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STRUCTURAL CHARACTERISTICS OF CASHEW (*ANACARDIUM OCCIDENTALE* L.) REPRODUCTIVE MATERIAL SOURCES IN WEST-CENTRAL BURKINA FASO

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ABSTRACT

The sustainability of cashew (*Anacardium occidentale*) cultivation depends on the quality of available sources of reproductive material (RMS). In Burkina Faso, some planting material of this species comes from RMS with unknown characteristics. This study aims to improve knowledge of cashew RMS in west-central Burkina Faso to support efforts to improve the seed production system. Data were collected from 30 randomly selected RMS on 53 square plots of 2,500 m2. Trunk diameters, tree height were measured, and health status was assessed. Equivalent diameter, density and importance value index were calculated. The structures were fitted to the Weibull distribution. The results showed that the RMS, constituted by stands (90%) and seed sources, were juvenile when considering their structures ($1 < c < 3.6$). Most RMS (80.5%) were attacked by fungi. Densities of individuals were 102.370±43.120 at To and 91.846±21.442 at Leo. Locally valued and vulnerable woody species were associated with the targeted RMS (78.33%) and cropping associations were practiced (93.33%).Unless there is other evidence, the conditions observed are representative of other unapproved RMS in the country. The results suggest that the quality of the plant material supplied by these RMSs should be improved.

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INTRODUCTION

Agroforestry resources support the economic and social development of rural communities in sub-Saharan Africa. Among them is the cashew tree (*Anacardium occidentale* L.), a species native to the Caribbean and northeastern Brazil whose introduction to Burkina Faso dates back to the 1960s (Hiema, 2011). The species has a wide range of uses, including food, feed, medicine, cosmetics and confectionery (Bélem, 2017; Semporé, 2022). Its importance is such that the raw cashew nut has become Burkina Faso's second most important agricultural export (INSD, 2022). However, the productivity of the country's cashew orchards, which average 354kg/ha, is low compared with highly productive countries, such as India, whoseproductivity averages 650kg/ha (RICAU, 2019). Due to the shortage of quality seed, rural growers exploit sources of reproductive materials (RMSs) with unknown characteristics to establish plantations (Sperling and Mc Guire, 2010; Lillesø *et al.*, 2011; Issoufou, 2022). According to OECD (2024), RMS include seed sources, stands, seed orchards, parents of families, clones and clonal mixtures in which forest reproductive material (RM) is produced. RM refers to seeds, plants and plant parts (OECD, 2024). Stands are naturally or artificially renewed from RM originating from the same delimited stand.Burkina Faso's commitment, through the Ministry of Environment, Water, and Sanitation, to distribute only certified forest reproductive material materialized through by the promulgation of a Plant Seed Law in 2006, then through the country's accession to the OECD Forest Material Scheme in 2008, with the Centre National de Semences Forestières appointed as the Designated Authority for the application of the Scheme. Since then, work has focused on four species of national and international interest: *Acacia senegal*, *Anacardium occidentale*, *Khaya senegalensis* and *Parkia biglobosa*. Insufficient scientific information on RMS limits proper selection and breeding initiatives, and constitutes a shortcoming for the seed sector (OECD, 2024). This study aims to improve knowledge of To and Leo RMS of *Anacardium occidentale* in the Centre-Ouest region. Some of the RMStargeted include candidate trees monitored as part of a breeding program in Burkina Faso.

MATERIALS AND METHODS

Study area: The study area includes the municipalities of Leo (11° 6′ 0″ Nord, 2° 6′ 0″ Ouest) and To (11° 27′ 0″ Nord, 2° 13′ 60″ Ouest) in the Centre-Ouest region of Burkina Faso (Figure 1). It is located between isohyets 900 mm and 1,200 mm in the South Sudanian phytogeographical zone. The vegetation is savannah (Fontès and Guinko, 1995). The dry season lasts from October to April, followed by a rainy season from May to September. Soils are hydromorphic and mainly leached tropical ferruginous (POUYA, 2016).

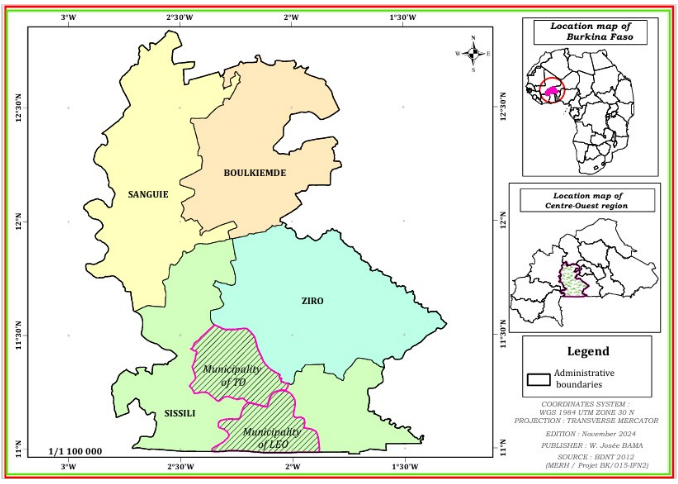


Figure 1. Map showing the location of the municipalities targeted by this study

METHODOLOGY

Surveys: Semi-structured interviews were conducted with 60 owners of RMS, selected using the snowball method. The data collected related to the geographical location of the RMS that supply planting material, the age of the trees, the size of the area, species composition and type of management. This information was double-checked on the ground, while conducting a floristic inventorycarried out in 2023.

Floristic inventory: The floristic inventory applied the sampling technique recommended by Thiombiano *et al* (2016). It was carried out in 53 square plots of 2,500 m2 locatedacross 30 randomly selected RMS. In each RMS with a surface area of more than 5 hectares, plots were installed with a seed tree as plot center, avoiding overlap of different plots. The data collected related to species name, health status and dendrometric variables of all woody individuals. Other cultivatedspecies grown in association with *Anacardium occidentale* were also recorded.

Typology and variables measured

The RMS typology used in this study was based on the OECD guidelines for forest seed and seedlings (OECD, 2024).The following dendrometric measurements were taken:

- ✓ The diameter (DBH) of the trunk was measured at 1.30 m from the ground;
- ✓ Height was estimated using an electronic dendrometer;
- ✓ The equivalent diameter (déq) of forked trees below 1.30 m from the ground, corresponding to the quadratic sum of the diameters of each stem i (Thiombiano *et al*.,2016) was obtained with the following formula (Lejeune and Rondeux, 1994; ChoJnacky, 1994):

$$deq = \sqrt{\sum_{i=1}^{n} d_i^2}$$

with n= number of stems; and di= diameter of each branch.

- ✓ The density(D)of all woody individuals / ha;
- ✓ The ecological importance of the woody species was assessed using the Importance Value Index (IVI). It is calculated according to the following formula (Mishra, 1968; Curtis, 1959; Curtis and McIntosh, 1950):

Importance Value Index (IVI) = Relative density + Relative dominance + Relative frequency

where:

- ✓ Relative dominance= (total basal area of species)/(basal area of all species)*100
- ✓ Relative density=(number of individuals of species/ha)/(total number of individuals/ha)*100;
- ✓ Relative frequency=(Frequency of species)/(Sum of frequencies of all species)*100.

Data analysis

To characterize stand structure, all woody individuals were grouped according to diameter and height classes at amplitudes of 10 cm and 5 cm respectively. Horizontal and vertical RMS structures were generated by applying the 3-parameter Weibull distribution (a, b and c) whose function f(x) is as follows:

$$f(x) = c/b\left(\left(x-a\right)/b\right)^{(c-1)} e^{(-((x-a)/b))}$$

with "x" being the diameter or height of the trees; "a" the position parameter; "b" being the scale or size parameter; "c" the shape parameter related to the diameter or height structure considered (Rondeux, 2021).

The value of "c" translates into the following Weibull distribution shapes (Ryniker *et al*., 2006):

c< 1:"inverted J" distribution, multispecific or uneven-aged RMS ;
c=1:exponentially decreasing distribution, RMS extinction;
1<c <3.6:positive asymmetric distribution, monospecific RMS with predominance of small-diameter individuals;
c=3.6:symmetrical distribution; normal structure, even-aged or monospecific RMS of the same cohort;
c>3.6:negative asymmetrical distribution, monospecific RMS with predominance of large-diameter individuals.

R software version 4.3.0 and Minitab 19 were used to calculate dendrometric parameters and apply the Weibull distribution. All data were tested for normality using the 5% Shapiro-Wilk test, before the analysis of variance, which was used to calculate means, standard deviations, minima and maxima. Means were compared using ANOVA ($P \geq 0.05$) and Kruskal Wallis ($P < 0.05$).

RESULTS

State of RMS: The RMS inventoried were seed sources (10%) i.e trees from which seeds are collected and stands (90%). The average age of RMSwas 10 ± 1.19 years in To and 15 ± 1.36 years in Leo. The areas covered by RMSwere generally greater than one hectare (Table 1). RMSin Tohad an average surface area of 3.5 ± 0.8 ha, compared with 4 ± 0.51 ha inLeo. The distance between RMSwas variable. It should be noted that weeds in the undergrowth of some RMS are not regularly cleared. Similarly, infested parts of the canopy are not removed or treated adequately.

Phytosociological characteristics of RMS

Floristic composition: The RMS studied were predominantly multi-species (78.33%), with 12 species belonging to 10 families in To, and 8 species belonging to 7 families in Leo (Table 2). Species from the Anacardiaceae family were the most numerous (25%). The most common indigenous species were *Parkia biglobosa* (Jacq.) R.Br. ex G.Don, *Vitellaria paradoxa* C.F.Gaertn and *Adansonia digitata* L.

Table 1. Average age and area of RMS of *A. occidentale* in to and Leo

RMS	Modalities	Leo zone	To zone
		Percentage (%)	Percentage (%)
Age	< 10 years	20	40
	10–25 years	70	60
	>25 years	10	0
Area	< 1 ha	14	17
	1–5 ha	60	50
	5–10 ha	23	23
	10–15 ha	3	7
	>15 ha	0	3

Table 2. Floristic composition of RMS in to and leo

To		Leo	
Families (n =10)	Species (n=12)	Families (n =7)	Species (n =8)
ANACARDIACEAE	*Anacardium occidentale* L. [cult.]	ANACARDIACEAE	*Anacardium occidentale* L. [cult.]
	Lannea microcarpa Engl. & K.Krause		*Mangifera indica* L.[cult.]
	Mangifera indica L.[cult.]		
SAPOTACEAE	*Vitellaria paradoxa* C.F.Gaertn.	COMBRETACEAE	*Terminalia sp*
FABACEAE-MIMOSOIDEAE	*Parkia biglobosa* (Jacq.) R.Br. ex G.Don	MALVACEAE	*Adansonia digitata* L
MALVACEAE	*Adansonia digitata* L	MYRTACEAE	*Psidium guajava L.* [cult.]
MORINGACEAE	*Moringa oleifera* L.	SAPOTACEAE	*Vitellaria paradoxa* C.F.Gaertn
MYRTACEAE	*Eucalyptus camaldulensis* Dehnh. [cult.]	ZYGOPHYLLACEAE	*Balanites aegyptiaca* (L.) Delile
EBENACEAE	*Diospyros mespiliformis* Hochst. ex A.DC.	FABACEAE-MIMOSOIDEAE	*Parkia biglobosa* (Jacq.) R.Br. ex G.Don
FABACEAE-CAESALPINIOIDEAE	*Isoberlinia doka* Craib & Stapf		
LAMIACEAE	*Vitex doniana* Sweet,		
COMBRETACEAE	*Combretum micranthum* G. DON		

Table 3. Ecological Importance Value Indices (IVI) for species inventoried at Toand Leo

Species	To		Leo	
	IVI	Proportion (%)	IVI	Proportion (%)
Anacardium occidentale	142,50±19,99[a]	24,24%	154,28±30,34 [b]	29,11%
Parkia biglobosa	71,04±35,92[b]	12,08%	64,42±14,36 [ab]	12,15%
Vitellaria paradoxa	61,58±19,17[b]	10,47%	60,71±17,71 [ab]	11,45%
Adansonia digitata	48,64±2,34[bc]	8,27%	66,00±9,86 [ab]	12,45%
Diospyros mespiliformis	45,02±00[bc]	7,66%		
Mangifera indica	43,50±9,13[bc]	7,40%	61,38±12,47 [ab]	11,58%
Balanites aegyptiaca			52,99±00 [ab]	10,00%
Terminalia sp			36,13±00 [a]	6,82%
Psidium guajava			34,14±0,79 [a]	6,44%
Isoberlinia doka	37,36±00[bc]	6,35%		
Lannea microcarpa	34,90±17,51[bc]	5,94%		
Combretum glutinosum	33,08±00[bc]	5,63%		
Vitex doniana	31,38±00[bc]	5,34%		
Moringa oléifera	19,86±0,31[c]	3,38%		
Eucalyptus camaldulensis	19,05±0,47[c]	3,24%		
P-value	0,0004		0,001	

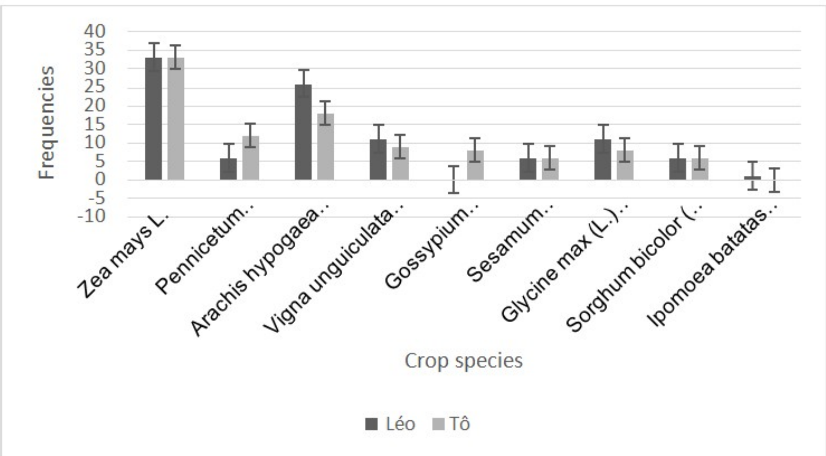


Figure 2. Statement of agricultural species associated in *Anacardium occidentale* RMS

Tables 3 present the rankingof species inventoried in RMS according to their IVI values. At both ToandLeo, *Anacardium occidentale*was the most ecologically important species. In contrast, the ranking for the other species was different between the two sites.

Agricultural species associated with Anacardium occidentale RMS: The inventory revealed that intercropping was practised on 93.33% of RMS's area. Maize (*Zea mays* L.), groundnuts (*Arachis hypogaea*), millet (*Pennicetum glaucum*), cowpeas (*Vigna unguiculata*) and sesame (*Sesamum indicum*) were the main associated crops. The analysis of variance showed no significant Diffrence (P=0.58) in the composition of agricultural crops found in the RMS at To and Leo (Figure 2).

Sanitary status of cashew individuals: Visible symptoms of gummosiswere noted on cashew trees (Figure 3). An infestation rate of around 80.5% was noted on all the RMS inventoried, i.e. 81% in To and 80% in Leo. The symptoms related to a fungal pathology caused by *Lasiodiplodia theobromae* and characterized by the flow of a rigid fluid onto the tree trunks. Used engine oilwascommonly applied directly to the infested areas to treat the fungal attack.

Figure 3. Symptoms of gummosis

Density and structure of *A. occidentale* RMS of to and Leo

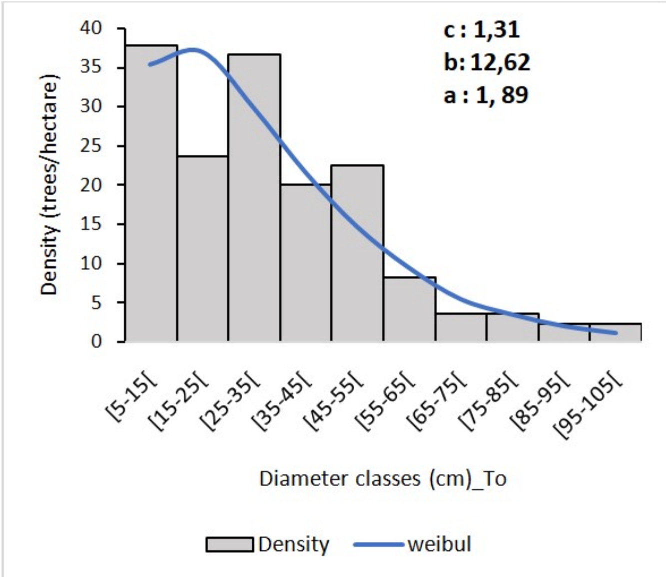
Density: The Kruskal Wallis test performed at the 5% threshold on the mean density of individuals of *A. occidentale*and on their mean diameters showed a highly significant difference (p = 0.0032) in the densities of this species inRMS in To and Leo. Density of the target species was higher in To, with 102,370±43,120 individuals per hectare, while Leo RMS presented 91,846±21,442 individuals per hectare (Table 4).

Spatial structures

Horizontal structure: There was a significant difference (p= 0.0145) in DBH between the two localities.The horizontal structure has the appearance of a positive asymmetric distribution that fits the Weibull density function (1 < c < 3.6) and is characteristic of monospecific artificial RMS (Figures 3).

Table 4. Average densitie, average diameters and heightof woody plants in *A. Occidentale* RMS in Tô and Léo.

site	Density (ind/ha)	DBH(m)1	Height (m)
Tô	102,370±43,120a	0,19±5,55a	4,29±0,72a
Léo	91,846±21,442b	0,15±4,37b	3,69±0,63a
p-value	0,0032	0,0145	0,12



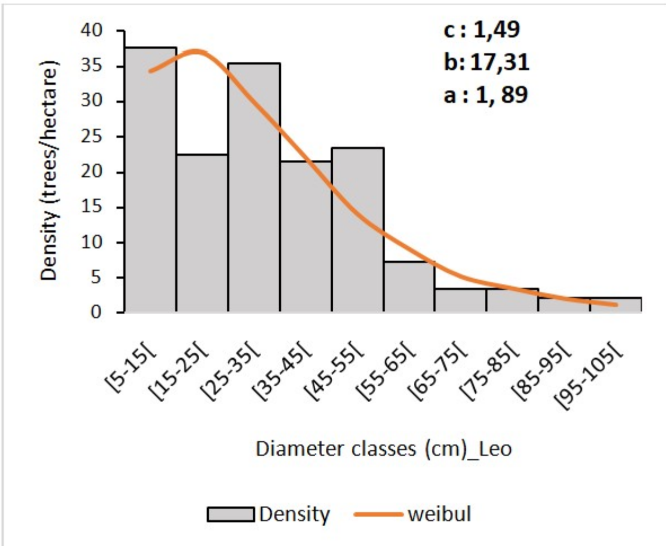


Figure 4. Horizontal structure of *A. occidentale* RMS in To and Leo

Vertical structure: The vertical structure visualized for *A. occidentale*-based RMS in Leo and To shows a positive asymmetrical distribution (1 < c < 3.6), characteristic of monospecific artificial stands with a relative predominance of young, small-diameter individuals (Figures IIa, b).

DISCUSSION

In this study, the stands recorded were more abundant (90%) than seed sources (10%). This is explained by the fact that, for a long time, plantations were established with reproductive material of unknown characteristics, and planting material was sources from these plantations, selecting the best existing productive trees. The creation of the first seed sources has recently been documented in the country as part of the implementation of a genetic improvement program (Soloviev *et al*., 2010).That also explains why the majority of RMS are between 10 and 25 years old. Referring to the age of Peni's RMS at the date of their regulatory approval (BAMA *et al*., 2025), the RMS of To and Leo are considered eligible for regulatory approval.Stands provide grafts for vegetative propagation, while seed sources are supposed to provide improved seeds. The use of these two types of RMS reflects the widespread need for high-quality plant material for establishing *A. occidentale* orchards. Then, given the expansion of agriculture, it is difficult to establish RMS large enough to meet demand due to competition for land, hence the 1 to 5 ha areas. The large seed companies with large acreages are mainly involved in agricultural and vegetable seed production. Ndiaye *et al*. (2017) and Sali *et al*. (2020) observed similar characteristics for agroforestry parks in Senegal and Cameroon.

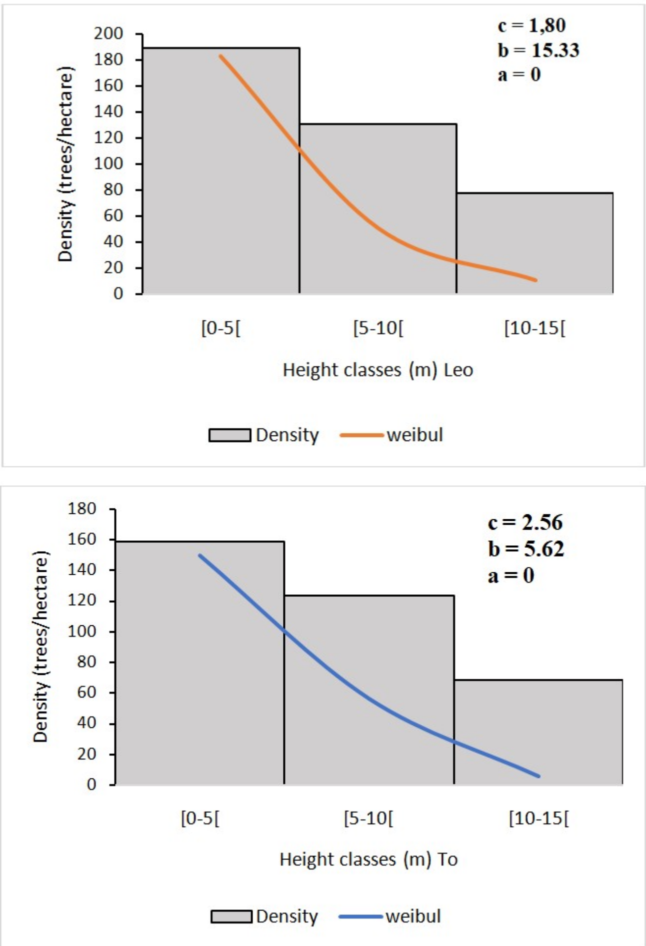


Figure 5. Vertical structure of *A. occidentale* RMS in Leo and To

The intercropping practices RMS indicate that farmers cannot afford to leave uncultivated spaces between trees. Furthermore, the sparing of other species during the establishment of cashew plantations is a means of adaptation that confirms the the scarcity of agricultural land (Ouattara *et al*. 2019; Koueta *et al*., 2023). Like McCune and Grace (2002) and Traoré *et al*. (2011), the IVI has enabled us to better appreciate the importance of species in a plant community. It highlighted four dominant agroforestry species in RMS namely *Anacardium occidentale*, *Parkia biglobosa*, *Adansonia digitata* and *Vitellaria paradoxa*. These species are widely recognized for their high socio-economic and ecological value (Dawson *et al*. 2020). *Parkia biglobosa, Vitellaria paradoxa* and *Adansonia digitata* are local species that are fully protected in Burkina Faso and considered highly vulnerable (Eyog Matig *et al*. 2002; YAOVI *et al*. 2021). The diversity of local tree species in RMS suggests that further investigation is needed into the impact of cashew cultivation on the composition and appearance of forest landscapes, as well as the condition of local tree species populations. The agroforestry practices constitute a form of diversification of producers' sources of income (Gintzburger *et al*., 2000; Barro, 2014; Ndiaye *et al*., 2017; Dawson *et al*. 2020; Diarra *et al*. 2023). However, the crop combinations observed are disparate, sometimes mixed with weeds, posing a risk of disease. Boland *et al*. (1980) recommend that RMS be monospecific and separated by a minimum distance of 100 meters from other RMS of the same species or different species. These conditions, combined with exposure to external pollination, suggest that the genetic performance of seed tree progeny could be impaired (Lacroix, 2003; OECD, 2022). Failure to comply with these guidelines explains *Lasiodiplodia theobromae* infestation observed in the majority of RMS, and confirms the findings of Soro *et al*. (2020) that lack of maintenance increases the risk of plantation infestation by around 5%. The positive asymmetric distribution visualized in the theoretical 3-parameter Weibull model for height and diameter structures is characteristic of artificial stands with a relative predominance of young, low-diameter, low-height individuals. DBH is 22.7 ± 0.09 cm in stands at Leo. This is high compared with that of seed sources (14.07 ± 6.26 cm). Generally speaking, the heights of RMS are low (4.98± 1.88 m at Leo and 4.03± 1.95 m at To) compared with those of the Dindéresso classified forest in western Burkina Faso, where the average is 6.68 ± 2.08 m, and individuals are older (40 years) (Yoni *et al*., 2023). It is therefore important to check whether the youthfulness of cashew RMS means the increase in the area devoted to the species. If that turned out to be the case, it would corroborate the fact that floristic diversity would be eroded in favor of cash crops (Ramboatiana *et al*., 2018).

CONCLUSION

The study showed that two types of RMS are exploited in To and Leo, namely stands and seed sources. Very important, protected and vulnerable local agroforestry species, are associated with RMS, notably *Parkia biglobosa, Adansonia digitata* and *Vitellaria paradoxa*. Agricultural species such as *Zea mays*, *Arachis hypogaea* and *Vigna unguiculata* dominate the undergrowth. While these associations help to improve soil health and diversify producers' income, their positive impact on reproductive material quality remains to be verified. Seed trees have a high infestation rate, increasing the potential risk of depreciating the quality of reproductive material. As a result, RMS do not comply with the rules laid down for producing forestry materials. However, given the relatively young age of all the RMS in the study area, strict adherence to technical procedures is necessary to guarantee the production of higher quality RMS.

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