Performance Evaluation of Different Accession of *Anacardium occidentale* L. Seed under Various Substrates

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Authors’ contributions

This work was carried out in collaboration among all authors. Author AH designed the study and wrote the protocol. Author MTJ performed the statistical analysis and wrote the first draft of the manuscript. Authors YE, BJ, ABC and RD managed the data collection of the study. Author OPM managed the literature searches and supervised all the study. All authors read and approved the final manuscript.

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ABSTRACT

This study aims to determine which accession of cashew has the best growth rate and germination in the nursery. Trial was conducted in the year 2019 using split-plot design. The first factor is the provenance of seeds, namely the Sudano-Sahelian zone and High Guinean savannah zone, and the second factor is type of organic matter entering the substratum composition cow dung (BV),

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1. INTRODUCTION

The cashew tree (Anacardium occidentale L.) is a tree that belongs to Anacardiaceae family, highly branched, port drooping, reaching up to 10m high at adult age and with average crown diameter of about 14 m [1]. It develops in regions where annual rainfall is between 500 and 3700 mm and adapts to climate characterized by a dry season of up to six months and an average annual temperature of between 22°C and 35°C [2,3]. The plant is grown for its fruits and contributes to the socio-economic development of several countries of the world [4,5]. The fruit of the cashew tree is composed of two parts: the cashew apple or fake fruit and the cashew nut which is the essential object of the world trade in cashew [6,7]. The cashew apple, juicy and rich in vitamin C, is used in the form of fresh fruit and for preparation of jam, juice, alcohol, vinegar or syrup [8]. Of Brazilian origin, this plant was introduced to Africa around the 16th century by the Portuguese [9] and for the purpose of reforestation [10]. Global cashew production is estimated at more than 2 million tonnes of nuts in 2002, this production increased to 4152315 tonnes in 2012 [6]. The main producing countries are: India, Vietnam and Brazil. Côte d'Ivoire, with more than 200,000 tonnes, is Africa's largest producer [11]. In Cameroon, this plant is more widespread in the northern part of the country but more abundant in the North and Far North regions. In recent years, given its socio-economic importance, the cultivation of this plant has attracted the attention of several producers from other regions (Adamawa, East and part of the Centre) of the country. Despite the increased growing interest in this crop in recent years, orchard yields remain low in the country's producing communities as little is known regarding plantation and unsuitable peasant farming practices. To help resolve these constraints, the identification of quality seed and the type of organic matter present in the substratum may constitute a great potential for improving seed germination and plant growth of Anacardium occidentale. Seed from sudano-sahelian zone and substratum that consists cow dung and goat droppings may be suggested to farmers for better production of Anacardium occidentale saplings in a nursery.

2. MATERIALS AND METHODS

2.1 Study Site

The study was conducted at the Wakwa Agricultural Research Centre, Vina division, and Adamawa region of Cameroon. It is located between 07°16.936 North; 013°30.092 East, and is located at an altitude of 1130 m. The climate of the area is of the Sudano-Guinean type, characterized by two seasons: a dry season that
lasts for about five months and a rainy season that lasts about seven months. The average annual rainfall is 1581 mm, and the average annual maximum temperature is around 32°C. The sunshine is 15810 W/m² and the soil on the site has an acidic character.

2.2 Study Material

Study material consists of seeds from existing local cashew plantations in two agroecological zones (the area of the high Guinean savannahs – zone 2 and the Sudano-Sahelian zone – zone 1). The seed has been harvested directly in the cashew plantation and were kept in the laboratory condition before being sown. It is the best quality of cashew nut and the average weights of these nuts are around 7 g. The different substrates are made up of a mixture of black earth, sand and animal excrement (cattle, poultry and goats). Three types of substratum were used for this study: 1st substratum consisting of 2/4 of black soil, 1/4 of sand and 1/4 of cow dung (BV substratum); 2nd substrate with 2/4 black soil 1/4 sand and 1/4 poultry droppings (FP substratum); and 3rd substratum with 2/4 black earth, 1/4 sand and 1/4 goat droppings (BC substratum).

2.3 Methods

Before sowing, seed quality is assessed by the flotation test. Only the immersed nuts were selected to conduct the test. The retained nuts were then soaked for 24 hours to overcome their integumentary dormancy and sown in polyethylene pots of 61 microns (20 length x 15 width) filled with various substrates. The pots were sufficiently watered 24 hours before sowing and after sowing they were watered twice a day (morning and evening). The pots are then stored according to an experimental design in split-plot. The first factor is the origin of the seeds with two treatments (zone I and zone II) and the second factor the type of organic matter contained in the substrate with 3 treatments (BV, BC and FP). Twenty (20) nuts were sown per elementary plot and each elementary plot is repeated three times for a total of 60 nuts per each substrate. A total of 630 nuts have been sown (60 nuts per substrate) from seed sources. After sowing, the pots were covered with straw and the temperature of site study is indicated in the Table 1, this table shows the temperature of the first day of sowing and during all the germination period.

In order to assess the percentage of germination observations were made from sowing to stabilizing the number of pots where seed germination is observed. The germination criterion used to assess the germination rate is the breakthrough of the radicle. The daily observations made consisted of recording the survival rate during the 4 weeks in the different pots. The dendrometric parameters taken into account are: the number of leaves, the length and width of the leaves, the diameter of the collar and the height of the plants. They are collected two months after sowing. Maximum length and width were used to calculate the leaf area using the following formula [13]:

\[ \text{Area} = 0.68 \times \text{(length} \times \text{width)} - 0.114 \]  

Table 1. Temperature of the first day of sowing and during all the germination of seed

| Date         | Temperature (°C) | Period                |
|--------------|------------------|-----------------------|
| 21/03/2019   | 33               | First day of sowing   |
| 04/04/2019   | 34               | First day of germination |
| 05/04/2019   | 33               | During germination    |
| 06/03/2019   | 33               | During germination    |
| 07/04/2019   | 29               | During germination    |
| 08/04/2019   | 33               | During germination    |
| 09/04/2019   | 32               | During germination    |
| 10/04/2019   | 32               | During germination    |
| 11/04/2019   | 32               | During germination    |
| 12/04/2019   | 34               | During germination    |
| 13/04/2019   | 29               | During germination    |
| 14/04/2019   | 31               | During germination    |
| 15/04/2019   | 32               | Last day of germination |
2.4 Statistical Analysis

The data collected were subjected to analysis of variance at the 5% threshold and the averages were compared using the LSD (Least Significant Difference) test. These analyses were carried out using STATGRAPHIC 5.0 software and graphs by EXCEL.

3. RESULTS

3.1 Germination Rate with Respect to Time

Fig. 1 shows the evolution of percentage of germination with respect to time. Growth began 14 days after sowing (DAS) for most treatments and evolved exponentially until the 26th day before stabilizing until the 28th day. Overall it should be noted that for all treatments, the percentage of germination reached 50% around 20 DAS. The percentage of seed germination from the two agroecological zones varied according to each type of substrate. The seeds from the Sudano-Saharan zone recorded a higher percentage of germination in the substrate containing BC from 14 DAS to 22 DAS compared to the other two substrates. However, from the 26th to the 28th DAS, this germination percentage obtained in this substrate was identical to that recorded in the substrate containing the cow dung (BV). On the other hand, for seeds in the upper Guinean savannah area, the evolutionary trend of the percentage of germination is maximum in the substrate containing the poultry droppings (FP).

Therefore, despite the difference on percentage of seed germination between the substrate of each zone, analysis of variance show that none of the factors (substratum and origin of seed) or interactions have a statistically significant effect on percentage germination at the 95,0% confidence level (P-value = 0,2570).

3.2 First-lift Time and Maximum Lifting Rate of Different Seeds in Each Type of Substrate

The duration between the first lifts after sowing is shown in Fig. 2. The statistical analysis shows that the first germination time does not differ significantly between treatments. Nevertheless, we found that in general compared to the seeds of the high Guinean Savannah zone, the seeds from the Sudano-Saharan zone had an average

![Fig. 1. Changes in germination percentage two zones and three substrata](image-url)

ZSS: Sudano-Sahelian zone; ZHSG: High Guinean savannahs zone; BV: cow dung; BC: goat dung; FP: poultry droppings
duration of shorter first germination on all three substrates studied. This can be explained by the geographical distribution of cashew that grows better in dry areas. These results show that the two substrates containing BC and BV (14.66 days) provided a better boost to the germination of seeds in the Sudano-Sahelian zone compared to the substrate containing FP (15.33 days). On the other hand, for seeds in the high-Saharan-Guinean zone, it was the substrate containing the organic amendments of the FP (14.33 days) that had a better influence on seed germination compared to substrates containing BC and BV (17 days; 17.66 days).

Results for the maximum percentage of germination 28 DAS (Fig. 3) in all substrate showed that the highest percentage of germination was observed with the seeds of the Sudano-Sahelian zone and the lowest with the seeds of the area of the high Guinean Savanna zone. The substrates containing BV and BC simulated significantly (86.11%; 80%) the percentage of seeds germination from the Sudano-Sahelian zone compared to the FP substratum (62.33%). However, for the high savannah zone seeds, the effect of substrates does not differ significantly between treatments (p>0.05). We recorded a variation of 84.44% in the FP substratum to 71.11% in substrate BV. There was no significant difference in the effect of substrates on the germination rate of the two seeds used. However, the substratum and seed origin interaction showed that these two factors had a significant effect on the germination of the cashew.

3.3 Growth of Seedlings

The results for the growth of cashew plants after 60 days of sowing are illustrated in Table 2. The parameters taken into account were: the number of leaves, the height of the plants, the diameter at the collars, the leaf surface area and the height-to-diameter ratio. It was observed that the averages of the parameters measured in all substrates show that the seeds of the Sudano-Sahelian zone had good growth vigour compared to those of the high Guinean Savannah zone except for collar diameter.

The height of the cashew plants 2 months after sowing placed under different substrates showed significant differences at the 5% threshold following the variance analysis (p-value = 0.0036. The substrate and seed origin interaction showed that the two factors had a significant effect on the height of the cashew plants (P-value=0.0010). Plants from seeds of Sudano-Sahelian zone, grown in the substrate containing FP recorded less height (14.88cm) and the greatest height was recorded on the substrate containing BC (19.88cm). Meanwhile, in the plants of the high savannah zone of Guinea seed, the greatest height was obtained in plants that were grown in the substrate containing BV (20.27cm) and the smallest height in the plants from substrate containing the FP (10.89cm). Similarly, for the diameter of the collar, the plants with the lowest diameters were obtained in the substrate containing the FP for the two types of seeds (6.22 mm; 6.85 mm) and the higher diameter values were measured on substrates containing BV with values ranging from 7.81mm to 8.51mm respectively for plants from seeds of Sudano-Sahelian zone and high Guinean savannah zone respectively. Collar diameter do not differ between substrate treatment in the both zone and these two factors (substrate and origin of seed) have a not statistically significant effect on collar diameter at the 95.0% confidence level (P-value = 0.2626).

The data on number of leaves summarized in Table 2 showed that the substrate containing BV is the substrate that stimulated better leaf production for the two seed types (9.11 and 7.78) for seeds from the Sudano-Sahelian zone and the High Guinean savannahs zones respectively, while the PF substrate is the substrate with low leaf production (7.89 and 5.44). The analysis of variance at the 5% threshold indicates a not significant difference for the leaf surface area parameter. For seeds in the Sudano-Sahelian zone (zone 1), the leaf area ranges from 47.28 cm² to 16.05 cm² respectively for the substrate containing BC and FP. While for seeds in the high Guinean savannah zone (zone 2), cashew plants obtained from the BC-containing substrates were characterized by a large leaf area (24.63 cm²), while that of the cashew plants substrate containing FP showed low leaf surface values (12.3 cm²).

The height /Diameter ratio values obtained from seed plants of the Sudano-Sahelian zone (zone 1) range from 32.98 to 24.40 respectively in the BC substratum and in the FP substratum. However, for seeds from the high savannah zone, it varies from 23.98 (BV substrate) to 17.92 (FP substratum).
Fig. 2. Average first germination time of both seed types in each substrate
ZSS: Sudan-Sahelian zone, ZHSG: High Guinean Savannah Zone; BV: cow dung; BC: goat droppings; FP: poultry droppings. The averages affected by the same letter, are not significantly different, at the threshold of $\alpha = 0.05$

Fig. 3. Maximum percentage of seed germination (28 DAS) of two types of seeds in each substrate
ZSS: Sudano-Sahelian zone, ZHSG: High Guinean Savannah Zone; BV: cow dung; BC: goat droppings; FP: poultry droppings. The averages affected by the same letter, are not significantly different, at the threshold of $\alpha = 0.05$
### Table 2. Average plant growth parameters 60 days after sowing

| Seed origin | Substrate | Height (cm) | Diameter (mm) | Number of leaves | Leaf surface (cm²) | H/D ratio  |
|-------------|-----------|-------------|---------------|------------------|-------------------|------------|
| ZSS         | BV        | 19.25±1.63c | 7.81±0.83a    | 9.11±4.81b       | 29.93±13.51ab     | 24.82±2.71ab |
|             | FP        | 14.88±0.85ab| 6.22±0.85a    | 7.89±1.92ab      | 16.05±4.6a        | 24.40±4.51ab |
|             | BC        | 19.88±1.65c | 6.82±1.90a    | 8±0.88ab         | 47.28±3.10b       | 32.98±16.90b |
| ZHSG        | BV        | 20.27±2.41c | 8.51±0.76a    | 7.78±4.02ab      | 15.48±6.52a       | 23.98±3.57ab |
|             | FP        | 10.89±4.54a | 6.85±2.92a    | 5.44±2.45a       | 12.3±7.98a        | 17.92±6.68a |
|             | BC        | 16.75±1.84bc| 8.4±0.15a     | 7.11±0.83ab      | 24.63±4.61ab      | 19.98±2.61ab |

P-value | 0.0036 | 0.6056 | 0.2257 | 0.1581 | 0.3336

ZSS: Sudano-Sahelian zone, ZHSG: High Guinean savannah zone; BV: cow dung; BC: goat Droppings; FP: poultry droppings, the averages affected by the same letter, are not significantly different, at the threshold of α = 0.05.
4. DISCUSSION

This study showed that in order to have a rapid and homogeneous germination of *Anacardium occidentale* seeds, the use of good quality of seeds adapted to the environment and an effective substrate is necessary. Indeed, for a good germination of the seeds, the use of a quality substrate is necessary [14]. The results of this research show that 28 DAS, the germination percentage of the seeds range from 71.11 to 84.45% respectively in the substrate containing BV for the two zones (1 and 2). Germination percentages obtained in this work are comparable or even higher than those obtained by Djaha et al. [12]. By studying the germination of seeds of the same species on a substrate composed of free soil, sand and manure in equal proportions, these authors recorded a percentage of germination ranging from 66.6% to 75%. This observed difference between the percentages of germination may be due to the effect of organic matter and the proportion brought into each substrate. The percentage of germination of cashew seeds usually ranges from 93 to 98% in the first few months after harvest and gradually decreases with the storage of the seeds after harvest [15]. Our results on percentage of germination values are similar to those described by this author because the seeds we used in this trial were kept for about four months before being sown.

More or less high percentages of germination were obtained with other species by several authors whose seeds were subjected to different pre-treatments of their own. The work of Ahoton et al. [14] reported that the percentages of germination of *Prosopis africana* seeds reached 100% in erosion sand substrate and 89% in the bar earth substrate. Similarly, a germination percentage ranging from 90 to 100% was obtained on the seeds of *Leucaena leucocephala* (Lam. Wit) [16]. Further a field germination rate of 76.87 to 38.12% on *Balanites aegyptiaca* seeds collected in different ways was reported [17].

The time of first sprout and the germinative faculty 28 DAS varies depending on the substrate and each type of seed. Other studies have also shown that the first time of first sprout of *Prosopis africana* seeds varies according to the quality of the substrate used. In our trial, the FP substrate (77.77%) was less effective on the germination and date of the first sprouting of seeds from Zone 1. On the other hand, this same FP substrate is better stimulated the first sprout time and the percentage of seed sprouting from zone 2 compared to the other two substrates.

With regard to the growth vigour of cashew plants, in the case of our study the values of the Height /Diameter ratio range from 32.98 to 17.92. The higher the Height /Diameter ratio is above 80, the more filiform and poorly held the plants are [18]. Our values are less than 80, reflecting a good vigour of the seeds used. Our observations are consistent with those of Djaha et al. [12] who reported lower values of 80. The values of the Height /Diameter ratio obtained by these authors range from 40.86 to 34.04 respectively for the LAX1432 and LAX 2081 cashew varieties. The number of leaves and the collar diameter does not differ significantly between the two seed and substrate sources. Furthermore, it was reported that the number of leaves and collar diameter parameters did not show a significant difference at the 5% threshold between the LAX 1432 and LAX 2081 cashew varieties. We found, after two months of vegetative growth, that the substrate containing FP (77.77%) was less effective on all measured growth parameters (height, number of leaves, collar diameter and leaf surface area) for both seed types. This result could be explained by the chemical quality of this substrate (FP) which was insufficient to stimulate the growth of cashew plants. Other works have also shown that the low chemical quality of organic manures does not have a stimulatory effect on plant growth [19]. The low efficiency of this substrate is also due to the fact that, the hen droppings used directly (undecomposed) would inhibit plant growth. Toundou [20] noted a restriction of tomato plants under the effect of organic matter (compost from household waste). On the other hand, the other two substrates (BV and BC) had almost similar effects on the growth of cashew plants. This would confirm the availability of essential minerals in these organic manures (cow and goat dung) for the growth and development of cashew. These results are consistent with those obtained by Muyayabantu et al. [21] who found that organic manures contain minerals essential for plant growths.

5. CONCLUSION

The objective of the study at the Wakwa Agricultural Research Centre was to determine the highest rate of sprouting and the best growth of the cashew plants in the nursery. The data obtained in this study showed that seed quality and organic matter used (BV, BC and FP) can...
improve the germination and growth of the cashew tree in a nursery. However, these organic materials do not have the same effects on seed type and parameters measured. Overall, the results showed that of the two types of seeds used, seeds from the Sudano-Sahelian zone showed a better germination rate and good growth vigour compared to that from the Guinean zone. Indeed, the different substrates acted differently on the germination and growth of the two types of seeds used. The study suggests that the origin of seeds and the type of organic matter used in the substrate composition could contribute significantly to the improvement of germination and growth of cashew plants in a nursery.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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