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# SANDALWOOD SEED NURSERY AND PLANTATION TECHNOLOGY

PROCEEDINGS OF  
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## Commentary : Field Visits

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### Introduction

This paper summarises the main points relating to the various field visits undertaken during the Sandalwood Workshop. Comments are included regarding plantations at Ouénarou that could not be visited due to bad weather. Abstracts of three verbal presentations are given at the end.

### Plantations on Bare Ground

Plantations established on several soil types have been unsuccessful. These failures have been mainly due to very poor soil fertility and inefficient designs.

### Soil Characteristics

Experimental sites located on ultramafic soils at both Ouénarou and the Plateau of Ile des Pins, have very low exchangeable cation levels combined with high and sometimes toxic concentrations of metallic ions (Ni, Cr). The very low content of clay minerals prevents the soil from retaining fertiliser nutrients in the absence of organic matter. This is often exacerbated by frequent fires experienced in these areas.

At Païta the seed orchard area is located in a valley where flooding is frequently experienced. The soil is clayey. Frequent flooding has destroyed many seedlings and young plants by mechanical action and, when the flooding has been of long duration, by asphyxia. On steep slopes in dry areas fertility tends to be low but losses have also occurred with flash flooding in the rainy season. An example was seen at St Léon, above Païta.

### Trials on ultramafic soils

In the trials on ultramafic soils at Ouénarou many layouts were tried :

(a). host plant in the same pot. The host provided excessive competition with the sandalwood and had to be destroyed after a few years. Thereafter, lacking a host, the sandalwoods began to die, except for those at the edge of the plantation that were able to find hosts outside the plot.

(b). two rows of sandalwood for one row of *Paraserianthes falcataria*. Here there was only one *Paraserianthes* every 6 m in the row. The distance between the rows was 3 m. The pot hosts were tree species. Once competition with the sandalwood was too severe they were destroyed (age : 5 years) but the sandalwoods were not able to develop properly after this operation. Only a few *Paraserianthes* grew well and the only well grown sandalwood trees are located around them. Fertilisation was done at planting and again at 2.5 years.



(c). alternating sandalwood and *Acacia spirorbis* in the row. The most recent plantations were established in 1988. Sandalwood growth has been very variable but all the plants are alive and are often in healthy condition. Fertilisation was done one year ago and both *A. spirorbis* and sandalwood responded well to it.

(d). old plantation with several hosts : host plant trial. This trial was unfortunately badly damaged by flooding during a cyclone. The only plots where sandalwood is growing properly are those with *A. spirorbis* and *Araucaria luxuriens*.

From these several trials, it is possible to draw the following conclusions. Firstly, ultramafic soils are not suitable for sandalwood under usual planting conditions. The only possibility to grow it is with major cultivation including deep cross ripping, ploughing, use of a cover-crop and frequent fertilisation either for the sandalwood or the host plant. Secondly, desirable layouts require that alternating sandalwood and host plants occur in the row and that the host plant is established at least one year before the sandalwood is planted. Finally, the most adapted host plants for these soils are *Acacia spirorbis* and *Casuarina collina*. However, these do not seem to be particularly good hosts in these soils but no more efficient one has been identified so far.

#### Iles des Pins

Plots were established in 1985, 1990 and 1993. The area is located on a foothill in quite a windy area. One plot is very heterogeneous with old *Acacia spirorbis* and sandalwood, ages range from 1 to 8 years. Sandalwood trees growing among the old *A. spirorbis* have a good form and are often healthy but when the shade of the host is too dense, they are not growing well.

In a plot established with the usual layout, of alternating sandalwood and host in the row, both planted in 1990, the sandalwood trees are still small and weak. They are small and badly shaped with many dead end branchlets. The plot was weeded just before the visit. One week after, the sandalwood was more yellowish than before.

Another plot was planted without a host plant in 1994.

Observations in these plots suggest several major problems in these kind of plantations. Firstly, the wind has a strong influence on the growth of sandalwood : when protection is good (tall host plants) sandalwood trees grow quite well. On the other hand, those exposed to the wind due to the small size of the host, present many dead end branchlets which lead to a multi-leader or broom shaped tree. Secondly, too dense shade prevents the sandalwood plants from growing well. Thirdly, in the case of poor *Acacia spirorbis* growth, sandalwood depends a lot on the grasses and weeds for hosting. Consequently, weed destruction has an influence on their growth.

#### Trial on soil developed on sedimentary rocks

A plantation on a dry hill above Païta covers 0.7 ha with 392 sandalwoods. The top of the plantation is steep, close to the ridge of the hill, and a track drains all the water from the top away of the plantation. Consequently dry conditions prevail.

The site is also exposed to the wind. The bottom part is less steep, the soil is deeper.

Ground preparation: due to the slope only planting holes were prepared following destruction of grass and small bushes.

Layout: alternating sandalwood and host plants in each row.

Host plants: there are 2 host plant species in the 1988 plot. These are old *Sesbania grandiflora* many of them nearly dead; and young, small *A. spirorbis* (between 1 and 2 years old).

The first host species, *Sesbania*, lived only 4 to 5 years and then died. *A. spirorbis* was planted later on, in 1993/1994 in order to replace the dead *Sesbania*. Where the *Sesbania* are still living, sandalwood trees are often growing well with dark green foliage. Elsewhere, since the *A. spirorbis* is too young, it is not parasitised and the sandalwood trees are often yellowish. In the 1990 plot adjoining, *A. spirorbis* was planted at the same time as the sandalwood, and both are growing quite well.

The form of the sandalwood trees varies greatly between the top and the bottom of the plantation. The trees towards the top are smaller than the ones at the bottom. Their form is different too. They are often broom shaped instead of having a single leader as do the trees at the bottom of the plantation. Water stress is responsible for this form. It is caused either by soil drought or a combination of high evaporation due to wind exposure and low soil moisture. The extremities of the branches die and, when they start to grow again after rainfall, many axillary or epicormic buds sprout giving rise to this particular shape.

A strong pruning was done recently. It was not sufficient to allow development of a single leader to the trees because they would have lost the major part of their foliage, but it greatly improved their appearance. Such a pruning should be done as soon as possible, when it is still possible to easily shape the tree. Trees that have strong height growth retain their single leader form and natural pruning occurs. No artificial pruning is then required.

It was observed that the youngest plot was severely damaged by deer. The bark of the young plants was removed and many of them died. All damaged sandalwoods were able to coppice from the stumps. The shoots were quite strong and selection of best is possible. *A. spirorbis* was also damaged, but to a lesser extent and its bushy form protects it from such damage.

TABLE 1. Growth of sandalwood at St Léon, Païta (girth taken at 20 cm from the ground).

Planted Year	Plants Number	Mean size		Mean growth		Dead %	Fertiliser 13/13/21	
		Height (m)	Girth (cm)	Height (cm y <sup>-1</sup> )	Girth (cm <sup>-1</sup> )		Times	Quantity
1988	196	2.94	20.4	53.40	3.7	0	5	50 g
1990	45	2.58	15.1	-	-	26	3	50 g
1993	151	1.45	6.3	1.25	5.4	40	2	50 g

The plots were recently completely cleaned, the ground was worked around the trees and fertilisation was done. The reaction of sandalwood to this fertilisation was



obvious. In three weeks time, all the sandalwood trees at the top of the plantation that were yellowish before turned to a pale green. Growth results for this plantation are summarised in Table 1.

From this trial area it may be concluded that *Sesbania grandiflora* was an efficient host since the sandalwood trees growing between the residual live trees were in good condition with bright green foliage. However, *Sesbania* is of too short a life span to be used as a final host plant. It can be used as an intermediate host plant. When the intermediate host plant begins to die, the final one must be well established, preferably of tall stature, providing shade to the sandalwood and being well parasitised. Sandalwood is susceptible to drought conditions particularly on wind exposed areas. Protection against wind is highly recommended, this may be achieved with older host plants forming a windbreak. Natural pruning occurs when trees are growing well but "shape pruning" is necessary in order to control multiple leaders due to climatic constraints. Sandalwood plantations must be protected in those areas where the density of herbivorous animals is high. Strong coppicing ability of sandalwood is an important attribute that can allow rehabilitation of damaged stands. Fertilisation of sandalwood with a complete fertiliser is efficient.

#### **Plantations Under Existing Vegetation (Ile des Pins)**

One plot was visited in Ile des Pins. The soil is a shallow ultramafic soil but has a significant organic matter content. The pre-existing stand is almost pure *A. spirorbis* and *Alphitonia* of height 5 - 6 m. Little herbaceous vegetation grows under it. A comparison between sandalwood trees planted in a dense stand of *A. spirorbis* and those planted in an open area (old garden) was possible at the site visited.

The trees under existing *A. spirorbis* were straighter with a single leader compared to sandalwood trees in the open. The branches were thin, still characteristic of the height growth phase and the leaves were greener. However, height growth was uneven between the sandalwoods and the girth growth was far less than in the open area.

From this demonstration it may be concluded that planting under existing vegetation provides good form to the tree and parasitic links are well established. Light must be particularly well managed. A good balance between shade, wind protection and weed control on the one hand and light on the other hand is essential for the best growth of sandalwood. Devitalisation of existing trees is better than a wide, clear opening. Dead branches will hold up the neighbouring trees, providing better protection against the wind.

#### **Plantations Established in Old Shifting Cultivation (Ile des Pins)**

The site visited was located on coralline limestone. The surface was very rough due to stones. The stand of more than 1 ha had been gradually established by the landowner over the last ten years. The owner had used the slash and burn technique. After destruction of all the native vegetation by bush knife, the branches were left to dry. Just before burning the almost dry vegetation, the owner sows sandalwood fruits everywhere then he lights the fire. The seedlings grow with



vegetables and other root crop for one year, then, when the field is abandoned (fallow) the owner comes back every year in order to weed around the sandalwood.

Just before the workshop, the owner was given a subvention in order to clean the whole area. The result was really astonishing. Sandalwoods were measured and the results showed exceptionally good growth. After this silvicultural intervention where all the herbaceous vegetation was removed as well as many of the small trees, a few host trees, mainly *Melia azedarach* were left. The sandalwoods initially had yellowish foliage but, with a good rain period of two weeks and regrowth of the herbaceous vegetation, the colour changed again to green. The form of the sandalwood was straight with thin branches. If these trees are compared with the other plantations in Ile des Pins, they are generally taller, straighter, and their colour shows that they are healthy.

From this example it may be concluded that soils developed on coralline limestone are well suited for sandalwood. When seeds are available, sandalwood propagation is quite easy but frequent weedings are needed in order to obtain a dense stand. On the other hand, this technique with few weedings could give good results also but with a lower sandalwood density. Too strong a weeding is likely to affect the growth of the sandalwood if only for a short spell. This kind of silviculture should be extended. Even if the evolution of such a dense plot is unknown these initial results are very good and all the problems linked to plantations in open areas are avoided.

### Natural Stands

#### Ile des Pins

Natural stands of sandalwood occur only in depleted forest and in shifting agriculture areas. No sandalwood is found in dense rain forest, or, when it does, it is generally as isolated big trees, that have probably grown after an accidental opening of the forest for example in gaps created by fallen trees after cyclones. Where sandalwood is found in the forest, an analysis of the surrounding vegetation shows that such areas had been previously cultivated *e. g.* for coconuts, *Hibiscus tiliaceus* etc. When the native forest is replaced by secondary forest or bush, the density of sandalwood is high particularly on coralline soils.

On ultramafic soils, sandalwood trees are found mainly in the areas where people were gardening and the major part of the trees are "creeping sandalwood", a form that comes from vegetative multiplication by suckers. Their shape is then crooked and bushy and the major part of the heartwood is contained in the roots. Regeneration of sandalwood in these soils is quite difficult and rare.

Beautiful trees are located on the edge of the forest, close to the beach. They do not suffer from the salt spray that occurs in such areas.

#### Maré

On Maré sandalwood shows the same characteristics as in Ile des Pins. It is mainly found in old cultivated areas, abandoned coffee plantations or around ruins of houses. Many tall sandalwood trees are scattered in such areas. Often, the surrounding vegetation is of high bush and trees. In this kind of dense stand big sandalwood trees are scattered. They began to grow when the areas were still under

cultivation. It is possible to find under them sandalwood seedlings of the current year but not older than a few months. The dense shade hinders their growth and they disappear quickly.

In some areas of shifting cultivation many bushes of "creeping sandalwood" occur. But it is almost impossible to find any "true sandalwood" *i. e.* grown from seed. The short spell between two cultivations (8 - 10 years) does not allow the trees to grow tall and little regeneration is possible. All the area is cleared, including the sandalwood and on poor soil growth is slow. The very short rotation has depleted the soil fertility and, except in the year following the fertilisation of the soil by ashes, growth is limited. This sandalwood has no commercial value due to the very small size of its branches but it has an important role in the colonisation of the bare land after cultivation through its suckers and shoots.

Differences between Maré and Ile des Pins include the shorter rotation, total destruction of all the vegetation at each clearing, and no sowing. The result is a poor stand of badly shaped bushes of sandalwood with no commercial value. The Maré sandalwood, as with all the Loyalty Islands sandalwood, has important morphological and phenological differences from those of Ile des Pins. This could explain differences in other characteristics.

#### Ouen-Toro

Near Nouméa, sandalwood is found only in secondary forest, mainly with *A. spirorbis*. The few patches of native forest are devoid of sandalwood. It seems too that even in the sclerophyll forest, it grows mainly in degraded stands.