Chapter 6.2
The Mandena Tree Nursery, an Example of Plant Production Adapted for Site Rehabilitation after Mining

Christian Rarivoson and Roger Mara

Abstract

The Mandena nursery was established to produce plants for the QMM reforestation program, which commenced in 2002 at the rate of 100 ha of trees being planted per year, as well as for post-mining reforestation. This chapter presents the technical steps used to produce the plants, and gives useful information on some key considerations in developing a successful nursery under the conditions present in southeastern Madagascar.

Résumé

La pépinière de Mandena, un exemple pour la production de plantes adaptés à la réhabilitation après exploitation minière. La pépinière de Mandena a été établie afin de produire des plants pour les activités du programme de reforestation sur lequel QMM s'est engagé avant le démarrage de l'exploitation minière (100 ha/an) mais aussi pour celles de la réhabilitation du site après exploitation minière. Ce chapitre présente les étapes techniques suivies pour produire les plants et fournit des informations pertinentes sur les aspects importants à considérer dans l'élaboration d'une pépinière réussie dans le sud-est de Madagascar. Il peut être utilisé à titre d'outil par les prochains gestionnaires des pépinières de Madagascar.

Introduction

In the context of the post-mining rehabilitation program, there is the component of restoration of natural ecosystems (see Vincelette *et al.* Chapter 6.5), as well as the plantation of fast growing tree species. In 2002, prior to the commencement of mineral exploitation scheduled for 2009, QIT Madagascar Minerals (QMM) began planting trees outside the mining sites at a rate of 100 ha of new trees per year. Herein, we describe the techniques employed for obtaining quality, fast-growing, exotic tree species, and some associated methodological decisions.

Defining goals

Deciding the style of plantations

Determining the number of trees to produce was the first decision in the process. Of paramount importance is meeting household energy needs with fast-growing trees; this is part of the "Schéma de Développement Régional de la région de l'Anosy," or Anosy regional strategy (CRD 2003). This aspect does not consider other products and services provided by the trees, such as soil and water protection. A recent study (SEDRA 2006) indicates that existing sources of wood for domestic use in the region come mostly from native forests and a few, economically viable *Eucalyptus* plantations. It is certain that domestic energy demand will increase with new demographic pressures and economic development (SEDRA 2006).

There are two technical options when setting up a plantation. The first is to plant trees with low spacing and more trees/ha, which favours the number of plants over quality and wood value. The purpose of such sites is to maximize wood energy plantation and planting costs may be high. The other option, with more widely spaced trees and lower planting costs, favours taller growth and wood with a higher market value. The current technique used in the QMM plantations is the second with 1,100 trees per hectare (spaced 3 x 3 m apart) and approximately 110,000 trees each year for the reforestation of 100 ha. This option would meet both wood energy and saw timber needs (the latter aspect is not yet very important given the low industrialization of the Anosy Region). Nevertheless, the establishment of the new port, and a range of other local building projects will need timber supplies. The Anosy regional strategy mentions the need to develop a saw timber industry in order to meet local needs.

QIT Madagascar Minerals, BP 225, Tolagnaro 614, Madagascar. Email: christian.rarivoson@riotinto.com

Producing the required plants

Given the relatively high number of plants needing to be produced, and after assessing the risks and benefits it was decided to produce the seedlings under controlled conditions. The benefits of this option include suitable production costs, control over the quality of the plants, and the means to quickly adapt to changing strategies. Having a local, professional staff is also an important asset. Numerous plantation failures have been a direct result of nursery seedling production problems (standards, deadlines not met, etc.).

Type of nurseries

Two nursery types have been considered: a nursery system made up of several small nurseries; or a single, large, permanent, centralized nursery. In the case of the former, there are low investment and construction costs, and the nurseries can generally be placed close to the plantation sites. The larger and more permanent nurseries provide greater control of seedling quality and production schedules. The second type of nursery was chosen for several reasons: the anticipated operating time of the nursery is the same as the planned period of mineral exploitation (about 20 years), and the total seedling production can be used by the reforestation project; there is greater guarantee of quantity, quality, and production timing; and unit production costs are smaller and more easily calculable.

Nursery location

The Mandena area was chosen for the nursery site, inside the conservation zone and where an open area was available within 200 m of the Ianandrano River, Close to the main road, natural protection from the wind with the forest around, and the proximity of a permanent water source, made this site an appropriate place for a central nursery. It covers a surface area of 1,350 m^2.

Choice of system

After an assessment of the nursery systems currently in use in the country (plant beds on the ground or on wood supports, or plants in plastic bags) and those used overseas, a system was chosen which requires greater initial financial investment, but which has notable advantages with respect to production and ergonomics, including safety. The following techniques were chosen to produce approximately 110,000 seedlings per year on a site with a restricted surface area: 1) Galvanized metal screen tables on concrete-filled, PVC poles. Each table measures 12 x 1.50 m and is 1 m off the ground; 2) Stiff, reusable PVC trays with cells for seedlings and growing media. Each tray has 45 cells of 110 cm^3 and measuring 350 x 220 x 120 mm. The cell diameter is 40 mm; 3) Water pumping consists of the use of rotating sprinklers or nozzles above the tables. The specifications of the Mandena nursery include 28 tables, each with 120 trays. Thus, with 45 plants per tray, the nursery can produce 150,000 plants per growing season.

The watering system is a network of pipes of varying diameters and a regulating valve system. It includes three, 2,000 liter water tanks, one gas-motor pump for pumping river water and capable of delivering 930 l/minute (power of 1.5 kW), and an electric pump or supercharger to regulate delivery pressure when watering. A filter system reduces the risk of obstruction by particle matter from the river source. A 40 kW diesel generator provides electrical power.

Plant production

Seedling supply

Special care has been given to finding reliable sources of seeds. The criteria include a high assured percentage of seed germination, genetically heterogeneous seed trees, guaranteed supplies, high phyto-sanitary standards, and varied commercial sources for each species.

In the final assessment, there is little difference in cost between seeds of the same species from different suppliers (Table 1). Further, for numerous technical reasons, it is important to obtain seeds for new plantations from commercial sources, rather than random collection in established plantations (see Rarivoson and Mara Chapter 6.3).

The Australian Tree Seed Center of the Commonwealth Scientific and Industrial Research Organization (CSIRO) was chosen as the seed source based on several factors. Soil and climate conditions in certain parts of Australia are very similar to those in the Tolagnaro region, and Australia has a vast range of source areas for the fast-growing species chosen. Moreover, the center can provide complete information on seed trees and seed treatment, and a database is accessible on the web for information on each species (www.ffp.csiro.au).

Seed treatment

For *Acacia mangium* and *A. crassicarpa*, treating the seeds is needed to increase the germination rate. The technique used was soaking the seeds for 24 hours in 100°C water. The seeds of the other species chosen do not require any special treatment before being sown (dormancy release or scarification). The only other special treatment was protecting seeds against humidity by storing them in sealed, airtight packages and keeping them at cool temperatures. Failure to take these precautions leads to significant reductions in seed germination rates and a reduced life span (Schmidt 2000).

Choice of substrate or growing medium

The choice of an appropriate growing medium was not immediately available on Madagascar based on published references. Most nurseries on the island have their own "recipe," and it was necessary to experiment with different growing mediums. Nine different growing mediums were tested. Trays were filled with these media in an attempt to provide homogeneous soil compaction in all tray cells, and several different parameters were noted. The drainage speed was measured based on the water remaining on the surface of the media (high drainage = quick disappearance of surface water, low drainage = long-lasting appearance of a surface water layer, and average drainage = appearance of a surface water layer that progressively disappears). The presence of ants or other insects on the growing media, which is a sign of poorly decomposed organic matter and presents potential risks for the plants, was also noted. The cohesion of culture media was estimated by extracting soil core samples from the trays, and testing the texture using simple finger pressure.

Treatment of the growing mediums

In order to prevent parasite and nematode attacks, the seedling medium was pasteurized using 30 to 45 minutes of pressurized steam (70°C) from an electri-

Table 1. Tree seed costs in plantation establishment (Midgley 1989).

Species	Approx. cost/kg ($US)	Average number of seeds/kg	Approx. number of plantable seedlings	kg/ha (at 3 x 3 m)	Approx. cost/ha ($US)	% of total establishment costs **
*Eucalyptus camaldulensis**	150	670,000	167,500	168	0.89	0.1
Eucalyptus grandis	150	652,000	163,000	163	0.92	0.1
Eucalyptus globulus	300	73,500	18,375	18	16.30	2.2
Eucalyptus unnii	600	237,000	59,250	59	7.59	1.0
Eucalyptus nitens	800	264,000	66,000	66	9.09	1.2
*Acacia mangium**	600	70,000	23,333	23	13.05	1.7
*Acacia auriculiformis**	450	50,000	16,667	17	27	3.6

*Species chosen by QMM.

**For a plantation estimated at $750/ha

Table 2. Results of soil mediums tested at the Mandena nursery, and their characteristics.

Type of medium	pH	Drainage		Availability		Cohesion		Presence of ants	Plant growth and health		Comments
		Average	Low	High	Low	High	Low		Good	Poor	
50% black wetland earth and 50% brown ferralitic soil	N/A	+			+	+				+	Tends to become compact once dry
50% black wetland earth and 50% sisal waste	≥ 7	+		+			+	+			
50% black wetland earth and 50% saw dust	N/A	+			+		+			+	
50% black wetland earth and 50% soil beneath Casuarina plantation	N/A	+			+	+					

Table 2. continued

Drainage Availability Type of medium	Cohesion	pH	Presence		Plant growth				of ants	and health		Comments
			Average	Low	High	Low	High	Low		Good	Poor	
75% (wetland soil + humus) and 25% sisal waste	7			+		+			+			
50% (wetland soil + humus) and 50%. (decomposed zebu manure + sisal waste)	8			+		+			+			
75% (wetland soil + humus) and 25% decomposed zebu manure	7			+	+		+			+		
60% zebu manure and 40% river sand	≥ 7		+		+					+		

cally operated steam generator. It is recommended not to exceed 70°C in order to avoid destroying the useful microfauna (bacteria) found in the growing medium, which would make it biologically sterile (Brown 1986). Before being processed, the growth medium is first sprayed with water to increase the effectiveness of the steam. This method is efficient, requiring only one person, and can treat 800 l of medium per day.

Potting

Following pasteurization, the trays are filled manually and the growth medium is consistently compacted. Using this method, one person can fill an average of 30 trays per day.

Seeding

Tests indicate that the best period for planting seeds in the Tolagnaro region is at the end of the cool season, from September to October. The growth medium in the trays is moistened prior to seeding. Three to four seeds are sown per cell at a depth of approximately 3 mm in a hole that was dug with a small wooden rod. The seeds lightly covered with earth and the seeded trays are then placed on the screen tables.

Thinning plants

For most of the species used, germination takes place within two weeks of seeding. At about one month after seeding, when the plants have a second pair of leaves, plants are removed so that there is only one plant in each cell. Removed seedlings are replanted in empty cells or in new trays. There is an additional nursery cost for this operation and the decision to undertake it should be based on an analysis of the costs and anticipated benefits.

Plant maintenance and protection

Watering

The seeded trays are covered with a light mulch of *Imperata cylindrica* straw to protect the sown seeds from the shock of rain or watering. Once all the seeds had sprouted, the mulch was removed. The plants were watered twice per day, once in the early morning and again in the late afternoon, for a variable period based on meteorological conditions, growing medium moisture, and plant height. It is important that the growing medium remains moist, particularly in the first days following germination. The duration of waterings was shortened as the plants grew; however, the frequency was increased to three or four times per day during the hot season.

Shade

All tables were covered with a shade house-type plastic net designed to block 50% of sunlight for several months starting at the seeding stage. It was removed when the plants could bear full sunlight.

Fertilization and mycorrhiza

NPK 3-6-3 and 2-3-2 fertilizer was applied manually to each plant in the form of pellets based on previously tested dosages. Fertilizer was applied when the first leaves appeared, and again one month thereafter. For better soil nutrient uptake by the seedlings, mycorrhizal (ectomycorrhizal) fungus, found in the

native forest and in a variety of plantation settings, was used. This fungus, *Pisolithus tinctorus*, is harvested, reduced to a powder, and then diluted in water. Each seedling is lightly watered once with the solution shortly after seed germination.

Protection against insects and fungi

The best protection against insect and fungi problems is to seed during the cool season, and then to properly monitor watering. With the advancement of the warm and humid season, the risk of attack by these organisms increases.

Weed control

This was done by hand, without herbicides. The frequency depends on the appearance of the weeds and was associated with the watering regimen.

Retention period for plants at the nursery

The maximum period the plants are retained at the nursery is 6-7 months, and not beyond a height of 60-70 cm.

Discussion

Based on the experiments presented herein and the associated results, the growing medium chosen was composed of 60% zebu manure and 40% washed river sand. The mixture is formed after sieving and removal of all debris. This type of soil performed the best with the delineated parameters. Further, in a region such as Tolagnaro where the transport of goods is difficult and expensive, it was important for all of the components in the chosen media to be available locally.

The proper installation of a tree nursery is an important investment. Several different workshops on reforestation have been held in the Anosy Region, often with rather intense discussion, and it is clear that such projects have lacked any sense of environmental or socio-economic obligation. Considering the amount of deforestation that has taken place in the Anosy Region (see Vincelette *et al.* Chapter 2.4), the rate of reforestation is still insufficient. Priorities must be better managed with respect to implementing reforestation, which include aspects of wood energy at the village and town levels, saw timber, industrial supplies, and the complex economics of exploitation and sale. Furthermore, reforestation costs, including nurseries, have been precisely and accurately calculated. The simplest options are often chosen without reference to long-term economics and production. Different types of nurseries must be established to supply quality plants at competitive costs. Adaptation is required in matters of land-use planning and local input supply, which are important links in the production of plants of the quality needed. The advancement of local reforestation will lead to advancements in human community well–being, and will help to preserve the biota in the remaining natural forests of the region.

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