Effect of Spacing on Growth Performance and Leaf Biomass Yield of *Moringa stenopetala* (Bak.f.) Plantation at Arbaminch

ZewduYilma*[1,] Abeje Eshete[2], Dereje Gashaye[3], and Mulugeta Geremew[3]

[1]Central Ethiopian Environment and Forest Research Center (CEEFRC)
[2]Ethiopian Environment and Forest Research Institute (EEFRI)
[3]Hawassa Environment and Forest Research Center (HEFRC)
*Corresponding author: ☎ 0913077638, zewduyilma@gmail.com

Source: Zenebe Mekonnen, Tatek Dejene, Abayneh Derero, Alemayehu Essayas, Teshome Tessema, Daniel Gebeyehu, Agena Anjulo, Miftah Fekadu, Biruk Gobena, and Abiyot Berhanu (eds). 2021. Current Information and Technologies on the Environment and Forest: Proceedings of the Ethiopian Environment and Forest Research Institute, 4th Annual Research Outputs Dissemination Workshop, February 17-20/ 2020, Adama, Ethiopia.

Abstract

Moringa stenopetala is a multipurpose tree distributed in the lowland areas of the southern part of Ethiopia. The aim of this study was to determine the effect of plant spacing on plant growth parameters and leaf biomass production of *M. stenopetala*. The study was conducted in Arbaminch woreda. Three planting spacing (0.5 x 0.5 m; 1 X 1 m and 2 X 2 m) were arranged in a randomized complete block design and the treatments were replicated three times. Survival %, root-collar diameter, height and stem diameter of the trees in each plot were recorded at three monthly intervals. Data for leaf biomass was collected at the age of 27, 32 and 48 months. The wider spacing produced the largest quantity of dry leaf biomass (119.28 ± 9.02, 143.85 ± 10.29 and 249.8± 24.22 g/tree and 298.2 ± 22.54, 359.62 ± 25.73 and 624.49± 60.59 kg/ha) while the narrow spacing produced the smallest quantity (48.36 ± 5.10, 44.74 ± 3.19 and 88.15 ± 30.28 g/tree and 1934.4 ± 203.89, 1789.56 ± 127.78 and 3526.01± 1211.2 kg/ha) at the 1st, 2nd and 3rd harvest, respectively. This indicates that an increase in the plant spacing led to higher dry leaf biomass production per tree, but the lesser the yields per hectare due to unpronounced competition at early ages of the plantation.

Keywords: Spacing, Plant growth, Leaf Biomass,

Introduction

Ethiopia has diverse physio-geographic features and a very high variation in macro and micro-climatic conditions that contributed for the formation of diverse ecosystems inhabited with a great diversity of life forms of both animals and plants (Teketay *et al*., 2005). Such diverse ecological conditions enabled the country to inhabit about 6000 higher plants of which about 10% are endemic (Hedberg *et al*., 2009). Friss *et al*. (2010) classified the vegetation resources of Ethiopia into 12 vegetation types. The country is also known as Vavilov center of origin and diversity for many food plants and their wild relatives (Edwards, 1991). Despite these rich natural resources and being an agrarian country with over 80% of its population, more than 35% of Ethiopian people are food insecure (FAO, 2010). *M.stenopetala* is one of the edible plants in southern Ethiopia which has been domesticated as a 'cabbage tree' by Konso people from their territory lowland dry forests (Jahn, 1991). *M. stenopetala* is one of the two most common species among the 14 species of the Genus Moringa, in Moringaceae family (Beyene, 2005; Jiru *et al*., 2006). It is endemic to East Africa including Kenya and Ethiopia (Jahn, 1991). It is distributed in the lowland dry ecology of the southern part of Ethiopia and cultivated for food, fodder, shade, windbreak and medicinal value around homesteads and in farmlands (Jiru et al., 2006). It has various local names: Shiferaw in Amharic, Haleko in Gofa areas, Shelagda in Konso (Jahn 1991; Teketay, *et al*., 2010).

M. stenopetala is a multipurpose tree with vital nutritional, industrial, and medicinal applications (Jahn, 1991; NRC, 2006). The different part of the tree is used for different purposes. The green leaf is consumed as a vegetable, dried leaf for tea, leaves and pods are used as fodder for animals, seeds are used to purify muddy water, seeds are also source of cooking oil or for other industrial applications, roots are used to clarify dirty water, and is a medicine to treat differentaliments, wood is used for pulp production (Seifu, 2014). The tree is also a drought resistant that provides shade in arid and semi-arid areas, provide nectars for honeybees, serve as a live fence and ornamental plant and conserve agricultural soils when intercropped in farmlands (ICRAF, 2006). The tree is mainly grown as a staple and supplemental food where the leaves are eaten daily together with cereal balls in Konso, Gamo, and Gofa people in southern Ethiopia (Endeshaw, 2003). Almost every household in the areas grow at least four leaf yielding Moringa trees in their homesteads and 10 trees in their farmlands for their daily consumption (Abuye *et al*., 2003; Yisehak *et al*., 2011). The extra production of the leaves and recently the seeds are sold in the market to generate cash income (Jiru *et al*., 2006).

Despite its multitude benefits and a wide range of adaptation from arid to humid climates with a prospect to be grown in a wide range of land use classes, its distribution is limited to mainly southern Ethiopia and its potential has not been taped (Jiru *et al*., 2006). Recently, the production and marketing of the leaves and seeds of *M. stenopetala* has increased in other parts of the country owing to its perceived medicinal and nutritional values (Abay *et al*., 2015) and the tree is now being grown in most lowland and midland parts of the country (Jiru*etal*., 2006, Abay *et al*., 2015). The production is expanding and new businesses are flourishing from time to time where women and youth are benefiting from the growing businesses, creating new jobs and employments, which are believed to reduce poverty (Kaleb and Busha, 2013; Abay *et al*., 2015). *M. stenopetala* can attract more unemployed youth and women to involve in income generating activities through growing, processing and marketing of the tree and its products. Recently investors have also showed interest in establishment of plantation from *M. stenopetala* for massive production of leaves and seeds and in establishing value-added products (Kaleb and Busha, 2013; Saint Sauveur and Armelle, 2001). Even though the tree has such high value for food security at smallholder farmers' level and industrial value at national and international level, the tree is being cultivated traditionally without any technical and technological support. Previous studies focused on documenting the use of different plant parts, estimating number of trees per household per hectare, nutritional contentmentof the tree. Generally, there is limited scientific information on the effect of different silvicultural practices on growth performance and leaf biomass yield of *M. stenopetala* (Seifu, 2014). Such scientific studies are important to determine the productivity levels of *M.stenopetala* as a cabbage tree for its leaf biomass in the arid and semi-arid areas of Ethiopia. This study was thus initiated to determine the optimum spacing for better growth performance and leafy biomass yield of *M. stenopetala*. We hypothesized that the decrease in spacing between trees would decrease the stem growth and leaf biomass per tree but increase the leaf biomass yield on hectare basis.

Materials and Methods

Description of the study area

The experiment was conducted in Arbaminch zuria woreda, Gamo zone, SNNPR. It is found between UTM coordinates of 37N 313305 – 37N 353505 northing and 37N 630585 – 686632 easting at 489 km south of Addis Ababa. The woreda has an area of 168,172 hectare, of which 34,137 ha is crop land and 15,163 ha forest land. There are 14 *M. stenopetala* growing kebeles in the woreda with average land holding of 1.75 ha and with the family size of 6 individuals.

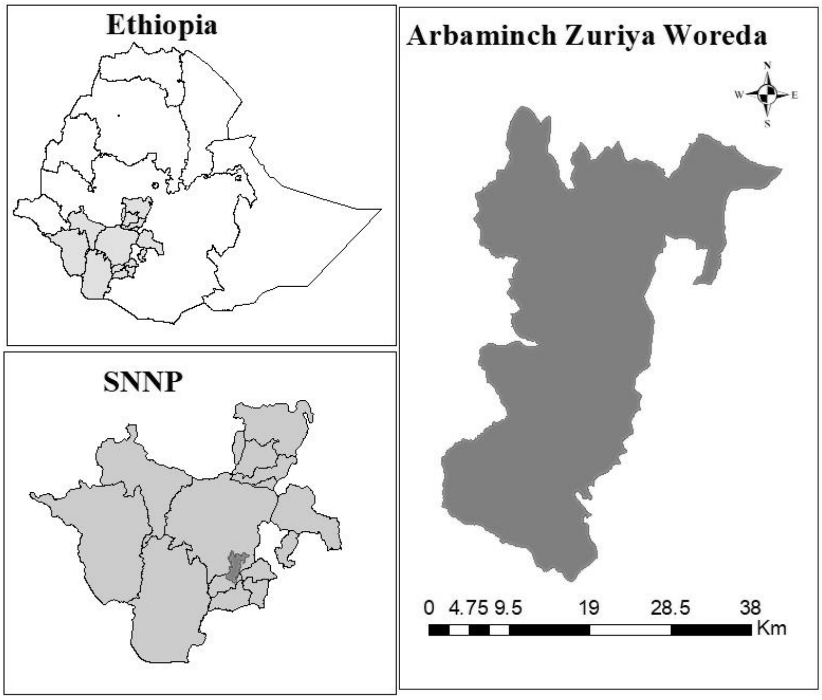

Figure 1: Location of the research site in Arbaminch Zuria woreda, SNNPR, Ethiopia

The altitude of the woreda ranges between 1150 and 2330 metres above sea level.The rainy season is bi-modal with the mean annual rainfall ranging from 800 and 1200 mm and the mean annual temperature between 16°C and 37°C. The livelihood of more than 92% of the woreda population is based on farming. The main crops grown in the area are maize, sorghum and teff. *M. stenopetala* is widely grown in the woreda, almost every rural household plant Moringa trees in home gardens and/or farmlands. The soil type of the study area is ranging between clay and silt loam.

Experimental Design and Treatment

The experiment was arranged in a randomized complete block design (RCBD) with 3 replications. A land size of 10,000 m^2 was divided into three blocks and 9 experimental plots per block. The treatments consisted of 3 spacing levels namely narrow spacing (0.5mx0.5m), medium spacing (1mx1m) and wider spacing (2mx2m) in three replications. The blocks and plots were separated from each other by 3m and 2m, walkways, respectively with a border of 0.50 x 0.50 m created around the treatment plots.

Establishment and Management

The experimental site was cleared and ploughed before planting seedlings. Seeds were collected from Konso Woreda, SNNPR, which is very close to the experiment site established. Seedlings were raised with12 cm diameter flat polythene tubes in the nursery at Arbaminch zuria woreda. The study was conducted under rain fed conditions and planting was done on the site during the rainy season at the end of July, 2017. Each seedling was planted in a pit that has a 50 cm depth and a cross section area of 900 cm^2. In each plot, 36 seedlings of *M. stenopetala* were planted in row and in total 972 seedlings were used in the experiment. Initial root collar diameter (RCD) and height measurement was done before planting. After planting, a thorough ramming of the fine earth was done to avoid air circulation. During the course of the study, the plots were well maintained by the picking of weeds and cultivated regularly to loosen soils for aeration after establishment of seedlings. All experimental plots received similar silvicultural practices.

Plant Measurement and Leaf Harvest

The inner 16 seedlings/plot were considered for the required data collection. Survival percent, height and RCD of the trees in each plot were recorded at three months intervals. Height was measured with a pole graduated in meters and centimeters, and RCD with digital caliper. Leaves were harvested from the experimental trees at the age of 27, 32 and 48 months after planting. Based on indigenous leaf harvesting practice of Konso and Derashe people, up to 85% of leaves were harvested per tree per season and 15% leaves were left on each Moringa tree for the enhancement of photosynthetic process and to sustainably harvest three times.The harvested leaves from each tree were partitioned into leaf, petioles and stem. Only the leaves were considered for further analysis. Fresh weight of every leaf part of each individual tree was recorded immediately by using an electronic balance after harvesting.

Oven dry weight of sample leaves were measured after drying the leaves at 60˚C for 72 hours (to a constant weight) using an electric oven (Amaglo et al. 2006) at the laboratory facility of Ethiopia Environment and Forest Research Institute.

Statistical Analysis

All data were subjected to analysis of variance (ANOVA). The least significant difference at the 5% level was used to identify significant statistical differences between the three spacing levels.

Results and Discussion

Survival

M. stenopetala has shown relatively better mean survival rate in the narrow spacing than the medium and wider spacing at the 3, 6, 9, 12 and 15 months after planting (Table 1). The mean survival rate decreased with time until the 12th month for the narrow and medium spacing while the survival showed a decreasing trend until the 6th month for the wider spacing and was constant then after. The survival rate of the plantation averaged 94%, 89.6%, 88.7%, 87% and 87% at the age of 3, 6, 9, 12 and 15 months after planting, respectively.

Table 1: Survival rate of *M. stenopetala* over 15 months after planting under three spacing treatments

Spacing	**Survival rate (%)**				
	3rd month	**6th Month**	**9th Month**	**12th Month**	**15th Month**
0.5 x 0.5 m	96.5	94.4	93.1	90.3	90.3
1 x 1 m	91.7	86.1	84.7	82.6	82.6
2 x 2 m	93.8	88.2	88.2	88.2	88.2
Overall	94.0	89.6	88.7	87.0	87.0

Root Collar Diameter, Plant Height and Stem Diameter Growth

Growth was slow over the first three months after planting but showed a steady increment in the following months. RCD at 3, 6, 9, 12 and 15 months averaged 0.8 cm, 1.3 cm, and 1.5 cm, respectively.

The mean root-collar diameter increments in narrow and medium spacing (0.5 × 0.5 m and 1 × 1 m) resulted in the greatest root-collar diameters (0.51 and 0.55 cm respectively), while the wider spacing (2 × 2 m) recorded the lowest RCD increments (0.4 cm) in the 1st three months (Table 2). In the 6th month, the medium and wider spacing gave significantly higher mean RCD increments than the narrow spacing of 0.5 × 0.5 m. Similar results were also found in the 9th month, where the medium and wider spacing gave greater mean RCD increments than the narrow spacing. In the 12th and 15th months, the wider spacing gave a significantly higher mean RCD increment than the medium and narrow spacing and the medium spacing gave a significantly higher mean RCD increment than the narrow spacing.

The medium and wide spacing (1× 1m and 2 × 2 m) resulted in the greatest plant height growth (0.66 and 0.55 m, respectively), while the narrow spacing (0.5 × 0.5 m) recorded the lowest plant height growth (0.35 m) in the 6th month (Table 2). The medium and wider spacing gave significantly higher mean height growth than the narrow spacing of 0.5 × 0.5 m at 6thmonth after planting. Similar results were found in the 9, 12 and 15th months after planting where the medium and wider spacing gave greater plant height growth than the narrow spacing.

Stem diameters averaged 1.42 cm 2.0 cm, and 1.96 cm at 9 months for narrow, medium and wider spacing, respectively; 1.84 cm, 2.7 cm, and 2.99 cm at 12 months for narrow, medium and wider spacing, respectively; and 2.12 cm, 2.96 cm, and 3.19 cm at 15 months for narrow, medium and wider spacing, respectively.The medium and wide spacing (1× 1 and 2 × 2 m) had significantly larger stem diameter than the narrow spacing in the 9, 12 and 15th months after planting (Table 2).

Leaf Biomass Production

The dry leaf biomass on individual tree level across the densities ranged from 7.8 to 530.4 g/tree, from 9.36 to 608.4 g/tree and from 6.24 to 1684.8 g/tree for the 1st, 2nd and 3rd harvests, respectively. A significant difference in the dry leaf biomass production on individual tree level was observed due to spacing. The increase in planting spacing led to the increase in dry leaf biomass at the three harvest seasons. At the first harvest, the wide spacing gave significantly higher dry leaf biomass than the medium and narrow spacing and the medium spacing gave significantly higher dry leaf biomass than the narrow spacing (Table 3). A similar significant difference in the dry leaf biomass production was observed across spacing levels at the second and third harvest.

Table 2: Mean Root-collar diameter increments, plant height growth and stem diameters of *M. stenopetala* at 6, 9, 12 and 15 months after planting.

	0.5 x 0.5 m	**1 x 1 m**	**2 x 2 m**
Root-collar diameter (cm)			
6 months	1.67^{a}± 0.10	3.01^{b} ± 0.12	3.20^{b}± 0.13
9 months	2.30^{a} ± 0.13	4.61^{b}± 0.17	5.42^{c} ± 0.18
12 months	2.72^{a}± .15	5.63^{b} ± 0.21	6.92^{c} ± 0.20
15 months	3.12^{a} ± 0.16	6.14^{b} ± 0.24	7.45^{c} ± 0.20
Plant height (m)			
6 months	0.35^{a}± 0.03	0.66^{b}± 0.04	0.55^{b}± 0.03
9 months	0.81^{a} ± 0.05	1.36^{b} ± 0.06	1.28^{b} ± 0.05
12 months	0.88^{a}± 0.06	1.54^{b}± 0.07	1.48^{b}± 0.06
15 months	1.02^{a}± 0.07	1.72^{b}± 0.08	1.69^{b}± 0.06
Stem diameter (cm)			
9 months	1.42^{a}± 0.10	2.0^{b}± 0.09	1.96^{b}± 0.08
12 months	1.84^{a}± 0.11	2.70^{b}± 0.13	2.99^{b}± 0.07
15 months	2.12^{a}± 0.14	2.96^{b}± 0.13	3.19^{b} + 0.11

Means in the same row followed by the same lowercase letter are not significantly different at $P < 0.05$

The dry leaf biomass on hectare bases across the spacing levels ranged from 31.2 to 8112 kg/ha, from 23.4 to 8736 kg/ha, and from 15.6 to 67392 kg/ha, for the 1st, 2nd and 3rd harvests, respectively. A significant difference in the dry leaf biomass production on hectare bases was due to the spacing. The increase in planting spacing led to the increase in dry leaf biomassper treeat the three harvest seasons. At the first harvest the wide spacing (2× 2 m) gave significantly higher dry leaf biomass than the medium and narrow spacing and the medium spacing (1× 1 m) gave significantly higher dry leaf biomass than the narrow spacing (Table 3). A similar significant difference in the dry leaf biomass production was observed across spacing levels at the second harvest. At the third harvest, the wide spacing gave a significant higher dry leaf biomass than the medium and narrow spacing but there was no significant difference between the medium and narrow spacing in dry leaf biomass production.

Table 3. Mean (± standard error of the mean) leaf biomass production at the 1st, 2nd and 3rd harvest across the three spacing levels.

Leaf biomass Production	**0.5 x 0.5 m**	**1 x 1 m**	**2 x 2 m**
at individual tree level (g/tree)			
1st harvest	48.36 ^{a}± 5.10	90.0 ^{b} ± 8.82	119.28 ^{c} ± 9.02
2nd harvest	44.74^{a} ± 3.19	115.08 ^{b} ± 9.77	143.85 ^{c} ± 10.29
3rd harvest	88.15^{a} ± 30.28	145.77^{b} ± 15.87	249.8^{c}± 24.220
on hectare bases (kg/ha)			
1st harvest	1934.40 ^{a} ± 203.89	900.04^{b} ± 88.19	298.20^{c} ± 22.54
2nd harvest	1789.56 ^{a} ± 127.78	1150.79 ^{b} ± 97.7	359.62 ^{c} ± 25.73
3rd harvest	3526.01^{a}± 1211.2	1457.67^{a}± 158.71	624.49^{b}± 60.59

Means in the same row followed by the same lowercase letter are not significantly different at $P < 0.05$

Conclusion and Recommendation

The results of the present study showed that the RCD, plant height and stem diameter were maximized at narrower, medium and wider spacing, respectively.

Planting Moringa at a relatively wider spacing increased leaf biomass production of individual trees. The increase is two to three folds from narrow to wider spacing. However, the species is found to be capable of producing a good leaf biomass yield at a relatively high density of plants on hectare bases. The leaf biomass production per hectare was very high at narrow spacing than the medium and wider spacing. The increase is five to seven folds from wider to narrow spacing. Currently the population number of Ethiopia is exponentially growing and the land resource became scarce and the need to plant and utilize Moringa trees is growing in different parts of Ethiopia. Our finding shows that Moringa can be planted and produce high biomass in small areas by local communities and investors. .

Based on site condition, Moringa leaves should be harvested at appropriate cutting height. It will be preferable to collect leaves during early morning and late afternoon and using clean scissors can help workers to become efficient in collecting more quantity and quality leaves. Planting Moringa trees can create job opportunity for youths and women to earn money by selling Moringa leaves at local and national market and improve their livelihoods.

M. stenopetala is one of the few multipurpose trees that are able to survive in harsh growing conditions. In order to enhance both the plant growth and leaf biomass production, it is desirable to consider fertilizer application and supplementary irrigation under diverse weather conditions and soil types. Such studies are very important for farmers and investors who are willing and able to grow the plant on a larger or commercial scale.

Acknowledgement

We would like to acknowledge the Ethiopian Environment and Forest Research Institute (EEFRI) for providing financial support and CEEFRC for facilitating logistic service for our research activity. Sincere thanks also go to Hawassa Environment and Forest Research Center (HEFRC), zonal, and woreda agricultural development officials and experts and to GantaKanchamaOcholekebele administration officials for their support in providing suitable land for conducting the Moringa research. We also would like to give special thanks to AtoEliyasBorsamo for his unreserved and honest effort in guarding and data collection during the life span of our research. The professional contribution of KibruyisefaSisay (PhD) in preparing the map of study area is well acknowledged.

References

Abay, A.,Birhane, E., Taddesse, T. and Hadgu, K.M. 2015. Moringastenopetala Tree Species Improved Selected Soil Properties and Socio-economic Benefits in Tigray, Northern Ethiopia. Sci. Technol. Arts Res.J.4(2): 68-78

Aberoumand, A. 2009.Nutritional evaluation of edible Portulacaoleracea as plant food.FoodAnalyt. Meth.(2): 204-207.Abuye, C., Urga, K., Knapp, H., Selmar, D., Omwega, A. M. and Imungi, J. K. 2003.Acompositional study of Moringastenopetala leaves. East African Medical Journal. 80(5): 247-252

Addis, G. 2009. Wild and Semi-wild edible plants of Hamar and Xonso (South Ethiopia) with emphasis on their ethnobotany and nutritional composition of selected species.PhD thesis, Addis Ababa University.

Asfaw Z and Tadesse M. 2001.Prospects for sustainable use and development of wild food plants in Ethiopia. Economic Botany 55:47–62.

Assefa, A. and Abebe, T. 2011. Wild edible trees and shrubs in the semi-arid lowlands of southern Ethiopia. J. Sci. Dev. 1:5–19.

Bahru T, Asfaw Z and Demissew S. 2014.Ethnobotanical study of forage/fodder plantspecies in and around the semi-arid AwashNational Park, Ethiopia. Journal of ForestryResearch 25:445–54.

Beyene, D. 2005. Genetic Variation in MoringastenopetalaGermplasm of Ethiopia by usingRAPD as Genetic Marker, MSc Thesis, AddisAbaba University, Ethiopia

Edwards, S. B. (1991). Crops with wild relatives found in Ethiopia. In: Plant Genetic Resources of Ethiopia.(J.M.M. Engels, J.G. Hawkes and MelakuWerede, eds.). pp. 42-74. Cambridge University Press,Cambridge.

Endeshaw, H. 2003. “Promoting the miracle tree of hope”, Ethiopian Herald, 19 July 2003

FAO (Food and Agriculture Organization of the United Nations). 2010. Global forest resources assessment 2010. FAO Forestry Paper 163. Rome: FAO.

Fentahun M.T. and Hager H. 2009.Exploiting locally available resources for food and nutritional security enhancement: Wild fruits diversity, potential and state of exploitation in the Amhara region of Ethiopia. Food Security 1:207–19.

Guinand, Y. and Lemessa, D. (2000). Wild-food plants in Southern Ethiopia: Reflections on the role of famine-foods at a time of drought. UNDP-EUE.Field mission report, Addis Ababa, Ethiopia.

Hedberg, I., Friis, I., and Person, E. (eds.). 2009. General Part and Index to Vol 1-7. Flora of Ethiopia and Eritrea Volume 8.The National Herbarium, Addis Ababa, Ethiopia and Uppsala, Sweden.

ICRAF,(2006),"Moringastenopetala",http://www.worldagroforestry.org/Sea/Products/AFDbases/AF/asp/SpeciesInfo.asp (Accessed 8 September 2006)

Jahn, S. A. A. 1991. The traditional domesticcation of a multipurpose tree Moringastenopetala (Bak. F.) Cuf. in the Ethiopian Rift Valley. Ambio: 20(6): 244-247

Jiru, D., Sonder, K., Alemayehu, L., Mekonen, Y, Anjulo, A. 2006. Leaf yield and Nutritive value of Moringastenopetala and Moringaoleifera Accessions: its potentialrole in food security in constrained dry farmingagroforestry systems. Addis Ababa, Ethiopia.

Kaleb K. and Busha T. 2013. Experience from Moringa Value ChainDevelopment in Ethiopia. In: Moringa Proceedings Papers. Pp.1-18.

Lulekal E, Asfaw Z, Kelbessa E and van Damme P.2011. Wild edible plants in Ethiopia: A reviewon their potential to combat food insecurity.Afrika Focus 24:71–121.

NRC (2006), Lost Crops of Africa, Vol. II, Vegetables, The National Academies Press,Washington, DC

Ocho, D.L., Struik, P.C., Price, L.L., Kelbessa, E. and Kolo, K. 2012. Assessing the levels of food shortageusing the traffic light metaphor by analyzing thegathering and consumption of wild food plants,crop parts and crop residues in Konso, Ethiopia.Journal of Ethnobiology and Ethnomedicine8:1–17

Saint Sauveur (de), and Armelle. 2001. Moringa exploitation in the world: State of knowledge and challenges. DevelopmentPotential for Moringa Products. International Workshop, Dar esSalaam, Tanzania.

Seifu, E. 2014. Actual and Potential Applications of Moringastenopetala,Underutilized Indigenous Vegetable of Southern Ethiopia: A Review. International Journal of Agricultural and Food Research: 3(4): 8-19.

Seyoum, Y.,Teketay, D., Shumi, G. and Wodafirash, M. 2015.Edible Wild Fruit Treesand Shrubs and TheirSocioeconomicSignificancein Central Ethiopia.Ethnobotany Research & Applications 14:183-197.

Tebkew M, Asfaw Z and Zewudie S 2014. Underutilized wild edible plants in the ChilgaWoreda, northwestern Ethiopia: focus on wildwoody plants. Agriculture & Food Security 3:12.doi:10.1186/2048-7010-3-12

Teketay, D. and Eshete, A. 2004.Status of indigenous fruitsin Ethiopia.Pp. 3–35 in Review and Appraisal on the Statusof Indigenous Fruits in Eastern Africa.InChikamai, B.,Eyog-Matig, O. andMbogga, M. International Plant Genetic Resources International Sub-Saharan AfricaForest Genetic Resources in the framework of Associationof Forestry Research Institutions in Eastern Africa,Cotonou, Benin, and Nairobi, Kenya.

Teketay, D., Senbeta, F., Maclachlan, M., Bekele, M. and Barklund, P. (2010).Edible Wild Plants in Ethiopia.Addis Ababa University Press, 575pp.

Yisehak, K., Solomon, M., and Tadelle, M. 2011. Contribution ofMoringa (Moringastenopetala, Bac.), a Highly NutritiousVegetable Tree, for Food Security in South Ethiopia: AReview. Asian Journal of Applied Sciences 4: 477-488.