



Research Article

Landrace Diversity and Production Systems of Cowpea (*Vigna unguiculata* L. Walp.) in Southern Chad

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Abstract

In Chad, cowpea (*Vigna unguiculata* (L.) Walp.), is increasingly becoming a cash crop. The objective of this work is to assess the varietal diversity, analyze the traditional management of landraces and the production systems of cowpea in southern part of Chad. An inventory and an ethnobotanical survey was conducted through a participatory approach in 17 villages corresponding to two agro ecological zones. Thirty-four vernacular names and 45 landraces are inventoried. On average, 2 names are assigned per village. The number of landraces varies from 4 to 13 with an average of 9.00 per region and 2.70 per village. The highest diversity is observed in Mayo Kebbi. Sixteen morphotypes have been identified and their distribution varies according to the agro ecological zones. Productivity (31.10 %), taste (25.92 %) and grain size (18.34 %) are the farmer main preferred criteria. Farmers use leaves (47 %), pods (29.50 %) and seeds (14.75 %) to identify landraces. Cowpea cultivation is practiced on small areas and in intercropping system (78.60 %). Conservation of seeds (36.07 %), low fertility of the soils (27.85 %) and drought (17.77 %) were the main production constraints. Cowpea is stored mainly in traditional granaries (34.96 %) and on racks (22.93 %). For seeds treatment, farmers use mainly traditional means (32.37 %) and chemical products (6.67 %). Several cowpea-based dishes are identified. Cowpea has also therapeutic virtues. To improve cowpea production, appropriate actions must be considered against the constraints inventoried. The interesting landraces should also be used in a breeding program.

Keywords: Cowpea; diversity management; production constraints; conservation; landrace; Chad.

Introduction

The promotion of the local plant genetic resources in Chad is one of the main priorities of national research institutions. These resources have great potential that can be used in a breeding program. Better knowledge of these resources, the preservation, and integration of some of their traits in national varietal improvement program, will certainly contribute to achieve food security. Cowpea (*Vigna unguiculata* L. Walp.), is a main African leguminous in sub-Saharan Africa region. It is a well-isolated species within

the genus *Vigna*, but it is very diverse (Pasquet *et al.*, 1997). Cowpea is a neglected crop with a strong potential allowing it to contribute to the major challenges of food and nutrition security and even in sustainable agriculture (Gomes *et al.*, 2021). In Chad, even if millet and sorghum constitute the staple food of the populations, cowpea, native of Africa (Padulosi and Ng, 1997) and which West Africa is said to be the first center of domestication (Baudoin and Maréchal, 1985), is one of the most cultivated crops. Its annual

production worldwide is 8,9 million tons from 14,4 million hectares. In Africa, Nigeria is the largest producer with 3,5 million tons (FAOSTAT, 2019). In Chad, cowpea was initially considered as a lean crop but is increasingly becoming cash leguminous. At the national level, the average cowpea production over the past 10 years is 129,506 t. However, for the 2020-2021 season, the sown areas are 227,341 ha for an estimated production of 154,586 t, i.e. an increase of 25,080 t compared to the previous season. Regarding the main protein-oil seed crops, during the 2020 season, cowpea ranks third after peanuts, whose production is 840,035 t and 202,074 t for sesame (DPSA/ANADER, 2021).

Compared to research activities, unlike crops such as sorghum (*Sorghum bicolor* L. Moench) (Gapili and Djinodji, 2016; Nadjiam, 2020), and cassava (*Manihot esculenta* Crantz) (Nadjiam *et al.*, 2016) which has been the subject of much work, little research was done on cowpea. It should be noted that in 1987, a few landraces were collected in the Sahelian zone of Chad. Subsequently, further surveys were carried out in part of the Sudanian zone in two regions where 60 cowpea cultivars were collected (Gapili *et al.*, 2020). An ethnobotanical and genetic diversity study of these cultivars has identified the criteria for nominating cultivars and the relevant traits that may contribute to the creation of new early and productive varieties. Likewise, 44 local cultivars were characterized from an agro morphological point of view. The diversity revealed show the importance of the local genetic potential (Nadjiam *et al.*, 2015). Moreover, in order to improve the agricultural production, improved varieties have been introduced through regional projects in different agro ecological zones in Chad. An assessment of the precocity and productivity of improved varieties was also done and promising varieties for the semi-arid zones of Chad were identified (Nadjiam and Touroumngaye, 2014).

Concerning the local practices for the management of plant genetic resources, much work has been carried out on different crops (Gaouna *et al.*, 2011; Nadjiam *et al.*, 2016; Gapili and Djinodji, 2016; Nadjiam, 2020) except only one that focused on cowpea (Gapili *et al.*, 2020). From these observations, it emerges at the national level that there has been less work on this subject on cowpea. Indeed, prospecting, collection, management practices and specific uses of cowpea landraces have not been sufficiently documented, listed, or valued. Although according to Baco *et al.* (2007), only few local knowledge as «cultural symbolism of varieties» based on anthropo-economics parameters allowed to maintain diversity but it is no longer sufficient to conserve this diversity. However, a good knowledge of these traditional practices will make it possible to better understand their logic in order to propose solutions adapted to the improvement of agricultural production. Indeed, many authors have reported that most

farmers use local cultivars for reasons of production stability (Willemen *et al.*, 2007). Likewise, farmers prefer local cultivars instead of improved varieties for their organoleptic characteristics and high commercial value (Alemu *et al.*, 2016).

All over the world, cowpea cultivation faces many production constraints. In addition, cultivation techniques, processing, conservation, storage techniques and means of combating pests remain the real problems of farmers. Cowpea is also considered as one of the leguminous whose uses are very varied because of its multiple qualities. In Benin, for example, a farmer management system tries to ensure the maintenance of varieties based on practices such as botanical treatments, seed multiplication and intercropping system (Baco *et al.*, 2008). In terms of treatments for therapeutic uses, in a study conducted in Togo, Agbodan *et al.* (2020) identified local varieties of cowpea that help to fight against malnutrition because they have remarkable antioxidant potential compared to the introduced varieties. In Ethiopia, the green leaves and grains of cowpea are used in the treatment of liver disease, gastritis and malaria (Alemu, 2019).

The objective of the present study is to assess the varietal diversity, analyze the traditional management of landraces and the production systems of cowpea in southern part of Chad.

Material and Methods

Study Area

The study was conducted in the southern part of Chad which is situated between the latitudes 7°26'35'' and 11°12'43'' North and the longitudes 13°58'30'' and 17°35'27'' East. The area of this site is 81,070 square kilometers. Seventeen villages of the departments of Monts de Lam, Tandjilé Ouest and Centre, Lac Wey, Lac Léré, and Mayo Dalla from the regions of Logone Oriental, Logone Occidental, Tandjilé, Mayo Kebbi Est and Mayo Kebbi Ouest are involved in prospecting and collecting landraces. The geographic coordinates of the villages were recorded with a GPS and plotted on a map using ArcGIS version 10.2 software (Fig. 1). The study area is located between the 8th and 10th parallel. The climate is tropical semi-humid, isohyets 900 to more than 1200 mm with a dry and a rainy season. Specifically, Monts de Lam department is located in the Guinean isohyets zone over 1200 mm, while the other departments are in the Sudanian zone in the 900 to 1200 mm (CNRD, 2018). Average temperatures vary from 24 to 38°C. The soils are ferruginous leached red in color, with a texture bought from clay and sand to clay. The vegetation is characterized by dense tree savannas with very sparse savannas in the flood zones in the Sudanese part, forest tree savannas and very clear forest tree savannas in the Guinean zone (CNAR, 2015).

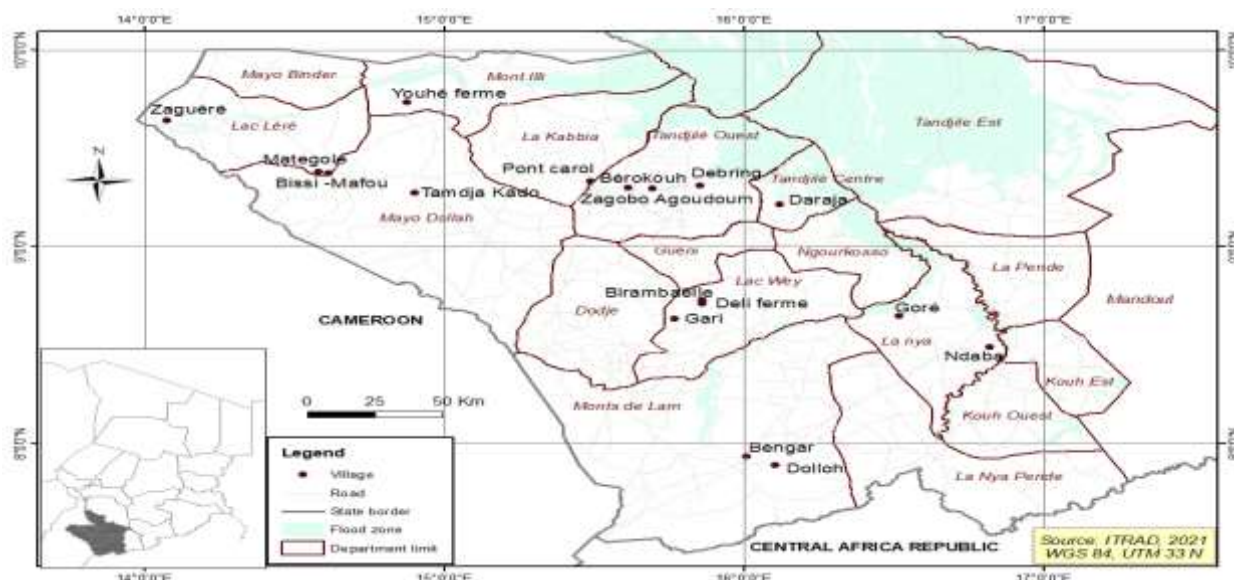


Fig. 1: Location of villages surveyed.

Data Collection

After bibliographical research and an exploratory mission, the areas of major cowpea production were listed and the villages were identified in each of the departments. A questionnaire was developed and validated. The survey was conducted in a participatory manner by the research team made up of a researcher and a technician in charge of extension in each sector. In each village, the interview was done with a focus group made up of 15 farmers. Data collection include general information on the village, cowpea production systems, list of landraces of the village, their names and meanings, the selection and recognition criteria, the constraints linked to the production and conservation of crops as well as the uses of cowpea. Subsequently, the landraces were collected according to a collection sheet, in the form of pods or grains, numbered, processed, and stored in suitable packaging.

Data Analysis

Survey data were processed and analyzed using Sphinx software (*Sphinx Plus 2- Ed. Lexica-V5*). A morphological classification was done on the basis of the color of grains, the color and shape of the pods. The landraces were grouped into morphotypes and their distribution in the area of study was determined. The MS Excel 2007 table was used to process some quantitative data and tables and graphs were then produced.

Results

Profile of Respondents

The survey is conducted using a participatory approach in the targeted villages. For 255 farmers questioned, 79.05 % are men and 20.95 % are women. The most representative ethnic groups identified in the area are the *Laka*, *Ngambaye*, *Moundang*, *Kado*, *Zimé*, *Lélé*, and *Toupouri*. The majority

of those surveyed are Protestants (63.80 %), Catholics (31.00 %) and animists (5.20 %).

Cowpea Landrace Diversity in Southern Chad

Forty-five cowpea landraces are inventoried. The number of landraces ranges from 4 to 13 with an average of 9.00 landraces region-wide. The greatest number is collected in Mayo Kebbi Ouest with 13 landraces for only 4 which are found in Logone Occidental. The greatest diversity are observed in Mayo Kebbi Est and Mayo Kebbi Ouest and Logone Oriental with 4.00 and 3.25 landraces per village respectively. On the other hand, this diversity is low in Logone Occidental. Across the entire study area, the average is 2.70 landraces per village (Table 1). Furthermore, for the farmers, the main preferences criteria are productivity (31.10 %), taste (25.92 %), and grain size (18.34%). As for the criteria of distinction, the leaves (47 %), the pods (29.50 %), the grains (14.75 %), and the habit of the plant (8.27 %) are the most used.

Cowpea Landraces Vernacular Names

The study revealed 34 vernacular names for 45 cowpea landraces collected (Table 2). The most common names identified in the different languages most spoken in the surveyed localities are *Mindji*, *Mondjé*, *Moudjou*, *Aïn*, *Euh*, *Tongou* and *Tikssa* where a qualifier is added when it's needed. There are 8 names in Logone Oriental, 10 in Logone Occidental, 4 in Tandjilé, and 12 in Mayo Kebbi. The main languages used for these names are *Zimé*, *Lélé*, *Moundang*, *Kado*, *Ngambaye*, *Laka*, and *Toupouri*. The average naming of landraces is 2 per village. Logone Occidental has an average of 3.33 per village and this is the highest rate of the regions studied. On the other hand, in the regions of Logone Oriental and Mayo Kebbi, there are 2 per village. In the Tandjilé region, on average per village, only one name was recorded according to the majority ethnic group of the village (Table 3).

Table 1: Rate of cowpeas' landraces per village.

Region	Villages number	Number of landraces	Number of landraces per village
Logone Oriental	4	11	2.75
Logone Occidental	3	4	1.30
Tandjilé	4	9	2.25
Mayo Kebbi Est	2	8	4.00
Mayo Kebbi Ouest	4	13	3.25
Study area	17	45	2.70

Table 2: Vernacular names of cowpea landraces and their meaning.

Region	Village	Ethnic group	Vernacular name	Mean	
Logone Oriental	Dolloh	Ngambaye	Leltambâh	It's so sweet and the stranger wants to eat more	
	Dolloh	Laka	Ngasang		
	Dolloh	Laka	Mindjindoul	Black grain cowpea	
	Dolloh	Laka	Mondjé Bê	Cowpea from Land	
	Dolloh	Laka	Kembaydessel	Chief must eat it	
	Bengar	Laka	Mbogdjo		
	Bengar	Laka	Djarwai/Djogyo		
Logone Occidental	Goré	Ngambaye	Goladjé	It sells fast	
	Goré	Ngambaye	Minji Teun		
	Ndaba	Ngamabaye	Bugaotal	Invisible to old people	
	Gari	Ngambaye	Djiguidjé Kouloulou	Millipede cowpea	
	Deli	Moundang	Ladamra	Try it	
	Deli	Moundang	Ugzalé		
	Deli	Ngambaye	Bugaotal	The old man can eat before he dies	
	Deli	Ngamabaye	Mindji nda	Cowpea with white grain	
	Birambawelle	Ngambaye	Godjé	Coarse grains	
Deli ferme	Ngambaye	Allahadoum	God gave me		
Tandjilé	Debring	Lélé	Tongou	Cowpea	
	Debring	Zimé/Mesmé	Tikssa Kourdou	Curved pod	
	Daraja	Lélé	Tongou Kourbian	Rainy season cowpea	
	Bereokou	Zimé/Mesmé	Tikssa ndor	Early cowpea	
Mayo Kebbi Est et Ouest	Bissi Mafou	Moundang	Euh phaï	Cowpea with white pod and grain	
	Bissi Mafou	Moundang	Euh fou	Cowpea with long black pod	
	Bissi Mafou	Moundang	Seygui	Long and thin pod like a mouse tail	
	Mategolé	Moundang	Gouaring	Curved pod	
	Mategolé	Moundang	Ezalé	Rainy / Early season cowpea	
	Tamdja Kado	Kado	Medndor	Early cowpea	
	Tamdja Kado	Kado	Redfouta	Late cowpea	
	Youé ferme	Toupouri		Aïn waïla	Cowpea long pods
		Toupouri		Aïn yéé	
		Toupouri		Naou do dui ti dui	Cowpea 55 day cycle
Toupouri			Ma dé tchonrêh	Sweet cowpea	
Toupouri		Aïn fiougou	Cowpea with coils pod		

Table 3: Landraces' local name rate per village.

Region	Local names number	Villages number	Rate per village	Main ethnic group
Logone Oriental	8	4	2.00	Laka and Ngambaye
Logone Occidental	10	3	3.33	Ngambaye
Tandjilé	4	4	1.00	Lélé, Zimé/Mesmé
Mayo Kebbi Est/Ouest	12	6	2.00	Moundang, Kado, Toupouri
Total	34	17	2.00	

Evolution of Cowpea Varietal Diversity

According to 28 % of farmers, a certain number of landraces have disappeared. The locality where this loss is most significant is the village of Bengar in Logone Oriental. The most cited landraces are: *Moudjou kla*, *Moudjou tounou*, *Moudjou kag*, *Mindjé-Tog* and *Mindjé ndoul*. The main possible reasons for these disappearances mentioned by the farmers are the unavailability of seeds (41.28 %), their susceptibility to insects (21.10 %), diseases (15.60 %) and the late cycle of some landraces (11.93 %).

Traits and Distribution of Cowpeas' Morphotypes

Based on morphological traits such as grain color, pod color and pod shape, landraces are grouped into 16 morphotypes (Fig. 2). Examination of the areas where these morphotypes are collected made it possible to determine the level of their extent throughout the study area (Table 4).

Farming System and Main Constraints in Cowpea Production

Sorghum is the dominant crop in this area as specified by 56.20 % of the farmers and 13.80 % for groundnuts. For cowpea, only 6.30 % of farmers say it is their main crop. In fact, cowpea is mainly cultivated in intercropping system at 78.60 % and 21.40 % alone except, in four villages namely *Zagueré* in Mayo Kebbi, *Berekou* in Tandjilé, *Bengar* and *Dolloh* in Logone Oriental. Specifically, in the *Zagueré* flood plain, cowpea is practiced in pure and out of season by nearly 80 % of farmers. For the village *Berekou*, cowpea is cultivated in pure form and in the rainy season by 73.30 % of farmers.

Regarding the areas allocated to cowpea cultivation, less than one hectare is intended for cowpea according to 29.10 % of farmers questioned and 31.90 % do so on 1 to 2 ha. Compared to the evolution of areas sown with cowpea, 42.40 % of farmers consider it stable and 34.30 % believe that it is increasing. Rather, around 9.50 % indicated that

the areas intended for production have fallen sharply. As for the sources of seed supply, these are essentially made through exchanges between farmers in the same locality, as confirmed by nearly 95.06 % of them. Only 1 % of respondents reported that improved varieties have been introduced by research in recent years in rural areas. In addition, cowpea production is subject to many constraints. Thus 36.07 % of farmers believe that the main constraint is the difficulty of conservation of seeds. Others constraints, as the low level of soil fertility, drought, diseases and pests are also factors that negatively impact cowpea production (Table 5). Among these pests, the most cited by farmers, are bruchids, aphids, termites, ants, and hairy insects. For the most frequent diseases causing the decrease in cowpea production, they are mainly leaf wilting, multiple spots on leaves and pods, pod rot and damping-off (Table 6).

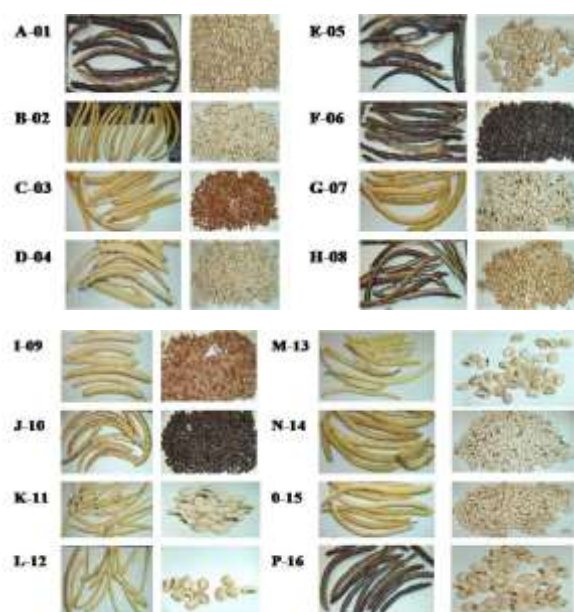


Fig. 2: Morphotypes of cowpea collected (From A to H and I to P).

Table 4: Some traits and extend of cowpea morphotypes.

Code	Traits	*Distribution	Agroecological zone
A-01	White grains, brown pod shaped as a half arch	LOR, LOC, TA, MKE, MKO	Sudanian and Guinean
B-02	White grains, reddish and elongated pod	LOR	Guinean
C-03	Red grains, white pod shaped like a half arch	LOR	Guinean
D-04	White grains, white pod shaped as a half arch	LOR	Guinean
E-05	Brown grains, whitish pod shaped as a half arch	LOR	Guinean
F-06	Dark brown grains, brown and elongated pod	LOC	Guinean
G-07	Brown grains, whitish and elongated pod	LOR, LOC, TA, MKE, MKO	Sudanian and Guinean
H-08	Brownish grain, elongated brown pod	MKO	Sudanian
I-09	Reddish grain, white, elongated pod	TA	Sudanian
J-10	Dark brown grain, curved pod, white with brown speckles	TA, MKE	Sudanian
K-11	White grain, white curved pod	MKE, MKO	Sudanian
L-12	White grain spotted with gray, curved white pod	MKE	Sudanian
M-13	White grain spotted with gray, elongated white pod	MKO	Sudanian
N-14	White grain, reddish pod like a half arch	LOC, MKO	Sudanian
O-15	White grain, white and elongated pod	LOR, LOC, TA, MKE, MKO	Sudanian and Guinean
P-16	White grain, elongated pod, brown with white areas	MKO/MKE	Sudanian

*LOR : Logone Oriental ; LOC : Logone Occidental ; TA : Tandjilé ; MKE : Mayo Kebbi Est ; Mayo Kebbi Ouest.

Table 5: Main constraints in cowpea production.

N°	Main constraints	Percentage of responses (%)
1	Lack of land	5.57
2	Low soil fertility	27.85
3	Drought	17.77
4	Seed conservation difficulty	36.07
5	Destruction by herds	4.77
6	High susceptibility to diseases and pests	6.63
7	Lack of manpower	0.80
8	Others	0.54

Table 6: Cowpea Pests and diseases reported by farmers.

Pests	Responses (%)	Diseases	Percentage of responses (%)
Bruchids	24.96	Wilting leaves	34.83
Aphids	25.38	Spots on leaves and pods	29.53
Termites	18.47	Rotting of pods	16.50
Ants	10.58	Damping-off	16.60
Hairy insects	16.45	No idea	2.54
Others	4.16		

Cowpea Seed Conservation and Storage Practices

The survey reveals that traditional granaries remain the most used places for the storage of grains of cowpea (34.96 %). This storage is also done on the racks (22.93 %) and hangars (10.90 %). Few farmers keep their cowpea stock in their rooms (13.16 %) or in community stores (18.05 %). However, with regard to seeds, their conservation is mainly done in bags (70 %), in jars (12.69 %) and in metal barrels (11.54 %). Traditional techniques are also recommended by the farmers, namely preserving cowpea with their pods (4.62 %), packing them in bales of straw (0.38 %) or put them in cans (0.77 %). Regarding the bags for conservation, the nature of these bags has not been specified but it said that the bags are imported from Nigeria (*Baba Gana*). The second kind of bag is a triple bagging bags called *PICS* bags.

In addition, about 60 % of farmers say they do not process their cowpea stock. The pepper is used by a significant number of farmers, 28.57 %. In total, 32.37 % of farmers use traditional means of struggle. On the other hand, chemicals are only used by 6.67% of respondents.

Consumption and other Uses of Cowpea

The uses of cowpea are varied and relate to human consumption, soil fertilization, livestock feed, botanical treatments and medicinal. In human consumption, 32.09 % of respondents indicate that the grains are usually eaten. For immature pods and fresh or dry young leaves, these proportions are respectively 31.15 % and 31.62 %. The lignified leaves are only appreciated by 5.14% of farmers.

As for cowpea-based dishes, it is mainly sauces made from ingredients of grains and fresh or dry leaves, which are cited by 32.80 % of respondents. The grains are also eaten after cooking by 24.85 %. It's also used in the preparation of soup

(14.91 %), pasta (11.93 %), porridge (7.95 %) and donuts (3.38 %). Cowpea haulm is used for livestock.

In addition, specific uses of cowpea grains and leaves have been reported by farmers who consider them as sources of "vitamin" (10.31 %) and therapeutic virtues. Indeed, 28.87 % of farmers actually use them to treat abscesses and 15.46 % for skin swelling. Porridge enriched with cowpea is also reported by 20.62 % of farmers. To a lesser extent, cowpea grains and leaves are used to treat certain diseases and even used as an aphrodisiac (Table 7).

Table 7: Cowpea stock processing products and medical uses.

Modalities	Percentage of responses (%)
Cowpea stock processing products	
Chemical product	6.67
Neem oil (<i>Azadirachta indica</i>)	1.9
Pepper (<i>Capsicum sp</i>)	28.57
Without treatment	60.00
Threshing without winnowing	1.90
Others	0.96
Medical uses of cowpea	
Abscess	28.87
Gastritis	7.22
Enriched porridge	20.62
Skin swelling	15.46
'Vitamin'	10.31
Chicken pox	4.12
Nausea	4.12
Wounds	5.16
Aphrodisiac	4.12

Discussion

In Chad, cowpea, considered for a long time as a vital crop during lean periods, appear more and more like a second cash legume after peanuts. In the study area, the estimated production during 2020 is 38,418 t which is 61.23 % of the production of the entire Sudanian zone. However, even if cowpea production has increased over the past four years, its average productivity during the 2020-2021 seasons is still low, 627 kg/ha in rural areas (DPSA/ANADER, 2021). This low yield is due to several combined factors, as climate change, lack of technical itineraries, and the low coverage rate of the supervision of farmers.

Varietal diversity observed at the regional and village level is highly variable. Indeed, the regions of Mayo Kebbi Est and Ouest, present a significant diversity per village. Regionally, the average number of landraces in this part of southern Chad is almost similar to that of three regions located in the southwestern parts of Ethiopia (Alemu *et al.*, 2019). However, the average of landrace collected per village which is 2.70 is low compared to 4.29 reported by Gapili *et al.* (2020). This diversity is even less than that observed in southern Benin (Gbaguidi *et al.*, 2013). However, farmers continue to use their local varieties which are usually selected in the fields. This is not only for socio-cultural considerations but also as pointed out by Willemen *et al.* (2007) for reasons of stability of their production.

The study also made it possible to identify 34 vernacular names for 45 cowpea landraces collected. The languages which were used for these appellations are those which are mainly spoken in the localities surveyed. Thus, in both Logones, cowpea is designated by the words *Mindji*, *Mondjé*, and *Moudjou*. In Tandjilé, it is called *Tongou* in Lélé language and *Tikssa* in Zimé. On the other hand, in Mayo Kebbi, it is called *Aïm* in the Toupouri language, *Red* in Kado and *Euh* in Moundang. According to several authors, farmers identify landraces of many crops, by naming them on the basis of criteria and parameters. Caillon *et al.* (2005), in a study on taro (*Colocasia esculenta* L. Schott), report that these local criteria are relevant. In this present study, the traits used by the farmers in the vernacular nomenclature, are based on the color and shape of the grains, the color and size of the pods, the taste, the cycle, the market value of the variety. Sometimes they even use expressions and proverbs. In the Maritime-East region of Togo, the farmer nomenclature of cowpea landrace is based on the color of the grains and their flavor (Agbodan *et al.*, 2020). In general, local names are important socio-cultural traits used by these communities in the management and selection of plant resources (Missihoun *et al.*, 2012). Likewise, Wembou *et al.* (2017) assert that this taxonomy is essential for the documentation of farmer knowledge linked to the management of the genetic diversity of cultivated plants. It thus plays an important role in the management of biodiversity (Manusset, 2006). Local

names are most often given according to the dialects of the locality. Very often, same landrace have different names or different landrace have identical names. Sometimes a landrace can have more than one name. Indeed, many authors claim that these names vary from one ethnic group to another and from one locality to another (Elias *et al.*, 2001; Mekbib, 2007).

In Chad, in the case of cowpea, specific selection and distinction criteria are commonly used by farmers. In terms of landrace recognition, they use in particular the color and texture of the grains, as reported by Ouedraogo *et al.* (2010). These criteria are important. In Senegal, a classification based on the color and shape of pods and grains from nine varieties named by the farmers, identified 18 variants corresponding to 18 varieties (Konan *et al.*, 2007).

During the collection phase, interviews with the farmers enabled us to collect some information on the reasons which lead them to choose cowpea landraces. The choice criteria used are productivity, importance of biomass, earliness, resistance to drought and specific cooking skills such as grains that swell during cooking and their sweet taste. However, the main priority criteria are productivity, taste and grain size. As for the criteria of distinction, the leaves, pods, grains and the habit of the plant are the most used but other additional criteria such as the shape, color, and appearance allow the recognition device to be refined.

Moreover, the main reasons for landrace loss mentioned by farmers seem to be linked to their practice of conserving diversity. In fact, they preserve their landrace *in situ*, however, with climate change the rate of seed loss is quite high due to poor harvests. The survey showed also that farmers use very few chemicals regarding sensitivity of cowpea to insects and diseases. Although this loss has only been observed in Bengar village in the Logone Oriental region, five landraces have disappeared. The loss rate is 83.33 % at the level of this village. Over the entire study area, it is 10 %. Compared to previous work on cassava carried out in five regions of southern Chad (Nadjiam *et al.*, 2016) and on sorghum (Gapili and Djinodji., 2016) in two regions of the same area, this rate is low. Similar studies conducted in Togo on yams, have shown that for ecological, agronomic, socio-cultural, and economic reasons, their varietal richness has decreased in 78 % of the localities surveyed (Wembou *et al.*, 2017). The decrease in productivity and the susceptibility to biotic factors are identical to those observed in the present study.

The survey also shows that sorghum is the dominant crop in the study area. However, cowpea occupies an important place in production systems. It is mostly cultivated in association mainly with sorghum, millet, maize, cassava and very little in pure. In the first case, it is a question of a strategy of crop diversification, improvement of soil fertility, especially during associations with cereals, but also

to secure production. In association with cereals, late varieties of cowpea are maintained through these cropping systems which optimize labor productivity (Baco *et al.*, 2008). In Niger, Harouna Issa *et al.* (2014) showed that 73 % of farmers produce voandzou (*Vigna subterranea* L.) in pure against 27 % who associate voandzou with millet and sorghum. In the cowpea production system practiced in Southwest Nigeria, cowpea, according to 55.1% of farmers, is mainly cultivated in association with cassava (Saka *et al.*, 2018). Likewise, in a study conducted in three states in northern Nigeria, Mohammed *et al.* (2021) showed that 42 % of farmers produce cowpea in traditional intercropping, 25 % do it pure while 23 % had cowpea fields in both single crop and intercrop. In the study area, single cowpea cultivation is practiced mainly in the plain of Zaguéré village during the off-season, after the waters of Lake Léré have receded. In Zaguéré, there are several varieties, each of which is grown on a small plot. This practice of polyvarietal cultivation is similar to that observed in Benin for yam (Dansi *et al.*, 1997) and in some fields in Chad for cassava (Nadjiam *et al.*, 2016).

Regarding the modes of exchange of plant material, the sources of seeds supply are mainly through exchanges up to 95% between farmers in the same locality. Nadjiam *et al.* (2016) reported in the case of cassava that the main modes of obtaining cuttings are 60.84 % in the same area. In Benin, Baco *et al.* (2007) reveal that the exchanges of varieties are practices of proximity, which mainly take place between farmers of the same village (70 %). These authors assert that these exchanges favor the mixing, conservation, and geographical distribution of varieties. In contrast, in the Kara region of Togo, in the case of yam, the proportions are 45 % as reported by Wembou *et al.* (2017) are rather low.

The cowpea production constraints, are practically the same compare to others crops. However, in this Sudanian part of Chad, the difficulty of saving seeds, the low level of soil fertility, drought, diseases, and pests, were identified as major constraints. In the Sudanian zone of Ethiopia, insects are one of the main constraints in cowpea production (Alemu *et al.*, 2019). This parasitic pressure on cowpea was also mentioned by 31.6 % of cowpea farmers in the Maradi and Zinder regions in Niger (Abdourahamane *et al.*, 2020). In relation to soil fertility, in Chad, cowpeas are generally grown without the addition of fertilizers. Cowpea is widely used in crop rotations where it improves soil fertility in symbiosis with bacteria of the genus *Rhizobium spp.* and *Bradyrhizobium spp.* (Zablotowicz *et al.*, 1981; Quin, 1997). However, for a balanced level of soil fertility, it is necessary to add other mineral elements as well as organic matter. In order to improve the productivity of varieties under water deficit conditions, varieties adapted to drought have been also introduced. Various tests relating to the evaluation of the agronomic performance of cowpea

varieties have been carried out, in the Sahelian zone (Nadjiam and Touroumngaye, 2014).

Regarding the management of cowpea stocks, the majority of farmers do not process their stocks contrary to the work of Gapili *et al.* (2020) which report that in the department of Barh-Kôh, region of Moyen Chari, 85 % of farmers use chemicals to preserve their harvest products while 15 % do so without treatment or with natural products. In the present study, farmers claim that processing chemicals for preserving cowpea grains are expensive and inaccessible. Likewise, the modes of use chemical products are not often mastered by the farmers. However, a third of the farmers questioned favored traditional techniques and methods of pest control based on pepper (*Capsicum sp*) and to a lesser extent neem oil (*Azadirachta indica*). In addition, it has been reported that farmers additionally use extracts from fresh neem leaves, dry tobacco leaves, and soap powder (Gapili *et al.*, 2020). Treatments of cowpea using plants have also been reported by Baco *et al.* (2008). These botanical products are neem powder or oil (*Azadirachta indica*), shea ash (*Vitellaria paradoxa*) and caïlcedrat bark powder (*Caya senegalensis*). Likewise, Touré *et al.* (2013) reported that in the Korhogo area in Côte d'Ivoire, nearly 42 % of farmers use chemicals and 24 % use ash for the conservation of Voandzou grains (*Vigna Subterranea* L.). The present study reveals also that bags are often used for the conservation of cowpea. One of them is called bag PICS. It is made of a woven polypropylene layer containing two other high density polyethylene (HDPE) bags of 80 microns each, which reproduces the conditions of hermetic storage (Murdock *et al.*, 2012).

Cowpea is also very popular and consumed by the population. The grains, pods, and young fresh leaves are used in human consumption in the form of many derived products. The grains are particularly rich in proteins, the contents of which can reach a quarter of the dry matter (Bressani, 1985; Singh and Rachie, 1985). However, a significant variability was observed in the protein composition. Likewise, essential amino acids such as methionine, cysteine, and tryptophan have been identified in some varieties of cowpea (Bliss *et al.*, 1973). In Chad, as in arid and semi-arid areas of Kenya, the leaves are also eaten as porridge, blanched, and dried as reported by Owade *et al.* (2020). Cowpea haulm, also rich in protein, are intended for livestock feed. Particularly in small ruminants, Azoutane *et al.* (2020) showed that the complementation with cowpea haulm increase intake and digestibility of *Dactyloctenium aegyptium* L.

Medicinally, therapeutic uses of cowpea have also been reported. These results are similar to other previous work even if the types of diseases treated are sometimes different according to the studies. Indeed, according to 23 % of the farmers surveyed in the Gambella and Oromia regions in Ethiopia, two varieties of cowpea are mainly used as

medicinal plants. The green leaves of cowpea are used for the treatment of yellow fever. The grains are used to treat malaria and gastritis (Alemu, 2019). In some localities of Niger, for 14 % of the populations surveyed, it is another legume of the same genus, Voandzou (*Vigna Subterranea* L.) which is used in the treatment of hemorrhages and also as an aphrodisiac (Harouna Issa *et al.*, 2014).

Conclusion

The study showed the importance of cowpea cultivation in Chad and its various uses. The varietal diversity observed into the study area is significant. Thus, it is important, to preserve and enhance these landraces in order to reduce genetic erosion. Cowpea is mainly cultivated in intercropping system and on small areas. However, the major production constraints are conservation of seeds, low level of soil fertility, drought, diseases and pests. To remove these constraints, appropriate actions must be considered for farmers. It was also found that of various reasons, farmers continue to maintain their landraces *in situ*. Likewise, their preferred criteria are highlighted in the present study. In order to improve the production of cowpea, the identified landraces can be used as sources of interesting genes for breeding after agromorphological and molecular characterization.

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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