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Article

Floristic Composition and Structure in the Undergrowth of Agroforests in Neems in the Far North Region (Cameroon)

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Abstract: This study took place in the Far North region of Cameroon. The general objective was to assess the floristic diversity of the undergrowth of Agrosystems in *Azadirachta indica*. The data were collected in 100 m long by 20 m wide transects surveyed in plantations of different ages. In total, 5 transects were carried out, ie a total area of 1 ha per site. The sampling bands were established using the compass, decameter, GPS and wires. The experimental set-up used was a 5-repetition split plot. A total of 7689 individuals divided into 9 families, 13 genera and 16 species have been identified. *Guiera senegalensis* and *Piliostigma thonningii* are the most common in terms of relative abundance. The analysis of the Family Importance Index (VIF) shows overall that the Combretaceae, and Mimosaceae are the most important in ecological terms. While those of the species show that *Guiera senegalensis*, *Combretum micranthum* and *Acacia nilotica* finally for the genera, it is Acacia, Guiera and Combretum which contains the most important ecological indices. The overall density of species within the plots varies between 129 and 105 ind / ha. The basal area varies from 2.02 to 3.88 m² / ha. The Importance Value Index (IVI) is of the order of 300 in the different plots. The floristic diversity of the undergrowth of Agrosystems (average ISH> 2) shows homogeneity and an even distribution between the different plots. Plots with similarity indices of less than 50% do not meet floristic affinity while similarity indices are high in plots with floristic affinities greater than or equal to 50%. The diameter structure showed a predominance of young individuals. This information drawn from the conclusion of the present study shows that they constitute an important argumentation of the advantages so that the services of agricultural development should be interested in the conservation and valuation of such an agroforestry system for the protection of the environment against the climate change mitigation and sustainable development of local communities.

Keywords: Floristic composition, Structure, Agrosystem, Neems, Far-north, Cameroon

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1. Introduction

Thanks to the fact that it adapts well to hot and dry climates, neem has become a very commonly planted species in the dry tropics and subtropics of Oceania, Asia, Africa and America [1] (Faye M., 2010). In Africa, more specifically in Cameroon, natural resources are of definite socio-economic interest for local populations and enable them to meet their basic needs. The introduction of *Azadirachta indica* species native to India imported from Nigeria (Maiduguri) by the Administrators of the time (1947-1948) in the region of the Far North Cameroon [2] (Seignobos et al, 2000 in Rousgou, 2017) is a real step forward. The neem remains a priori one of the exotic species with rapid growth and the most distributed in the north; we can perceive it from its predominance in the vegetation and the geographical space which is the subject of our study.

This being the case, we can question the interactions between man and his environment due to the exploitation of the said plant; In other words, even if we are on the impact in terms of improving the well-being of populations in terms of traditional pharmacopoeia, food, construction materials, etc., we wonder about the pressure put on the essence of *Azadirachta indica* and the induced and direct effects on the environment in terms of soil degradation, deforestation and Climate Change.

Since its introduction in the north until today, this species, in homogeneous or heterogeneous plantations, occupies large areas in urban agglomerations and reforestation areas. Thus, the departments of Mayo-danay, Diamaré, Mayo-kani, Mayo-sava, Mayo-tsanaga and Logone and Chari are real forests in the making despite the lack of replenishment of khaya and neem stands. In aerial view, they can be compared to gallery forests [3] (GIZ, 2014). Indeed, the use of A. indica occupies an increasingly large place in the daily life of the local population thanks to its many uses in traditional pharmacopoeia, food, timber. However, this process of deforestation in the northern part of Cameroon is largely due to the population's use of wood as the main source of domestic energy [4] (Sofalne et al., 2017). This contributes to the reduction or loss of flora and fauna diversity. Indeed, the degradation of ecosystems is now a threat to biodiversity, because the destruction of natural environments inevitably leads to the scarcity or even the disappearance of species [2] (Swaminathan, 1990, in Rousgou, 2017). According to the United Nations Food and Agriculture Organization (FAO), around 13 million ha of forests disappear annually on the earth [5] (FAO, 2010). In 2000, the Convention on Biological Diversity estimated that 54,000 plant species and 5,200 animal species, due to human action, were facing extinction [6] (SCBD, 2000). Recently a joint study conducted by the Institute of Agricultural Research for Development (IRAD) and the Royal Botanic Garden of London revealed that out of 7,850 plant species encountered in Cameroon, 815, or nearly 10% are threatened with extinction [7] (Onana& Cheek, 2011). It is necessary to promote education and awareness among local populations to put in place measures for the protection, enhancement and domestication of these endangered species.

2. Materials and methods

2.1. Study site

With a population of 3,480,414 inhabitants, the Far North region is the most populous region in northern Cameroon. It is made up of six departments, namely Diamaré, Mayo-Danay, Mayo-Kani, Mayo-Sava, Logone and Chari and Mayo-Tsanaga. The study is taking place more precisely in the departments of Diamaré, capital of Maroua; Mayo-Danay, Yagoua capital; Mayo-Kani capital Kaélé and Mayo-Tsanaga capital Mokolo. Geographically, the Far North is located between 10 ° N and 13 ° N in the heart of the tropical zone with a Sudano-Sahelian climate. It shares common and porous borders with Chad, Nigeria and Niger. On the physical level, this region is divided into three natural sub-regions which are the Mandara Mountains, the Diamaré plain and the flood zones of Logone and Chari. Each sub-region has natural characteristics [8] (DJARMAILA, 2011). Its soil is ferruginous and clayey with low penetration. The scarcity of precipitation conditions the type of vegetation. It is very disparate and dominated by the "nemie" resulting from reforestation projects.

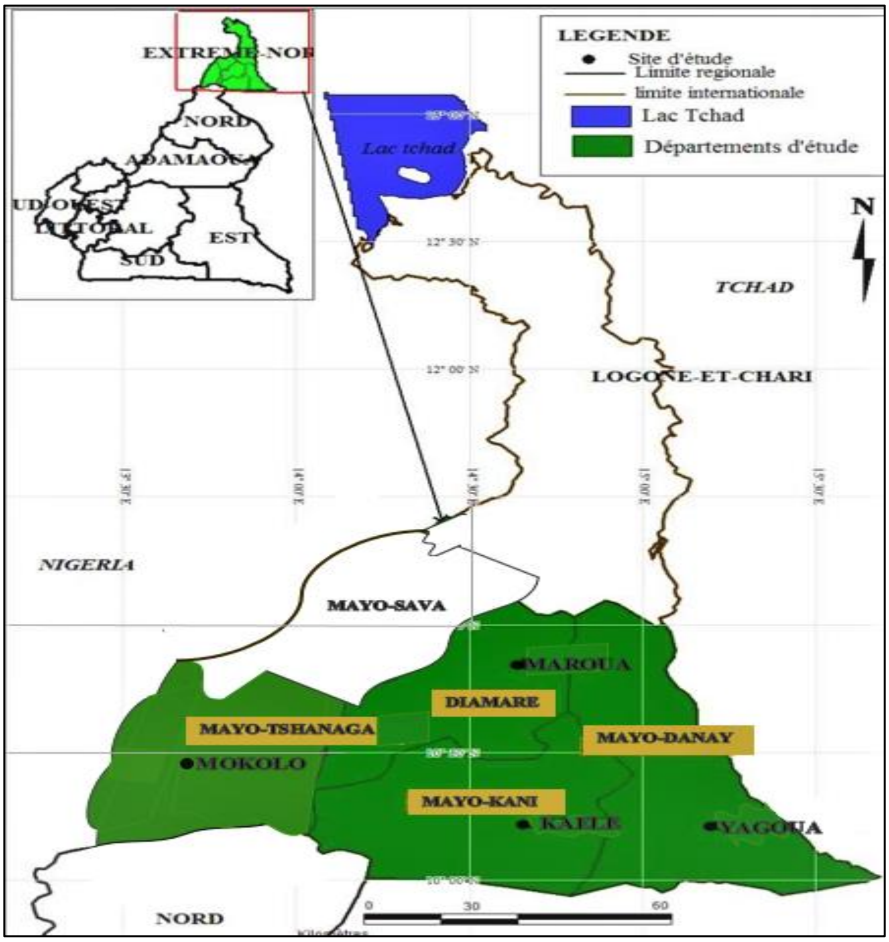

Figure 1. Source: Marquis et al., (2011), Figure 1: Location map of study sites.

2.2. Choice of study sites and experimental set-up

The socio-economic and environmental importance, availability, topography and area of Agrosystems in *Azadirachta indica* in the Far-North region of Cameroon were the main motivations for the choice of these species for their floristic analysis and carbon stocks. The experimental set-up is a complete 5-repetition randomized block. The departments of Mayo-danay, Diamaré, Mayo-kani, and Mayo-tsanaga are considered as main treatments, Neem Agrosystems of different ages as secondary treatments and the three plots of 100 m x 20 m as replicates.

Data Collection

The data were collected in transects of 100 x 20 m^2 (North-South direction) or 2000 m^2. Geographic coordinates were taken using GPS for each tree in the sample to determine its geographic position in the field. In the 3 sub-plots established using the wires and the compass, all the woody plants with a DBH ≥ 5 cm were systematically measured and counted using a tape measure at 130 cm and at 30 cm above the ground for some plants to avoid stem grafting. The team for this work consisted of four people. All trees with a diameter at breast height greater than or equal to 5 cm are measured in the main 2000 m^2 plot.

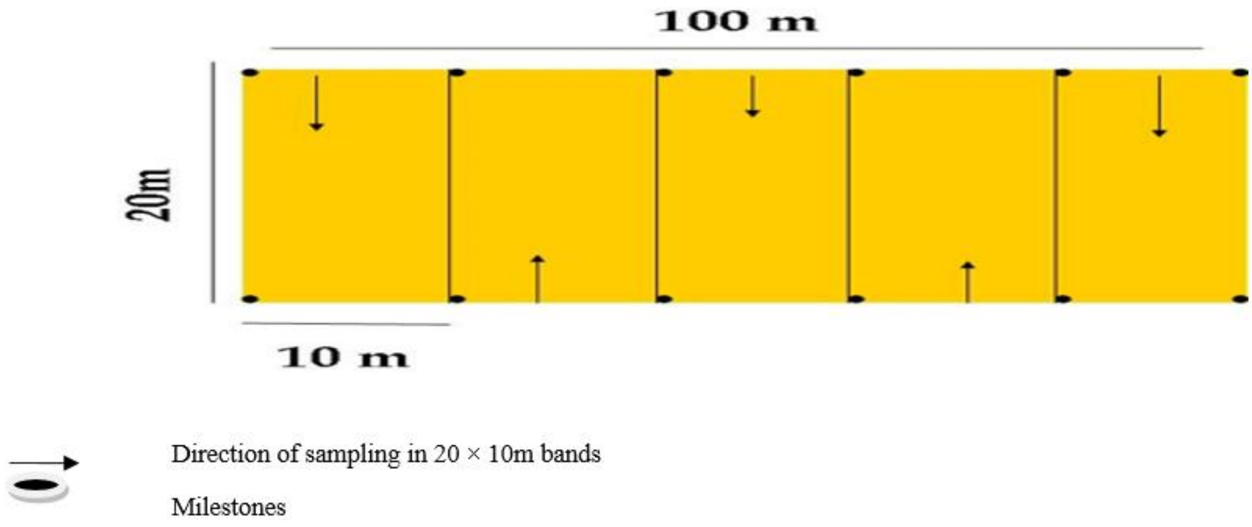

Figure 2. Device plan illustrating a sampling unit

Data analysis

The data were encoded in EXCEL software then analyzed using STATGRAPHICS plus 5.0 software. Significance and correlation tests were performed using ANOVA and Duncan's test at 5%.

Characterization of flora and vegetation

The analysis of floristic diversity focused on:

- The specific richness (S) represents the total number of species in the community studied. Absolute abundance represents the total number of individuals of a species; while relative abundance is the ratio of absolute abundance to the total number of individuals as a whole.

- The Floristic diversity indicates the way in which individuals are distributed among the different species represented within a community. It is a dispersion parameter whose measurements are obtained, among other things, by the Shannon index, the Simpson diversity index and the Piélou Equitability.

- The Shannon diversity index (ISH): ISH = $-\sum (ni / N) * Log2 (ni / N)$, with ni = number of species i, N = number of all species; ISH is expressed in bit. Independent of the size of the population studied, the Shannon Index (ISH) is the most widely used in comparative stand studies. This index gives great importance to rare species [9] (Frontier and Pichod-viale, 1992).

- Piélou Equitability (EQ): It corresponds to the ratio between the observed diversity and the maximum possible diversity of the number of species (N). Piélou's fairness varies from 0 to 1. It tends towards 0 when almost all of the numbers are concentrated on a single species. It is 1 when all species have the same abundance. Low fairness is of great importance for some dominant species [10] (Dajoz, 1982 in Noiha et al., 2017). We used the formula opposite: EQ = ISH / Log2N.

- The Sorensen similarity coefficient is: K = (2c / a + b) x 100, with a = number of species from record 1, b = number of species from record 2, c = number of species common to two readings. This index makes it possible to evaluate the floristic affinity between 2 surveys. If K> 50%, then the two records belong to the same plant community.

- The Importance Value Index (IVI): The Species Importance Value Index (IVI) was developed by [11] Curtis and MacIntosh (1950): IVI = FREQesp + DENSesp + DOMesp.

- Density (D): the ratio of the number of individuals of a species to the total number of individuals of all species in the sample. This is the number of individuals per ha. In agroforestry parks, the density (D) is calculated on the basis of the formula: D = n / S; D: density (in trees / ha), n: number of trees present on the area considered and S: area considered (ha).

- The basal area (St): the calculation in this context, makes it possible to determine the sum of the sectional areas of barrels in a given. This allows Agrosystemes to present in m² / ha the area of each trunk at 1.30 m from the ground on the basis of the formula: $S = \frac{\pi}{4}\sum_{i=1}^{n} d_i^2 = \frac{1}{4\pi}\sum_{i=1}^{n} C_i^2$ with S: basal area (m² / ha), d: diameter (m), C: circumference (m).

The trees were distributed by diameter class and were trained to characterize the diametric structure of the vegetation. 4 diameter classes with an amplitude equal to 40 cm have been established. These classes are:] 0-40];] 40-80];] 40-80];] 80-120];] 120-160 [.

3. Results and discussion

3.1. Floristic diversity

Specific richness and taxonomic abundance

The floristic inventory in Agrosystems in *Azadirachta indica* in the four departments made it possible to obtain 7689 individuals divided into 9 families, 13 genera and 16 species depending on the locality. We note that the specific richness of the undergrowth of Mayo-danay with (23 species) in plots over 20 years old is the most important in terms of specific richness of the undergrowth (Table 1).

Table1. Specific richness of the undergrowth of Agrosystems of *Azadirachta indica*.

Subdivisions	Sites (Years)	Ne	Ng	Nf	Ni
Mayo-danay	0-10	15	13	8	804
	10-20	17	14	9	835
	+20	23	22	14	940
	Total	**18**	**16**	**10**	**2579**
Diamaré	0-10	11	9	8	440
	10-20	15	11	9	620
	+ 20	21	18	10	884
	Total	**16**	**13**	**9**	**1944**
Mayo-kani	0-10	14	12	10	472
	10-20	16	16	10	568
	+ 20	20	17	12	723
	Total	**17**	**15**	**11**	**1763**
Mayo-tsanaga	0-10	6	6	5	404
	10-20	10	7	6	493
	+20	18	15	11	506
	Total	**11**	**9**	**7**	**1403**
	General total	**16**	**13**	**9**	**7689**

Ne = number of species; Ng = number of genera; Nf = number of families; Ni = number of individuals

Shannon Diversity Indices (ISH), Piélou Equitability (EQ), and Significance Value Index (IVI) of plots

Shannon's index of diversity within the undergrowth of *Azadirachta indica* plantations varies differently in the four zones. The Mayo-danay records the highest Shannon index (3.02 ± 0.09 bits) in the +20 year old plots also the highest average (2.97 ± 0.1 bits) while the Mayo -kani records the lowest Shannon index (2.14 ± 0.18 bits) in 0-10 year old plots and the lowest mean (2.32 ± 0.1 bits). The variance made by Duncan's test reveals that there are no significant differences between the plots on the one hand (F = 1.13; P = 0.3464> 0.05). The equitability of Piélou within the undergrowth of the studied plots is of order 1 does not vary, this shows that in all the studied plots *Azadirachta indica* is the dominant species. The analysis of variance done by Duncan's test reveals that there are no significant differences between the plots on the one hand (F = 1.03; P = 0.4240> 0.05). The species importance value index within the plots is maximum (300 ± 21.37) in all the plots studied. The analysis of variance made by Duncan's test reveals that there are no significant differences between the plots on the one hand (F = 0.78; P = 0.6561> 0.05) (Table 2).

Table2. Shannon diversity indices (ISH), Piélou fairness (EQ), and value of importance index (IVI) of the plots.

Subdivisions	Sites(Years)	ISH	EQ	IVI
Mayo-danay	0-10	2,90±0,09c	0,82±0,03ab	300±11,73ab
	10-20	2,98±0,12abc	0,94±0,04ab	300±14,00a
	+20	3,02±0,09abc	0,98±0,03ab	300±12,27ab
	Moy±E	**2,97±0,1AC**	**0,98±0,03AB**	**300±0,1AB**
Diamaré	0-10	2,64±0,07abc	0,85±0,02ab	300±9,55ab
	10-20	2,69±0,09bc	0,91±0,03ab	300±10,67ab
	+20	2,94±0,18c	0,71±0,19b	300±18,57ab
	Moy±E	**2,79±0,11BC**	**0,82±0,08AB**	**300±12,93AB**
Mayo-kani	0-10	2,14±0,18abc	0,45±0,06ab	300±16,14ab
	10-20	2,15±0,05ab	0,40±0,01a	300±8,00a
	+ 20	2,67±0,07a	0,79±0,02a	300±20,67b
	Moy±E	**2,32±0,1AB**	**0,54±0,03A**	**300±14,93AB**
Mayo-tsanaga	0-10	2,39±0,20abc	0,84±0,07ab	300±26,05ab
	10-20	2,60±0,16abc	0,74±0,05ab	300±22,81ab
	+20	2,70±0,15abc	0,80±0,05ab	300±15,26ab
	Moy±E	**2,56±0,17ABC**	**0,79±0,05AB**	**300±21,37AB**

ISH: Shannon index; EQ: Piélou fairness; IVI: Significance value index; Avg ± E: Mean ± Standard deviation. Values assigned the same letter are not statistically different (P> 0.05; Duncan's test).

Density and basal area

The analysis of variance of all the plots of *Azadirachta indica* of different age groups according to the four departments, shows a significant difference (F = 3.42; P = 0.0004 <0.05) for the average density neem agrosystems of different age groups. The density of species within plots varies from stand to stand. In Mayo-danay it is high in plots of 0-10 years (129 ± 27.06 individuals / ha), average in those 10-20 years (127 ± 39.61 individuals / ha) and less in plots of +20 years (122 ± 33.99 individuals / ha). On the other hand, Diamaré records the highest density in plots of 0-10 years (119 ± 13.11 individuals / ha), average in plots of 10-20 years (116 ± 20.59 individuals / ha) and less. In plots over 20 years old with (110 ± 55.72 individuals / ha). In Mayo-kani, however, the highest density is recorded in the 0-10 year-old plot (117 ± 32.15 individuals / ha), average in the 10-20 year-old plot (112 ± 17.60 individuals / ha) and less dense in those over 20 years old (107 ± 35.21 individuals / ha). Finally, we note that the Mayo-tsanaga records the maximum density in the plot of 0-10 years (114 ± 31.39 individuals / ha), followed by that of 10-20 years (109 ± 29.45 individuals / ha), finally that of more than +20 years (1053 ± 5.21 indiv / ha) The table shows that the 0-10-year-old plot of Mayo-danay is the densest (129 ± 1.02 indiv / ha) compared to other plots in all four departments (Table 5).

The analysis of variance shows that there is a significant difference (F = 10.61; P = 0.0000 <0.05) in the basal area between the different plots in all four departments studied. In Mayo-danay, the highest basal area is recorded in the +20-year-old plot (14.04 ± 1.51 m² / ha), average in the 10-20-year-old plot (9.94 ± 1.07 m² / ha) and less in that of 0-10 years (3.88 ± 0.41 m² / ha). On the other hand, Diamaré contains the highest basal area in the +20-year-old plot (12.37 ± 1.78 m² / ha), average in that of 10-20 years (6.26 ± 0.90 m² / ha) and less in that of 0-10 years (2.17 ± 0.34 m² / ha). However, the highest basal area in Mayo-kani is recorded in that of + 20 years (10.89 ± 1.71 m² / ha), then decreases in that of 10-20 years (6.11 ± 0.96 m² / ha). However, in Mayo-tsanaga, the highest basal area is recorded in that of more than +20 years (10.18 ± 1.76 m² / ha), decreases in that of 10-20 years ((5.09 ± 0.88 m² / ha) and less in that of 0-10 years (2.06 ± 0.35 m² / ha). It appears that the general value of the highest basal area was observed in plots of over +20 years (14.04 ± 1.51 m² / ha) of Mayo-danay. The average basal area of the four departments is (9.28 ± 0.99 m² / ha) for Mayo-danay, (6, 93 ± 1.00 m² / ha) for Diamaré, (6.34 ± 0.99 m² / ha) for Mayo-kani and (5.77 ± 0.99 m² / ha) for Mayo-tsanaga. Therefore, does not note any significant difference between the four departments (Table 3).

Table3. Density and Basal Area of Agrosystems in *Azadirachta indica.*

Subdivisions	Parcels (years)	Density (indiv/ha)	Basal area (m²/ha)
Mayo-danay	0-10	129±27,06cde	3,88±0,86ab
	10-20	127±39,61cde	9,94±6,81e
	+ 20	122±33,99e	14,04±4,43cd
	Moy±E	**126±33,55E**	**9,28±4,03AB**
Diamaré	0-10	119±13,11ab	2,17±0,17a
	10-20	116±20,59abcd	6,26±0,57ab
	+20	110±55,72de	12,37±4,44de
	Moy±E	**115±28,80AB**	**6,93±1,72A**
Mayo-kani	0-10	117±32,15ab	2,02± 0,40a
	10-20	112±17,60abc	6,11±0,57ab
	+20	107±35,21bcde	10,89±1,72bc
	Moy±E	**112±28,32AB**	**6,34±0,89AB**
Mayo-tsanaga	0-10	114±31,39a	2,06±0,61a
	10-20	109±29,45ab	5,09±1,15ab
	+20	105±29,39ab	10,18±2,64cd
	Moy±E	**109±30,07AB**	**5,77±1,46A**

D: density; S.T: Basal surface; Avg ± E: Mean ± Standard deviation. Values assigned the same letter are not statistically different (p> 0.05; Duncan's test).

Species importance value index under the *Azadirachta indica* plots

The species of the undergrowth of Agrosystems a *Azadirachta indica* which have the highest importance index values (IVI) are *Acacia nilotica* (IVI = 71.24) in Mayo-tsanaga, *Guiera senegalensis* (IVI = 66.00) in Mayo-danay, *Combretum micranthum* (IVI = 46.14) in

Mayo-kani and *Acacia nilotica* (IVI = 35.80) in Diamaré. These predominant species are among the most abundant and / or the most dominant (Table 4).

Table 4. Relative dominance (DoRe), relative density (DeRe), relative frequency (FeRe), importance value index (IVI) of the most representative species in *Azadirachta indica* plantations.

Subdivisions	species	DoRe %	DeRe%	FeRe%	IVI%
Mayo-danay	*Anacardium occidentale*	9,89	1,63	1,63	13,15
	Annona senegalensis	0,36	10,19	10,19	20,75
	Combretum micranthum	0,35	5,81	5,81	11,97
	Faidherbia albida	14,63	3,66	3,66	21,94
	Guiera senegalensis	1,00	32,50	32,50	**66,00**
	Hexalobus monopetalus	0,42	7,98	7,98	16,38
	Piliostigma thonningii	0,60	15,08	15,08	30,76
	Sterculia setigera	8,62	0,72	0,72	10,07
Diamaré	*Acacia nilotica*	7,44	14,18	14,18	**35,80**
	Balanites aegyptiaca	12,00	2,35	2,35	16,69
	Combretum micranthum	0,29	5,83	5,83	11,95
	Combretum nigricans	0,64	5,81	5,81	12,27
	Faidherbia albida	7,27	2,49	2,49	12,24
	Hexalobus monopetalus	2,34	3,83	3,83	10,00
	Piliostigma thonningii	0,82	7,94	7,94	16,69
Mayo-kani	*Annona senegalensis*	0,66	8,45	8,45	17,56
	Anogeissus leiocarpus	0,74	4,97	4,97	10,68
	Combretum micranthum	2,27	21,94	21,94	**46,14**
	Guiera senegalensis	1,08	18,53	18,53	38,14
	Hexalobus monopetalus	2,87	15,19	15,19	33,25
	Piliostigma thonningii	0,92	7,11	7,11	15,14
Mayo-tsanaga	*Acacia nilotica*	24,97	51,14	51,14	**71,24**
	Acacia seyal	1,07	5,80	5,80	12,67
	Acacia sieberiana	2,39	23,74	23,74	49,87
	Balanites aegyptiaca	13,79	4,66	4,66	23,11
	Faidherbia albida	20,87	7,74	7,74	36,34
	Piliostigma thonningii	0,61	5,46	5,46	11,52
	Ziziphus mauritiana	2,11	7,49	7,49	17,10
	Ziziphus mucronata	0,88	7,78	7,78	16,43

Family importance value index under *Azadirachta indica* plots

The Families with the highest family index values (IVF) are the Combretaceae with (IVF = 92.32) in Mayo-danay, (IVF = 75.66) in Mayo-kani, (IVF = 58.58) in Diamaré and Mimosaceae in Mayo-tsanaga (IVF = 92.32). These predominant families are among the most abundant and / or the most dominant (Table 5).

Table5. Relative dominance (DoRe), relative density (DeRe), relative frequency (FeRe), importance value index (IVI) of the most representative families in Agrosystems a *Azadirachta indica.*

Subdivisions	Families	DoRe%	DeRe%	FeRe%	FVI%
Mayo-danay	Anacardiaceae	13,19	3,28	3,28	19,76
	Annonaceae	0,79	18,74	18,74	38,28
	Combretaceae	2,98	62,67	62,67	**92,32**
	Fabaceae	24,67	8,16	8,16	40,98
	Malvaceae	8,63	1,20	1,20	11,03
	Mimosaceae	0,35	2,73	2,73	5,82
	Rhamnaceae	0,39	6,56	6,56	13,51
	Sapotaceae	0,65	1,74	1,74	4,13
Diamaré	Anacardiaceae	3,87	1,00	1,00	5,88
	Annonaceae	2,34	3,83	3,83	10,00
	Balanitaceae	12,00	2,35	2,35	16,69
	Combretaceae	3,74	27,42	27,42	**58,58**
	Fabaceae	9,07	5,91	5,91	20,90
	Mimosaceae	7,67	14,99	14,99	37,64
	Rhamnaceae	1,72	6,20	6,20	14,11
Mayo-kani	Anacardiaceae	6,12	1,58	1,58	9,29
	Annonaceae	3,62	24,69	24,69	53,00
	Apocynaceae	0,18	1,34	1,34	2,86
	Balanitaceae	2,64	0,52	0,52	3,68
	Combretaceae	5,03	51,81	51,81	**75,66**
	Fabaceae	12,18	2,96	2,96	18,09
	Loganiaceae	0,64	4,22	4,22	9,07
Mayo-tsanaga	Balanitaceae	10,36	2,09	2,09	14,55
	Capparaceae	0,05	0,59	0,59	1,24
	Combretaceae	0,74	6,27	6,27	13,27
	Fabaceae	29,60	40,20	40,20	54,99
	Mimosaceae	25,36	52,12	52,12	**94,61**
	Rhamnaceae	2,99	15,27	15,27	33,53

Genera importance value index under *Azadirachta indica* plots.

The Genus which have the highest gender indices (IVG) are Acacia (IVF = 101.79) in Mayo-tsanaga, Guiera (IVF = 66.00) in Mayo-danay, Combretum (IVF = 48.49) in Mayo-kani and Acacia (IVF = 92.32) in Diamaré. These preponderant Genus are among the most abundant and / or the most dominant (Table 6).

Table 6. Relative dominance (DoRe), relative density (DeRe), relative frequency (FeRe), importance value index (IVI) of the most representative genera in neems.

Subdivisions	Genera	DoRe%	DeRe%	FeRe%	IVI%
Mayo-danay	Acacia	2,63	3,79	3,79	10,21
	Anacardium	9,89	1,63	1,63	13,15
	Annona	0,36	10,19	10,19	20,75
	Combretum	0,84	12,81	12,81	26,45
	Faidherbia	14,63	3,66	3,66	21,94
	Guiera	1,00	32,50	32,50	**66,00**
	Hexalobus	0,42	7,98	7,98	16,38
	Piliostigma	0,97	18,69	18,69	38,35
	Sterculia	8,62	0,72	0,72	10,07
Diamaré	Acacia	8,42	16,93	16,93	**42,27**
	Balanites	12,00	2,35	2,35	16,69
	Combretum	0,80	11,37	11,37	23,54
	Faidherbia	7,27	2,49	2,49	12,24
	Hexalobus	2,34	3,83	3,83	10,00
	Piliostigma	0,82	7,94	7,94	16,69
	Ziziphus	1,72	6,20	6,20	14,11
Mayo-kani	Anacardium	4,79	0,19	0,19	5,18
	Annona	0,75	9,50	9,50	19,75
	Anogeissus	0,74	4,97	4,97	10,68
	Combretum	2,65	22,92	22,92	**48,49**
	Guiera	0,80	15,25	15,25	31,31
	Hexalobus	2,87	15,19	15,19	33,25
	Piliostigma	0,93	4,99	4,99	10,91
Mayo-tsanaga	Acacia	28,43	80,68	80,68	**101,79**
	Balanites	13,79	4,66	4,66	23,11
	Faidherbia	20,87	7,74	7,74	36,34
	Piliostigma	0,61	5,46	5,46	11,52
	Tamarindus	5,02	2,33	2,33	9,67
	Ziziphus	2,99	15,27	15,27	33,53

Floristic similarity within *Azadirachta indica* plantations

Plots with similarity indices of less than 50% do not meet floristic affinity while similarity indices are high in plots with floristic affinities greater than or equal to 50% (Table 7).

Table 7. Floristic similarity

		Mayo-danay			Diamaré			Mayo-kani			Mayo -tsanaga		
Zones	Parcelles	N1	N2	N3	N1	N2	N3	N1	N2	N3	N1	N2	N3
Mayo-danay	N1	100											
	N2	50,25	100										
	N3	42,10	50,00	100									
Diamaré	N1	38,46	57,14	35,29	100								
	N2	40,00	68,75	31,57	69,23	100							
	N3	38,88	47,36	50,00	37,5	44,44	100						
Mayo-kani	N1	68,96	51,61	37,83	32,00	27,58	22,85	100					
	N2	51,61	60,60	61,53	51,85	45,16	43,24	53,33	100				
	N3	45,71	48,64	46,51	45,16	40,00	29,26	41,17	50,00	100			
Mayo-tsanaga	N1	38,09	34,78	27,58	35,29	38,09	29,62	30,00	45,45	15,38	100		
	N2	40,00	51,85	36,36	51,14	56,00	45,16	33,33	38,46	26,66	62,50	100	
	N3	42,42	45,71	34,14	48,27	54,54	56,41	25,00	35,29	21,05	50,00	64,28	100

N1: Plots of 0-10 years; N2: Plots of 10-20 years; N3: Plots over 20 years old

Diametric structure of individuals in Agrosystems with *Azadirachta indica*

In the context of this work, the diameter classes with an amplitude equal to 5 cm have been established. The analysis of this Figure 3 shows that all the distributions have an L shape. The distribution is then positive asymmetric or right asymmetric, characteristic of monospecific populations with predominance of young individuals, centered on the class] 0-40 cm] (Figure 3). The analysis of variance confirms that there is a highly significant difference (p = 0.0000 <0.05) at the level of the diameter classes. In fact, in all four departments, the majority of populations are individuals whose diameter is between 0 and 40cm.

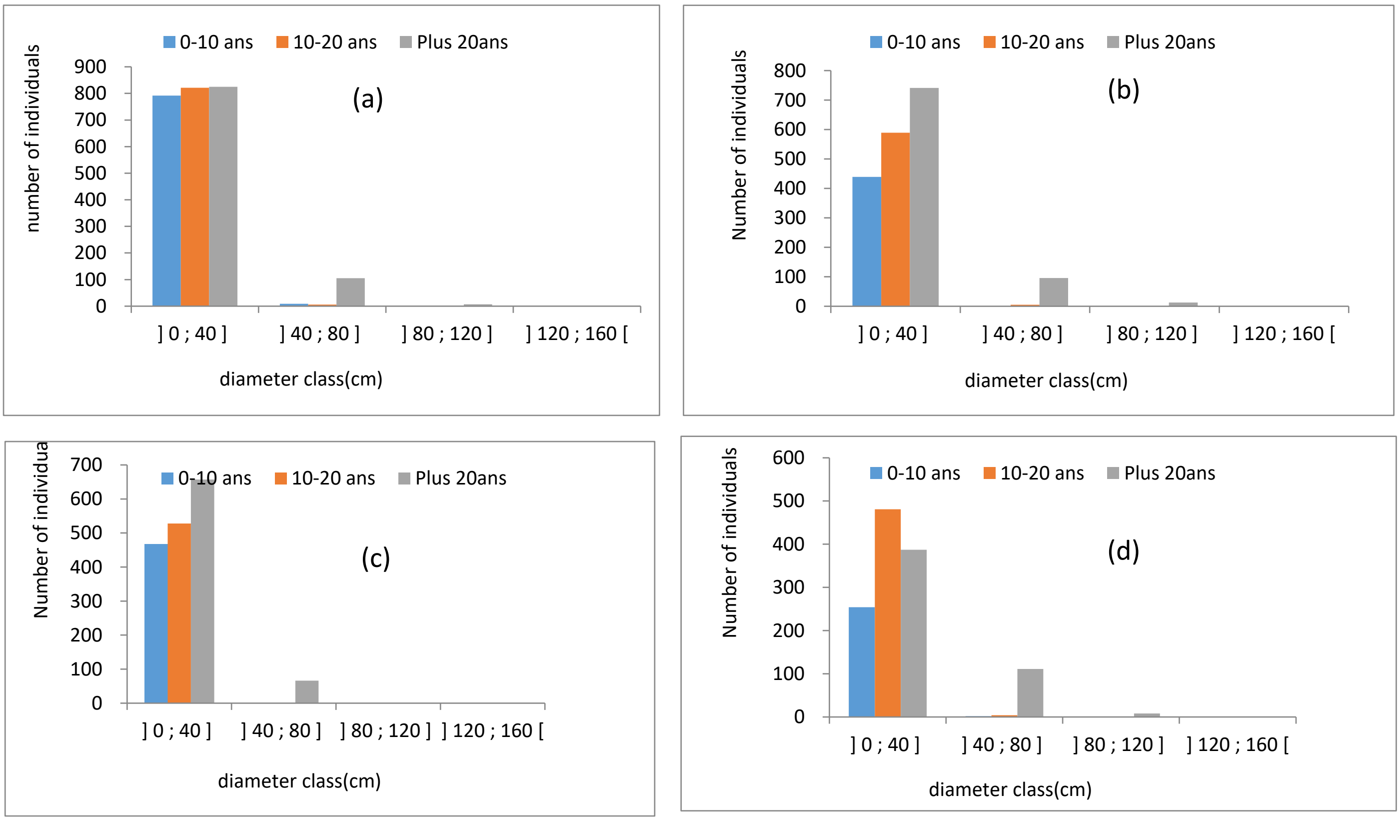

Figure3. The structure of the diameter classes of individuals in the plots. (a): Mayo-danay; (b): Diamaré; (c): Mayo-kani; (d): Mayo-tsanaga.

4. Discussion

The floristic inventory in Agrosystems in *Azadirachta indica* in the four departments made it possible to obtain 7689 individuals divided into 9 families, 13 genera and 16 species depending on the locality. These results are close to those of [12] Niang *et al.* (2014), found 20 species divided into 18 genera and 12 families in Senegal. The results of the inventories in the four studied parks show a lower diversity compared to the inventories of [13] Mapongmetsem et al. (2016) identified 61 species divided into 55 genera and 28 families in agroforests in the peri-urban area of the city of Bafia; [14] Diedhiou *et al.* (2014) who found 54 species divided into 24 families and 43 genera in agroforestry parks in the village of Mar Fafaco in the large island of Mar and in Togo, [15] Kebenzikato *et al.* (2014) who found 52 species distributed in 45 genera and 23 families in the parks of *Adansonia digitata* L. (baobab).

The floristic diversity of the undergrowth of the neem plantation does not corroborate with the results of [16] (Arouna *et al.*, 2016; Noiha *et al.*, 2017). These differences may be due to the nature of the Agrosystems and the impact of human influence due to the maintenance of these Agrosystems which could better explain the low diversity observed in the study site. The dominate families and species in our study areas are species deliberately left for multiple uses (*Guiera senegalensis, Piliostigma thonningii* and *acacia nilotica* etc). The floristic diversity of the Mayo-danay department (23 woody species) is significantly higher than those of other departments with Diamaré (21 woody species), Mayo-kani (20 woody species), Mayo-tsanaga (18 woody species). These results lead to the conclusion that land management methods offer significant floristic diversity. Which varies according to techniques, ages and regions. These results are lower than those of [17] Dan Guimbo *et al.* (2011) who found 35 woody species in the *Vitellaria paradoxa* park in southwestern Nigeria; [18] Guedje *et al.* (2002). This difference could be explained in addition to the drastic climatic conditions, by the practice of agriculture and breeding in the North region which would seem to be an area transition between the sylvo-pastoral zone and the groundnut basin. Indeed, the climate plays an essential role in the composition and the floristic structure [19] (Sambou, 2004; Ouédraogo, 2006; Tchobsala *et al.*, 2010; Noiha *et al*., 2015; Noiha *et al*., 2018a).

The equitability of Pielou tends towards 1 in all the neem plots, this indicates a good equi-distribution of individuals between the different species, no doubt because of the favorable conditions of the environment and a good reconstitution of the floristic diversity of the sub- wood on the other hand, all species have the same abundance, no doubt because they are subject to the same conditions. These results are similar to those of [20] Tabue (2013) in the eastern part of the Dja Fauna Reserve; [21] Noiha *et al*. (2017) in cashew orchards in North Cameroon.

The Importance Value Index (IVI) is of the order of 300 in the different plots. This could be explained by the strong presence of tall trees in these plots. These results corroborate those of [22] Savadogo et al. (2016) who assert that trees with tall crowns contribute more to cover and up to a certain degree of cover. This value is greater than that found in the Sudanian zone by [23] Savadogo *et al.* (2007); in northeastern Burkina Faso by [24] Kabore *et al.* (2013) and in northern Cameroon by [21] Noiha *et al.* (2017) who found respectively 214.52; 220, 84 and 150. But remains similar to that of [25] Iddo (2017) in Agrosystems with Mangiferaindica of Adamaoua (Cameroon).

The analysis of the Family Importance Index (VIF) shows overall that Combretaceae, Fabaceae and Annonaceae are the most important in ecological terms. The overall density of species within the plots varies between 159 and 346 stems / ha. These results do not corroborate those found by [21] Noiha *et al.* (2017) in the North Cameroon region, [26] Tayo (2014) in central Cameroon [27] (Ali *et al.* (2014) in south-eastern Benin. This is due to the agronomic standards of planting which vary from species to species. Another one.

The basal area varies from 2.02 to 14.04 m^2 / ha. These results corroborate those of [21] Noiha *et al.* (2017) who obtained in the region of North Cameroon a basal area ranging from 5.81 to 15.23 m^2 / ha. This similarity is due to the species found in the undergrowth. The low value of basal areas in these plots testifies to the spatial structure of trees in neem Agrosystems which is characterized by the scarcity of large trees to the detriment of small trees which are the most abundant.

Plots with similarity indices of less than 50% do not meet floristic affinity while similarity indices are high in plots with floristic affinities greater than or equal to 50%. This shows that these four sampled plots are not similar and floristically homogeneous because their similarity indices vary according to the plots and the departments. These results are close to those of [28] Savadogo *et al.* (2015) in the Sahelian zone of Burkina Faso. This similarity between the plots does not prevent their description as distinct formations.

The study of the diameter distribution in the sampled areas shows that small individuals are much more important. This is due to the youth of the plantation hence the "L" shape, ensuring good regeneration of the vegetation. These results are in agreement with those of [29] (Jiagho *et al.*, 2016; Tsoumou *et al.* 2016; Zapfack *et al.*, 2016; Noiha *et al.*, 2017). This fits with the configuration of the plots with more individuals in the 0-10-year age group. This structure shows that the plots studied have several future individuals to ensure regeneration. This is the main characteristic of forest stands assumed to be in equilibrium, with many individuals of small diameter and few individuals of large diameter. Indeed, neem Agrosystems are the object of conservation and protection, hence their height growth, they are fruit-producing individuals. These results can be explained by the fact that Agrosystems are not Agrosystems where almost all the woody plants that are there in their undergrowth are those that people need for multiple uses. These individuals are generally subject to conservation and special maintenance. These results are not similar to those of [15] Kebenzikato *et al.* (2014) in *Adansonia digitata* (baobab) parks in Togo (West Africa); [30] Noiha *et al.* (2018d) in stands of *Gmelina arborea* in Ngaoundéré (Cameroon).

5. Conclusion

Formerly wild and ornamental, reserved for shade and traditional uses, neem is a tree that can be considered today as a specific agro-resource of tropical areas and whose culture can be developed in many localities of the part northern Cameroon. Besides its favorable effects for soil stabilization and wood supply, harvesting seeds it allows many said species to coexist with it. Having reached the end of this present work which had as main objective the evaluation of biodiversity in the underwoods of neem Agrosystems in the region of the extreme North Cameroon, the floristic inventory in Agrosystems has *Azadirachta indica* in the four departments made it possible to obtain 7689 individuals divided into 9 families, 13 genera and 16 species according to the localities, classified according to their ages with a dominance of *Guiera senegalensis*, *Piliostigma thonningii* and *Acacia nilotica*. The floristic diversity of the undergrowth of Agrosystems (average ISH> 2) shows a strong homogeneity and an even distribution of the neems in the different plots. Everything suggests that the undergrowth species in these Agrosystems were left on purpose or even planted and maintained for purpose. Since all the Agrosystems studied are located in the same agro-ecological region, the effect of air temperature, sun and wind speed on the differences in biomass accumulation can be generally the same for all Agrosystems.

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