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Research Article

Evaluation of the Grafting Aptitude of *Cola cordifolia* Rootstock with Five Kola Tree Clones (*Cola nitida*)

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Abstract

Improving the yield of ivorian kola orchards involves creating high-performing plant material. The use of seed nuts faces challenges due to slow germination and late fruiting of the resulting plants. Therefore, the production of grafted plants with high-yielding clones is being considered. The objective of this study was to determine the effect of the clone on the success rate of plants grafted with *Cola cordifolia* and, by extension, to determine the effectiveness of the rootstock type *Cola cordifolia*. Five clones are involved: AMA, BOGO, DIDI, MOUSS, and SELI. The experimental design was a completely randomized design with one factor studied (Clone) and three replications. Cleft grafting was performed in a nursery under a tunnel. The experimental unit consists of 10 plants. The success rate of the plants was measured after two months of experimentation. Results showed an average success rate of 55.33%. The genotype had a significant effect on the number of successful grafts. The success rate varied depending on the clones, ranging from 36.67% to 63.33%. The DIDI clone had the lowest success rate, while the SELI clone had the highest success rate and produced the largest number of new leaves, followed by the AMA clone. These SELI and AMA clones show good grafting aptitude and rapid recovery after grafting. Thus, cleft grafting applied to *Cola cordifolia* as a rootstock is advantageous for the multiplication of *C. nitida*. *Cola cordifolia* could therefore be proposed in the future to kola producers as an alternative rootstock to *Cola nitida* for grafted plant production. However, the grafting aptitude of clones proposed for distribution should be systematically evaluated. Grafted plants with *Cola cordifolia* should also be tested in the field.

Keywords

Cola Nitida, Cleft Grafting, *Cola Cordifolia*, Success Rate

1. Introduction

The kola tree is a fruit tree of the African forest that grows in tropical and equatorial regions of Africa. It typically reaches heights of 10 to 15 meters, sometimes exceeding 25 meters. This species belongs to the *Cola* genus in the Malvaceae family. The genus includes around 140 species, about fifty of which are native to West Africa [1, 2]. Two species are cultivated and supply the market: *Cola nitida* and *Cola acuminata* [4]. The species *Cola nitida* is the only one cultivated

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in Côte d'Ivoire. The kola tree is grown for its seeds, known as kola nuts, which are rich in caffeine (2.3%). Kola nuts are highly valued worldwide and in Africa for their sociocultural uses (dowries, weddings, baptisms, funerals) and industrial applications (soap, dyes, medicines, and soft drinks) [3, 15]. Côte d'Ivoire is the world's leading producer, with an annual production estimated at 260,000 tons of fresh nuts [8], generating a revenue of approximately 78 billion CFA francs. Despite these achievements, the cultivation of the kola tree in Côte d'Ivoire faces numerous challenges. Indeed, kola nuts have slow germination, and seedlings enter production late [5]. Nut yields in Ivorian orchards remain low due to plantations established with unimproved plant material and unsuitable traditional farming practices. Additionally, there are low success rates for vegetative propagation through cuttings. To address these limitations, the production of plants through grafting with high-yielding clones is being considered. Studies [11] have identified *Cola nitida* rootstock as the most suitable for grafting kola tree clones, with rapid recovery and success rates ranging from 73.33% to 81.67%, depending on the clone. However, several studies have shown that grafting success also depends on the rootstock and scion used [9, 13, 10]. Therefore, we conducted a trial on different types of rootstocks in *Cola nitida*, including *Cola cordifolia* as a rootstock. This study aims to evaluate the grafting aptitude of *Cola cordifolia* as a rootstock for *Cola nitida*. It will also assess the grafting aptitude of five kola tree clones grafted with *Cola cordifolia* as the rootstock.

2. Materials and Methods

2.1. Description of the Experimental Site

The work presented in this study was carried out at the nursery of the CNRA research station in Man. The geographical coordinates are 7° 19' North latitude and 8° 19' West longitude. The average altitude of the study site is 354 meters above sea level. The rainfall in the Man area is monomodal. The dry season generally extends from October to March, and the rainy season from April to September. The average rainfall data, as provided by the meteorological service of the Man research station, was 1703.71 mm over ten years (2007-2017). The soils in the Man area are ferralitic. There are also soils developed on basic rocks (potentially nutrient-rich), hydromorphic soils (lowlands), and soils rich in minerals (iron, manganese, gold, etc.).

2.2. Plant Material

The plant material used for this trial consists of rootstocks and scions. The rootstocks used are 12-month-old seedlings of *Cola cordifolia* grown from seeds. This is a cosmopolitan species with a well-developed root system, which will allow the expansion of the cultivation area for the kola tree (*Cola nitida*) and increase its survival rate in plantations. Five genotypes were involved in the grafting process: AMA, BOGO, DIDI, MOUSS, and SELI. The scions were taken from semi-hardened terminal shoots of *Cola nitida* at the Man nursery. A total of 150 *Cola cordifolia* plants were used as rootstocks in the trial, with 30 scions per *Cola nitida* clone.

2.3. Technical Equipment

Various tools and materials were used. These included a pruner for collecting the scions and making notches and splits on the rootstock, and a cooler to store the scions in humid conditions. Plastic bands (cut into pieces 20 cm in length and 2 cm in width) were used for tying the scions to the rootstocks. A caliper and a graduated ruler were used to measure the diameter of the rootstock and the length of the scion, respectively.

2.4. Rootstock Production

Cola cordifolia seedlings were produced at the Man nursery over 12 months from common seeds. A total of 150 seedlings produced were used in the trial. These seedlings were regularly watered (twice a day) after the seeds were sown in pots filled with potting soil.

2.5. Selection of Scions

High-yielding clones AMA, BOGO, DIDI, MOUSS, and SELI were selected for the test. Ideal scions for grafting were 15 cm in length and had two to three buds, including an active apical bud, which will develop into a new shoot. These are semi-hardened shoots harvested from the mother trees of clones AMA, BOGO, DIDI, MOUSS, and SELI. The diameter of the scions was matched to that of the rootstock to maximize the success rate.

2.6. Cleft Grafting Method

The grafting method used for the kola tree was cleft grafting [12]. The grafting of seedlings from seeds began as soon as they were 12 months old. This period is considered necessary for optimal development of the rootstock diameter for grafting. The first step in this process involves collecting suitable semi-hardened scions early in the morning using a pruner from clones AMA, BOGO, DIDI, MOUSS, and SELI. The collected scions were stored in a cooler to prevent dehydration and transported to the grafting site. The stem of both the scion and rootstock was sterilized with 70% ethanol and a cotton wipe to clean their surfaces. The scions were cut into a wedge shape using a grafting knife. The 12-month-old rootstock stem was cut approximately 10 cm above the soil surface in the plastic pot, leaving a set of leaves on the rootstock. The scions had the same initial number of leaves (preferably two, cut in half) for the cleft grafting. The second step involves gently splitting the surface of the cut rootstock stem without penetrating too deeply, approximately the size of the

scion base, to allow for snug fitting. The scion was inserted into the rootstock, and the entire assembly was tied with a grafting band. The grafted plants were placed under a one-meter tunnel covered with plastic sheeting, creating a humid environment around the graft. The plant bases were watered every three days, ensuring that water did not reach the graft union, as this could cause rotting. The final step is unwrapping, which involves removing the plastic film. The success of grafting was assessed two months after the operation, and the plants were removed from the tunnel.

2.7. Experimental Design

The experimental design was a completely randomized design with one factor studied (the clone) and three repetitions. Cleft grafting was carried out in the nursery under the tunnel. The experimental unit consisted of 10 plants. A total of 30 scions per clone and 150 rootstocks were used for the trial.

2.8. Data Collection

The parameters observed two months after grafting were the number of successful grafted plants and the number of new leaves or shoots on the grafted plants. The grafted plant success rate (GR) was then calculated using the formula:

$$GR=\frac{TNGP\text{-}NDGP}{TNGP}\times 100$$

Where GR is the Grafting Success Rate, TNGP is the total number of grafted plants, and NDGP is the number of dead grafted plants.

2.9. Statistical Analysis

All data were statistically analyzed using Statistica 7.1 and Microsoft Office tools. For the parameters examined, a comparison of means was conducted using analysis of variance (ANOVA). When a significant difference was observed between treatments for the factor studied, ANOVA was followed by post-hoc tests, notably the Newman-Keuls test, to identify significant differences between means at a 5% significance level.

3. Results

Study of the impact of clone on the number of successfully grafted plants two months after grafting

Table 1. *Analysis of variance of the effect of clone on the number of successfully grafted plants.*

Title	F	P
Y-Intercept	574,08	0,000
Clone	4,2917	0,028

The data collected on the number of successfully grafted plants allowed for a variance analysis. This analysis of variance (ANOVA) (Table 1) showed that the clone factor had a significant effect on grafting success (*p=0.028*).

Evaluation of grafting success rate based on clones two months after grafting

Among the five clones grafted onto the rootstock *Cola cordifolia*, clone DIDI exhibited the lowest success rate at 36.67%. This rate is statistically different from those of clones AMA, BOGO, MOUSS, and SELI, which achieved higher success rates ranging from 56.67% to 63.33%, resulting in an average success rate of 55.33%. The success rate based on the number of successfully grafted plants indicated that some clones were better suited for grafting than others (Figures 1 and 2).

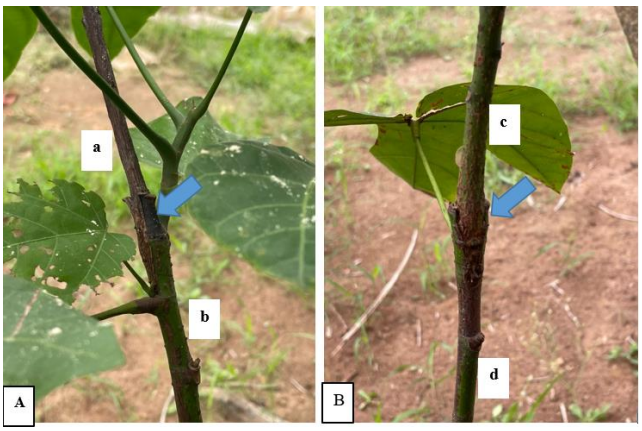

Figure 1. Plant of Cola cordifolia two months after grafting; A: Incompatibility Between the Rootstock and the Scion (a: dead scion; b: living rootstock); B: Compatibility between the rootstock and the ccion (c: living scion; d: living rootstock). The arrow indicates the junction point between the rootstock and the scion.

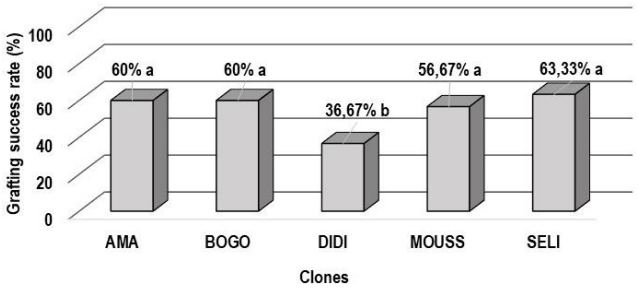

Figure 2. *Grafting success rate based on clone.*

Means followed by the same letter are not significantly different at the 5% level.

Grafting suitability of clones based on the number of new leaves produced two months after grafting

The count of new leaves emerging from the successfully grafted plants two months after grafting was recorded (Figure 3). Clone SELI produced 11 new leaves, followed by clone

AMA with a total of 10 new leaves. For clones DIDI and MOUSS, although the grafting appeared successful visually, they had not produced any new leaves two months after grafting onto *Cola cordifolia*.

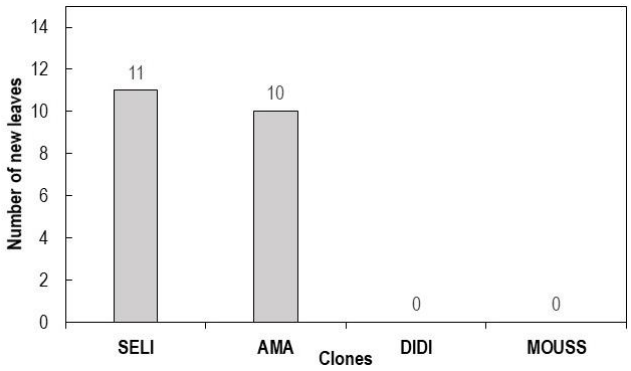

Figure 3. *Number of new leaves per grafted clone two months after grafting.*

4. Discussion

Our study allowed us to compare the response of five clones of the cola tree (*Cola nitida*) to terminal cleft grafting on the rootstock *Cola coordifolia*. This study tested *Cola coordifolia* as a substitute for the rootstock *Cola nitida* and assessed the compatibility between the scion (*Cola nitida*) and the rootstock (*Cola coordifolia*). Our findings indicate that the clone influences the success rate of grafting [6]. This suggests that the effectiveness of grafting is dependent on the clone. Among the five clones grafted onto the rootstock *Cola coordifolia*, the DIDI clone had the lowest success rate at 36.67%. It was statistically different from the clones AMA, BOGO, MOUSS, and SELI, which had higher success rates ranging from 56.67% to 63.33%. The AMA and SELI clones also exhibited rapid recovery rates with increased production of new leaves. The specific growth regulators of the different clones regulate their development and responses to various biotic and abiotic stresses. These growth regulators influence the formation of the graft junction and the success rate of grafting [7]. The average success rate of 55.33% obtained from cleft grafting with *Cola coordifolia* rootstocks under tunnel conditions was lower than the rates reported by Séry and colleagues in 2020 [11], which were 73.33% and 81.67% with *Cola nitida* as the rootstock. However, it remains high. In our case, this success can be attributed to the fact that the species *Cola coordifolia* is a plant of the same genus as *Cola nitida* [14]. This affinity facilitated the alignment of the vascular cambiums of both species in the case of terminal cleft grafting. The high success rates, though lower than those with *Cola nitida* rootstocks, may be due to morphological differences between the *Cola coordifolia* rootstock and the *Cola nitida* scions. The terminal cleft grafting technique of the kola tree (*Cola nitida*) with *Cola coordifolia*-type rootstocks is suitable for grafting clones of the *Cola nitida* species.

5. Conclusion

Our study tested the response of five clones of *Cola nitida* (AMA, BOGO, DIDI, MOUSS, and SELI) to terminal grafting on *Cola cordifolia* rootstock over two months. The results showed an average success rate of 55.33% across the clones. The study indicated that genotype had a significant effect on the number of successful grafts, with success rates varying from 36.67% to 63.33% depending on the clone. Clone DIDI had the lowest success rate, while clone SELI had the highest success rate and produced the most new leaves, followed by clone AMA. Clones SELI and AMA exhibited good grafting suitability and rapid recovery after grafting. Therefore, *Cola cordifolia* could be proposed in the future to cola producers as a substitute for *Cola nitida* rootstock for the production of grafted plants. However, the grafting suitability of the proposed clones for dissemination should be systematically evaluated. Grafted plants with *Cola cordifolia* should also be tested in the field.

Abbreviations

CNRA	National Center for Agronomic Research
FCFA	Financial Community Franc in Africa

Author Contributions

Drolet Jean-Marc Séry: Conceptualization, supervision, writing

Yaya Ouattara: Reading and editing of the manuscript

Lisette Zeh Tokpa: Reading and editing of the manuscript

Ehouman Jean Brice Ohoueu: Reading and editing of the manuscript

Karine Gba: Reading and editing of the manuscript

Charlène Gnagra: Data collection and monitoring of the experiment

Conflicts of Interest

The authors declare no conflicts of interest.

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