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Effects of *two* Potting Soils on Growth of *Moringa oleifera* (Lam.) and *Leucaena leucocephala* (Lam.) in Kéréwane (Kolda/Sénégal)

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Abstract: *Moringa oleifera* and *Leucaena leucocephala* are two species which constitute a significant food, medicinal and economic source for the populations of Casamance. The objective of this study is to determine the most suitable substrate for good germination and better growth of these species. Thus a completely randomized block design with two factors (species and substrates) repeated four times was installed. The germination rate, the number of leaves, the diameter at the collar, the height, the humidity and the biomass were determined. The results of the germination rate showed that there was no significant difference between the treatments for both *M. oleifera* and *L. leucocephala* regardless of the treatment. The number of leaves, the growth in diameter and in height are significantly higher in the plants of the treatment S1 (9.70 leaves / plant; 0.41 cm for the diameter at the collar and 28.05 cm for the average height of the plants) for *M.oleifera* compared to other treatments (number of leaves P=0.003; diameter at the collar P=0.001 and height P=0.04). With regard to *L. leucocephala*, no significant difference (P=0.75) was noted for the number of leaves and the diameter at the collar (P=0.19) between the different substrates. The height of the plants of the substrate S3 (13.54 cm) of *L. leucocephala* is significantly different (P=0.001) compared to the other substrates. The results of the moisture content of the *M. oleifera* and *L. leucocephala* plants did not show any significant difference whatever the substrate. Regarding the dry aerial and root biomass of the plants of *M. oleifera* and *L. leucocephala*, the results showed that there is no significant difference between the substrates (P=0.46 for *M. oleifera* and P=0.21 for *L. leucocephala*).

Keywords: *Anacardium occidental*, *Parkia biglobosa*, *Moringa oleifera*, *Leucaena leucocephala*, Germination, Growth

1. Introduction

In Senegal, the poverty line is around 57% in the cities and 65% in the countryside, i.e. an average of 57% for the whole country [2]. In rural areas, where this situation is more marked, populations develop two activities (agriculture and exploitation of forest products) to meet their needs. With the lack of rainfall combined with the decline in soil fertility, resulting in a drop in agricultural yield, rural populations are increasingly turning to non-timber forest products as a strategy for adaptation and risk mitigation. As a result, in recent years there has been a renewed interest in these products (NTFP) [2].

These NTFP contribute to the development of these populations in terms of monetary income but also in terms of job creation. In addition, forest species have considerable potential to contribute to solving rural poverty problems such as food intake, sources of cash income and job creation for the most vulnerable groups such as women, youth and children [1, 3, 8-10].

However, these forest species do not receive sufficient attention commensurate with their potential from forest stakeholders. Among these forest species are *Moringa oleifera* and *Leucaena leucocephala*, which are among the most important species due to their contribution in food as fruits, in traditional medicine, in soil fertility management as legumes and their considerable economic contributions [3-5]. The

Casamance Economic Development Support Programme (PADEC) reports that in developing countries, nearly 80% of the population use NTFP to meet their primary needs.

The Casamance Economic Development Support Programme final report on the exploratory study of the Non-Timber Forest Products (NTFP) market, considers that despite significant potential, the exploitation of NTFP has been on a downward trend in recent years in Casamance. However, with regressive trends linked to anthropic pressures and climatic hazards, these species are under threat of extinction. *Moringa oleifera* and *Leucaena leucocephala*, due to strong local and national demand, are subject to accentuated overexploitation. This situation indicates the fragility of these forest resources and the risks of disappearance if measures are not taken to guarantee upstream production. Indeed, the changes and irrational methods of exploitation (immature fruit picking, barking, poor pruning and pruning) are detrimental to NTFP in general and *Moringa oleifera*, *Leucaena leucocephala* in particular. It is on the basis of this observation that this study is being carried out in order to contribute to the conservation and control of the development of these two species in nurseries.

2. Materials and Methods

2.1. Study Area

The study was carried out in the maraicher perimeter of the village of Kéréwane located in Upper Casamance (Kolda), more precisely in the department of Médina Yoro Foulah. This village is located at 13°26'48"N latitude and 15°7'19"W longitude. The commune of Kéréwane is bordered to the north by the Republic of The Gambia, to the south by the communes of Bourouco and Ndorna, to the west by the Republic of The Gambia and to the east by the commune of Niaming.

The climate is of the coastal South Sudanese type, marked by relatively high temperatures, varying between 20 and 40°C depending on the season. It is mainly characterized by a dry season from November to May and a rainy season from June to October. Rainfall observed between May and October varies between 600 and 1200 mm [14].

There are three main types of soil in the Commune: tropical ferruginous soils, ferralitic soils and hydromorphic soils. These soils have different textures and agronomic, forestry, pastoral and hydrological aptitudes. The Commune is mainly composed of Peulhs (37%) and Sarakolés (25.5%). Religiously speaking, the population is made up of Muslims only [14].

2.2. Vegetal Material

The *Moringa oleifera* seeds used come from the Matam region, precisely in the commune of Ourossogui, while those of *Leucaena leucocephala* were collected locally by the PADEC of Kolda.

2.3. Experimental Design

A complete randomized complete randomized block experimental design was set up with two factors (species and substrate) and four replicates. The experiment was carried out over an area of 11.47 m^2 (length 2.70 m and width 4.25 m), with elementary plots of 0.15 m^2. It was carried out in polyethylene sheaths filled with compost of *Anacardium occidentale*, *Parkia biglobosa* and a mixture of half a *Parkia biglobosa* and *Anacardium occidentale*. The mass of each filled sheath is 0.6 kg of potting soil. In each elementary plot, 12 sheaths were placed.

2.4. Conduct of the Experimental

2.4.1. Sowing

The semi operation was carried out on July 28, 2019 with a homogeneous watering. In each packet four seeds were sown. A daily watering was made for each treatment.

2.4.2. Demarriage

A demarriage has been done to maintain one plant per sheath and a relining is done for empty sheaths. Demarriage and relining took place on JAS 29 for *Moringa oleifera* and JAS 25 for *Leucaena leucocephala*, respectively. Weeding was carried out on a weekly basis.

2.5. Data Collection

2.5.1. Germination Rate

A survey count per substrate was conducted daily after seeding for 24 days. The germination rate was determined using the following formula:

$$\text{Germination rate} = \frac{\text{Number of germinated seeds}}{\text{Number Total of seeds sown}} \times 100$$

2.5.2. Number of Leaves

The counting of the number of leaves was carried out weekly starting from the 36th JAS and repeated four times.

2.5.3. Height and Diameter

Height and diameter measurements were made at JAS 35. These measurements were made weekly. The diameter at the collar was measured with a caliper and the height with a tape measure.

2.5.4. Aerial and Root Biomass

The seedlings were harvested in the 90th JAS. The plants were uprooted and cleaned with water to remove the layer of soil and debris from the roots. The above-ground and below-ground parts were separated at the crown. The different parts were then weighed using a 10^{-4}g precision electronic scale. The biomasses were then dried in an oven at a temperature of 70°C for 72 h and weighed again with the same electronic balance. From the data collected, the moisture content of the aerial and root parts was determined using the following formulary

$$\text{Relative water content} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Fresh weight}} \times 100$$

2.6. Statistical Analysis

The data obtained were subjected to an analysis of variance (ANOVA) using the Fisher's test to identify whether or not there was a significant difference (at the 5% probability threshold) between the means of the treatments as a function

of the variables studied. To do this, XLSTAT version 2014 was used to analyze the data.

3. Resultants and Discussion

3.1. Germination Rate

The analysis of variance showed no significant difference between the germination rate of *M. oleifera* obtained regardless of substrate (P=0.07). The same trend was noted for *L. leucocephala* with P=0.14 (Table 1). However, when comparing the two, the highest germination rates were recorded for *M. oleifera*. Germination rates ranged from 93.48 to 95.83% for *M. oleifera* and 37.25 to 40.91% for *L. leucocephala*.

Table 1. *Germination rates by species and substrate.*

Substrates	*M oleifera*	*L. leucocephala*
	Germination rate (%)	
S1	93,75 ± 14,84[a]	37,25 ± 11,07[a]
S2	93,48 ± 15,10[a]	38,10 ± 11,95[a]
S3	95,83 ± 11,14[a]	40,91 ± 14,30[a]
Probability	0,07	0,14
Grand mean	94,35 ± 13,69[a]	38,75 ± 12,44[a]

S1=100% *Anacardium occidentale* substrate, S2=100% *Parkia biglobosa* substrate, S3=50% *A. occidentale* substrate and 50% *P. biglobosa* substrate.

3.2. Growth Parameters

3.2.1. Number of Leaves

The mean number of leaves obtained (10 leaves/plant) in plants of substrate S1 for *M. oleifera* is significantly different from that noted in other substrates (p=0.003). Substrate S1 has more leaves compared to the other substrates.

However, no significant difference was observed between the number of leaves noted in *L. leucocephala* regardless of treatment (p=0.07). The number of leaves ranged from 10 (S1) to 12 leaves/plant (S1) (Figure 1).

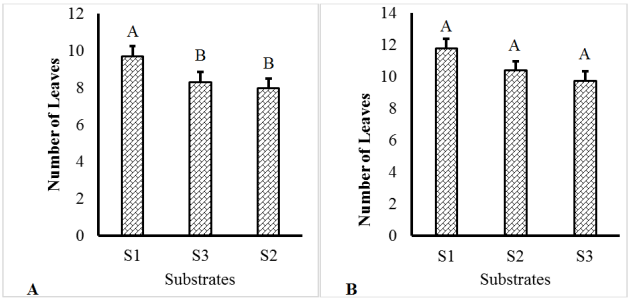

Figure 1. *Variation in the number of leaves of Moringa oleifera (A) and Leucaena leucocephala (B) plants as a function of substrate.*

S1=100% *Anacardium occidentale* substrate, S2=100% *Parkia biglobosa* substrate, S3=50% *A. occidentale* substrate and 50% *P. biglobosa* substrate.

3.2.2. Diameter at Collar

Variations in diameter growth at the collar of *Moringa oleifera* and *Leucaena leucocephala* plants are shown in Figure 3. The analysis of variance showed no significant difference in crown diameter measured on *M. oleifera* plants regardless of substrate (P=0.001). This diameter growth ranged from 0.33 cm (S2) to 0.41 cm (S1).

The same trend was observed in *L. leucocephala* plants. In fact, the ANOVA showed no significant difference in crown diameter measured in *L. leucocephala* plants regardless of substrate (p=0.19). It ranged from 0.17 cm (S3) to 0.11 cm (S1) (Figure 2).

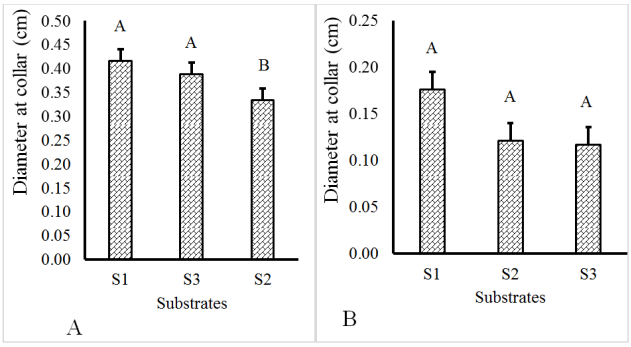

Figure 2. *Diameter growth of Moringa oleifera (A) and Leucaena leucocephala (B) plants in function of substrate.*

S1=100% Anacardium occidentale substrate, S2=100% Parkia biglobosa substrate, S3=50% A. occidentale substrate and 50% P. biglobosa substrate.

3.2.3. Height of the Plants

The ANOVA showed that the mean measured height of *M. oleifera* plants on substrate S1 (28.05 cm) was significantly different (P=0.048) from that observed on plants on substrate S2 (25.86 cm). However, the height measured at the plants on substrate S1 is not significantly different from that of S3 (27.64 cm).

The same trend was observed for *L. leucocephala*. Indeed, analysis of variance showed a significant difference (P=0.001) between the mean height noted in plants from substrate S2 (13.54 cm) and those from substrate S3 (10.71 cm). However, no significant difference (Figure 3) was noted between the height of plants in substrates S2 (10.70 cm) and S1 (13.54 cm) (Figure 3).

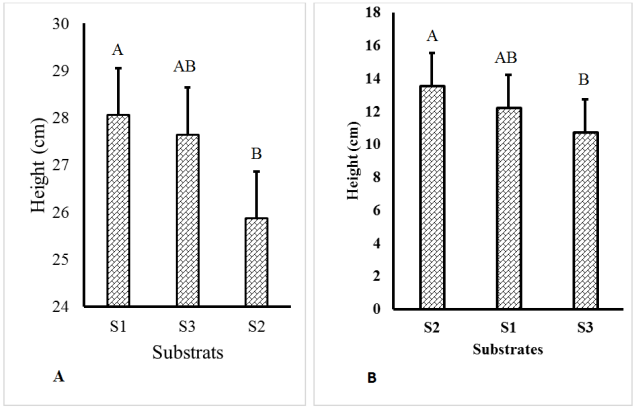

Figure 3. *Height of M. oleifera (A) and L. leucocephala (B) in function of substrates.*

S1=100% *Anacardium occidentale* substrate, S2=100% *Parkia biglobosa* substrate, S3=50% *A. occidentale* substrate and 50% *P. biglobosa* substrate.

3.3. Dry Biomass and Moisture Content

3.3.1. Dry Biomass of Plants

The analysis of variance showed no significant difference between the mean dry biomass of *M. oleifera* on any substrate (p=0.46). However, the highest dry biomass was noted at S1 (5.10 ± 4.85) and the lowest biomass at S2 (4.34 ± 5.57).

The same trend was observed for *L. leucocephala* plants. Indeed, the analysis revealed no significant difference between the measured dry biomass regardless of substrate (P=0.21). The highest biomass was 1.51 ± 0.84 (S1) and the lowest was 1.07 ± 0.79 at S3 (Table 2).

3.3.2. Relative Water Content

Analysis of variance indicated that there is no significant difference in the Relative water content noted on *M. oleifera* plants regardless of substrate. The highest Relative water content is 66.64% ± 15.58 (S2) and the lowest is 61.91 ± 16.18 (S3).

As for *L. leucocephala*, the analysis showed no significant difference for Relative water content regardless of the treatment. The relative water content content was 78.04% ± 8.96 (S3) and the lowest was 68.71 ± 19.70 (S1) (Table 2).

Table 2. *Relative water content and dry biomass of M. oleifera and L. leucocephala in function of substrates.*

Substrats	*Moringa oleifera*		*Leucaena leucocephala*	
	Relative water content (%)	**Dry Biomass (g) /Pant**	**Relative water content (%)**	**Dry biomass (g)/plant**
S1	64,96 ± 21,06[a]	5,10 ± 4,85[a]	68,71 ± 19,70[a]	1,51 ± 0,84[a]
S2	66,64 ± 15,58[a]	4,34 ± 5,57[a]	71,96 ± 23,08[a]	1,41 ± 1,46[a]
S3	61,91 ± 16,18[a]	5,06 ± 4,57[a]	78,04 ± 8,96[a]	1,07 ± 0,79[a]
Probability	0,13	0,46	0,57	0,21
Grand mean	64,50 ± 17,10[a]	4,88 ± 5,04[a]	72,90 ± 17,24[a]	1,13 ± 1,03[a]

S1=100% *Anacardium occidentale* substrate, S2=100% *Parkia biglobosa* substrate, S3=50% *A. occidentale* substrate and 50% *P. biglobosa* substrate.

4. Discussion

The highest germination rate is recorded with substrate S3 (95.83%) followed by S1 (95.75%) and S2 (95.48%) respectively. The higher germination rate recorded with substrate S2 could be due to the fact that the environmental conditions such as the mineral elements in the soil and the amount of water supplied are more favourable for germination, but also to the fact that the seeds were not stored for a long time before sowing. These results are higher than those obtained by [13] who estimates that the germination rate of fresh *M. oleifera* seeds is around 80%. Concerning the germination rate of the species *Leucaena leucocephala*, on substrate S3 gave the best result (40.91%) and the lowest results were obtained with substrates S2 (38.10%) and S3 (37%) respectively. However, this result is very low compared to that of [9] which obtained a germination rate of 91%. These relatively low results could be explained by the fact that the sown seeds are not fully mature or because they have not been pre-treated before sowing. The germination rate is usually very high but can drop to 0% after two years of storage [10]. The results showed that the mean height and collar diameter obtained at substrate S1 are significantly different compared to other substrates in *M. oleifera*. For *L. leucocephala*, no significant difference was noted between the mean leaf count and mean crown diameter observed on any substrate. As for height, the analysis showed that the height measured in plants of substrate S1 was significantly higher also regardless of substrate and species. This could be explained by the fact that substrate S1 (cashew nut soil) is richer in nutrients and also by the resistance of the species to harsh conditions. These results corroborate those of [7] who reported that the soil collected under cashew tree cover is much richer in Carbon, Calcium and Nitrogen than that of the soil outside the cover. This physico-chemical characteristic of the soil is favourable to plant development. Its resistance to drought means that even if it is not watered, the plant does not die [7].

As for the moisture content of *M. oleifera*, statistical analyses have shown that there is no significant difference between treatments. However, the highest moisture content is noted with substrate S2 (66%) followed by substrate S1 (64%) and finally substrate S3 (61%). This slightly higher than average moisture content of the plants could be explained by the fact that the leaves of *Moringa oleifera* were attacked by a fungal disease which caused significant defoliation of the young plants. [12] had pointed out that leaves and roots represent the parts of the plant that contain more water in *Moringa oleifera*. For the species *L. leucocephala* the highest relative water content is noted with substrate S3 (78.04%) followed by substrate S2 (71.96%) and finally substrate S1 (68.71%). Indeed, the knowledge of the water content of the wood is essential because this parameter conditions the variations in volume and shape. This maximum observed at the level of substrate S3 could be related to the form in which the water is present in this substrate and in the wood. It is reported that the different forms (water of constitution, water of impregnation and water of capillarity) under which water is presented in wood obviously prevent its complete elimination from the wood. This better result obtained (S3=78.04%) does not corroborate that of [9] who obtained 64.32% after 210 days of cultivation and at a temperature of 25°C.

Concerning the dry biomass of plants on the different substrates, results show that there are no significant differences between treatments for both *M. oleifera* and *L. leucocephala*. Indeed, the dry biomass produced under S1 is higher than the biomasses obtained under S2 and S3 for both species (*M. oleifera* and *L. leucocephala*) in absolute value. However, these results are lower compared to those of [9] who obtained an average of 15.36 g dry biomass per L. leucocephala plant after 210 days of sowing.

5. Conclusion

It results from this study that the best plant emergence rate is noted with cashew substrate mixed with *P. biglobosa* (S3) potting soil for both species (*M. oleifera* and *L. leucocephala*). Growth in crown diameter and leaf count of *M. oleifera* and *L. leucocephala* plants are much higher with cashew substrate (S1). On the other hand, for the average height of *M. oleifera* and *L. leucocephala* plants, substrates S1 and S3 gave the best results. As for the relative humidity and dry biomass of *M. oleifera* and *L. leucocephala* plants, the best results were obtained with substrate S1. In view of the results, it would seem that cashew substrate (S1) allows good plant development.

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