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Evaluation of Two Moringa Species for Adaptability and Growth Performance under Bako Conditions

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Abstract
A Moringa species adaptability experiment was conducted at Bako Agricultural Research Center, Western Oromia for three consecutive years (2010/11-2013/14). The objective of the study was to assess the growth performance and adaptation of moringa species to the area depending on their early growth patterns and survival. This is a sort of matching the moringa species with the Bako environment. In this experiment, two different Moring species (Moringa oleifera and Moringa stenopetala) were included, and compared by using randomized complete block design with three replications. Results showed that there was a significant difference in height growth ($p \leq 0.01$) and non significant difference in root collar diameter ($p \geq 0.05$), diameter at breast height (dbh) ($p \geq 0.05$) and survival ($p \geq 0.05$) between the two moringa species at this particular area. But results showed that there was highly significant difference root collar diameter ($p \leq 0.01$) measured at one month and significant difference diameter at breast height (dbh) ($p \leq 0.05$) at one year age of establishment performance of the species. This could be due to the environmental factors and inherent genetic potentials of the species which generally govern tree growth. The height growth of Moringa oleifera (4.01 m) outsmarted than Moringa stenopetala (2.40 m). There was significant difference between Moringa stenopetala (0.84 cm) and Moringa oleifera (0.66 cm) regarding root collar diameter development at the first assessment (after one month age), but both of species was not significant difference at increased the age of species. Of both species Moringa stenopetala and Moringa oleifera showed good survival rates with mean values of 97.33 and 100% respectively. Based on the results of three years growth data, the performance of these Moring oleifera species is promising and hence they can be considered for further technology specific and on-farm agroforestry works around Bako.
Keywords: diameter at breast height, genetic potentials, Moringa oleifera, Moringa stenopetala, and root collar diameter.

Introduction

Moringa is a tropical plant belonging to the family *Moringaceae* that grows throughout the tropics. The genus *Moringa* consists of 13 species (NRC, 2006) of which only *Moringa oleifera* has been accorded research and development attention. It is represented by 13 species, out of which five species namely, *Moringa stenopetala, Moringa oleifera, Moringa longituba, Moringa rivae* and *Moringa ruspoliana* are found in Ethiopia (www.geocites.com). Among the five species *Moringa stenopetala* is often referred to as the African Moringa tree because it is native only to southern Ethiopia and northern Kenya (Mark, 1998). Northeast tropical Africa is a center of endemism plus diversity for the genus (Mark, 1998). *Moringa oleifera* is native to sub-Himalayan tracts of northern India and is commonly referred to as "horseradish tree" or "drumstick tree" (Jahn, 1991). Moringa is a multipurpose tree of significant economic importance, as it has vital nutritional, industrial, and medicinal applications (Jahn, 1991; NRC, 2006).

Generally, different tree species responds differently to the different environments (Rocheleau et.al, 1988). Because every tree species has its own range of biotic and a biotic factors in which it performs with its maximum capacity (FAO, 1974; EVAN, 1992). Similarly different sites may also have different qualities. Thus, whenever one plans to plant a tree species in any form, he has to match the requirements of a species with the site condition. This adaptation of *Moringa species* was initiated to assess their performance and adaptation to Bako site condition, and finally make use of them for agroforestry works in Bako area as well as at sites of similar agro-ecology. Therefore, the objective of this study was to identify the best adaptable, compatible, productive, disease and pest tolerant Moringa species for Bako area, and other sites with similar agro ecology.

Materials and Methods

Study area

The trial was conducted at Bako Agricultural Research Center 9°07' N latitude and 37°05' E longitude (Figure 1). The area is mid-altitude, sub-humid tropical climate with unimodal rainfall pattern (Figure 2), experiencing an average annual rainfall of 1270 mm and an average annual temperature of 20°C (maximum - 27°C and minimum - 13°C). The altitude at the Bako Meteorological station is about 1650 m above sea level. The soil is dominantly reddish brown Nitosol, with a pH of 5-6, and clay dominated in texture (Legesse *et al*, 1987; Abebe, 1998).

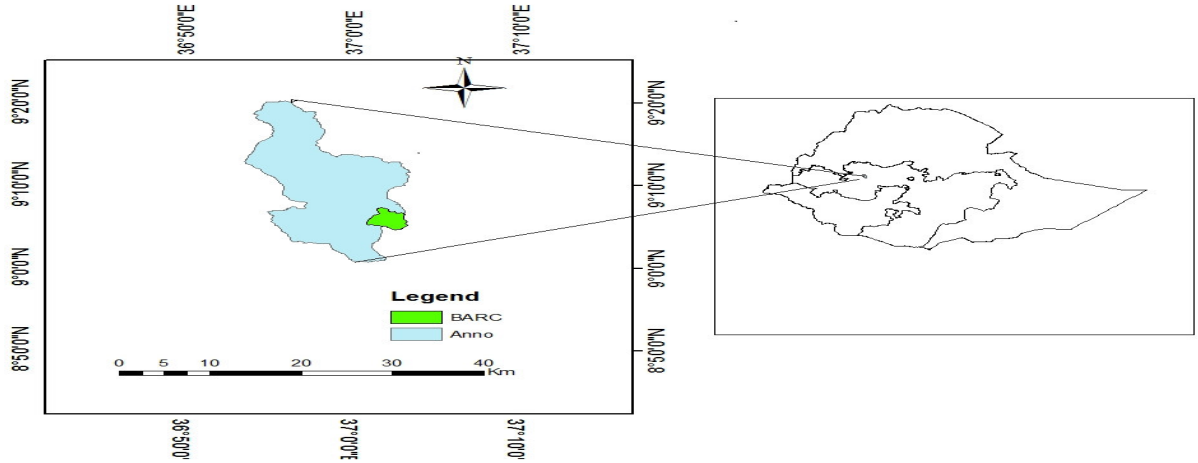

Figure 1. Location of the study area.

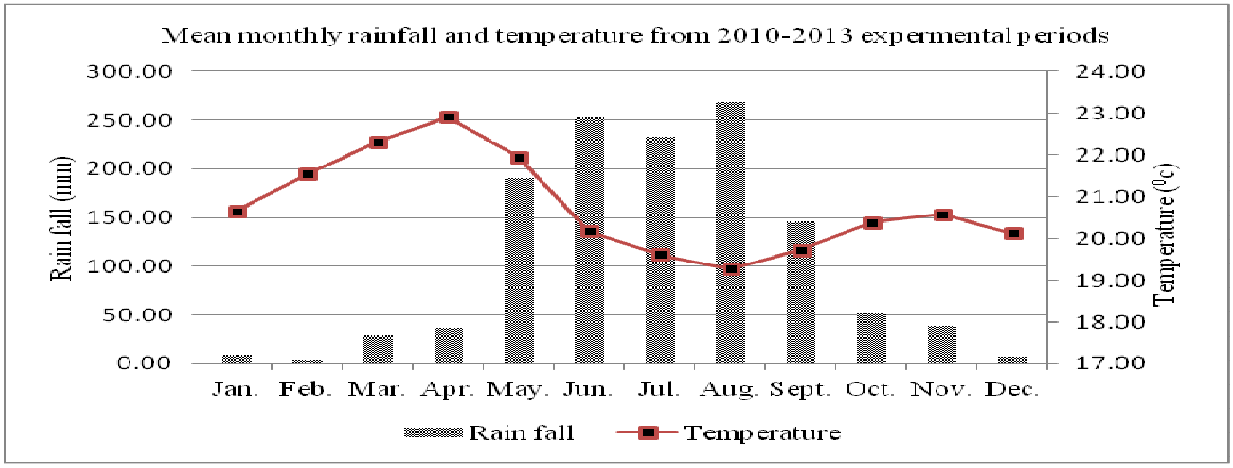

Figure 2. Mean monthly rainfall and temperature experimental period of Bako area.

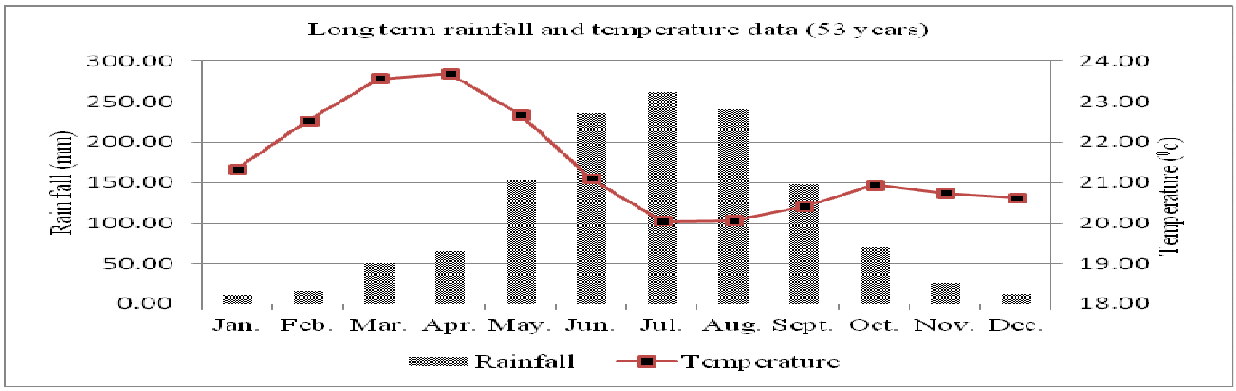

Figure 3. Along-term mean monthly and temperature of Bako area, based on 1996-2013 meteorological data Bako research center.

Treatments and experimental design

The treatments are 2 different tree species stated as follows:

Table 1. Moringa species and their seed source.

Tree species	Family	Seed source
1. *Moringa oleifera* Lam.	Moringaceae	MARC, Ethiopia
2. *Moringa stenopetala* (Bak.f.) Cuf.	Moringaceae	FRC, Ethiopia

FRC= Forestry Research Center MARC = Melkassa Agricultural Research Center

Seedlings of the trees were raised at Bako tree nursery using a polyethylene tube of 10 cm diameter and 15 cm long in April 2010, and out-planted during the rainy season in end June of the same year. The experiment

was laid out in a randomized complete block design with three replications. The block was folded to accommodate the two treatments within fairly uniform soil condition. The block lies from West to East with a distance of 3 between them, and 2m between plots within a block. The spacing between trees was 1.5 m x 1.5 m, and the plot area was 144 m^2 (12 m x 12 m) with a total of 81 trees per plot.

Data collection and analysis

Height, root collar diameter, diameter at breast height and survival rate were the four growth and adaptation parameters that were measured for the three years at an interval of 2 months. Survival count was made for the whole trees in a plot (81 trees per plot), while the trees in the middle (25 trees per plot) were taken as a sample for height, root collar diameter and diameter at breast height measurement so as to minimize the border effect. Height growth was determined by using measuring tapes, root collar diameter and diameter at breast height by caliper. Analysis of variance was made for plot-mean data, and F-test was used to test the significance of differences between species using SAS computer software. Treatment means that showed significant difference by F-test were separated by least significant difference (LSD).

Results and Discussion

Summary of the results for Height and root collar diameter are presented in Table 2. The diameter at breast height and survival are presented in Table 3. And also the trend observed for each species in height, diameter at breast height and survival rate over three years is indicated in figures 3, 5 and 6 respectively and root collar diameter over a month indicated in figure 4.

Height growth

The analysis of variance revealed that there was a marked difference in height growth among the moringa species included in the trial. At the age of two years after establishment *Moringa oleifera* (4.01 m) outsmarted than *Moringa stenopetala* (2.40 m). However, the results of the current study is in contrast with Fuglie and Sreeja (2001) indicating that *Moringa oleifera* provenance during the first year of establishment can reach a height of 5 m at 16 months after planting. These were the *Moringa oleifera* and *Moringa stenopetala* that showed fastest growth with the annual height growth rate of the first year of establishment 2.69 m and 1.23 m respectively. The annual higher growth rate of the first year of establishment recorded by *Moringa oleifera* contrast with earlier reports that it is a fast-growing species (Abebe *et al*., 2000) as compare *Markhamia lutea*, *Acacia mearnsii*, *Chamaecytisus palmensis*, *Acacia cyanophyla*, *Acacia melanoxylon*, *Calliandra calothyrsus* and *Moringa oleifera* by it self commonly used in agroforestry. In other way round the performance of both species is significant difference because the growth performance is mainly depending up on the characteristics of the species that has towards the specific agro-ecology. This could be due to either their superior genetic potential or the environmental requirements of these species.

There was also significant interaction between tree species and tree age, as clearly shown in Table 2. At the early age of establishment, the variation in height growth among *Moringa stenopetala* (0.56 m) and *Moringa oleifera* (0.28 m) was minimal but at increased age *Moringa oleifera* attained high mean height than *Moringa stenopetala*, but the difference became evident with time as the tree age increased.

Root collar diameter development

Growth in root collar diameter also differed significantly among the two tree species. The difference in growth of root collar diameter between *Moringa stenopetala* (0.84 cm) and *Moringa oleifera* (0.66 cm) was significant at the age of one month after establishment with respective six month root collar growth rates of 4.22 and 4.09 cm. But both species not significantly different in the age increased. But *Moringa stenopetala* and *Moringa oleifera* considerably increased the average root collar diameter of the latter - otherwise higher difference couldn't have been noticed between the two species. Results indicated that tree species having greatest root collar diameter were those which grew tallest. Height growth and root collar diameter development were well correlated ($r = 0.976$, $p = 0.0009$) at first month of establishment. Similarly, smaller root collar diameter was recorded for shorter species during the first month of establishment.

Diameter at breast height

Growth in diameter at breast height also differed significantly among the two moringa species. The difference in growth of diameter at breast height (1.3 m) above the ground between *Moringa stenopetala* (1.52 cm) and *Moringa oleifera* (2.97 cm) was highly significant at the age of one year diameter at breast height growth. But diameter at breast height growth was non-significant difference both species at the age of the species above one year old. As the below table 3 result showed that both moringa species has a good performance in diameter at breast height. From both species *Moringa oleifera* has show high diameter at breast height result within three years data records. So, this helps for the species to provide seed within one year after planting and also this

species has a good stand in the field, but *Moringa stenopetala* not yet give any seed until the activity completed. However, the results of the current study is in contrast with Fuglie and Sreeja (2001) indicating that *Moringa oleifera* during the first year of establishment can reach a height of 5 m, producing flowers and fruit yet 16 months after planting.

Tree survival percent

There were not significant differences between species in survival rate. At assessment seedling survival measured after one month *Moringa stenopetala* and *Moringa oleifera* at the assessment seedling survival measured after one month 100 and 100% respectively. But at the age of three years after establishment *Moringa oleifera* and *Moringa stenopetala* showed relatively better survival with mean values of 100 and 97.3% respectively, but survival rate with mean of both species not significant differences. The findings of this study also contrast earlier reports suggesting that Moringa species higher mortality was recorded (Abebe *et al*., 2000) as compare to *Markhamia lutea*, *Albizia gummifera*, *Acacia mearnsii*, *Erythrina abyssinica* and *Calliandra calothyrsus* commonly used in agroforestry.

Tree seedling survival was not strongly correlated with height growth ($r = 0.637$, $p > 0.05$), root collar diameter ($r = 0.4035$, $p > 0.05$) and diameter at breast height ($r = 0.693$, $p > 0.05$). This means those trees with highest height, root collar diameter and diameter at breast height growths could not attain highest survival, and vice versa.

Table 2. Height and root collar diameter of two moringa species over three years Bako Research.

Moringa species	**Height (m)**				**Root collar diameter (cm)**			
	Assess.1	2011	2012	2013	Assess.1	Assess.2	Assess.3	Assess.4
Moringa oleifera	0.28b	2.97a	4.01a	3.97a	0.66b	2.18a	3.75a	4.75a
Moringa stenopetala	0.56a	1.79b	2.40b	2.63b	0.84a	2.16a	4.14a	5.06a
Mean	0.42	2.39	3.21	3.30	0.75	2.17	3.94	4.903
LSD (5%)	0.09	0.31	0.99	1.12	0.06	0.44	1.19	0.80
SE	0.0147	0.052	0.164	0.184	0.009	0.073	0.195	0.131
CV (%)	6.05	3.76	23.84	9.66	2.14	5.84	8.59	4.63
P value	0.0056	0.0038	0.0202	0.0356	0.0051	0.8867	0.294	0.240

SE= Standard error of the mean CV= Coefficient of variation P = Probability Assess. = Assessment LSD = Least Significant Difference

Assess.1 = Assessment seedling height and root collar diameter measured after one month.
Assess.2 = Assessment seedling root collar diameter measured after three months.
Assess.3 = Assessment seedling root collar diameter measured after five months.
Assess.4 = Assessment seedling root collar diameter measured after seven months.

Mean values followed by different small letters within columns are significantly different at probability level of 0.05

Table 3. Diameter at breast height and survival count of two moringa species over three years Bako Research.

Moringa species	**Diameter at breast height (cm)**			**Survival (%)**			
	2011	2012	2013	Assess.1	2011	2012	2013
Moringa oleifera	2.97a	4.22a	4.92a	100.0a	100.0a	100.0a	100.0a
Moringa stenopetala	1.52b	2.58a	3.31a	100.0a	97.33a	97.33a	97.33a
Mean	2.25	3.40	4.11	100.0	98.7	98.7	98.7
LSD (5%)	0.71	1.95	2.61	0.00	11.47	11.47	11.47
SE	0.117	0.320	0.429	0.000	1.89	1.89	1.89
CV (%)	8.99	16.3	18.1	0.000	3.3	3.3	3.3
P value	0.0127	0.0679	0.1183	NS	0.4226	0.4226	0.4226

SE= Standard error of the mean CV= Coefficient of variation P = Probability Assess. = Assessment LSD = Least Significant Difference, NS= Non-significant Difference.

Assess.1 = Assessment seedling survival measured after one month.

Mean values followed by different small letters within columns are significantly different at probability level of 0.05.

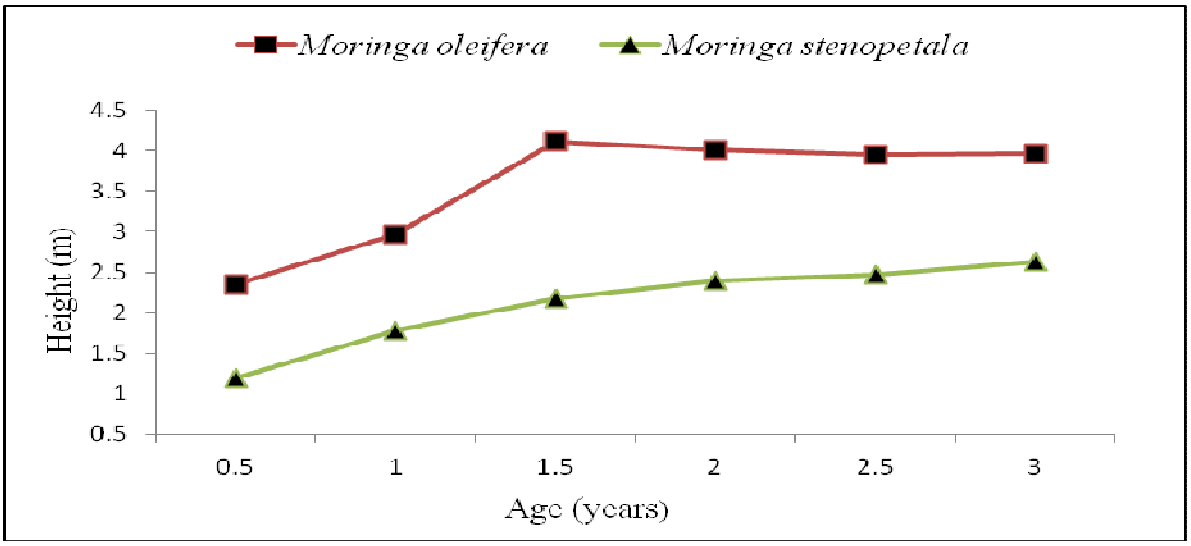

Figure 3. Height growth as a function of moringa species age

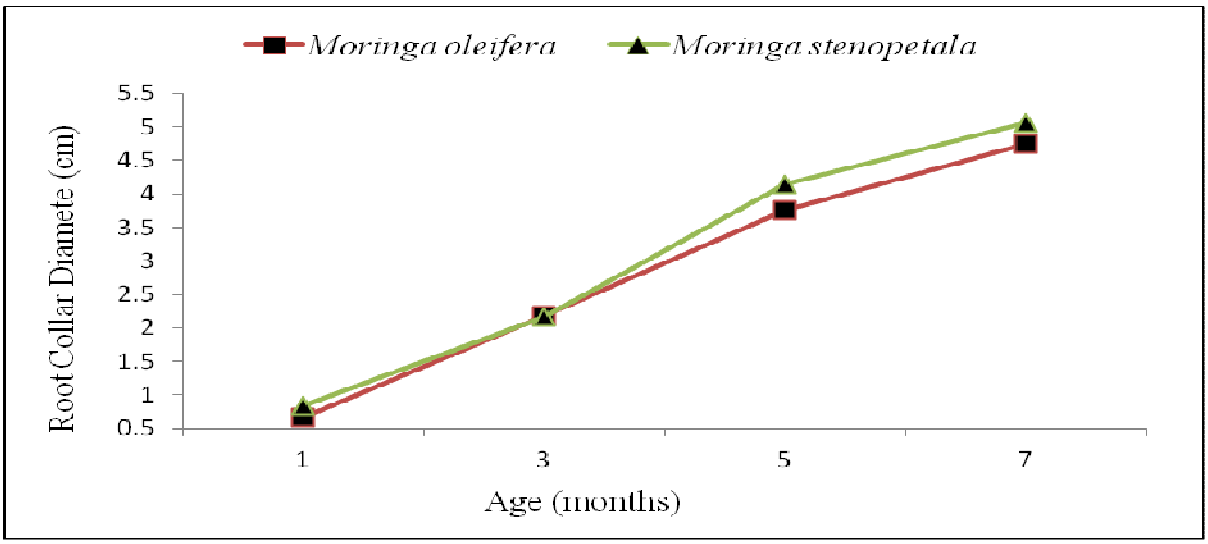

Figure 4. Root collar diameter growth as a function of moringa species months.

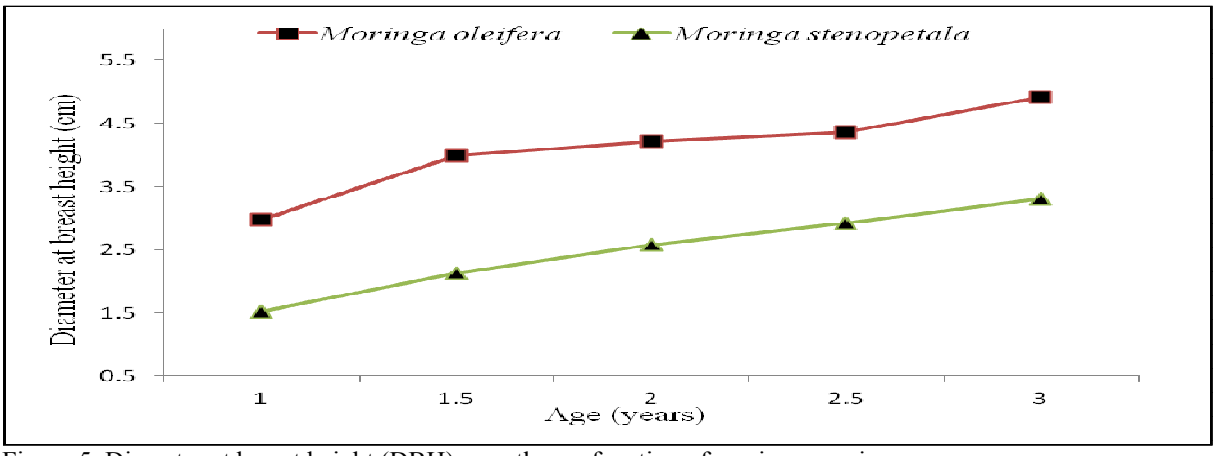

Figure 5. Diameter at breast height (DBH) growth as a function of moringa species age

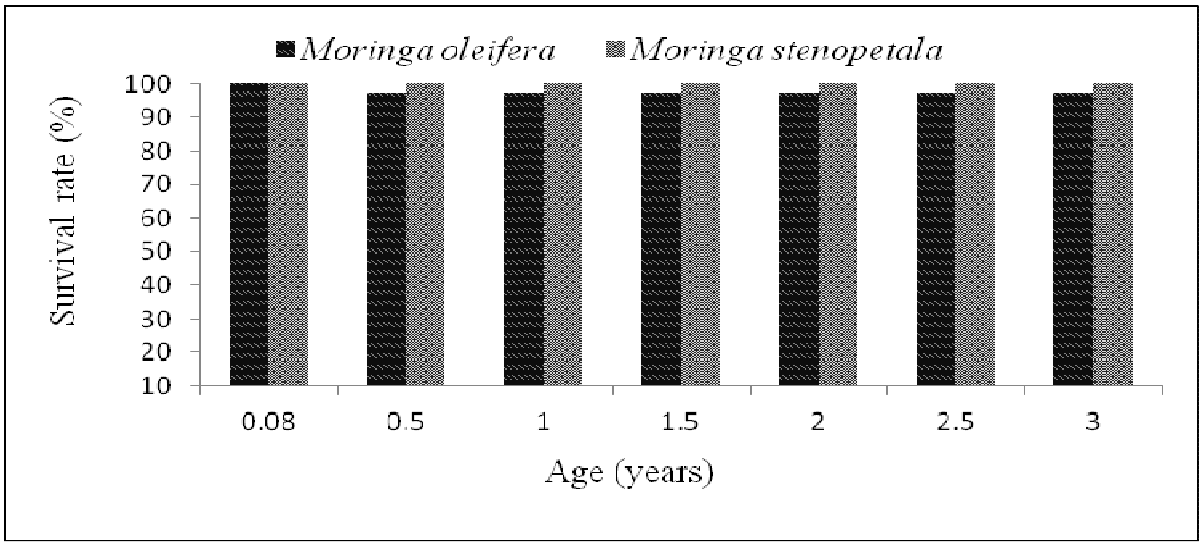

Figure 6. Survival as a function of moringa species age

Conclusion and recommendation

Both of moringa species included in the trial, *Moringa oleifera* was the most vigorous in height growth and root collar diameter showing promising performance under Bako site conditions. Both of them are a multipurpose tree of significant economic importance, as it has vital nutritional, industrial, and medicinal applications. To make use of the potential of these both of moringa species to the maximum, further technology specific (i.e. silvicultural, nutritional value, utilization and other management studies) and on-farm agroforestry works should be done on these moringa species in the area.

For the immediate use, however, it is possible to recommend the following species for Bako area and for sites with similar agro-ecological conditions with Bako-Both of *Moringa oleifera* and *Moringa stenopetala* for boundary planting, homestead/homegarden and woodlots establishment as a source of provides both direct (food, feed, wood, medicinal and water purification) and indirect potential benefits (soil and water conservation, shade and shelter, salinity control, etc) for the society and their domestic animals (NRC, 2006). So it should be given due attention by all concerned bodies and considered a priority moringa species to alleviate malnutrition, climate change mitigation and reduce poverty by scaling-up, given high attention for research and development, demonstration and multiplication of these both moringa species.

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References

Abebe Yadessa, Diriba Bekere and Taye Bekele. 2000. Growth performance of different multipurpose tree and shrub species at Bako, Western Oromia, pp. 177-186. *In: Nutrient Management for Improving Soil /Crop Productivity in Ethiopian Agriculture.* Proceedings of the Fifth Biennial Conference of Ethiopian Society of Soil Science (ESSS), March 30-31, 2000, Addis Ababa, Ethiopia.

Dawit Mulugeta and Legesse Dadi. 1987. Chemical control of weeds in maize at Bako, 1980 1986. In: a. W. Michieke (ed.), Proceedings of the eleventh east African weed science society conference, Nairobi, Kennya, 25 – 31, May, 1987.

Evans,J. 1992. Plantation forestry in the tropics. Tree planting for industrial, Social, environmental, and agro – forestry purposes. 2nd ed. Calendron press. Oxford.

FAO. 1974. Tree planting practices in Africa savannas. Rome, Italy.

Fuglie, L.J. and Sreeja, K.V. 2001. Cultivation of Moringa. The multiple attributes of Moringa The Miracle Tree. CTA Publication, Wageningen, The Netherlands pp. 153-157.

Hunde A. and Abebe A. 1991. Preliminary study on water clarification properties of Moringa stenopetala, A multi-purpose Tree Tropical Ecology 36(1): 49-57, 1995.

IAR (institute of agricultural research). 1991. Meteorological data for IAR centers, sub-centers and trial sites. IAR, Addis Ababa, Ethiopia, miscellaneous publications no.1.

Jahn, S. A. A. (1991), "The traditional domestication of a multipurpose tree *Moringa stenopetala* (Bak. F.) Cuf.

in the Ethiopian Rift Valley", *Ambio*, Vol. 20 No. 6, 244-247

Mark, E., O. 1998. Research on applied uses of Moringa stenoprtala.

NRC (2006). *Lost Crops of Africa, Vol. II, Vegetables* The National Academies Press,Washington, DC Oliveira, J. T. A., Silveira, S. B., Vasconcelos, I

Rams, J., 1994. Moringa a highly nutritious vegetable tree, Tropical Rural and Island/atoll Development Experimental Station (TRIADES), technical Bulletin No.2.

Rocleleau, D.,Weber, F., and Field – Jumma, a.1998. Agro-forestry in dry land Africa. ICRAF, Nairobi.