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Characterization and Evaluation of the Germination Capacity of Mango Nuts *Mangifera indica* L. on Different Ligneous Substrates in Casamance, Senegal

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Abstract: ***In Casamance, the mango (Mangifera indica L) sector is facing several difficulties such as fruit flies and the aging of plantations. As a result, it is urgent to undertake studies in order to propose solutions to these constraints. Then the study aim to findout the most suitable varieties for a rapid reconstitution of aging mango orchards in Casamance. This was done through an evaluation of the germinative capacity of different mango nut varieties. To do this, a split plot device with two factors (factor variety and factor substrate) was installed. Thus, the characteristics of the nuts of the different varieties (Pince, Kouloubadaseky, Sierra léone, Diourou and Papaye) were evaluated. The latter were then sown in sheaths filled with different substrates (cashew potting soil, cauliflower potting soil and mango potting soil). The results shown greatest width (46.25 ± 5.82 mm) and weight (38.8±7.79 g) of the nuts were recorded by Diourou variety. The largest average nut length and thickness were recorded with the Papaye variety with 99.9±8.53 mm and 23.34±3.55mm respectively. The average germination rate of the seeds was 65.34% and their latency period varied from 8 to 13 days after sowing. The varieties that recorded the earliest germination peaks were Diourou (32nd JAS) and Kouloubadaseky (37th JAS). The highest germination rate (77.08%) was obtained by Diourou and the lowest rate was obtained with the Pince (52.5%). These results thus constitute an essential contribution to the development of a useful database for the rapid regeneration of orchards in Casamance.***

Keywords: *Mangifera indica*; Varieties; Substrates; Germination capacity, Casamance

1. Introduction

Originating from the Indo - Burma region, mango trees later diversified into two other areas of Southeast Asia namely the area, northwestern India and the area grouping Burma, Thailand, Indonesia and southern Indochina peninsula. These two areas have yielded the monoembryonic and polyembryonic varieties respectively (COLEACP, 2013). Globally, mango production is estimated at 43.9 million tons in 2003 (Gerbaud, 2015) behind banana, apple, grape, and citrus crops (FAOSTAT, 2015). In 2014, it increased to more than 45 million tons (FAO, 2017a) becoming the 7th most produced fruit in the world and representing 23% of the world's tropical fruit production (FAO, 2017b). However, in Casamance, the mango sector is facing several difficulties such as: the inorganization of producers, the proliferation of fruit flies (Ndiaye et al., 2015) and the aging of orchards (Diatta et al., 2018; Niabaly et al, 2018).

It is therefore urgent to develop strategies for the rapid reconstitution of these orchards. These strategies necessarily involve the rapid production of mango seedlings by sowing and grafting (Mouhammed, 1984). Indeed, the sowing carried out starting from the seeds which are harvested and preserved. The germination of the latter results in the formation of new plants (Dedhiou et al., 2015). However, this germination of mango seeds is highly variable depending on the varieties and substrates. Determining the germination capacity of seeds, which is an important characteristic for plant production (Dedhiou et al., 2015), thus appears to be an imperative necessity in any planting project. It is in this perspective that the present study has set as its objective to contribute to the rapid reconstitution of orchards in Lower Casamance. This was done through a determination of the germination capacity of seeds of different varieties of Mangifera indica.

2. Materials and Methods

2.1 Presentation of the studied area

This study was carried out in the commune of Ziguinchor, at the application farm of the Department of Agroforestry of the University Assane SECK. This farm is located at 12°32' 54"88 North latitude and 16°16' 40"89 West longitude (Figure 1). The area is characterized by a coastal South Sudanese type climate characterized by the existence of a dry season and a rainy season (Sagna, 2005). The average annual rainfall over the 1980 - 2018 series is 1302.04mm (Coly et al., 2020). The monthly minimum and maximum temperature values are 21.5°C and 35°C respectively during the 1990 - 2016 series (Sagna, 2005). The soil types belong to the continental shelf lands. There are two types of soils: leached tropical ferruginous soils and low to medium desaturated ferralitic soils (Charreau and Fauck, 1967; CSE, 2008).

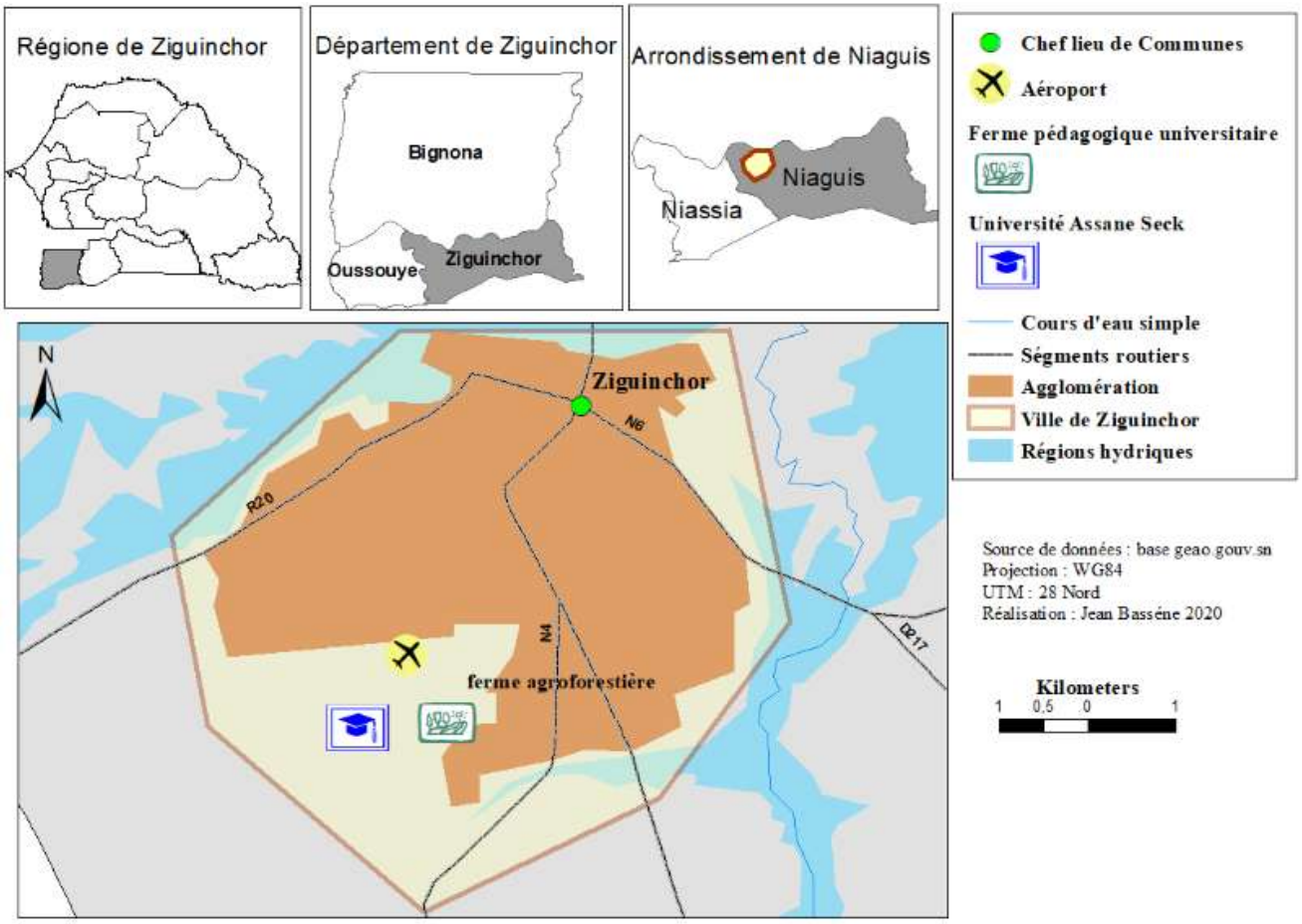


Figure 1: Localisation of the Farm of the department of Agroforestry (Base geo. gouv. sn)

Plant materials

Mango nuts collected in the locality of Mlomp in the department of Oussouye were used. The selected varieties are commonly called Siéra Leone (Sl), Diourou (Di), Pince (Pc), Kouloubadaseky (kL), and Papaye (Py).

Substrates used

The substrates used were forest soils of *Mangifera indica* L., *Anacardium occidentale* L. and *Khaya senegalensis* (Desr.) A. Juss. These substrates were collected under the crowns of the above species, sieved and placed in sheaths.

Experimental design setup

The setup used in this study is a split plot with two factors (variety factor and substrate factor). The substrate factor is declined in 3 modalities: chalky soil (Ca), mango soil (Mg) and cashew soil (An). And five (5) modalities are defined for the variety factor: Pince (Pc), Kouloubadaséky (Kl), Siera leone (Sl), Diourou (Di) and Papaye (Py), i. e.15 treatments in one block. Blocks are 15.25 m long and 1 m wide, covering an area of 15.25 m². Each block is divided into 3 sub - blocks (large plots) corresponding to the 3 types of substrates. On each substrate type, the five *Mangifera indica* varieties were randomized. The large plots are each 4.75 m long and 1 m wide and are separated by 50 cm. The small plots correspond to the factor « Variety » and the large plots to the factor « Substrate ». Each elementary plot (small plots of 0.75m²), contains 20 sheaths arranged in 4 rows of 5. These small plots are separated from each other by 25cm (**Figure 2**).

The system is made up of 4 blocks spaced 1.10 m apart. Each

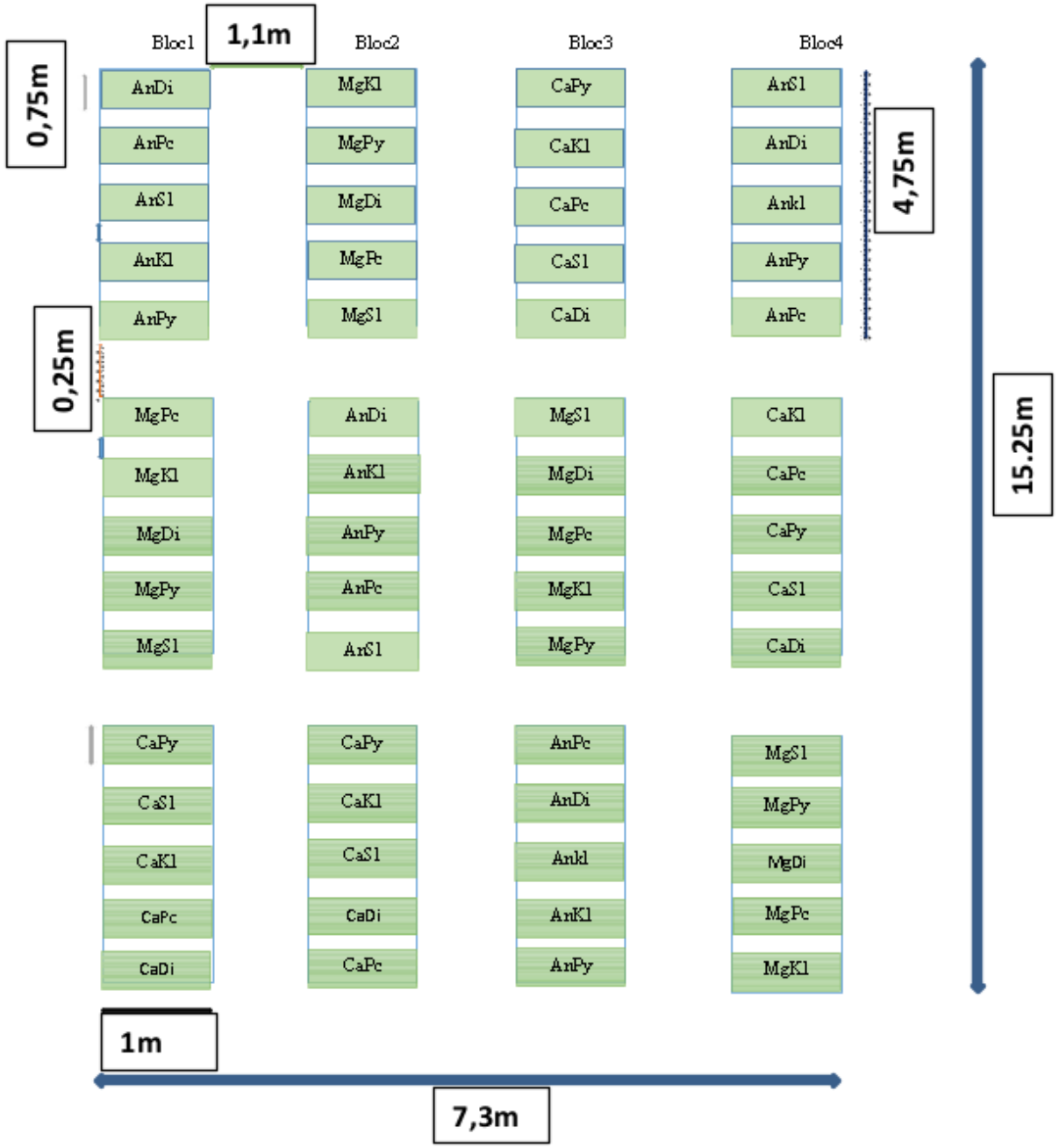


Figure 2: Experimental design

Conduct of the trial

For the installation of the experimental set - up, clearing work was carried out in order to lay out the land. Shovels and rakes were used to clear the land and the experimental set - up was then delineated using metric tapes and string. Mango, cashew and cashew potting soils were collected with shovels and then sieved with onion bags to remove all impurities. These well - sieved potting soils were then used for potting the sheaths. These were arranged separately to differentiate each type of soil. The selection of good seeds and their discrimination by variety was then carried out. For the identification of the good nuts, the seeds of the different varieties were immersed in basins and buckets of water (floating test). The floating nuts were recovered and then discarded as being the bad ones. And those at the bottom of the containers were selected, cleaned and spread by variety on rice bags for drying.

The nuts of the different varieties were identified morphologically by the shape of their ribs. Indeed, the nuts of the Diourou and Kouloubadaséky varieties have veins following furrows or canaliculi more pronounced in the former than in the latter. The veins follow slightly hollow to superficial grooves in the nuts of Siéra Léone and Pince. Finally, Papaye nuts are thicker and longer than the others as shown in **Figure 3.**

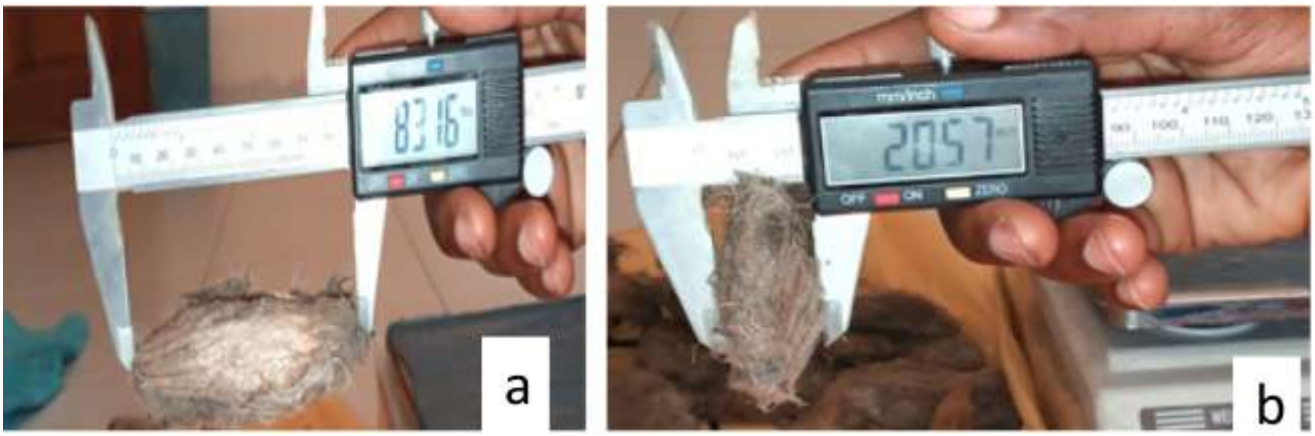
Figure 3: Varity Nuts of Kouloubadaseky (a), Diourou (b), Siera Leone (c), Pince (d) and Papaye (e)

After selection and measurement of their morphometric parameters, the seeds of each variety were sown in the already potted sheaths of 100% Cashew, 100% Cacao or 100% Mango potting soil. The seeds were sown on June 25, 2020, without pre - treatment. Weeding was done every 15 days

Measurement of the morphometric parameters of the seeds and observation of the germination

Measurement of the morphometric parameters of the seeds

For each variety, a sample of 100 randomly selected nuts was taken. The dimensions (length, width, thickness) of the selected nuts were measured with a caliper and their weight determined with an electronic scale (**Figure 4**).



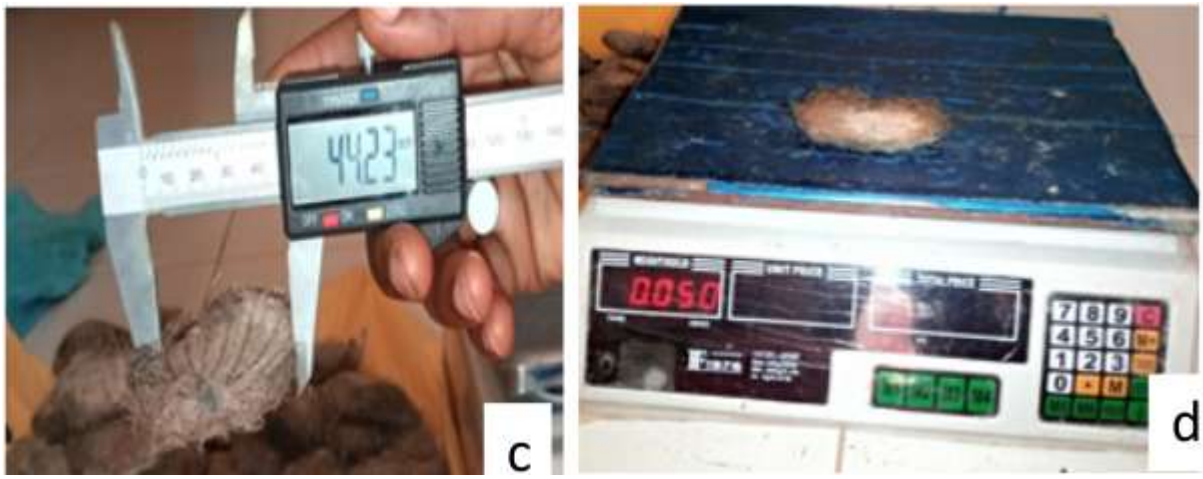


Figure 4: Measures of length (a), thickness (b), width (c) and weighing of the nut (d)

Observation of germination

A seed is considered to have germinated when the cotyledons spread to allow the radicle to emerge. By the eighth day after sowing, the seeds have begun to germinate. A daily count of germinated seeds per treatment was made to determine the germination rate.

The germination rate (GR) is calculated using the following formula:

$$GR = \frac{N_i}{N_t} \times 100$$

With Ni: number of germinated seeds and Nt: total number of seeds put in germination

The Rate of germination (GR) corresponding to the percentage of seeds germinated during the germination process. The Latent Life Span (LLS) of seeds defined as the time after which the first germination of the experimental batch took place was evaluated.

Statistical analysis

The collected data were entered into the Excel spreadsheet which was used to develop tables and figures. Analysis of variance (ANOVA) and multivariate treatment (PCA) were performed using XLSAT software version 2014. Comparison of means was performed using the Newman Keuls test at the 5% significance level.

3. Results

3.1 Morphometric characteristics and weight of mango nuts

The analysis of variance revealed that the factor « variety » induced a very highly significant difference (P=0.0001) on the length of mango nuts (**Figure 5**). Indeed, the nuts of the Papaye variety had the greatest length (99.9 ± 8.53 mm) followed by those of the Diourou (81.98 ± 7.76 mm), Kouloubadasèky (65.08 ± 6.15 mm) and Siera léone (66.81 ± 67.3 mm) varieties. The nuts of the Pince variety was the smallest seed length with 54.56 ± 4.98 mm (Figure 5).

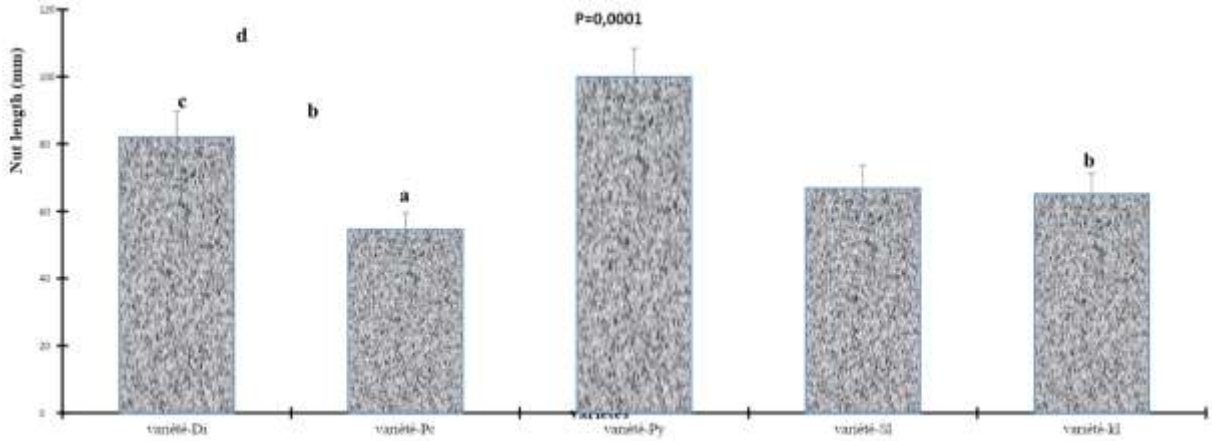


Figure 5: Variation of mango nut length by variety

Considering the width of the mango nuts (**Figure 6**), statistical analysis revealed that its variation was highly significant (p = 0.0001) between the varieties. The largest width was noted in the Diourou variety (46.25 ± 5.82 mm) and the smallest with Pince variety (31.78 ± 2.82 mm).

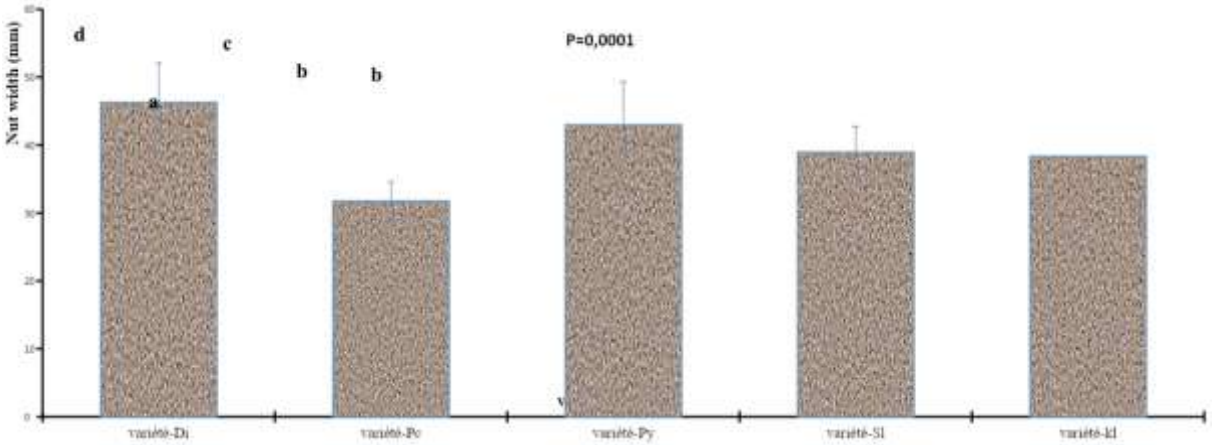


Figure 6: Variation of nut width according to the varieties

The nuts of the Papaye and Diourou varieties with respective thicknesses of 23.34 ± 3.55 mm and 22.86 ± 3.73 mm are significantly thicker (p=0.0001) than those of the other varieties. The lowest nut thickness was recorded with the Pince variety (18.92 ± 2.39 mm). It also appears that there is no significant difference between the thickness of the seeds of Kouloubadasèky and Siera léone varieties and between the thickness of the nuts of the Diourou and Papaye varieties (**Figure 7**).

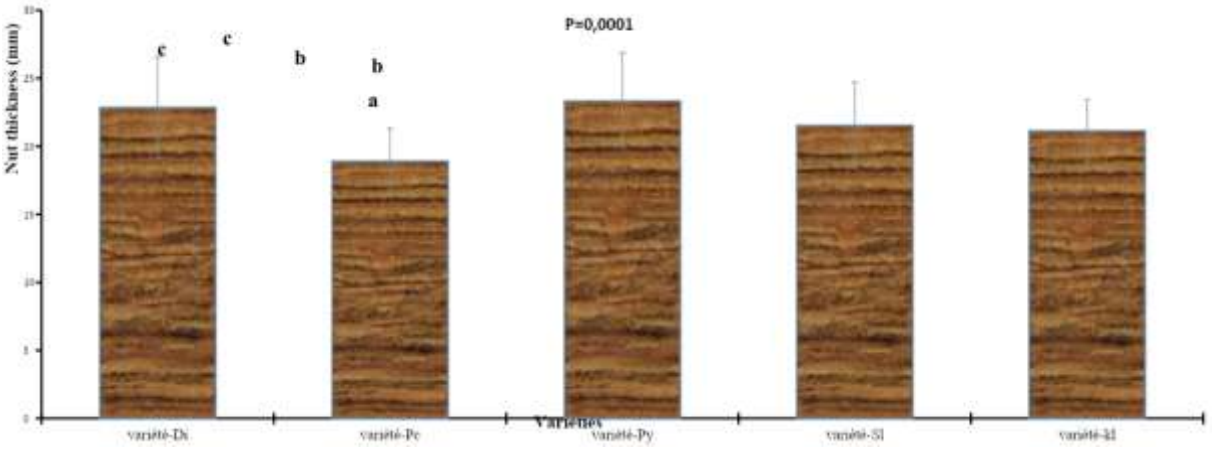


Figure 7: Thickness of the mango nuts

The variety factor induced a very highly significant effect (p=0.0001) on mango seed weight (**Figure 8**). The highest weight was noted in the Diourou variety (38.8 ± 7.79 g). However, no significant difference was noted between the varieties Kouloubadasèky (20.6 ± 5.03 g) and Pince (19.35 ± 4.12 g), which had the lowest weights.

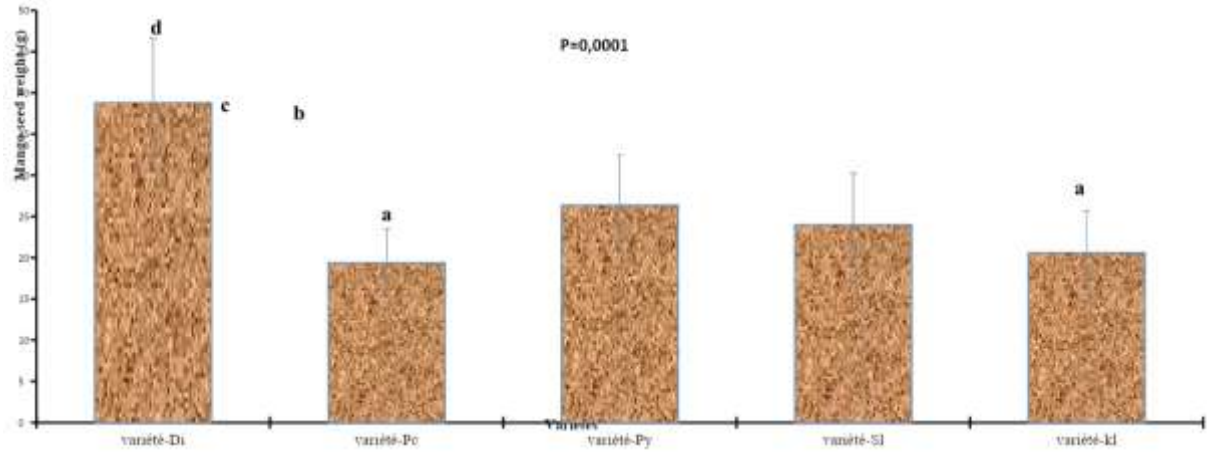


Figure 8: Weight of the mango nuts

Germination of mango seeds

Effect of treatments on seed germination rate of different varieties

There is no significant effect of treatment on the germination rate of mango seeds **as** shown in **Figure 9**. However, the best germination rate (83.75 ± 8.54%) was obtained with the MgDi treatment (Diourou variety on mango potting soil) and the lowest rate (46.25 ± 24.6%) was noted with the AnPc treatment (Pince variety on cashew potting soil).

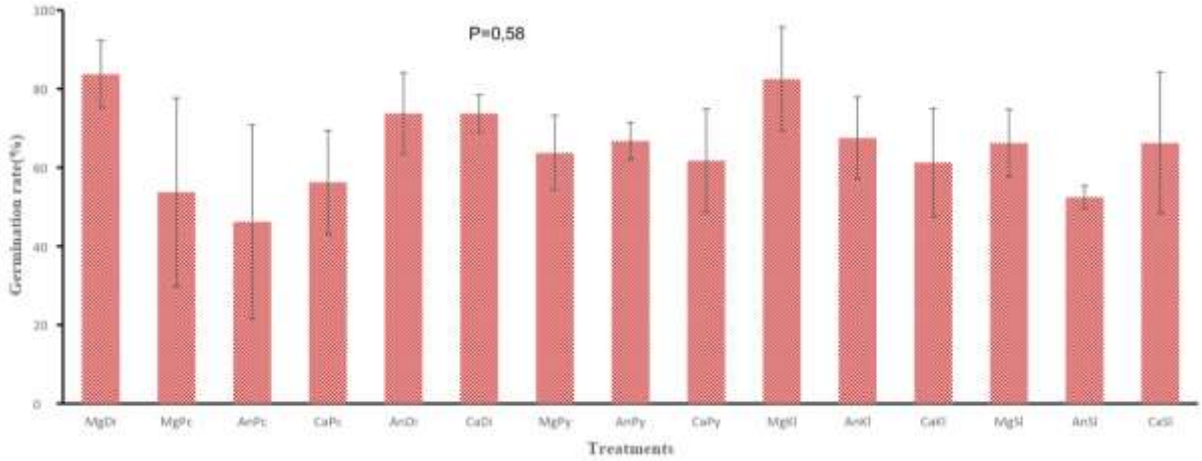
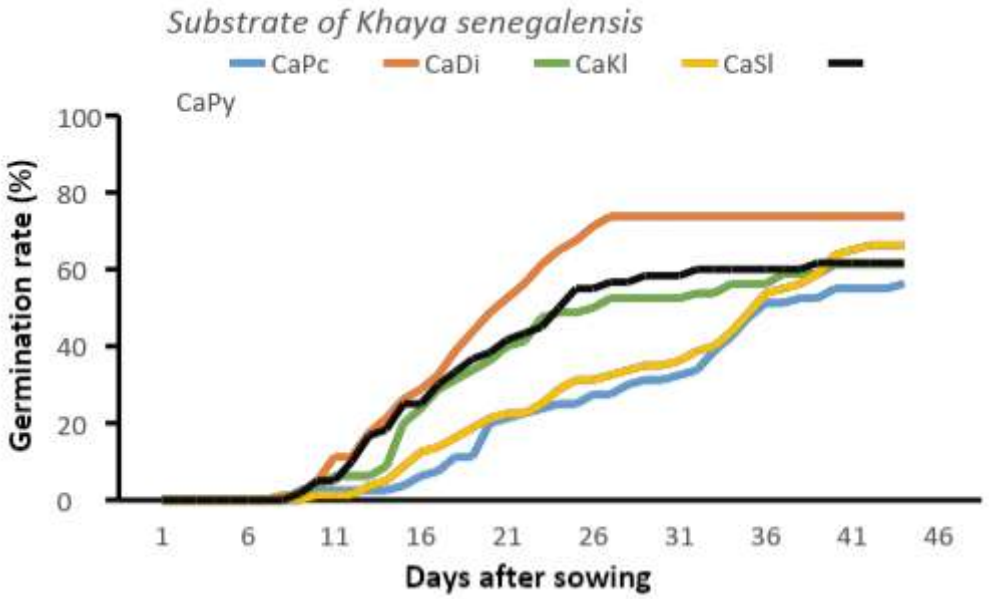


Figure 9: Germination rate in all treatments

Evolution of the germination rate of the mango nuts sowed on the different substrates

Whatever the type of substrate, the Diourou variety recorded the best germination rate (83, 75% on the mango substrate, 73, 75% on the cashew and cailcedrat substrates). And the peaks of germination of this variety were reached respectively at the 38th, 33rd and 27th day after sowing. The lowest germination rate was recorded with the Pince variety regardless of the type of substrate (47.5% on cashew substrate, 53.75% on mango substrate and 56.25% on cailcedrat substrate). For all the varieties, a duration of seed latency varied 7 to 13 days. The Diourou variety had the shortest latency life (7 days) on the cashew and cailcedrat substrates while on the mango substrate the Papaye variety had the shortest latency life (7 days). On cashew and cauliflower substrates, the nuts Papaye had a latency period of 8 and 9 days respectively. Regardless of the type of substrate, the varieties Pince and Siera leone showed a longer latency life (**Figure 10**).



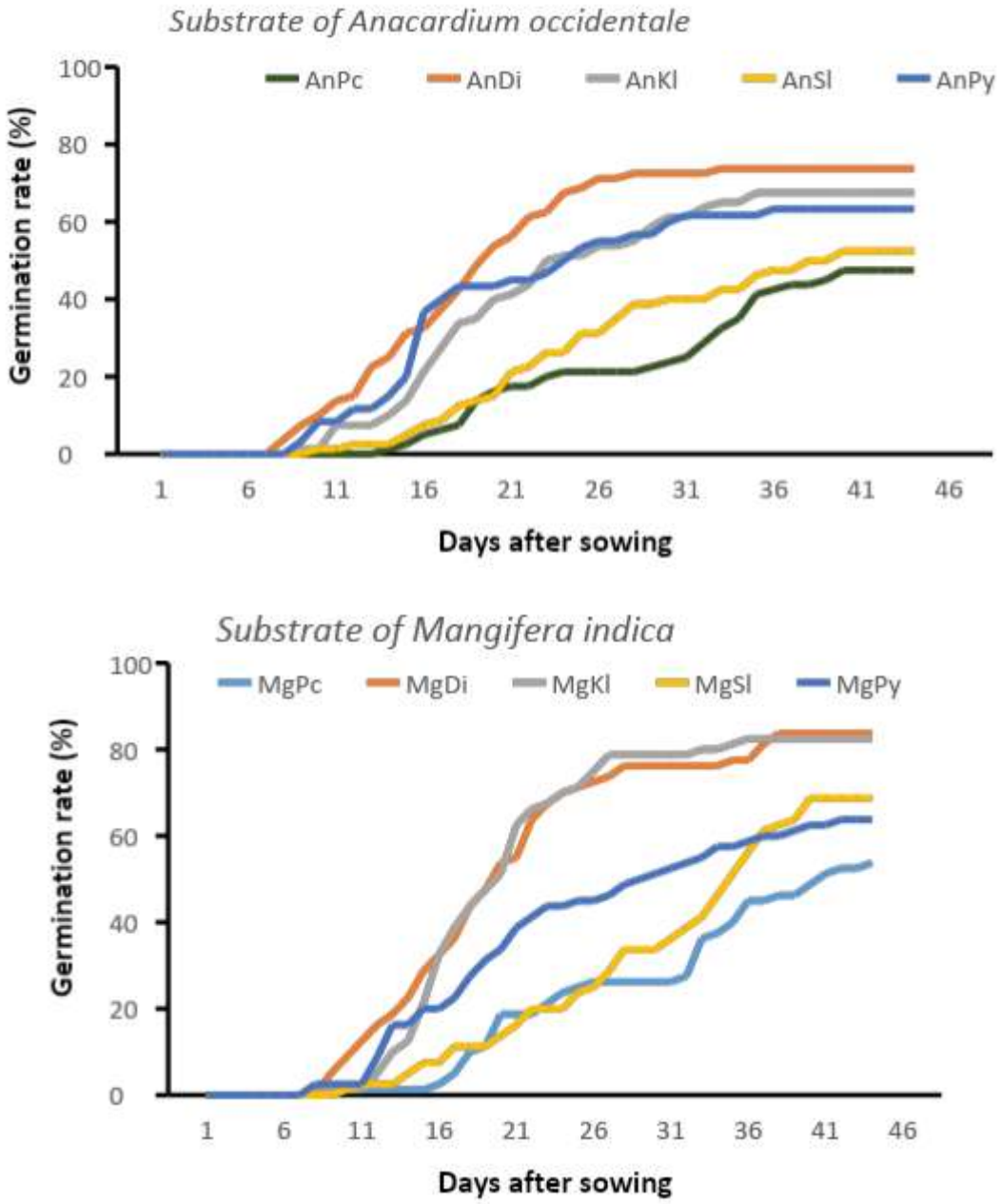


Figure 10: Evolution of daily germination rate of the mango nuts on different substrates

Correlation between the variables assessed and the different varieties

The Principal Component Analysis (PCA) was carried out on the basis of the evaluated parameters and the five mango varieties studied (**Figure 11**). The analysis of the graph obtained shows that the axes F1 and F2 absorb 93.56% of the variability studied, which allows a good graphic representation of the information contained in the matrix.

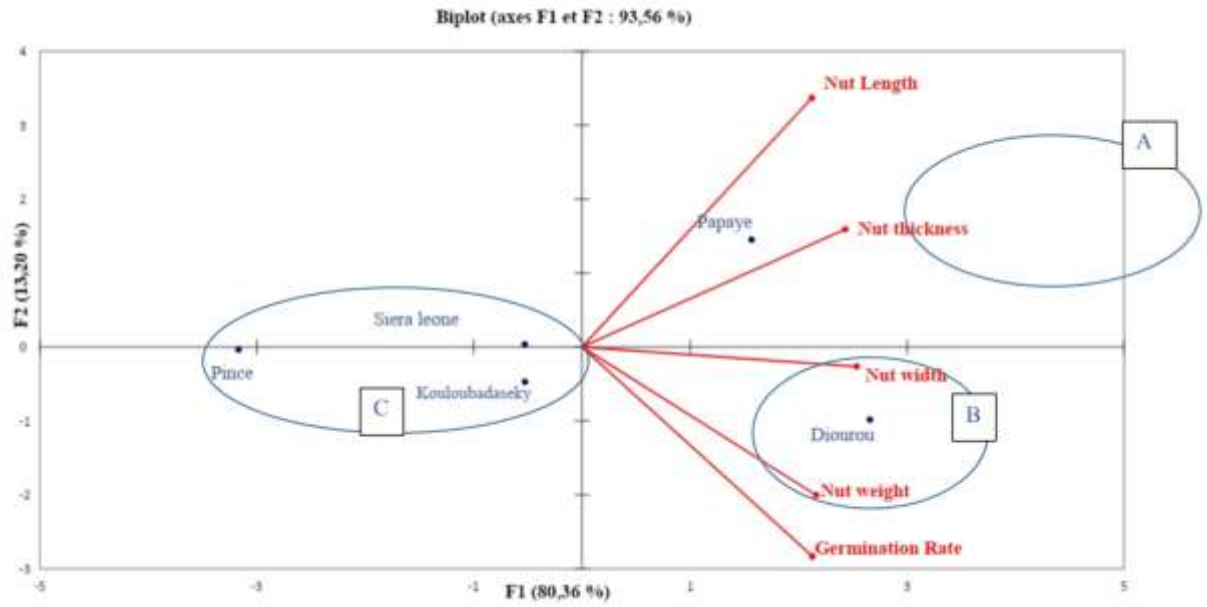


Figure 11: Distribution of mango nut varieties through the evaluated variables

The analysis of this figure has allowed to discriminate three groups of varieties:

- Group A represented by the variety Papaya characterized by long and thick seeds;
- Group B represented by the variety Diourou characterized by broad seeds, with an important nut weight and a high germination rate;
- And the group C represented by the varieties Pince, Siera léone and Kouloubadaseky characterized by a weak width, length, and thickness of its nuts.

4. Discussion

The germination work carried out on *Mangifera indica* showed a latency life varying between 8 and 13 JAS. And that the germination of mango seeds is maximum between the 32nd and 42nd JAS. Indeed, the varieties that recorded the earliest germination peaks were Diourou (32nd JAS) and Kouloubadasèky (37th JAS). While the germination peaks for the varieties Papaya, Pince and Siera léone were respectively reached at the 39th, 41st and 42nd JAS. These results seem to be in line with those of De Laroussilhe (1979) who reported that mango seeds required 6 to 30 days for germination. Furthermore, for our local varieties, nuts could remain in the soil in pots for at least 50 days after sowing before plants appeared (Ndiaye et al., 2020a). Differential germination among the five mango varieties sown was observed. This could be explained by variation in mango nut dormancy between and within varieties. In addition, the highest germination rates were noted with the varieties Diourou (77.08%) and Kouloubadasèky (70.42%) regardless of the substrate. The variety Pince had the lowest germination rate (52.5%) on all substrates and mainly on the substrate of *Anacardium occidentale* with a germination rate of 47.5%. The germination rates recorded with the Diourou and Kouloubadasèky varieties are relatively higher than those obtained by Hamidou et al. (2013) with *Scerocarya birrea (*A. Rich.) Hochst. The latter obtained a germination rate of 68.33%. However, the results obtained by these authors appear higher than those obtained in this study with the Pince variety.

No significant effect of the substrate on the germination rate was observed even if in absolute value the mango potting soil seems to give the best results. These results are in line with those of Normand (2009) according to whom mango can grow on different types of substrates. The *Mangifera indica* substrate could be important because of the inoculation of microorganisms that could act by stimulating or inhibiting the germination process. (Ndiaye et al., 2020b). These results are also similar to those of (Ndiaye et al., 2018a) in southern Senegal. These authors showed that the effect of substrate was not significant on germination and growth of *Moringa oleifera* Lam, *Acacia mellifera* (Vahl) Benth. and *Zizyphus mauritiana* Lam. These results are also in line with those of Hessou et al. (2009) in Benin, who stated that there was no significant difference between the mean germination rate of *Caesalpinia bonduc* (L.) Roxb seeds depending on the substrates and that the germination rate of the seeds was not dependent on the substrate condition. This can be explained by the fact that according to some authors, the substrate is only a support for seed germination. Indeed, according to the research work of Chaussat and Ledeunef, (1975) in Brussels, Montreal quoted by Marouf and Reynaud, (2007), the germination necessarily requires water at the level of the support. This one must be brought to the liquid state. The highest germination rate (83.75%) was noted with the Diourou variety treatment on Mango substrate (MgDi) and the lowest germination rate (47.5%) was noted with the Pince variety on cashew substrate (AnPc). This difference in germination could be mainly related to the variety because the results obtained showed that the substrate has no effect on germination. This corroborates the results of Ndiaye et al. (2018b) in southern Senegal that show that the effect of substrate on germination rate and growth of *Moringa oleifera* lam, *Acacia mellifera* (Vahl) Benth and *Zizyphus mauritiana* lam was not significant.

5. Conclusion

The objective of this study, conducted in the commune of Ziguinchor, was to determine the germination capacity of seeds of different *Mangifera indica* varieties. It established the morphometric characteristics of the nuts of five *Mangifera indica* ecotypes, and evaluated the influence of the type of soil and the variety on the germination of mango seeds. Indeed, the measurements morphometric parameters of the studied nuts showed that, the Papaya variety presented the most important length and thickness of the nuts while the width and the weight of the nuts are more important at the Diourou variety. The latter also recorded the best germination rate on all substrates (77.08%). No significant effect of the substrate on the germination rate was observed even if in absolute value the mango potting soil seems to give the best results. As for the variety, it induces a very significant effect on the germination rate of the seeds. In order to greather more data base for a quick reconstitution of mango orchards, it seems appropriate to evaluate the effect of the type of substrate and the variety on the growth and development of the mango tree stock. The response to grafting of different mango varieties could be evaluated.

6. Acknowledgments

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