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Availability of forest tree species in nurseries for domestic use and for reforestation in different climatic zones in Burkina Faso (West Africa)

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Nurseries are used to supply plants for domestic purpose and for reforestation. However, few studies have focused on forest tree species cultivated by horticulturists for domestic use and for reforestation in African countries such as Burkina Faso. With the aim of contributing to better knowledge and participating in better use of forest tree species in nurseries, 37 nurseries were identified and studied in two cities, Bobo-Dioulasso in the Sudanian zone and Dori in the Sahelian zone. The floristic inventory revealed that in the Sudanian zone, 243 plant species are cultivated, while in the Sahel, 90 species are recorded. However, the availability of forest tree species cultivated in nurseries for domestic use and for reforestation is related to climate conditions. In fact, 24.28% of produced species were forested in the Sudanian zone, while in the sahel, they represented 73.33%. Furthermore, among forest tree species recorded at the sudanian zone, 32.20% are indigenous compared to 65.15% at the Sahel. The financial analysis indicated an RBC = 1.42 and 1.02 in the Sudanian and Sahelian zones, respectively. Consequently, horticulture is more profitable in the Sudanian zone compared to the Sahelian zone. If nurseries are economically beneficial, the production of forest tree species intended for domestic use and mainly for reforestation contributes to the preservation of forest resources.

Key words: Burkina Faso, nursery, forest tree species, preservation, horticulture, benefits.

INTRODUCTION

Biological diversity plays an important role in the life of many human societies (Kosh-Komba et al., 2021). Indeed, natural resources constitute the basic support for human life. One of the most important resources remains the flora. It is one of the drivers of ecosystem stability and is involved in almost all human activities (Pale et al., 2021). Nowadays, man carries out harmful actions such as uncontrolled land clearing, excessive logging and many other actions on the environment, thus contributing to deforestation. Today, many woody species are threatened with extinction (Betti, 2001; Ouédraogo, 2008; Traoré, 2008) due to poor harvesting practices, poor

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regeneration and overexploitation (Belem, 2008). Indeed, the overuse of plant resources, meeting 90% of the needs of the population, is one of the major factors in the degradation of forest resources (Benoît, 2008). The level of regression of forest formations a year is estimated to be 110,500 ha, or 4% on average in the world (FAO, 2000). There is therefore a need for conservation of forest species in particular (Boffa, 2000; Devineau et al., 2009) and plant species in general. Conservation of plant species becomes more urgent in the Sahelian zone where species are becoming rarer and in the Sudanian zone where pressure on plant resources is very strong (Thiombiano et al., 2010). Therefore, it appeared necessary to take actions in order to preserve forest ecosystems and their resources (Dubois, 2019). One of the imperatives is to resort to the domestication of forest resources (Tchounji, 2012). Thus, the domestication of forest species is one of the ways, not only for the promotion and valorization but also of protection and conservation of these species. Agriculture such as horticulture, which is in fact the domestication and cultivation of plants, represents an important issue in terms of preserving the environment and improving the quality of life (Radji et al., 2010). Thus, agriculture through arboriculture becomes a strategy to combat environmental deterioration across Africa (Kimbatsa et al., 2018). According to Lilleso et al. (2011), it consists of the creation of plant nurseries responsible to supply plant species for large scale use. Indeed, in Burkina Faso, reforestation is one of the actions undertaken to restore vegetation cover and degraded natural forest habitats. Thus, from 2008 to 2012, 11,178,184 seedlings of various species in nurseries were planted, which represents a reforested area of 65,376 ha (MEDD, 2012).

Furthermore, nursery activity which essentially concerns the cultivation and marketing of plants, employs hundreds of young people. The sector is certainly proliferating because of its economic profitability, thus contributing to the reduction of unemployment rate (Aké-Assi, 2002). In many African countries, this sector remains informal and structurally poorly organized. The level of organization and professionalism is only known in a few countries of the continent such as Kenya (Neven et al., 2009). If in the Western countries, much research work has been carried out on the resources and diversity of plants grown in nurseries, in most sub-Saharan countries, few studies have focused on the potential and diversity of forest species encountered in nurseries for domestic use and for reforestation. In Central Africa, a study on the production of rural nursery showed that forest plant species produced in nurseries provide non-timber forest products (NTFPs) of high economic, social and cultural value to rural populations (Tabuna et al., 2009). In addition, studies carried out on the cultivation of plant species in nurseries of some cities in Burkina Faso show that nurseries have great socio-economic importance (Korbéogo, 2016; Traoré and Zongo, 2023). Furthermore, the expansion of nurseries in cities with forest tree species produced there, strongly contributes to the regeneration of forest ecosystems and offers considerable potential for sustainable development and management of natural resources, particularly forestry (CIFOR, 2004). Due to the strong value of nurseries, it is essential to understand how their floristic potential varies between climatic zones. Burkina Faso has a tropical climate, ranging from an arid climate in the north to a semi-arid climate in the south (Hiernaux et al., 2009). This climatic disparity of the country can have repercussions significant effects on the availability and diversity of plant species in nurseries. Therefore, the study aims to explore the floristic potential of nurseries located in two climatic domains of Burkina Faso while focusing on the identification and evaluation of forest tree species present in these nurseries. By understanding the floristic composition according to climatic conditions, the impact of nurseries on forest ecosystems will be understood for better management of forest resources in the context of climate change.

METHODOLOGY

Study zone

A survey was carried out in two cities with different climate conditions and different agro-ecological situations. Therefore, the choice of cities was made according to the climatic variation following a north-south transect. Thus, the city of Bobo-Dioulasso at the Sudanese climate in the south of Burkina Faso and the city of Dori at the Sahelian climate in the north (Figure 1) were selected. The vegetation of Bobo-Dioulasso reflects less arid climatic conditions which characterize the South Sudanese sector and Dori, more arid, is part of the Sahelian sector (Fontès and Guinko, 1995).

The city of Bobo-Dioulasso that is the capital of the Houet province and the capital of the Hauts-Bassins region, is located in the south Western part of Burkina Faso. The south Sudanese sector is characterized by the existence of shrub savannahs, tree savannahs, wooded savannahs, light forests, gallery forests and riparian formations (Nacro et al., 2006). From 2009 to 2018, rainfall varied from one year to another in the city of Bobo-Dioulasso and the average rainfall was 1079 mm (Yaméogo et al., 2020). The rainiest years are 2014 and 2018 with 1278.3 and 1320.2 mm, respectively. The least rainy years are 2011 and 2017 with 775.4 mm and 747.9 mm respectively. In this area, the vegetation is characterized by woody species along the Kou and Houet watercourses. Average monthly temperatures varied between 22.4 and 33.70°C with an annual average of 27.97°C. The highest temperatures are mainly observed in the months of March and April and the lowest during the months of January and December.

The city of Dori is the capital of the Sahel region and the capital of the Seno province. This city is located in the Northeastern part of Burkina Faso. The vegetation is characterized by tree and shrub steppes, steppe vegetation predominates with herbaceous plants and locally woody plants which are more or less regularly distributed (Descoings, 1978). However, we note an herbaceous steppe generally located along watercourses (Dori Pond, Yakouta river). Dori experiences a Sahelian-type climate whose main characteristic is the greater prolongation of the dry season of 8 to 9 months compared to a rainy season of 3 to 4 months (Ozer et al., 2010). The zone has a very poor natural hydrographic network because it only includes the Goudebo river, which runs from Yakouta to Dani. We could add the two ponds in the central commune (the large pond with a capacity of 25 million m^3 and the

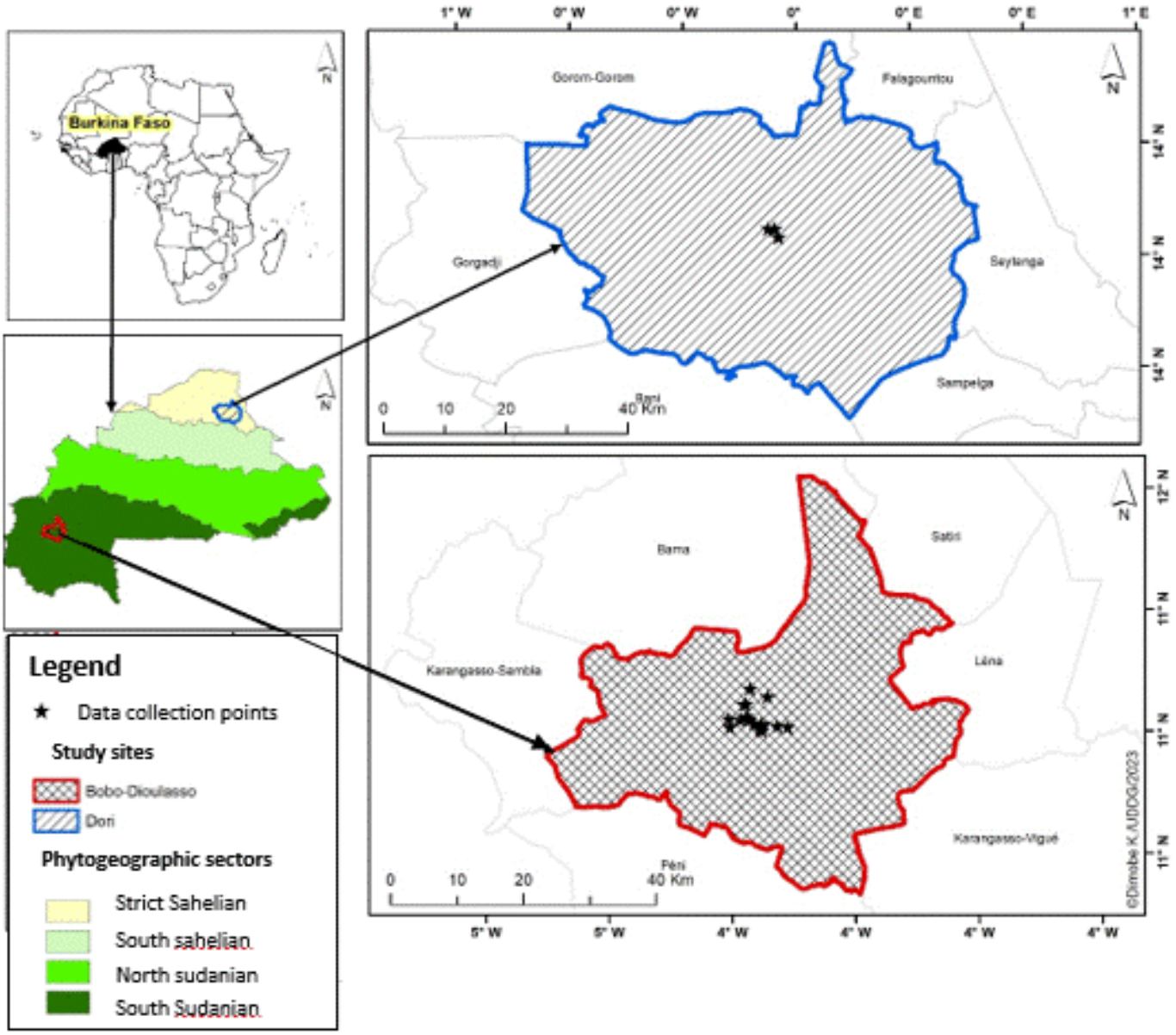

Figure 1. Location map of study areas.

small pond) as well as the Djigo pond (Tsioba Moubouali, 2010).

Collection of data

Location of nurseries

For the location of nurseries in the cities, the “snowball” sampling method defined by Sehoueto et al. (2015) was used. According to this method, a respondent provides information allowing other people carrying out the same activity to be found. After identifying the production sites in the two climatic zones, the geographic coordinates of each nursery was obtained using a GARMIN 62 model GPS. The coordinates of the nurseries were then associated less than 10 m apart. The coordinates were used to locate and graphically represent identified nurseries on a map.

Ethnobotanical surveys

An ethnobotanical survey was conducted in 2021 with horticulturists from the different selected nurseries using a questionnaire. As a survey method, semi-structured interviews were used to gather information. Indeed, thirty-three horticulturists in the Sudanese zone and only four in the Sahelian zone, relatively to the number of nurseries in each respective area, were interviewed. In total, 37 horticulturists coming from ethnical groups such as Mosi, Bobo, Samo, Gouin, Gourmantché, Dafi, Siamou, Bissa, Senoufo and Peulh were interviewed in order to identify the reasons for the production of species in general, the production of forest tree species compared to other species in nurseries. The questionnaire also included information on the economic values of nurseries, the typology of nurseries and the number of forest tree species produced per year.

Identification of species

Floristic inventory of nurseries was also carried out in 2021. This consisted of listing all the cultivated species that were present in nurseries at the period of the study. A list of species was thus drawn up. The scientific identification of inventoried species was carried out in the laboratory of botanic at Nazi Boni University, on the basis of herbaria produced documents (Kyalangalilwa et al., 2013) with the help of a standard book called: “the West African Flora” (Hutchinson, 1954). The list of species was then compared to that of the catalog of vascular plants of Burkina Faso (Thiombiano et al., 2012). Other standard works such as those of Thiombiano and Kampmann (2010) and Ganaba (2020) were used for species dentification.

Data analysis and processing

Collected data were inserted into a database using Excel 2019 software. Afterwards, comparisons between nursery types using the composition of produced species were apprehended. Therefore, Pearson correlation coefficient was used to measure the correlation between nursery types. Only correlation coefficients with a significance threshold (p-value) close to 0 (< 0.05) were considered. The calculation of correlation coefficients was performed using R software. QGIS 2.18 software was used to map nurseries. The means and standard deviations were used to present socio-demographic characteristics of producers in the different cities. Four (4) indicators: Variable costs (VC), fixed costs (FC), benefits (B) and the ratio benefit/cost (RBC) inspired from the works of Ayena and Yabi (2013), Biaou et al. (2016) and Miassi and Dossa (2018) were used for the economic analysis of forest tree species production. Variable costs (VC) are expenses which directly relate to the production volume. This involves the acquisition of inputs (fertilizers, insecticides, pesticides, labour etc.). Fixed costs (CF), on the other hand, mainly correspond to investments that are not directly related to the volume of production. It is the price of materials such as pickaxes, machetes, hoes, bulges and many others. From these variables, the following economic values were obtained:

1. The turnover (T) or revenue is expressed by the value of sales made by the producer or the sum of revenues generated in a locality by all the producers surveyed (Miassi and Dossa, 2018).
2. The production cost (PC) expresses the sum of expenses incurred during the production process. It is obtained using the following formula (Miassi and Dossa, 2018; Biaou et al., 2016):

$$PC = \Sigma \text{ expenses}$$

3. The profit (P) is expressed by the difference between the expenses incurred by production and the revenue obtained and is given by the following formula (Miassi and Dossa, 2018; Biaou et al., 2016):

$$P = T - PC$$

Where T is the turnover and PC the production cost.

4. The ratio benefit/cost (RBC) represents the total financial gain obtained by the investment of a monetary unit (1 CFA franc for example). It is given by the following formula (Ayena and Yabi, 2013):

RBC = benefit/cost of the production

In economic profitability analysis, the interpretation of the RBC is done by comparing it to the value 1. RBC > 1 means that an invested 1 franc generates more than one franc in profit, and the business is considered economically profitable. When, on the other hand, RBC < 1, then 1 franc invested generates less than one franc as a profit, and the activity is considered economically unprofitable, because the producer earns less than he invests.

RESULTS

Nursery and customer profiles

Location of nurseries

A map indicating the location of nurseries in the study areas (Figure 1) was obtained from geographical coordinates of the different production sites and analysis using QGIS 2.18 software. The location of 33 nurseries in the Sudanian zone and 4 nurseries in the Sahelian zone revealed that all of them are perennial nurseries. Furthermore, at least 25 species were cultivated in each nursery. As horticultural sites always using water, nurseries are mainly grouped around water points (Photo 1). Indeed, in the Sudanian zone, they are located along the "Marigot Houet" (a river that runs through the entire city of Bobo-Dioulasso) and its tributary. Nurseries in the Sahelian zone use water from boreholes and ponds. However, some nurseries are located near environmental services in different areas, specifically the provincial and regional environmental departments, respectively.

Sociodemographic characteristics of horticulturists

Among identified 37 horticulturists belonging to the ten (10) ethnical groups (Figure 2), horticulturists from the Mossi ethnical group constitutes the majority and represents 27.03%. They are followed by the Bobo and Samo ethnical groups which represented 10.81% each and the Gouin group with a proportion of 8.11%. The least represented ethnic groups are the Gourmantché, Dafi, Siamou, Bissa, Senoufo and Peulhs. The average age of horticulturists was 42 years old with a high number of people in the age group of [30; 50]. As shown in Figure 3, this representation reveals that most of the respondents were young and adult people. They have an average of 33 years of experience in the production of seedlings (Figure 4a) and those with a good level of education represented 66% (Figure 4b).

Economic activities of horticulturists

Horticulture is mostly one of the economic activities of horticulturists. However, they are all engaged in other activities. The importance of realized economic activities differs depending on the study area. In the Sudanian zone, nursery activity remains the main activity of the majority of interviewed people (52.69%). The situation is almost reversed in the Sahelian zone. With a proportion

Photo 1. Horticultural sites encountered in downtown Bobo-Dioulasso; (A) *Cordyline fruticosa* Comm. ex R.Br, (B) *Codiaeum variegatum* (L) A.Juss, (C) *Ananas bracteatus* (lindl.) Schult et Schult.f, (D) *Nephrolepis exaltata* (L.) Schott, (E) *Cycas revoluta* Thunb.

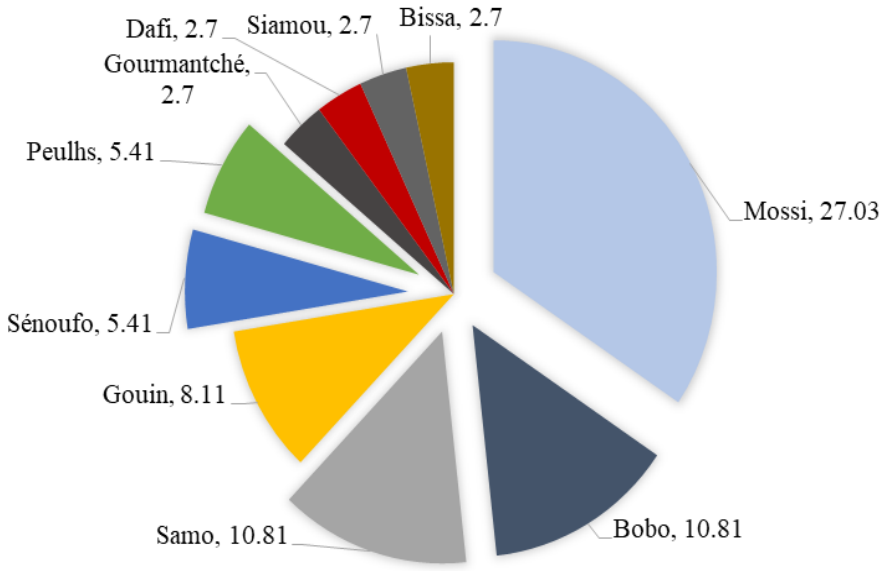

Figure 2. Frequencies of different ethnic groups of horticulturists.

of 75%, livestock breeding constitutes the first income-generating activity in this area.

Characteristics of the nurseries in both climatic zones

Floristic composition in both areas

In total, 243 plant species divided into 179 genera and 69 families were recorded in nurseries of the Sudanian zone (Table 1). On the other hand, in the Sahelian zone, 90 plant species divided into 66 genera and 28 families have been inventoried (Table 2). However, 2 main categories of species were identified in the two zones: Forest and non-forest species. Indeed, in the Sudanian zone, among the 243 recorded species, 59 species are forest species (Table 1) with a proportion of 24.28%. However, in the Sahelian part, out of the 90 species recorded, 66 species (73.33%) were forested species (Table 2). Unlike the

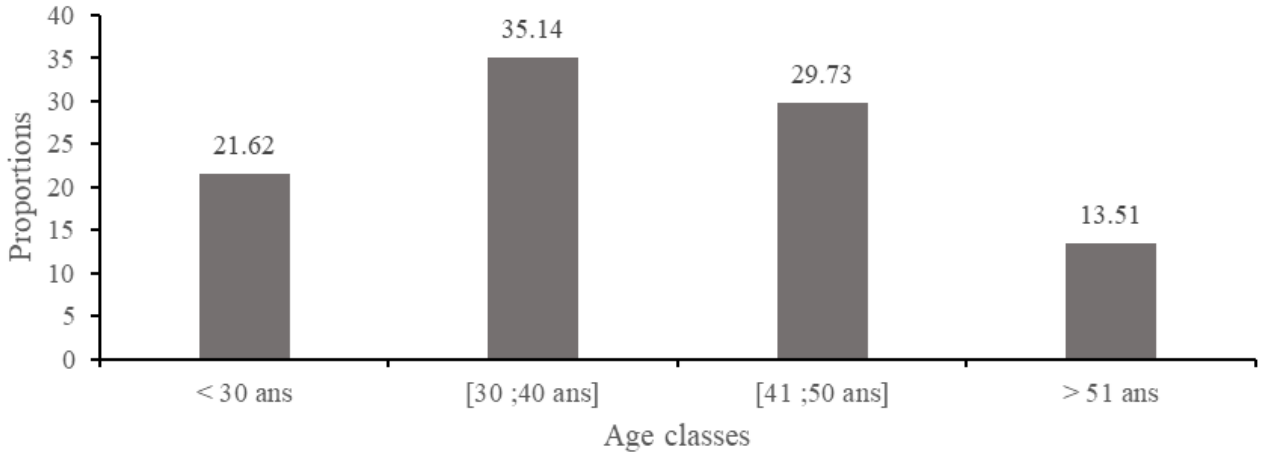

Figure 3. Frequencies of nurserymen horticulturists by age.

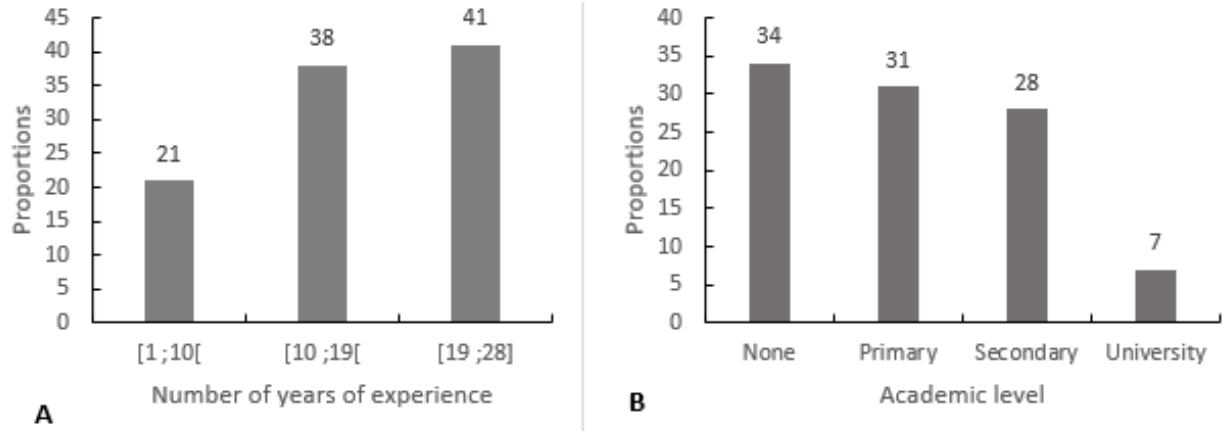

Figure 4. Frequencies of nurserymen according to the number of years of experience (A) and the academic level of horticulturists (B).

Sudanian zone, the nurseries of the Sahelian zone contain more forest species.

Typology of nurseries

Interviews with horticulturists have highlighted the diversity of nursery structures. Three types were identified in the Sudanian zone and two types in the Sahelian zone. In the Sudanian zone, we distinguished individual nurseries owned by private individuals, public nurseries owned by state entities, and family nurseries owned by groups of individuals, often from the same family. In the Sahelian zone, nurseries are divided into individual and public ones. However, nurseries are not installed for the same objectives. In the Sudanian region, only public nurseries (6.06%) prioritize the production of forest tree species. Conversely, in the Sahelian zone, all nursery owners have oriented their production towards forest tree species. Overall, individual nurseries predominate and represent a proportion of 84% (Figure 5).

Significant similarities and differences between the three types of nurseries were revealed during an in-depth analysis of plant species grown in nurseries. Statistical exploration, highlighted at $p < 0.05$, a significant distinction between family nurseries and individual nurseries ($r = 0.73$, $p < 2.2e\text{-}16$). However, despite this significant difference, both family nurseries and individual nurseries did not exhibit pronounced variations compared to public nurseries. Therefore, at $p < 0.05$, family and individual nurseries are not strongly different in species composition compared to public nurseries ($p = 0.2763$, $r = 0.058$ and $p = 0.3584$, $r = 0.068$, respectively).

The local forest species

Among the 59 species of forest trees present in the 33

Table 1. Classification of species recorded in the Sudanian zone.

Family	Genres	Species
Acanthaceae	*Ruellia*	*Ruellia simplex* C.Wright
	Barleria	*Barleria prionitis* L.
Aloeaceae	*Aloe*	*Aloe vera* L.
		Aloe variegata L.
Amaranthaceae	*Spinacia*	*Spinacia oleracea* L.
	Celosia	*Celosia spicata* L
Amaryllidaceae	*Amaryllis*	*Amaryllis belladonna* L
	Cyrtanthus	*Cyrtanthus elatus* (Jacq.) Traub
Anacardiaceae	*Anacardium*	*Anacardium occidentale* L.*
	Mangifera	*Mangifera indica* L.
	Sclerocarya	*Sclerocarya birrea* Hochst.*
	Lannea	*Lannea microcarpa* Engl. & Krause*
Annonaceae	*Annona*	*Annona squamosa* L
		Annona senegalensis Pers.*
		Annona muricata L.
		Annona reticulata L.
Apiaceae	*Polyalthia*	*Polyalthia longifolia* (Sonn.) Hook.f.& Thomson
	Cananga	*Cananga odorata* (Lam.) Hook. F. et Thomson
	Daucus	*Daucus carota* L.
	Centella	*Centella asiatica* (L.) Urb.
Apocynaceae	*Thevetia*	*Thevetia neriifolia* Juss. ex Steud
		Thevetia peruviana (pers.) K.Schum.
	Catharanthus	*Catharanthus roseus* (L.) G. Don
	Adenium	*Adenium obesum* Roem. & Schult.
	Allamanda	*Allamanda cathartica* L
	Plumeria	*Plumeria rubra* L
	Saba	*Saba senegalensis* (A.DC.) Pichon*
Araceae	*Alocasia*	*Alocasia macrorrhiza* Schott.
	Aglaonema	*Aglaonema commutatum* Schott
		Aglaonema Crispum Zina Pitcher
	Dieffenbachia	*Dieffenbachia seguine* (Jacq.) Schott
	Monstera	*Monstera deliciosa* Adans.
	Philodendron	*Philodendron bipinnatifidum* Schott
	Syngonium	*Syngonium* podophyllum Schott
	Colocasia	*Colocasia esculenta* (L.) Schott
	Caladium	*Caladium bicolor* (Ait)Vent.
Araliaceae	*Aralia*	*Aralia balfouriana* (André) L.H. Bailey
		Aralia fructicosa Hort.
	Fatsia	*Fatsia japonica* (Thunb.) Decne.
	Hedera	*Hedera helix* L

Table 1. Contd.

Araucariaceae	*Araucaria*	*Araucaria angustifolia* (Berto.) Kuntze
Arecaceae	*Chamaedorea*	*Chamaedorea Seifrizii* Burret
	Archontophoenix	*Archontophoenix alexandrae* (Muell.) H.Wendl & Drude
	Chamaerops	*Chamaerops humilis* L.
	Elaeis	*Elaeis guineensis* Jacq.*
	Borassus	*Borassus aethiopum* Man.*
	Dypsis	*Dypsis lutescens* (H. Wendl.) Beentje et J. Dransf
	Cycas	*Cycas revoluta* Thunb.
	Washingtonia	*Washingtonia filifera* (Linden ex André). H.Wendl
	Phoenix	*Phoenix Dactylifera* L*
	Cocos	*Cocos nucifera* L*
	Caryota	*Caryota mitis* L.
Asparagaceae	*Chlorophytum*	*Chlorophytum comosum* (Thunb.) Jacques
	Agave	*Agave americana* (Salm-Dyck) A. Terracc
		Agave sisalana Perrine
		Agave angustifolia Haw
	Cordyline	*Cordyline fruticosa* (L.) A. Chev
		Cordyline mauritiana (Lam.)Jf.Macbr
	Yucca	*Yucca gloriosa* L
	Asparagus	*Asparagus aethiopicus* L.
Asteraceae	*Artemisia*	*Artemisia annua* L.
	Leucanthemum	*Leucanthemum vulgare* Lam.
	Ageratum	*Ageratum conyzoides* L
	Vernonia	*Vernonia colorata* (Willd.) Drake
Balsaminaceae	*Impatiens*	*Impatiens niamniamensis* Gilg
	Artocarpus	*Artocarpus heterophyllus* Lam
		Artocarpus altilis (Parkinson) Fosberg
Begoniaceae	*Begonia*	*Begonia semperflorens* hort.
Bignoniaceae	*Crescentia*	*Crescentia cujete* L*
	Jacaranda	*Jacaranda mimosifolia* D. Don
	Kigelia	*Kigelia africana* (Lam.) Benth*
	Tecoma	*Tecoma stans* (L.) Juss. Ex Kunth.*
Bromeliaceae	*Ananas*	*Ananas Comosus* (L.) Merr
		Ananas bracteatus (Lindl.) Schult. Et Schult.f
Cactaceae	*Epiphyllum*	*Epiphyllum oxypetalum* (DC.) Haw.
	Selenicereus	*Selenicereus validus* S.Arias et U.Guzman
	Opuntia	*Opuntia ficus-indica* (L.) Mill
		Opuntia monacantha (Willd.) Haw
		Opuntia azurea Rose
		Opuntia frangilis (Nutt.) Haw.
		Opuntia humifusa Raf.
		Opuntia elatior Mill
	Cereus	*Cereus repandus* (L.) Mill

Table 1. Contd.

Cannaceae	*Canna*	*Canna indica* L
Caricaceae	*Carica*	*Carica papaya* L
Caryophyllaceae	*Dianthus*	*Dianthus libanotis* Labill
Casuarinaceae	*Casuarina*	*Casuarina equisetifolia* L
Combretaceae	*Guiera*	*Guiera senegalensis* J.F. Gmel.
	Terminalia	*Terminalia macroptera* Guill. & Perr.*
Commelinaceae	*Tradescantia*	*Tradescantia fluminensis* Vell
		Tradescantia pallida (Boom) Hook
Convolvulaceae	*Convolvulus*	*Convolvulus tricolor* L.
Corokiaceae	*Corokia*	*Corokia cotoneaster* Raoul
Crassulaceae	*Kalanchoe*	*Kalanchoe daigremontiana* Raym.-Hamet & H. Perrier
		Kalanchoe pinnata (Lam.) Pers.
		Kalanchoe laetivirens Desc.
		Kalanchoe thyrsiflora Harv
Cupressaceae	*Cupressus*	*Cupressus arizonica* Greene
		Cupressus glabra Sudworth
		Cupressus sempervirens L.
		Cupressus bakeri Jeps.
Cycadaceae	*Cycas*	*Cycas revoluta* Thumb.
Cyperaceae	*Cyperus*	*Cyperus papyrus* L
Ebenaceae	*Diospyros*	*Diospyros mespiliformis* Hochst. ex A.DC.*
Euphorbiaceae	*Acalypha*	*Acalypha wilkesiana* Mull.Arg
		Acalypha cuneata Hort.
		Acalypha hispida Burm.F.
	Codiaeum	*Codiaeum variegatum* (L.). Juss
	Euphorbia	*Euphorbia milii* Des Moul
		Euphorbia tirucali L
		Euphorbia ingens E.Mey. Ex Boiss
		Euphorbia candelabrum Kotschy
		Euphorbia kamerunica Pax
	Hura	*Hura crepitans* L*
	Jatropha	*Jatropha curcas* L.
		Jatropha gossypiifolia L
		Jatropha pandurifolia Andr.
		Jatropha multifida L.
		Jatropha podagrica Hook
Fabaceae	*Acacia*	*Acacia nilotica* (L.) Willd. ex Delile*
		Acacia seyal P.J.H.Hurter.*
		Acacia senegal (L.) Britton*
		Acacia sieberiana (DC.) Kyal*
	Caesalpinia	*Caesalpinia pulcherrima* (L.) Sw
	Detarium	*Detarium microcarpum* Guill. et Perr.*
	Delonix	*Delonix regia* (Bojer ex Hook.) Raf*
	Prosopis	*Prosopis africana* L.*
	Erythrina	*Erythrina variegata* L.*
	Afzelia	*Afzelia africana* Sm.*

Table 1. Contd.

	Cajanus	*Cajanus cajan* L.*
	Albizia	*Albizia lebbeck* (L.) Benth*
		Albizia chevalieri Harms*
	Cassia	*Cassia siamea* Lam.*
		Cassia occidentalis L.
	Senna	*Senna alata* (L) Roxb
	Tamarindus	*Tamarindus indica* L*
	Parkia	*Parkia biglobosa* (Jacq.) R.Br. ex G.Don*
	Piliostigma	*Piliostigma thonningii* (Schum.) Milne-Redh*
	Bauhinia	*Bauhinia rufescens* Lam.*
	Dalbergia	*Dalbergia sissoo* Roxb.*
	Daniella	*Daniella oliveri* (Rolfe) Hutch. et Dalziel*
Lamiaceae	*Hyssopus*	*Hyssopus officinalis* L.
	Mentha	*Mentha piperita* L.
		Mentha spicata L.
	Plectranthus	*Plectranthus variegata* Swedish
	Glechoma	*Glechoma hederacea* L.
	Ocimum	*Ocimum basilicum* L
	Vitex	*Vitex doniana* Sweet*
	Tectona	*Tectona grandis* L. f*
Lauraceae	*Persea*	*Persea americana* Mill
	Laurus	*Laurus nobilis* L.
Liliaceae	*Sansevieria*	*Sansevieria cylindrica* (Wenceslas Bojer)
		Sansevieria trifasciata Prain
Lythraceae	*Lawsonia*	*Lawsonia inermis* L.
	Punica	*Punica granatum* L
Malvaceae	*Adansonia*	*Adansonia digitata* L*
	Ceiba	*Ceiba pentandra* (L.) Gaertn*
	Bombax	*Bombax costatum* Pellegr. & Vuillet*
	Cola	*Cola cordifolia* jCav.) R. Br.*
		Cola nitida (Vent.) Schott et Endl*
	Hibiscus	*Hibiscus syriacus* L.
		Hibiscus rosa-sinensis L
	Theobroma	*Theobroma cacao* L*
	Waltheria	*Waltheria indica* L
	Calathea	*Calathea ornata* (Linder) Korn.
		Calathea picturata K. Koch et Linden
		Calathea zebrina (Sims) Lindl
Meliaceae	*Azadirachta*	*Azadirachta indica* A. Juss.*
	Khaya	*Khaya senegalensis* (Desr.) Juss*
	Carapa	*Carapa procera* DC.*
Moraceae	*Ficus*	*Ficus benjamina* L.
		Ficus elastica Roxb. Ex Hornem
		Ficus religiosa L.
		Ficus gnaphalocarpa (Miq.) Steud. ex A. Rich.

Table 1. Contd.

	Morus	*Morus alba* L.
Moringaceae	*Moringa*	*Moringa oleifera* Lam*
Musaceae	*Musa*	*Musa acuminata* L. *Musa paradisiaca* L. *Musa mannii* H. Wendl
Myrtaceae	*Eucalyptus* *Psidium* *Syzygium*	*Eucalyptus camaldulensis* Dehnhardt.* *Psidium guajava* L *Syzygium malaccense* (L.)Merr.& L.M. Perry
Nephrolepidaceae	*Nephrolepis*	*Nephrolepis exaltata* (L.) Schott *Nephrolepis cordifolia 'Duffii'* Lemon Button Fern *Nephrolepis biserrata* (Sw.) Schott
Nyctaginaceae	*Bougainvillea* *Mirabilis*	*Bougainvillea spectabilis* Willd. *Bougainvillea glabra* Choisy. *Mirabilis jalapa* L
Olacaceae	*Ptychopetalum* *Ximenia*	*Ptychopetalum Olacoides* Benth *Ximenia americana* L.*
Oleaceae	*Jasminum* *Ligustrum* *Syringa* *Olea*	*Jasminum fluminense* Vell. *Jasminum sambac* (L.) Aiton *Ligustrum vulgare* L. *Syringa vulgaris* L. *Olea europaea* L
Oxalidaceae	*Oxalis* *Averrhoa*	*Oxalis triangularis* A.St.-Hil. *Averrhoa carambola* L*
Pandanaceae	*Pandanus*	*Pandanus odoratissimus* L.f.
Papaveraceae	*Bocconia* *Argemone*	*Bocconia fructescens* L. *Argemone mexicana* L.
Passifloraceae	*Passiflora*	*Passiflora edulis* Sims
Pinaceae	*Picea*	*Picea pungens* Engelm.
Poaceae	*Bambusa* *Cymbopogon* *Stipa* *Festuca*	*Bambusa vulgaris* Schrad.ex. Wendl *Cymbopogon citratus* (DC.) Stapf *Stipa capillata* L. *Festuca rubra* L.
Rhamnaceae	*Ziziphus* *Garcinia*	*Ziziphus mauritiana* Lam* *Garcinia kola* Heckel*
Rosaceae	*Rosa* *Malus* *Fragaria*	*Rosa canina* L. *Rosa gallica* L. *Malus domestica* Borkh *Malus pumila* Miller *Fragaria iinumae* L.
Rubiaceae	*Ixora*	*Ixora chinensis* Lam.

Table 1. Contd.

		Ixora coccinea L
		Ixora javanica (Blume) DC
	Gardenia	*Gardenia erubescens* Stapf & Hutch*
	Coffea	*Coffea arabica* L.*
Rutaceae	*Citrus*	*Citrus maxima* (Burm.) Merr
		Citrus limon (L.) Burm.f.
		Citrus sinensis L.
		Citrus clementina Hort.ex Tan.
		Citrus paradisi Macfad
		Citrus reticulata L.
Sapindaceae	*Blighia*	*Blighia sapida* K.D.Koenig*
	Dodonaea	*Dodonaea viscosa* Jacq.
Sapotaceae	*Chrysophyllum*	*Chrysophyllum cainito* L
	Vitellaria	*Vitellaria paradoxa* C.F.Gaertn.*
Scrophulariaceae	*Russelia*	*Russelia equisetiformis* Schlecht & Cham.
Selaginellaceae	*Selaginella*	*Selaginella buchholzii* Hieron.
Sterculiaceae	*Cola*	*Cola acuminata* Schott & Endl.*
	Sterculia	*Sterculia setigera* Del*
Strelitziaceae	*Ravenala*	*Ravenala madagascariensis* Sonn
Theaceae	*Camellia*	*Camellia japonica* L
Verbenaceae	*Duranta*	*Duranta erecta* L
		Duranta repens L.
	Gmelina	*Gmelia arborea* Roxb. ex Sm.*
	Lantana	*Lantana camara* L
	Verbena	*Verbena officinalis* L
Vitaceae	*Vitis*	*Vitis rotundifolia* L.
		Vitis vinifera L.
Zingiberaceae	*Zingiber*	*Zingiber officinale* Roscoe
Zygophyllaceae	*Balanites*	*Balanites aegyptiaca* (L.) Del.*

* = forest tree species.

Table 2. Classification of species recorded in the Sahelian zone.

Family	**Genres**	**Species**
Anacardiaceae	*Anacardium*	*Anacardium occidentale* L.*
	Mangifera	*Mangifera indica* L.*
	Sclerocarya	*Sclerocarya birrea* Hochst.*
	Lannea	*Lannea microcarpa* Engl. & Krause*
Annonaceae	*Annona*	*Annona squamosa* L
		Annona senegalensis Pers.*
		Annona muricata L.
	Polyalthia	*Polyalthia longifolia* (Sonn.) Hook.f.& Thomson
Apocynaceae	*Thevetia*	*Thevetia neriifolia* Juss. ex Steud

Table 2. Contd.

		Thevetia peruviana (pers.) K.Schum.
	Saba	*Saba senegalensis* (A.DC.) Pichon*
	Elaeis	*Elaeis guineensis* Jacq.*
	Borassus	*Borassus aethiopum* Man.*
Arecaceae	*Phoenix*	*Phoenix Dactylifera* L*
	Roystonea	*Roystonea regia* (Kunth) O.F.Cook*
	Cocos	*Cocos nucifera* L*
Caricaceae	*Carica*	*Carica papaya* L
Casuarinaceae	*Casuarina*	*Casuarina equisetifolia* L
	Combretum	*Combretum paniculatum* Vent*
		Combretum micranthum G. Don*
Combretaceae	*Guiera*	*Guiera senegalensis* J.F. Gmel.
	Terminalia	*Terminalia macroptera* Guill. & Perr.*
		Terminalia mantaly H.Perrier*
Ebenaceae	*Diospyros*	*Diospyros mespiliformis* Hochst. ex A.DC.*
Euphorbiaceae	*Euphorbia*	*Euphorbia milii* Des Moul
	Jatropha	*Jatropha curcas* L.
	Acacia	*Acacia albida* Del.*
		Acacia nilotica (L.) Willd. ex Delile*
		Acacia macrostachya DC.*
		Acacia seyal P.J.H.Hurter.*
		Acacia senegal (L.) Britton*
		Acacia tortilis (Forssk.) Hayne*
		Acacia gourmaensis A.Chev.*
		Acacia laeta R. Br. ex Benth.*
		Acacia Polyacantha Willd.*
	Detarium	*Detarium microcarpum* Guill. et Perr.*
	Delonix	*Delonix regia* (Bojer ex Hook.) Raf*
	Prosopis	*Prosopis africana* L.*
		Prosopis juliflora (Sw.) DC.*
	Afzelia	*Afzelia africana* Sm.*
Fabaceae	*Cajanus*	*Cajanus cajan* L.*
	Albizia	*Albizia lebbeck* (L.) Benth*
		Albizia chevalieri Harms*
	Cassia	*Cassia siamea* Lam.*
		Cassia occidentalis L.
	Peltophorum	*Peltophorum pterocarpum* (DC.) Backer ex k. Heyne*
	Tamarindus	*Tamarindus indica* L*
	Parkia	*Parkia biglobosa* (Jacq.) R.Br. ex G.Don*
	Parkinsonia	*Parkinsonia aculeata* L.*
	Piliostigma	*Piliostigma reticulatum* (DC) Hochst.*
		Piliostigma thonningii (Schum.) Milne-Redh*
	Bauhinia	*Bauhinia rufescens* Lam.*
	Leucaena	*Leucaena leucoceplala* (Lam.) de Wit*
	Dalbergia	*Dalbergia sissoo* Roxb.*
	Daniella	*Daniella oliveri* (Rolfe) Hutch. et Dalziel*

Table 2. Contd.

Lamiaceae	*Vitex*	*Vitex doniana* Sweet*
	Tectona	*Tectona grandis* L. f*
Lythraceae	*Punica*	*Punica granatum* L
	Adansonia	*Adansonia digitata* L*
Malvaceae	*Ceiba*	*Ceiba pentandra* (L.) Gaertn*
	Bombax	*Bombax costatum* Pellegr. & Vuillet*
Meliaceae	*Azadirachta*	*Azadirachta indica* A.Juss.*
	Khaya	*Khaya senegalensis* (Desr.) Juss*
Moraceae	*Ficus*	*Ficus benjamina* L.
		Ficus gnaphalocarpa (Miq.) Steud. ex A. Rich.*
		Ficus pumila L.*
Myrtaceae	*Eucalyptus*	*Eucalyptus camaldulensis* Dehnhardt.*
	Psidium	*Psidium guajava* L
Nyctaginaceae	*Bougainvillea*	*Bougainvillea spectabilis* Willd.
Olacaceae	*Ximenia*	*Ximenia americana* L.*
Poaceae	*Bambusa*	*Bambusa vulgaris* Schrad.ex. Wendl*
Polygalaceae	*Securidaca*	*Securidaca longipedunculata* Fresen.*
Rhamnaceae	*Ziziphus*	*Ziziphus mauritiana* Lam*
		Ziziphus mucronata Willd*
Rubiaceae	*Ixora*	*Ixora chinensis* Lam.
	Gardenia	*Gardenia erubescens* Stapf & Hutch*
	Morinda	*Morinda citrifolia* L
	Nauclea	*Nauclea latifolia* Sm.*
Rutaceae	*Citrus*	*Citrus maxima* (Burm.) Merr
		Citrus limon (L.) Burm.f.
		Citrus sinensis L.
		Citrus reticulata L.
Sapindaceae	*Blighia*	*Blighia sapida* K.D.Koenig*
	Dodonaea	*Dodonaea viscosa* Jacq.
Sapotaceae	*Vitellaria*	*Vitellaria paradoxa* C.F.Gaertn.*
Sterculiaceae	*Sterculia*	*Sterculia setigera* Del*
Verbenaceae	*Duranta*	*Duranta erecta* L
	Gmelina	*Gmelia arborea* Roxb. ex Sm.*
Zygophyllaceae	*Balanites*	*Balanites aegyptiaca* (L.) Del.*

* = forest tree species.

nurseries of the Sudanian zone, only nineteen have been identified as local species (Table 3). Classification of locally threatened tree species in Burkina Faso according to climatic zones revealed that among the local species of forest trees recorded in nurseries in this zone, six are considered threatened (Table 4). However, despite the limited number of nurseries in the Sahelian zone, a larger number of local species of forest trees have been

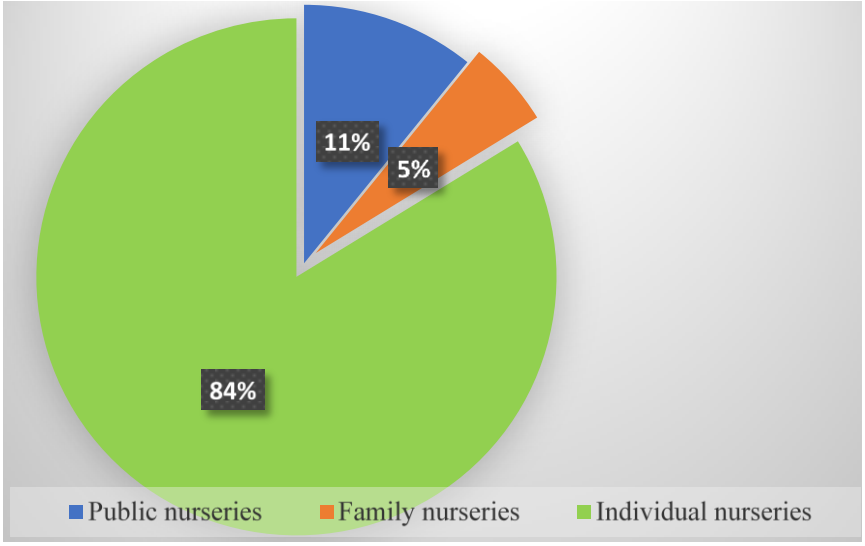

Figure 5. Proportion of different types of nurseries.

Table 3. List of local forest tree species in the Sudanian and the Sahelian zones in reference to Thiombiano and Kampmann (2010).

Local species of the Sahelian zone	Local species of the Sudanian zone
Acacia albida Del.	*Lannea microcarpa* Engl. & Krause
Acacia gourmaensis A.Chev.	*Annona senegalensis* Pers.
Acacia laeta R. Br. ex Benth.	*Saba senegalensis* (A.DC.) Pichon
Acacia macrostachya DC.	*Borassus aethiopum* Mart.
Acacia nilotica (L.) P.J.Hurter & Mabb.	*Acacia nilotica* (L.) P.J.Hurter & Mabb.
Acacia polyacantha Willd.	*Acacia senegal* (L.) Willd.
Acacia tortilis (Forssk.) Hayne	*Afzelia africana* Smith.
Acacia senegal (L.) Willd.	*Entada africana* Guill. & Perr.
Acacia seyal P.J.H. Hurter.	*Detarium microcarpum* Guill. & Perr.
Afzelia africana Smith.	*Tamarindus indica* L.
Anogeisus leiocarpus (DC) Guill & Perr.	*Parkia biglobosa* (Jacq) Benth.
Azadirachta indica	*Bauhinia rufescens* Lam.
Balanites aegyptiaca (L.) Del.	*Bombax costatum* Pellegr. & Vuillet
Bauhinia rufescens Lam.	*Kaya senegalensis* (Desr.) Juss
Blighia sapida K.D.Koenig	*Ximenia americana* L.
Bombax costatum Pellegr. & Vuillet	*Ziziphus mauritiana* Lam
Borassus eathiopum Mart.	*Blighia sapida* K.D.Koenig
Cassia sieberiana DC	*Vitellaria paradoxa* C.F.Gaertn.
Combretum micrantum G.Don	*Balanites aegyptiaca* (L.) Del.
Daniella oliveri Hutch & Dalziel	
Detarium microcarpum Guill. & Perr.	
Diospyros mespiliformis Hochst. ex A.DC	
Gardenia erubescens Stapf & Hutch	
Guiera senegalensis J.F. Gmel.	
Khaya senegalensis (Desr.) Juss	
Lannea microcarpa Engl & K.Krause	
Parkia biglobosa (Jacq) Benth.	
Piliostigma reticulatum (DC) Hochst	
Piliostigma thonningii (Schumach) Milne-Redh	

Table 3. Contd.

Prosopis africana L
Pterocarpus erinaceus Poir
Pterocarpus luscens Lepr
Saba senegalensis (A.DC.) Pichon
Sclerocarya birea (A.Rich) Hochst
Securidaca longepedonculata Fresen
Steriospermum kunthianum Cham
Tamarindus indica L.
Vitellaria paradoxa C.F.Gaertn
Vitex doniana Sweet
Ximenia americana L.
Ziziphus mauritiana Lam
Ziziphus mucronata Lam

Table 4. List of local threatened species cultivated in nurseries (Thiombiano and Kampmann, 2010).

S/N	Endangered local species in the Sahelian zone	Endangered local species in the Sudanian zone
01	*Acacia macrostachya*	*Borassus aethiopum*
02	*Anogeisus leiocarpus*	*Afzelia africana*
03	*Bombax costatum*	*Tamarindus indica* L.
04	*Combretum micrantum*	*Parkia biglobosa*
05	*Lannea microcarpa*	*Kaya senegalensis*
06	*Pterocarpus luscens*	*Vitex doniana*
07	*Saba senegalensis*	
08	*Sclerocarya birea*	
09	*Ziziphus mauritiana* Lam	

Table 5. Profit generated by the sale of forest tree plants per year.

Variable	Sudanian zone	Sahelian zone
Number of plants produced/year	7,000	50,000
Variable costs (FCFA)	800,000	400,500
Fixed costs (FCFA)	300,200	20,000
Production cost (FCFA)	1,100,000	420,500
Turnovers (FCFA)	2,200,600	850,000
Profit (FCFA)	2,099,800	429,500
BRC	**1.91**	**1.02**

RBC = Ratio benefit/production cost.

identified compared to the low number of local tree species in the large number of nurseries in the Sudanian zone. Indeed, with only 4 nurseries identified in the Sahel, 43 local species have been recorded among a total of 66 forest trees species (Table 3). Among the local species of forest trees in the Sahelian zone, nine species are listed as threatened (Table 4).

Assessment of the profitability of forest species

The profitability of forest species in each zone was assessed by considering the profit and the total cost of production (Table 5). Indeed, it appears from this table that in the Sudanian zone, horticulture of both forest and non-forest species mobilizes 910,000 FCFA per year for

each nursery. With a turnover of 2,200,600 FCFA, nurseries have an average annual profit of 1,290,600 FCFA. The RBC was greater than 1 (1.42). This indicates that a horticulturist who invests 1 FCFA in the production of forest tree species earns more than 1 CFA franc. This activity is therefore found to be profitable in the Sudanian zone. In the Sahel, nursery growers are investing 420,500 FCFA in the production of the species in each nursery. In addition, the turnover was estimated at 850,000 FCFA with an average profit of 429,500 FCFA per year. Besides this, the results reveal that the profit/production cost ratio was also greater than 1. However, the benefit was too low as RBC was only 1.02. Consequently, nursery growers in the Sudanian zone make more profits compared to nursery growers in the Sahelian zone.

DISCUSSION

Nurseries in the preservation of forest tree species

The entirety of the nurseries catalogues two hundred and eighty-seven (287) plant species, with 243 in the Sudanian zone and 90 in the Sahelian zone. In natural ecosystems, a gradual increase in species richness, as reported by REEB (2017) is observed from the North to the South of Burkina Faso, with 60 species in the strictly Sahelian zone, 104 species in the south Sahelian zone, 153 species in the north Sudanian zone, and 201 species recorded in the south Sudanian zone. In contrary, in nurseries at the Sahelian zone, forest species predominantly prevail, totaling 66 out of the 90 recorded species. This predominance can be explained by various factors, including reforestation efforts to counter desertification and promote environmental restoration.

The drier climatic conditions of the Sahelian region have likely favored tree species adapted to these challenging environments, as the Sahel has been the epicenter of intense reforestation initiatives for about a century (Mugelé, 2020). Local forest species produced in nurseries in both zones are considered critical in natural forests. They are facing the threat of extinction according to the IUCN Red List (IUCN, 2021). However, these species are less produced in nurseries in the Sudanian zone, primarily due to lower customer demand. Reforestation plants are more easily sold only during the rainy season, a favorable period for planting and for reforestation of degraded ecosystems in Burkina Faso. According to Fanampihery (2011), the primary objective of creating a nursery in some regions is to reproduce endangered plants to contribute to biodiversity preservation. Unfortunately, in several African countries, including Burkina Faso, there is a lack of interest among the local population of forest species. Populations seem more attracted to fruit plants for their courtyards (Traoré and Zongo, 2023). However, the cultivation of forest plants for reforestation purposes is crucial for forest restoration, the provision of ecosystem services, and large-scale climate change mitigation (Fargione et al., 2021). Thus, government structures, such as the Ministry of Environment, its decentralized departments, and some NGOs involved in environmental and biodiversity preservation, are mostly the main customers during the rainy season. They acquire plants for reforestation and the restoration of vegetation cover in degraded forests. While local forest species play a crucial role in biodiversity preservation and environmental restoration, their valorization remains a challenge in the local context. The process of seedling production in nurseries is directly influenced by the demands expressed by local populations. Consequently, the majority of species cultivated in these nurseries are non-local (exotic) plants, mainly intended for ornamental purposes. This predominance of exotic species is explained by some ecological and cultural factors, including the low productivity of local species and the relatively low interest of customers in them (Soma, 2012). The preference of horticulturists for non-local species is highlighted by their choice to invest primarily in the production of local plants only during the rainy season, corresponding to the reforestation period. Thus, the demand for forest tree species, although present, contributes to the diversification of species in nurseries and is often linked to reforestation initiatives (Traoré and Zongo, 2023). The entire process reflects the complexity of interactions between local biodiversity, nursery practices, and consumer preferences. To overcome these challenges, concerted efforts are needed, including awareness campaigns to promote the importance of local forest species, as well as economic incentives to encourage the production and use of species in reforestation and environmental restoration projects. By working collaboratively with local communities, governments, and environmental organizations, an essential role can be played in biodiversity preservation and the promotion of sustainable practices in the nursery and reforestation field.

Social and economic importance of nurseries

The establishment of nurseries is largely driven by several factors, with the most significant being the contribution to income. Seedlings are produced according to the needs expressed by local populations in order to earn more money. Thus, the majority of species produced in nurseries are exotic plants mostly used for ornamentation purpose as observation at the Sudanian zone in nurseries of Bobo-Dioulasso (Traoré and Zongo, 2023). The production of forest tree species mainly during rainy season for domestic use and for reforestation participates to the diversification of species in nurseries. Horticultural activity is lucrative and improves the social

and economic living conditions of populations. In the city of Bobo-Dioulasso, horticulturists earn more money compared to those of Dori city. Forest tree species are mostly grown in public nurseries and directly used by the government or NGOs for reforestation. The great part of forest tree species is directly used by the government for free and the other part is sold. This situation explains the low RBC found in the city of Dori (RBC = 1.02) compared to the city of Bobo-Dioulasso (RBC = 1.42) where horticulture is more profitable. As observed in this study, horticulturists in the city of Cocody in Côte d'Ivoire are satisfied with their activity and 94% of respondents find it lucrative (Dabié and Gbitry, 2016). The economical portability of horticulture in nurseries comes from the fact that produced plants are primarily destined to be sold. They are socially profitable because they are used as ornamental plants at home or elsewhere in the city, or given as a gift in some African countries like Cameroon (Tchounji, 2012). In the city of Bobo-Dioulasso, the demand for ornamental plants is high, leading to the dominance of ornamental plants produced in nurseries in this city. The population of such a city that is the second larger town of Burkina Faso, with a higher standard of living, is more interested in ornamental plants compared to the population of Dori (a small Sahelian town) where few nurseries with few ornamental species are encountered. Indeed, the purchase of ornamental plants and flowers for use is related to the standard of living of population in the city, the level of education and the family income of consumers. Even though horticulture is found to be profitable, the unavailability of land, water and land pressure in cities are constraints to the expansion of nursery plant cultivation (Niang, 2018). Diversification of cultivated species, especially forest tree species, that is encouraged through reforestation initiatives and awareness programs could increase interest in these species and profitability of horticulturists.

Conclusion

This study provides comprehensive analysis of the challenges and opportunities associated with cultivating plants species, especially forest tree species in nurseries at the Sudanian and Sahelian climatic zones of Burkina Faso. The floristic composition of nurseries in the cities of Bobo-Dioulasso at the Sudanian zone and Dori at the Sahelian zone highlighted a strong prevalence of forest tree species in the Sahelian zone primarily used for reforestation. This situation emphasizes the positive impact of reforestation initiatives in challenging environments. In the meantime, the production of plant species in nurseries is a source of income for populations. However, higher profits were observed in the Sudanian zone compared to the Sahelian zone where species are mainly cultivated for reforestation as well as for domestic use. Ultimately, the valorization of local forest species plays a crucial role, not only in the economic prosperity of stakeholders' sector but also in promoting forest resources and the ecological sustainability of the region.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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