

Comparative analysis of Indigenous tree seed germination for a revamping biodiverse reforestation

indigenous tree varieties?

ABSTRACT

Aims: This paper is to carry out a comparative analysis on seed germination of four indigenous tree varieties so that they may be used for reforestation and enhancing biodiversity in their ecosystems.

Study design: An experimental research was on four indigenous tree varieties were chosen based on their socio-economic and biodiversity importance: *Maesopsis eminii* (Umuhumure) ; *Albizia gummifera* (umusebeyi), *Entandrophragma excelsum* (Umuyove) and *Prunus africana* (Umuremera). Three substracts were separately prepared in which 100 seeds of each varieties were planted and their growth were monitored daily in ~~were~~ controlled nursery.

5 days interval?

Place and Duration of Study: From October to December 2023, data were collected after 5 days on the following indicators, growth, cinetic and duration of germination. Analytical tools such as anova and regression were applied.

Statistical analysis using...

Methodology: Three substracts were separately prepared in which 100 seeds of each varieties were planted and their growth were monitored daily in ~~were~~ controlled nursery.

Results: The number of grain germinated increased as the time goes by but it is the variety *Umuhumure* which marked with a higher and steady growth than other ~~varieties~~ and *Umusebeyi*, 80 out of 100, tops in the number of grain germinated after three months. The study shows that rates of growth were 74, 37, 29 and 14 out of 100 for *Umusebeyi*, *Umuremera*, *Umuyove* and *Umuhumure*, respectively. On overall, with one-way ANOVA, means of grains germinated of the three indigenous trees are significantly different (<0.01) when grain variety factor is considered but when the interaction between variety and replication are also considered (two-way ANOVA), the two have a significant effect on the number of grains germinated (<0.01). Other findings are the effect of the germinated grains depends on the number of replication and period of grains growth (in terms of days). 6% and 48% variations explain the interaction between replication and type of variety on one hand and the number of variety growth on the other hand.

Conclusion: the *Albizia gummifera* (*Umusebeyi*) to be considered when the reforestation of indigenous tree is undertaken. However, other varieties may be used if the right substracts and growth conditions are found.

repetitive

Keywords: indigenous trees, replication, ANOVA, biodiversity

1. INTRODUCTION

After The Burundian, natural environment is decreasing ~~mainly~~ due to the expansion of human activities (Nkengurutse *et al.* 2019). However, this environment contains indigenous species which have functions or are beneficial to mankind and the biosphere in general but they are threatened by deforestation. Doggart *et al.* (2020) and Kissinger *et al.* (2012) have pointed out the diverse factors leading to deforestation, some may be proximate (agriculture expansion, urban growth, infrastructure development and mining) while others are or underlying such as those that relate to macro-level interactions of demographic, economic, technological, social, cultural and political factors (Bukuru *et al.* 2022). In fact, during 1990, Burundi marked a high international record of deforestation rate, reaching 9% (Athman *et al.* 2006). The estimations of deforestation varied from 8000 to 32000 ha due to civil war (Banderembako, 2006). In Burundi, human activities such as agriculture is ranking the first factor that affects the forest canopy and hence the biodiversity reduction.

% from what?

Environmental restoration and biodiversity programs are hampered by the low variety of species with multiple functions, which limits the choices and possibilities and leads to the homogeneity of spaces. However, the government of Burundi has put in place a national strategy and action plan on Biodiversity (2013-2020) which had dismal effects on the environment restoration and protection (INECN, 2016). Now the attention is directed on the alien or indigenous trees. These ~~ones~~ are species that have developed and adapted to a specific environment over time. They play a crucial role in local ecosystem and contribute to biodiversity, climate regulation and soil protection.

However, exotic species such as *Eucalyptus* sp., *Pinus* sp., *Callitris* sp. et *Grevillea robusta*, have harmful effects which were not suspected when they were introduced (Guedes *et al.* 2018). The indigenous species seems to be scarce in Burundian silvicultural and agroforestry programs. It is urgent that tests on the performance of native species be carried out to solve this problem and counter the problem of landscape degradation. The indigenous trees may serve as tool for afforestation, reforestation and restoration of ecosystem, hence improve the biodiversity of tree species. In addition, as a means of promoting the benefits of trees as habitat and food for other biodiversity, it is often stated that indigenous (native) trees should be encouraged above alien (exotic/non-native) species, because the services that they provide are already part of the local ecology, and other native species will have co-adapted with them (Chalker-Scott, 2015; Johnson *et al.*, 2012; Smith *et al.*, 2006, and Kandle *et al.*, 2000).

Accordingly, many institutions including public-government (local, national), private sector, and civil society have undertaken policy options and programmes aimed at reversing deforestation in the country whilst meeting the demand for requisite forest products. The government of Burundi has introduced the National strategy and Action Plan in order to revamp the biologic diversity in 2020. This was in line with the International Convention of Biologic Diversity ratified on 15 August 1997. The aim was to implement among others the pledge of reducing the gas emissions by 3% (unconditionally) and 20% (conditionally) by 2030 (CIFOR, 2022 and INECN, 2013).

objectives not tallied with
beforehand objective

This study aims at contributing to the conservation and dissemination the indigenous trees of economic use. Specifically, this paper seeks to examine the most performing woody indigenous trees through (1) indigenous tree seed germination performance and (2) the growth type through some specific parameters such as height of seedlings, diameter of stem and the number of leaves. The results of this study can contribute to better understanding the aspect of role of indigenous trees in vegetative biodiversity and conservation of plant species. Understanding seed germination is essential for restoring ecosystems and preserving endangered species.

2. EXPERIMENTAL DETAILS

This study follows an experiment design which starting by selecting four types seeds of indigenous trees. The species were chosen on the basis of the existing literature concerning their socio-economic importance of each species and taking into account the availability of their seeds, four tree species were selected namely: (1) *Maesopsis eminii* (Umuhumure), (2) *Entandrophragma excelsum* (Umuyove), (3) *Albizia gummifera* (umusebeyi) and (4) *Prunus africana* (Umuremera).

1. *Maesopsis eminii*



2. *Albizia gummifera*



3. *Entandrophragma excelsum*



4. *Prunus africana*



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Plate 1 : The selected four species

According to Bionet (2022), *Maesopsis eminii* is invasive in parts of Tanzania (Haysom and Murphy 2003). The species is indigenous to Uganda where it grows in moist evergreen forests and moist semi-deciduous forests as well as in grasslands and seasonal wetlands at altitudes of 700 to 1500m. *Albizia gummifera* is a deciduous tree with a flattened, open crown, growing up to 30 metres tall. The straight, cylindrical bole can be up to 100cm in diameter; it is usually without buttresses or with small, thick buttresses. The tree is harvested from the wild for local use as a food, medicine and source of wood. *Entandrophragma excelsum*, is Africa's tallest indigenous tree native to tropical East Africa and occurs in eastern D.R.C of the Congo, Rwanda, Burundi, Uganda, Tanzania, Malawi and Zambia. This species is scattered in areas of upland semi-deciduous forest, in mid-elevation and montane rainforest, at 1280 – 2150 metres elevation. It is locally also found in riverine forest. Finally, used intensively for traditional medicine, *Prunus africana* is a medium to large, handsome evergreen tree with a spreading crown of 10 to 20 m when mature. become quite huge under frost-free conditions, but is usually medium-sized in gardens. Its leaves, barks and roots are harvested for medicinal uses.

2.1 Sources and treatment of tree seeds

Maesopsis eminii seeds/seeds were collected in Kirundo province. Some fruits were collected after they had fallen while others were picked from the trees. The latter were placed in conservation awaiting physiological maturity (i.e. when the flesh becomes tender). After three (3) days, we crumbled the fruits in a bucket filled with water to remove their flesh and sticky fibers. The seeds obtained were dried in the sun for one day. were crumbled

The seeds/seeds of the other three tree species (*Albizia gummifera*, *Entandrophragma excelsum*, *Prunus africana*) came from the Kibira National Park. They were purchased from an experienced nurseryman (a retired officer of the Burundian Office for the Protection of Environment).

2.2 Preparation of Substrate

Three types of substrates were used for sowing the seeds:

Type 1: substrate made from a mixture of 4 wheelbarrows of manure, 2 wheelbarrows of black soil (humified soil) and 1 wheelbarrow of sand (4-2-1); ✓

Type 2: substrate made from a mixture of 2 wheelbarrows of manure, 2 wheelbarrows of soil (humified soil) and 0 wheelbarrows of sand (2-2-0);

Type 3: substrate made from a mixture of a wheelbarrow of manure, a wheelbarrow of black soil (humified soil) and a wheelbarrow of sand (1-1-1).

For each type, the components were spread on tent and mixed up using a shovel until a homogeneous mixture was obtained. Seed experiment treatment were three time replicate in order to observe the differences in seed germination parameters.

replicated three times

2.3 Seed Sowing and Monitoring

The experiment took place in a nursery installed within the perimeter of the Faculty of Agronomy and Bio-Engineering (FABI) educational farm of University of Burundi in Gitega. The seeds were sown in polyethylene bags containing the soil for each type of substrate. After filling the bags, the seeds were sown vertically with a depth of two (2) times the size of the seed. The bags were arranged in completely randomized blocks. The seeds do not all germinate at the same time. Therefore, we regularly observed the seedlings throughout the experiment between 9 a.m. and 10 a.m. Germination monitoring consisted of noting the germination dates as well as the number of germinated seeds.

2.4 Seed parameters collection during seed germination

The parameters used to evaluate the behavior of the seeds during germination were assessed through the following variables:

- Seed germination rate (TG)= Number of seeds germinated (n) * 100/ Total number of seeds sown (N)
- Germination= The germination kinetics (CG), providing information on the evolution of the
- Cumulative germination rates (TCg)= Number of newly germinated seeds (ni) * 100/ Total number of seeds sown (N)

Germination time or latency time: time it takes a seed to germinate after it has broken free from its dormant seed. The measured seedlings were first chosen from the rows also chosen among others. These seedlings constituted the samples which were concerned by the measurement whenever necessary. The sample plants were marked by inserting a strand of colored toothpick into the bag. Height of seedlings, stem diameter and number of leaves,

2.5 Data Analysis

Quantitative estimation was used, basically parametric and non-parametric estimations were done such descriptive statistics and ANOVA. Analytical tools used were SPSS for data analysis and R for graphic visualization

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

The analysis compares different varieties of native trees in terms of germination rates. This helps select the varieties most suited to local conditions and reforestation or conservation objectives. It assesses seed viability by measuring the percentage of germinated seeds compared to the total number of seeds sown. This gives information on the quality of the seeds used.

Table 1: Mean of germinated seeds per variety and replicate trials

Variety	Replicate	Mean (Unit)	SD	N
Umuhumure (Maesopsis eminii)	R1	17.60	9.08	48
	R2	12.54	11.02	48
	R3	10.81	11.06	48
	Total	13.65	10.75	144
Umuremera (Prunus africana)	R1	43.29	14.95	21
	R2	36.00	11.03	21
	R3	31.76	9.98	21
	Total	37.02	12.91	63
Umusebeyi (Albizia gummifera)	R1	86.27	9.31	30

Umuyove (<i>Entandrophragma excelsum</i>)	R2	71.03	8.20	30
	R3	66.40	5.88	30
	Total	74.57	11.59	90
	R1	30.67	12.08	24
	R2	29.38	9.69	24
	R3	25.83	7.51	24
	Total	28.63	10.01	72

The *Umusebeyi* variety has the highest average germination rate, with 74.57 seeds germinated on average for all repetitions combined. *Umuremera* has an average germination rate of 37.02 germinated seeds. *Umuyove* has a rate of 28.63 seeds germinated on average. *Umuhumure* has the lowest average germination rate, with only 13.65 seeds germinated on average.

The number of observations varies depending on the variety, with 144 seeds for *Umuhumure*, 90 for *Umusebeyi*, 72 for *Umuyove* and 63 for *Umuremera*. This difference in sample size can influence the precision of the estimates, particularly for varieties with fewer observations. Roughly speaking, these descriptive results highlight significant differences in average germination rates between varieties, with *Umusebeyi* performing the best and *Umuhumure* the worst. Intra-varietal variability is also notable, as shown by the high standard deviations. This information is useful for identifying the most promising varieties and adapting nursery practices accordingly.

Three features present the difference in indigenous seed germination. High germination is observed in the *Umusebeyi* which stands out with the highest average of germinated seeds, indicating that it could be the most productive variety in terms of germination. In terms of stability, *Umuhumure* and *Umuyove* show more stable germination between repetitions, which can be an indicator of consistency. Finally, Variations between replicates in *Umusebeyi* may indicate sensitivity to environmental conditions or variations in sowing techniques.

The Figure 1 shows the averages of germinated seeds for each repetition (R1, R2, R3) according to the four tree varieties: *Umuhumure*, *Umuremera*, *Umusebeyi* and *Umuyove*.

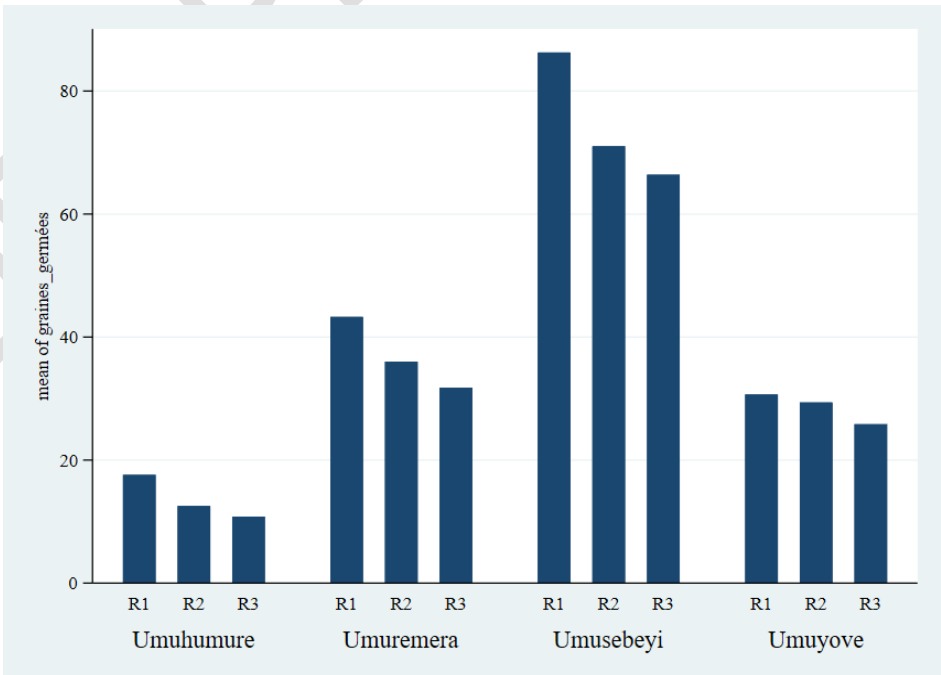


Figure 1: Average germinated Seeds by Replicate and Variety

Umusebeyi shows an exceptionally high germination in R1, while *Umuhumure* and *Umuyove* have the lowest. However, the general trend shows a decrease compared to R1 for all varieties, with *Umusebeyi* always in the lead. In R3, a continuous reduction in germination for all varieties, but *Umusebeyi* remains the most prolific variety.

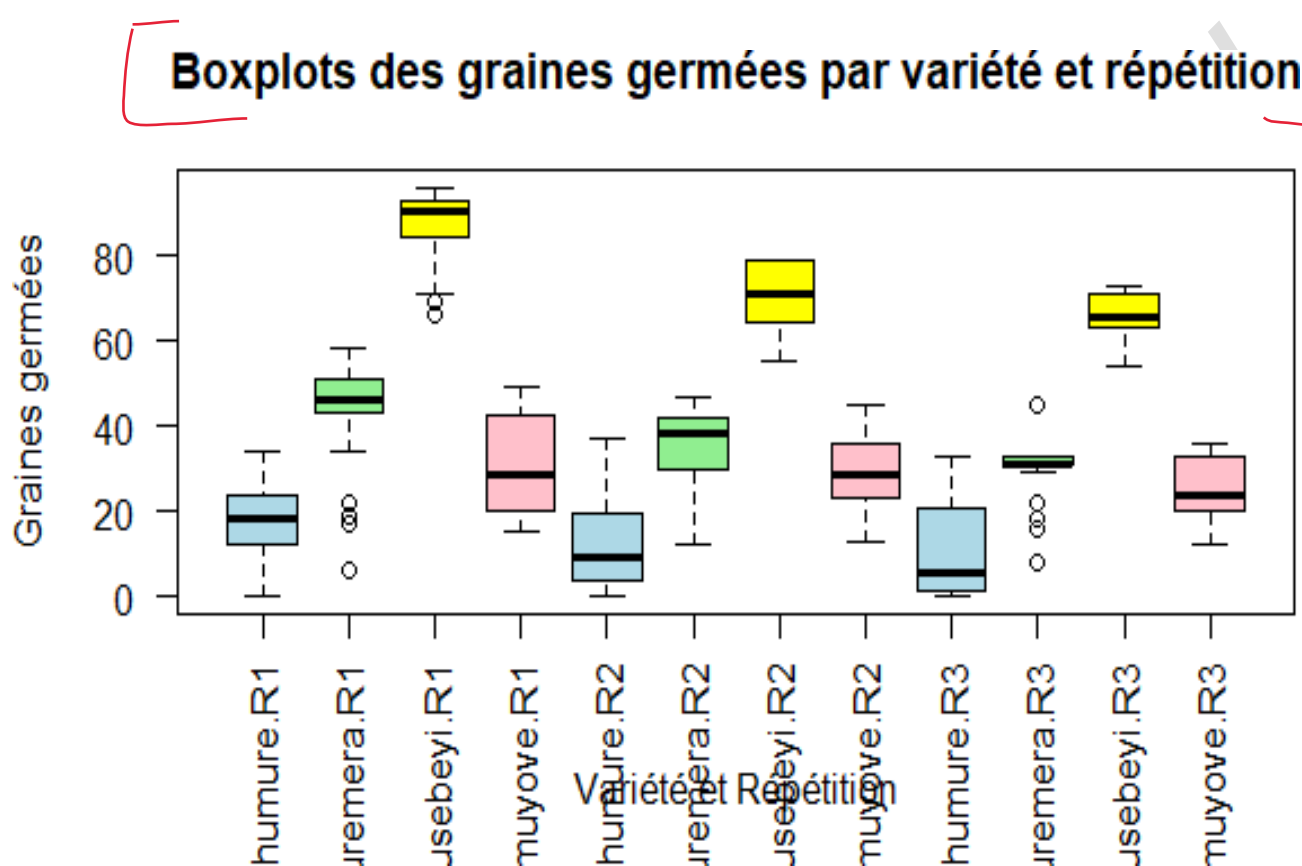


Figure 2: Box and whisker plot of germinating data,

3.3 Analysis of Variance (ANOVA)

Before running a parametric anova, we checked if the data with homogeneous variance were normally distributed. Shapiro-Wilk and homogeneity variance tests were done.

The study was carried out to find out which indigenous tree seed germinates well in the environmental conditions provided. The aim was to find out the right indigenous tree seed that will boost the forest biodiversity given that some of the indigenous trees are at risk of extinction (Botton, 2020 and Shackleton, 2016). The seedling growth rate of plantation is the only means for selection for the appropriate species for forest survivorship and height growth (Martinez-Bravo *et al.* 2022). The experiment done shows that out of the indigenous tree varieties, *Albizia gummifera* (*Umusebeyi*) presented features such as high germination and variability, that prove to be the right choice for the farmers. The *Umusebeyi* is widely used as traditional medicine. Its bark is infused and then used to treat malaria while the pounded bark is also used to treat headache in Burundi. Another potential indigenous tree tested was the *prunus africana* (*umuremera*). As it has been revealed by Jaouadi *et al.* (2010), the latter shows a moderate rate of germination. Most used as traditional medicine and poison for arrow, this variety is found in the protected areas such as national park of Kibira and Ruvubu. A well-funded study was carried out in 2019 in order to make a preliminary inventory standing stock and also to assess the level of sustainable exploitation of tree cut quota. The *Prunus africana* is accounted by CITES among the indigenous tree to be protected given its importance in enriching the forest biodiversity and also human uses in many economic activities.

discussions?

4. CONCLUSION

The study aims at contributing to the conservation and dissemination the indigenous trees of economic use. Specifically, this paper seeks to examine the most performing woody indigenous trees through (1) indigenous tree seed germination performance and (2) the growth type through some specific parameters such as height of seedlings, diameter of stem and the number of leaves.

The methodology follows an experiment design on the four types of indigenous seed tree sowed in the nursery of the institution station. After germination, measures on key indicators were taken. Descriptive and inferential statistical analyses such as ANOVA were done. The two-way ANOVA results show that varieties, replicates and their interaction have significant effects on the number of germinated seeds and the effect of the number of days after sowing. Partial effect sizes indicate that varieties explained most of the variance, followed by days, replicates, and finally the interaction between varieties and replicates.

These results highlight the importance of considering both varieties and replicates when analyzing native tree seed germination in nurseries. The significant interaction suggests that the effect of varieties on germination depends on the context of the repetition and vice versa.

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