



(RESEARCH ARTICLE)



## Evaluation of peasant practices of maize and cassava crops intercropping with oil palm cultivation on the growth parameters of oil palm at the immature stage

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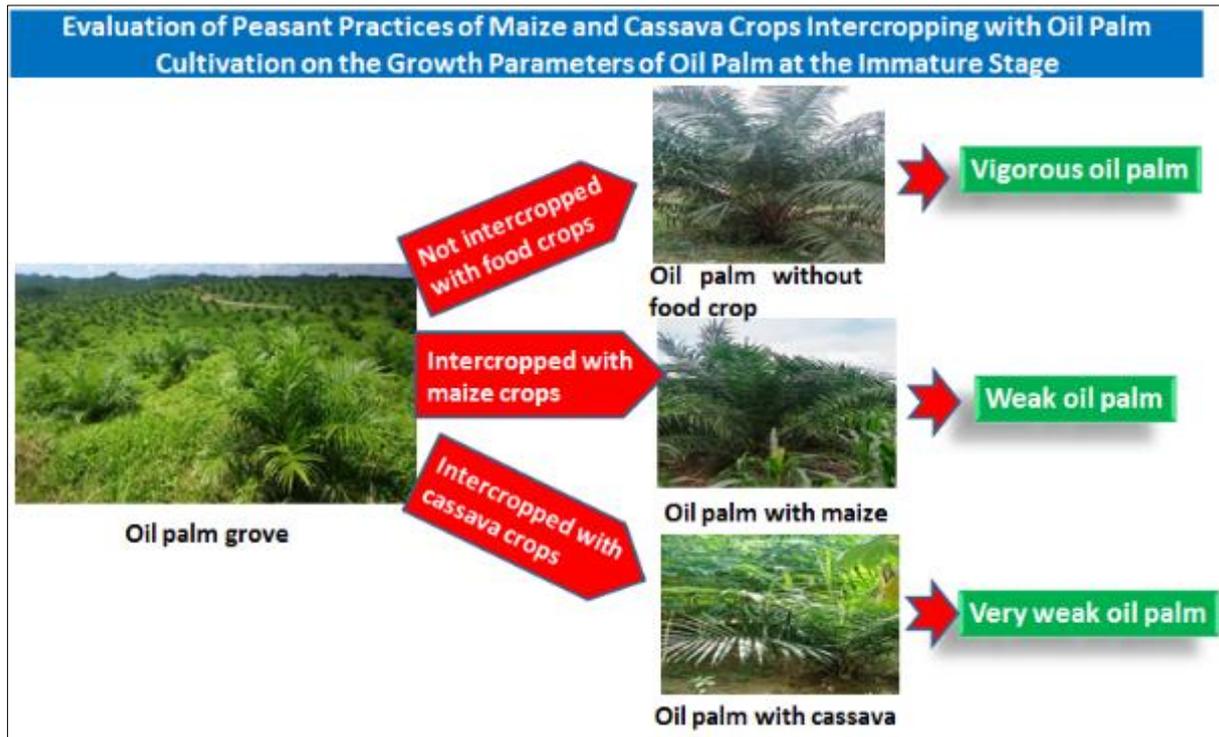
### Abstract

Compliance with technical itineraries in immature oil palm groves is a guarantee of their good development and good production at the adult stage. It is in this context that the present study aimed to evaluate peasant practices of maize and cassava crops intercropping with oil palm cultivation on the growth of oil palm at the immature stage. To do this, cultural systems such as oil palm groves without intercropping with food crops (Ta0: Control), those intercropped with maize crops (Ta1) and those intercropped with cassava cultivation (Ta2), constituted the different treatments. The results showed that peasant practices of maize and cassava crop intercroppings negatively influenced the growth of oil palm. The comparison of the results showed that cassava cultivation has more detrimental effects on the growth of oil palm, compared to that of maize. It would therefore be wise to dissociate oil palm cultivation from those of cassava and maize. Otherwise, it would be appropriate to restore to the soils of the palm groves, through fertilization, the mineral nutrients exported through the cassava and maize harvests.

**Keywords:** Collar Circumference; Functional Leaves; Leaf Rank 9; Cultural System; Mineral Nutrients

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## Graphical Abstract



## 1. Introduction

With its scientific name *Elaeis guineensis* Jacq, the oil palm is a monocotyledonous tree plant of the Areaceae family [1]. Native to West Africa, more precisely the Gulf of Guinea, this plant is cultivated throughout the world for the rich oil content of its fruits [2]. Its global production is estimated at around 79.52 million tons [3]. This production is mainly carried out by major producing countries such as Malaysia and Indonesia [3].

In Côte d'Ivoire, oil palm production creates 200,000 jobs, contributes to the livelihoods of 2 million people and generates a turnover of 500 billion FCFA [4]. To meet the national need and respond to the ever-increasing global demand for palm oil, agricultural research is working to support the development of the oil palm sector by providing efficient plant material and technical itineraries adapted to the rapidly changing production environment (water deficit, replanting challenges, declining soil fertility, etc.) [5]. To this end, it has been recommended that *Pueraria phaseoloides*, which is a creeping legume, be used as a cover plant for immature oil palm groves. This plant combats soil erosion [6]. It also has the advantage of increasing the organic matter content of soils, reducing nutrient leaching, improving the physical structure of soils and allowing easier maintenance of plots [7]. Although *Pueraria phaseoloides* has these advantages, it is not used for food production and, moreover, is expensive. Furthermore, the fact that the shares of agricultural land obtained through inheritance are becoming increasingly restricted in the face of rapid population growth, planters are forced to cultivate food crops in their immature palm groves, particularly maize and cassava, to ensure their food self-sufficiency. However, practices combining oil palm with food crops could cause competition for mineral elements and water and create conditions favorable to the spread of diseases [8]. This could hinder, in the short term, the vegetative growth of oil palm.

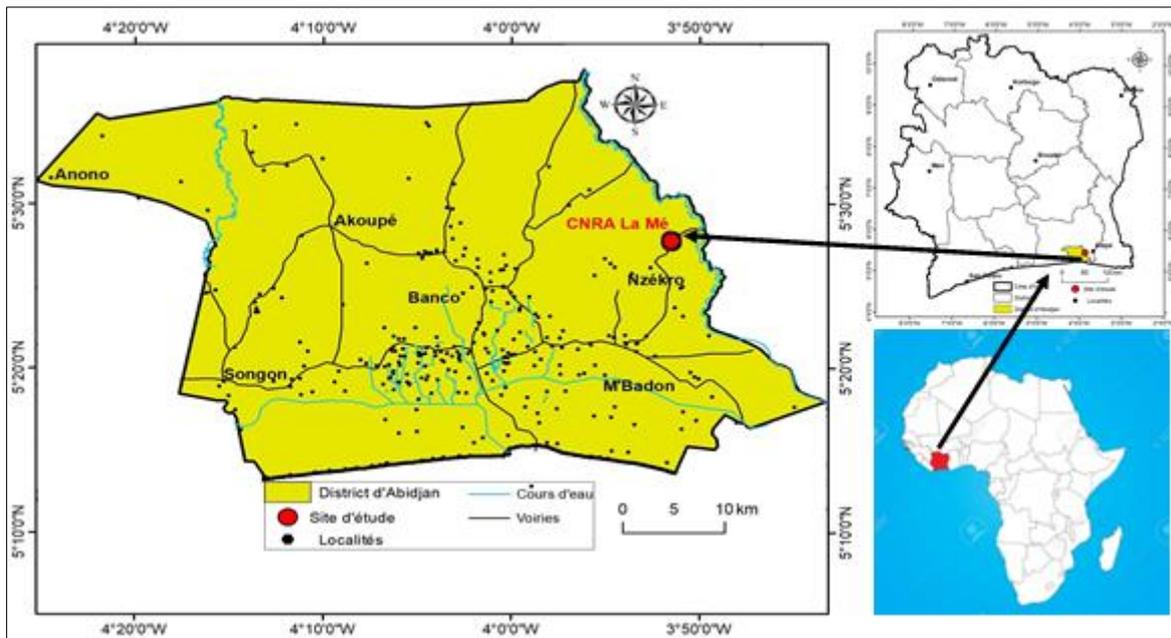
This study therefore aims to evaluate peasant practices of maize and cassava crops intercropping with oil palm groves on the vegetative growth of oil palm.

## 2. Materials and methods

### 2.1. Materials

#### 2.1.1. Study Site

The trial was conducted at the CNRA La Mé Research Station. Located in the Southeast of Côte d'Ivoire, 24 km from Abidjan, the CNRA La Mé Station (Figure 1) is an experimental and production site. It is bordered by the village of Kongofon to the North, Aghien Télégraphe to the South, and Ahoutoué and the Mé River to the East. Its geographical coordinates are 05°26' North latitude and 03°50' West longitude. The area has a humid subtropical climate, partly influenced by the Attiéan climate along the coast. Rainfall is high but irregular, averaging 1750 mm per year over the last ten years. There are two rainy seasons and two dry seasons. Temperatures vary between 24 and 28 °C, with a humidity level of 75 to 90% [9]. The soil is ferralitic, derived from tertiary sands, very degraded, low in potassium, deep, sandy on the surface and without coarse elements. The dominant clay is of the kaolinite type, with a low exchange capacity [10].



**Figure 1** Geographical Location of the CNRA Research Station at La Mé

#### 2.1.2. Plant Material

Food crops such as maize and cassava intercropped with oil palm groves (Figures 2 and 3) constituted the plant material used. Maize and cassava were all-run. The oil palms are 3 years old. The cultivated oil palms come from the C1001F seed category, selected and distributed by the CNRA. Since 1995, this seed from the second cycle of reciprocal recurrent selection (RRS) has been used [9]. It produces 25 tons of bunches per hectare each year, with an oil content of 26% and an industrial extraction rate of between 22 and 23% [9]. It is also known for its early production, its good resistance to *fusarium* wilt and its economic lifespan of approximately 30 years. This variety is now used to create palm groves in all production areas of the Côte d'Ivoire.



**Figure 2** Maize crops intercropped with oil palm grove



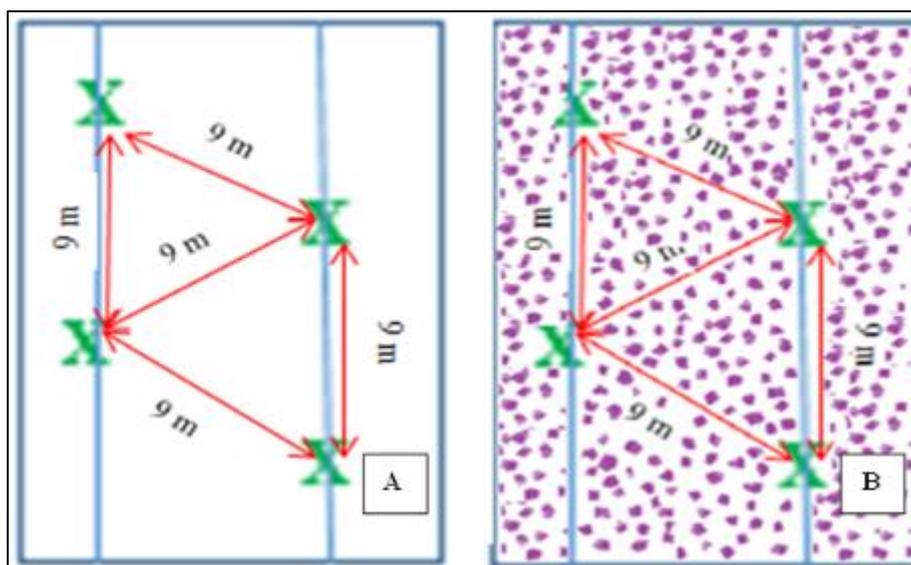
**Figure 3** Cassava crops intercropped with oil palm grove

## 2.2. Methods

### 2.2.1. Choice of Plots

The study was conducted on immature stage oil palm groves (N3: oil palm aged 3 years). These oil palm groves are located at the CNRA Research Station in La Mé. To better detect the impact of maize and cassava crops on oil palm crops, the plots chosen are those that have not been fertilized since the creation of the oil palm groves.

### 2.2.2. Experimental Device



A: Monoculture of oil palm; B: maize or cassava crops intercropped with oil palm grove; X: Oil palm; ● : maize or cassava crops

**Figure 4** Experimental Device for Treatments Applied to Oil Palm

The rational choice of oil palm groves constituted the experimental design. The planting of oil palms was carried out according to the design of an equilateral triangle (staggered) of 9 m giving a density of 143 plants/ha (Figure 4A). Cassava was planted at densities from 9771 to 12344 plants/ha, while maize was sown at densities from 50000 to 70500 plants/ha (Figure 4B). Depending on the cultural systems, the combination of food crops with that of oil palm

constituted the treatments: hence three (3) treatments (Table 1). The treatments (tests and controls) were implemented in the same block. Each block was repeated two (2) times.

**Table 1** Different Treatments Applied to Immature Oil Palms

Treatments	Description
Ta0	3-year-old oil palm groves, not intercropped with food crops (Control)
Ta1	3-year-old oil palm groves, intercropped with maize crops
Ta2	3-year-old oil palm groves, intercropped with cassava crops

### 2.2.3. Evaluation of the Effect of Maize and Cassava Crops Intercropping with Oil Palm Grove on Growth Parameters at the Immature Stage of Oil Palms

By treatment, the agro-morphological data concerned growth parameters such as the number of functional leaves, the length of the leaf of rank 9, the circumference at the collar and the vigor index. The collection of these data was carried out as soon as the trial was set up and, thereafter, at a frequency of two (2) months. The number of functional leaves was determined by counting on all the oil palm groves of the trial. Also, the length of leaf of rank 9 was measured using a tape measure. The circumference at the collar of the oil palm was also determined by measurement using a tape measure. The vigor index (VI), for its part, was calculated from the circumference at the collar (C) and the length of leaf of rank 9 (L) according to the following formula:

$$VI = \text{Log} [(L \times C^2)/4\pi]$$

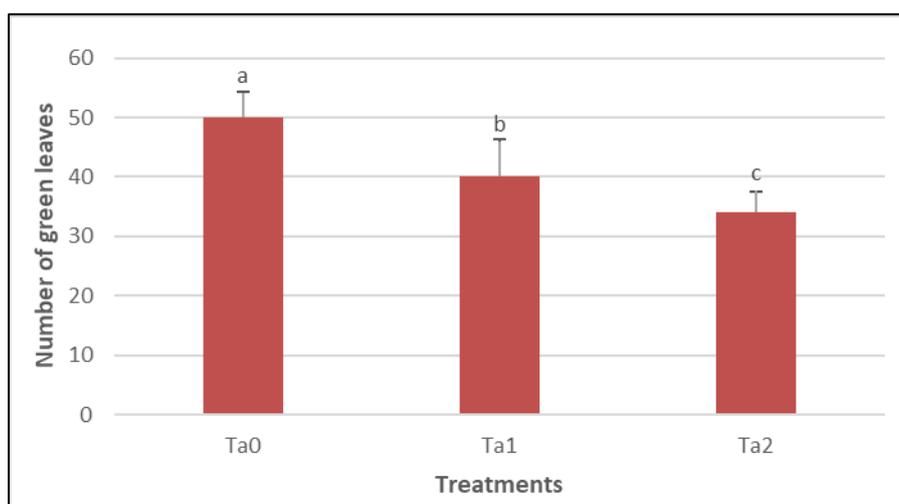
VI: vigor index; L: leaf length rank 9; C: circumference at the neck;  $\pi$ : constant 3.14

### 2.3. Statistical Analyses

Statistical analyses were performed using SAS software (version 9.4). One-way analyses of variance were performed on the means of the different parameters. Comparisons of means were made at the 5% threshold using the Student Newman-Keuls test. The different graphs were constructed using Excel 2016.

## 3. Results

### 3.1. Influence of Maize and Cassava Crops Intercropping with Oil Palm Grove on the Number of Functional Leaves of Oil Palms depending on the Treatments



Mean values with the same letter are not significantly different according to the 5% Newman-Keuls test; Ta0: control (without food crops); Ta1: three-year-old oil palm groves intercropped with maize crops; Ta2: three-year-old palm groves intercropped with cassava crops

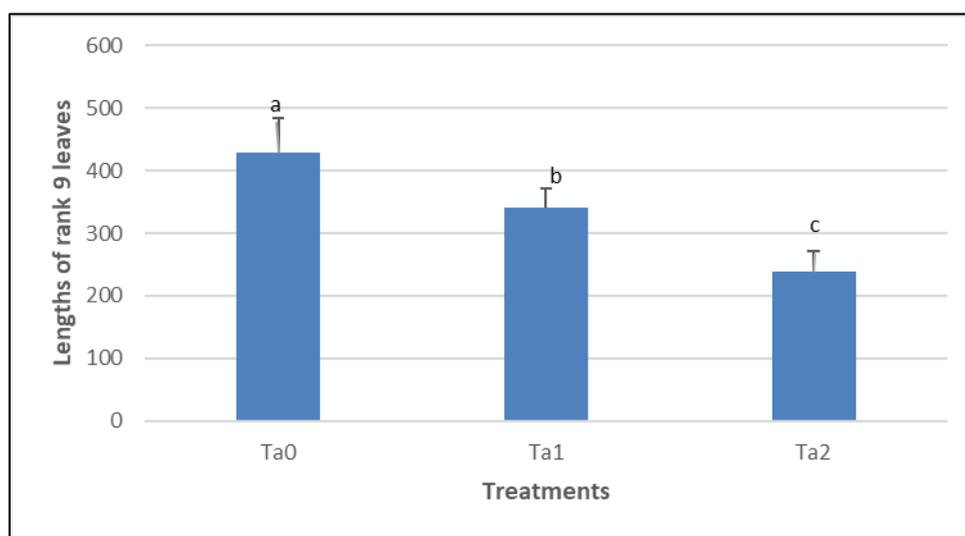
**Figure 5** Number of Functional Leaves of Oil Palms according to Different Treatments

Figure 5 shows that the different treatments influenced the number of functional leaves (green leaves) of the oil palm ( $P = 0.0001$ ).

Treatment Ta0 (Control) produced the highest number of functional leaves per oil palm ( $49.97 \pm 4.35$ ). This number of functional leaves was followed by that expressed by treatment Ta1 (Maize crop intercropping with oil palm grove), which was  $40 \pm 6.38$ . In contrast, treatment Ta2 (Cassava crop intercropping with oil palm grove), with a number of functional leaves of  $34 \pm 3.58$ , displayed the lowest value.

### 3.2. Influence of Maize and Cassava Crops Intercropping with Oil Palm Grove on the Length of Rank 9 Leaves according to Different Treatments

Analysis of Figure 6 shows a significant difference between the lengths of leaves of rank 9 presented by the different treatments ( $P = 0.0001$ ). Treatment Ta0 (Control) generated the highest growth of leaf of rank 9 ( $428.41 \pm 56.51$  cm), while treatment Ta2 (Cassava crop intercropping with oil palm grove) displayed the lowest growth value of leaf of rank 9 ( $341 \pm 30.35$  cm). This value from Ta2 was lower than that presented by treatment Ta1 (Maize crop intercropping with oil palm grove) which was  $238.06 \pm 33.28$  cm.

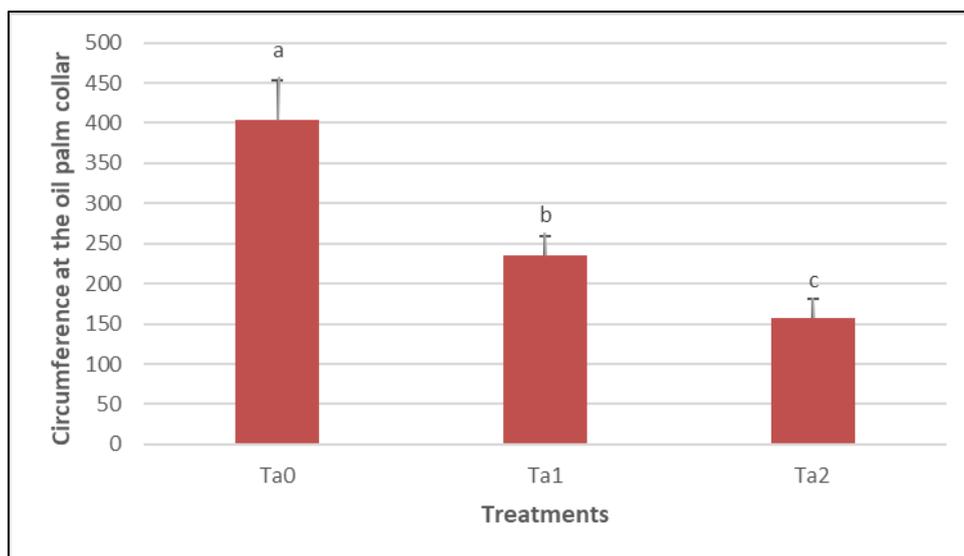


Mean values with the same letter are not significantly different according to the 5% Newman-Keuls test; Ta0: control (without food crops); Ta1: three-year-old oil palm groves intercropped with maize crops; Ta2: three-year-old oil palm groves intercropped with cassava crops

**Figure 6** Lengths of Oil Palm Leaves of Rank 9 according to Different Treatments

### 3.3. Influence of Maize and Cassava Crops Intercropping with Oil Palm Grove on Collar Circumference according to Different Treatments

The different treatments significantly influenced the radial growth of the oil palm crown ( $P=0.0001$ ) (Figure 7). The Ta0 treatment (Control) induced the highest radial growth at  $403.57 \pm 50.30$  cm. This value was higher than that expressed by the Ta1 treatment (Maize crop intercropping with oil palm grove;  $235.61 \pm 23.90$  cm), which was also higher than that presented by the Ta2 treatment (Cassava crop intercropping with oil palm grove), which was  $157.38 \pm 23.71$  cm.



Mean values with the same letter are not significantly different according to the 5% Newman-Keuls test; Ta0: control (without food crops); Ta1: three-year-old oil palm groves intercropped with corn crops; Ta2: three-year-old oil palm groves intercropped with cassava crops

**Figure 7** Oil Palm Collar Circumferences according to Different Treatments

### 3.4. Influence of Maize and Cassava Crops Intercropped with Oil Palm Grove on the Vigor Index according to the Different Treatments

Analysis of Table 2 reveals that the vigor index of oil palms significantly changed depending on the treatments ( $P=0.0001$ ). Treatment Ta0 (Control) generated a vigor index ( $0.62 \pm 0.01$ ) higher than that expressed by treatment Ta1 (Maize crop intercropping with oil palm grove;  $0.58 \pm 0.01$ ) which was also higher than that presented by treatment Ta2 (Cassava crop intercropping with oil palm grove) which was  $0.54 \pm 0.01$ .

**Table 2** Oil Palm Vigor Indices according to Different Treatments

Treatments	Vigor indices
Ta0	$0.62 \pm 0.01^a$
Ta1	$0.58 \pm 0.01^b$
Ta2	$0.54 \pm 0.01^c$
P	0.0001

Mean values with the same letter are not significantly different according to the 5% Newman-Keuls test; Ta0: control (without food crops); Ta1: three-year-old oil palm groves intercropped with corn crops; Ta2: three-year-old oil palm groves intercropped with cassava crops

## 4. Discussion

This study aimed to determine the influence of peasant practices of maize and cassava crop intercroppings on the vegetative growth of oil palm at the immature stage.

The growth parameters evaluated were the number of functional leaves, the length of leaves of rank 9, the circumference at the collar and the vigor index of the oil palm. Regarding this evaluation, the results revealed that immature oil palm reacted differently depending on the treatments applied to them. Indeed, the highest values of these growth parameters were those presented by oil palm groves without intercropping with food crops (Control).

In terms of vegetative development performance of young oil palm, the maize crops intercropping with oil palm cultural system ranked second after oil palm groves without food crop intercropping and before those of the cassava crops intercropping with oil palm cultural system. The moderate growth expressed by oil palm from the maize crops intercropping with oil palm cultural system could explain the fact that maize is a short-cycle plant and does not develop significant shade. Also, maize has the ability to fix atmospheric nitrogen like legumes via its aerial roots which secrete a viscous gel that hosts nitrogen-fixing microorganisms after rain [11]. Indeed, nitrogen is an essential element used to

build all the green parts that ensure the growth and life of plants [12]. Similarly, part of the nutrients absorbed by maize during its growth and development would return to the soil through the decomposition of the stem and leaves by microorganisms, after harvest. This is not the case for the cultivation of *Jatropha curcas* where maize does not express any significant impact [13].

The low vegetative growth observed in the cassava crops intercropping with oil palm cultural system is thought to be due to nutritional competition for nitrogen between the oil palm and cassava due to its aerial vegetative development. This situation could also be due to the fact that cassava is a plant with a long vegetative cycle and significant shade development, which could hinder the young plants access to sunlight, thus reducing the efficiency of photosynthesis.

During the three consecutive years of the immature phase of the oil palm groves, maize was grown twice a year while cassava was grown permanently. During this period, maize requires a significant amount of water for its flowering [14] and for the development of its grains [15]. For Silvestre & Arraudeau [16], it is when the cassava plant is developed that its water needs are greater, despite the fact that it overcomes many periods of prolonged drought. It would therefore be obvious that oil palms are victims of pronounced water stress at the immature stage when they are associated with either maize or cassava cultivation. This could also explain the fact that the growth values expressed by oil palms from the maize crops intercropping with oil palm grove and cassava crops intercropping with oil palm grove cultural systems are low compared to those presented by palm groves without food crop intercropping. This reduction in growth values, which is more pronounced in the cassava crops intercropping with oil palm cultural system, is thought to be due to the fact that cassava exports more potassium through the harvest of its tuber [17]. Indeed, potassium helps oil palms resist diseases, drought stress and extreme temperatures [18, 19, 20]. This situation is thought to be aggravated by the fact that West African soils are poor in potassium [10] and that, in the context of this study, the major mineral nutrients exported through the harvests were not returned to the soils by fertilization regardless of the cultural system.

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## 5. Conclusion

At the end of this study, it should be noted that peasant practices of intercropping maize and cassava negatively influence the growth of oil palm. Comparison of the results of this study showed that cassava cultivation has more detrimental effects on the growth of oil palm, compared to that of maize. To ensure good growth of oil palm at the immature stage, it would be wise to dissociate oil palm cultivation from cassava and maize or, at least, to reduce the density of food crops. Otherwise, it would be advisable to return to the soils of oil palm groves, through fertilization, the mineral nutrients exported through cassava and maize harvests.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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