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Mangifera indica L. Local Varieties, Substrate, Growth Germination

Germination, Growth and Development of *Mangifera indica* L. Varieties Used as Rootstocks on Different Substrates

Abstract

Mango (*Mangifera indica* L.) is a tree of the family Anacardiaceae, native to southern Asia, widely cultivated in tropical countries for its fruit, the mango. The mango production has achieved worldwide usefulness as a fruit, a medicinal use and a economic importance. Despite the importance of *Mangifera indica* L. Senegal is facing to the loss of the mango productivity and the decline of mango tree diversity. It is therefore important to improve the selection and the genetically improvement of the rootstocks. This study aims to test the germination, growth and development of Mangifera indica L varieties locally known as Diourou, Siera Leone, Pince and Kouloubadaseky on three types of substrates. The substrates used were three potting of forest soil of Anacardium occidentale, *Mangifera indica* and *Khaya senegalensis*. Thus, the nuts of the different varieties were sown in sheaths filled with pure potting forest soil from the different substrates (*Anacardium occidentale*, *Mangifera indica* and *Khaya senegalensis*. A germination test and a follow-up of seedlings on different substrates was carried out in the nursery to determine the effect of substrates on growth parameters. The germination dynamics of the three varieties reveals two peaks the first at the 24th day for Diourou and Kouloubadaseky varieties and another the 34th day for the Siera Leone and Pince varieties on all substrates. And the overall germination rate is 63.22% ± 1.88. The results showed that the number of stems per seed depends on the variety but not on the substrates. The Principal Component Analysis showed significative correlations between parameters such as the number of leaves, the height and the diameter at the crown of the stem. The analysis of variance showed a significant difference (P-value<0.05) between varieties and according to the substrate on the parameters studied. All this information can be basic use for growers when choosing the varieties and type of substrate for mango rootstock production in their nurseries.

INTRODUCTION

The mango tree (*Mangifera indica* L.) is native from North India and South East Asia (Bompard, 1989). In Senegal, mango production was estimated at 123250 tons in 2015 (Ndiaye, 2016). In 2018, Senegal exported 16,100 tons to the European Union (Coleacp, 2019). With the establishment of Agropoles in Senegal, national strategies focus on mango and cashew in Casamance where orchards involved several varieties as shown by Vannière et al. (2004), Vayssières et al. (2011), Ndiaye et al. (2012) and Grechi et al. (2013) in West Africa. However, in Casamance, the mango sector is facing many difficulties such as farmers organization, fruit fly damages (Ndiaye et al., 2015), advanced age of orchards (Niabaly et al., 2018; Diatta et al., 2018, Ndiaye et al., 2020). The Keitt (58%) and Kent (20%) varieties are dominant in front of local varieties such as Diourou, Siera Leone, Kouloubadaseky, and Pince mostly used as rootstocks. Mango trees have average heights of 8.94m in the Blouf with individuals peaking at 17m (Niabaly et al., 2018). Also in most orchards, asymmetric shapes have been observed on mango tree trunks due to graft and rootstock adequacy (Ndiaye et al., 2020). The mango root system included a deep and vigorous pivot system and a large number of fasciculate root systems exploring a large shallow area (Normand, et al., 2009). This study aim to contribute to the generation of data on germination, growth and development of local mango varieties used for rootstocks in the orchards. These varieties are mostly Siera Leone called Tête de chat (Rey et al. 2004), Diourou named after a commune in Casamance, Pince also known as Sewe or Sewal in the Niayes (Ndiaye et al, 2012; Rey et al., 2004) and the Djibelor (Rey et al., 2004) locally called Kouloubadaseky or Sukar (Sane, 2016). Information about the germination, growth and development of these local varieties are limited in Casamance as their behaviors in substrates. The study is specifically focused on the germination and different dendrometric characteristics of the *Mangifera indica* L. varieties used as rootstocks, in order to identify the most vigorous varieties and the most suitable substratum for rootstock production in mango nurseries.

MATERIAL and METHODS

Study area

The study is carried out at the Teaching and Research Farm of Department of Agroforestry Assane Seck University of Ziguinchor, Ziguinchor. The farm is geographically located at 12°32' 57.2"

latitude north and 16°16' 37.3" longitude west. Ziguinchor city is characterized by a southern coastal Sudanian climate (Sagna, 2005) with an annual temperature up to 27.10°C and a rainfall average at 1322.66 mm in a period going from 1984 to 2015.

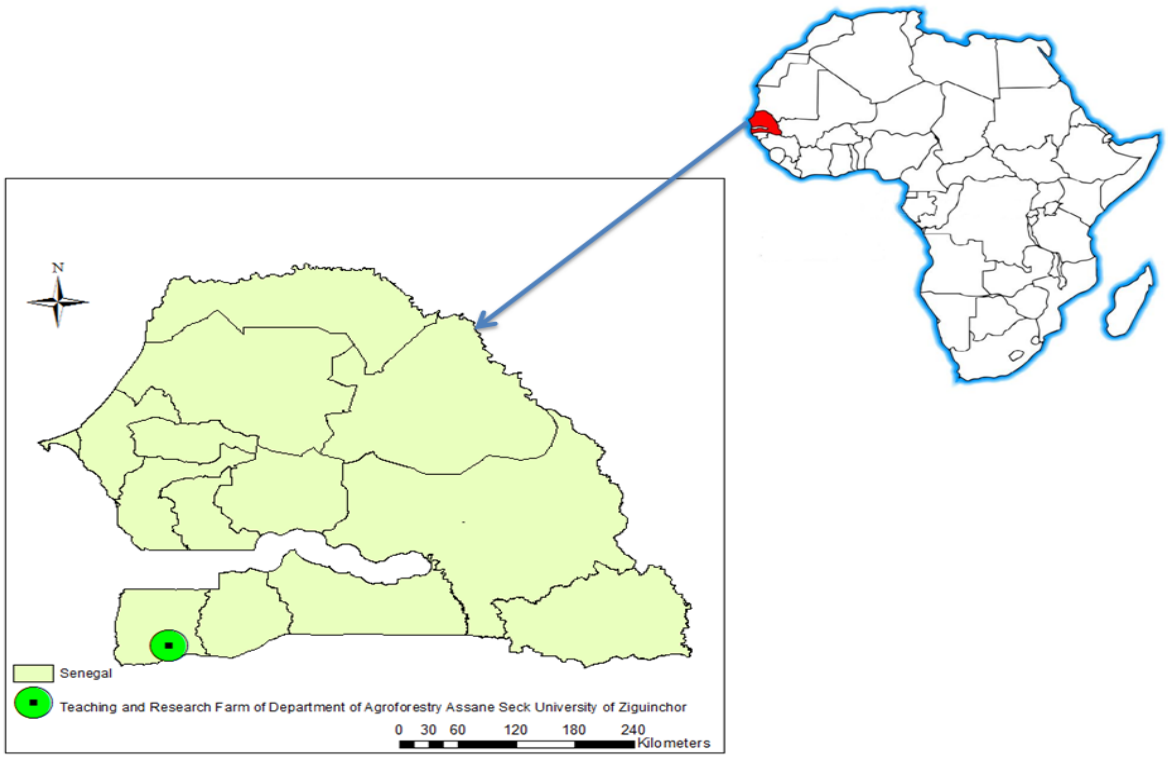


Figure 1. Location of Teaching and Research Farm of Department of Agroforestry Assane Seck University of Ziguinchor, Ziguinchor

Vegetal material

Mango nuts collected from Mlomp locality in Oussouye district were used as vegetal material. These varieties are commonly known as Siera Leone (Si), Diourou (Di), Pince (Pc) and Kouloubadaseky (Kl). The nuts were collected and sieved to remove all t waste before being potted in polyethylene bags. The nuts were immersed in a wheelbarrow filled with water, the floating nuts were removed and those at the bottom of the water were selected for planting. The nuts were sorted after a flotation test with water to determine the good seeds. After determining their dimensions (length and width) using a ruler, these nuts were sown in polyethylene bags of potting soil. In each polyethylene bag, one nut was sown.

Substrate and potting preparation

The substrates used were the forest soil of *Mangifera indica* (Mi), *Anacardium*

occidentale (Ao) and *Khaya senegalensis* (Ks). These forest soils were collected from remnant vegetation area of Assane Seck University of Ziguinchor and potted in polyethylene bags of 24.5 Cm X 15 Cm (Roussel, 1995; Ndiaye et al., 2018).

Experimental design

The experimental designs were carried out in split plot design (Dagnelli, 2012) or nested designs (Krebs, 1999) with four blocks. In each block, four large plots were established for each *Mangifera indica* variety.. Each large plot was divided into three small elementary plots randomized by the substrates including *Anacardium occidentale*, *Khaya senegalensis* and *Mangifera indica*. The small plots were used for the substrate factor and the large plots for the variety factor. Thus the "variety" factor with four modalities (Diourou, Kouloubadaseky, Pince and Siera Leone) was studied. To ensure good watering management, the polyethylene bags in each plot are placed 25cm apart between two successive plots in a block. The large plots are separated by 50cm while the distance between two neighboring blocks is one meter. The number of treatments were 12 repeated in 4 blocks and one elementary plot has 20 potted plants (Figure 2).

Bloc 1	Bloc 2	Bloc 3	Bloc 4
DiAo 111	SiMi 223	PcMi 333	KlKs 442
DiKs 112	SiAo 221	PcAo 331	KlMi 443
DiMi 113	SiKs 222	PcKs 332	KlAo 441
SiAo121	DiMi 213	KlKs 342	DiAo 411
SiKs122	DiAo 211	KlAo 341	DiMi 413
SiMi123	DiKs 212	KlMi 343	DiKs 412
PcAo131	KlAo 241	SiKs 322	PcMi 433
PcKs132	KlMi 243	SiAo 321	PcAo 431
PcMi133	KlKs 242	SiMi 323	PcKs 432
KlAo141	PcAo 231	DiKs 312	SiMi 423
KIKs142	PcKs 232	DiAo 311	SiAo 421
KIMi143	PcMi 233	DiMi 313	SiKs 422

Figure 2. Experimental design

LEGENDS:

Mango Varieties: Siera Leone (**SI) ;** Diourou **(Di) ;** Pince (**Pc)** and Kouloubadaseky (**KI**)

Substrates: Anacardium Occidentale (**Ao**) ; Khaya senegalensis (Ks), Mangifera indica (**Mi**)

Treatments: two factors (substrate and variety) and 12 treatments : SiAo – SiKs – SiMi ; DiAo – DiKs – DiMi ; PcAo – PcKs – PcMi ; KlAo – KIKs – KlMi

Data collection

Mango nuts dimensions (length and width) were measured using a ruler. The observations were also done on the morphology and the shape of the nuts. Emergence of seedlings was recorded daily to determine the germination rate. The total germination rate, the germination rates per species, substrate and treatment were calculated. Growth parameters like number of leaves and stems, diameter and height were assessed.

Data treatment and analysis

The seeds were categorized by diameter class, determined by Sturge's formula:

$h = 1 + 3\log(n)$

and amplitude of the classes by the formula :$a = {Xmax - Xmin}/{h}$

Xmax: maximum diameter ; Xmin: minimum diameter ; h: number of diameter classes ; n: total number of nuts in the sample. Data such as germination rate, number of leaves, height, diameter and number stems were collected and settled into data base tables using Ms Excel. The collected data were processed with XLSTAT software. ANOVAs were used to compare the means of the variables by the Fisher test (multiple comparison tests) at the 5% level. Principal Component Analysis (PCA) was performed to find out the relationship between the different parameters such as the germination rate, the number of stems per nut, the number of leaves, the height and the diameter of seedlings.

RESULTS

Nut morphology and size

The nuts were morphologically different with enervation shapes. The Diourou and Kouloubadaseky nuts have veins following furrows that are more pronounced compared to the other varieties. The veins follow slightly hollow to superficial grooves in the Serra Leone and Pince nuts (Figure 3). The size of the nuts was significantly different ($p \leq 0.05$) between the varieties. Nuts of Kouloubadaseky were significantly larger and wider (78.14±0.88 and 43.03±0.47) than Diourou (76.18±1.05 and 39.99±0.71), Siera Leone (66.08±1.48 and 38.7±0.95) and Pince (55.87±1.31 and 31.38±0.61)56; 31). In addition, the width and the length were proportional (Figure 4).

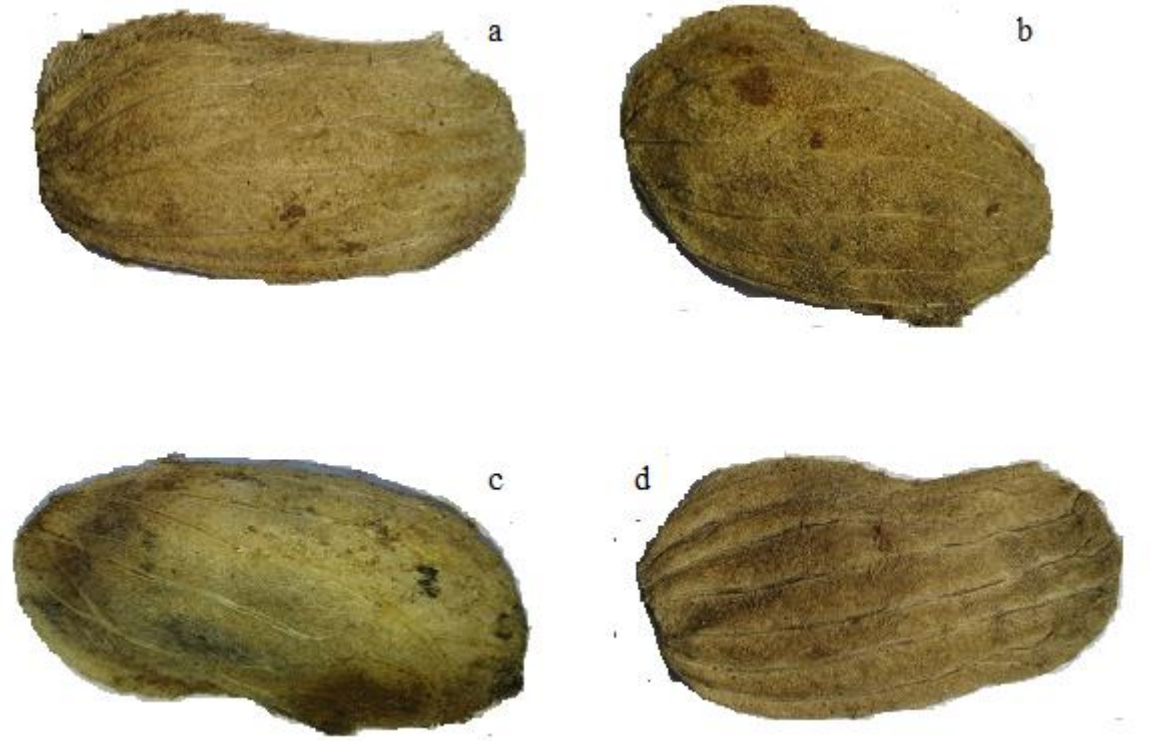
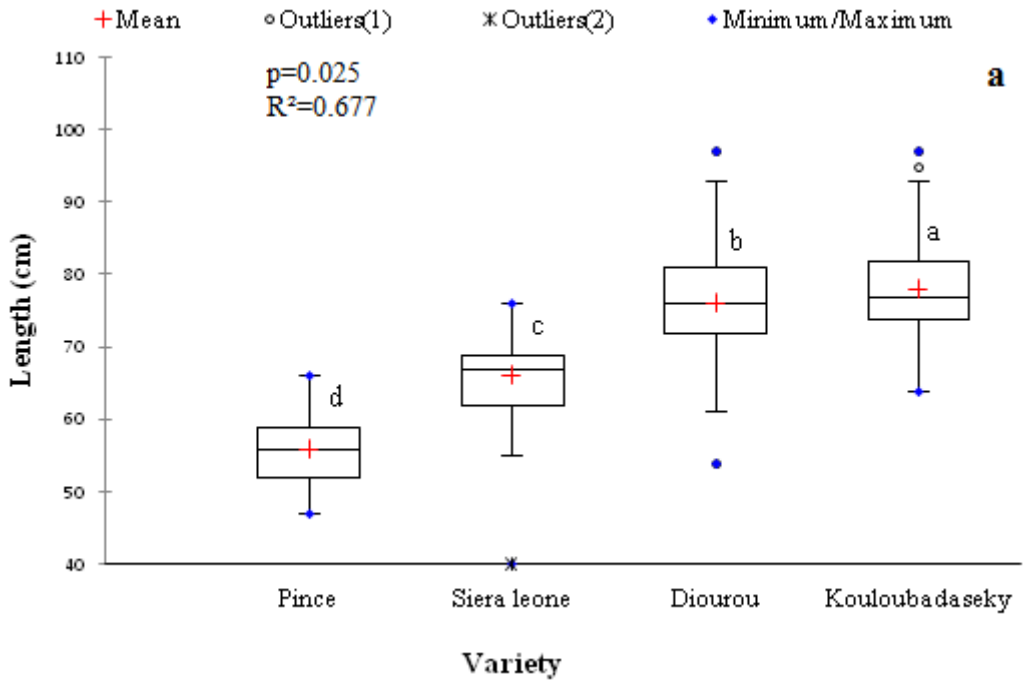


Figure 3. Morphology and shape of nuts: Kouloubadaseky (a), Pince (b), Siera Leone (c) and Diourou (d)



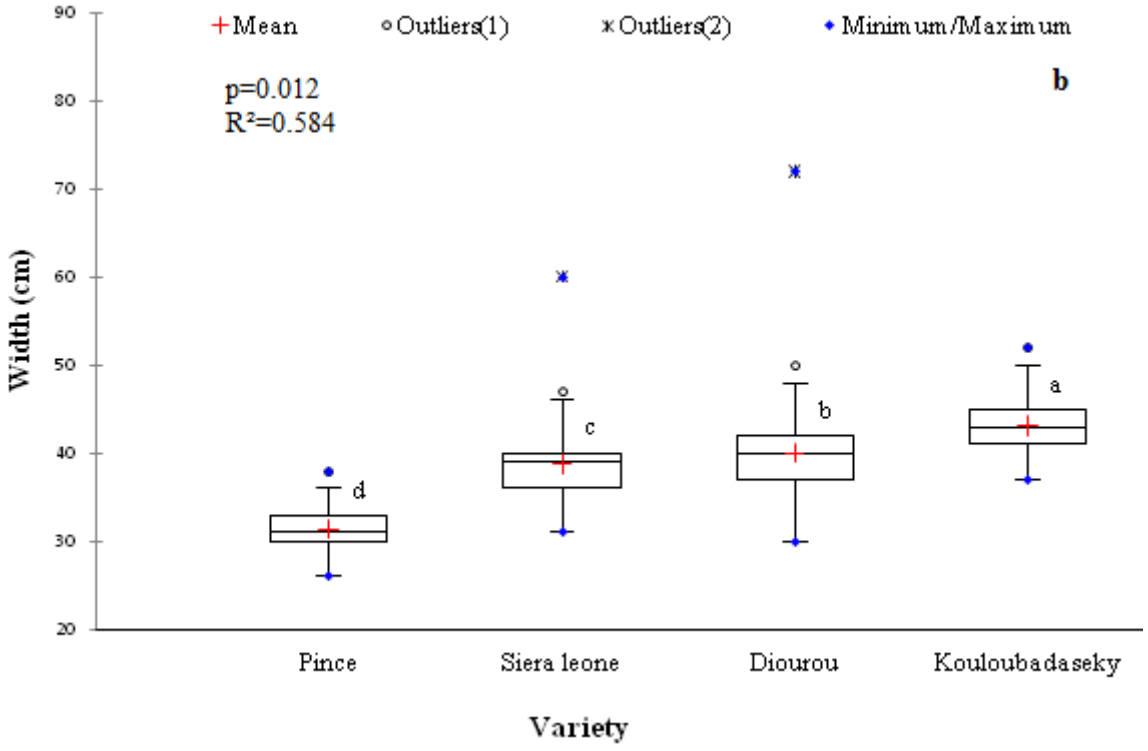
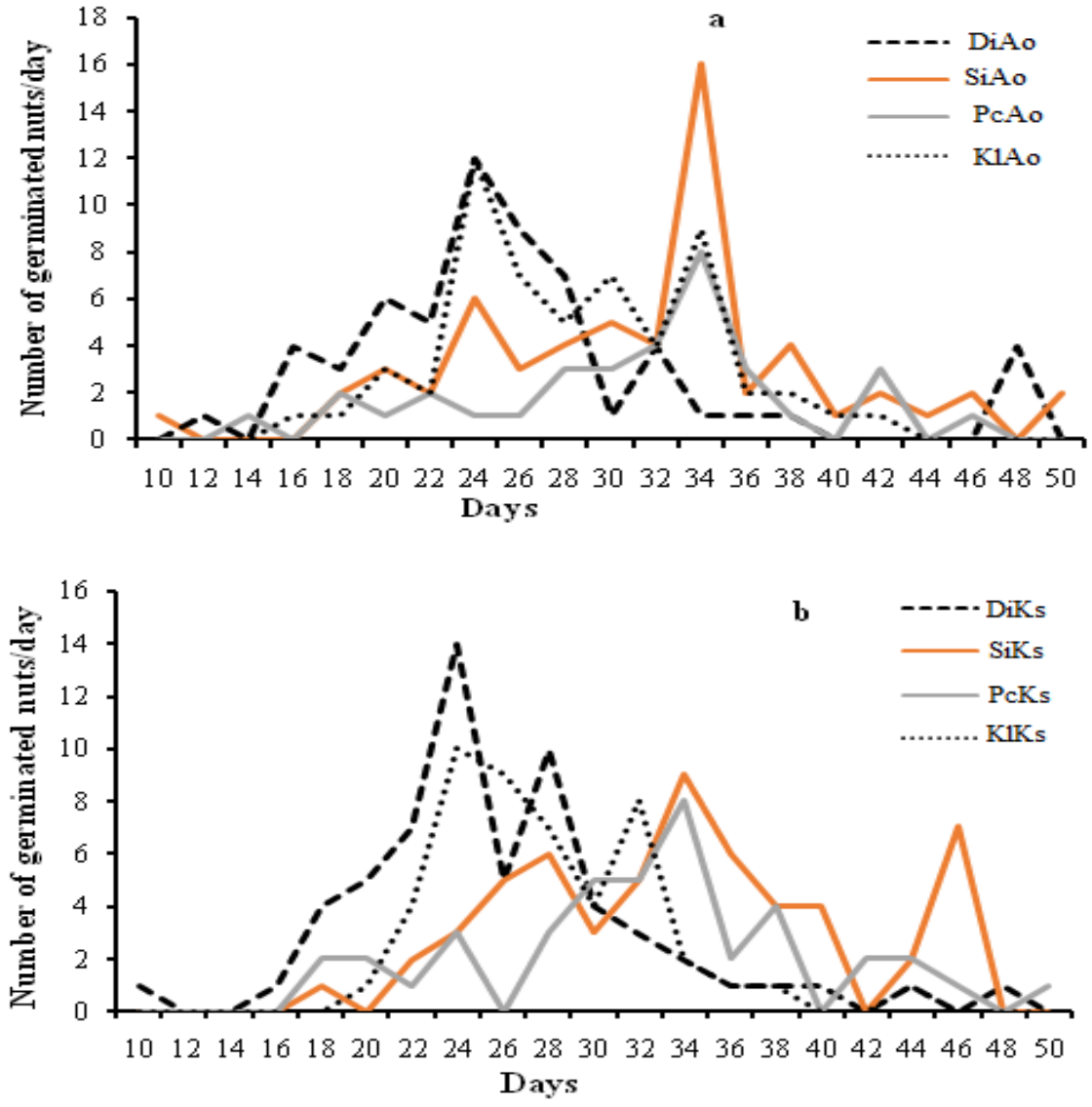


Figure 4. Nut length (a) and width (b)

GERMINATION

The evolution of nut germination per day regarding all varieties on different substrates (Figure 5) showed different patterns of daily germination. In *Anacardium occidentale* substrate, the higher number (peak) of germination were recorded at the 24thday for Diourou and Kouloubadaseky and at 34th day for Siera Leone and Pince. The amplitude of the peak was different from one variety to another. The most important peak was for Siera Leone (Figure 5a). The same trend of nuts germination dynamic was observed on *Khaya senegalensis* and *Mangifera indica* substrates. The earlier peaks were the highest (Figure 5b). The germination peak of Diourou nuts was at least 2 times more important than the peaks of the other varieties (Figure 5c). Germination rate of *Mangifera indica* nuts was not significantly different ($p>0.05$) between the substrates. The overall germination rate mean was 63.22% ±9. However, the germination rate was significantly different ($p=0.03$) between the varieties. Diourou and Siera Leone were the varieties that showed the best germination rates while Pince variety had the lowest germination rate (Table 1).The germination rate of the seedlings

varied from one treatment to another (p=0.042). Diourou nuts recorded the best germination rate among the four varieties tested, especially when sown in *Mangifera indica* substrate (81.2% ±5.7) . On the other hand, the Pince sown on *Mangifera indica* *substrate* (PcMi) had the lowest germination rate (35% ±1.58). More variability appeared when Kouloubadaseky nuts were sown on Khaya senegalensis substrate. But the germination rate of Pince nuts was lower in all substrates (Figure 6).



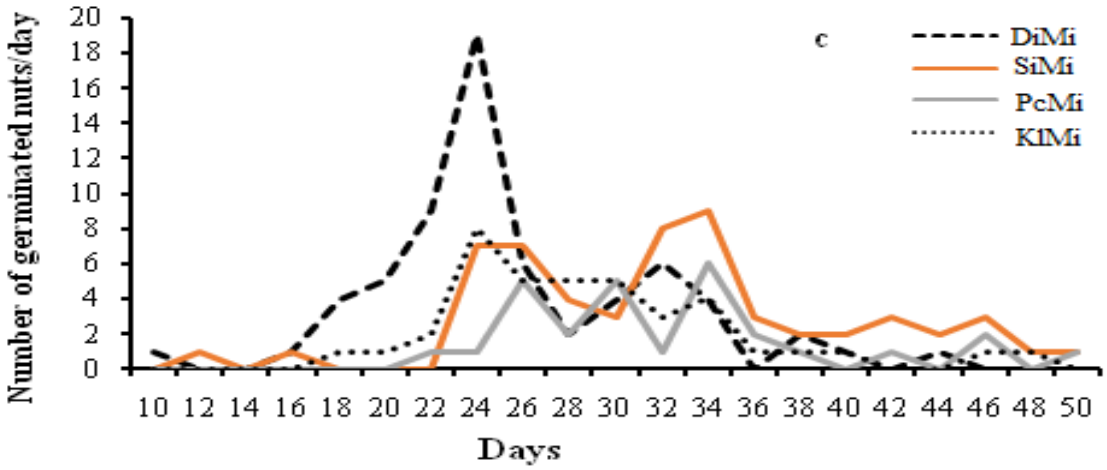


Figure 5. Number of germinated nuts per day on *Anacardium occidentale* (a), *Khaya senegalensis* (b) and *Mangifera indica* (c)

Table 1. Germination rate of *Mangifera indica* nuts following the substratum and variety

Parameters		Germination rate	P value
Substrates	AO	65,9±9,8 a	P>0,05
	KS	64,6±9,8 a	
	MI	59,0±11,1 a	
Varieties	Di	77,0±4,8 a	P=0,03
	Si	72,5±4,5 a	
	Kl	60,4±10,5 b	
	Pc	42,9±7,4 c	

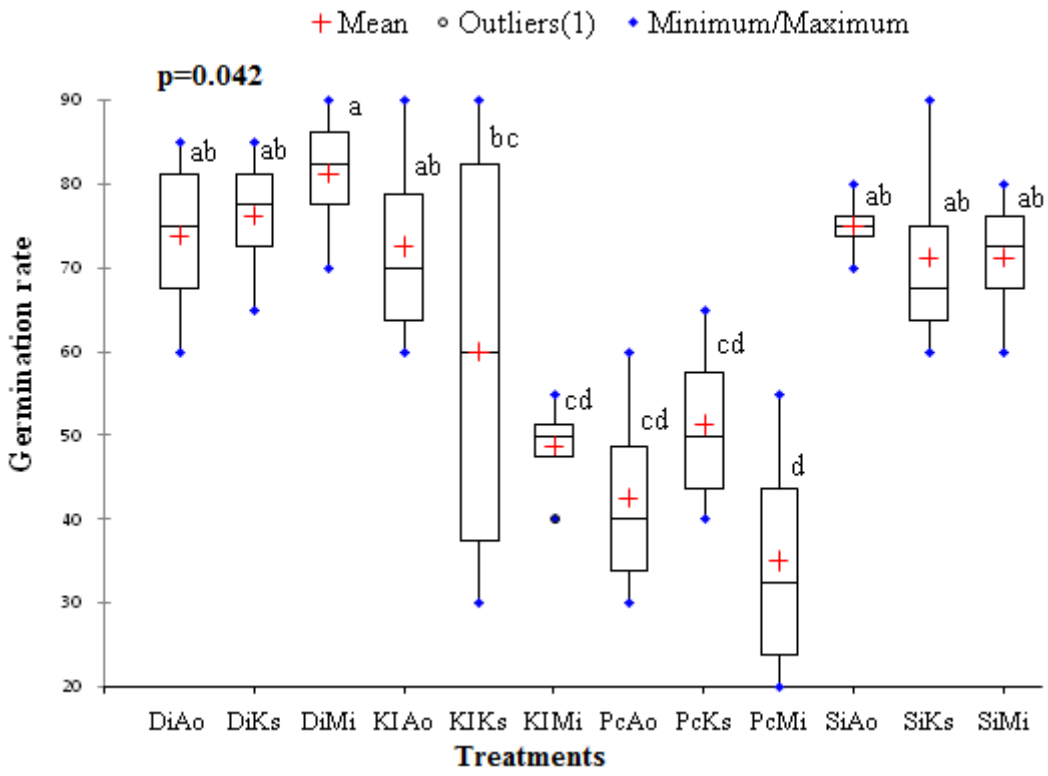


Figure 6. Germination rate according to varieties and treatments

Growth parameters

The analysis of variance on the growth parameters did not reveal any significant difference between the substrates but the varieties performed differently. Siera Leone had grown up faster than Diourou followed by Kouloubadaseky and Pince (Table 2).

The average number of leaves per week varied significantly (p=0.045) from one treatment to another. Siera Leone grown on *Mangifera indica* substrate (SiMi) produced the highest number of leaves (12.7 ±3.7). On the other hand, *Mangifera indica* substrate seemed to have a stimulating effect on the number of leaves produced by Siera Leone and Diourou plants, but a depressive effect on leave production of Pince and Kouloubadaseky varieties (Figure 7a). The height of the seedlings varied according to the treatments, so there was a significant interaction between the variety and the substrate. Thus, the analysis of variance showed a significant difference between the treatments (p=0.045). It appeared that Diourou planted on *Mangifera indica* substrate and Kouloubadaseky planted on *Anacardium occidentale* substrate had higher height. Thus SiKs and KlKs treatments had the highest seedlings (Figure 7b).

The diameter of the seedlings varied according to the treatments. The recorded diameter was significantly (p=0.035) larger in SiKs than in PcMi, PcAo, PcKs, KlMi, KlKs, DiKs and DiAo treatments. Thus, Siera Leone had the largest diameter on all substrates. Diourou and Kouloubadaseky had recorded larger diameter in *Mangifera indica* and *Anacardium occidentale* substrates respectively (Figure 7c).

The number of stems emerged from a seedling varied significantly (p=0.041) according the treatment.. Kouloubadaseky registered the highest number of stems (4 ±0.13), whereas Pince recorded the lowest stem number (2.2 ±0.14) (Figure 7d).

Table 2. Growth parameters according to substrate and variety

Substrates/ Varieties	Types	Growth parameters			
		Nb of leaves	Height (Cm)	Diameter (Cm)	Nb of stems
Substrates	KS	9.55±0.81 [a]	29.1±0.8 [a]	0.40±0.05 [a]	3.06±0.23 [a]
	MI	9.44±1.01 [a]	27.4±0.9 [a]	0.38±0.04 [a]	3.23±0.21 [a]
	AO	9.23±1.50 [a]	27.6±0.9 [a]	0.40±0.05 [a]	3.01±0.20 [a]
Varieties	Si	11.70±1.56 [a]	29.5±0.8 [a]	0.44± 0.056 [a]	2.9±0.11 [b]
	Di	9.71±0.45 [b]	29.1±0.6 [a]	0.43± 0.041 [a]	3.2±0.08 [b]
	Pc	8.71±0.80 [bc]	24.2±0.6 [b]	0.33± 0.046 [b]	2.2±0.14 [c]
	Kl	7.50±0.48 [c]	29.2±0.8 [a]	0.39± 0.043 [ab]	4.0±0.13 [a]

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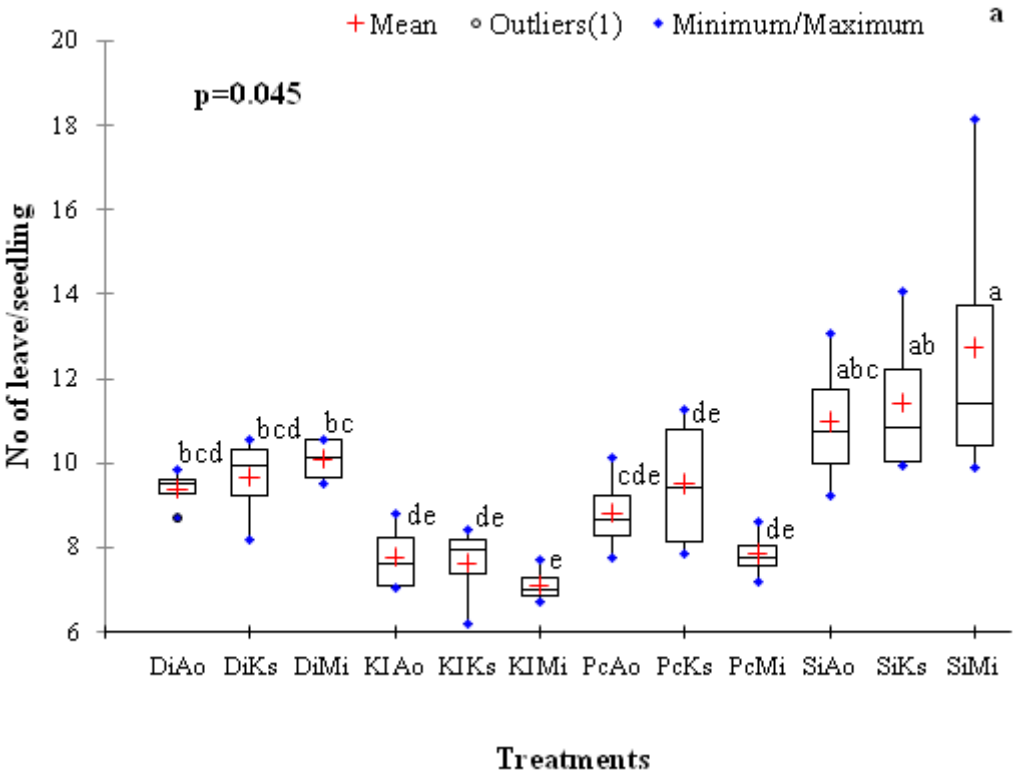

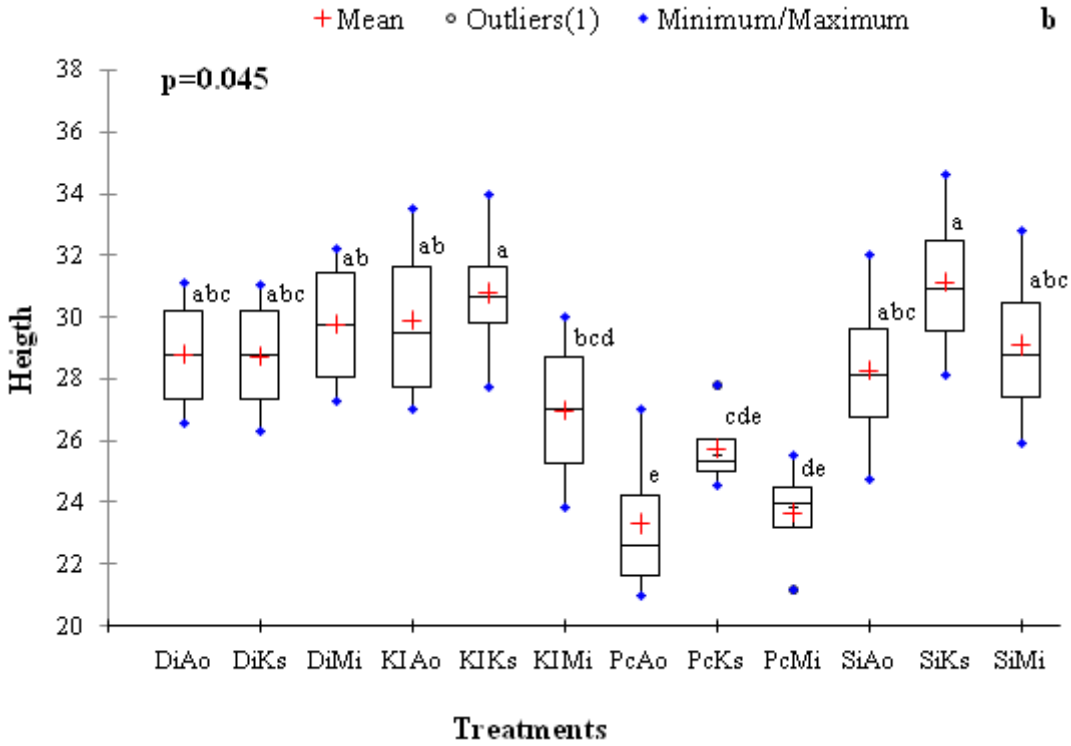

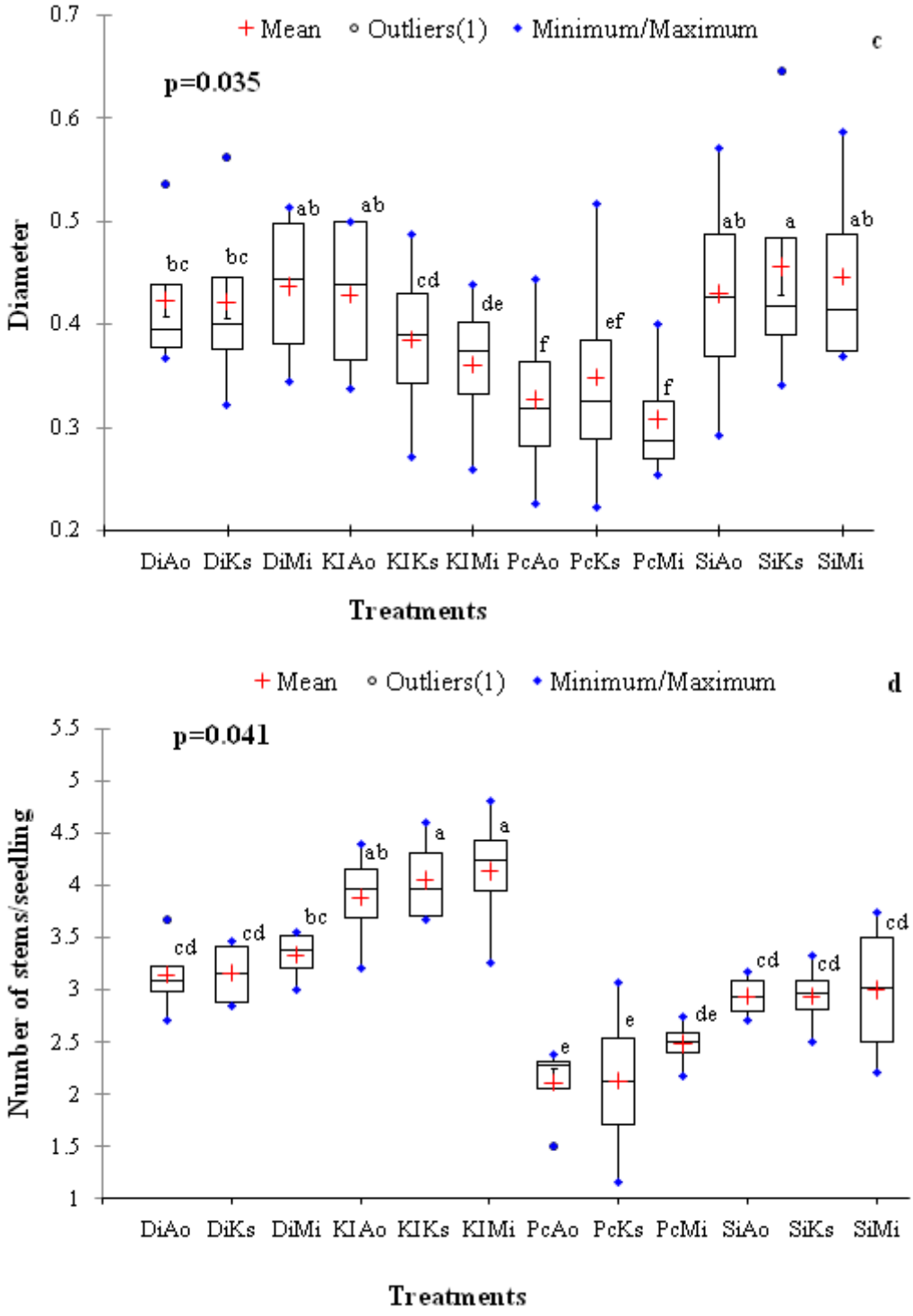

Figure 7. Number of leaves (a). Height (b). Diameter (c) and number of stems per Treatment

Relationship between the parameters

The Bartlett test applied to the studied parameters (germination rate.. number of stems, height. number of leaves and diameter) attested significant correlations between variables (p-value< 0.0001) at the 95% level. Indeed. Pearson's correlation matrix indicated a positive or negative significant correlation between the parameters. Germination rate had a positive significant correlation with diameter (0.951) and height (0.824) . There is also a significant correlation between the number of stems and height (0.645). On the other hand. the number of stems is negatively correlated with the number of leaves (-0.364) (Table 4). Principal component analysis applied to the different treatments according to the variables studied revealed germination rate (27.57%). diameter (29.51%) and height (26.46%) contributed more to the formation of the F1 axis while the number of stems (49.81%) and number of leaves (44.18%) contributed to the F2 axis. Kouloubadaseky producing the larger nuts seemed to be more polyembrionic with also a better growth in height while the Diourou and Siera Leone had the best germination rate and seedling robustness. However. Diourou had a better growth in height while Siera Leone was characterized by the most important foliar development. Pince was characterized by a lowest germination rate and growth parameters (Figure 8).

Table 4. Correlation matrix between the parameters: Germination rate. number of stems. height. number of leaves and collar diameter of pant.

Parameters	Nb of stems	Diameter	Nb of leaves	Height	Germination
Nb of stems	**1**				
Diameter	0.376	**1**			
Nb of leaves	-0.364	**0.635**	**1**		
Height	**0.645**	**0.875**	0.319	**1**	
Germination	0.356	**0.951**	0.545	**0.824**	**1**

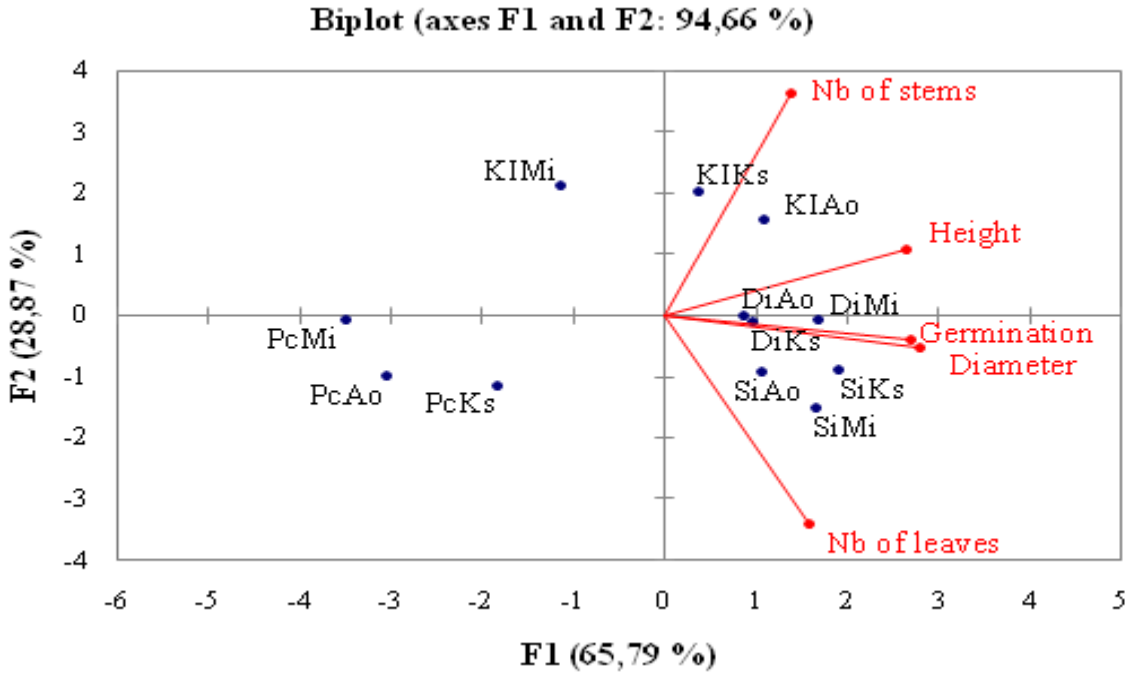

Figure 8. Relationship between treatments. germination and growth parameters

DISCUSSION

The study showed that there is maximum germination on the 24th or 34th day Indeed. The varieties like Diourou and Kouloubadaseky recorded an earlier germination peak at the 24th day. While the varieties Pince and Siera Leone registered a later germination peak on the 34th day. These data seemed to lead in the same direction as the purposes by De Laroussilhe (1979) that mango seed germination required 6 to 30 days. In addition. For our local varieties nuts could stay into potting soil at least up to 50 days after sowing before the plants emerged. However, there is differential germination between the four mango varieties sown. Thus, according to these results we can say that the dormancy of mango nuts varied from one variety to another and in the same from a nut to another. In addition, the higher germination rate were recorded with Diourou and Siera Leone showing their germination powerful regardless of the substrate. Kouloubadaseky had a good germination rate in *Anacardium occidentale* and *Khaya senegalensis* substrates (≥ 60%) and a low germination rate in Mangifera indica substrate. In addition. Pince had the lowest germination rate on all substrates except for *Anacardium occidentale* substrate with a medium germination rate. The germination

rate average was high. A research carried out by Hamidou et al. (2013) with *Scerocarya birrea* showed a high germination rate (68.33%). The used nuts could grow in the different substrates but the germination rate was different from one substrate to another. And according to Normand (2009) the mango tree can grow on different types of varied substrates. The fact that *Mangifera indica* substrate could be important because of inoculation of microorganisms that could act by stimulating of inhibing the germination process. This phenomenon could contribute to explain the foliar growth observed on SiMi and DiMi. The number of leaves varied from one treatment to another but Diourou produced the same average of leaves on all substrates. In fact, for Pince Siera Leone and Kouloubadaseky there was a difference in number of leaves. Thus, the results relating to the growth of the varieties showed that on *Mangifera indica* substrate. The number of leaves for the Pince and Kouloubadaseky decreased. While for the Siera Leone it increased. Finally the number of leaves did not only depend on the substrates and the seedlings. But depended also on other factors. Nevertheless another split plot design (Krebs, 1999) can be used by taking the mould as the big plots where the varieties could be spread randomly to find whether the effect of the substratum will be significant. The development of the mango tree depends on exogenous factors and climate as reported by Persello (2018). Whiley (1989) sustained that the number of leaves depends on temperature during the initiation phase and it increases with temperature. Here all the nuts were sown at the same temperature. Growth in height varies depending on the variety and the substratum. In fact, the varieties such as Siera Leone. Diourou and Kouloubadaseky had a faster growth in height compared to Pince. The growth in diameter varied depending on the treatment. Therefore. Kouloubadaseky showed a significant difference high diameter on Anacardium occidentale than on *Mangifera indica* and *Khaya senegalensis* substrates. From these results it was deduced that germination and growth for the Kouloubadaseky were better in *Anacardium occidentale* substrate whereas for the Pince germination and growth were low in all substrates. Results indicated that all varieties produced many stems then were polyembrionic. In fact, the number of stems does not depend on the substrate but on the variety. And according to his results we can say that the varieties Diourou. Kouloubadaseky. Pince and Siera

Leone were polyembrionic as described by Rey et al. (2004). However, the number of embryos expressed through the emerged stems varied from one variety to another with a probable influence of the substrate used. The ability of nuts to let emerge two or more stems may or may not develop into complete embryos and even young seedlings at germination was mentioned by Lebègue (1952). The results showed significant correlations between germination rate and the dendrometric parameters. The growth in diameter would be influenced by the number of leaves. There was also a correlation between the number of stems and the height. Hence the importance of thinning and nursery maintenance or how the pruning intensity and severity can affect vegetative growth process (Parcello, 2018). The number of stems played a role in the growth of the seedlings through the phenomenon of competition on water and nutrients between them. In this study, a proportional relationship between the number of leaves. diameter and height was recorded. The same relationship was reported by Touckia (2015) with *Jatropha curcas* L. which highlights significant correlations between the parameters such as the leaves number. The height and collar diameter of the juvenile plant. Dossa et *al*. (2020) in Benin reported significant correlations between the germination rate for *Detarium senegalense* seedlings the vigor and the height in nursery.

CONCLUSION

This study on germination growth and development of local mango varieties such as Diourou. Pince. Siera Leone and Kouloubadaseky in substrates of *Anacardium occidentale*. *Khaya senegalensis* and *Mangifera indica* L. was done in order to identify the most vigorous rootstocks and the adequate substrate in nursery. Quantitative measurements of the parameters studied (germination rate. number of stems. number of leaves. height and collar diameter) showed that Diourou and Siera Leone varieties were very vigorous on all the substrates used but Kouloubadaseky was less vigorous on *Mangifera indica* substrate. Whereas the Pince variety was not vigorous on all used substrates. In this experiment. The four varieties were tested on three types of substrates that are important in Casamance. The tests were also intended to evaluate the root biomass in order to properly assess the capacity of these varieties. Indeed, grafting test with Kent and Keitt need to be carried out with the same varieties used to help

farmers to choose suitable rootstock for their orchards.

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