Asian Plant Research Journal

4(3): 9-16, 2020; Article no.APRJ.57134
ISSN: 2581-9992

Compost Derived from Cattle Manure: Appropriate Organic Amendment for the Regeneration of *Afzelia africana* under Sudano-Guinean Climate of Adamawa Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. Author LTT designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author BKM managed the analyses of the study. Author CM managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/APRJ/2020/v4i330086
Editor(s):
(1) Dr. Langa Tembo, University of Zambia, Zambia.
Reviewers:
(1) Chemutai Roseline, Bukalasa Agricultural College, Uganda.
(2) Juvy G. Mojares, Batangas State University, Philippines.
Complete Peer review History: http://www.sdiarticle4.com/review-history/57134

Original Research Article

Received 12 March 2020
Accepted 19 May 2020
Published 29 May 2020

ABSTRACT

Experiments in pots were conducted in order to establish appropriate technical route for regeneration of *Afzelia africana*, which becomes rare because of overexploitation in the Northern Cameroon. Study was conducted within campus of the University of Ngaoundere (Cameroon) from December 2017 to September 2018. A randomised experimental design with 04 treatments (control: unfertilized plant (T), compost derived from 100% cattle manure (CBV), compost derived from 100% poultry litter (CFP) and mixture 50% compost derived cattle manure with compost derived 50% poultry litter (MCBVFP)) was used. There were 45 plants per treatment. Seedling emergence rate and growth parameters (plant height, number of leaves per plant, diameter of stem at collar and total dry biomass of plant) were assessed, and 30 plants were sampled. Seedling

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emergence rates from treated pots by CBV, CFP and MCBVFP were 2.19, 1.81 and 1.31 respectively fold higher than that from unfertilized pots. There was a significant ($p<0.05$) difference between compost qualities used relative to the growth parameters. CBV, CFP and MCBVFP encreased the total dry biomass of plants at 62.40%, 47.81%, 29.93% respectively compared to T. These results suggest that the origin and the quality of composting substrate was important not only for seedling emergence, but also for the growth of *A. africana*. We recommend the compost derived from 100% cattle manure for the regeneration of *A. africana* in the Nortern Cameroon.

Keywords: Afzelia africana; cattle manure; poultry litter; growth; Cameroon.

1. INTRODUCTION

Afzelia africana is is a woody which belongs to Caesalpiniaceae family [1]. This species is a large tree (up to 35 m) that is widespread in Western Africa in the dry forest zones bordering the savanna. It is mainly found in the Northern hemisphere, from Senegal to Cameroon and Uganda in the East [2]. The hard wood called *Afzelia* is sought for house building. *A. africana* is overexploited for firewood and wood. The stands of this timber species are often cleared for agricultural purposes. *A. africana* presents economic, pharmacological values, and high forage. Breeders prune branches to feed the animals. The bark is very effective in the treatment of many diseases [3]. *A. africana* is included in the International Union for Conservation of Nature (IUCN) Red list of threatened sepecies as vulnerable because of overexploitation [4].

In Northern Cameroon, *A. africana* is under anthropogenic pressure which may lead to its complete extinction. Its leaves are harvested for grazing during the dry season in the Northern Cameroon. Wood are also overexploited for charcoal production. The intensive exploitation of its fodder, combined with bush fires that are very frequent in this part of Cameroon, affects the species' possibilities of regeneration. Previous studies relative to *A. africana* aimed to develop growth and development techniques of this woody species. In this respect, Ahouangonou [5] studied the germination and juvenile growth of *A. africana* in Benin and found that heavy seeds grow better. Seeds heavier than 2 g grow much better than lighter seeds. In addition, Diédhiou [6] studied the effects of mycorrhizal inoculation on the growth and development of *A. africana* in Senegal and reported that this biofertilizer is beneficial for plant growth. *A. africana* is not cultivated in Cameroon.

To our knowledge, no work has been carried out on the growth and development of *A. africana* in Cameroon. In this respect, the establishment of an appropriate technical route for regeneration of this species, which becomes rare because of overexploitation, is a necessity. Therefore, by producing and using compost for the growth of *A. africana* in the Adamawa Cameroon, we would contribute to improve plant productivity, to the sanitation of environment, to limit agropastoral conflicts while ensuring sustainable agriculture. Indeed, the beneficial effects of compost has been demonstrated [7,8,9,10]. Compost plays a major role in maintaining soil fertility and, consequently, in the sustainability of agricultural production. This organic amendment contains various mineral elements necessary for plant growth. It improves soil physico-chemical properties [11] as well as its biological composition.

The main objective of this study was to improve the growth and development of *A. africana* in Cameroon while ensuring sustainable agriculture. Specifically it aimed to: (1) determine the influence of compost derived cattle manure and poultry litter on seedling emergence rate ; (2) assess the effetcs of compost quatlity on the growth parameters of *A. africana*. The importance of the current study was that, the compost quality that would better improve the productivity of *A. africana* will be popularized

2. MATERIALS AND METHODS

2.1 Study Site

Study was conducted in the experimental farm of Laboratory of Biodiversity and Sustainable Development of the University of Ngaoundere (Cameroon) from December 2017 to September 2018. Ngaoundere Cameroon belongs to agro-ecological zone II known as sudano-guinean savannahs with six months raining season (April to October) and six months dry season (November to March). Total annual precipitation and mean annual temperature were 1898.6 mm and 25.75°C respectively [12]. Study site was located at latitude 03°38'805", at longitude 08°20'806", and at 1106 m elevation. The vegetation of study area was a herbaceous savanna dominated by *Pennisetum purpureum, Annona senegalensis*, *Piliostigma thonningii*, and *Imperata cylindrica.*

2.2 Seeds of *Afzelia africana* and Agricultural Pots

Seeds were from the Benoue National Park located in the North Cameroon region. They were collected in March 2017 under adult plants of *A. africana*. These seeds are ellipsoid or oblong-ellipsoid, 1.5-3 cm long, black in colour with an orange cupped aril at the base (Fig. 1). Agricultural pots used measured 20 cm wide and 25 cm long. They are black in colour. These agricultural pots were bought in the local market of Ngaoundere Cameroon.

Fig. 1. Seeds of *Afzelia africana*

2.3 Fertilizers: Composts and Chemical Fertilizers

The different composts used in the current study were produced at the experimental composting unit of the Laboratory of Biodiversity and Sustainable Development located behind the deanship of the University of Ngaoundere. Three types of compost were used. It is compost derived from 100% cattle manure, 100% poultry litter and the mixture of 50% cattle manure with 50% poultry litter (Fig. 2).

2.4 Soil

Soil was collected from the experimental site. It was excavated at 30 cm depth using a shovel. Then, root fragments were manually removed before being used as growing substrate for *Afzelia africana*. This soil was reddish brown in colour and it pH was 6.57±0.20. Moisture, organic matter, nitrogen, carbon, iron, magnesium, calcium and phosphorus contents of soil were 5.83 ±0.15%, 12.11±0.10%, 4.23±0.59%, 7.04±0.10%, 1.81±0.07%, 0.10±0.02%, 0.49±0.00%, 0.41±0.02% respectively [10].

2.5 Composting

Cattle manure originated from a sheep-pen located nearby the campus of the University of Ngaoundere were sequentially collected from 8-9 am daily according to its availability. Poultry litter originated from a henhouse located nearby the campus of the University of Ngaoundere were collected from 8-9 am daily according to its availability and it was stored in 50 kg bag. Both cattle manures and poultry litter were stored in bags and then, transported in the composting area using a rickshaw.

The composting experiment was conducted in 825 m^2 area. Composting process took place from December 2017 to April 2018 (5 months). Composting in pile was used in the process [13]. Herbs and shrubs are removed from the composting site. Then for each compost pile the site is moistened and watered with 1.5 L of bin juice (inoculum). This bin juice is rich in various microorganisms involved in the process of organic matter degradation. Then for each pile of compost, 2 Kg of *Tithonia diversifolia* leaves are spread on the ground. 1.5 L of inoculum is sprayed on these leaves and a layer of raw material (50 Kg) is spread on the moist soil. Finally, 1.5 L of bin juice is sprayed on this layer. After this first arrangement, the pile is watered using water. The same process was repeated three times in order to obtain a pile with 150 kg weight of biodegradable material weight and 1 m height. Finally, each pile was covered with a plastic in order to increase internal temperature of background and to allow the thermophilic microorganisms to enter in activity. Watering and turning took place at regular interval of 10 days to maintain moisture and to ensure good degradation of raw material [10,14]. Fig. 3 illustrates some of the steps of composting.

2.6 Experimental Design and Sowing

The experimental site measured 8.36 m long and 5.40 m wide (45.15 m^2 area). The experimental site was cleared. A randomised experimental design with 04 treatments (control: unfertilized plant, compost derived from 100% cattle manure, compost derived from 100% poultry litter and mixture 50% compost derived cattle manure with compost derived 50% compost derived poultry litter) was used. They were 45 plants per treatment. Space between two consecutive plants was 10 cm. Seeds sown were chosen on their phenotypic characteristics and the best

2a. Cattle manure **2b. Poultry litter** **2c. Mixture of cattle manure with poultry litter**

Fig. 2. Compost derived from cattle manure, poultry litter, and mixture cattle manure with poultry litter

3a. Composting on the 1st day **3b. Piles of compost** **3C. Mature compost**

Fig. 3. Compost appearance at different stages of composting

phenotypes are healthy seeds and are not attacked by pests. The sowing was carried out in June 2018. 02 seeds of *Afzelia africana* were put per pot at 4 cm depth. 10 days after sowing, the plant removal took place and one seedling was left per pot in order to limit competition between seedlings for hydromineral nutrition and light.

2.7 Study Parameters, Sample and Statistical Analysis

Seedling emergence rate were evaluated 10 days after sowing. Plant height and number of leaves per plant were evaluated at regular intervall of 10 days. The diameter of stem at collar and total dry biomass of plant were evaluated at 100 days after sowing. 30 plants were sample. Seedling emergence rate of plant was evaluated according to this formula : TL=100 X n/90 were TL=seedling emergence rate, n=number of seedling emerged plant, 90=number of seeds sown per treatment.

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. Regarding the assessment of dry biomass of *Afzelia africana*, plants were removed from pots with their rhizosphere, after roots were washed with water. 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/100 g) 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.

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

3. RESULTS AND DISCUSSION

3.1 Seedling Emergence Rate of *Afzelia africana* at 10 Days after Sowing

Seedling emergence rate of *Afzelia africana* at 10 days after sowing is presented in Fig. 4. Seedling emergence rate varied from 35.55% for control to 77.77% for compost derived cattle manure. Seedling emergence rates from compost derived poultry litter and mixutre cattle manure with poultry litter were 64.44% and 46.66% respectively. Seedling emergence rates from treated pots by cattle manure, poultry litter and mixture cattle manure with poultry litter were 2.19, 1.81 and 1.31 respectively fold higher than that from unfertilized pots.

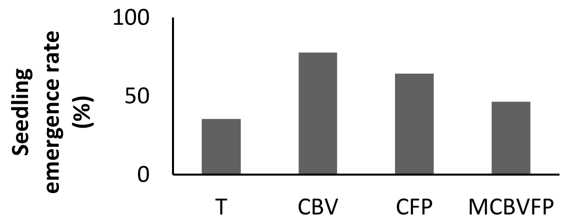

Fig. 4. Seedling emergence rate depending on fertilizer

T: Unfertilized plant; CBV: Compost derived 100% cattle manure; CFP: Compost derived 100% poultry litter; MCBVFP: Compost derived mixture cattle manure with poultry litter

3.2 Effects of Compost Quality on the Growth Parameters of *Afzelia africana*

The growth parameters studied include : plant height, number of leaves per plant, diameter of stem at collar and dry biomass of plants of *Afzelua africana*. Based on the values obtained in the experiment, there was a significant difference for the treatments relative to growth parameters. Compost derived cattle manure exhibited significantly ($p<0.05$) the highest value of growth parameters while the smallest values of these parameters were from unfertilized plants. Generally, there are not significant difference between compost derived poultry litter and compost derived mixture cattle manure with poultry litter on agronomic parameters studied.

3.2.1 Plant height

Fig. 5 presented the variation of plant height of *Afzelia africana* depending on compost quality and time. At 100 days after sowing, treated plants by compost derived cattle manure were the tallest (17.2 ± 1.95 cm) while unfertilized plants were the shortest (14.00 ± 1.5 cm). The height of *Afzelia africana* growth on plot treated by poultry litter and by mixture cattle manure with poultry litter were 16.81 ± 2.11 cm and 15.30 ± 1.95 cm respectively. Treated plants by cattle manure was 1.23 fold than unfertilized plant, while the height of treated plants by poultry litter and by mixture cattle manure with poultry litter were 1.20 and 1.10 fold higher than unfertilized plants respectively. There is a positive and significant ($r=0.90$; $p<0.0001$) correlation between plant height and leaf production of *A. africana.* In this respect, we expected the greatest leaf production from treated plants by compost derived cattle manure because its were the tallest.

3.2.2 Number of leaves per plant

The variation of leaf production of *Afzelia africana* at is presented in Fig. 6. At 100 days after sowing, the greatest leaf productions were from traeted plants by cattle manure (12.40 ± 2.16 leaves per plant) and poultry litter (11.60 ± 2.26 leaves per plant) while plant from pot without any fertilizer exhibitest thes lowest leaf production (8 ± 1.34 leaves per plant). The leaf production treated plants by cattle manure was 1.55 fold higher than that of plants from pots without fertilizer. However the leaf production of treated plants by compost derived poultry litter and compost derived cattle manure with poultry litter were 1.45 and 1.25 fold higher than that of control plants, respectively. The knowledge of foliar production of *A*. *africana* presents multiple interests. The foliage of this tree plays a particularly important role as a source of fodder for livestock during the dry season in the Northern Cameroon, suggesting that the production of this foliage would help to limit transhumance, and consequently the agropastoral conflicts in this part of Sub-saharan Africa. Furthermore, leaf production represents a recyclable biomass: indeed, leaves can be degraded by the action of microorganisms and release the mineral elements necessary to improve soil fertility.

3.2.3 Diameter of Stem at Collar and Total Dry Biomass of Plants

The diameter of stem at collar and plant dry biomass varied from 0.40±0.06 cm and 2.74±0.72 for control plants to 0.62±0.03 cm and 4.45±0.38 for treated plants by cattle manure, respectively (Table 1). In this study, there was a positive and significant correlation ($r=0.82$; $p<0.001$) between the dry biomass of plants and the diameter of stem at collar. Compost derived cattle manure, compost derived poultry littter and compost derived mixture cattle manure with poultry litter encreased the diameter of stem at 55.00%, 42.50%, 27.25% respectively, and the total dry biomass of plants at 62.40%, 47.81%, 29.93% respectively compared to control.

In the present study, the correlation test showed that there is a positive and significant correlation (r=0.82; p<0,001) between plant dry biomass and stem diameter at the collar of *Afzelia africana*. Furthermore, Plants are carbon sinks, and then the higher dry biomass of a plant suggests the important amount of CO_2 sequestered [15], thus suggesting that the use of compost derived cattle manure for the cultivation of *A. africana* can effectively contribute to fight against climate change and desert encroachment in the Far North of Cameroon.

It was observed in the current study that produced compost improve the growth of *A. africana*. The beneficial effect of animal waste on plant productivity has been demonstrated [9,10, 16]. Indded, Poultry litter is a mixture of the substrate, usually rice straw or wood shavings, with food scraps, bird droppings, and feathers. It is rich in various nutrients (N, P and K) [17], this would justify the greater values of growth parameters observed on treated plants using compost derived from poultry liiter than those of *A. africana* plants from no fertilized pots. Due to its composition and availability at low cost, poultry litter can be used by farmers in crop fertilization [18]. Furthermore, Tchuenteu [10] reported that compost derived from cattle manure contains various mineral elemnts like N, P, Ca, Mg, and Fe, thus justifying the beneficial effects of this natural fertilizer on the seedling emergence rate and growth of *A. africana* observed in the current study. Globally, compost derived from cattle manure better enhanced the growth parameters of *A. africana*, this would be explained by the fact that this amendment organic would contain the amounts of mineral elements necessary to well growth of *A. africana* in the study area. However, the nutrient requirements of *A. africana* remain to be studied in order to better explain the beneficial effects of compost derived from cattlle manure on plants productivity.

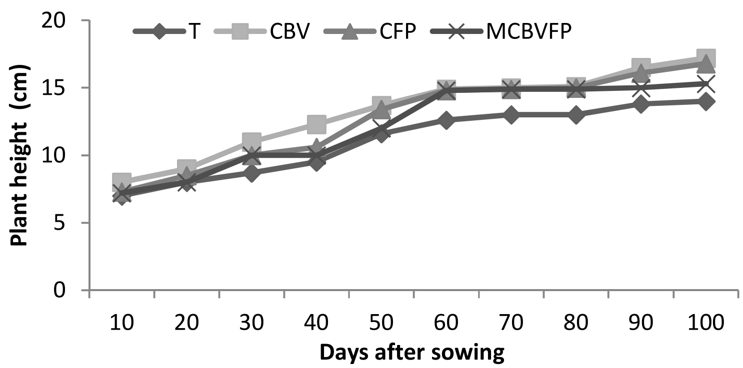

Fig. 5. Variation of plant height depending on compost quality
T: Unfertilized plant; CBV: Compost derived 100% cattle manure; CFP: Compost derived 100% poultry litter; MCBVFP: Compost derived mixture cattle manure with poultry litter

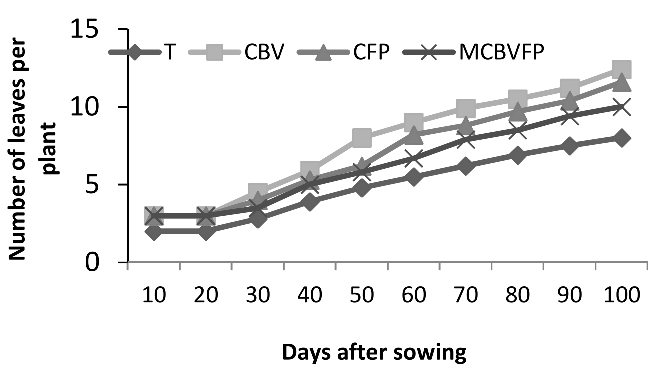

Fig. 6. Leaf production depending on compost quality and time
T: Unfertilized plant; CBV: Compost derived 100% cattle manure; CFP: Compost derived 100% poultry litter; MCBVFP: Compost derived mixture cattle manure with poultry litter

Table 1. Diameter of stem and dry biomass of plant at 100 days after sowing

Parameters	T	CBV	CFP	MCBVFP
DC (cm)	0.40±0.06[a]	0.62±0.03[b]	0.57±0.05[c]	0.51±0.02[c]
BMSP (g)	2.74±0.72[a]	4.45±0.38[b]	4.05±0.51[b]	3.56±0.35[C]

T: unfertilized plant; CBV: Compost derived 100% cattle manure; CFP: Compost derived 100% poultry litter; MCBVFP: Compost derived mixture cattle manure with poultry litter; DC: Diameter of stem at collar; BMSP: Dry biomass of plants

4. CONCLUSION

Based on results obtained from this study, we can conclude that, compost derived from cattle manure better improves the growth and development of *Afzelia africana* under Sudano-Guinean climate of Adamawa Cameroon. Seedling emergence rates from treated pots by cattle manure, poultry litter and mixture cattle manure with poultry litter were 2.19, 1.81 and 1.31 respectively fold higher than that from unfertilized pots. Compost derived cattle manure, poultry littter and mixture cattle manure with poultry litter encreased the total dry biomass of plants at 62.40%, 47.81%, 29.93% respectively compared to control. By producing and using compost derived from cattle manure for the cultivation of *A. africana*, we will contribute not only to improve the growth and development of this plant, but also to effective fight against climate change, and to limit agropastoral conflicts, while ensuring the survival of this woody species, which is threatened with extinction in the Northern Cameroon due to overexploitation.

ACKNOWLEDGEMENTS

The authors thank the anonymous readers for their contribution which permited to improve this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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