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Research Article

Germination trials of *Phœnix reclinata* Jacq. and *Raphia sudanica* A. Chev. two palm species of Guinean Savanah

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Abstract

Faced with the risk of over-exploitation and the rarefaction, or even disappearance of non-cultivated palms, conservation measures must be taken. However, palms have varying degrees of dormancy due to their pericarp and hard integument, which are impermeable to water and oxygen. This study looked at the germination of *Phœnix reclinata* and *Raphia sudanica* seeds. After seed collection, three treatments were applied to the seeds: soaking in tap water, soaking in boiling water, and immersion in tetrasulphate IVacid for 5 minutes after soaking in tap water. Following the treatments applied, the germination rate of seeds soaked in tap water was 88.80% for *Phoenix reclinata* and 8.89% for *Raphia sudanica*. Germination time and mean germination time were 39 days and 81.5 days respectively for *Phoenix reclinata* and 74 days and 90 days for *Raphia sudanica*. Seeds scarified and immersed tetrasulphate IVacid gave a germination rate of 15.56% for *Raphia sudanica* and 0% for *Phoenix reclinata*. Germination time and mean time for *Raphica sudanica* were reduced to 38 days and 60 days respectively. The treatments had a positive effect on germination time and average germination time. However, the germination rate was low

1. Introduction

Palms are a group of plant species in the Arecaceae family. They play an undeniable role in the lives of people in many tropical countries [1]. In Côte d'Ivoire, this family is represented by 18 species. All the organs [2] of these plants have their uses, from roots to palms [3]. Palm species are used for food, traditional medicine, building habitats, handicrafts and many other purposes. The work of Da Giau [4] inventoried 5 categories and 12 sub-categories of use for palms native to Côte d'Ivoire. The products resulting from exploitation and processing are intended either for local markets (craft and industrial products) or for export. In addition, the marketing of rattan palm and the making of Raphia loin cloths among the Dida are income-generating activities in Côte d'Ivoire [5-4].

Despite this socio-economic importance, most palm species are marginalised in terms of domestication in Côte d'Ivoire. With the exception of the oil palm (*Elaeis guinensis* Jacq.) and the coconut palm (*Cocos nucifera* L.), all palm species are exploited by local people in their natural environments. The disappearance of habitats due to agricultural pressure,

Figure 1. (**a**) Fruits of *Raphia sudanica*, (**b**) Seeds of *Phœnix reclinata*

timber exploitation, climate change and the intense and continuous exploitation of palm trees has reduced palm tree populations [6]. These activities are a threat to the survival of the last existing palm populations [7]. Faced with the risks of over-exploitation and the rarefaction, or even disappearance, of uncultivated palms, conservation measures need to be taken. These measures could include germination work. Traditionally, these species are propagated by seed. However, germination often takes longer than two months [8].

The germination of a seed is defined as the sum of events that begin with imbibition and end with the emergence of the radicle. In palms, many seeds germinate very slowly, often requiring weeks, months or even years to germinate [9]. This is because palms have varying degrees of dormancy due to their pericarp and hard seed coat, which is impermeable to water and oxygen. Healthy seeds can remain dormant for more than two months after exposure to all the favourable conditions required for germination [10]. Dormancy can hinder embryonic growth [11-12]. Dormancy induction is linked to the relative concentration of abscisic acid in the seeds [13]. However, it is necessary to break dormancy through applied treatments and to induce germination easily. Seed scarification and chemical techniques have been used to accelerate the germination of certain palm seeds [9]. However, Boonyawat [14] observed that longer periods of acid exposure produce a negative effect on germination, which may be due to toxicity. Recalcitrant seed dormancy can have physical and chemical components that vary from species to species [15]. Three treatment methods can be used to break seed dormancy: mechanical, physical and chemical methods [16]. According to Salisu [17], *Raphia sudanica* and *Phoenix reclinata* seeds are mechanically dormant due to the hard seed coat. After soaking for 2 to 8 days, the author obtained a germination rate between 2.5% and 4.5% with *Phoenix reclinata*. The action of concentrated sulphuric acid was negligible on the germination of the two savannah species. The germination rate of the species of interest using the physical method and sulphuric acid remains an interesting avenue for optimising germination. It is within this framework that this work was initiated to improve the germination of *Raphia sudanica* and *Phœnix reclinata*, which are hygrophilous species of the Guinean savannah.

2. Materials and methods

2.1 Experimental site

The fruits of *Raphia sudanica* and the seeds of *Phœnix reclinata* were collected in April 2018 in the Lamto Scientific Nature Reserve, located in central Côte d'Ivoire. Germination tests were carried out on a plot at the University NANGUI ABROGOUA experimental station in the city of Abidjan (southern Côte d'Ivoire. An area was weeded and a shade canopy was installed using bamboo and palms. The

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fruits of *Raphia sudanica* (Fig 1(a)) were harvested from living plants. Seeds of *Phœnix reclinata* (Fig. 1(b)) were collected from the ground as no fruit was found on living plants at this time of year.

2.2 Seed treatments

2.2.1 Controls

The control batch of *Raphia sudanica* consisted of 45 seeds with their pericarps removed. The *Phœnix reclinata* control consists of 45 seeds. These different seeds were not treated in any way.

2.2.2 Soaking in tap water

The seeds of both species were immersed in tap water contained in a plastic bowl for 24 hours, to separate the bad seeds, which floated, from the good seeds, which settled to the bottom of the water [18].

2.2.3 Scarification and soaking in tap water

The 45 seeds of each of the two species were scarified using worm paper before being immersed in tap water contained in a plastic basin for 24 hours.

2.2.4 Soaking in boiling water

The 45 seeds of each of the two species were immersed in boiling water removed immediately from the heat source and left to cool slowly for 24 hours.

2.2.5 Soaking in tap water and immersion in Tetraoxosulphate (IV) acid

After soaking for 24 hours, 45 seeds of each species were immersed in pure Tetraoxosulphate (IV)_acid (95-98%) in a plastic bottle for 5 minutes. They were then removed from the acid and washed promptly with water for 5 minutes.

2.3 Creation of the nursery

After the seeds had been treated, they were sown in nursery bags filled with potting soil at a depth of 10 cm *for Raphia sudanica* and 5 cm for *Phoenix reclinata* to give better coverage for each seed. This difference in depth is due to the size of the seeds. Phoenix reclinata seeds are 1 cm long and 0.5 cm wide. The seeds of *Raphia sudanica* are 8-9 cm long and 3-4 cm wide. This potting soil was taken from soil covered with vegetation consisting mainly of *Pueraria phaseolides* (Rosb.) and *Panicum maximum* (Jacq.) on the edge of the forest relict at Nangui Abrogoua University. These bags were arranged in linear blocks by treatment under a shade house. The shade house was constructed from bamboo and palm leaves. Each block represented a replication and bore a label indicating the nature of the treatment applied. For each species, 45 seeds x 4 treatments plus a control lot were sown, giving a total of 225 seeds per species and 450 bags under the shade.

2.4 Monitoring germination and measuring parameters

The seedlings were regularly watered every two days, using a watering can with a capacity of 16 litres of water. Two watering cans were used for a block of 45 bags. The shaded environment was characterised by an average temperature of 26 ± 2°C and a relative humidity of 87%. The experiment was conducted for 120 days. Weeds in the bags were regularly removed by hand.

2.5 Agronomic parameters assessed

2.5.1 Germination rate (TG)

According to Come [19], this represents the percentage of seeds capable of germinating under the experimental conditions (temperature, time, duration). It is expressed as the ratio of the number of germinated seeds to the total number of seeds sown multiplied by 100. The number of germinated seeds was determined after 120 days. A calculation was then made:

$TG =$ (Number of seeds germinated X 100) / Total number of seeds sown.

2.5.2 Germination time (DG)

Germination time is the time interval between the day of sowing and the date of germination of the first seed [20]. In the case of this work, it is the minimum time required to obtain the first germination. This time was determined by species and by treatment.

2.5.3 Mean germination time (MGT)

Germination speed can be expressed in terms of mean germination time. It is the time required to obtain 50% of germinated seeds under perfectly controlled conditions. In the study, the average time it took to obtain half the germinated seeds after 120. This time was calculated according to Kotowski [21] using the following formula:

TMG=1/CV X100 CV=(∑n)/(∑(n.jn)) x 100

n: Number of germinated seeds; Dn: Number of days of observation; CV: velocity coefficient.

2.6 Statistical analysis

To process the results, the Kruskal-Wallis test was applied using R software version 3.5.1 to compare the means between the different treatments and the

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Table 1. Effect of treatments on germination rate

Agronimic parameter	Treatments					Statistical		Species
	Control	H_2O rob	H_2O b	H_2SO_4	SCF	F	P	
Germination rate (%)	44,44 ^{a}	8,89 ^{b}	0 ^{c}	15,56 ^{b}	6,67 ^{b}	14,201	0,0026	*Raphia sudanica*
	88,89 ^{a}	88,80^a	0 ^{c}	0 ^{c}	8,89 ^{b}	6,591	0,037	*Phoenix reclinata*

H2O rob: tap water; H2O b: boiling water; H2SO4: Tetraoxosulphate (IV) acid; SCF: scarification

Table 2. Effect of treatments on germination time

Agronomic parameter	Treatments					Statistical		Species
	Control	H_2O rob	H_2Ob	H_2SO_4	SCF	F	P	
Germination time (days)	45^b	74^a	0^d	38^c	38^c	12,781	0,0051	*Raphia sudanica*
	45^a	39^b	0^c	0^c	45^a	4,846	0 ,027	*Phoenix reclinata*

H_2O rob: tap water; H_2O b: boiling water; H_2SO_4: Tetraoxosulphate (IV) acid; SCF: scarification

Table 3. Effect of treatments on average germination time

Agronomic parameter	Treatments					Statistical		Species
	Control	H_2O rob	H_2O b	H_2SO_4	SCF	F	P	
Average germination time (days)	91,59^a	90^a	0^c	60^b	60^b	11,551	0,009	*Raphia sudanica*
	84,4^b	81,5^c	0^d	0^d	85,0^a	0,004	0,004	*Phoenix reclinata*

H_2O rob: tap water; H_2Ob: boiling water; H_2SO_4: Tetraoxosulphate (IV) acid; SCF: scarification

control batch. For each agronomic parameter, the probability obtained was compared with the theoretical threshold $\alpha = 0.05$.

3. Results

3.1 Germination rate of seeds

The best germination rate was obtained with the control batch; 44.44% for *Raphia sudanica* seeds and 88.89% for *Phoenix reclinata* seeds (Table 1). For seeds treated with tetraoxosulphate (IV) acid, the germination rate obtained was 15.56% for *Raphia sudanica*, while none of the *Phoenix reclinata* seeds germinated. On the other hand, soaking the *Phoenix reclinata* seeds resulted in 88.80% germination and 8.89% for *Raphia sudanica*. After scarification, the germination rate obtained was 6.67% for *Raphia sudanica* and 8.89% for *Phoenix reclinata* (Table 1). For the two species studied, no germination was obtained when the seeds were placed in boiling water.

3.2 Germination time of seeds

The effect of the treatments on germination time (Table 2) shows that *Raphia sudanica* seeds scarified and placed in tetraoxosulphate (IV) acid germinated sooner (38 days) than (74 days) and (45 days) respectively. *Phoenix reclinata* seeds soaked in water for 24 hours germinated sooner (39 days) than (45 days) for the control or scarified seeds. For the two species studied, the germination time was zero for seeds soaked in boiling water (Table 2).

3.3 Average seed germination time

The average time for obtaining half of the germinated seeds after 120 days was better for the batches of scarified seeds and seeds soaked in tetraoxosulphate (IV) acid (Table 3) with 60 days, as opposed to the control, which was 91.59 days for *Raphia sudanica*. As for *Phoenix reclinata*, the best average germination time was 81.5 days for the batch of soaked seeds compared with 84.4 days (Table 3). For the two species studied, the average germination time was zero with the seeds soaked in boiling water (Table 3).

4. Discussion

The treatments applied in this study did not yield a satisfactory result. In fact, the control batches gave the best germination rates compared to the treatments applied to *Raphia sudanica* and *Phoenix reclinata* seeds. There are several possible reasons for the poor germination results obtained with these treatments applied to *Raphia sudanica* and *Phoenix reclinata* seeds. For this study, the fruits of *Raphia sudanica* were harvested from living plants and collected from the ground. *Phœnix reclinata* seeds were collected from the ground under living plants. From the ground as no fruit was found on living plants. In the case of harvested seeds, the low germination rate after the

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treatments were applied could be linked to the high concentration of abscisic acid. The seeds are still breasted but embryonic emergence is inhibited. This has been supported by Hilhorst & Karssen [13] who maintain that dormancy induction is linked to the relative concentration of abscisic acid in the seeds. As a result, dormancy time can oppose embryonic growth [11-12]. The time the seed spends on the ground could have an effect on the seed coat by softening it. Thus, the treatments applied may have had a negative impact on germination capacity. As for the scarification of the seeds, the low germination rate obtained could be due to the exposure of the seeds to parasitic attacks and telluric insects. Scarification, which exposes the embryo and cotyledons, which are full of water and protein, can lead to rotting and parasitic attack, which considerably reduces the germination rate. Contrary to the work of Ahaton et al. [22], the scarification and scalding of seeds of *Prosopis africana* gave very high germination rates.

The lack of germination with boiling water could be due to the death of the embryo caused by the high temperature. Similar results were obtained for *Pterocarpus erinaceus* [23].

The effect of tetraoxosulphate (IV) acid reduced the duration of germination, while the germination rate remained low. This clearly illustrates that sulphuric acid acted on the seed coat and even on the embryo. According to Ahaton [22], treating seeds with concentrated tetraoxosulphate (IV) acid is detrimental to embryo survival. Dewir, [16] showed that tetraoxosulphate (IV) acid softens the seed coat. As a result, the seed could be exposed to parasitic attacks and telluric insects. In addition, the high concentration of tetraoxosulphate (IV) acid must have reduced the germination capacity of *Raphia sudanica* and *Phoenix reclinata* seeds. Indeed, Salisu [17] maintains that the action of high concentrations of tetraoxosulphate (IV) acid reduces germination capacity. Boonyawat [14] observed that longer periods of acid exposure produce a negative effect on germination, which may be due to toxicity.

5. Conclusions

At the end of this study, it emerged that the best germination rate was observed with the control batches of each of the two species. The treatments reduced the average germination time. Tetraoxosulphate (IV) reduced the germination time to (38 days) for Raphia sudanica seeds compared with (45 days) for the control. However, the germination rate was low (15.56%) compared with the control germination rate (44.44%). Soaking in tap water for 24 hours resulted in a germination rate (88.80%) in (39 days) compared with (45 days) for the control seeds.

Authors' contributions

Developed the research protocol, collected the data and wrote this article, L.M.K.; Helped to analyse the data, added literature to consolidate the discussion, N.S. and D.N.O.; Supervised and improved this article, F.N.G.K. and A.B.

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Availability of data and materials

All data will be made available on request according to the journal policy

Conflicts of interest

The authors declare no conflict of interest

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