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Production of *Acacia auriculiformis* A. Cunn. ex Benth. for reforestation in southern Benin

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Abstract

The viability of *Acacia auriculiformis* production system in southern Benin was studied from an analytical perspective combining the production techniques and the financial profitability. The driving research question was as follows: "Will the nurseries be able to supply the seedlings suited to successful reforestation programmes?". A survey was carried out among nursery holders in the Atlantique Department. The snowball sampling method enabled the survey of 55 nursery holders, based on semi-structured interviews. Respondents provided data on the organisation of production, production techniques, production costs, and sales revenues. There were two types of nurseries: individual nurseries and group nurseries. The stages of acacia seedlings production were as follows: seed collection, dormancy breaking, sowing, and tending of young seedlings. Overall, the production techniques used by nursery holders were effective. The net revenue for 1000 seedlings ranged between XOF 9000 and 26000. Group nurseries had lower production costs, hence higher revenues, compared to individual nurseries. It is essential to assist nursery holders through capacity strengthening training and the provision of good quality seeds.

Keywords

Nursery; *Acacia acuriculiformis*; Techniques; Production cost; Revenue

Contents

1 Introduction

Poverty alleviation, especially in rural areas remains a major policy concern (Dorward et al. 2004, World Bank 2011). Strategies to achieve this include the diversification of rural sources of income (World Bank 2011). In this context, the present study focused on the production of *Acacia auriculiformis* Cunn. ex Benth in southern Benin.

The production of forest seedlings in nurseries is a secondary activity practiced in rural areas of southern Benin. It enables the availability of seedlings for the establishment of forest plantations by smallholders (Aoudji et al. 2014). This activity of diversifying sources of income is upstream of forestry.

Forestry is a strategic sector providing economic, social and environmental benefits for human societies (Gerrand et al. 2003). Forest functions include the supply of timber and non-timber products for various uses, the contribution to people's livelihoods (jobs and incomes), biodiversity conservation, reduction of water erosion (Zhou et al. 2002; Cao et al. 2008), carbon storage (Shirima et al. 2011) and climate change mitigation (Gerrand et al. 2003). In tropical regions, most of which are facing severe degradation of natural forests (FAO 2016), forest plantations are expected to play a key role in the preservation of the economic, social and environmental functions of forestry.

The success of reforestation programs requires close attention to the nursery business which is upstream of the plantation. Indeed, the nursery is a critical stage in the production of seedlings needed for reforestation. Therefore, the question "will the current forest seedling production systems be able to supply the seedlings suited to successful reforestation programmes?" be of critical importance to policymakers. The present study seeks to answer this question, and aims to analyze the viability of *Acacia auriculiformis* seedling production system in Southern Benin.

Two complementary approaches were used to evaluate the production of *Acacia auriculiformis* seedlings namely: the techniques of production and the financial profitability of the nursery business. The analysis of the techniques of production is useful to identify additional training needs for nursery holders, while the analysis of financial profitability assesses the sustainability of the business. Indeed, the income generated reflects the ability of the business to improve livelihoods. Moreover, this income is a criterion for business holders to keep motivated to continue the business (Shepherd 2007).

The practical value of this study is twofold: the assessment of opportunities for diversification of rural income and the search for an efficient system of forest

seedlings production in order to support reforestation. Although this study is carried out in Southern Benin, it is of interest to sub-Saharan African countries in general given the importance of rural income diversification in poverty reduction strategies and the need to promote forest plantations given the current context of natural forest degradation. This article progresses as follows: the next section deals with study methods. Sections 3 and 4 present respectively the results and their discussion. The last section (5) highlights the key lessons of the study with policy implications.

2 Methods

2.1 Data collection

This study took place in the Atlantique Department in Southern Benin: 6°17' to 6°58' North latitude, and 1°56' to 2°31' East longitude (Figure 1).

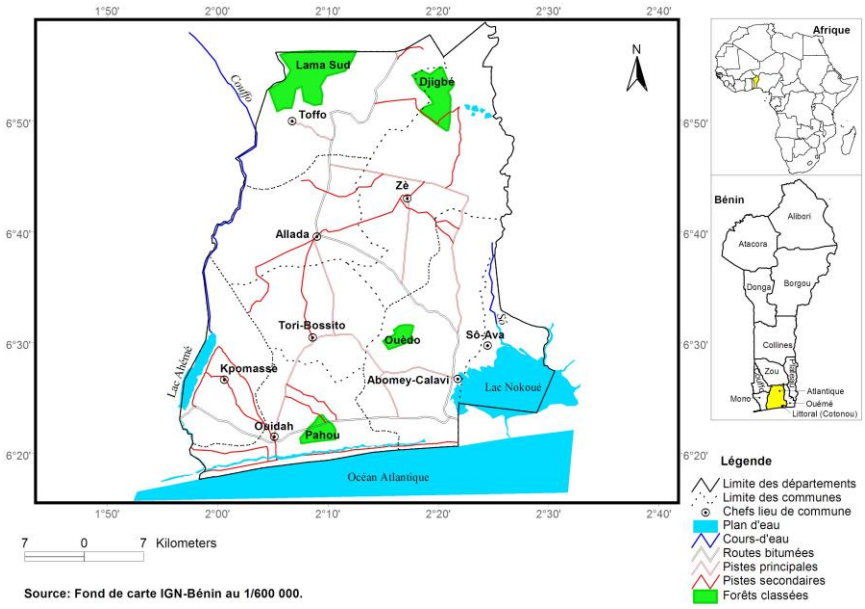

Figure 1. Map of study area.

A survey was conducted with a sample of 55 nursery holders selected by using the "snowball" method. This non-probabilistic sampling method consists of taking from a respondent any information helpful to identify another person of the same socio-professional category (Giannelloni and Vernette 2001).

Data collection from nursery holders was based on semi-structured interviews. The information collected includes the organization of production activities, the techniques of *Acacia auriculiformis* seedlings production, the production costs and the revenues generated from the sale of seedlings.

2.2 Processing and analysis of the data

Data processing consists of two points: the synthesis of the techniques of production and the analysis of financial profitability.

The description of production techniques was given according to the different stages of the production process, from seeds supply to the sale of seedlings. The

financial profitability of the production of *Acacia auriculiformis* seedlings was analyzed according to the type of nurseries. Two types of nurseries were distinguished according to the organization of forest seedlings production in Southern Benin: individual and group nurseries (Séhouéto et al. 2015). The individual nursery was supported by a single individual for his own use or for sale. It was a nursery with a relatively small size. The group nursery was supported by a group (village or cooperative). The supply of seeds to the group nursery was provided by an official institution and the production was carried out by the group itself. For each type of nursery, production costs, turnover and net revenue (*NR*) were calculated. These various parameters were determined for a production of 1000 seedlings, in order to enable comparisons between the types of nursery. Net revenue was calculated as follows: *NR = TO-TP* (Lebailly et al. 2000); With *NR* the net revenue, *TO* the turnover and *TP* the total production cost (obtained by adding up all the variable and fixed costs). Cost-accounting was used to refine the costs of equipment used in common with other farm speculations. Student's *t*-tests (Glèlè Kakaï and Kokodé 2004) were done to compare individual nurseries and group nurseries according to the production costs and the net revenue per thousand of acacia seedlings.

3 Results

3.1 Technique of *Acacia auriculiformis* seedlings production

The season of acacia seedlings production lasts about seven months per year (February to September). This production goes through the following stages: seeds supply, dormancy breaking treatment, sowing and tending of young seedlings.

3.1.1 Seeds supply

Nursery holders get seeds through direct collection or purchase. Collection consists of harvesting fruit on adult acacia tree, before dehiscence and seed fall. This activity takes place between November and February, period of fruit ripening for *Acacia auriculiformis* in the region. The seeds are usually purchased from residents or local organizations for co-management of forest around the public plantations of acacia.

3.1.2 Dormancy breakage treatment

The seeds of *Acacia auriculiformis* are characterized by dormancy i.e. the inability of a mature seed to germinate under favorable conditions. The pre-germination treatment of dormancy breakage of acacia seeds was done with hot water. Two variants were used by nursery holders. According to the first approach, the seeds were poured into water previously boiled and stayed there for 12 to 48 hours. In the second approach, the seeds were poured into boiling water on the fire, and were removed after 5 minutes. They were then spread on a cloth in the open air for cooling.

3.1.3 Seed sowing

Seedlings were produced in polyethylene bags using the direct sowing. Two types of polyethylene bags (about 20 cm length and 10 cm width) were used, namely: black bags (figure 1), recommended for the production of seedlings, and the white

bags (figure 2) which constitute an adaptation made by nursery holders. The bags were filled in manually with compost. The pre-treated seeds were sown (2-3 seeds per bag) at a maximum depth of one centimeter. After germination of the seedlings, a form of shading was placed during the first two weeks to protect the young seedlings from direct sunlight.

Figure 2. Three months *Acacia auriculiformis* Seedlings in a village nursery. (Photo: Séhoueto C)

Figure 3. One month *Acacia auriculiformis* seedlings in a village nursery. (Photo: Séhoueto C)

3.1.4 Tending of young seedlings

The tending of young seedlings includes: watering, thinning, mineral fertilization, pest control and weeding. Watering is usually done twice a day, in the morning and evening. However, adjustments are made based on natural rainfall.

The thinning is done one month after sowing, and helps to reduce the seedlings to one per bag when several seeds germinate.

The mineral fertilization, based on urea mixed with water for seedlings watering, is intended to fasten seedlings growth. In place of urea, some nursery holders use wood ashes for fertilizations.

The use of insecticides helps to address the attacks of termites, ants, and other insects. The insecticide often used is "DECIS®" (15g l-1 of deltamethrin). Fungicide (Topsin M (70% thiophanate-methyl)) is also applied, by mixing it with compost when filling the pots.

Periodic weeding of the pots is done by hand. The acacia seedlings are matured for plantation 2 to 4 months after sowing, and can be sold to tree planters.

3.2 Financial profitability of the production of acacia seedlings

3.2.1 Production costs

Acacia seedlings production involves both variable and fixed costs (Table 1). Variable costs include the following items: polyethylene bags, compost, seeds, fertilizers (NPK or urea), fungicides and insecticides, and occasional labor (Table 1). As for the fixed costs, they include the following: rental of the nursery field, permanent labor force (guarding), depreciation of equipment, and financial costs (Table 1).

Table 1. Structure of production costs of 1000 acacia seedlings, in XOF.

Items	Type of nursery	
	Individual nurseries	**Collective nurseries**
Polyethylene bags	2479 (11.9%)	6809 (73.4%)
Compost	116 (0.6%)	85 (0.9%)
Seeds	175 (0.8%)	350 (3.8)
Fertilizer	168 (0.8%)	121 (1.3%)
Fungicide-Insecticide	141 (0.7%)	51 (0.5%)
Occasional labor	13554 a (65.5%)	1437 b (15.5%)
Variable Costs	**16633 a (80.4%)**	**8853 b (95.5%)**
Rental of the field	475 (2.3%)	127 (1.4%)
Permanent labor (guarding)	1513 (7.3%)	0 (0%)
Depreciation of equipment	1791 (8.7%)	294 (3.2%)
Financial costs	270 (1.3%)	0 (0%)
Fixed costs	**4049 a (19.6%)**	**421 b (4.5%)**
Total costs	**20683 a**	**9274 b**

* Average exchange rate during the study period: XOF 1 = USD 0.002.

Bracketed figures represent the percentage of each item in the total cost.

Numbers followed by different letters on a given line are significantly different (Student's *t*-test; p<0.05).

Variable costs largely predominate, regardless of the type of nursery, and represent 80 to 95% of the total seedlings production costs. Among variable costs, casual labor is the highest in individual nurseries (2/3 of total costs); whereas it represents less than 1/6 in group nurseries (Table 1). Polyethylene bags also contribute significantly to the production cost of acacia seedlings: about 1/10 and 3/4 respectively in individual nurseries and group nurseries (Table 1).

Variable costs and fixed costs are higher in individual nurseries, than group nurseries (Table 1). Accordingly, their total production cost of 1000 seedlings is significantly higher, compared to group nurseries (Student's *t*-test, $p < 0.05$).

3.2.2 Revenues and net revenue

The average revenue generated by the production of 1000 seedlings ranged between XOF 29000 and 36000 (Table 2). The difference between individual nurseries and group nurseries is not statistically significant (Student's t-test, $p > 0.05$).

Table 2. Net revenue from the production of 1000 acacia plants (in FCFA).

Items	Type of nursery	
	Individual nurseries	**Collective nurseries**
Revenues	29689 a	36000 a
Total costs	20683 a	9274 b
Net revenue	9006 a	26726 b

* Numbers followed by different letters on a given line are significantly different (Student's *t*-test; $p<0.05$).

Whatever the production system considered, the net revenue (NR) per thousand of seedlings was positive; meaning that *Acacia auriculiformis* seedlings production was profitable. The NR generated by the production of 1000 seedlings equals USD 18 (average exchange rate during the study period: XOF 1 = USD 0.002) for individual nurseries and USD 53.5 for group nurseries (Table 2). However, the net revenue for group nurseries was three times higher (Student's *t* test, $p < 0.05$) than that of individual nursery (Table 2).

4 Discussion

4.1 Techniques of seedling production

The practices of nursery holders denote both a good mastery of the techniques of production and adaptations to reduce production costs. Thus, the practice of pre-germination treatment on the seeds of *Acacia auriculiformis* aims to break dormancy - state of a mature seed that does not germinate under favorable conditions (Li and Foley 1997) - in order to reduce the duration of germination and improve the germination rate. In tropical areas, the seeds of many forest species such as acacia are subject to dormancy (Eyog-Matig et al. 2006). Treatment of seeds with boiling water is also part of pre-germination treatment methods used for other species (Eyog-Matig et al. 2007; Séhouéto et al. 2015).

The practices of nursery holders, in terms of seedling production in general and the tending of seedlings in particular, diverge from the theoretical guidelines of

ABE (1998). These practices constitute nursery holder's adaptation strategies to reduce production costs. For example, many nursery holders use white (cheaper) bags instead of black polyethylene bags. The latter are used mainly by cooperatives, given the demands of their clientele composed mainly of forestry projects. Nursery holders do not systematically apply phytosanitary treatments. These treatments take place in case of ants' attacks. This is also a means of adaptation for them to reduce production costs, but it also shows a sense of environmental responsibility of nursery holders to use pesticides moderately. The techniques used by nursery holders in seedlings production are effective even if they do not fully meet theoretical standards.

Nevertheless, weaknesses are noted in the seed supply system. Indeed, most nursery holders collect seeds from any tree, instead of selected trees. Nursery holders should be encouraged to use seeds from elite trees. These seeds are distributed by State forest structures, such as the Center for Studies, Research and Forestry Training (CERF). The use of quality planting material by the producers is expected to have a positive impact on the profitability of the acacia plantations grown from the seedlings. In fact, a previous research revealed that the performance of forest plantations is influenced by the source of planting material affects (Azankpan et al. 2009). Therefore, the use of quality seeds in seedling production ensures the productivity and profitability of forest plantations (Bekker et al. 2004). The discussion above reveals the need for technical support to producers for access to quality seeds. This task is primarily the responsibility of the Forestry Service.

4.2 Financial profitability of seedling production

The study revealed a predominance of variable costs: more than 80% to the total production costs whatever the type of nursery (individual or group). The low proportion of fixed costs highlights a low level of capital. This also show the fact that the production of forest seedlings follows the logic of the peasant economy, with the use of family resources to produce (Brossier 2007).

Production costs and net revenue per thousand seedlings varied across the types of nursery. Similarly, the cost structure showed significant differences between the two types of nursery (Table 1). These differences in performance indicators confirm the relevance of the method used to analyze the financial profitability of *Acacia auriculiformis* seedlings production. Indeed, the method helps to group producers into homogeneous categories, which makes it possible to improve the effectiveness of development interventions by defining specific actions according to the different categories or types of producers identified (Jamin et al. 2007).

The differences between individual nurseries and group nurseries in terms of net revenue stem from the discrepancies in production costs. Indeed, the revenues generated by the production of 1000 seedlings did not vary significantly according to the type of nursery. The differences between the types of nurseries in terms of production costs stem from the ways of organizing activities and other specific characteristics of each type of nursery. For instance, external labor costs were lower in group nurseries where members of the cooperative combine work force to produce seedlings. In the cost structure, the absence of guarding costs for cooperatives is supported by the fact that they are mostly located in public forest areas. Thus, they enjoy the protective effort made by the Forestry service (Séhouéto et al. 2015). The

settlement of group nurseries in public forest also supports the low rental costs for the production area.

The net revenue from 1000 seedlings is positive, whatever the system concerned. Previous studies reported the profitability of forest seedling production activities by nurseries, including Benin (Séhouéto et al. 2015) and Nigeria (Ajayi and Babalola 2006). For development agencies, this result is interesting from several perspectives. First, the production of *Acacia auriculiformis* seedlings generates returns to producers. Therefore, this activity could be taken into account in strategies for income diversification in rural areas. Indeed, the production of forest seedlings is a secondary activity for producers, thereby diversifying the livelihoods of rural populations. Diversification of livelihoods reduces the vulnerability of rural populations to the impacts of variability and climate change (Islam et al. 2013). Secondly, group nurseries are an opportunity to implement other rural development initiatives. Besides the production of *Acacia auriculiformis* seedlings, cooperatives' members are involved in other activities, in particular agricultural production. If these organizations are viable, they can play an important role in market access for producers (Devaux et al. 2009, Markelova et al. 2009, Shiferaw et al. 2008). Further studies will help to identify the success factors guiding collective actions in the cooperatives of seedling production.

5 Conclusion

The study provided information on the practices of nursery holders for the production of acacia seedlings in the Atlantique Department (in Benin), and evaluated the financial profitability of their activity. Two types of seedling production units were analyzed: individual nurseries and group nurseries. The latter are cooperatives whose members work together around the nursery. The production of acacia seedlings encompasses the following steps: seed harvesting, dormancy breaking, direct sowing of seeds in bags and nursery cultural practices. The pre-germination treatment of the seeds was done by soaking in boiling water. The techniques of production used by nursery holders to produce seedlings were generally efficient, even if they adapted to theoretical standards in order to save costs.

The financial analysis showed that nursery holders get returns from the production of *Acacia auriculiformis* seedlings. This activity is financially viable, regardless of the type of nursery considered. Group nurseries bear lower production costs than individual nurseries, hence their higher net revenue.

The study highlighted weaknesses in the system of seeds supply. Indeed, seeds are not harvested from elite trees selected for desired characteristics. This implies the need for technical support to producers to ensure the availability of high-performing planting material. Regarding the implications for development, the profitability of the production of *Acacia auriculiformis* seedlings shows that forest nursery business can be promoted in livelihoods diversification strategies for rural populations. Group nurseries which are cooperatives can serve as a basis for other rural development interventions, such as support for collective marketing for producers' access to the market.

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