Plantation Trial in Semi-Arid Land —An Example in Kenya—

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Abstract

In eastern Kenya, there is a vast area of semi-arid land covered with poor vegetation, the floral composition of which differs depending on the region or location within a region. This vegetation has been markedly degraded due to various factors. Since 1986 trials have been conducted to improve such a degraded vegetation. The methods employed are as follows: species screening, nursery practices especially for raising drought-resistant seedlings, stump planting, vegetative propagation, water harvesting, site preparation, etc. The following six species were deemed to be promising: *Acacia polyacantha, Cassia siamea, C. spectabilis, Croton megalocarpus, Prosopis juliflora*, and *Tamarindus indica*. Although a lower supply of water is considered to be important for hardening seedlings, it is difficult to decrease the amount practically. Stump planting can be applied at least to *Cassia siamea, C. spectabilis*, and *Croton megalocarpus*. *Melia volkensii* can be propagated by induced root suckers. Water harvesting attempts remain to be evaluated. This measure is labor-intensive and may not necessarily be effective. Except for *Croton megalocarpus*, sound growth of seedlings planted in the belts cleared cannot be confirmed unless the cleared belts are wide enough or the seedlings are released from shading by reserved belts along the cleared belts.

Introduction

The percentage of forest cover in Kenya which amounts to 3.1%, according to the statistics for 1988, has remained relatively constant for more than a decade. The forest cover here refers to the so-called gazetted forest, and actually the area covered with forest lands, more exactly woodlands, is much larger. It is generally recognized that such woodlands have been degraded in various ways for nearly a century, due mainly to the increasing demand for fuelwood. Recent statistics have indicated that fuelwood accounts for nearly 95% of the annual wood demand and in rural areas 100%of the energy required is supplied by fuelwood. Consequently, most of the woodlands show a very limited floristic composition from the viewpoint of wood utilization. To meet the estimated future demand, the Kenyan government has adopted various measures since several years, including the planting of useful trees and enrichment of the floristic composition of woodlands, for which a production target of 200 million seedlings annually was fixed. To achieve this objective, a larger number of nurseries and staff and better techniques and facilities were required. Thus the cooperation from Japan was requested and in the late 1985s, a project entitled: "Nursery Training and Technical Development Project for Social Forestry in Kenya" was initiated with the cooperation between the Japan International Cooperation Agency (hereinafter referred to as JICA) and Kenya Forestry Research Institute (hereinafter referred to as KEFRI) (Hayashi, 1986a, b). This project was renamed as "Social Forestry Training Project" soon after the start and a "pilot forest scheme" was planned in the project. The primary objective of the scheme was to establish a kind of model plantation to demonstrate to the rural people how woodlands could be enriched by planting useful trees and to let them plant useful trees around their homes and shambas.

This article aims at introducing the activities related to plantation establishment since 1986 when the

Presented at the International Symposium on "the Rehabilitation of Degraded Forest Lands in the Tropics": Technical Approach, Tsukuba, Ibaraki, Japan, 17 September 1992, held by Tropical Agriculture Research Center (TARC)

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project was actually initiated.

Description of the site

1 Location

The project site is located at Kwa-Vonza, Kitui District, Eastern Province of Kenya (about 1° S and 38° E) and its elevation is about 1,000m asl. The site is located at about 160km east of Nairobi and 20km west of Kitui town.

2 Climate

According to the Agroclimatic Zone Map of Kenya (Teel, 1985), the site belongs to zones V and 2, where V : —average annual rainfall (r) : 450–900mm ; average annual potential evaporation (E°) : 1,650–2,300mm ; r/E° (%) : 25–40 ; classification : semi-arid ; and typical vegetation : bushland ; and 2 : —mean annual temperature (°C) : 22–24 ; classification : warm ; night frost : none ; altitude : 900–1,200m ; and general description : midlands. Climatic data are shown in Table 1 and Fig. 1. As seen cleary in the figure, the peak of monthly rainfall usually occurs from March to April and from late October to December, but rainfall is very variable even in the rainy season.

Table 1 Climatic data at Tiva Nursery, Kitui : average for 1988 ~ 1991

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
P (mm)	60	22	109	201	39	1	2	2	11	78	267	145	932
RD	4	2	8	14	5	1	1	1	2	5	17	14	74
T (°C)	23.1	24.0	24.4	23.9	23.4	21.5	20.9	21.0	22.8	23.7	23.3	23.1	22.9

Note : P : precipitation in mm ; RD : rainy days ; T : temperature in °C.

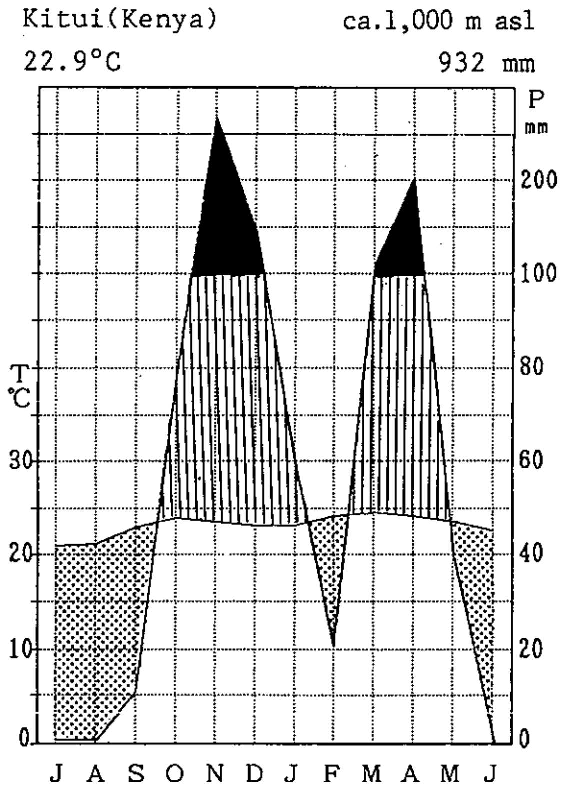

Fig. 1 Climatic diagram at Tiva Nursery, Kitui.

3 Vegetation around the site

Natural vegetation in Kenya is classified roughly into seven categories (Ojiambo, 1978). The vegetation around the site may be included into "bushland and thicket" according to its physiognomy, but at present stands dominated by *Commiphora* species can be seen around the site where plantations have been established, although the floristic composition varies with the location. According to Hayashi (1991), in fact, the density in the number of *Commiphora* spp. was 32% and 40% in tree layer.

4 Topography and soils

The site is located on rolling hills and generally the slope is gentle. Soils in the site are classified into Acrisols (light red soils), Luvisols (dark red soils), and Vertisols (black cotton soils). In some parts of the area, the former two soils which contain laterite (murram) may be referred to as plinthic Acrisols and plinthic Luvisols (Matsui, 1987).

Plantation trials

1 Species screening

Since November 1986, nearly fifty species in total have been planted for screening as indicated in Table 2. Twenty-three are indigenous species and twenty-seven are exotic ones. Eleven species in *Acacia* and four species in *Eucalyptus* were introduced from Australia through the courtesy of KEFRI Seed Centre and CSIRO Seed Bank, but only the species listed below were outplanted. Screening is still underway, but the survival and performance of the trees provide a tentative assessment for those species. In the meantime, the following seven species were considered to be promising: *Acacia gerrardii, A. polyacantha, Cassia siamea, C. spectabilis, Croton megalocarpus, Prosopis juliflora,* and *Tamarindus indica*. At the beginning, however, their survival and/or performance may have been affected by inexperienced practices or only inferior varieties/strains may have been used for some species. Therefore, screening should be carefully repeated before excluding these species which have not been promising so far.

2 Nursery practices

When the project was initiated, a suitable manual for nursery practices was already available in Kenya (Abell and Armstrong, 198?), but it appeared that the manual had been prepared mainly with reference to the practices for highlands. For plantation establishment in arid and semi-arid lands, the production of seedlings which can become established under severe drought conditions requires careful studies. It was considered that hardening processes would be most important although actual practices had not been identified yet.

1) Irrigation (Watering)

In most manuals including the above-mentioned, it is recommended to decrease the amount of water supplied and also to decrease the frequency of watering, but actually few definite figures have been given yet. At the Tiva nursery of the site, 30l of water a day was supplied to 1,000 pots after some experiments, twice a day for the earlier stage and later once a day. These guidelines may have not been necessarily followed and over-watering was often observed. Therefore, since some of the seedlings may not have been subjected to sufficient hardening, field survival was low.

2) Stump planting

Either in large-scale planting or in community planting, the use of potted seedlings is inconvenient for transportation and handling. Stump seedlings have been used operationally for teak, gmelina, and some other trees (Evans, 1992). In this project, since it was anticipated that stump planting should be applied to as many species as possible, ten species were tested at the experimental level and three species at the semioperational level. The three species were *Cassia siamea, C. spectabilis,* and *Croton megalocarpus* and the ten included *A. gerrardii, A. polyacantha, Acrocarpus fraxinifolius, Eucalyptus camaldulensis, Leucaena leucocephala, Prosopis juliflora,* and *Tamarindus indica* besides the three. So far, the results have been favorable and in the case of *Croton megalocarpus* for the first time stump planting had been applied to this species.

Table 2 Species planted since 1986

Species	⟨1986⟩	⟨1987⟩	⟨1988⟩	⟨1989⟩	⟨1990⟩	⟨1991⟩
⟨Indigenous species⟩						
Acacia abyssinica		0	0	0	0	0
A. albida			0		0	
A. gerrardii		0	0	0	0	0
A. nilotica		0	0	0	0	0
A. polyacantha			0	0	0	0
A. senegal		0	0			
A. tortilis	0	0	0	0	0	
A. xanthophloea			0	0	0	
Albizia amara				0		
A. anthelmintica				0		0
Balanites aegyptiaca		0	0		0	
Bauhinia thonningii		0			0	
Croton megalocarpus		0	0	0	0	0
Dalbergia melanoxylon			0	0		
Melia volkensii		0		0		
Moringa stenopetala			0			
Newtonia hildebrandtii			0		0	
Sesbania sesban		0	0			
Tamarindus indica	0			0	0	0
Terminalia brownii				0	0	
T. mentalis			0		0	0
T. prunioides			0		0	
T. spinosa			0		0	
⟨Exotic species⟩						
Acacia auriculiformis			0			
A. harpophylla				0	0	
*A. holoicilica**			0	0	0	
A. pendula				0		
A. salicina				0		
A. plectocarpa				0		
A. stenophylla				0		
Acrocarpus fraxinifolius				0	0	
Azadirachta indica	0	0	0		0	0
Caesalpinia decapetala					0	
Callitris robusta		0				
Cassia siamea	0	0	0	0	0	0
C. spectabilis	0	0	0	0	0	0
Casuarina equisetifolia	0		0	0	0	
Delonix regia			0			
Eucalyptus camaldulensis		0	0	0	0	0
E. citriodora		0				
E. paniculata		0	0	0	0	
E. tereticornis		0		0	0	
Gmelina arborea			0		0	
Grevillea robusta	0	0	0	0	0	0
Leucaena leucocephala		0	0	0	0	
Melia azedarach		0	0	0	0	
Parkinsonia aculeata		0	0	0	0	0
Prosopis juliflora	0	0	0	0	0	0
Schinus molle		0	0			
Terminalia catappa				0		

*This species may be *A. holosericea*.

3) Vegetative propagation

Melia volkensii is one of the most valuable trees for the drylands of eastern Kenya. However, the seeds of this species do not germinate well. For this species, "root-piece planting", which is a common method of propagation of *Paulownia* spp., was examined, together with *Terminalia brownii* and *Gmelina arborea*. The results appear to be favorable. According to Teel (1985), *Melia volkensii* can be propagated by root suckers, which may account for the successful outcome of root-piece planting, at least in this species. *T. brownii* seeds also do not germinate well (Specht and Schaefer, 1990).

3 Site preparation

In Kenya the guidelines required that all of the existing vegetation should not be cleared for site preparation, that most of the advance growth (trees larger than 5cm in diameter) of the upper layer should remain intact and that only the grass layer, including shrubs, should be cleared. In 1986, these guidelines were followed and the grass layer was completely cleared. As the complete clearance was costly, however, strip preparation was adopted instead from 1987 onward. In either case, the trees left often shaded the seedlings planted unless appropriate tending was performed during the rainy seasons. In strip preparation, furthermore, the vegetation left between the cleared belts also shaded the seedlings planted. As most of the species used for planting were light-demanding, their survival or subsequent performance was affected by shading. The system was improved so as to widen the cleared belts, from 1m in 1988, 2m in 1989, to 4m in 1990, and eventually the site was cleared to reach a certain size of patch-like opening, at least partially, in 1990 and 1991. Of the species used, *Croton megalocarpus* was different from the others and its seedlings were comparatively shade-tolerant. In fact, there was a negative correlation between the height increment and relative light intensity (Takahashi *et al.*, 1992) although a larger quantity of light will be required for their subsequent growth soon. In some parts of this project site, even cleared belts 4m in width do not seem to receive enough light except for *Croton megalocarpus*, although the width must be changed by the kind and height of the vegetation left between them.

4 Outplanting

For outplanting, the size of the planting holes and "water-harvesting" devices must be carefully examined.

1) Size of planting holes

Values of 45cm in diameter x 45cm in depth had been adopted for the first three years (1986 to 1988). In 1988, however, an experiment was carried out using three sized (25cm, 45cm, and 65cm for all three dimensions) of planting holes. It was shown that the survival and early performance were higher when the size of the holes increased. Therefore, the hole size for operational planting was increased to 65cm for the three dimensions from 1989 onward. However, in another experiment conducted to examine the influence of nursery practices on the growth of outplanted seedlings, the seedlings showed a remarkable growth even when the size of the holes was 45cm for the three dimensions. In this experiment, the site was almost cleared by bulldozer prior to outplanting. In other words, with a few species such as *Acacia polyacantha, Cassia siamea*, and *C. spectabilis* complete ground preparation promoted the survival and early growth of the seedlings planted into holes 45cm in size. Therefore, further studies are required to determine whether larger holes are really necessary for outplanting under the soil conditions of this site. In this connection, the author measured the soil hardness in the transitional period from the dry season to the rainy season (early November). Just before the rains, the value of soil hardness exceeded 30mm by Yamanaka's tester (ca. 38kg/cm^2), while immediately after the first rain the value decreased to about 20mm (ca. 6kg/cm^2) or less, when the soil had been well infiltrated. Based on a simple experiment on the relationship between root growth and soil hardness (Asakawa and Nonaka, 1992), it was apparent that even the root growth of *Acacia* seedlings was markedly retarded when the soil hardness reached a value of 30mm, while it was not appreciably affected when the soil hardness was 20mm. In this regard, it may be worth noting that the daily root growth of some *Acacia* species was about 40mm in root-box (Asakawa and Harayama, 1990) and *Prosopis juliflora* seedlings developed their roots down to a depth of 125cm during 56 days under the actual conditions of the site (Kireger *et al.*, 1989), although the soil hardness had not been measured. These findings suggest that these seedlings are able to develop their roots down to the depth where they can get enough moisture to survive, before the soil becomes hardened. Therefore such large holes as 65cm may not necessarily be required if appropriate planting time is selected, although it is obvious that a larger size is preferable for early root development.

2) Water-harvesting devices

In the so-called semi-arid lands, in addition to the deficit in rainfall, roughly 500 to 1,000mm annually, the distribution is also very variable from year to year. Therefore, rainwater should be used as efficiently as possible. From this viewpoint, a few devices for water-harvesting were compared, including horizontal ditches (along the contour) with some intervals, modified Turkana system, and microcatchments. It does not appear that labor-intensive water-harvesting devices exert a significant effect on the survival and early performance of planted seedlings, presumably due to the low water-holding capacity of the soil around the site. In any case, hydrological studies are required to evaluate the effect of water-harvesting devices.

3) Time of planting

As seen in Table 1 and Fig. 1, there are two peaks in monthly rainfall – in April and November, the latter corresponding to a higher level of precipitation than the former. Usually, therefore, planting is performed in early November. Planting practices are as follows. Preparation of planting holes starts from the site where the ground clearance ends, soon after the first rainy season, and must be completed by the end of the dry season (mid-October). After a sufficient amount of rainwater is available and the soil is well infiltrated, a part (the upper side of the slope) of the surface soil around of the hole is filled back to the hole. The time of refilling may be determined by measuring the soil hardness in this area, because there is an appreciable decrease of soil hardness after infiltration of rainwater (Asakawa and Nonaka, 1992).

5 Extension activities for model farmers

From the viewpoint of social forestry, extension activities have been emphasized for both technical and social aspects. Prior to plantation establishment, the local conditions were surveyed at different levels of rural societies by interviews. Based on the results of these surveys, plans were made for the activities. Extension activities are also useful in mobilizing the rural people for establishing community plantations. In fact, the project consists of two aspects: individual planting around homes including shambas and group planting in communal land. The former is being practised by selected model farmers, and the latter by a group of farmers from a certain location. So far the planting by most of the model farmers appears to be successful, unlike some of the group plantations, partly due to limited participation in the latter.

Acknowledgements

The author has been involved in the project since 1987 and visited the site every year as a short-term expert. He thanks the JICA authorities and long-term experts, especially Mr. K. Watanabe and Mr. H. Okabe, the first and second chief advisors, for allowing him to present the paper. He also noted that the achievement is due to both Japanese experts and Kenyan counterparts.

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Note. No year is indicated in the references 1) and 11).