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Mango cultivation practices and termite pest attacks: Case of mango orchards in Northern Côte d'Ivoire

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Abstract
Termites are one of the main constraints for mango producers in Africa. In the orchards of northern Cote d'Ivoire, three cultural practices are observed among producers : direct seedlings of mango pits, planting of mango seedlings, trimming of old mango trees. The objective of this study was to evaluate the impact of these cultural practices on termite pests of mango trees. Three orchards were sampled per type of cultivation practice. In each orchard, 100 mango trees were observed during the months of November to December 2013. Termite attack rates were calculated for each type of cropping system. The results show that a total of 13 species of termite were collected. The receped orchards and those made from seedling planting recorded the highest number of termite pests with 11 and 8 species collected respectively. The highest termite attack rates were observed in the trimmed orchards and in the orchards planted with mango seedlings, with 99.33±3.33% and 82.33±11.50% of attacks, respectively. Orchards made from seedlings of mango stones recorded the lowest attack rate (37.66 ± 10.23%). This study revealed that certain cultural practices would increase the aggressiveness of termites on mango trees, and would thus hinder the development of this crop in the Korhogo area.

Keywords: termite pests, cultural practices, mango trees, attacks, Korhogo, Côte d'Ivoire

1. Introduction
Côte d'Ivoire is an essentially agricultural country. The agricultural and agro-industrial sector contributes 38% of total GDP (Gross domestic product) and is the main source of income for two-thirds of the working population [1]. In its policy of diversifying agricultural exports, the state gives a predominant place to fruit production [2]. The exporting countries make a lot of profit from the marketing of fruit, of which mango has proved to be very promising for several decades [3]. Thus, from 71 tonnes in 1981 [4], more than 10,000 tonnes of mangoes were recorded in 2001 [5]. Since 1995, this has made Côte d'Ivoire the leading African producer and the second largest supplier of mangoes to the European market, after Brazil [6]. The mango has thus become the third most exported fruit, after pineapple and banana [3]. In 2006, the mango sector brought in around 11.2 billion CFA francs (20.3 million USD) for producers in Côte d'Ivoire [7]. In northern Côte d'Ivoire, a major production area, mango contributes to food security and the fights against poverty. Unfortunately, the fruit sector in Africa, and particularly in Côte d'Ivoire, is facing heavy economic losses due to numerous pest attacks [8]. Thus, for some years now, the enormous difficulties experienced by the mango sector have caused Côte d'Ivoire to regress on the European market. Today, the country ranks third after Brazil and Peru, despite exporting 10,105 tonnes in 2011, 15,289 tonnes in 2012, 20,475 tonnes in 2014 and over 30,000 tonnes in 2017 to the European Union market [9, 10]. This decline is mainly due to insect pests, including termites.
In West Africa, termites are one of the enemies of the mango tree because they cause not only dieback but also the progressive drying of the plant until its death [11, 12]. In the northern region of Côte d'Ivoire, mango orchards are established through three cultural practices: transplanting young mango plants produced in nurseries, sowing pits directly on the plots and receiving old orchards for the renewal of old ones. Recently, the work of [13] has shown that termites are a real problem for mango producers in this region. However, the work of these authors did not relate cultural practices to termite attacks.

The objective of this study is therefore to evaluate the impact of certain cultural practices on termite pest attacks on mango trees. Specifically, the aim is (1) to draw up a list of termite pest species and (2) to evaluate the attack rates and damage of these insects according to the type of cultivation practices.

2. Materials and Methods

2.1 Study area

The studies were conducted in the dry season from November to December 2013, in the Korhogo region (9°34' N - 5°37' W). The climate is dry Sudanese tropical with two contrasting seasons: the rainy season extends from mid-April to October and the dry season from November to mid-April. The average annual rainfall varies between 1000 and 1600 mm. Rainfall is the most important climatic factor. The average humidity is 65-70%. The average annual temperature varies between 24 °C and 36 °C. The vegetation is of the savannah type and the soils are generally low in humus and of average fertility.

2.2 Termite sampling

Three cultural practices were evaluated in this study. These are:

- Seedlingsmango pits (Os) directly on the plots.
- Planting of young (Op); grafted plants from nurseries
- Trimming of old orchards in the renewal of the orchards (Ot).

Three orchards of 1 ha each (100 plants) were sampled by cultural practice. The trees in these plots were observed for the presence of termites. The observed termites were collected in pillboxes containing 70 °C alcohol.

2.3 Estimating termite attack rates

Termite attacks in these different cropping systems were compared in order to determine which cropping practice was most vulnerable to attack. The termite attack rate is estimated based on the principle of Han and Ndiaye [11]. The organ is said to be attacked when it bears galleries or veneers with or without termites. The termite attack rate per plot is calculated according to the following formula:

Ta= Npa x 100 / Ntp (1)

Ta = termite attack rate per plot (in %)

Npa = Number of termite-affected plants

Ntp = Total number of observed feet per plot

2.4 Characterisation of the damage caused by the attacks

Termite damage on mango trees was classified into two (2) main groups (Table 1). Each group includes 2 types of damage. The classification is based on the density of harvest veneers and especially on the progression of termites in the anatomical structures of the plant (bark, sapwood and heartwood) [14].

Table I: Rating scale for termite damage to trees.

Groups	Damage type	Characteristics
Minor damage	D1	Presence of food-borne veneers or a reduced number of veneers with perfect bark health
	D2	Sufficient coverage of the mango plant by harvest veneers with bark degradation by termites that settle between the bark and the sapwood, often accompanied by sap flow
Major damage	D3	The establishment of termites in the sapwood with sometimes an abundance of harvesters.
	D4	Termites move into the heartwood. Dead mango trees or decomposed trunks and systematic cutting of young plants.

2.5 Identiication of collected termites

The collected termites were first determined to genus and then species level under a binocular magnifying glass, using the identification keys [15-21]. After identification, each species was classified into one of the trophic groups (fungus-growers, and wood-feeders).

2.6 Data analysis

The data obtained were subjected to an analysis of variance (ANOVA, $p<0.05$) using Statistica software (version 7.0). The homogeneous means were then grouped using the Newman-Keuls test. The results were used to determine whether the attack rates were significantly different between the different cropping practices

3. Results

3.1 Termite species collected from mango trees

A total of 13 termite species were collected from mango trees. These species belonged to 3 subfamilies and 10 genera (Table I). Macrotermitinae and Termitinae were the most diverse with 7 and 4 species respectively. Coptotermitinae and Rhinotermitinae were each represented by one species. The species collected belonged to 2 trophic groups: fungus-growers and wood-feeders. The fungus-growers were present in 7 species while the wood borers were represented by 6 species. Four species were common to all area: *Ancistrotermes cavithorax, Pseudacanthotermes militaris, Amitermes evuncifer, Odontotermes pauperans* and *Microcerotermes* sp.1.

The number of species collected varied from one cultivation practice to another. Receiving orchards and orchards planted with seedlings had the highest number of termite pests with 11 and 8 species harvested respectively. Orchards planted with seedlings, with only 4 species harvested, had the lowest number of termite pests.

Table II: Termite species richness by type of cultivation practice

Sub-familles/ species	feeding group	Seedling (Os)	Planting (Op)	Trimming (Ot)
Coptotermitinae				
Coptotermes intermedius	w		-	*
Rhinotermitinae				
Schedorhinotermes lamanianus	w		-	*
Macrotermitinae				
Ancistrotermes cavithorax	f		*	*
Ancistrotermes crucifer	f		*	*
Macrotermes subhyalinus	f		-	*

Microtermes sp.1	f		*	-
Microtermes sp.2	f		*	-
Odontotermes pauperans	f	*	*	*
Pseudacanthotermes militaris	f	*	*	*
Termitinae				
Amitermes guineensis	w	-	-	*
Amitermes evuncifer	w	*	*	*
Microcerotermes fuscotibialis	w	-	-	*
Microcerotermes sp.1	w	*	*	*
13		4	8	11

F : fungus-growers and w : wood-feeders

3.2 Variation in attack rates

The highest termite attack rates were observed in the received orchards and in the orchards made from planting of young plants produced in nurseries, with 99.33±3.33% and 82.33±11.50% of attacks, respectively. Orchards made from mango kernel seedlings recorded the lowest attack rate with 37.66±10.23% of attacks. Statistical tests revealed that termite attacks varied significantly according to cultural practices (ANOVA, $p < 0.05$). The attack rate in the mango core seedling orchards was significantly different (Newman-Keuls test, $p<0.05$) from the high rates observed in the other two cropping systems. There was no significant difference between the attack rates obtained in the latter (Figure 1).

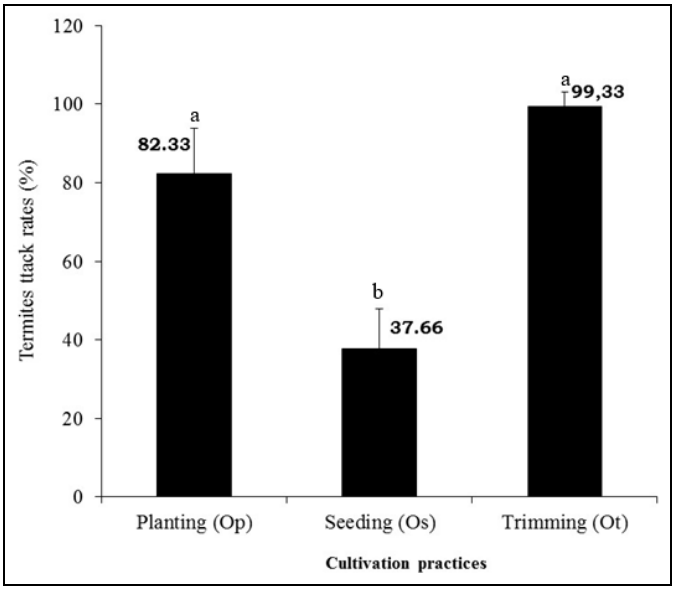

Fig 1: Variation in attack rates according to cultivation practices

3.3 Abundance of damage types according to cropping practices

Minor damage (D1 and D2) was observed in all cropping practices (Figure 2). Minor damage (D1) was relatively low in all cropping practices with about 10 infested plants/ha in each cropping practice. D2 damage was also low for all cropping practices. However, the received orchards recorded the highest number of infested plants. It should be noted that this minor damage (D1 and D2) was generally superficial and has no real impact on the mango trees. The received orchards recorded the highest number of major type III damage (D3), with 29 ± 2.33 infested plants/ha. This type of damage was relatively low compared to other cultural practices. The received orchards and the orchards made from planting of young mango seedlings recorded the highest number of type IV (D4) damage with respectively 44.66± 4.66 and 55.66± 4.50 infested plants/ha. The orchards made from stone seedlings recorded the lowest number of type IV damage with 20.66 ± 5.24 infested plants/ha. Both types of damage can lead to the death of mango trees.

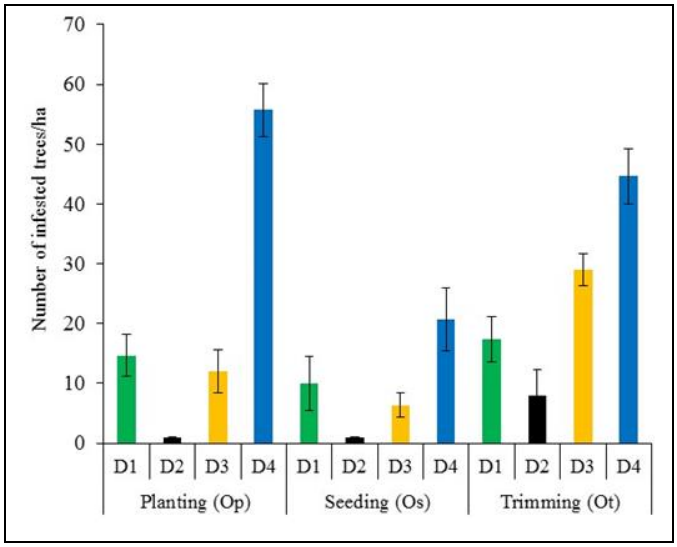

Fig 2: Average density of damage types by cultivation practices

3.4 Variation in structures attacked by termites

The observation of the attacked plants showed that in the orchards from seedlings, the main part of the termite attacks was done at the level of the root system, mainly at the level of the main root, cut during transplanting (Figure 3A1 and A2). Thus, 76% of the dead plants unearthed had roots destroyed by termites, compared to only 13.33% for orchards from seedlings. The major damage was observed at the level of the mango receiving areas (Figure 3B1). These cut branches were the targets of termite pests. At first, the attacks did not prevent the emergence and development of shoots. These cut branches, which were attacked, weakened and degraded over time under the effect of the termite attacks (Figure 3B2). Observation of some branches not infested by termites showed that the wounds caused by the reception gradually closed (Figure 3C1 and C2) until they were completely healed (Figure 3C3).

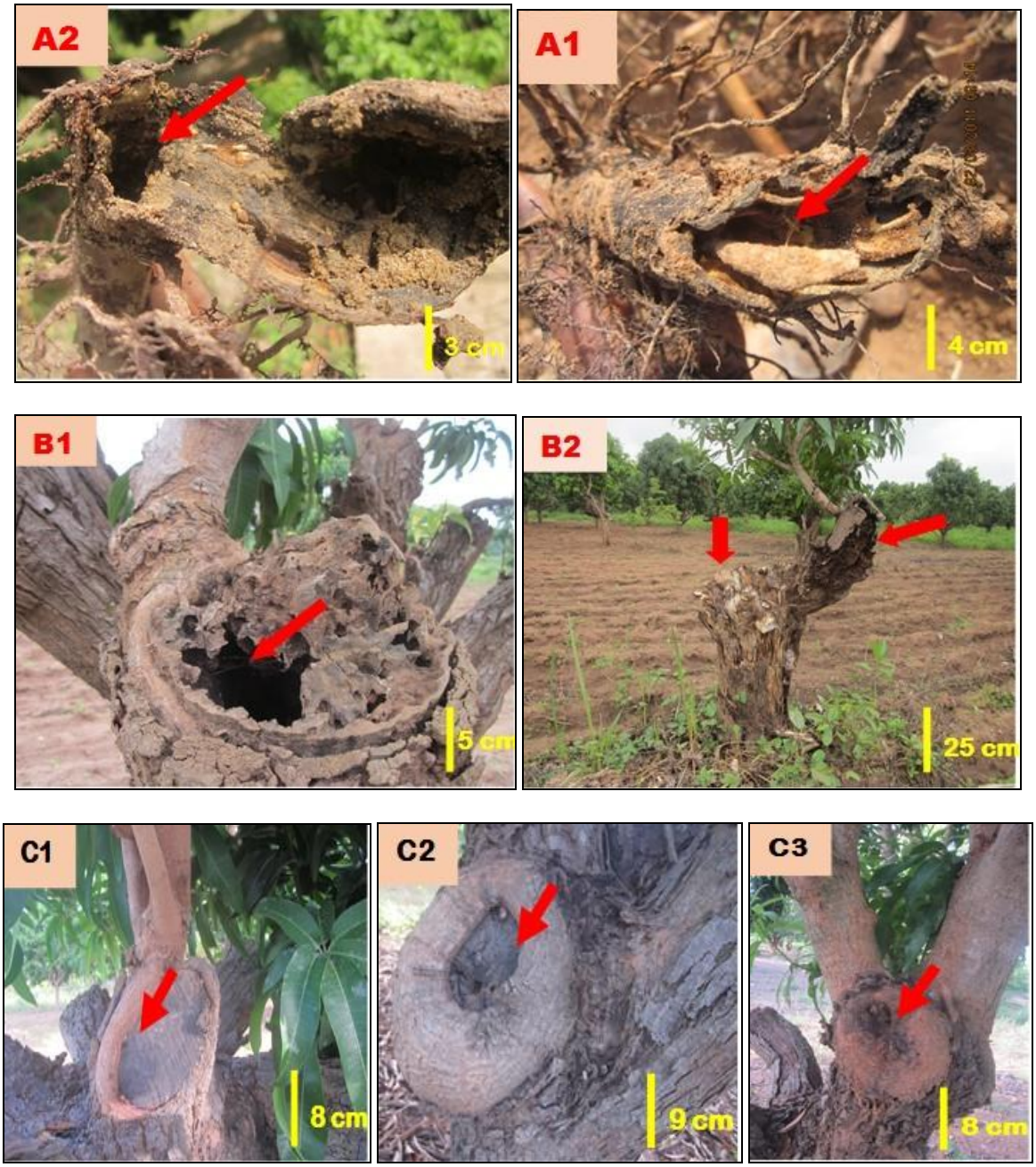

Fig 3: Termite attacks on mango trees from orchards of the most vulnerable cropping systems. **A1, A2**: Attacks on the main root of transplanted mango trees, **B1**: Termite attack at the level of the trimming zone, **B2**: Advanced state of degradation of a trimmed plant attacked by termites. **C1, C2** and **C3**: Healing process of a trimming zone

4. Discussion

The study carried out, based essentially on observations made on mango trees in nurseries and orchards, in a farming environment, allowed the identification of a total of 13 termite species. This number is much lower than the one obtained by Coulibaly *et al.* [13], who collected 18 species of termite pests using the same observation method in mango orchards in the same study area. The difference in species collected would be related to the type of orchards sampled. Contrary to the present study carried out in 9 orchards, the work of Coulibaly *et al.* [13] was carried out in 5 classes of mango orchards, i.e. a total of 15 orchards. Several authors have shown that the sampling method or the sampling effort influences the number of species. However, trophic composition is not affected [22, 23].

The termites collected belong mainly to the fungus and wood-boring groups. The importance of these groups was demonstrated on rubber seedlings [24] and on trees on the Lomé campus and by Anani *et al.*, [25]. The presence of fungus beetles in all cultural practices is due to their remarkable adaptation favoured by the symbiotic relationship they have with a fungus of the genus *Termitomyces* which facilitates their degradation of food [26, 27]. Wood-feeders are also assisted by zooflagellates in the degradation of cellulose and its derivatives [28], which allows them to colonise different environments.

Termite attacks vary according to cultural practices. Orchards made from recutting of old orchards and young orchards made from transplanting of young mango trees produced in nurseries are the most attacked by termites, compared to young orchards made by direct seedlingsof mango pits. The high infestation rate in these systems is explained by farmers' practices. In the received orchards, almost all the branches of the trees are cut off, exposing the wood. Similarly, in young orchards made from transplanted mango seedlings, the main root of the seedlings is cut off before transplanting, to enable

them to better withstand the stress after transplanting.
These severed areas are thought to be a gateway for termites. Work has shown that certain practices can favour termite attacks. N'Dri *et al*., [29] showed that 84% of *Crossopteryx febrifuga* (Rubiaceae) cavities > 2 m in size are exploited by fungus-growers, and wood-feeders termites in the Lamto savannah. Tra-Bi [30] also showed that the cutting of certain bulky trunks and cocoa tree offshoots favoured termite attacks, as they constituted real entry points.
The orchards created using direct seedlingsof mango pits are relatively less attacked by termites. However, in the field, farmers seem not to appreciate this mango cultivation technique. In fact, according to most farmers, orchards grown using this technique take more years to reach fruiting.

5. Conclusion
The objective of this study was to evaluate the impact of cultural practices on termite pests of mango. Three cultural practices were evaluated. These were direct sowing of pits, direct planting of seedlings produced in nurseries, and receiving of old mango plants. A total of 13 termite species were collected. The received orchards and the orchards made from planting of young plants recorded the highest number of termite pests with respectively 11 and 8 species collected. The highest termite attack rates were observed in the nursery orchards and in the orchards planted with seedlings produced in the nursery, with 99.33±3.33% and 82.33±11.50% of attacks respectively. This study reveals that certain cultural practices increase the aggressiveness of termites on mango trees, and thus hinder the development of this crop in the Korhogo area. These results make it possible to draw the attention of producers and professionals in the mango sector to the need for appropriate protection measures to be put in place to protect mango trees against the ravages of these insects.

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