



Castor bean: main uses and biodiversity in the Adamawa, Cameroon

Lucien TATCHUM TCHUENTEU*, Awal MOHAMAMED and Clautilde MEGUENI

Department of Biological Sciences, Faculty of Science, University of Ngaoundere-Cameroon, P.O. Box 454
Ngaoundere, Cameroon.

*Corresponding author; E-mail: tatchumlucien@yahoo.fr; Tél: +237 699145141

ABSTRACT

Ricinus communis L. (castor bean) is an oilseed plant with multiple socio-economic benefits. It grows wild in Cameroon. The study aimed at determining main uses, describing, evaluating the carbon stock as well as carbon credits and geolocalizing castor bean accessions from Adamawa Cameroon. The location of various sites for ethnobotanical survey was identified by random sampling techniques which consist in randomly selecting the various locations, overall sample consists of 1440 peoples; the respondents were questioned individually using a questionnaire form. Results showed that castor bean is used to treat several diseases; seeds oil is consumed and plants present margico-religious powers. Four local castor bean accessions (Vina, Martap, Nyambaka and Bélel) were identified. Overall, there was a significant difference ($p < 0.05$) between castor bean accessions identified with respect to the physical characteristics of vegetative organs and seeds. Plants of Bélel accession were tallest (302.96 ± 44.36 cm) while the smallest plants height (148.63 ± 19.05 cm) were from Vina accession. Vina accession was the most widespread while Nyambaka and Bélel accessions were the least widespread in the study areas. This information will be useful in the implantation program of castor bean as alternative crop of the Cameroonian agriculture.

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Keywords: *Ricinus communis* L., ethnobotanical survey, vegetative organs, carbon stock, geolocalizing, Adamawa-Cameroon.

INTRODUCTION

Castor bean (*Ricinus communis* L.) is an oilseed plant (40-60% oil) cultivated for its seeds which yield viscous, pale and non-volatile yellow oil (Pina et al., 2005). This oil has many industrial applications, notably in the manufacture of paints, dyes, inks, waxes, varnishes, lubricants and brake fluids (Ogunniyi, 2006). Castor oil obtained by cold pressing of seeds is also used in household for soap production and as purgatives and laxatives (Weiss, 2000). Castor bean is grown

for its seeds rich in oil (Pina et al., 2005; Tchuenteu, 2014).

This plant with high agro-economic values has been extensively cultivated in India (870 ha), China (220 ha) and Brazil (163 ha) (Pina et al., 2005). World production of oil from castor bean seeds is estimated at about 550000 tons per year (Scholz and Da Silva, 2008). India alone exports 80% of castor oil and therefore largely dominates the market. Ethiopia, South Africa, Angola, Kenya and Tanzania are the main producing countries of castor bean in Africa (Diallo et al., 2013).

Recent work on castor bean aimed at selecting the genotypes with greater seeds yield. This is how in a previous study, we did the agronomic characterization of 03 local accessions of castor bean from North Cameroon and revealed that castor bean productivity varies according to genotype and experimental area (Tchuenteu, 2014). In addition, Ezzedine (2017) studied the genetic variation and seed yield in Tunisian castor bean and revealed that seeds yield varied between populations. Despite these many works, castor bean grows wild in Cameroon. The characteristics of castor bean from countries such as India, China, U.S.A. and Madagascar have been studied (Tchuenteu et al., 2013).

To the best of our knowledge, no work has been conducted on inventory and characterization of castor bean accessions of Sudano-Guinean savannahs of Cameroon. This lack of data seems to be a handicap for appreciation of local castor bean accessions, which may not only be an additional source of income for Cameroonian peasant, but also present interesting properties in chemical industry. This oilseed plant with multiple socio-economic benefits is among the species under exploited and under valorized by Cameroonian populations. In this respect there is a risk of genetic erosion and loss of potentiality.

The objective of current work consisted to (1) identify the main uses of castor bean in order to determine local peasants knowledge of this plant and their perception of its socioeconomical value; (2) describe the physical characteristics of local castor bean accessions; (3) assess the carbon stock as well as carbon credits of local castor bean accessions; (4) geolocate castor bean accessions in the Sudano-Guinean savannahs of Adamawa Cameroon. Data obtained regarding the identification of castor bean accessions and geolocation should be used in the implantation program of castor bean as alternative crop for the Cameroonian agriculture.

MATERIALS AND METHODS

Study area

This work took place in 02 Divisions (Vina and Mbéré) of Adamawa Cameroon region. Vina Division has 08 Sub-division (Ngaoundere I, Ngaoundere II, Ngaoundere III, Bélel, Martap, Mbé, Nganha and Nyambaka) while Mbéré Division has 04 Sub-division (Meiganga, Djohong, Dir and Ngaoui). This area is located between the 6th and 8th degrees of north latitude and between the 10th and 16th degrees of east longitude. Climate of Adamawa Cameroon region is from the Sudano-Guinean type (Deffo et al., 2009). Vegetation is various and composed of grasslands; grassy, shrubby and tree savannahs (Mapongmetsem et al., 2000). Agriculture and livestock are the main activities (Deffo et al., 2010). Administratively, Adamawa Cameroon region has 05 Divisions (Vina, Mbéré, Faro and Deo, Djerem, Mayo Banyo).

Ethnobotanical survey

Survey design

Ethnobotanical surveys were conducted among peasants and sellers of therapeutic products. The location of various sites for ethnobotanical survey was identified by random sampling techniques which consist in randomly selecting the various locations (Dagnelie, 2013). In this work, sample was divided into 24 strata at level of 2 villages per Sub-division, corresponding to the eight (08) Sub-divisions of Vina Division and four (04) Sub-divisions of Mbere Division. Samples of 60 peoples were formed for each of 24 strata and overall sample was 1440 participants.

Data collection

The ethnobotanical survey was conducted from March to July 2017 (05 months). To collect the ethnobotanical data, the respondents were questioned individually using a questionnaire form. The interview was standardized. Data collected during surveys relate to castor bean plants such as knowledge levels, uses and organs used.

Physical characterization of local castor bean accessions

Physical characteristics of plants such as color of vegetative organs, plants height, petiole length and leaf area of castor bean plants were evaluated and 30 plants are sample. The leaf area was determined according to Lauri (1988) using following formula: $SL = 1.285 \times (L1 \times L2.3) \times 0.98$ where SL = blade area; $L1$ = length of main lobe and $L2.3$ = average length of both lobes adjacent to main lobe. The total dry biomass of plants was evaluated using the following formula: $DBP = 0.84T - 0.59$ where DBP = dry biomass of a plant and T = plant height as previously described Tchuenteu et al. (2013). For evaluation of seeds physical characteristics, length, width and thickness of seeds were assessed using a 0.01 precision electronic vernier caliper; seeds weight is evaluated using a 0.01 precision electronic scale and 100 seeds are sampled.

Geolocalization of castor bean accessions

The geographical location of different castor beans from, Vina and Mbere Divisions was made using a GPS (Global Positioning System) brand Garmin®. The geographic coordinates of castor bean accessions encountered in the study area were recorded. The QGIS 2.8 (Quantum Geographic Information System) software was used to realize a geographical map. Geographic coordinates were downloaded using GPSBabel, a program used to transfer GPS data from the GPS device to the computer. These coordinates were entered into a QGIS study area that pops up from the bottom of the map by loading a MapInfo layer using the internet connection.

Statistical analysis

Data were subjected to variance analysis followed by the Duncan multiple range tests when any significant effect was observed. The statistical software “Statgraphics plus” was used for this propose. Excel 2010 software was used for data entry and graphing.



A : Vina accession



B : Martap accession



C : Nyambaka accession



D : Bélel accession

Figure 1: Color of plants and seeds physical characteristics depending on castor bean accessions.

RESULTS

Ethnobotanical survey on Castor bean plant

Knowledge and use levels of castor bean according to vegetative organs

Table 1 shows the knowledge and use levels of castor bean according to plants organs in Vina and Mbere Divisions of Adamawa Cameroon region. It comes from table 1 that almost half of the population (44%) has no knowledge on castor bean. Concerning the utilities of castor bean, roots were the most used organs with a utilization rate of 37%, followed by seeds (30%), leaves (19%) and stems (14%).

Uses of castor bean

In Adamawa Cameroon, castor bean is used mainly as therapeutics (69,43%), magicoreligious (17,2%) and food (13.37%). Castor bean is not cultivated in this area. Therapeutically, oil extracted from seeds is used for treatment of rheumatism by simple massage. The anointed oil on skin treats leprosy. Seeds ingestion heals intestinal worms, facilitates delivery by accelerating uterine contractions during delivery and prevents insomnia. Also, seeds are purgative and laxative. The oral absorption of roots decoction treats internal hemorrhage and arterial hypertension. The bath of a mouth by roots decoction treats toothache. The massage with the previously boiled castor bean leaves heals fracture and sprain. The leaf decoction is used against dysmenorrhea. Also, the leaves have anti-inflammatory properties. At a magico-religious level, castor oil is for delivering anybody from a spell by fumigates the patient using leaves and roots decoction mixed with several other products; stems and leaves are used for manufacture of magic counter-balls commonly called "yéssi" among Bororo. Seeds oil is used for cooking. The application of leaves at bottom of traditional fermentor accelerates the wines fermentation. Leaves and stems are burned to obtain native salt or potash much appreciated in Adamawa Cameroon kitchens.

Physical characterization of plants

Vegetative organs

The vegetative apparatus of castor bean from the study area showed presents different colors. The vegetative organs of Vina and Martap accessions are green while those of Nyambaka and Bélel accessions are violet. As shown in table 2, there is a significant difference ($p < 0.05$) in plant height, limb area and petiole length between the 04 local castor bean accessions identified in the present work. Bélel accession showed the highest plants height (302.96 ± 44.36 cm) while the smallest (148.63 ± 19.05 cm) was recorded with the Vina accession. Meanwhile Martap and Nyambaka accessions presented intermediate values of plant height which were 297.13 ± 91.50 cm and 201.10 ± 32.09 cm respectively. Moreover, Limb area varied from 59.93 ± 23.26 cm² for Martap accession to 329.60 ± 79.31 cm² for Bélel accession. Limb areas of Vina and Nyambaka accessions exhibited intermediate values and are 271.13 ± 43.3 and 29.66 ± 2.84 cm² respectively. Petiole lengths of Vina, Nyambaka and Bélel accessions of castor bean were 29.90 ± 2.48 ; 29.66 ± 2.84 and 28.23 ± 1.33 cm respectively. In general, petiole length of Vina, Nyambaka and Bélel accessions was 3.74 fold higher than that of Martap accession.

Seeds

Seeds physical characteristics vary significantly ($p < 0.05$) between the four castor accessions (Table 3). In general, seeds of Nyambaka accession have the greatest values of physical characteristics studied (length, width, thickness and weight). Seeds of Vina accession had the lowest values of these parameters while those of Martap and Bélel accessions presented intermediate values. Overall, weight, length, width and thickness of seeds of our local castor bean accessions were 0.16 ± 0.05 g; 0.95 ± 0.06 cm; 0.63 ± 0.11 cm and 0.47 ± 0.06 cm respectively.

Dry biomass of castor bean plants, carbon stock and carbon credit

The analysis of variance (ANOVA) showed that there was a significant difference ($p < 0,05$) between: Vina, Martap, Nyambaka

and Bélel accessions of castor bean obtained in this study with respect to dry biomass, carbon stock and carbon credit (Table 3). Bélel accession presented the highest values for these parameters while Vina accession showed the smallest values. Dry biomass of Bélel accession of castor bean was 3; 1.03 and 2.17 fold greater than those of Vina, Martap and Nyambaka respectively.

Geolocation of castor bean from Vina and Mbéré Divisions of Adamawa Cameroon

Figure 2 shows the geographical map of both Divisions of Adamawa Cameroon region, Vina and Mbéré with locations of Vina, Martap, Nyambaka and Bélel accessions of castor bean identified in this work. Vina, Martap and Belel accessions are present in the two Divisions that were the subject of this study. However, among 12 Sub-divisions of

Vina and Mbéré Divisions, Vina, Martap, Nyambaka and Bélel accessions of castor bean are found in 10; 08; 02 and 03 Sub-division respectively. Vina accession does not exist in Mbé Sub-division of Vina Division and Dir Sub-division of Mbéré Division. Martap accession is not found in Martap and Mbé Sub-division of Vina division and in the both Sub-division, Dir and Ngaoui of Mbéré division. Nyambaka accession is found only in 02 Sub-division of Vina division: Ngaoundéré III and Nyambaka. Concerning Bélel accession, it is present in Belel and Martap Sub-division of Vina Division and in Meiganga Sub-division of Mbéré Division. These results obtained on geolocalisation of the local castor bean accessions suggest that Vina accession is the most widespread while the Nyambaka and Belel accessions are the least widespread in our study areas.

Table 1: Knowledge and use levels of castor bean depending on organs of plant.

Rate of knowledge (%)		Rate of use according to the parts of plant (%)			
Knowledge	unknowing	Roots	stem	leaves	seeds
56	44	37	14	19	30

Table 2: Physical characteristics of vegetative organs and seeds.

Parameters	Accessions of castor bean			
	W	X	Y	Z
PH (cm)	148.63 ± 19.05 ^a	297.13 ± 91.5 ^c	201.10 ± 32.09 ^b	302.96 ± 44.36 ^c
LA (cm ²)	271.13 ± 43.30 ^c	59.93 ± 23.26 ^a	206.66 ± 55.56 ^b	329.60 ± 79.31 ^d
PL (cm)	28.23 ± 1.33 ^b	7.83 ± 2.00 ^a	29.66 ± 2.84 ^b	29.90 ± 2.48 ^b
SL (cm)	0.88 ± 0.04 ^a	0.92 ± 0.10 ^b	1.03 ± 0.03 ^c	0.95 ± 0.03 ^b
SWi (cm)	0.54 ± 0.03 ^a	0.59 ± 0.09 ^b	0.79 ± 0.03 ^c	0.61 ± 0.10 ^b
ST (cm)	0.41 ± 0.01 ^a	0.48 ± 0.03 ^b	0.55 ± 0.03 ^c	0.43 ± 0.02 ^a
SWe (g)	0.12 ± 0.02 ^a	0.13 ± 0.03 ^a	0.24 ± 0.04 ^c	0.15 ± 0.02 ^b

W: Vina accession; X: Martap accession; Y: Nyambaka accession; Z: Bélel accession ;PH : plants height ; LA : limb area ; PL : petiole length ; SL : seeds length ; ST : SWi : Seeds width, Seeds thickness ; SWe : seeds weight. Values of a line followed by the same letter are no significantly different.

Table 3: Dry biomass, carbon stock and carbon credit of castor bean plants.

Parameters		Dry biomass	Carbon stock	Carbon credit
		(kg/plant)	(t/ha)	(FCFA/ha)
Accessions of castor bean	Vina	0.66 ± 0.16 ^a	1.10 ± 0.18 ^a	6200.44 ± 1069.11 ^a
	Martap	1.90 ± 0.76 ^b	3.18 ± 0.87 ^b	17945.62 ± 5167.40 ^b
	Nyambaka	1.09 ± 0.22 ^c	1.83 ± 0.30 ^c	10350.14 ± 1781.86 ^c
	Bélel	1.95 ± 0.37 ^d	3.26 ± 0.42 ^b	18406.99 ± 2494.60 ^b

Values of a column followed by the same letter are no significantly different

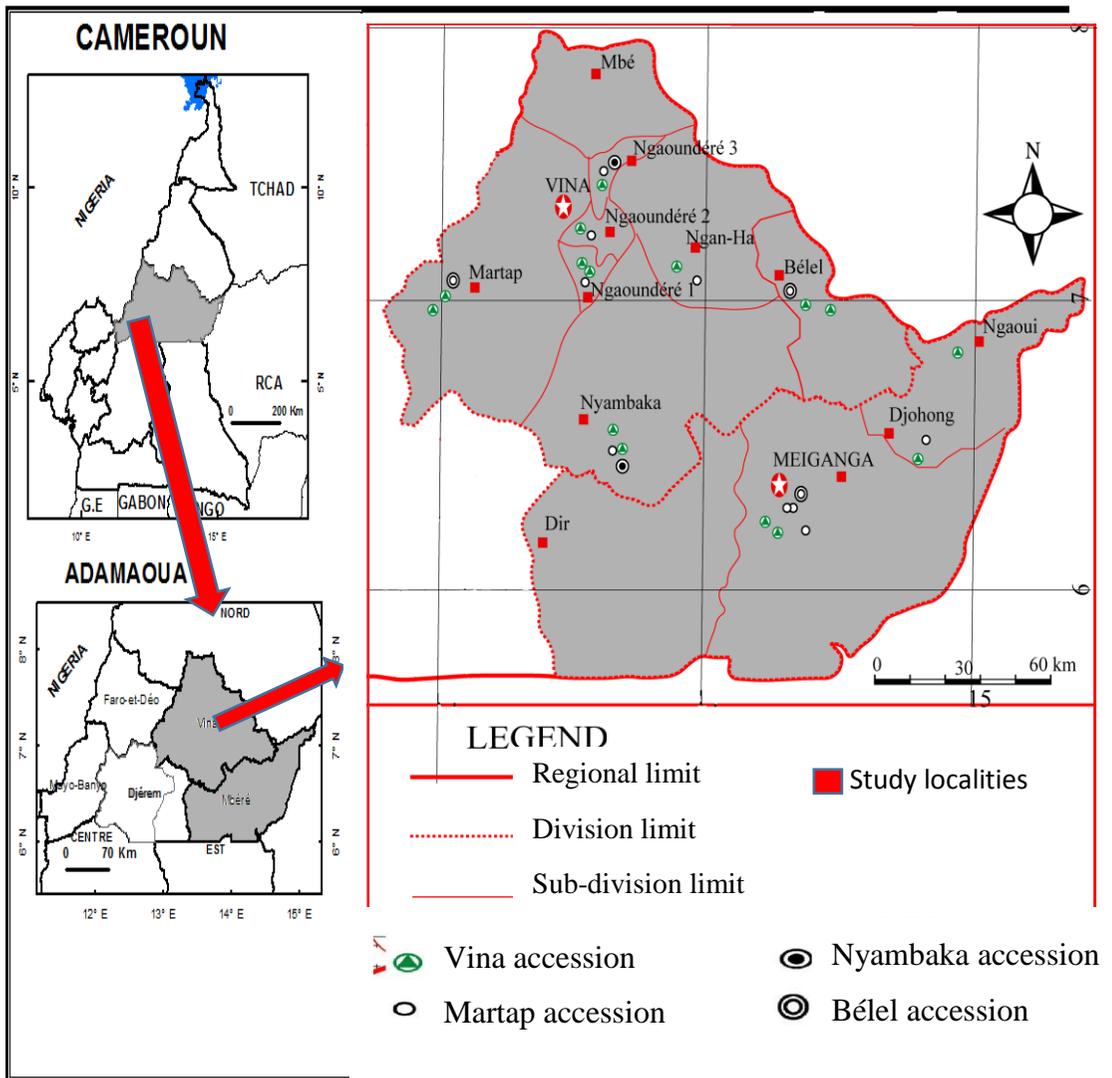


Figure 2 : Position of castor bean accessions on the map of Vina and Mbéré Division of Adamawa Cameroon region.

DISCUSSION

The poor knowledge of castor bean by people from the Adamawa region could be explained by the fact this plant is not usually cultivated in the sub-Saharan Africa. Castor bean grows wild in Cameroon (Tchuenteu *et al.*, 2013, Tchuenteu, 2014). It was reported in this study that the rate of use of different parts of castor bean plants varied depending to organ. This could be justified the fact that different organs of our local castor accessions would have different chemical properties. Indeed, N'guessan *et al.* (2009) in a previous study on Ivorian medicinal plants used in Krobou (Agboville, Côte d'Ivoire) revealed that plants concentrations in sterols, polyterpenes, polyphenols, flavonoids and alkaloids varied depending to the vegetative organ, which gives them various therapeutic properties. In this study, castor bean roots were the most used vegetative organ. In this respect, castor bean roots would be richer on secondary metabolites than leaves and stems. However, a phytochemical screening of various organs of ours local castor bean accessions remains to be studied.

Data obtained in this study on castor bean uses corroborate in part data found in the literature: In fact, Weiss (2000) showed that oil from castor bean is a source of purgative, laxative and anesthetic products. Besides, Mana (2000) revealed that stems of castor bean are used in the manufacture of rock salt; Maroyi (2007) reported that young fruits of this plant are eaten in Bengal (India) and mature leaves are dried and eaten as a vegetable in Korea. It was noted in this study that castor bean is not used in our study area on ornamental, agricultural, pastoral, veterinary, artisanal and industrial levels as several authors have pointed out. Indeed, Pina *et al.* (2005) revealed that India, China, Brazil and Madagascar industrially grow castor bean. Multiple uses of castor bean observed in this study suggest that the extension of castor bean crop production in Cameroon would contribute to rational exploitation of our local flora, diversifying of raw materials sources

and avoiding to exert increased pressure on species of agricultural interest. This will prevent on genetic erosion and environment degrading.

The vegetative organs of castor bean accessions inventoried in this study have presented different colors. This is in accordance with Maroyi (2007) who reported that castor bean can have a beige, brown, green or purple bark.

It was observed in this study that plants height of our local castor bean accessions ranged from 148.63 ± 19.05 to 302.96 ± 44.36 cm. These results are in line with previous studies. Indeed, several authors (Mana, 2008; Maroyi, 2007; Tchuenteu *et al.*, 2013) revealed that plants height of castor bean varies from 1 to 8 m depending to genotype and experimental area. Knowing the height of a plant is an important parameter on harvest process. Indeed, fruits harvest of tall plants is hard than those from shorter plants. In this respect, our research group indicated previously that the harvest of castor bean fruits is easier when plants height is less than 2 m. In the current study, plants height of Martap, Nyambaka and Bélel accessions are greater than 2 m while plants height of Vina accession is less than 1 m, thus suggesting that fruits harvesting of Vina accession would be easier and conversely for Martap, Nyambaka and Bélel accessions.

To the best of our knowledge it was for the first time that leaf blade area of castor bean was evaluated. Foliar production is a recyclable biomass. Indeed, leaves can be degraded under microorganisms actions and release mineral elements necessary to improve soil fertility. Leaf production and plant height are among the main factors to determining seeds yields (Reedy and Matcha, 2010; Tchuenteu, 2014). In this respect, any factor that affects these parameters will also affect plants production. Ours previous studies showed a significant correlation ($p < 0.05$) between plant height and leaf production; between foliar production and seeds yield (Tchuenteu, 2014). Indeed, leaves are the

organs in charge of photosynthesis. Thus a leaf area increasing of castor bean plants would suggest an increasing of photosynthetic activity, and therefore a seeds yield increasing. In this study, limb area varied depending on castor bean accession: limb area of Bélel accession was found 1.21; 5.51 and 1.6 fold higher than that of Vina, Martap and Nyambaka accessions respectively. The greatest foliar production observed on Bélel accession suggests that this local accession of castor bean would provide the highest seeds yield. However, the potential of adaptability and seeds yield of the four castor accessions identified in the present work remains to be investigated..

Seeds physical characteristics of the local castor bean accessions were different from those found by Perdomo et al. (2013) on 07 local Mexican castor bean accessions. According to these authors reported that that the weight of Mexican castor bean seeds ranged from 0.13 to 0.40 g, seeds length from 1 to 1.5 cm, seeds width from 0.61 to 0.97 cm and the thickness ranged from 0.46 to 0.71 cm. An interest to study the physical characteristics of seeds lies in that geometric properties of castor seeds provide useful data for engineers in the design of seed-harvesting machines as well as for extracting seeds oils (Tchuenteu, 2014). Seeds weight from the Nyambaka accession was respectively 2.00, 1.85 and 1.6 fold higher than those of Vina, Martap and Bélel accessions. In this work, physical characteristics of vegetative organs and seeds vary depending on castor bean accessions thus suggesting that it would present different genotypic constitutions, however molecular characterizations of castor bean accessions identified in this work remains to be studied.

Several authors (Pina et al., 2005; Tchuenteu et al., 2013) revealed that castor bean is grown for its seeds rich in oil. Also, castor bean crop would produce a significant vegetative biomass amount. In this respect, this plant would have a strong ability to sequester atmospheric CO₂, which is one of

the greenhouse gases responsible for global warming. It would therefore be interesting to evaluate the biomass as well as carbon sequestration of 04 local castor bean accessions obtained in this work. Ibrahima and Habib (2008) reported that there is a positive correlation between plants biomass and amount of CO₂ sequestered, which justifies the high carbon stock and carbon credit observed on Bélel accession. The high values of plants dry biomass, carbon stock and carbon credit provided by Bélel accession compared to castor Vina, Martap and Nyambaka accessions suggest that this local accession of castor bean could contribute effectively to fight against climate change and desert advancement in the Far North Cameroon. However, the adaptability potential and seeds yield of these local castor accessions remain to be deeply investigated.

The geographical distribution of our local castor bean accessions varied depending on localities from the study area, thus indicative that Sub-divisions of the both Divisions, Vina and Mbéré would have different climatic conditions (microclimates) as well as edaphic factors (soils physicochemical properties and soils biological composition). Indeed, plants growth varies according to genotype and experimental area.

Conclusion

In Vina and Mbéré Divisions of Adamawa Cameroon region, castor bean is used to treat several diseases; seeds oil is consumed and plants present margico-religious powers. 04 local castor bean accessions (Vina, Martap, Nyambaka and Bélel) were identified. Overall, there is a significant difference between four local castor bean accessions identified on physical characteristics of vegetative organs and seeds. Plants of Bélel accession was the tallest while the smallest plants height were found in Vina accession. Vina accession is the most widespread, followed by Martap accession while the Nyambaka and Bélel accessions are

the least widespread in our study area. This information will constitute basic data in the implantation program of castor bean as alternative crop for the Cameroonian agriculture. Our future research will focus on evaluating oils physicochemical properties from castor bean accessions identified in order to determine their industrial potential.

COMPETING INTERESTS

The authors declare that there is no competing interest regarding the publication of this manuscript.

AUTHORS' CONTRIBUTIONS

CM initiated the study, supervised the work and reread the manuscript. LTT has processed the data and wrote the manuscript. AM carried out the studies (ethnobotanical surveys, determination of the physical characteristics of castor bean accessions, evaluation of carbon stock and carbon credits as well as geolocation of castor bean accessions).

ACKNOWLEDGMENTS

The authors thank the people in the study area for the hospitality and endogenous sharing of knowledge. They also thank the anonymous readers for their scientific contribution which permitted to improve this manuscript.

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