International Scholars Journals

African Journal of Wood Science and Forestry ISSN 2375-0979 Vol. 3 (9), pp. 191-197, September, 2015. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

A study of the field capacity of some sacred forest soils of the West Region of Cameroon

[1]Sadou A. Djone, [1]Nlend Eteki, [2]Yang Inoni and [3]Boubakary Nzo Njoya

[1]Department of Forestry, University of Dschang, P. O. Box 67, Dschang, Cameroon.
[2]Department of Horticulture, the University of Bamenda, P. O. Box 39- Cameroon.
[3]Department of Natural Resources Management, Faculty of Agriculture, University of Bamenda, Bamenda, North West Region, Cameroon.

Accepted 24 August, 2015

This study was aimed at investigating the field capacity of three sacred forest soils of the West Region of Cameroon and their effect on the germination potential and early plant growth characteristics of fresh and dried seeds of *Aframomum melegueta.* Sample soils were collected from Bamendjo (BO), Bamendjinda (BA), and Mbing Mekoup (MB) sacred forest areas. Each area was divided into three location sites 1, 2 and 3 and each of the sites was made up of 3 collection points (P1, P2, and P3). The field capacity (FC) of each site was determined before the planting of the seeds. For each collection site, the soil of a collection point was randomly chosen to form two groups with five replicates each. In each pot, 10 fresh seeds and 10 dried seeds were planted respectively and monitored for germination. Measurements for seedling growth were spread over 14 weeks. Results showed that the field capacity (FC) of BO (71.18%) and of BA (68.64%) were significantly different from those of MB (51.66%). The germinating percentages of the seeds were very high in the soils of BO (76. 67%) and BA (61. 33%) as compared to those of MB (48%). The latent period of the seeds was longer in the soils of MB (12 days) and shorter in the soil of BO (7 days). The average height of the plants in the soils of BO (6. 75 cm) and BA (6. 05 cm) were greater than those of the plants in the soils of MB (4.61 cm). The number of leaves of the plants of BO (4), BA (4) and MB (4) were not significantly different. The leaf surface area was higher in BO (10.43 cm²) and BA (8, 30 cm²) as compared to that of MB (5. 37 cm²). This study has shown that the FC of the soils of the sacred forests of BO and BA positively affected the germination percentage and the latent period of the fresh seeds; the leaf surface area and the heights of young plants. Meanwhile, the germination rates of the fresh seeds and *A. melegueta* dried seeds were not affected by the FC of the soils.

Key words: Field capacity, Bamendjo, Bamendjinda, Mbing Mekoup, sacred forests, germination, growth, *Aframomum melegueta*.

INTRODUCTION

The forest is a living environment comprising biodiversity which allows communities to meet their socio-cultural or socio- economic needs. The forests ecosystems of Central Africa offer rural people the

opportunity to always collect non-timber forest products (Honoré, 1999), among these being *Aframomum melegueta* (Jujube), a herbaceous perennial in the Zingeberaceae family. The leaves are simple and asymmetrical with a membranous ligule. The inflorescences are born at the base of the stem with reddish bracts. The fruit is a bright red berry at maturity. It is indehiscent with seeds enclosed in a white pulp.

According to Lékané (2009), *A. melegueta* is an important plant on the socio-economic and socio-cultural planning as its fruits are presented whole during various traditional rites such as in the induction of traditional leaders, successions of next-of-kin, protection, blessing rites and in traditional medicine. The fruits are also consumed as food by humans, primates and some rodents. In modern and traditional medicine, all the parts of this plant are used to cure several illnesses depending on the users and the region in which it is encountered (Rafatullah et al., 1995). According to Baumeer (1995), these fruits are sold in domestic and international markets with prizes varying between 50 and 100 FCFA per berry while a 50 kg bag costs between 14,000 and 20,000 FCFA. Honoré (1999) states that commercialization generates revenues that are intended for household economy and the sales play major economic income generation for the population at large.

A. melegueta is native to West Africa, and is found in Guinea, Nigeria, Gabon, and Cameroon (Geudje et al., 1996). In Cameroon, it is found in the Western Highlands of some sacred forests. These forests include those of Mbing Mekoup (MB), Bamendjinda (BA) and Bamendjo (BO). The populations of this plant and other *Aframomum* species are very low (Tiokeng, 2007). According to Geudje et al. (1996), the propagation of *A. melegueta* presents difficulties at the germination phase but, states that the propagation of *A. melegueta* would be more appropriate with its rhizomes. But this method proved inconclusive during our experience probably due to soil and climatic factors. According to Eyob (2008), the seeds of *A. corrorima* also present germination problems, probably due to their low permeability to water, and observed that the seeds can remain dormant for two to three years before germinating.

Niang-Diop et al. (2010), observed that the germination of seeds in natural ecosystems can be limited by a number of factors including integumentary seed dormancy. It can also be related to other factors including the soil retention capacity of soil water. Lachiheb and Neffati (2005) observed that *Aframomum* seeds could remain dormant for 2 to 3 years before germinating after seeds are planted. Indeed, a seed can germinate if the embryo has the ability to imbibe.

However, seed germination by Babou et al. (2001) is not always the only problem in the regeneration of a species, because sometimes after germination, the seedlings are subjected to several factors such as bush fires, temperature variations and predation which significantly affect the growth thereof and lead to high mortality with few, reaching maturity. This is the case with *A. melegueta* which not only presents difficulties in its germination but also shows significantly high mortality of the plantlets. The amount of water needed by a plant for its metabolic cycle may be derived from its "reservoir" which is the ground. This will depend on its ability to retain water (Segalen, 1958). Assie et al. (2010) state that, the ability of a soil to retain water depends on its texture and topography.

There is however, no existing works on the soil retentive capacity of the sacred forests of Bamendjo (BO), Bamendjinda (BA), and Mbing Mekoup (MB), and thus faced with the problem of regenerating *A. melegueta*, this study was aimed at contributing to the regeneration of this plant taking into account edaphic factors including the water retention capacity of the soil of the three sacred forests and their effects on the germination and early growth parameters.

MATERIALS AND METHODS

Study area

This study was conducted in three sacred forests located in the Western Highlands of the West Region of Cameroon. It culminates at an average altitude of 2,000 m (Kuete and Dikoume, 2000). Residual forest formations that are most often maintained because of their "sacred" nature include Bambotous Sacred forests of Mbing Mekoup located about 2,183 m above sea level at 5° 37'32 'north latitude and 10° 06'28' 'East longitude. It occupies an area of 27.7 ha in the Batcham district. Bamendjinda, another sacred forest, has small and large forest surface areas of 1.2 and 4.2 ha respectively. The study was carried out in the large. These forests are located around 1,327 m above sea level at 5° 36 '48' 'north latitude and 10° 17' 48 '' East. Bamendjo on the other hand, covers an area of 1.8 ha. It culminates to 1,376 m above sea level between 5° 33 '47' 'north latitude and 10° 17' '42' east longitude.

Climate

The Western Highlands have a temperature influenced by altitude fluctuating between 18.9 to 21.1°C (Centre Technique de la Forêt Communale, 2013). The prevailing climate is cool and moist because of their altitude, exposure and latitudinal position. Accor-ding to Suchel (1972), a short dry season (4 months) from November to February and a long rainy season (8 months) from March to October. These highlands receive rainfall of about 2,000 mm/year.

Plant material: *A. melegueta* K. Shum

The plant materials for germination were the fresh and dried seeds collected from populations of the Western Highlands (Figures 1 and 2).

Methodology

The experiment had two specific objectives with the first being to investigate the field capacities of the soils in each of the sacred forest BO, BA and MB; and the second, to investigate the

Figure 1. Fresh fruits and seeds of *A. melegueta*.

performance in the germination of seeds and growth of seedlings of *A. melegueta* in these soils.

Determination of the field capacity

For each sacred forest, soil samples were collected on laid out transects of one hectare from the periphery to the interior of the forest. Each forest area (BO, BA, MB) was divided into three location sites (S1), (S2) and (S3), with each having three collection points that is, .replicates (P1, P2 and P3). Each replicate was separated from the next by a spacing distance of 50 m, and two adjacent sites were also separated by a spacing distance of 50 m (Figure 3). A machete was used to drill to a depth of 0 to 10 cm in the soil. The soil samples were stored in polyethylene bags. A GPS was used to obtain the geographical coordinates (longitude, latitude and altitude). A tape was used to measure the distances among points and between sites. The soil sample collection procedure was the same for the three forests. A total of 27 samples were collected for the three forests.

In the laboratory, soil samples of 350 g were weighed with an electronic balance of mark METTLERPM 2000, and dried. Each of the 27 samples were poured in an envelope of 23 cm x 16 cm layflats and run in an oven at a temperature of 105°C for one week, after which time a constant weight was obtained, and the dry weight (DW) of each sample measured. These were placed in cylindrical boxes of length 11 cm and diameter of 10 cm lay flats. The bottom of each box was perforated with 15 holes of 3 mm in diameter. Each box was placed on top of another of same size but not perforated. Each soil sample was washed with 350 ml of water. After 24 h soil samples were again weighed and the fresh weights (FW) noted. Both weight measurements allowed us to determine the water retentive capacity (WRC) of these soil samples and were calculated as a percentage according to the method of Braudeau and Mohtar (2005).

$$WRC = \frac{FW-DW}{DW} \times 100$$

WRC: water holding capacity, FW: fresh weight, DW: dry weight.

Seed germination

The experiment on germination was spread over eight weeks involving the collection of three soil samples from three sites within the nursery of the Forestry Department of the University of Dschang. According to Nwame (1997) Dschang is at an altitude of 1400 m, between Latitude 5°10' and 5°30' North and Longitude 9°50' and 10°20' East. There are two distinct seasons, the rainy season and the dry season whose start and end periods are not definite nowadays due to climate change. The average annual rainfall ranges from 13 mm in December to 340 mm in September. The temperatures range from between 18.9 to 21.1°C. A total of 900 seeds of *A. melegueta* divided into two groups of 450 fresh seeds and 450 dry seeds respectively were used.

Three soil samples from each site (Site 1, 2 and 3), were collected randomly. The S1 soil from P3 was used to fill 10 polyethylene bags. For S2, P6 soil was used to fill 10 bags of polyethylene and for S3, P9 was used, which gave a total of 30 pots filled per forest site and a grand total of 90 pots for the three sites from which soil samples were collected. The 90 pots filled were treated with fungicides (Furaplants, Country) to prevent fungal attack. Each batch of 10 pots filled was divided into two groups of five pots in which were sown 10 fresh seeds and 10 dry seeds of *A. melegueta* respectively.

Germination parameters measured for over 8 weeks period included: the seed germination rate expressed by the average germination time AGT (the time at which it reached 50% of sprouted seeds); latency (which is the time between planting and first germination) (LT) (Ahoton et al., 2009) and the percentage of seed germination (PG).

Measuring seedling growth

This phase of the work spread over 14 weeks. Shoot height was measured from the base to the apex of the shoot. The leaves produced were counted after every two weeks. The measurement of the length axis of the limb multiplied by the measurement of the short axis multiplied by a coefficient yielded the leaf surface area according to the formula L × W × 2/3 (Raunkiaer, 1934). Growth

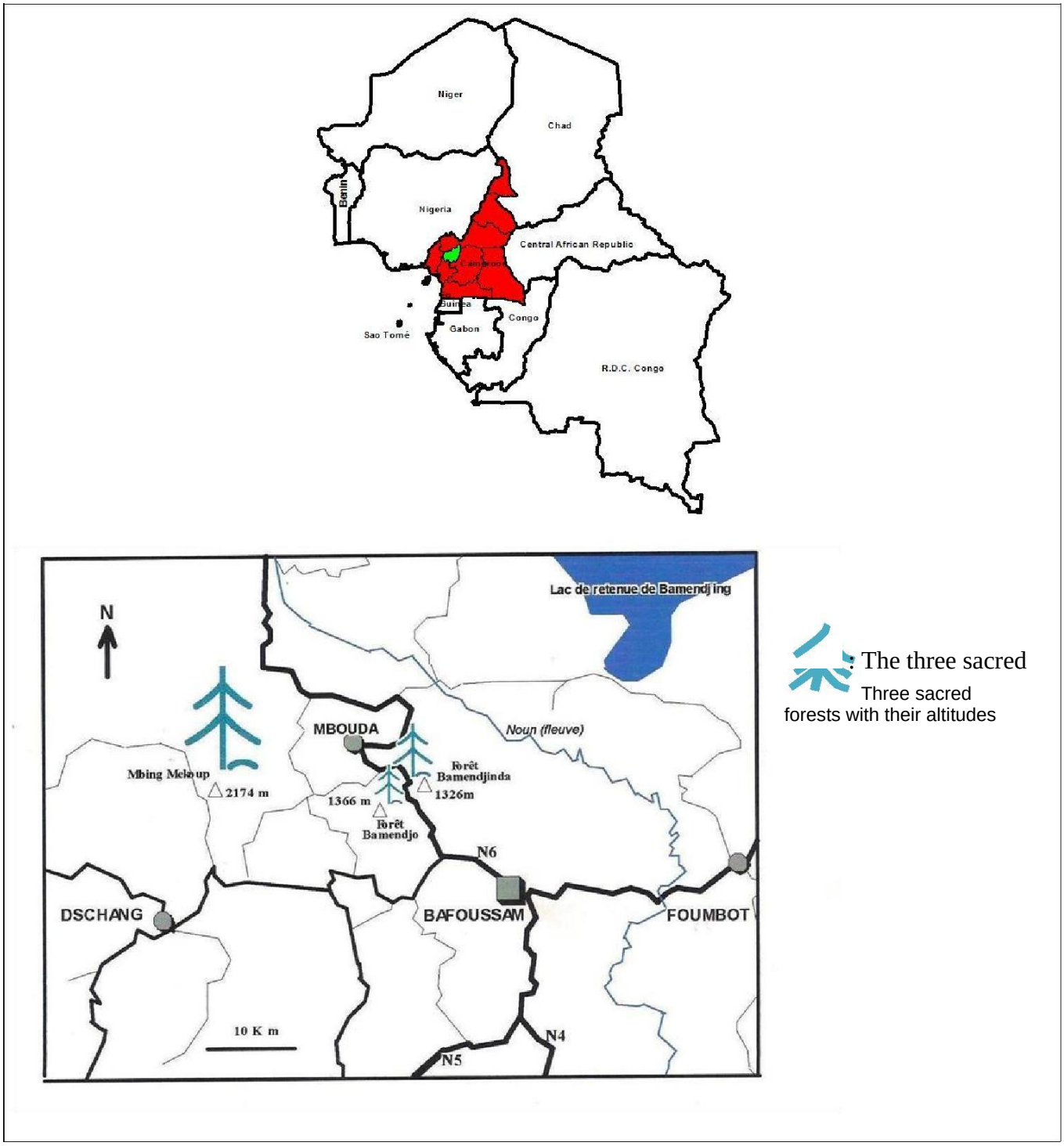

Figure 2. Location map of the study area in West and Central Africa.

Sources: Administrative maps of Cameroon, MOTHERS ISH Centre National Geographic, Yaoundé,1984 - Lifting GPS, September 2006, April 2007 and GARMIN Database 2003.

parameters were measured as follows: the average number of leaves, the average leaf area and the average height of seedlings. These parameters were observed with four seedlings randomly selected from germination bags.

Data analysis

Data were subjected to analysis of variance (ANOVA) and means were separated using the Fischer LSD test. The Sigma Plot

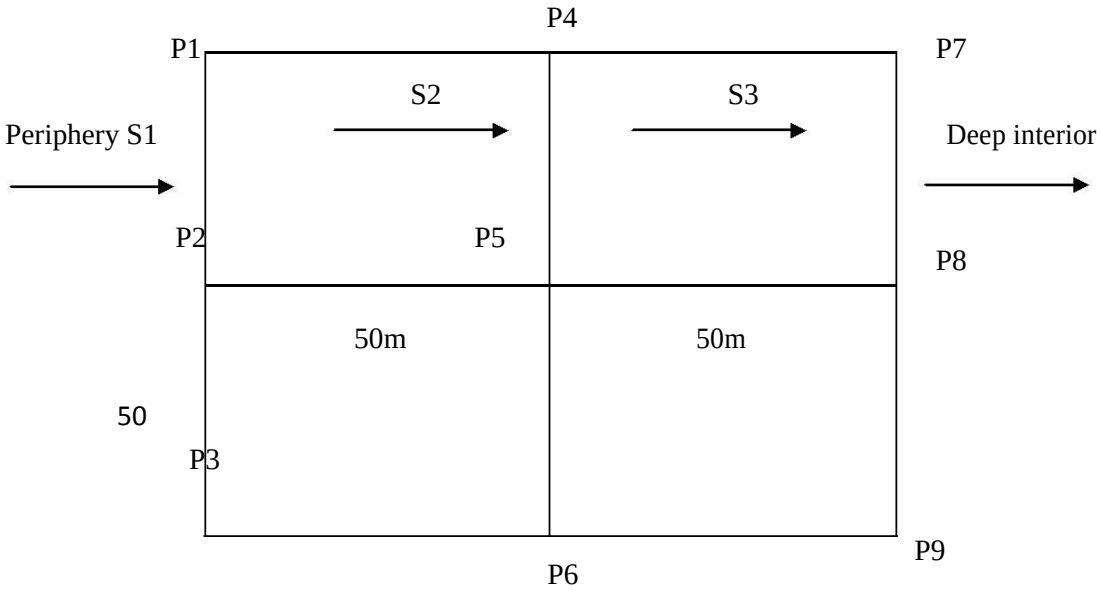

Figure 3. General scheme of the location of sites and points where soil samples were collected S1, S2, and S3 =periphery, mid-interior, and deep forest respectively; P = replicates (P1, P2, P3).

Figure 3: General scheme of the location of sites and points where soil samples were collected S1, S2, and S3 =periphery, mid-interior, and deep forest respectively; P = replicates (P1, P2, P3).

of 27 samples were collected for the three forests. Statistical Version 11 Software was used.

RESULTS

Determination of the field or water retention capacity of the sacred forests soils

Water retention capacity was not significantly different for all sites in collection areas of BO and BA (Table 1). But all the sites of MB recorded significantly low values.

Germination rate

The seed germination rate, expressed by the average germination time (AGT) was not significantly different in the three sites of each area (Table 2).

Latency in days (TL)

The latency time was significantly ($P<0.05$) different for all collection zones, starting from MB, BA and BO in descending order. However, there was no significant ($P>0.05$) difference for the three sites of the same zone (Table 3).

Germination percent

There was no significant difference ($P>0.05$) for seed germination for Site 3 in the different locations (BO, BA, MB). All the seeds of Site 1 of BO germinated, marking a significant difference ($P<0.05$) with the other sites and locations (Table 4).

Seedling growth parameters

Average number of leaves

During the 14 weeks of growth, the mean number of leaves for each site (Table 5) varied between 3.75± 0.52 to 4.12±0.45 for all the sites in all the collection areas, but without any significant difference ($P>0.05$).

Leaf area

The mean values for leaf surface area after 14 weeks of growth varied significantly ($P<0.05$) for the different locations (Table 6) in decreasing order from BO to MB. However, there was no significant difference ($P>0.05$) for the sites within the same collection area.

Height of seedlings in different sites

The seedlings of MB were not significantly different ($P>0.05$) in height for all three sites, but were significantly ($P<0.05$) inferior in height to those of the sites in BO and BA. Very tall seedlings were found in sites 2 of BO and 3 of BA (Table 7).

Table 1. Water retention capacity in the different sites for each forest area.

Area collection	Water holding capacity (%)			
	Site 1	Site 2	Site 3	Zone
BO	72.68^{a} ±0.45	69.65 ^{a} ±0.50	71.02 ^{a}± 0.42	71.18 ^{a} ±1.50
BA	67.23 ^{a} ±0.50	68.67 ^{a}±0.35	70.01 ^{a}±0.25	68.64 ^{a}±0.50
MB	50.96 ^{b} ±0.55	54 ^{b} ±0.52	50.03 ^{b} ±0.53	51.66 ^{b} ±0.54

Means ± SD values from 3 replicates; Values followed by different letter superscripts in the same column are significantly different (P <0.05).

Table 2. Germination rate of seed per area.

Area collection	AGT (weeks)			
	Site 1	Site 2	Site 3	Zone
BO	3.02^{a}±0.35	2.7^{a}±1.50	3.5^{a}±0.50	3.02^{a}±0.51
BA	2.5^{a}±0.71	3.3^{a}±0.42	2.8^{a}±0.51	2.9^{a}±0.45
MB	2.9^{a}±0.61	3.03^{a}±0.44	2.9^{a}±0.54	2.9^{a}±0.56

Means ± SD values from 5 replicates; Values followed by different letter superscripts in the same column are significantly different (P <0.05).

Table 3. Germination latency in days at various sites and collection areas.

Collecting zone	Germination latency time (days)			
	Site 1	Site 2	Site 3	Zone
BO	7.01^{c}±0.50	7.07^{c}±0.35	7.05^{c}±0.45	7.04^{c}±0.51
BA	9.03^{b}±0.65	9.06^{b}±0.56	9.05^{b}±0.46	9.08^{b}±0.36
MB	12.01^{a}±0.25	11.03^{a}±0.52	11.07^{a}±0.45	11.04^{a}±0.50

Means ± SD values from 5 replicates; Values followed by different letter superscripts in the same column are significantly different (P <0.05).

Table 4. Percentage germination (PG) in different sites and soil collection area of each zone

Area	PG (%)			
	Site 1	Site 2	Site 3	Zone
BO	100^{a}±0.00	66 ^{b}±1.52	64 ^{b}±1.55	76.67^{a}±1.53
BA	56 ^{b}±1.58	60 ^{b}±1.45	68 ^{b}±0.59	61.33 ^{b}±0.55
MB	46 ^{c}±0.50	46 ^{c}±0.51	52 ^{b}±0.49	48 ^{c}±0.54

Means ± SD values from 5 replicates; Values followed by different letter superscripts in the same column are significantly different (P <0.05).

Table 5. Average number of leaves in different sites and each area of sample collection and area.

Collection area	Number of leaves			
	Site 1	Site 2	Site 3	Zone
BO	4.10^{a}±0.35	4.12 ^{a}±0.45	4.09 ^{a}±0.51	4.11 ^{a}±0.53
BA	4 ^{a} ±0.02	4 ^{a}±0.01	4 ^{a}±0.03	4 ^{a}±0.04
MB	3.82 ^{a}±0.35	3.75 ^{a}±0.52	3.79 ^{a}±0.50	3.79 ^{a} ±0.51

Means ± SD values from 4 replicates; Values followed by different letter superscripts in the same column are significantly different (P <0.05).

Table 6. Average leaf surface area in the different sites.

Collection area	Leaf area (cm^2)			
	Site 1	Site 2	Site 3	Zone
BO	11.39^{a}±0.30	9.87 ^{a}±1.20	10.02 ^{a}±1.12	10.43^{a}±1.31
BA	8.21 ^{b}±1.51	7.88 ^{b}±1.53	8.81 ^{b}±0.51	8.3^{b}±1.50
MB	5.43 ^{c}±0.50	5.17 ^{c}±0.50	5.5 ^{c}±0.50	5.37^{c}±0.50

Means ± SD values from 4 replicates; Values followed by different letter superscripts in the same column are significantly different (P <0.05).

Table 7. Height of seedlings after 14 weeks of growth.

Collection area	Height (cm)			
	Site 1	Site 2	Site 3	Zone
BO	6.94 ^{a}±1.45	7.68 ^{a}±1.50	5.61 ^{b}±1.55	6.75 ^{a}±1.51
BA	5.41 ^{c}±1.41	5.52 ^{c}±1.40	7.22 ^{a}±1.42	6.05 ^{a}±1.43
MB	4.3 ^{c}±0.54	5.17 ^{c}±0.50	4.34 ^{c}±0.51	4.61 ^{c}±0.52

Means ± SD values from 4 replicates; Values followed by different letter superscripts in the same column are significantly different (P <0.05).

DISCUSSION

The study which investigated the field capacity of soils of three sacred forests in the Western Highlands of Cameroon and the germination and growth potential of *A. melegueta* in these soils, was worthwhile since it has gone a long way to determine at what water retentive field capacity to propagate especially, the fresh seeds of *A. melegueta.*

The soil with the optimum field or water retention capacity positively influences the germination latency and percentage of germination, as stated by Braudeau and Mohtar (2005). The field capacity is significantly important in the sacred forests of BO and BA compared to those of MB. High field capacities positively influence the germination latency of the fresh seeds of *A. melegueta*, which is significantly shorter in BO and BA compared to MB. According to Dirik (2000), these seeds have germination latency between 7 to 12 days. This is in agreement with the data obtained in this study. The seed germination rate did not appear to have been significantly affected by the soil field capacity, because it did not vary significantly among the three areas.

In the MB area, the field or soil water retention capacity did not seem to be sufficient or optimal for rapid germination. The values of the latency and germination percentages were low. These soils are not so favourable for seed germination of *A. melegueta*. The sacred forests of BO, BA and MB are located at 1.376, 1.327 and 2.183 m altitudes respectively, implying that climatic conditions are not comparable. These slower and lower germination factors at MB may be primarily a temperature effect due to the considerable higher altitude. It is also possible that weather conditions have had an influence on the physical and chemical properties of soils of the sacred forests of BO and BA which helped to get a good germination of *A. Melegueta.*

Despite the significantly large water retention capacities of the sacred forests of BO and BA, dry seeds of A. *melegueta* could not germinate after 22 weeks of obser-vation, this, confirming the results of Lachiheb and Neffati (2005) that *Aframomum* seeds could remain dor-mant for 2 to 3 years before germinating after planting. But this does not exclude the fact that the amount of water is very important for the germination of a seed because, accor-ding to Niang-Diop et al. (2010) a seed can germinate if the embryo has the ability to imbibe.

Soil water holding capacity had a positive effect on growth of leaf surface area of seedlings. Bamendjo (BO), with higher water holding capacity significantly affected the growth in leaf area of seedlings of *A. melegueta*. The same holds for Bamendjinda (BA) which had an elevated water holding capacity and achieved growth in leaf area significantly higher compared to MB. There was however, no significant difference in number of leaves indicating that other factors such as light, temperature and composition of mineral elements could have influenced the growth of this plant (Lachiheb and Neffati, 2005). According to Theodore et al. (1971), the variations in quantity of water in the soil can affect the metabolism of a plant which may have an influence on the growth of a plant species. The water holding capacity of soils of BO and BA positively affected the growth in height of seedlings while that of MB did not. These results are similar to those of Enti (1998); who observed that high soil water holding capacity can ensure good plant growth.

Conclusion

In conclusion, soil field or water retention capacity of different sites of sacred forests of the Western Highlands affected the germination of fresh seeds of *A. melegueta*. It is also clear from this experiment that the domestication of this plant is possible with fresh seeds since the dry seeds did not germinate.

The soil water retention capacity of different sites in a sample collection area of soil and those of a collection zones also affected seedling growth of *A. melegueta*. The sacred forest of Bamendjo and Bamendjinda showed a positive effect and this affects the regeneration of *A. melegueta*. The values for the sacred forest Mbing Mekoup show that higher soil water retention capacities are needed for a better regenerate of *A. melengueta*.

Conflict of Interest

The authors declare that they have no conflict of interest.

ACKNOWLEDGEMENTS

We wish to acknowledge the moral and financial support of the Heads of the Laboratories of Applied Botany, and that of the Soils and Environmental Science, not forgetting, the authority of the Forestry Nursery Unit, all of the University of Dschang. Our appreciation is also extended to the traditional rulers of the localities of the Sacred Forests of the Western Highlands of Cameroon.

REFERENCES

Ahoton LE, Adgakpa BG, M'po Fonti M'po, Akpo LE (2009). Effets des prétraitements des semences sur la germination de *Prosopis africana* (*Caesalpianceae*). *Tropicultura*, 4:233-238.

Assie KH, Angui KTP, Danho DM, Tamia AJ, Savane I (2010). Effets des contraintes morpho- pédologique sur quelques propriétés hydrodynamiques des sols sous différents agrosysteme au (oumé) Centre –ouest de la Cote d'Ivoire. J. Appl. Bio-Sci. 34:2145-2155.

Babou AB, Sibiri GS (2001). Longevity of seeds and constraints to the survival of seedlings of *Afzelia africana* in a woodland of Burkina Faso. Ann. For. Sci. 58(69):1–11.

Baumeer M (1995). "Trees, shrubs and bushes foster in West Africa." Dakar: Enda Tiers – Monde. P 260.

Braudeau SM, Mohtar RH (2005). "Hydrostructural characteristics of two African tropical soils." Eur. J. Soil Sci. 56:375-388.

Centre Technique de la Forêt Communale (2013). Rapport d'enquête socio-economique des villages riverains a la reserve forestiere (nteingue). Centre Technique de la Forêt Communale, Yaoundé, Cameroun. Pp. 1-24. http://www.foretcommunale-cameroun.org/download/ESEForeke.pdf

Dirik H (2000). "Effect of osmotic water stress on seed germination among provenances of Cedar of Lebanon of Turkish origin." Ann. For. Sci. 57:361-367.

Enti AA (1998). "The rejuvinating Plants of Tropical Africa. Ed. FSL Scale In the North Institute, San Francisco. P 3.

Eyob SM, Appelgren, Rohloff G, Tsegaye A, Messele G (2008). "Traditional medicinal uses and essential oil composition of leaves and rhizomes of *Aframomum Corrima*". Gansen Southern Ethiopia. S. Afr. J. Bot. 74:181-185.

Geudje NM, Van DJFW, Nkongmeneck BA (1996). "Ecological Evaluation of some Non Timber Forest Products of Bipindi region. Akom II: abundance, distribution and the impact of harvesting on forests. "Tropenbos Cameroon program. (Internal document).12p

Honoré T (1999). "The Market for Non-Timber Forest Products in Central Africa in France and Belgium." Occasional Paper. 32p.

Kuete MR, Dikoume A (2000). "Space, power and conflict in the highlands of West Cameroon." Space, Society, CEREHT. University Press of Yaoundé. P 149.

Lachiheb K, Neffati ZM (2005). "Germination ability of some spontaneous halophyte grass of the Southern Tunisia." Higher Institute of Arid Regions. Medenine, Tunisia. Faculty of Sciences of Tunis, University Campus 2092 Tunisia. P 6.

Lékané TD (2009). "*Aframomum* serving the natural and cultural diversity of Grass fields of Cameroon: Valuation Issues of cultural products and sustainable management of shallows and interfluve." University of Yaoundé I Geography Department. Symposium "locate products." P 7.

Niang-Diop F, Sambou LBA (2010). "Natural regeneration of *Prosopis africana* Constraints: factors affecting seed germination." Institute of Science Anta Diop. Dakar Fanna, Senegal. 4 (5):1693-1705.

Rafatullah SA, Gabal AM (1995). "Gastric and duodenal antiulcer and cytoprotective effect of *Aframomum melegueta* in rats." Int. Pharmacogn. J. 33:311-316.

Raunkiaer F (1934). The life forms of plants and statistical plant geography. Oxford and the Clarendon Press. 547p.

Segalen P (1958). Les sols de l'Ouest Cameroun. Notice sur la feuille de Mgitapon. Repport I.R.CAM. pp 94, 31.

Suchel JB (1972). "The distribution of rainfall and rainfall patterns in Cameroon. Contribution to the study of climates from Tropical Africa. "Trav. and Doc. Tropical geographies. Univ. Fed. Cam. Bordeaux, France. P 287.

Theodore AE, Hsiao C, Henderson WD (1971). Immediate and Subsequent Growth Responses of Maize Leaves to Changes in Water Status. Plant Physiol. 48:631-636.

Tiokeng B (2007). "Diversity, structure, use and local conservation mode of some sacred forests in the Western Highlands of Cameroon." Master's thesis, University of Dschang. 120 P.