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Study of the influence of physico-chemical characteristics of cassava (*Manihot esculenta* Crantz) stem on its varietal vulnerability to termites ravaging cuttings *Odontotermes* sp. aff. *Erraticus*

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Cassava (*Manihot esculenta Crantz*) includes a multitude of varieties different by several parameters, each of them with specific characteristics. Some of these varietal specificities may constitute the seat of an influence on the vulnerability of this plant to stresses. In this present study, we proposed to assess the impact of physico-chemical parameters of the cassava stem on its varietal sensitivity to termites ravaging cuttings *Odontotermes* sp. aff. *erraticus* in Senegal. At the end of experiments conducted in laboratory, we have seen that the cassava varieties in which the stem bark was thick and hard with a reduced diameter of the marrow were more tolerant to the action of these pests, while those with thin and fragile bark and large stem marrow were more sensible. However the pH of the cassava stem did not affect the incidence of attack of the cuttings by the termites.

Key words: Cassava, cuttings, tolerance, physico-chemical parameters, *Odontotermes* sp.

INTRODUCTION

Cassava (*Manihot esculenta*) is a plant of the *Euphorbiaceae* family native to Latin America. It is grown mainly for its starchy tubers which constitute the basis of food and the main source of energy of many populations across the world (FAO, 1990). Cassava world production of was estimated in 200 at 184 million tons with 55% in Africa (FAO, 2000).

It is a very undemanding plant in relation to the fertility of the soil, rainfall and cultural practices (Raffailac, 1993). The starch content of roots is high and that of protein of leaves is too important (FAO, 2000).

With an annual production of about 90 million tons, cassava is the most important of the R & T (Roots and Tubers) in Africa. About 200 million Africans consume

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cassava as staple food. Almost all of the African production is consumed locally, and is therefore a subsistence crop. Cassava is a strategic product in the fight for food insecurity in Africa. Many products derived from its tubers (flour, starch, *gari*, *attieke*, pellets, *tapioca*, etc.) relate its importance (Coraf, 2010).

In Senegal, the importance of cassava cultivation continues to increase in these recent years and research is more and more interested. It accounts for 25% in the total vegetables production (Aïchatou, 2007).

However, this plant is attacked by several pests and diseases that cause extensive damage on its culture. Indeed, in addition to, between other enemies, the Cassava African Mosaic Disease and the floury cochineal that cause yield losses respectively from 20 to 90% and up to 100% (Mbaye, 1991), termites ravaging cuttings constitute also a major threat against the cultivation of this plant. In the Department of Tivaouane (Senegal) where its culture is strongly practiced, the attack of termites *Odontotermes* sp. among other species on cuttings planted in fields, wins more and more scale (Faye et al., 2014).

To remediate to that biotic stress, the use of tolerant and resistant varieties is the best way of controlling pests and diseases and may be an attractive alternative to the use of pesticides which residues are harmful for the consumers' health and the environment (Renoux, 1997). Varietal tolerance is considered here as inheritable capability of certain varieties within a plant species to limit development and damage caused by insects. Unlike resistance to diseases that often includes genes, varietal tolerance of plants to pests is rather, according to Painter (1951), linked with physical, mechanical or chemical intrinsic parameters and may involve different tissues of the plant (cuticle, mesophyll, phloem, etc). Thus, a study conducted in rural cassava plantations in the department Tivaouane showed that certain varieties were, more than others, tolerant to termites ravaging cuttings in the area (Faye et al., 2014).

In this present study, it was to study the impact of physical and chemical parameters of the cassava stem on its vulnerability to *Odontotermes* sp. aff. *erraticus* termites' action. Specific objectives included evaluating the effects of the bark thickness and hardness, the marrow diameter and the pH of the cassava stems on the incidence and severity of attack of cuttings by these termites in different varieties.

MATERIALS AND METHODS

Plant material

The plant material was cuttings of caliber 18 mm and 20 cm long from 8 varieties of cassava grown in the Department of Tivaouane (Senegal) including 6 local (*Soya*, *Kombo*, *Niargi*, *Cololi*, *Nigeria* and *Wallet*) and 2 from Brazil (*Cacau* and *Cacau roja*). The mother plants were grown in experimental plot for 8 months prior to collection of the cuttings.

Experimental device

36 plastic trays large of 70 and 50 cm deep, at 2/3 filled of previously sterilized soil have been used as culture media. Sterilization of the substrate was made by heating to 80°C over a wood fire in a large metal container, after being wetted. Each tray was then infested by introduction of 200 individuals of termites *Odontotermes* sp. aff. *erraticus* previously collected in farms and identified in the laboratory. In order to put these termites in activity before planting, vegetable debris were placed on the surface of the culture substrate until signs of attack were observed.

Cuttings of each variety were thus planted into 4 infested trays at the rate of 8 cuttings per tray and watered every 2 days with 5 L during 2 months of culture.

Other cuttings of the same dimensions were used for the measurement of physical and chemical parameters of the stem in each variety of cassava.

Evaluation of the physico-chemical parameters of the stem of the different varieties of cassava

The physico-chemical parameters evaluated in the different cassava varieties were the thickness and hardness of the stem bark, the diameter of the stem marrow and their pH. Each of these intrinsic parameters was measured in each variety on cuttings from different plants, with 4 repetitions. For what concerns the bark thickness and diameter of the stem marrow, measurements were made on cuttings' cross-sections using a graduated rule. Concerning the bark hardness, it was measured in cuttings emptied of their marrow, by measuring the breakthrough pressure using a hardness meter. The pH of the stems have been evaluated on bark and marrow v/v solutions in distilled water maintained at 28°C for 24 h before measuring it with a pH meter.

Evaluation of sensitivity parameters of different varieties of cassava to the *Odontotermes* sp. aff. *erraticus* termites' action

The sensitivity parameters assed in the different varieties of cassava were the incidence and the severity of attack of cuttings by termites and the mean number of individuals of insects from each cutting per variety. The assessments of the incidence of attack and the number of individuals of termites extracted were conducted on exhumed cuttings after 2 months of culture. The incidence of attack (I) was determined using the following formula:

$$\mathrm{I}(\%) = \frac{NA}{32} \times 100$$

in which NA is the number of attacked cuttings and 32 the total number of cuttings for a considered variety.

The average number of termites per cutting was determined on the 32 exhumed cuttings of each variety through a count of individuals of termites (N) extracted from, reporting N/32.

For the severity of attack (S) of the cassava cuttings by the termites, it was evaluated every 15 days during one month and half using the formula:

$$\mathrm{S}\ (\%) = \frac{X1(1-1) + X2(2-1) + X3(3-1) + X4(4-1) + X5(5-1)}{Y(5-1)} X\ 100$$

where xi = number of cuttings of the class I; i = 1: no attack; i = 2: low attack; i = 3: medium attack; i = 4: severe attack. i = 5: mortal attack; Y = total number of cuttings of the variety.

Table 1. Influence of the bark thickness and the marrow diameter of the stem on the degree of attack of cuttings by termites *O.* sp. in the 8 varieties of cassava after 2 months of culture.

Varieties	Means of		
	Marrow diameter	Bark thickness	Number of termites/cutting
Soya	9.8 [g]	5.2	3.2
Kombo	16.3 [a]	1.7	16.4
Niargi	11.4 [e]	4.6	3.6
Cololi	10.2 [f]	4.8	2.8
Nigeria	13.8 [c]	3.2	8.3
Wallet	15.8 [b]	2.2	13.1
Cacau	13.1 [d]	3.9	3.9
Cacau roja	9.9 [g]	5.7	2.5

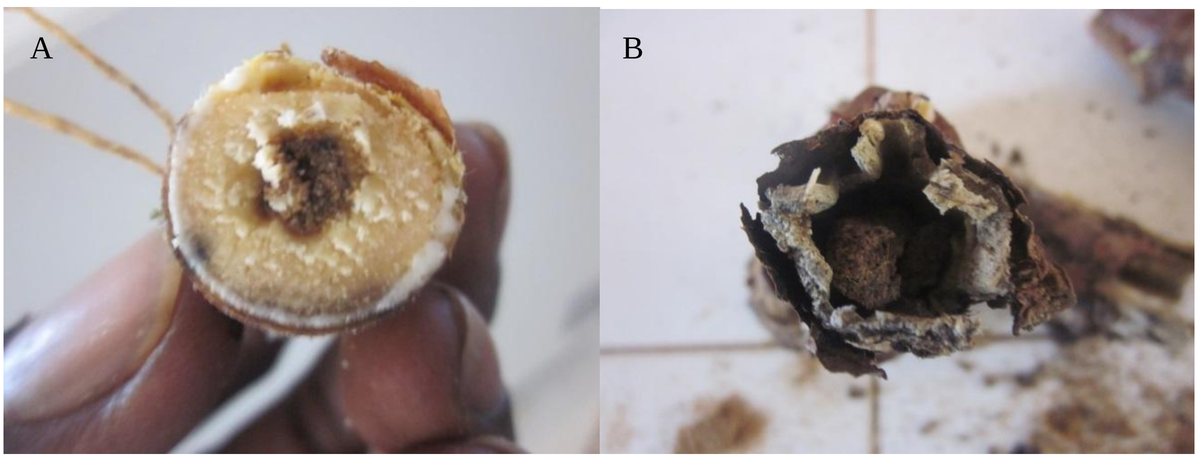

Figure 1. Showing *Soya* (A) and *Kombo* (B) cuttings' cross-sections attacked by termites O. sp., after 60 days of culture.

Statistical analyses

Data collected on this study were entered on Excel and analyzed with software Costat. They have been subjected to analysis of variance (ANOVA) and comparison of means of the Student, Newman and Keuls test at the 0.05 probability.

RESULTS

Influence of the bark thickness and the marrow diameter of the cassava stem on the degree of attack of the cuttings by the termites

A correlation could be established between the diameter of the cassava stem marrow and the number of termites extracted from cuttings. Indeed, the varieties with a large stem marrow presented a low thick bark and vice versa. Table 1 show that cuttings with large marrow diameter have been penetrated by greatest numbers of termites. On the other hand, the varieties which cuttings have a thick bark and a reduced marrow were less attacked. Thus we could count in varieties *Soya* (marrow diameter = 9.8 mm; bark thickness = 5.2 mm) and *Cacau roja* (marrow diameter = 9.9 mm; bark thickness = 5.1 mm) 1.96 and 1.46 against 9.25 and 7.12 in varieties *Kombo* (marrom diameter = 16.3 mm; bark thickness = 1.7 mm) and *Wallet* (marrow diameter = 15.8 mm; bark thickness = 2.2 mm) of average numbers of termites extracted from each cutting respectively (Table 1 and Figure 1).

Analysis of variance showed that the variations in the bark thickness ($F = 2.14$; $P = 0.05$), the marrow diameter ($F = 0.34$; $P = 0.05$) and the number of termites per cutting ($F = 0.194$; $P = 0.05$) were very significant between the 8 cassava varieties studied. The comparison of means allowed to class them in 7 homogeneous groups (a, b, c, d, e, f and g).

Influence of the hardness of the cassava stem bark on the severity of attack of the cuttings by the termites

Figure 2 show that the hardness of the cassava stem bark has an impact on the vulnerability of the cuttings to

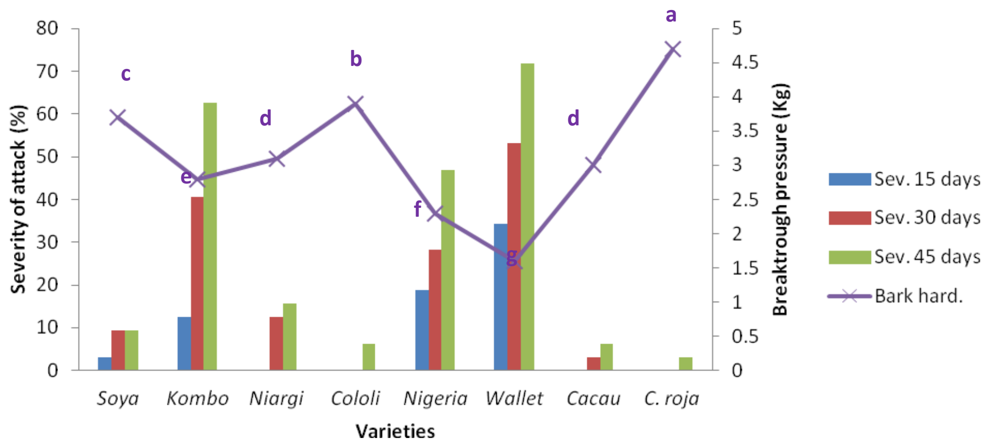

Figure 2. Influence of the stem bark hardness on the severity of attack of the cuttings by termites *Odontotermes* sp. in the 8 varieties of cassava for 45 days of culture.

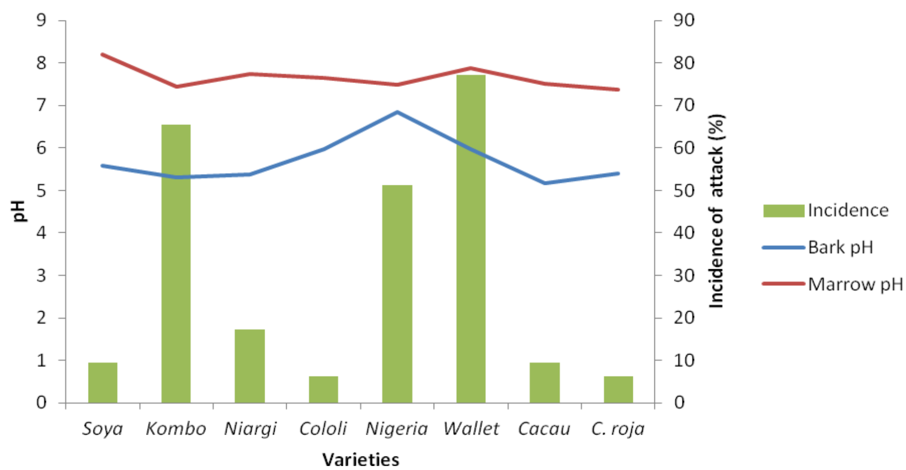

Figure 3. Influence of the stem pH on the incidence of attack of cuttings by termites *Odontotermes* sp. in the 8 varieties of cassava after 2 months of culture.

the action of termites *Odontotermes* sp. We could note a correlation between the hardness of the cuttings bark and their severity of attack by these insects. Indeed, the varieties *Cacau rosa*, *Cololi* and *Soya* with 4.7, 3.9 and 3.7 kg of breakthrough pressure of the bark have been proved more tolerant to the action of termites with respectively 3.12, 6.25 and 9.37% of severity of attack of their cuttings after 45 days of culture (Figure 2). However the varieties *Wallet*, *Kombo* and *Nigeria* which stem bark were relatively more fragile with 1.6, 2.8 and 2.3 kg of breakthrough pressure showed high vulnerability to termites with respectively 71.87, 62.5 and 46.87% of severity of attack of cuttings. According to the ANOVA, the variation in the stem bark hardness ($F = 1.05$; $P = 0.05$) as well as the severity of attack of cuttings by termites after 45 days of culture ($F = 2.107$; $P = 0.05$) were very significant between the 8 cassava varieties studied. These could be classified, according to the bark hardness variation, into 7 homogeneous groups (a, b, c, d, e, f and g) through the comparison of means.

Influence of the pH of the cassava stem on the incidence of attack of cuttings by the termites

No correlation could be established between the pH of the cassava stem bark or marrow and the incidence of attack of its cuttings by the termites *Odontotermes* sp. among the different varieties put in experience. Figure 3 shows that the attack of these insects on cuttings is not related to the acidity or basicity of the stems. Indeed, we have seen that varieties *Kombo* (I = 65.5%) and *Niargi* (I = 17.3%) with respectively 5.31 and 5.7 on one hand and the varieties *Wallet* (I = 77.07%) and *Cololi* (I = 6.25) with respectively 5.97 and 5.98 on the other hand, presented lowly variable bark pH. Similarly, the stem marrow that was less acidic than the bark in the 8 varieties of cassava, did not vary lot between these different varieties.

DISCUSSION

The thickness and the hardness of the stem bark would be the main parameters related to varietal tolerance of cassava to the action of termites ravaging cuttings *Odontotermes* sp. aff *erraticus*. Indeed, these two parameters of the stem that characterize the tolerant varieties would constitute a physical barrier to the activity of these xylophagous termites that use their mouthparts to gradually dig cassava cuttings. This observation perfectly agrees with the findings of Sauvion et al. (2013) that against xylophagous insects, several types of passive defenses can play the roles of physical barrier. According to these authors, the thickness of the bark can be a system of effective resistance to beetles such as *Pityogenes chalcographus* (*Coleoptera*, *Curculionidae*) on spruce and *Ips acuminatus* (*Coleoptera*, *Curculionidae*) on pines, which usually attack the upper portions of the trunk and the branches of the trees. On the other hand, a research by Rahbe and Giordanengo (2013) has shown that the liber and the outer bark of various conifer species contain structures called "stony cells" which are piles of lignin. Thus, when these structures were abundant at the level of the stem bark, their hardness could disrupt the action and development of beetles drilling galleries, as in the case of *Dendroctonus micans*. In this sense, Lieutier and Haddan (2007) cited by Sauvion et al. (2013) have observed a negative correlation in eucalyptus between the thickness of the liber and the proportion of larvae of the beetle *Phoracantha recurva* (*Coleoptera*, *Cerambycidae*) which could access to the sapwood after laying on the bark surface.

In our experimental conditions, we can therefore explain the cassava tolerance to termites ravaging cuttings *Odontotermes* sp. observed in varieties *Soya, Cololi*, *Cacau*, *Cacau roja* and *Niargi* by their relatively hard and thick stem unlike in varieties *Kombo*, *Wallet* and *Nigeria* which were more vulnerable to the activity of these insects.

Like the bark thickness and hardness, the diameter of the stem marrow also would be in relation to the varietal vulnerability of cassava to termites ravaging cuttings. Thus, high degree of infestation as severity of attack observed in varieties *Kombo*, *Wallet* and *Nigeria* would be also due to their relatively large stem marrow with bark consequently reduced. Indeed, a large diameter of this stem marrow includes a possibility of penetration of a great number of individuals of termites inside the cuttings and therefore an increase of their activity.

Chemically, the pH of the cassava stem varies from one variety to another and would be linked to its latex or cyanhydric acid contents. Indeed, the stem of the variety *Soya* is very rich in latex (a cut stem actually cast lot) while the *Nigeria* variety is poor (any drop from a cut stem). This stem latex essentially located at the level of the bark would be responsible for the acidity of this cortical part. Its abundance in a variety would however not act on termites ravaging cuttings. Our results have also shown that the marrow of cassava stem were less acidic than the bark. The basicity of this medullar part would be due to its poverty in latex and cyanogenic glycosides. Thus, these toxic composts mainly represented by linamarine and the lautostraline in cassava, are present in all parts of this plant and which content diminishes from the periphery to the middle of each organ, according to Alves (2012). In the stem, these acids would therefore be more present in the bark than in the marrow, and would be at the origin of the difference in pH between these two components of this organ. However, the pH of the cassava stem would not have repulsive or attractive effect on termites ravaging cuttings *Odontotermes* sp. aff. *erraticus*.

Conclusion

This study proposed to evaluate the influence of physico-chemical properties of the stem of cassava on its varietal tolerance to termites ravaging cuttings *Odontotermes* sp. aff. *erraticus*. Registered results have shown on one hand that the cassava varieties *Soya*, *Niargi*, *Cololi*, *Cacau* and *Cacau roja* are more tolerant to the action of these insects than those *Kombo*, *Wallet* and *Nigeria*. On the other hand, they have shown that the thickness and the hardness of the bark and the diameter of the marrow of the cassava stem are physical parameters influencing the vulnerability of this plant to the action of these pests. Indeed, a correlation could be established between the hardness of the bark and the severity of attack of cuttings by the termites on one hand and on the other hand between the diameter of the marrow and the number of individuals of termites which penetrated attacked cuttings of the different varieties of cassava. However the pH of the stem has not been proved influencing the attack of termites *Odontotermes* sp. aff. *erraticus* on cassava cuttings.

Conflict of Interest

The authors have not declared any conflict of interest.

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