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Social – Economic and Management Practices of soil fertility that Affects Cassava production in the Central African Republic: Case Study in Savanna and Forest areas

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ABSTRACT

Purpose: *Cassava is an important root crop in maintaining food security for the population in the Republic of Centrafrique (CAR). Despite this socio-economic importance, yields obtained remain low and demands are not yet met. The aim of this study was to identify socio economic and management factors that determine cassava yields in two agroclimatic zones of CAR.*

Research Method: *Socio-demographic characteristics, soil fertility management practices in cassava cropping systems and constraints related to cassava production in the CAR forest and savanna zones were collected using semi-structured interviews. Descriptive statistics, Student's t test and ordinal logistic regression were used to analyze data collected.*

Findings: *Cassava is the main crop in two agroclimatic zones. It is an activity carried out mainly by men. The areas sown for cassava vary between 0.45 and 0.85 ha. The main varieties grown were TMS 92/0329 (locally named Togo) and C96/OO5 (locally named Bobeketi). Disease resistance, high yield and organoleptic quality are the main criteria used for selecting varieties to grow. Cassava yields obtained for all varieties combined are significantly different (p = 0.0001) in the two zones, with an average of 4.41 t.ha-1 of root. These low yields were related to climatic constraints (violent wind and irregular rainfall) and a decline in soil fertility.*

Originality/ Value: *It is proposed to implement integrated soil fertility management strategies by combining mineral and organic fertilizers available in climatic zones that optimize plants' nutrient use efficiency in a context of climatic changes for sustainable cassava production.*

Keywords: *Climate variability, Food security, Roots and tubers, Soil degradation, Sustainable land management.*

INTRODUCTION

Global issues of food security define the major challenge of ecologically sustainable agriculture for more than seven billion people on the planet, which is based on safeguarding soil resources and the environment (Milleville and Serpantié, 2014). The Central African Republic (CAR), like the other countries of the Congo Basin, has significant agricultural production potential, estimated at 15,000,000 ha of fertile land, including numerous watercourses and highly productive forest areas that are among the largest in sub-Saharan Africa (Milleville and Serpantié, 2014).

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Agriculture plays a central role in the livelihoods of the majority of the Central African population, accounting for 92% of households, with strategic crops such as cassava maintaining food security such as crops cassava (Rockström, 2010; Griffon, 2016).

Among food crops grown in CAR, especially root and tuber crops, cassava is the most important because it is the staple food of the population (Mallouhin, 2002). Leaves are a highly prized vegetable and an important source of dietary protein (Zinga et al., 2013). Traditional medicine uses various parts of the plant. Leaves treat eye ailments, gonorrhoea, rheumatism and migraines (Kosh-Komba, 1999). The flour from the dried roots, which is very easy to digest, is recommended for gastric ulcers, acid reflux and abdominal bloating (Kosh-Komba, 1999). It also treats gastroenteritis, diarrhea and colitis. It is an ideal food for patients with poor digestive capacity (Kosh-Komba et al., 2021). Added to hot lemon juice, cassava flour is applied to boils and abscesses to make them ripen more quickly (Kosh-Komba, 1999). No food in the CAR today can replace cassava in people's diets (Mallouhin, 2002).

Cassava alone accounts for 70% of food crop production in CAR (MDRA, 2011; Kosh-Komba et al., 2021). Following the fall in world prices for coffee and cotton, which are the country's main cash crops, cassava has become a major source of income and subsistence for the population (Kafara, 2003; PRASAC,2017; Zinga et al., 2013). The crop was identified as a priority in the fight against hunger and poverty in the country's development policies (Roose et al., 1992; Pretty., 1997; DSRP2., 2011). Annual national production of cassava roots is estimated at 2.6 million tons.

Despite all this potential, production is still insufficient to meet the growing demand of the population (Zoundi, 2012; Zinga et al., 2013; Zinga et al., 2016; Yao., 2021). Agricultural production techniques are not very efficient. The farming system is dominated by extensive slash-and-burn agriculture. Soil structure is rapidly weakening and soil fertility is declining, which is contributing to low crop yields, resulting in the continued colonization of new farmland and the remoteness of fields. All these factors contribute to the decline of cassava yields. Given this situation, there is an urgent need to develop cultivation techniques that are accessible to farmers, enabling them to increase production and restore soil fertility in the long term. The study aimed to identify the factors (socio economic and soil management practices) that determine cassava yields in the climate zones of the CAR and strategies that farmers can implement to improve cassava yields in the field. Specifically, this involved i) analyzing cassava cropping systems in the CAR's forest and savanna zones, ii) determining the factors that govern cassava yield levels in farmers' fields and iii) identifying the strategies for improving cassava yields in the two agroclimatic zones.

MATERIALS AND METHODS

Study Area

Surveys were carried out in two agro-climatic zones of the Central African Republic (CAR): the forest zone (Lobaye prefecture) and the savanna zone (Ombella Mpoko prefecture) (Figure 1). The two zones cover a total area of 51,070 km^2. The forest zone has a Guinean forest climate, with two alternating seasons: a rainy season from March to mid-November and a dry season from December to February. Annual rainfall in this zone ranges between 1,500 and 1,800 mm yr^{-1} (Nguimalet, 2008).

The soils are ferralitic under high rainfall, which favors the leaching of minerals from the rocks to a certain depth (Doukpolo, 2014). These soils are nutrient-poor and acidic. Some ferralitic soils are developed from dolerites, while others lack clay and are found on sandy ground derived from quartzites (Doukpolo *et al.*, 2014). On the other hand, the savanna zone has a Sudano-Guinean climate with annual rainfall between 750 and 1100 mm yr^{-1} and an annual temperature of around 24.8°C (Nguimalet, 2008). The dominant soils are lithosols and shallower, moderately indurated cuirassed soils with good porosity. Generally, they have a massive structure and a clay-loam-sand texture (Ballot *et al.*, 2016). Cassava is one of the dominant crops in both zones.

Sampling

The sample size surveyed was obtained using the normal approximation of the binomial distribution proposed by Dagnelie (1998) :

$$N = \frac{(U_{1-\alpha/2})^2 \times p(1-p)}{d^2},$$

where $U_{1-\alpha/2}$ is the value of the normal random variable corresponding to a probability of $1 - \alpha/2$, with α being the risk of error. For $\alpha = 5\%$, the probability $1 - \alpha/2 = 0.975$ and thus $U_{1-\alpha/2} = 1.96$. The value of p, the proportion of producers engaged in cassava cultivation, was determined during an exploratory phase at the beginning of the survey

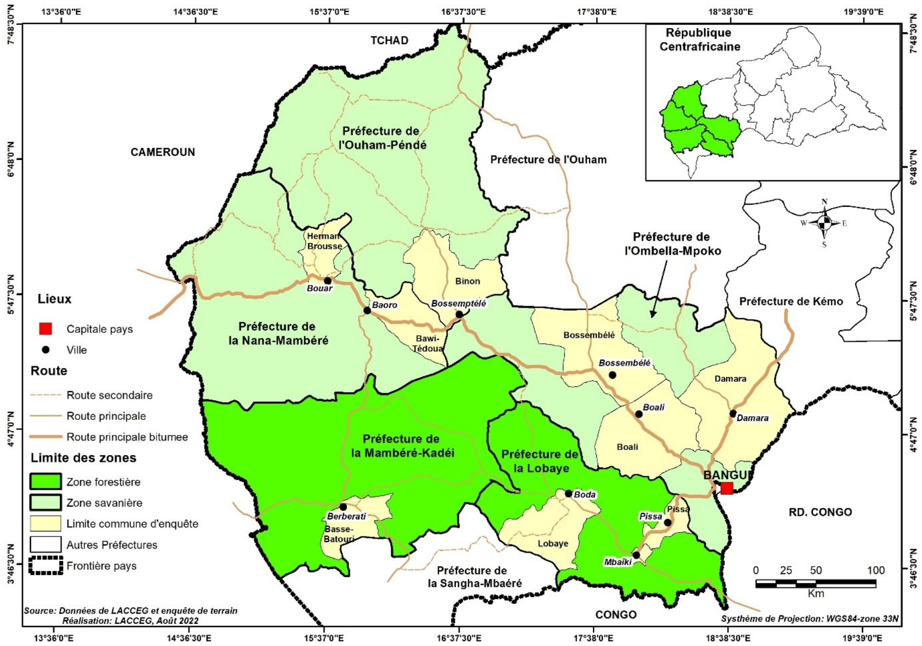

Figure 1: Overview of surveyed areas

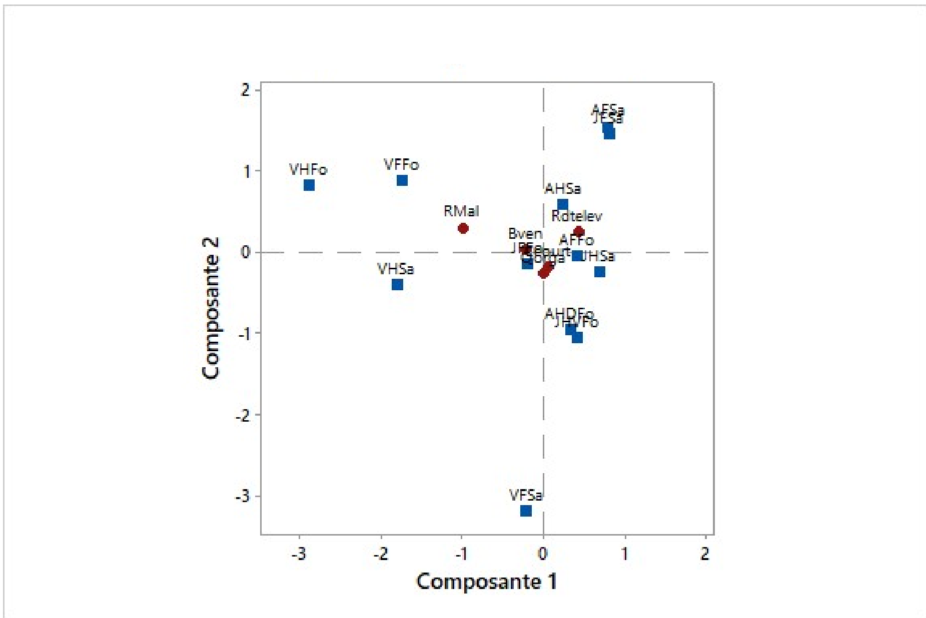

Figure 2: Projection of cassava accession selection criteria and socio-cultural groups in the Factorial Correspondence Analysis (FCA) factorial axis system.

Rdtelev: high yields; RMal: disease resistance; Bven: good sales; Ccourt: short cycle; Qorga: organoleptic quality; AFFo: adult female living in the forest; AFSa: adult female living in the savana; AHDFo: adult male living in the forest; AHSa: adult male living in the savana; JFFo: Young woman living in forest; JFSa : Young woman living in savana; JHSa : Young man living in savana; JHVFo : Young man living in forest; VFFo : Old woman living in forest; VFSa : Old woman living in savana; VHFo : Old man living in forest; VHSa : Old man living in savana

(Chabi *et al.*, 2019). Field surveys were conducted in 36 villages selected based on the percentages of producers ($\geq 45\%$) who indicated that cassava was their primary crop. The criteria for selecting villages were determined during the exploratory survey conducted from 16 July to 30 September 2021, based on information provided by the Statistics Department of the Ministry of Agriculture and data collected during the exploratory survey. A total of 699 producers were surveyed in both zones.

Data collected

Survey forms and interview guides were developed and deployed on a Kobo Toolbox interface spreadsheet. Smartphones were used to collect data in disconnected mode and then uploaded in real time to the ODK (Open Data Kit) server equipped with GPS capabilities, enabling georeferencing of the geographical coordinates of each person surveyed. The data collected included the socio-demographic characteristics of the farmers (age, gender, level of education, religion), their perceptions of the causes of declining cassava yields, production constraints, soil fertility management practices, and actual cassava yield figures. Information on climate constraints and adaptation strategies was also gathered.

Statistical analysis

The data collected was generated directly on the Excel spreadsheet, Office 2016 version. Statistical analyses were carried out using MINITAB 18 software. Descriptive statistics were determined for sociodemographic data and variables describing cassava cropping systems. Student's t-test with a threshold of 5% was used to compare cassava root yields in the two agroclimatic zones. Analysis of farmers' perceptions of the causes of the decline in soil fertility, the criteria for choosing the cassava varieties grown and climatic constraints was carried out using a Factorial Analysis of Correspondences (Uguru *et al.*, 2011; Bello *et al.*, 2017; Avaligbé *et al.*, 2021), taking socio-cultural groups into account. For this purpose, people surveyed were grouped according to the two climatic zones. Within each group, the farmers surveyed were grouped into three age categories: young people (aged < 50), adults (aged between 50 and 70), and old people (aged >70) (Assogbadjo *et al.*, 2008; Gnanglè *et al.*., 2011; Avaligbé *et al.*., 2021). A total of 42 sociocultural categories were considered, taking into account the climatic zone, age, and gender of the participants. Ordinal and nominal logistic regressions were used to identify the determinants of cassava yield and its evolution.

RESULTS AND DISCUSSION

Socio-economic characteristics of the producers surveyed

Results of the socio-economic variables of cassava farmers in the two zones surveyed were presented in Table 1. The majority of cassava growers were men in both agroclimatic zones, but there was a significant proportion of single women (45% in the savanna zone). The high involvement of women recorded contrasts with other regions where women's access to land is limited (Balogoun *et al.*, 2014). This high involvement of women recorded could be explained by customary rules favorable to women's access to land. Furthermore, the importance of cassava cultivation in these areas could be explained by the fact that it is a crop that is not exclusively linked to gender (especially as gender is not a factor determining yield levels).

The majority of cassava farmers in both zones have primary education (48.9%) or secondary education (34.24% of those surveyed). The majority of those surveyed (24.42% and 33.6% in the forest and savanna zones, respectively) were aged between 30 and 50. Agriculture is the main income-generating activity, with cassava the main crop in both zones (50 and 46% of respondents in the savanna and forest zones, respectively). This aligns with previous studies (Kafara, 2003; Zinga *et al.*, 2013), highlighting that cassava has become a major source of income and subsistence for the population.

Cassava cropping systems in the study area

The cropping practices of cassava growers in the forest and savanna zones are shown in Table 2. Cassava cropping is a long-standing activity for the farmers surveyed, who have 43 and 44 years of experience in forest and savanna zones. The majority of farmers had planted an average area between 0.5 and 0.85 ha. In the savanna zone, only 21.22% of farmers surveyed had planted between 0.85 and 1.5 ha of cassava. Two accessions are more widely grown in both zones: TMS 92/0329 (locally known as Togo) and Bobeketi. Tilt The main way to plant is using tilted cuttings, which is used by 44% of people in the forest and 39% in the savanna. Combined cropping is also common, used by 46% in the forest and 45% in the savanna, while only a small number of people use fertilizer.

The study highlights that cassava-based cropping systems in the surveyed zones are small-scale. The predominance of small-scale producers on small areas is the main feature of farming systems in sub-Saharan Africa (Pypers *et al.*, 2010; Zingore *et al.*, 2010).

Selection criteria for cassava accessions grown in the study area

The criteria for choosing the cassava varieties grown are shown in Figure 2. The factorial correspondence analysis shows that the first two axes explain 90% of the variance in variety choice criteria according to socio-cultural group. Disease resistance was the main reason for the cassava variety choice among older people (men and women) in forest areas. On the other hand, adult men in forest zones and young people living in forest and savanna zones, as well as adults in both zones, prefer to grow an accession because of the yield, which they consider to be high,

Table 1: Descriptive statistics for socio-economic variables of cassava growers in the study areas

Variables	Modality	Forest (%)	Savanna (%)
Sex	Male	27	31.42
	Female	21.12	20.51
Age	< 30	16.37	14
	]30–50[	24.42	33.6
	> 50	7.1	4.4
Education level	No	6.6	8.7
	Alphabetized	0	0.4
	Primary	22	26.9
	Secondary	18.54	15.7
	University	0.7	0.2
	Professional training	0.1	0
Marital status	Single	29.7	45
	Married	10.9	1.4
	Divorced	4.31	2.01
	Widowed	3.01	3.6
Religion	Traditional	1	0.05
	Catholic	20.6	18.01
	Protestant	26.3	33.4
Income-generating activities	Agriculture	30.9	28.6
	Livestock	1.7	8.6
	Trade	3.7	0.5
	Hunting	11.5	10.8
Main crops	Cassava	46.6	50
	Groundnuts	0.7	0.3
	Maize	2	0.1
	Sorghum	0.1	0

the good organoleptic quality of the by-products and the preference of traders. Soil fertility management practices under cassava cropping systems.

The different soil fertility management practices in cassava-based cropping systems in forest and savanna zones are shown in Figure 3. Fallowing plots is the primary method of regenerating soil fertility in inforest and savanna zones, with 55.79% of all respondents (28.23% and 27.47% in forest and savanna zones, respectively).

In general, crop rotation and the use of organic fertilizers are the other important soil fertility management practices observed in both forest and savanna zones (Figure 4). Mineral fertilizers are rarely used for cassava farming. However, guano is a viable alternative. Guano is organic fertilizer and this is the name given to the excrement of seabirds and bats. It can be used as a highly effective fertiliser, due to its high concentration of nitrate compounds. Guano consists of ammonia, uric acid, phosphorus, oxalic acid, carbonic acid and certain salts and impurities. Use of guano is a widespread practice among producers in the savanna zone (26% of those surveyed).

The incorporation of harvest residues into the soil is widespread among producers in both zones but more common among producers in the forest zone (24% of those surveyed in the forest). Finally, cattle manure is also used by farmers for soil fertilization in the savanna zone (5% of those surveyed). In general,

Table 2: Characteristics of cassava cropping systems in the two study areas

Variables		**Forest**	**Savanna**
Cassava-growing experience (years)		43.6±12.1	44.23±11.6
Area planted (%)	0–0.85 ha	40.5	17
	0.85–1.5 ha	7	21.2
	1.5–2.5 ha	1	11
	2.5–5 ha	0.1	3
Accessions of cultivated cassava (%)	TMS 92/0329	38.15	45
	Bobeketi	6	0
Planting method (%)	Flat	2.6	8.6
	Ridging	0.8	4
	Inclined planting	44.6	39.31
Application of fertiliser (%)	Yes	16.3	20.4
	No	23.1	40.3
Cropping system (%)	Pure cultivation	0.8	3.2
	Combination cropping	46.4	45
	Crop rotation	0.7	4

Table 3: Ordinal logistic regression of determinants of cassava yield

Predictor	**Coefficient**	**z**	**p**
Constant (1)	0.82	2.72	0.05
Constant (2)	3.03	5.85	0.000
Climate zone	1.7	6.73	0.000
Sex	-0.47	-2.12	0.034
Age	-0.01	-1.32	0.20
Education level	-0.04	-0.28	0.77
Marital status	-0.1	-0.87	0.38
Soil fertility	0.27	2.08	0.04
Climatic disturbances	0.15	2.22	0.02
Use of organic fertilisers	0.93	3.76	0.000

in sub-Saharan Africa (SSA), there is little interest in fertilizing cassava because, according to farmers' perceptions, it improves the yield of the subsequent crop (Saïdou *et al.*, 2009).

Cassava yield levels in cropping systems

The categorization of the people surveyed according to yield classes and the evolution of cassava root yields are presented in Figures 5 and 6, respectively. Cassava root yields are generally below 5 t ha-1 for producers in the savanna zone (67% of those surveyed). Few growers in both zones had cassava root yields between 15 and 25 t ha-1. The Student's t-test showed that yields in the two zones (Figure 5) were significantly different (p = 0.00001), with significantly higher yields in the forest zone (6.064 ± t.ha-1) than in the savanna zone.

According to growers in the savanna zone (Figure 6), yields have fallen in recent decades (26% of those surveyed); on the other hand, growers in the forest zone have the opposite perception, stating that yield levels have increased in recent decades (27% of those surveyed). Overall, cassava root yields are low in both zones, in line with the crop's potential yield.

In both forest and savanna zones, cassava root yields are low. Cassava-based cropping systems in both zones are zed by the non-use of mineral fertilizers and the use of crop residues as a source of organic fertilizer. Despite this, cassava root yields are low due to the low level of soil fertility. Low cassava yields have been noted among smallholders (Rusike *et al.*, 2010; Zinga *et al.*, 2013; Kintché *et al.*, 2017).

These practices show the decisive role of fertilizer use in improving cassava production, especially as observations reported by farmers showed that soil

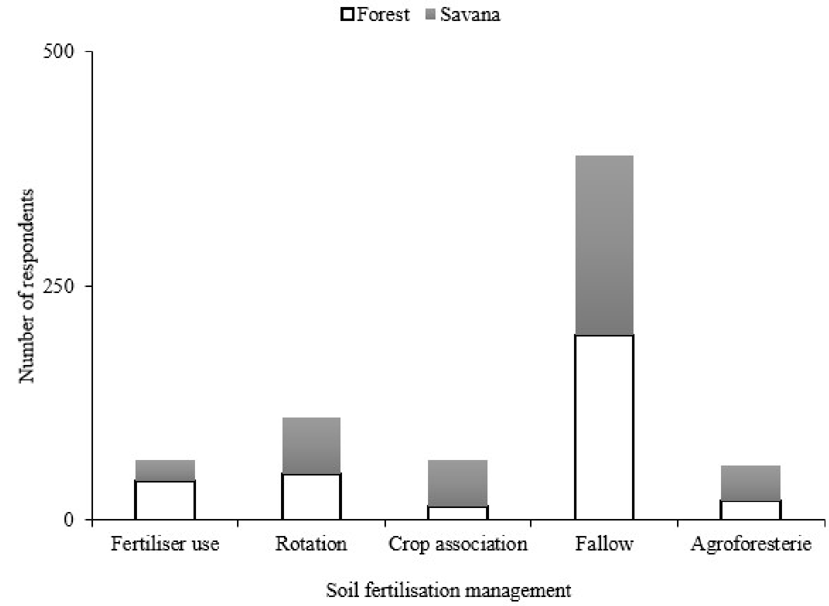

Figure 3: Soil fertilisation practices for cassava in the areas surveyed

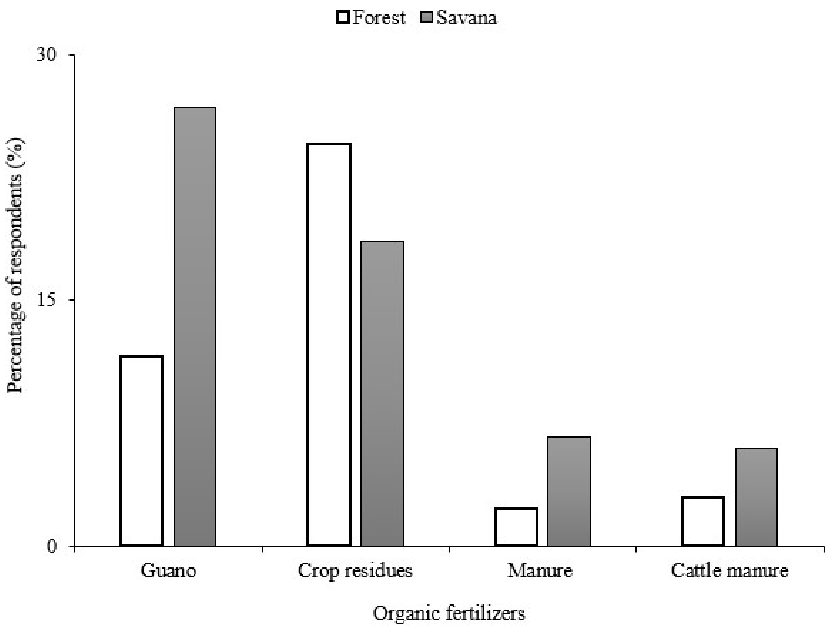

Figure 4: Types of organic fertiliser applied to cassava fields in the areas surveyed

fertility is very poor in the two study areas. This could be explained by the fact that optimal soil fertility management under cassava-based cropping systems often receives very little attention, as cassava has always been perceived as a crop tolerant of low soil fertility and irregular rainfall conditions (El-Sharkawy, 1968).

But taking into account the very high nutrient requirements of cassava (Byju and Suja, 2020), special attention should be paid to the balanced mineral nutrition of cassava not only to ensure good yields but also to guarantee soil quality (Kintché *et al.*, 2017; Ezui *et al.*, 2016).

Farmers' perceptions of soil fertility for cassava cultivation

Figure 7 illustrates the farmers' perceptions of soil fertility in the two surveyed zones. The majority of farmers in both the forest zone (23% of those surveyed) and the savanna zone (24% of those surveyed) believe that the soil is very poorly fertile. The survey showed that 13.8% of those surveyed in the savanna zone felt that the soil fertility level was mediocre. On the other hand, producers in the forest zone believe that some

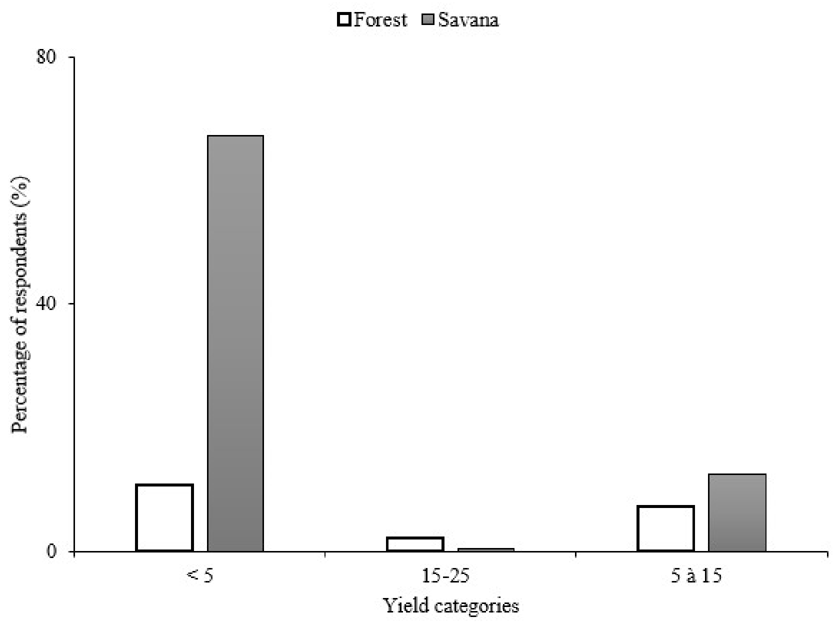

Figure 5: Classification of cassava root yields by soil and climate zone

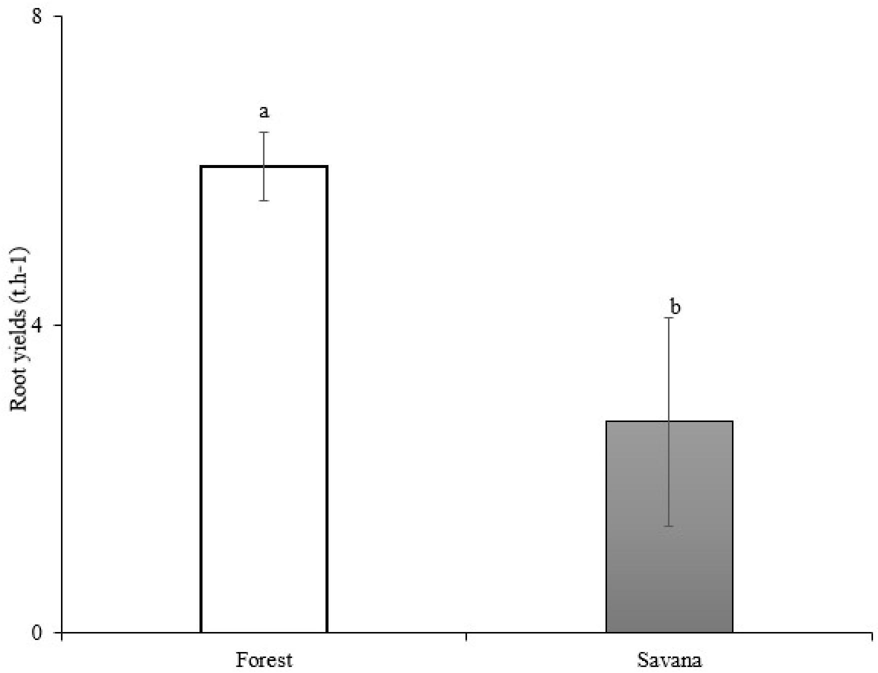

Figure 6: Cassava root yields by soil and climate zone

regions still have average (6% of those surveyed) and good (14% of those surveyed) levels of fertility.

According to farmers' perceptions, there are many reasons for the decline in soil fertility (unsuitable farming practices, climate change, divine will, non-use of fertilizers, bush fires, non-respect of customs) and these are shown in Figure 8. Correspondence factor analysis shows that the first two axes explain 85% of the causes listed according to sociocultural groups. Older men and women living in the forest and savanna zones attributed poor soil fertility levels to climatic conditions. On the other hand, older people attributed the decline in soil fertility to non-compliance with customary land management practices in the savanna zone. Adults (men and women) and young people (men and women) in both zones mainly mentioned the non-use of mineral fertilizers, bush fires, and inappropriate farming practices.

Constraints to cassava production

The manifestations of climatic constraints according to cassava growers in the two areas surveyed are shown in Figure 9. The results of the factorial correspondence analysis showed that the first two axes explain 86.5% of

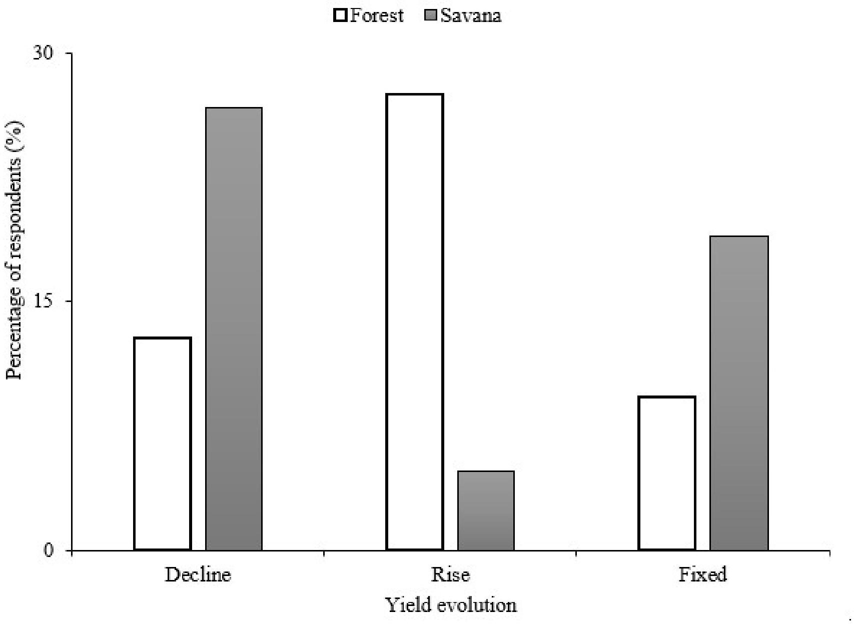

Figure 7: Farmers' perceptions of yield levels in recent decades

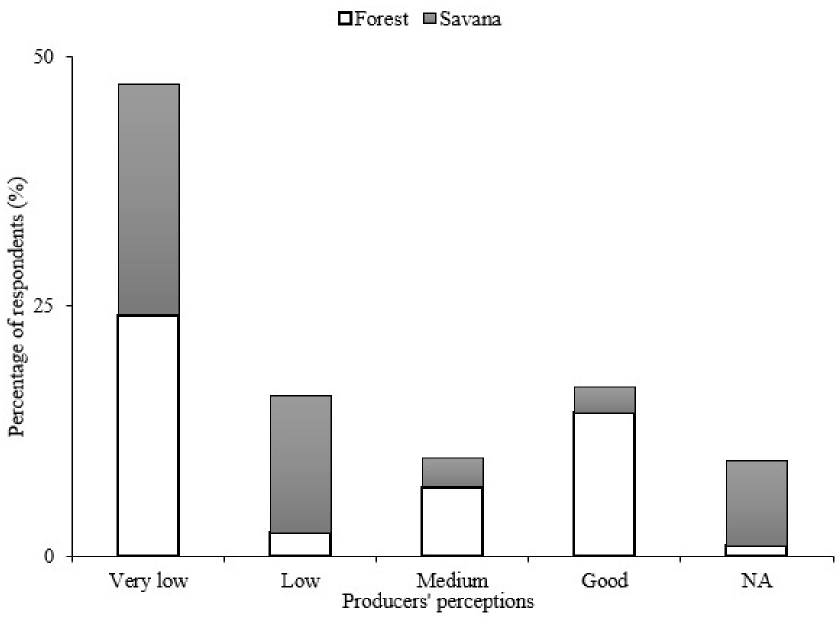

Figure 8: Cassava growers' perceptions of soil fertility levels

the perceptions of the different socio-cultural groups. Young men in forest areas believe that climate change is manifested by high temperatures, while increased rainfall is the main manifestation and constraint listed by adults in forest areas and by young men and older people in forest areas. On the other hand, adult women in savanna areas think that strong winds and reduced rainfall are the main climatic constraints affecting soils and crop yields. Irregular rainfall was the main constraint cited by young people of both sexes and adult men in the savanna zone.

Farmers have developed strategies to overcome these various constraints (Figure 10). The majority of people surveyed in both zones did not develop any strategies to overcome these constraints. They resigned themselves to the situation and attributed everything to God's will. Soil mulching and plot drainage are the main strategies used by farmers (10% and 11%, respectively, of respondents in the forest and savanna zones). Agroforestry was mentioned as a strategy by producers in the savanna zone.

Farmers see changes in weather, especially strong winds and inconsistent rainfall, as challenges that help explain why soil fertility is decreasing in cassava

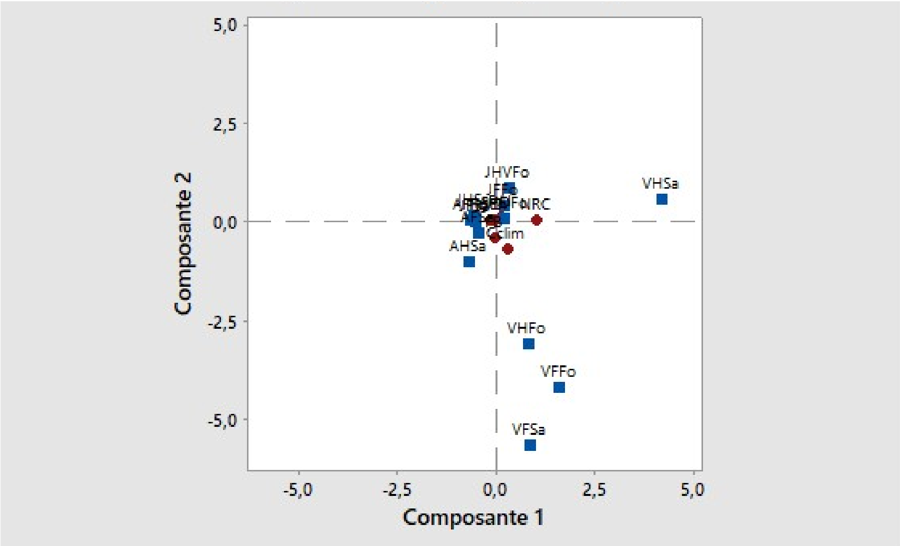

Figure 9: Projection of the causes of the decline in soil fertility and socio-cultural groups in the factorial axis system of the Correspondence Factor Analysis (CFA).

PAI: inappropriate agricultural practices; Cclim: climatic conditions; VD: divine will; NuEn: non-use of fertiliser; FB: bush fire; NRC: non-respect of customs; AFFo: adult woman living in a forest zone; AFSa: adult woman living in a savana zone; AHDFo: adult man living in a forest zone; AHSa: adult man living in a savana zone; JFFo: Young woman living in forest zone; JFSa : Young woman living in savana zone; JHSa : Young man living in savana zone; JHVFo : Young man living in forest zone; VFFo : Old woman living in forest zone; VFSa : Old woman living in savana zone; VHFo : Old man living in forest zone; VHSa : Old man living in savana zone.

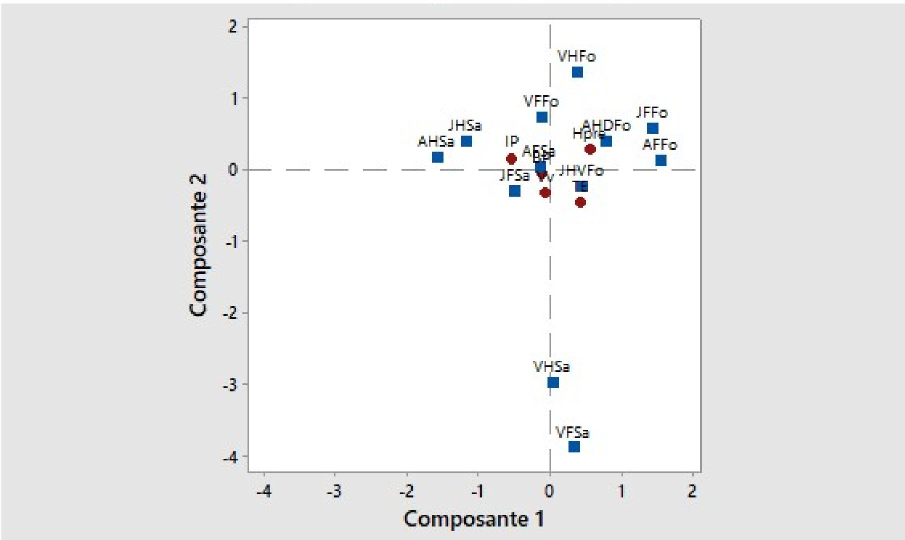

Figure 10: Projection of climatic constraints and socio-cultural groups in the Factorial Correspondence Analysis (FCA) factorial axis system.

BP: rainfall decrease; TE: high temperatures; IP: rainfall irregularity; Vv: strong winds; Hpre: rainfall increase; AFFo: adult woman living in a forest zone; AFSa: adult woman living in a savana savana zone; AHDFo: adult man living in a forest zone; AHSa: adult man living in a savana savana zone; JFFo : Young woman living in forest zone; JFSa : Young woman living in savana zone; JHSa : Young man living in savana zone; JHVFo : Young man living in forest zone; VFFo : Old woman living in forest zone; VFSa : Old woman living in savana zone; VHFo : Old man living in forest zone; VHSa : Old man living in savana zone.

farming in the two areas studied. Wind erosion is noted as a reason for losing fine soil particles, which leads to lower soil nutrient levels, with this loss taking 3 years for sandy soils and 15 years for clay soils (Smaling *et*

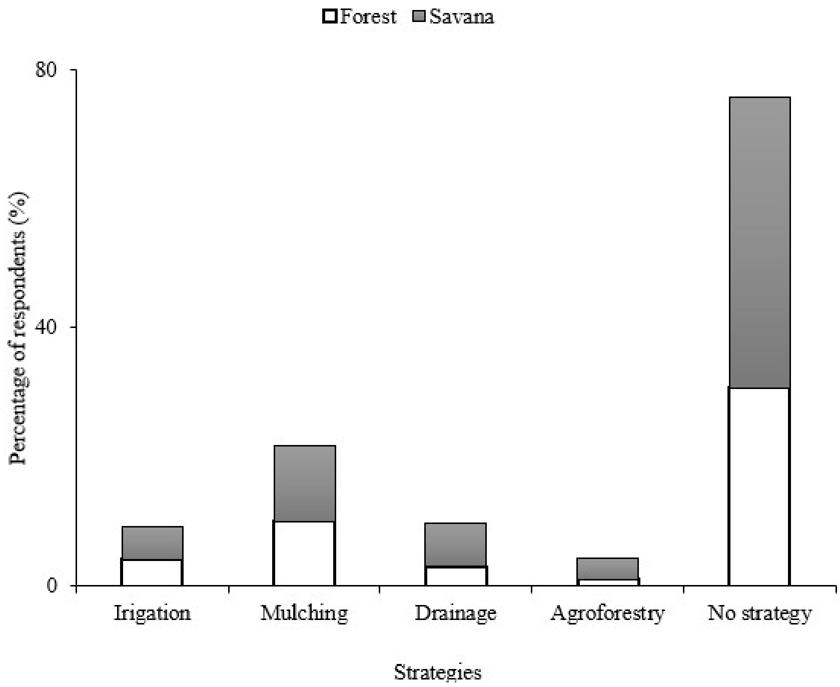

Figure 11: Endogenous climate change adaptation strategies for cassava production in the forest and savana zones of the CAR

al., 1997). Wind erosion has been reported as one of the factors exporting fine elements from the soil and thus contributing to the drop in soil nutrient levels, and this loss time is 3 years for sandy soils and 15 years for clay soils (Smaling *et al.*, 1997). All these factors contribute to the decline in soil fertility. Therefore, it is necessary to develop reliable strategies to guarantee optimum cassava production.

Determinants of cassava root yield in cassava cropping systems

Table 3 presents the results of the nominal logistic regression of the factors explaining the improvement in the level of cassava root yields in the two study areas, while Table 4 presents the results of the ordinal logistic regression of the determinants of cassava root yield. Analysis of the results in Table 3 shows that improvements in soil fertility and production zones are the factors that significantly ($p = 0.007$) increase cassava root yields.

On the other hand, the stability of cassava root yields was significantly influenced ($p < 0.05$) by the marital status of producers. Furthermore, the results in Table 4 showed that soil fertility, climatic disturbances and the use of organic fertilisers significantly ($p < 0.001$) and positively affect cassava root yields in both agro-climatic zones. Therefore, obtaining high cassava root yields in both zones depends on climatic conditions and soil fertility management practices.

The study showed that cassava yields in both forest and savanna were very low and well below potential yields. Logistic regressions showed that improving soil fertility is very important for increasing cassava root yields in both agro-climatic zones. Previous studies have shown climatic conditions and the use of organic fertilizers are also important factors in improving cassava yields (Ezui *et al.*, 2016). This shows that implementing integrated soil fertility management adapted to the conditions of these growing zones is important to ensure high cassava yields (Vanlauwe *et al.*, 2015; Moreno-Cadena *et al.*, 2021).

In addition, marginal areas are cultivated, as is the case in this study, where nutrients are used, and traditional management practices based on recycling soil nutrients are unable to maintain crop productivity levels (Smaling *et al.*, 1997). Integrated soil fertility management (ISFM) proposes technologies to increase productivity through improved germplasm, fertilizer application, organic matter management and adaptation to the local conditions of smallholder farmers (Vanlauwe *et al.*, 2015).

In a series of on-farm experiments in Kenya and Uganda, Fermont *et al.* (2010) demonstrated that cassava is highly reactive to fertilizers and that the use of fertilizers is important in integrated soil fertility management when disease resistance parameters are taken into account to ensure fertilizer response.

Indeed, organic matter generally improves fertilizer use efficiency (Vanlauwe *et al.*, 2010) and biomass can be produced in situ by integrating dual-purpose grain legumes into cropping systems. Especially the association of cassava with crops, which was noted in the results of the present study. This could offer the benefits of biological nitrogen fixation (BNF) while providing income from crop products (Mucheru-Muna *et al.*, 2010; Kintché *et al.*, 2015; Kintché *et al.*, 2017; Manners *et al.*, 2021).

Organic fertilizers, which are generally available locally, can therefore be used to improve crop productivity. However, smallholder farmers rarely apply mineral fertilizers to cassava, as they consider that the crop is adapted to poor soils and does not require fertilization. Generally, smallholder farmers apply limited amounts of manure or composted crop residues. All of the above points to the importance of fertilization and the use of organic fertilizers to improve crop productivity, in accordance with the first law of fertilisation.

CONCLUSION

Overall, cassava-based cropping systems in forest and savanna zones are small-scale farming units characterised by low soil fertility. Disease resistance and good organoleptic quality are therefore important criteria for growing cassava in these areas and selecting the varieties to be grown. In both forest and savanna zones, cassava root yields are very low and depend on soil fertility management practices such as using mineral fertilisers, climatic disturbances, using organic fertilisers and compliance with technical itineraries.

These factors are the main constraints limiting crop yields in the two production zones. Future research should focus on the formulation of fertiliser requirements and the development of integrated soil fertility management practices to sustain crop productivity levels, taking climatic disturbances into account.

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