Original Research Article

Compost derived from sugar cane processing waste better improves *Baillonella toxisperma* P. growth in Nkoteng-Cameroon locality

ABSTRACT

Aims: *Baillonella toxisperma* P. (moabi) is a woody which belongs to Sapotaceae family. It is endemic to the forests of Congo Basin, and therefore to Cameroonian forests. In Cameroon, *B. toxiperma* undergoes anthropogenic pressure which may lead to its complete disappearance. In this respect, the establishment of an appropriate technical route for regeneration of this species, which becomes rare because of overexploitation, is a necessity. This study aimed to improve the regeneration of moabi while contributing to sustainable agriculture.

Study Design: A random device design with 5 treatments (control, compost derived sugar cane processing waste, bagasse, molasses and bagasse-molasses mixture) was used.

Place and Duration of Study: Under Bimodal Forest climate in the Central Cameroon region, between September, 2018 and April 2019.

Methodology : Germination rate of moabi seeds, and growth parameters (plant height, foliar production, diameter of stem, and dry biomass of plant) were evaluated to determine the development of the seedlings.

Results : Moabi seeds stored cold at 4°C for 48 hours before sowing germinated better. Compost significantly ($p<0.001$) increased moabi plants growth compared to bagasse, molasses, bagasse-molasses mixture. Dry biomass of treated moabi plants by compost, bagasse, bagasse-molasses mixture and molasses were 1.80; 1.13; 1.78; 1.40 fold greater than those of unfertilized plants respectively.

Conclusion : By producing and using compost derived sugar cane processing waste for moabi growth in Nkoteng-Cameroon locality, we contribute to improve moabi regeneration, to sustainable management of wastes from Sugar Cameroon Society, to the sanitation of environment, and also to effective fight against climate change while ensuring sustainable agriculture.

Key words : *Baillonella toxisperma* P., compost, bagasse, molasses, growth, Nkoteng-Cameroon

1. INTRODUCTION

According to the World Resources Institute, the world has lost about half of its forest cover. Despite a number of initiatives to stop forest decline, the world continues to lose some 15 million hectares of forests every year [1]. Cameroon is endowed with a rich biological diversity within diverse ecosystems that are largely representative of Africa's ecosystems resulting in the reference to Cameroon as Africa in miniature. This high degree of specie, genetic and ecosystem diversity is of significant socioeconomic, scientific, and medicinal importance to its people. It underpins its economy, significantly contributing to the wellbeing of its people [2]. Cameroon's rich biodiversity has made it one of the word's biodiversity hostspots ; it ranks fourth for flora richness. Cameroon has about 465400 km^2 in surface area. In 2005 its forest area was estimated at 26 Mha while in 2000 it was estimated at 28 Mha [3, 4]. Other estimates assume that in 2010 the total forest area was about 19 Mha [5]. From this, about 42% of the total forests are made of tropical rainforest [3]. In Cameroon, about 220 Kha of forests were lost yearly during the decade 1990-2000 with deforestation rates between 0.6-1.0% per annum [5]. Sorne other authors argue that the annual forest area loss in Cameroon between 2000 and 2005 was about 54 Kha [4]. Growth programmes and the development of commercial woody species implemented by the Cameroonian State are carried out with varying degrees of success and this policy is not continuous and regular. Thus, several forest species exploited like moabi are threatened with extinction due to the cumulative action of loggers, farmers and local populations.

Baillonella toxisperma Pierre (moabi) belongs to Sapotaceae family. This species is endemic to the Guinean-Congolese forest of Atlantic coast. It is found in Southern Nigeria, Southern Cameroon, Gabon, Democratic Republic of Congo in Mayombe region, Angola in Cabinda region and in Equatorial Guinea [6]. This woody species has most of its range in the dense forest of Central Africa, Cameroon and Gabon [7, 8]. Mature Moabi produces a wood as hard and solid as oak, and has a reddish-brown tinge that appeals to consumers. It is suitable for exterior joinery (doors, windows, parquet flooring, furniture) [6]. It is exploited in most Central African countries, particularly in Gabon and Cameroon, for a predominant export to Europe [8]. In 2009 Moabi was the 9th most important national timber export in Cameroon [9]. Mooabi seeds oil is used for food, pharmacopoeia (treatment of skin diseases and rheumatism) and cosmetics (soap manufacturing) [10, 8]. *B. toxisperma* is classified as vulnerable according to the IUCN threat categories [11].

The occupation of savannah area in Nkoteng-Cameroon locality by sugar cane fields (a source of raw material for Sugar Cameroon Society (SOSUCAM)) favoured the over-exploitation of neighbouring gallery forests by the populations and loggers, that caused the desappearence of moabi in this area. Recent studies relative to moabi aimed to develop growth and development techniques of this woody species. In this respect, [12] studied the emergence of moabi seeds dormancy and reported that manual seeds scarification accelerates germination. [13] study the growth and development of moabi in two forest of Eastern Cameroon and found that regeration plants rate and survival plants rate at 24 months after transplantation of nursery plants of 6 months age were 100% and 96.20% respectively.

To the best of our knowledge, no work has been carried out on growth and development of moabi by using SOSUCAM wastes. These wastes are bagasse and molasses. They are used after composting for crops fertilization in Nkoteng-Cameroon locality. Thus, the use of bagasse, molasses and compost derived compost and molasses for moabi growth, which is becoming rare due to overexploitation, would contribute to the improvement of it productivity, to a good management of SOSSUCAM wastes while ensuring sustainable agriculture. Indeed, the beneficial influence of natural fertilizers on plant growth and nutrition has been demonstrated [14, 15, 16, 17, 19]. This natural fertilizer is rich in mineral elements necesCompost plays a major role in maintaining soil fertility and, consequently, in thsary for plant growth. It improves soil physical characteristics [20] as well as its biological composition.

The objective of this study was to contribute to growth and development of moabi in Cameroon while protecting the environment. Specifically it consisted to : (1) Determine the physico-chemical characteristics of soil from Nkoteng undergrowth and compost derived SOSUCAM wastes; (2) Study the effects of temperature and scarification on breaking moabi seed dormancy; (3) Study the effects of SOSUCAM wastes on moabli growth. The interest of this study was that treatments that better improve moabi seeds germination and moabi growth will be popularized.

2. MATERIALS AND METHODS

2.1. Study area

The experiment was carried out under Bimodal Forest climate (agroecological zone V) in the Central Cameroon region, precisely in Nkoteng locality. Nkoteng locality is from Haute Sanaga Division. It is located at 136 km Northeast of Yaoundé-

Cameroon. It is limited to the South by Mbandjock Sub-division; to the North by Nanga Eboko Sub-division; to the East by Lembe Yezoum Sub-division and to the West by Sanaga River.

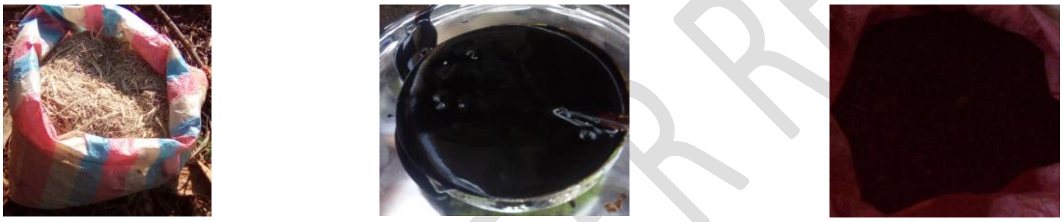
2.2. Moabi seeds

Moabi seeds used were obtained by collecting underneath adult moabi plants in September 2018 in Nomedjoh village located in Lomié Subdivision of Haut-Nyong Division in the East Cameroon region (figure 1).

Figure 1: Maobi seed from forest undergrowth of Nomedjoh village in East Cameroon.

2.3. Fertilizers

Fertilizers used in the current study consisted to SOSUCAM wastes (bagasse, molasses, bagasse-molasses mixture (figure 2)) and compost derived SOSUCAM wastes. Bagasse and molasses were supplied by SOSUCAM while compost was obtained by composting the mixture of bagasse-molasses-chicken droppings-charcoal-maize bran and moist soil from forest undergrowth during one month (September 2018).



a) Bagasse **b)** Molasses **c)** Compost

Figure 2: Fertilizers from sugar cane processing by SOSUCAM

The composting method in pile was used. Composting process was as follows: first, all weeds were removed on composting site. Then, site was moistened and 1 Kg of black soil (soil from undergrowth of Nkoteng forest) was sprinkled on the ground. Subsequently, 30 Kg of bagasse, 0.70 litre of molasses, 33 Kg of bagasse, 33 kg of maize bran and 10 Kg of charcoal were poured on the black soil. Black soil used is rich in various microorganisms involved in the process of organic matter degradation. After this first arrangement, the pile was watered. The same process had been repeated at three times to obtain a pile with a total weight of 180 Kg of biodegradable material and 1 m height. Finally, the pile was covered with a white plastic film in order to increase the internal temperature of the environment and allow thermophilic microorganisms to become active [19, 21]. Turning was done once a day to maintain humidity and ensure proper degradation of chicken droppings, bagasse and maize bran.

2.4. Assessment of physico-chemical properties of substrates

In regards to chamical properties of composts and growing soil, pH was measured using pH meter (Model ORION 230A – Range -2 – 19.99 ± 0.01, USA). Total organic matter was determined by calcining samples in the oven at 550 °C according to [22] and the ash residual was used for some mineral determination. Total nitrogen content was determined after mineralization of samples according to the Kjeldahl method [23] and the dosage was carried out according to calorimetric technique of [24]. The phosphorus content was assessed based on the methods described by [25]. Asseessment of calcium and magnesium were carried out by titration with Ethylene Diamine TetraAcetic [26].

2.5. Study of breaking moabi seeds dormancy

Germination rate of moabi seeds was estimated at 6 weeks after sowing. Soil from undergrowth of Nkoteng forest was used as substrate for the evaluation of this parameter. The soil was taken at 4 cm depth and 500 g were put in each pot. Moabi seeds were selected basic on their phenotypic characteristics, best phenotypes being healthy seeds that are not attacked by pests. A randomised experimental design with 05 treatments (control: untreated seeds; manual scarification: seed coat was scraped off using a razor blade; cold stratification: seeds put at 4 °C for 48 hours in refrigerator; hot stratification: seeds soaked in hot water at 100 °C for 2 minutes and seeds soaked in water at room temperature for 48 hours) was used. Each treatment was repeated 24 times. 02 consecutive pots were spaced 2 cm. Seedling germination rate were determined according to this formula: TG=100 X n/20 where TG=Germination rate; n= number of seeds emerged for a treatment and 24=number of seeds sown per treatment.

2.6. Study of influence of SOSUCAM waste on moabi growth

2.6.1. Land preparation, experimental design and sowing

The experimental site was cleared, and then a fence was put up to prevent animals from adversely affecting the crop. A randomised experimental design with 05 treatments (control : unfertilized plant, compost, bagasse, molasses and bagasse-molasses mixture) was used. Each treatment was repeated 24 times. Space between two consecutive plants was 10 cm. Sowing took place on August 2018. 01 seed was put per pot at 4 cm depth.

2.6.2. Studied parameters, sample and statistical analysis

Growth parameters were evaluated at 7 months after sowing. Plant height was assessed using a decameter and consists to take the height of plants from collar to the highest apex of plant. The number of leaves per plant was assessed by simple counting. The stem diameter was measured using caliper (Transitek, 5-digit LCD model) with 0.01 mm precision. For the assessment of moabi dry biomass, plants were removed from pots with their rhizosphere, after roots were washed with water. Moabi plants with no soil were wrapped in newspaper and then dried in an oven at 105°C for 24 hours and weighed after drying until constant weights were obtained. Dry matter noted MS (g/100g) is expressed as follows: $MS = \frac{(M2-M0)}{(M1-M0)} X100$ where M0 = mass in grams of empty capsule; M1 = mass in grams of capsule containing the test sample before drying; M2 = mass in grams of the capsule containing the test sample after drying and cooling. 10 plants were sampled.

All data were statistically analyzed using the Stagraphic plus Program version 5.0. The significance of differences was determined using Duncan test.

3. RESULTS AND DISCUSSION

3.1. Physico-chemical properties of substrates

There was a significant difference ($p<0.05$) between compost and soil from Nkoteng relative to physico-chemical properties (table 1).

Data relative to Compost moisture content (22.56±2.59%) obtained in the current study are not in conformity with the work of [27] who studied the evolution of physico-chemical characteristics and biological stability of household waste during composting in France and found that compost moisture content was 47.9%.

Produced compost had a pH of 7.12±0.01. This result is similar to data observed by [28, 29, 30] who reported that most composts have relatively high pH (8). In addition, [31] revealed that compost derived household waste had a pH above 9. Soil pH has a direct effect on the bioavailability of nutrients, through solubilization and insolubilization phenomena specific to each element. Thus each nutrient in the soil has a pH range around which it is most readily bioavailable to the plant. The hydrogen potential measures the chemical activity of hydrogen ions (H+) in a solution. pH influences nutrients assimilation by plants. The shape of a molecule changes according to pH of solution in which it is found [32].

The chemical properties of produced compost: nitrogen, phosphorus, calcium and magnesium contents are 1.07±0.03 %; 0.51±0.02 %; 1.01±0.09 ‰ and 130.00 ± 0.02 ‰ respectively, these results are different to those of [33] relative to the impact of organic fertilization on growth parameters of *Hevea brasiliensis* in the Southern Ivoiry Coast who found that nitrogen, calcium and magnesium contents were 0.35, 0.74 and 1.49% respectively. Nitrogen enters, together with other elements as carbon, oxygen and hydrogen in the composition of amino acids composition. It is an essential element for cells constitution and photosynthesis (chlorophyll). It is the main plant growth factor and a quality factor that influences plants protein content [34]. Phosphorus plays a physiological role at several levels. It promotes plant growth. It is an essential element for tissue rigidity, flowerin, earliness, root development, fruit enlargement and seed ripening [35]. An adequate supply of phosphorus allows for harmonious plant development [34]. Furthermore, organic matter plays an important role in management of soil fertility improvement. It provides food for soil life and promotes plant growth through growth synthesized substances by microorganisms when soil is moistened [36]. Its mineralization releases nutrients to plants. It promotes a aerated structure and increases the useful water reserve. In addition, organic matter increases the storage of nutrients such as calcium, potassium and phosphorus [34].

Overall, nutrient elements contents of the produced compost are significantly higher than those of Nkoteng soil, suggesting that this organic amendment could be used for sustainable improvement of soil fertility, however it would be interesting to study the influence of this fertilizer on moabi growth and development.

Table 1: Physico-chemical properties of substrates

Parameter	Soil	Compost
pH	7.13 ± 0.01[a]	7.12±0.01[a]
CondU/S	82.75 ± 4.72[a]	82.75±4.72[a]
Moisture (%)	22.56 ± 2.59[a]	22.56±2.59[a]
Carbon (%)	4.05 ± 0.47[a]	12.15±1.83[b]
Organic matter (%)	6.98 ± 0.80[a]	20.98±0.80[b]
N(%)	1.06 ± 0.80[a]	1.07±0.03[b]
Phosphore (%)	0.30 ± 1.22[a]	0.51±0.02[b]
Calcium (‰)	0.04 ± 0.99[a]	1.01±0.09[b]
Magnesium (‰)	77.73 ± 0.92[a]	130.00±0.02[b]

Values of line affected by the same letter are not significantly different

3.2. Breaking seed dormancy

Germination rates of *Baillonella toxisperma* seeds are presented in table 3. Cold stratification exhibited the highest germination rate (20%) while seeds soaked in the water at room temperature presented the lowest value (5%) of this parameter. Untreated seeds, manual scarification and hot stratification treatments provided the same germination rate (10%). It was observed in this work that the germination rate of *B. toxisperma* seeds varied from 5% to 20%, these values is very lower than data reported by [6] who reported that the development rate of moabi seeds was about 85%. [12] studied the moabi productivity in Dja Reserve of Cameroon and found that seeds germination rate ranged from 4% for seeds stored for 60 days in shady conditions to 86.4% for seeds collected from elephant dung. It is important to know the germinative power of moabi seeds and to study the breaking seeds dormancy in order to control the parameters and strategies for seeds conservation. In this study, cold stratification offered good results relative to breaking moabi seed dormancy because it provided the highest germination rate. It is therefore recommended that moabi seeds be stored cold at 4°C for 48 hours before sowing. If the breaking seed dormancy has been controlled and the best strategy for optimal germination of moabi seeds has been determined, it must still be possible to ensure plant growth by providing the appropriate fertilizer while protecting the environment.

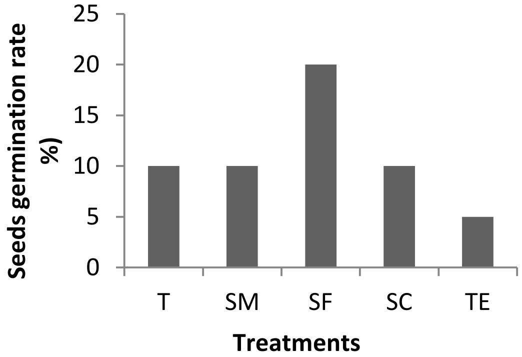


Figure 3 : Seeds germination rate depending on treatment
T: untreated seeds; SM: manual scarification; SF: cold stratification; SC: hot stratification; TE: soaking in water at room temperature.

3.3. Effects of wastes derived sugar cane processing on moabi growth

The analysis of variance (ANOVA) revealed that there is a highly significant difference ($p<0.0001$) between fertilizers (compost, bagasse, molasses, bagasse-molasses mixture and control) relative to growth parameters of *Baillonella toxisperma* (plant height, number of leaves per plant, diameter of stem at collar and dry biomass of plants). Overall, amended compost plants significantly exhibited the highest growth parameters while unfertilized plants significantly provided the lowest values of these parameters.

3.3.1. Moabi plants height

Plants height of *Baillonella toxisperma* at 7 months after sowing are presented in figure 4. Amended compost plants exhibited the highest plants height (52.16 ± 0.64 cm) while control plants were the shortest (30.00 ± 1.54 cm). Height of plants growth on treated pot using bagasse, bagasse-molasses mixture and molasses are 47.07 ± 0.67, 50.10 ± 1.23 and 40.1 ± 1.04 cm, respectively.

The beneficial effect of SOSUCAM wastes on plant growth was demonstrated: [37] studied the effects of wastes derived sugar cane processing and found that malosses encreased the stem weight of sugar cane at 15% compared to unfertilized plants. Futhermore, several authors [21, 38] revealed that there is a positive and significant correlation between plant height and leaf production, between plant height and plant biomass. In this work, the height of amended compost plants were 1.10, 1.04, 1.30 and 1.74 fold higher than that of treated plants using bagasse, bagasse-molasses mixture, molasses and unfertilized plants.

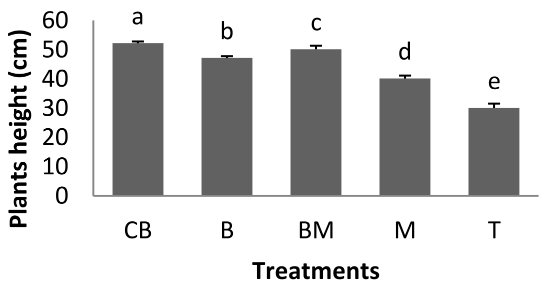


Figure 4 : Moabi plants height at 7 months after sowing
CB : compost, B : bagasse, BM : bagasse-molasses mixture, M : molasses ; T : unfertilized plants. Values of bands affected by different letter are significantly different $p<0.0001$.

3.3.2. Leaf production

The number of leaves per plant varied from 10.10 ± 0.70 for unfertilized plants to 20.20 ± 0.98 for amended compost plants. Leaf production of treated plants using bagasse-molasses mixture is greater (18.60 ± 0.49 number of leaves per plant) than that of treated plants by molasses or bagasse. The number of leaves of treated plants using bagasse and molasses were 17.50 ± 0.5 and 16.60 ± 0.48 respectively (figure 5).

The knowledge of foliar production of *Baillonella toxisperma* is of multiple interest. Foliar production is an indicator of fruit yield. Leaves are the organs responsible for photosynthesis, the increase of moabi leaves would suggest an increase of photosynthetic activity and consequently an increase of seed and oil yields. In this respect, we expected higher fruit yields on amended compost plants. Therefore, the study of influence of SOSUCAM wastes on moabi oil yield need to be investigated. Indeed, [9] revealed that Moabi seeds oil has softening virtues for the body (massage) and hair. In addition, moabi oil is edible and is the subject of a flourishing trade [8, 12]. Moreover, leaf production represents a recyclable biomass: indeed, leaves can be degraded by microorganisms actions and release the mineral elements necessary to improve the physical characteristics, chemical properties and biological composition of soil. Furthermore, [38] reported that there is a positive and significant correlation between foliar production and plant biomass, thus leaf production is an indicator of plant biomass. In this work, the number of leaves per plant of amended compost plant was 1.15, 1.09, 1.22 and 2.00 fold higher than treated plants using bagasse, bagasse-molasses mixture, molasses and unfertilized plants.

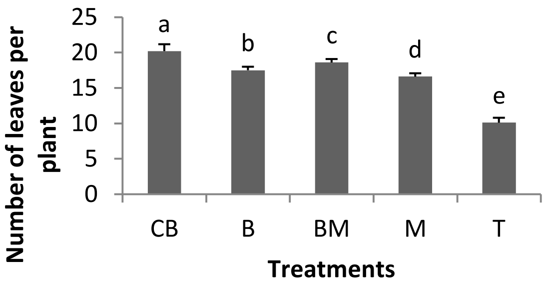


Figure 5 : Leaf production at 7 months after sowing
CB : compost, B : bagasse, BM : bagasse-molasses mixture, M : molasses ; T : unfertilized plants. Values of bands affected by different letter are significantly different ($p<0.0001$).

3.3.3. Diameter of stem at collar and dry biomass of plant

The diameter of stem at collar and dry biomass of moabi plants are recorded in table 2. There was a very significant difference ($p<0.0001$) betwen fertilizers used relative to these growth parameters. Unfertilized and amended compost plants were the shortest and the tallest respectively. Treated moabi plants with bagasse-molasses mixture exhibited the higher values of these growth parameters than fertilized plants by bagasse or molasses.

It is observed in this work that amended compost plants provided the high values of diameter of stem as well as plant biomass. This suggests that bark production of moabi from amended compost pots would be higher. Moabi bark and latex treat rheumatic pain, bronchopulmonary and gastrointestinal ailments, back pain and promote wound healing. The bark decoction is used to treat leukorrhoea and other venereal infections, women use it as a vaginal injection for post-delivery care. Also, bark is used by Bantu and Pygmy poachers to make themselves invisible during hunting. It is important to study the moabi dry biomass because moabi wood is in high demand in the forest industry [9]. Moabi wood is used for plywood, house frames, furniture and is also a good pulp.

In the current study, the diameter of stem at collar of amended compost plant was 1.20, 0.99, 1.47 and 2.27 fold higher than those of treated moabi plants with bagabagasse-molasses mixture, molasses and unfertilized plants. Dry biomass of treated moabi plants with compost, bagasse, bagasse-molasses mixture and molasses were 1.80; 1.13; 1.78; 1.40 fold greater than those of unfertilized plants respectively.

Table 2 : Diameter of stem and dry biomass of moabi plants

Parameters	CB	B	BM	M	T	P-Value
DC	1.34±0.07[a]	1.11±0.06[b]	1.35±0.21[a]	0.91±0.03[c]	0.59±0.05[d]	0.0000
BMSP	46.77±1.04[a]	41.57±1.10[b]	46.56±1.17[a]	36.35±1.14[c]	26.04 ±3.28[d]	0.0000

CB : compost, B : bagasse, BM : bagasse-molasses mixture, M : molasses ; T : unfertilized plants. Values of line affected by different letter are significantly different (p<0.0001).

The beneficial effect of compost relative to moabi growth does not surprise us. Indeed, the positive effect of compost on plant growth and nutrition has been demonstrated [15, 16, 19, 21, 39]. Compost plays a major role in maintaining soil fertility and, consequently in the sustainability of agricultural production. This natural fertilizer is rich in mineral elements necessary for plant growth. The beneficial effect of compost on moabi growth would be linked to combined action of soil properties improvement and the nutrients mineralization. In addition, studies have shown that applieds local resources such as organic wastes to poor and acidic tropical soils provide nutrients needed for plant growth [40]. Compost improves the soil physical characteristics [20] as well as its biological composition. In general, amended compost moabi plants were more productive than those from other pots.

3.4. Correlation between growth parameters

Table 5 showed that there is a positive and highly significant (p<0.001) correlation between moabi plants height and foliar production, diameter of stem and plant dry biomass, moabi plants height and plant dry biomass, number of leaves per plant and plants dry biomass. There was the highest correlation (r=0.96; p=0.0000) between moabi plant height and plants dry biomass while the lowest correlation (r=0.83; p=0.0000) was observed between diameter of stem and leaf production.

Results obtained in this study relative to correlation between parameters corroborate those of [38] who studied the agronomic characterization of local castor bean accessions in the Sudano-Guinean and Sudano-Sahelian savannas of Northern Cameroon and reported that there is a positive correlation between plant height and foliar production, dry biomass of plants and stem diameter. In addition, [21] found a positive correlation between foliar production and plants height. The correlation observed between differents growth parameters suggests that the moabi height growth follows that of tree diameter, foliar production and tree dry biomass.

Table 5 : Corrélation entre les paramètres agronomiques des plantules du moabi

Parameters	PH	NF	DC
NF	r=0.95 ; p=0.0000		
DC	r=0.86 ; p=0.0000	r=0.83 ; p=0.0000	
PDB	r=0.96 ; p=0.0000	r=0.93 ; p=0.0000	r=0.91; p=0.0000

PH : plants height ; NF : number of leaves per plant ; T : plants height; DC : diameter of stem at collar ; PDB : plants dry biomass.

4. CONCLUSION

Compost derived sugar cane process is significantly more rich in nutrient elements (nitrogen, phosphorus, calcium, magnesium) than those of soil from Nkoteng undergrowth. Cold stratified seeds germinate better than seeds that have been manual scarified, hot stratified, seeds soaked in water at room temperature, and untreated seeds. Produced compost significantly increase moabi plants growth compared to bagasse, molasses, bagasse-molasses mixture. Dry biomass of treated moabi plants with compost, bagasse, bagasse-molasses mixture and molasses were 1.80; 1.13; 1.78; 1.40 fold greater than those of unfertilized plants respectively. By producing and using compost derived sugar cane process for moabi growth in Nkoteng-Cameroon locality, we contribute to improve moabi regeneration, to the sustainable management of wastes from Sugar Cameroon Society, to the sanitation of environment, and also to effective fight against climate change while ensuring sustainable agriculture.

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