Vol. 17(8), pp. 65-75, September 2023
DOI: 10.5897/AJPS2023.2313
Article Number: A8D1D8A71412
ISSN 1996-0824

http://www.academicjournals.org/AJPS

ACADEMIC JOURNALS
expand your knowledge

African Journal of Plant Science

*Full Length Research Paper*

# Effect of soil provenances on seed germination and seedling growth of *Aframomum citratum* (Pereira) K. Schum

**Christiana Ngyeti Nyikob Mbogue[1], Anjah Mendi Grace[2]*, Nkemnkeng Francoline Jong[1] and Jane Iyinji Anyi[1]**

[1]Department of Plant Sciences, Faculty of Science, University of Bamenda, P. O. Box 39, Bambili, Cameroon.
[2]Department of Plant Biology, Faculty of Science, University of Dschang, P. O. Box 67, Dschang, Cameroon.

Received 13 May, 2023; Accepted 4 August, 2023

**Soil that is rich in organic matter means soil that is rich in physical and chemical properties and enhances plant growth and development. The objective of this study was to investigate the effect of soil provenance on seed germination and seedling growth of *Aframomum citratum.* Soil provenances were Buea, Dschang and Bamenda. These respective soil types were filled into 25 cm diameter polyethylene bags and pretreated with a systemic fungicide and nematicide prior to the sowing of 432 dried seeds and 432 fresh seeds of *A. citratum*, arranged in a Complete Randomized Design in a temperature-controlled glasshouse. Germination monitoring and data collection (germination percentage and germination speed) was done daily for six weeks. Early growth parameters (number of leaves, leaf surface area and height of seedlings) were measured weekly for eight weeks. Fresh seeds started germinating 2 months after sowing. Dried seeds treated with 50% diluted $H_2SO_4$ for 20 min, did not germinate. Soil types significantly affected the cumulative germination percentage and early growth ($p<0.05$). Highest germination percentage (58.33%) was produced in Bamenda soil, least in sand (20%) but then, Buea soil produced healthiest seedlings. Germination of *A. citratum* seeds can be effectively realized based on information from this research.**

**Key words:** Germination, seeds, soil physiochemical properties, Zingiberaceae.

## INTRODUCTION

Seed germination and early seedling growth phases are considered critical for raising successful crop stand density and consequently the yield of resultant crop (Hossain et al., 2005). Germination of seeds can be influenced by many factors such as the type of substrate used and environmental factors such as supply of oxygen and water, temperature, and light (Hartman et al., 2007). Germination and emergence are the two most important stages in the life cycle of plants that determine the efficient use of the nutrients and water resources available to plants (Gan et al., 1996) and their competition for an ecological niche (Forcella et al., 2000). Therefore, studies on factors that affect germination, survival percentage and seedling growth for a particular plant species are required.

*Aframomum citratum* is a perennial herb in the family

*Corresponding author. E-mail: ngracemendi@yahoo.com. Tel: 677539417.

Zingiberaceae (Ginger family) with underground rhizome and stems up to 4 m high, which are red at the young stage of growth. Its leaflets have petioles about 2 cm long with oblong linear blade and an asymmetric rounded base. Their inflorescences originate at the base of the stem with reddish ovate bracts up to 6 cm wide. They have trimerous flowers, tubular calyx and oblique truncates of up to 7.5 cm in length. They possess a 3-lobed tubular corolla spreading oval with sharp edges, measuring about 7 cm × 5 cm. The fruits are ovoid with a capsule of about 3 cm in diameter, extended by the long tube of the calyx. The seeds are small (± 3 mm in diameter), numerous, sub-globulous, and contained in a white pulp (MINFOF 2007). The fruits of *Aframomum* species are eaten fresh by men, monkeys and rodents (Lékané, 2009). The seeds of *A. citratum* serve as a condiment to add spice during seasoning and various other dishes in Bassa communities in Cameroon (Vivien and Faure, 1995). Their rhizomes and large leaves protect soils against erosion (Eyob et al., 2008). Agriculturally, Nelson et al. (2010) demonstrated that *A. citratum* seed extract is a potential antifeedant which can be used as an environmentally friendly insecticide. According to Tabuna (1999), the fruits of this species were sold in Africa and Europe to generate income. The seed is the only part of *A. citratum* which is used in the traditional pharmacology to cure cough. It also serves as a thickening agent in medicinal preparations (Laird, 2000). *A. citratum* has been designated a non-forest timber product (NTFP) in the Congo Basin and the part exploited are the seeds and leaves (FAO, 2005), thus its propagation potentials are paramount for sustainability.

Several studies have been carried out on the effects of soil physicochemical properties on germination and growth performance of some plant species. The declination of soil fertility is considered as an important cause for low productivity of many soils (Sanchez, 2002). Culture media or soil composition used influences the quality of seedlings (Wilson et al., 2001). This is confirmed by Agbo and Omaliko (2006), who wrote that nursery potting media influence the quality of seedlings produced.

Despite its socio-economic and pharmacological importance, knowledge on its propagation is still lacking (Anjah and Christiana, 2020). This study was aimed at investigating the effect of some soil physicochemical properties on the germination and early growth of fresh and dry seeds of *A. citratum*.

## METHODOLOGY

### Soil sample collection areas and study site

This study was carried out in two phases. The first involved the collection of soils from three Regions of Cameroon on a 1 ha land each: Buea situated in the Southwest Region in latitude 4°10′0″N, longitude 9° 14′ 0″ E and altitude 870, Bamenda situated in the Northwest Region in latitude 5° 57' N, longitude 10° 10' E and altitude 1,614 m and Dschang situated in the West Region in latitude 5° 26' N, longitude 10° 26' E and altitude 1,400 m. the seeds used for this study was collected from Bali Nyonga (Northwest Region of Cameroon) irrespective of the fact that it naturally grows in the South Region of Cameroon. Hence, in order to test if this plant can be domesticated in other arias, these sites were chosen for collection of soil because they are all in the Western Highland of Cameroon.

The second phase involved observation and monitoring of germination and early growth parameters, by the establishment of a non-midst propagator where seeds were sown in polyethylene bags. The study was conducted in Dschang, at the IRAD research farmland (Figure 1).

### Soil collection and soil analysis

The zigzag sampling method was used to collect soils (FAO, 2004). The laboratory of Soil and Environmental Chemistry of FASA was used for detailed chemical, textural and structural analysis of the soils. To prepare these soils for analysis, soil samples were mashed using a pestle and mortar, passed through a 2-mm sieve to remove large debris, and then air-dried. 500 g of each soil sample was then put into zip lock bags, labeled and analyzed in the laboratory using standard techniques (Ghosh and Kundun, 1991). The control media for this research was sand.

### Chemical analysis of soil

The soil organic matter was determined using the Walkley-Black procedure.

Soil pH for water and potassium chloride was done using a pH-meter with a glass electrode (Hanna Instruments) in a suspension of 1:2.5, soil and 0.01 M $CaCl_2$ (DIN ISO 10390 2005).

Soil P, Na, Ca and Mg concentrations were determined using the complexometric titration procedure outlined by Lakanen and Erviö (1971).

Determination of the Cation Exchange Capacity (CEC) was obtained by summing the exchange acidity (EA) and total exchangeable bases (TEB). Determination of EA was by $BaCl_2$-TEA (Barium dichloride- triethanolamine) method (Walkley and Black, 1934).

### Physical analysis of soil

Soil texture was analyzed using the hydrometer method (Shepherd, 2000).

For soil structure, together with a field guide, this phase consisted of a visual description of the different soil types (granular, blocky, platy, prismatic, etc.), size, grade and consistency (McGarry and Sharp, 2003).

### Plant material: *A. citratum* K. Shum

The plant materials for germination were fresh and dried seeds collected from population of the North West of Cameroon, precisely in Bali Nyonga (Figure 2).

### Floatation test

This process was to estimate the percentage of viable seeds in a seed lot. Water at room temperature was the separating agent (Wamegni, 1991). Both fresh and dried seeds of *A. citratum* were soaked into separate containers of water for 30 min. The seeds that floated were not viable while those which settled at the bottom of the container were considered viable to germinate.

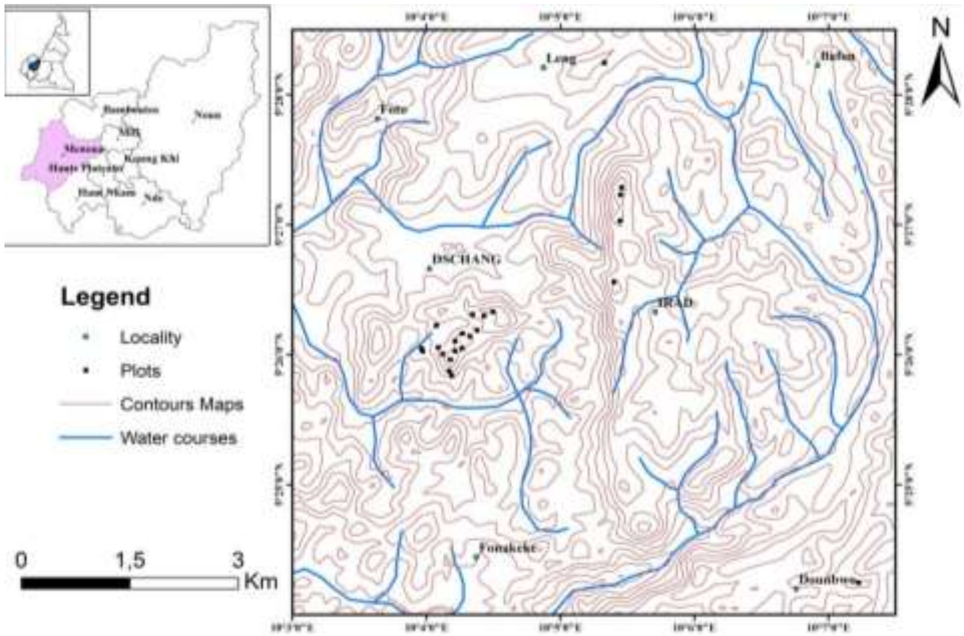


**Figure 1.** Location map of the regeneration study area.
Source: Research coordinates

**Figure 2.** Fresh fruits of *A. citratum* (a), dried fruits of *A. citratum* (b), and seeds of *A. citratum* (c).
Source: Anjah and Christiana, 2020

**Experimental design and data collection**

The study was conducted in the nursery of the Department of Forestry FASA located in "Campus A" of the University of Dschang. The experiment ran for a period of 22 weeks. A total of 864 seeds of *A. citratum* were used for this research. 432 fresh seeds and 432 dry seeds. 36 polythene bags were filled per soil origins and same for sand, hence a total of 144 polythene bags. The polythene bags were laid out in a Randomized Complete Block Design inside a non-mist propagator of 4 m × 2 m. The 144 filled pots were treated with fungicides (Furaplants) to prevent fungal attack. Each batch of 36 filled pots was then divided into two groups of 18 pots each, in which were sown 108 fresh seeds and 108 dry seeds of *A. citratum,* respectively. The dry seeds were treated with sulphuric acid diluted at 50% to enhance germination; while the fresh seeds received no treatment. In each bag, 6 seeds of *A. citratum* were sown but only one per hole. Manual watering was applied after every two days to the seeded bags using a watering can, so that the medium substrate was kept moist without getting water logged. The experimental design was the same for fresh and dry seeds.

Germination and early growth parameters were monitored and calculated as follows (Niang et al., 2010; Keshava et al., 2014):

$$\text{Germination percentage} = \frac{\text{Number of seeds that germinated}}{\text{Total number of seeds that were planted}} \times 100$$

$$\text{Germination speed (GS)} = \frac{n1}{1} + \frac{n2}{2} + \frac{n3}{3} + \cdots \frac{nx}{x}$$

where $n_1 \ldots n_x$ = number of seed germinated per day and 1, 2, 3…x = number of days.

(1) Shoot height (SH) was measured from the base of the plants to the apex.
(2) Number of leaves (NL) were counted on the stem every day after one week.
(3) Leaf surface area (SA): SA = L × W × 2/3 (Raunkiaer, 1934),

**Table 1.** Soil physicochemical properties.

| Soil texture (%) | Bamenda | Dschang | Buea |
|---|---|---|---|
| Sand | 43 | 45 | 45 |
| Silt | 6 | 8 | 10 |
| Clay | 51 | 47 | 45 |
| **Soil reactions** | | | |
| $H_2O$-pH | 6.90 | 7.30 | 5.80 |
| KCL-pH | 6.10 | 6.80 | 5.00 |
| **Organic matter** | | | |
| Organic carbon (%) | 4.33 | 3.20 | 5.23 |
| Organic matter (%) | 7.50 | 5.52 | 9.02 |
| Total nitrogen (g/kg) | 3.05 | 2.76 | 2.20 |
| C/N ratio | 14 | 12 | 24 |
| **Exchangeable cations (milliequivalents/100 g)** | | | |
| Calcium | 8.24 | 4.64 | 9.48 |
| Magnesium | 0.32 | 2.91 | 1.04 |
| Potassium | 0.54 | 0.38 | 0.88 |
| Sodium | 0.06 | 0.01 | 0.03 |
| Total | 9.16 | 7.94 | 11.43 |
| **Cation exchange capacity (meq/100 g)** | | | |
| Effective CEC | 9.16 | 7.94 | 11.43 |
| S/CECE (%) | 100 | 100 | 100 |
| CEC pH7 | 31.20 | 31.04 | 33.40 |
| Saturation bases (%) | 29 | 26 | 34 |
| Assimilated phosphorus | 33.00 | 67.23 | 46.00 |
| Exchangeable acidity | 0.00 | 0.00 | 0.00 |

where L: length of leaf blade and W: width of leaf blade.

(4) Seedling vigor (SV) =

$$\frac{\text{Total number of healthy seedlings}}{\text{Number of total seedlings}} \times 100.$$

### Data analysis

All data collected were entered in EXCEL sheets, the results were submitted to analysis of variance (ANOVA). Using XLSTAT, the least square means was used to detect significance of growth rate in *A. citratum* plants. An effect was considered significant if its p-value was ≤0.05 (Gomez and Gomez, 1984) and means were compared with the Duncan Multiple Range Test. Data is represented using tables and figures subsequently shown.

## RESULTS

### Soil physiochemical properties

Data in Table 1 shows the physiochemical properties of soil samples collected from different localities. The soil samples from Dschang and Buea had the highest percentage of sand (45%), while Bamenda had the least with 43%. 10% of silt was present in Buea soil, 8% in Dschang soil and 6% in Bamenda soil. The percentages of clay also varied in the different soil samples with Bamenda having the highest of 51% followed by 47% in Dschang soil and the least in Buea soil sample, which was 45%. As concerning the pH values of water ($H_2O$) and potassium chloride (KCl) for the different soil samples, the soil water pH had a low basic concentration in Dschang (7.3), very low acidic concentration in Bamenda soil sample (6.9), and finally, an acidic concentration in Buea soil sample (5.8). The same pattern occurred for KCl pH, but with different values: that of Dschang soil was 6.8, 6.1 for Bamenda soil and 5.0 for Buea soil. Also, a variety of cations were present in all three soil samples. The presence of these cations was quantified in milliequivalents/100 g. Total cations for Bamenda soil was 9.16, while that of Dschang was 7.94 and Buea was 11.43. In addition to that, the degradable contents of the sampled soils showed the quantity of organic carbon contents which were present in the soil

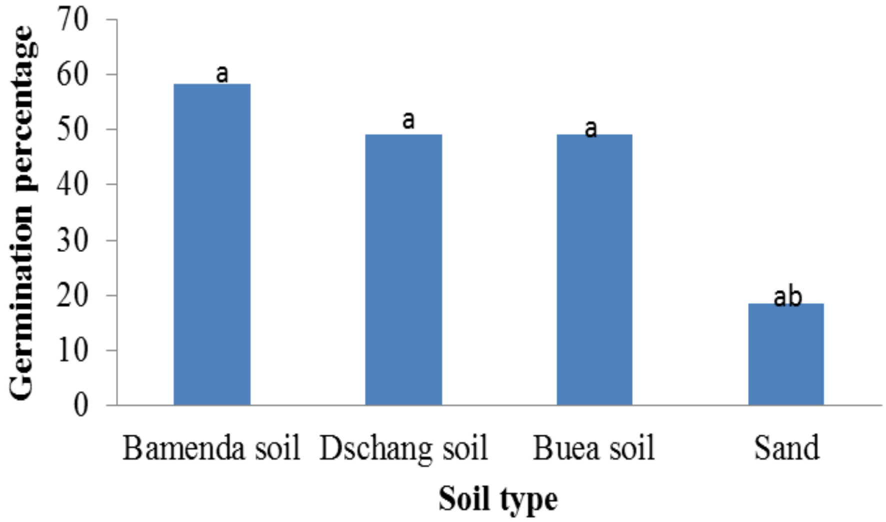


**Figure 3.** Effects of soil provenance on germination percentages.

samples. Generally, the C/N ratio was 24 for the soil of Buea, 14 for Bamenda and Dschang had the lowest (12). It is worth noting that, overall, the more desirable soil properties remain highest in Buea and weakest in Dschang soils.

## Germination and early growth parameters

The latent period for seed germination was seven weeks after the day of sowing and germination was monitored for the next 46 days, after which the observation and measurements of early growth parameters began. Out of the 432 fresh seeds and 432 dry seeds sown in the germination test, it was observed that only 200 fresh seeds germinated. The dry seeds were treated for 20 min in concentrated sulphuric acid diluted at 50% to enhance germination, since this concentration is reported to have given best results in past studies on *Aframomum* spp. At the end of this study, it was observed that the acid treatment instead killed all the dry seeds and none germinated.

Since the purpose of this experiment was to determine whether soil physiochemical properties could affect germination and early growth, germination was defined as the point at which a seedling at the soil surface.

## Germination percentage

Seed sown in Bamenda soil had the highest germination percentage of 58.33%. It was followed by Dschang and Buea soils with the same germination percentage of 49.07%, each. Statistically, this result was not significant in all soil types at $p > 0.05$, but was significant between the soils and sand (Figure 3).

## Germination speed (GS)

Figure 4 shows that seeds sown in Buea soil had the highest germination speed of 4.43, while that of Bamenda had a germination speed of 4.36, and the germination speed for Dschang soil was 4.32.

## Number of leaves

The number of leaves on seedlings varied per week in all soil types. Until the 4th week, the order in number of leaves per seedling was Dschang>Bamenda>Buea, but at the end of the 8th week seedlings in Bamenda soil had the least number of leaves, while those of Dschang and Buea were highest (Figure 5). Statistically, a significant difference ($p \leq 0.05$) in the number of seedling leaves was only observed in the second week. During the 4, 6 and 8th weeks of observation, there was no significant difference ($p \geq 0.05$) in seedling number of leaves for all soil types (Table 2).

## Shoot height

Seedlings in Dschang soil had the tallest heights, followed by those in Bamenda soil; while seedlings in Buea soil were shortest, and there was also a very clear increase in the shoot height as the weeks of observation increased (Figure 6). These differences were not significant at ($p<0.05$) in shoot height for all soil types in

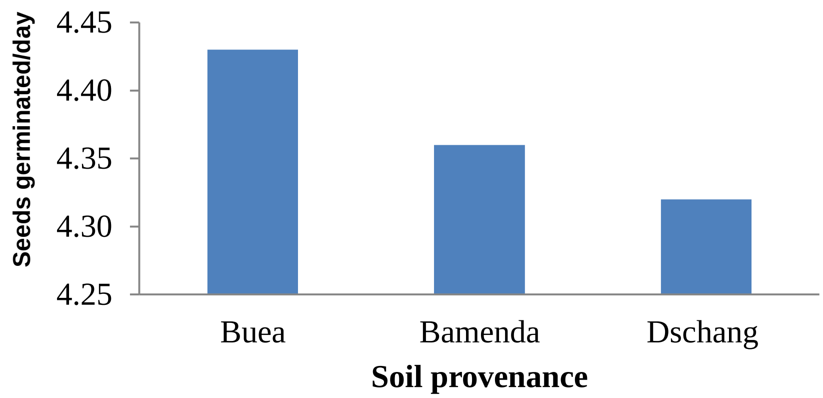


**Figure 4.** Effects of soil provenance on Germination speed**.**

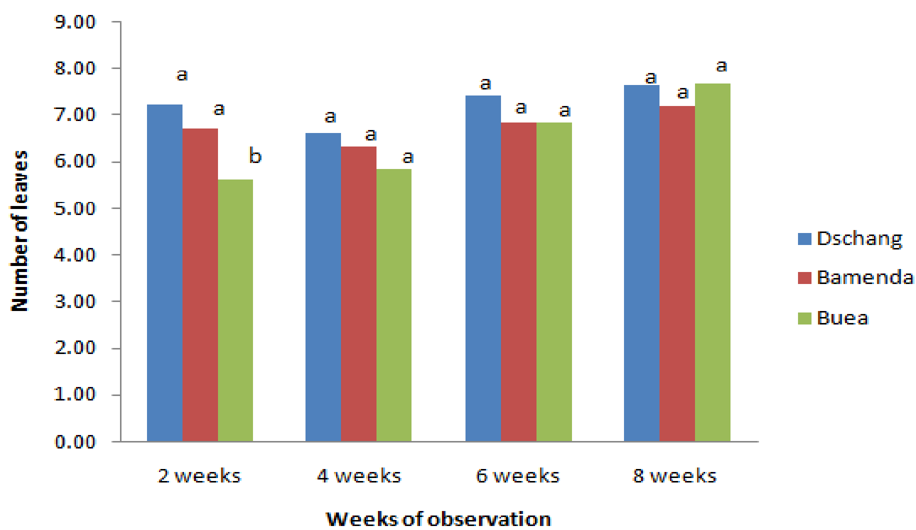


**Figure 5.** Variations of seedling number of leaves in different soil types.

the 2nd, 4th, 6th and 8th weeks of data collection (Table 3).

### Leaf surface area

Dschang soil produced seedlings with the largest surface area; while Buea soil had seedlings with the smallest surface area (Figure 7). Despite these constant increases of leaf surface area, there existed a significant difference ($p < 0.05$) in leaf surface area only in the fourth week; meanwhile in the 2nd, 6th and 8th week, there were no significant differences (Table 4).

### Seedling vigor

Figure 8 shows that the percentage of healthy seedlings was highest in Buea soil (98.11%), and Bamenda soil had the least number of healthy seedlings (87.30%).

## DISCUSSION

The results of the present study show that forest top soil (0-20 cm) produces a higher germination percentage for *A. citratum* compared to sand alone. Also, variations in soil physicochemical properties affected germination and growth of fresh seeds of *A. citratum*. The differences in germination percentage for the different soil types as reported in the results may be attributed to the differences in their physicochemical properties (Six et al., 2000; Carter, 2002). One of the most significant factors for seed germination in the nursery is the type of substrate and the substrate needs to have adequate aeration and moisture for germinating seeds (Kanmegne et al., 2015). Germination of *A. citratum* seeds may have

**Table 2.** Effect of soil physiochemical properties on the mean number of leaves.

| Soil provenance | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Bamenda | 6.33 ± 1.34[a] | 6.69 ± 1.19[ab] | 6.47 ± 1.02[ab] | 6.3 ± 0.84[ab] | 6.42 ± 0.87[ab] | 6.83 ± 0.94[ab] | 6.86 ± 0.97[ab] | 7.16 ± 0.79[ab] |
| Buea | 5.33 ± 1.83[a] | 5.61 ± 1.65[ab] | 5.78 ± 1.65[ab] | 5.83 ± 1.87[ab] | 6.22 ± 1.88[ab] | 6.83 ±1.72[ab] | 7.08 ± 1.97[ab] | 7.66 ± 1.77[ab] |
| Dschang | 6.05 ± 0.61[a] | 7.22 ± 0.34[ab] | 7 ± 0.36 [ab] | 6.61 ± 0.26[ab] | 6.89 ± 0.40[ab] | 7.38 ± 0.56[ab] | 7.22 ± 0.34[ab] | 7.61 ± 0.60[ab] |

Means in the same week followed by the same letter in the row and column do not differ significantly by Duncan test at 5%.

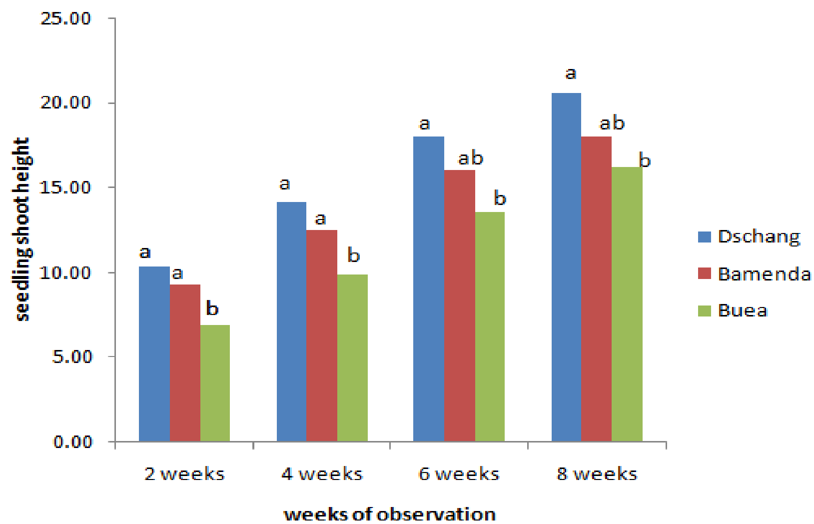


**Figure 6.** Weekly variations in shoot height for different soil types.

**Table 3.** Effect of soil physiochemical properties on the mean seedling height (cm).

| Soil provenance | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Bamenda | 8.19 ± 3.70[a] | 9.33 ± 3.59[a] | 10.77 ± 3.68[a] | 12.49 ± 3.81[a] | 14.3 ± 4.19[a] | 16.03 ± 4.77[a] | 16.72 ± 4.85[a] | 18 ± 4.65[a] |
| Buea | 5.61 ± 2.92[a] | 6.89 ± 3.89[a] | 8.25 ± 4.78[a] | 9.88 ± 5.39[a] | 11.75 ± 6.90[a] | 13.59 ± 7.98[a] | 15.01 ± 9.34[a] | 16.19 ± 9.77[a] |
| Dschang | 8.52 ± 3.45[a] | 12.19 ± 0.62[a] | 12.33 ± 3.54[a] | 14.15 ± 3.64[a] | 15.88 ± 3.88[a] | 18 ± 4.52[a] | 18.84 ± 4.45[a] | 20.59 ± 4.41[a] |

Means in the same week followed by the same letter in the row and column do not differ significantly by Duncan test at 5%.

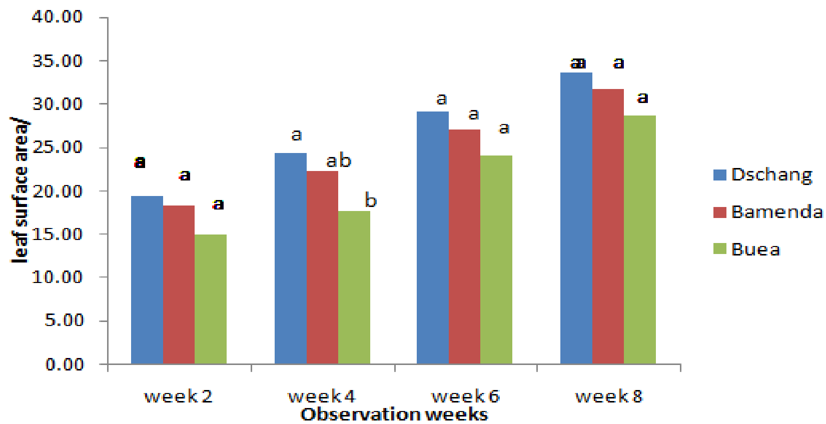


**Figure 7.** Changes in leaf surface area for different soil types.

**Table 4.** Effect of soil physiochemical properties on the mean leaf surface area ($cm^2$).

| Soil provenance | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Bamenda | 16.35 ± 8.47[a] | 18.26 ± 9.13[a] | 20.26 ± 9.51[a] | 22.32 ± 9.21[ab] | 25.03 ± 9.45[ab] | 27.05 ± 9.83[ab] | 28.75 ± 1.00[ab] | 31.62 ± 1.01[ab] |
| Buea | 13.36 ± 9.37[a] | 14.89 ± 9.95[a] | 16.18 ± 1.03[a] | 17.58 ± 1.08[ab] | 20.4 ± 1.34[ab] | 17.93 ± 1.56[ab] | 19.95 ± 1.65[ab] | 22.25 ± 1.66[ab] |
| Dschang | 16.97 ± 4.76[a] | 19.42 ± 5.02[a] | 21.62 ± 5.18[a] | 24.37 ± 6.28[ab] | 27.35 ± 6.51[ab] | 29.13 ± 7.28[ab] | 31.11 ± 7.29[ab] | 33.62 ± 6.70[ab] |

Means in the same week followed by the same letter in the row and column do not differ significantly by Duncan test at 5%.

been enhanced by the constantly moist condition in the soils, which is not possible in sand. Similar results have also been reported for seeds of many others species that soil is a better growth media than sand (Benvenuti, 2003; Rodriguez et al., 2014), although ISTA (2004) has suggested sand as a suitable medium for seed germination in some species.

Yerima (2011) stated that soils differ in characteristics such as texture, effective depth, gravel content, compactness and water infiltration rates. Bamenda soils were observed to be rich in alluvial deposits the soil types observed here include Inceptisols, Entisols, and Oxisols. It was suggested that due to these variations in soil types across elevation, important differences in physical, chemical and biological characteristics exist at regional scale; these could be the reason for the high germination percentage observed in the Bamenda soil. The high organic matter content noted in the soils collected from Buea could have probably enhanced the germination rate by improving the soil bulk density, porosity and particle size, which promote aeration and water retention that enhance seed germination and subsequent seedling emergence.

The rapid increase on germination speed in soils collected from Bamenda could probably be attributed to improved soil structure and moisture retention (García-Orenes et al., 2010). Adequate moisture in the soil supposedly triggered enzymatic processes in the seed cotyledon. These enzymatic activities promote production of plant growth gibberellin acid and cytokines that stimulate embryonic cell mitotic cell division and thereby trigger the germination speed. The pores

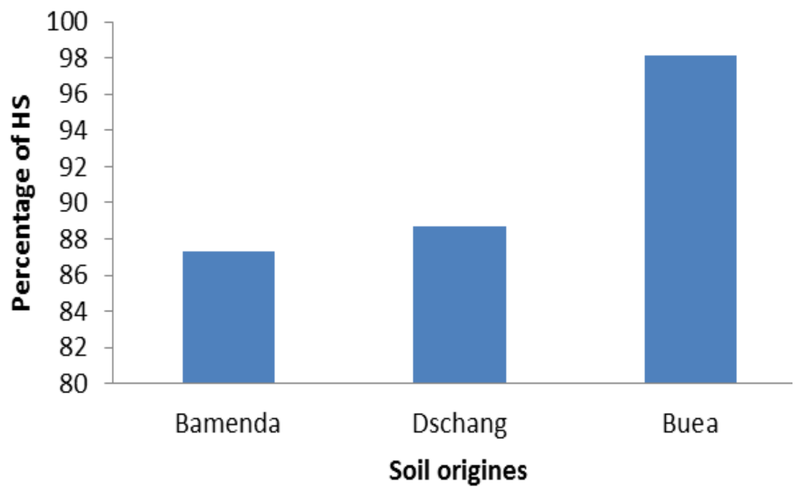


**Figure 8.** Percentage of healthy seedlings in different soil types at the end of experiment.

in the soil are the controlling factor influencing water retention. Furthermore, soil structure influences soil, air, and temperature which in turn affect all factors cumulatively influencing seedling germination processes (Ogunniyi et al., 2014).

The non-significant effect of soil types in growth parameters at the early stages can also be attributed to the fact that at this stage, the seedlings largely depended on nutrients in the seed's reserves (Yerima et al., 2015). Soil pH results of this study revealed that Buea soil had a good acidity, a condition favorable for nutrient uptake by plants (Tisdale and Nelson, 1975). As availability and uptake of both macro and micronutrient by plants is known to be influenced by soil pH, this study also analysed pH for various growth media. This is probably because some major nutrients which influence plant growth and development require slightly acidic to slightly alkaline pH levels to be available for uptake (Jones et al., 2003).

The comparatively better growth in seedlings grown in the soils from Buea was probably because of the availability of certain macro and micronutrients in the soil, which may have promoted the early rapid growth. Nutrients such as N, P and K play a significant role in plant growth and development. Nitrogen plays a vital role in the biochemical and physiological functions of the plant, which is, increasing photosynthetic processes, leaf production, leaf area, root development as well as net assimilation rate (Ogunniyi et al., 2014). Significance of P has also been established by several researchers (Ahmad et al., 2009).

Poor leaf production (early yellowing) in soils collected from Dschang at the end of the research was probably because of low levels of both macro and micro-nutrients including N, Mg and other trace elements, such as Fe and Zn, which play a major role in chlorophyll production. This could also be because of the percentage of sand present in the soil. Since, sand content is a physical parameter affected by soil erosion and, hence, can be measured and used as an indicator for evaluating soil degradation under different land use systems. These results are in agreement with the findings of Javad et al. (2014) who attested to the results of Ayele et al. (2013).

Irrespective of the fact that seedlings in Bamenda soil had high germination percentage and speed, the results of its early growth properties dropped by the end of the research. This result corroborates the findings of Yimer et al. (2008) who reported that the concentration of soil exchangeable $Na^+$ was lower in cropland than in the grazing and native forest. Alem et al. (2010) also observed higher soil exchangeable $Na^+$ concentration in soils under *Eucalyptus grandis* when compared with those of native forest in Ethiopia. Significantly high concentrations of exchangeable $Na^+$ in the soil, particularly in proportion to the other cations present, can have an adverse effect on crops and physical conditions of the soil (Bashour and Sayegh, 2007).

## Conclusion

Physicochemical properties of soils from three provenances (Bamenda, Dschang, Buea), of the Western Highlands affected the germination of fresh seeds but at different angles though this difference is not significant. The highest percentage of seedlings was produced on Bamenda soil but then Buea soil produced healthier seedlings. Sand is a very poor growth media for *A. citratum* since it has a very low water retention capacity. The domestication of *A. citratum* is possible with fresh seeds but dry seeds when treated with 50% dilution of sulfuric acid, will not germinate. This study examined soils in the Western Highlands of Cameroon, which is the same ecological zone hence not very much differences in the soil properties. Thus for further investigation, soils from different ecological zones should be considered.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

## ACKNOWLEDGEMENTS

The authors are grateful to the Department of Plant Biology in the University of Dschang, Cameroon for the provision of space and facilities in the Laboratory for this study. Also, the farmers of Bali Nyonga are highly appreciated for the seeds they supplied for this work.

## REFERENCES

Agbo CU, Omaliko CM (2006). Initiation and growth of shoots of *Gongronema latifolia* Benth stem cuttings in different rooting media. African Journal of Biotechnology 5:425-428.

Ahmad S, Ahmad MY, Ashraf M, Waraich EA (2009). Sunflower (*Helianthus annuus* L.) response to drought stress at germination and seedling growth stages. Pakistan Journal of Botany 41:647-654.

Alem S, Woldemariam T, Pavlis J (2010). Evaluation of soil nutrients under *Eucalyptus grandis* plantation and adjacent sub-montane rain forest. Journal of Forestry Research 21(4):457-460.

Anjah MG, Christiana NNM (2020). Effects of sowing depth on seed germination and seedling growth of *Aframomum citratum* (Pereira) K. Schum. African Journal of Plant Science 14(7):262-269.

Ayele T, Beyene S, Esayas A (2013). Changes in land use on soil physicochemical properties: the case of smallholders fruit-based land use systems in Arba Minch, southern Ethiopia. International Journal of Current Research 5(10):3203-3210.

Benvenuti S (2003). Soil texture involvement in germination and emergence of buried weed seeds. Agronomy Journal 95:191-198.

Bashour II, Sayegh AH (2007). Methods of analysis for soils of arid and semi-arid regions. FAO, Rome pp. 1-128.

Carter MR (2002). Organic matter and aggregation interactions that maintain soil functions. Soil quality for sustainable management. Agronomy Journal 94:38-87.

Eyob S, Appelgren M, Rohloff G, Tsegaye A, Messele G (2008). Traditional Medicinal uses and essential oil composition of leaves and rhizomes of (*Aframomum Corrima* (Braum) P.C.M.Jansen) from Southern Ethiopia. South African Journal of Botany 74:181-185.

FAO (2005). Communiqué " la déforestation se poursuit à un rythme alarmant- Nouveau Chiffres de la FAO sur les forêts mondiales '' Rome P 2.

FAO Handbook (2004). Federal Department of Agricultural Land Resources in collaboration with FAO on Soil Test-based Fertilizer Recommendations for Extension workers, pp.6-19.

Forcella F, Benech-Arnold RL, Benech-Arnold RL, Sanchez R, Ghersa CM (2000). Modeling seedling emergence. Field Crops Research 67(1):123-139.

Gan Y, Stobbe EH, Njue C (1996). Evaluation of select nonlinear regression models in quantifying seedling emergence rate of spring wheat. Crop Science 36(1):165-168.

García-Orenes F, Guerrero C, Roldán A, Mataix-Solera J, Cerdà A, Campoy M, Zornoza R, Bárcenas G, Caravaca F (2010. Soil microbial biomass and activity under different agricultural management systems in a semiarid Mediterranean agroecosystem. Soil and Tillage Research 109(2):110-115.

Ghosh MK, Kundun NK (1991). Soil profile studies as a part of environmental management in coal mining areas. Indian Journal of Environmental Protection 11(6):413-417.

Gomez KA, Gomez AA (1984). Statistical procedures for agricultural research. John Wiley and Sons Inc. New York, USA.

Hossain MA, Arefin MK, Khan BM, Rahman MA (2005). Effect of seed treatment on germination and seedling growth attributes of horitaki (*Terminalia chebula* Retz) in the nursery. Research Journal of Biological Sciences 1:135-141.

Javad RSA, Hassan K, Esmaeil HA (2014). Assessment the effects of land use changes on soil physicochemical properties in Jafarabad of Golestan province. Iran. Bulletin of Environment, Pharmacology and Life Sciences 3(3):296-300.

Jones JB (2003). In: Agronomic handbook: Management of crops, soils, and their fertility. New York, USA: CRC Press P 450.

Kanmegne G, Anouma'a MF, Mbouobda HD, Mbibong DA, Omokolo DN (2015). Germination of Cola anomala (K. Shum.) Shott and Endl seeds: effects of provenance, substrate and dehydration. International Journal of Biological and Chemical Sciences 9(3):1171-1180.

Keshava CK, Krishnakumar G, Shenoy HS (2014). Seed germination studies on lophopetalum wightianumarn. - An evergreen species of the Western Ghats. International Journal of Plant, Animal and Environmental Sciences 4(3):502-507.

Laird SA (2000). The management of forests for timber and non-wood forest products in central Africa. In Sunderland TCH, Clark LE, Vantomme P (eds.). Non-wood forest products of Central Africa: current research issues and prospects for conservation and development. Rome: FAO. pp. 51-60.

Lékané TD (2009). Aframomum au service de la diversité naturelle et culturelle des terroirs Grass fields du Cameroun: Enjeux de valorisation des produits culturels et gestion durables des bas-fonds et interfluves. Université de Yaoundé I département de Géographie. Colloque « localiser les produits » P 7.

McGarry D, Sharp G (2003). A comparison of soil physical properties and soil morphology, under adjoining fields of conventional, and reduced till with controlled traffic. In International Soil and Tillage Conference Proceedings. Brisbane, Australia, July 2003.

Nelson NN, Irene MH, Ron HB (2010). Extracts of tropical African spices are active against Plutella xylostella. Journal of Food, Agriculture and Environment 8(2):498-502.

Niang-Diop F, Sambou B, Lykkem A (2010). Contraintes de régénération naturelle de *Prosopis africana*: facteurs affectant la germination des graines. Institutdes Sciences Anta Diop. BP: 5005. Dakar Fanna, Sénégal 4(5):1693-1705.

Ogunniyi JE, Guo CH, Tian XH, Li HY, YX Zho (2014). The effects of three mineral nitrogen sources and zinc on maize and wheat straw decomposition and soil organic carbon. Journal of Integrative Agriculture 13:2768-2777.

Raunkiaer F (1934). The life forms of plants and statistical plant geography. Being the collected paper of C. Raunker. Oxford and the clarendon Press P 547.

Rodriguez OA, Vazquez AP, Martinez AJ (2014). Effects of seed weight and substrateon germination and growth of non-toxic *Jatropha curcas* L. seedlings. Annual Research and Review in Biology 4(24):4232-4245.

Sanchez PA (2002). Soil fertility and hunger in Africa. Science 295:2019-2020.

Shepherd G (2000). Visual Soil Assessment. Volume 1 Field guide for cropping and pastoral grazing on flat to rolling country. horizons. mw & Landcare Research, Palmerston North, New Zealand P 84.

Six J, Elliott ET, Paustian K (2000). Soil structure and soil organic matter II. A. Normalized stability index the effect of mineralogy. Soil Science Society of America Journal 64:1042-1049.

Tabuna H (1999). Le Marché des Produits forestiers non Ligneux de l'Afrique Centrale en France et en Belgique. Occasional paper P 32.

Tisdale SL, Nelson WL (1975). Soil fertility and fertilizers. Longman.

Vivien J, Faure J (1995). FruitiersSauvagesd'Afrique-Espèces du Cameroun. Edition Nguila- kerou, France P 416.

Wamegni J (1991). Etude de la phénologie, des fruits, des graines et de la germination de Fagar macrophylla. Mémoire d'Ingénieur des Eaux et Forêts à l'Université de Dschang P 50.

Wilson SB, Stoffella PJ, Graetz DA (2001). Use of compost as a media amendment for containerized production of two subtropical perennials. Journal of Environmental Horticulture 19:37-42.

Yimer F, Ledin S, Abdelkadir A (2008). Concentrations of exchangeable bases and cation exchange capacity in soils of cropland, grazing and forest in the Bale Mountains Ethiopia. Forest Ecology and Management 256(6):1298-1302.

Yerima PKB (2011). Protective measures taken for preserving species endangered of extinction due to the climate change in sub-Sahara Africa: Case of the Yongka Western Highlands Research Garden-Park, Nkwen- Bamenda, NW Region, Cameroon. In: Research and Development in sub-Saharan Africa, Support Africa International.

Yerima BP, Tiamgne YA, Fokou L, Tziemi TC, Van Ranst E (2015). Effect of Substrates on Germination and Seedling Emergence of Sunflower (*Helianthus annuus* L.) at the Yongka Western Highlands Research/Garden Park, Bamenda Cameroon. Tropicultura 33(2):91-100.