully produced roots and rhizomes, and after the first year were producing new culms. By the third year culms from these cuttings were slightly over 3 metres high.

Establishment of small bamboo plantations is feasible through a sexual propagation despite all the difficulties, the effort, and expense involved in the acquisition of propagation materials and the difficulties in propagation. This study suggests that the best vegetative material is off-sets (short culm

stalks with attached short rhizomes and roots). Off-sets had better survival and growth rates than rhizomes (table 2). The importance of the attached culm portion may be attributed to the many buds found at the base of the culm which are destroyed when digging and separating off the rhizomes from the culms. Propagation of these bamboos through cuttings may be a problem but survival and establishment rates in *B. vulgaris* may be improved through use of root-promoting substances (Uchimura 1980; Bumarlong 1977).

Once the difficulties of propagation are overcome and establishment is achieved, a developed clump will continue to produce culms. Successfully established clumps of the three bamboos planted out at Muguga Arboretum were measured annually and health conditions recorded. Figure 4 shows comparative growth rates of the three species over a period of 16 years. *A. alpina* grew faster than both *O. abyssinica* and *B. vulgaris* but less than in its natural environment (Wimbush 1945). The maximum culm height obtained was 8.5 metres. The culms also suffered deaths mainly through droughts. Clearly, Muguga is too dry for the species to realise its growth potential. However, the growth rate indicates that the species can grow at this altitude and rainfall regime.

For the first three years *B. vulgaris* was less

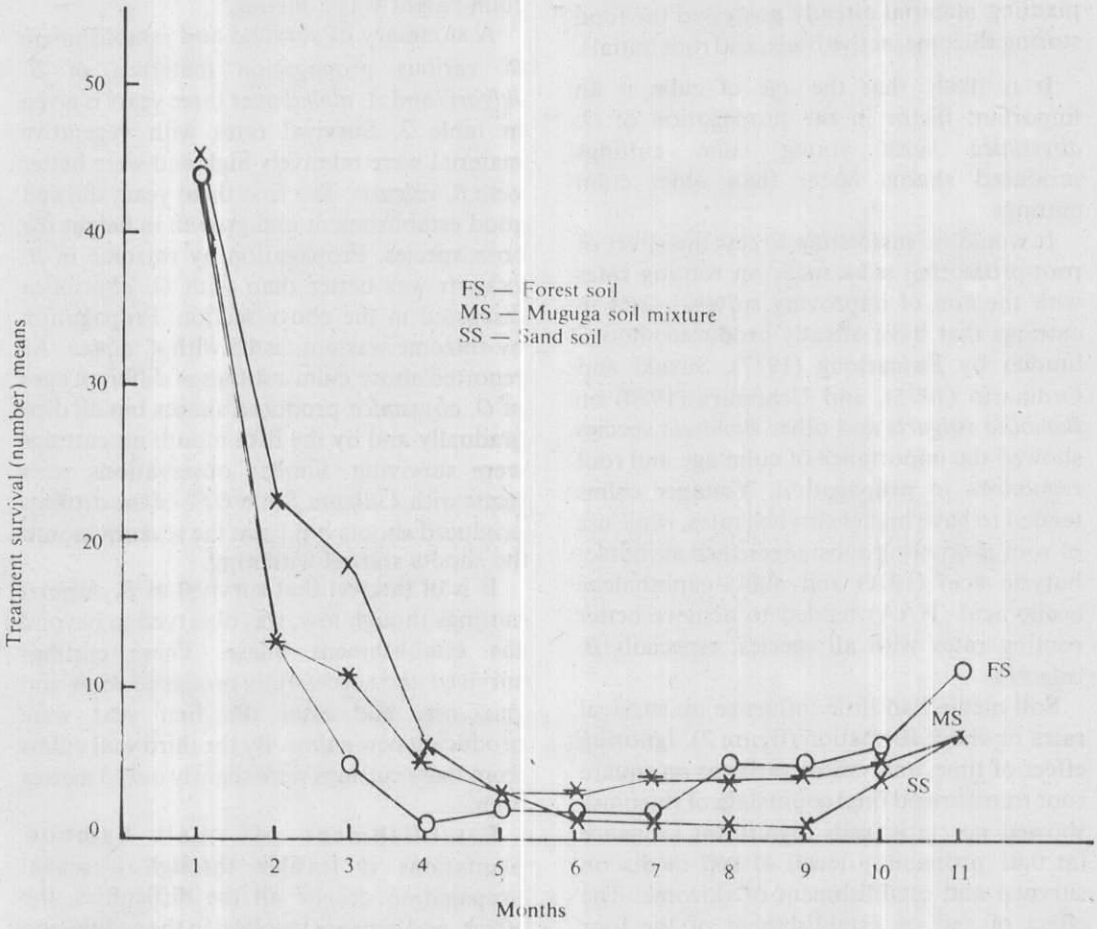


**Figure 2.** Performance of different propagation materials of ***O. abyssinica*** in different soil media over eleven months.

**Table 2. Survival and establishment of *B. vulgaris* and *A. alpina* by vegetative material over three years**

| Propagation material | Age (years) | *Bambusa vulgaris* | | *Arundinaria alpina* | |
|---|---|---|---|---|---|
| | | Survival % | height (m) | Survival % | height (m) |
| Rooted culms (off-sets) | 1 | 88.6 | 2.6 | 60.5 | 3.6 |
| | 2 | 81.3 | 3.4 | 60.5 | 4.6 |
| | 3 | 81.3 | 4.9 | 60.5 | 4.9 |
| Rhizomes | 1 | 85.4 | 2.4 | — | — |
| | 2 | 75.0 | 3.0 | — | — |
| | 3 | 75.0 | 4.5 | — | — |
| Unrooted culms | 1 | 18.3 | 0.3 | 60.0* | 0.3 |
| | 2 | 14.0 | 2.4 | 0 | — |
| | 3 | 14.0 | 3.4 | 0 | — |

* Survival for the first half of the year.

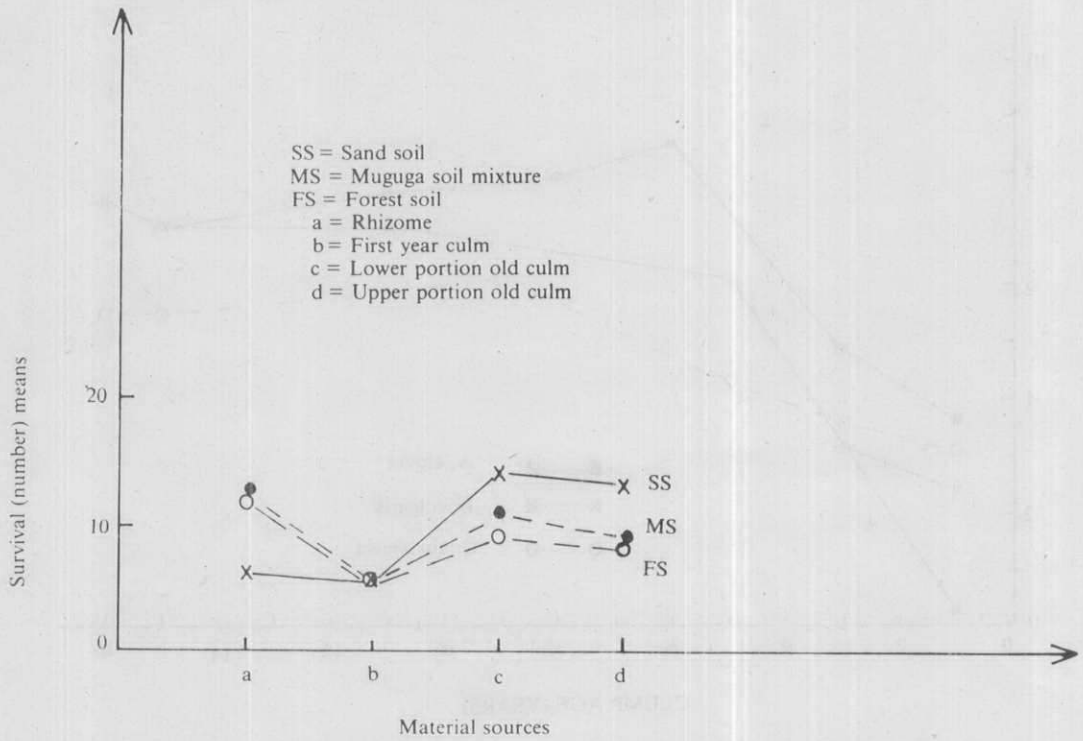


**Figure 3.** Effect of soil media on survival of different propagation material sources of *O. abyssinica*.

vigorous than the other two bamboos. Unrooted and rooted cuttings were used as the planting materials. Once the few surviving unrooted cuttings got established they caught up with the rooted plants. In tropical Asia, *B. vulgaris* grows naturally into a huge bamboo to a top height of over 15 metres and culm diameter at breast height of between 10 cm and 13 cm. At Muguga the maximum height obtained was 7.5 metres and the diameters were small. Although it was less vigorous in growth, the species showed an encouraging potential in terms of propagation, establishment, crop uniformity, and disease freedom The observed slow growth indicates that Muguga is too high, cold, and dry for the species.

*O. abyssinica,* an East African bamboo species but exotic to Kenya (Dale and Greenway 1961; Kigomo 1985), grew to a moderate size and reached a maximum culm height of 6.8 metres. As with *B. vulgaris,* the crop was continuously vigorous and healthy throughout the period of observation. The species was dense, productive, and yield observations indicated that depending on rainfall, an annual dry-weight culm production range of 14-28 tons per hectare may be expected from age six (Kigomo 1985).

## CONCLUSIONS

*A. alpina* can be cultivated successfully at slightly lower altitudes and drier conditions as at Muguga though its growth rate and vigour is slightly lower than in its natural environment. The introduction and growth of *B. vulgaris* and *O. abyssinica* on similar sites is a possibility. These two species are potentially capable of growing in even lower altitudes than Muguga and in the case of *O. abyssinica,* even under drier conditions.

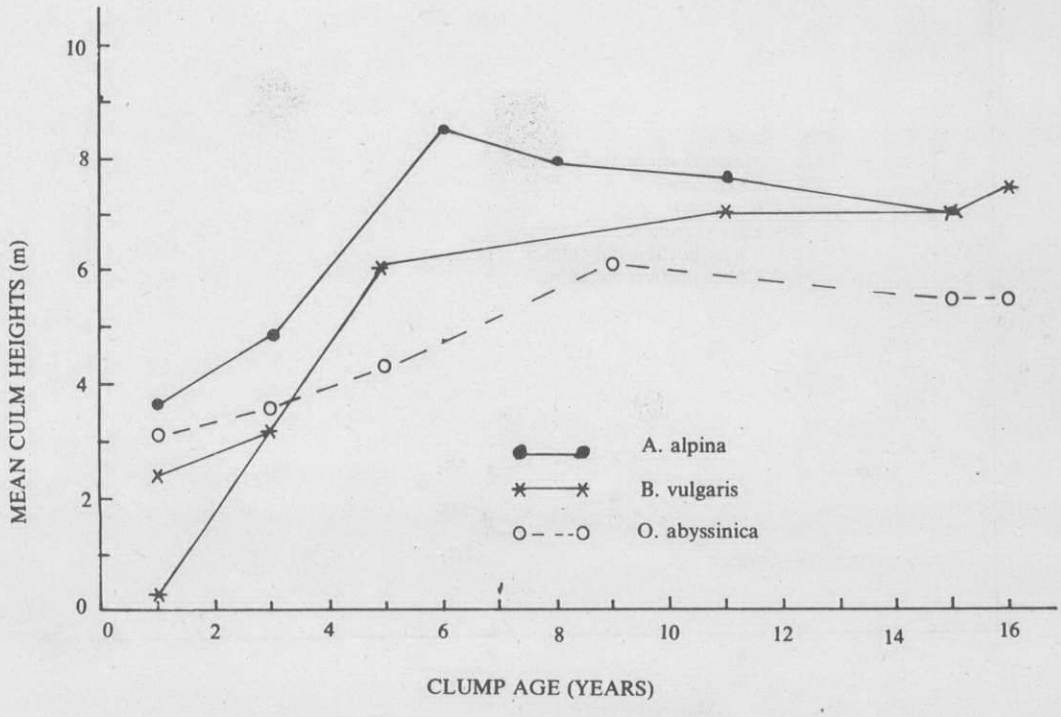


**Figure 4.** Comparative growth in height of *A. alpina, B. vulgaris,* and *O. abyssinica* with time

Propagation and establishment of the three species can best be approached through use of offsets or rooted cuttings. Rhizomes may be used but survival rates were lower than with the off-set method. With further testing, it may be possible to propagate *B. vulgaris* through unrooted cuttings. This method could be cheaper though use of root-promoting substances may be necessary. Due to the difficulty of obtaining offset materials, only small annual planting programmes may be possible. Raising of bamboo crops through seed would be more successful but more time consuming. Where seeds are available, raising of seedlings in nursery beds or by direct sowing in polyethylene containers should be made.

Investigations into better methods of obtaining planting materials from mother bamboo clumps and methods of sowing and raising seedlings in the nursery should be undertaken. Methods of improving survival rates through use of different material sources and establishment techniques should also be given attention. Success would improve the availability of bamboo for domestic and handicraft uses and also improve cultivars and techniques for use in the reafforestation of watershed and degraded areas.

**ACKNOWLEDGEMENT**

This paper is published with the permission of the Director, Kenya Forestry Research Institute (KEFRI).

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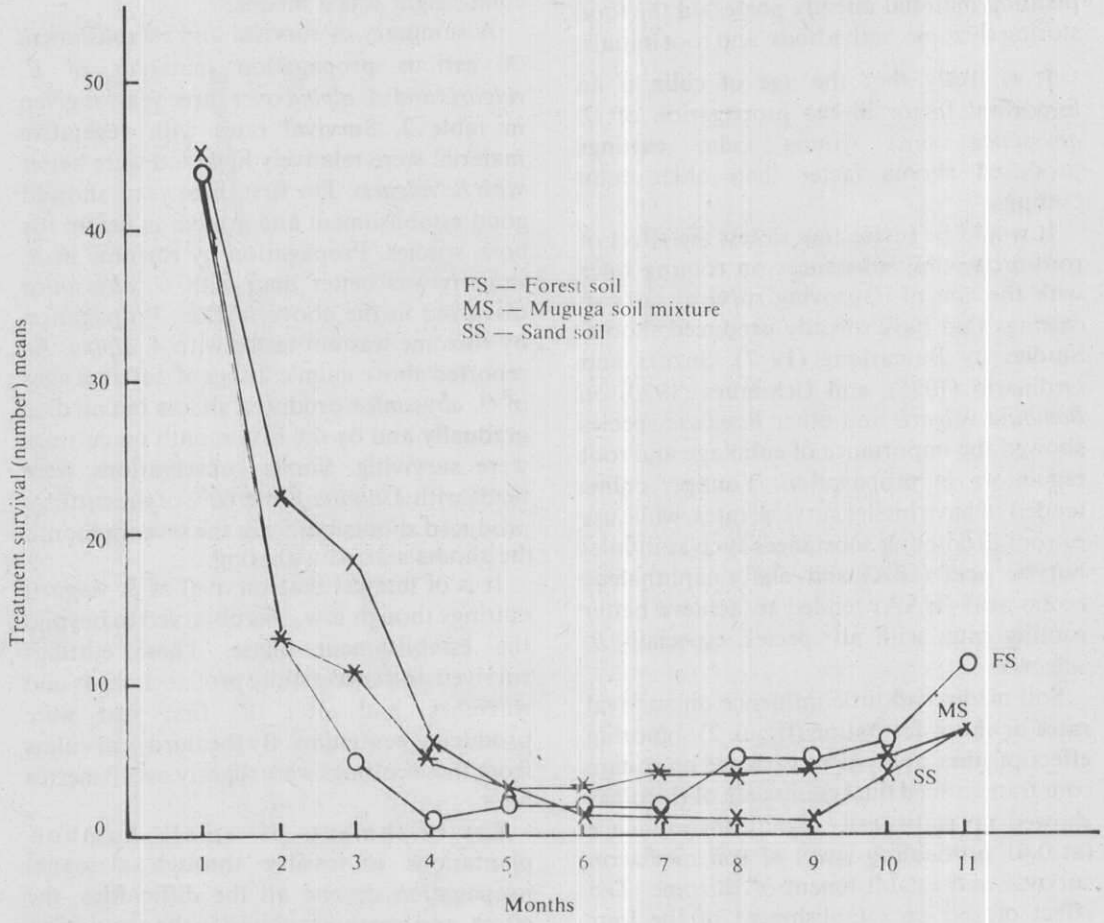


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## RESULTS AND DISCUSSION

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