Journal of Arid Environments 222 (2024) 105169

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Ethnobotany of *Moringa stenopetala:* A case study from *Derashe* and *Konso* ethnic groups in southern Ethiopia

Berhane Kidane *, Zewdu Yilma, Abeje Eshete

Ethiopian Forestry Development, Addis Ababa, Ethiopia

ARTICLE INFO

Keywords:
Moringa
Food
Medicine
Ethnobotany
Management
Utilization

ABSTRACT

Moringa stenopetala, an important vegetable tree locally called "Haleko" in Derashe and "Shelagda" in Konso area, is cultivated and managed mainly for its edible leaves and for various other purposes in the southern part of Ethiopia. The study explored Ethnobotanical knowledge of the local communities in Konso and Derashe districts. Data were collected using household survey, focus group discussion and key informant interview. A total of 180 households were interviewed using a semi-structured questionnaire. Focus group discussions were also conducted involving both men and women. The result showed that *M. stenopetala* (Haleko) is an important component of the daily dish of the study ethnic groups and used for medicinal purposes. Farmers in both ethnic groups propagate *M. stenopetala* using its seeds and cuttings. The studied ethnic groups plant the species in home gardens and their crop fields. Farmers produce and use succulent leaves for preparation of local dish. They also practice pollarding of *M. stenopetala* tree at about 2.30 m to avoid bird resting on the trees and damage their crops. The study also recommends further promotion of the species to other areas with similar agroecology, and propagation techniques research to investigate the optimum cutting height, age and season.

1. Introduction

Moringa stenopetala is an important plant species to the South Ethiopian Community in the semi-arid environment where it is a major drought tolerant vegetable tree (Berushka and Himansu, 2012). It belongs to a member of a single genus in the family Moringaceae and is indigenous to Ethiopia (Mohammed, 2013). The plant is also believed to be native not only to Ethiopia but also to Northern Kenya and Eastern Somalia. It is a deciduous tree widely cultivated in the southern part of Ethiopia. It is well known as a cabbage tree and locally known as "Haleko" in Derashe and "Shelagda" in Konso area. It is also called "Shiferaw" in Amharic in different parts of Ethiopia (Orwa et al., 2009).

Moringa stenopetala has gained much importance in the recent days due to its multiple uses and benefits. It is considered as one of the world's most useful trees, as almost every part of the tree can be used for food or has some other benefits (Ashfaq et al., 2012). The flowers are a good nectar source for honey and the seeds are a rich oil source for cooking. As the nutrient compositions of its leaves are higher than other edible leafy vegetables, the leaves are used as source of nutrients in the dry season when other vegetables are scarce. Leaves of *M. stenopetala* contain on average 263 (g/kg DM) crude proteins (Aberra et al., 2012). Moreover, its leaves can also be used for fortification of foods with low micronutrient content to improve their protein and minerals contents (Ntshambiwa et al., 2023).

Moringa stenopetala is believed to be one of God's abundant resources important for the struggle against world hunger (Reta, 2016). It is a drought tolerant and fast-growing tree that has high nutritional value and the potential to alleviate malnutrition in the tropics and has potential medicinal and industrial applications and significant economic contributions (Eyassu, 2014). It is also used as an alternative to food supplies to treat malnutrition and used as a metabolic conditioner to aid against endemic diseases in developing countries.

Moreover, traditional healers have prescribed different parts of the tree for the treatment of skin diseases, respiratory illnesses, ear and dental infections, hypertension, diabetes, cancer treatment, water purification, and have promoted its use as a nutrient dense food source (Anwar et al., 2007; Fahey, 2015; Fuglie, 1999). The different parts of the tree possess characteristics that are interesting for both scientific and commercial use.

M. stenopetala is distributed in the lowland ecology of the southern part of Ethiopia (Mekonnen and Gessese, 1998; Liyew and Daniel, 2015) and is believed to have a wide range of adaptation from arid to humid climates with a prospect to be grown in a wide range of land use classes. It also grows in the lowlands of the western escarpment of the East

* Corresponding author. Bkidane19@gmail.com

https://doi.org/10.1016/j.jaridenv.2024.105169
Received 26 April 2023; Received in revised form 14 April 2024; Accepted 15 April 2024
0140-1963/© 2024 Published by Elsevier Ltd.

African Rift Valley from arid to semi-humid areas with altitudinal range from 390m to 2200 m.a.s.l. (Dechasa et al., 2006) but the most potential native altitudinal range in Ethiopia lies between 1000 and 1800 m.a.s.l.

There are studies focused on different aspects of *M. stenopetala* (Agena, 2009; Aberra et al., 2012; Alemayhu et al., 2015). Nevertheless, detailed ethnobotanical study reports that describe Moringa *stenopetala* propagation, cultivation, management, and utilization based on traditional knowledge of *M. stenopetala* are scarce. The purpose of this study was therefore, to explore the ethnobotanical knowledge on *M. stenopetala* by Konso and Derashe ethnic groups, where they have long years tradition and experience not only in cultivation but also in utilization of the species.

2. Materials and methods

2.1. Study area and people

The study was conducted in Konso and Derashe special districts of the Southern Nations, and Nationalities and Peoples' Region (SNNPR) found at 600 and 550 km away from Adds Ababa, the capital city of Ethiopia, respectively (Fig. 1). The language of Konso people is "Konso", whereas Derashe speaks "Derashiteta". According to the census conducted by the Ethiopian Central Statistics Authority (CSA), Derashe district has a total population of 182,316 and Konso district has a total population of 288,621 (CSA, 2013).

2.2. Survey method and data analysis

Two special districts Derashe and Konso were selected from SNNPR because they are known for their long year's tradition of growing of *M. stenopetala*. From each selected districts three *kebeles* that have better planting experience and practices were randomly selected where "kebele" is the lowest administrative unit in Ethiopia.

Field data collection was carried out between October 2016 and December 2017. Checklists were prepared and used for focus group discussion, where 10 discussants composed of different gender and age groups from each district in selected *Kebeles* were participated in the discussions and knowledgeable persons including farmers have participated in the key informant interview. Based on the results of focus group discussion and key informant interview semi-structured questionnaires were prepared for the household survey. A total of 180 households (151 Male and 29 Female) were selected from six *kebeles* (three *kebeles* from each special district). Ninety households from each district were selected based on random sampling techniques. Descriptive statistics were used to calculate averages, percentages, frequencies, and to present the results.

3. Results and discussion

3.1. Propagation

Both ethnic groups usually use both seedlings and cuttings to plant *M. stenopetala*. Seedlings can be obtained either purposely grown from seeds in the nursery or seedlings that are obtained from naturally fallen seeds grown under mature *M. stenopetala* trees. Seeds are used to easily raise seedlings and to produce large number of seedlings at a time. Seedling raising is manageable with family labour and seeds can easily be collected from previously grown tree found in home gardens and crop fields. Both ethnic groups usually use cuttings that have length above 50 cm but communities do not suggest the use of cuttings with length greater than 1.50 m for better survival. The preferred diameter of cutting material by the studied ethnic groups is between 10 and 20 cm.

Therefore, it is possible to use either seeds or cuttings for propagation purpose. Although both methods are usually practiced by the local ethnic groups, the preference of planting materials varied among them as indicated in Table 1. The most preferred source of planting material

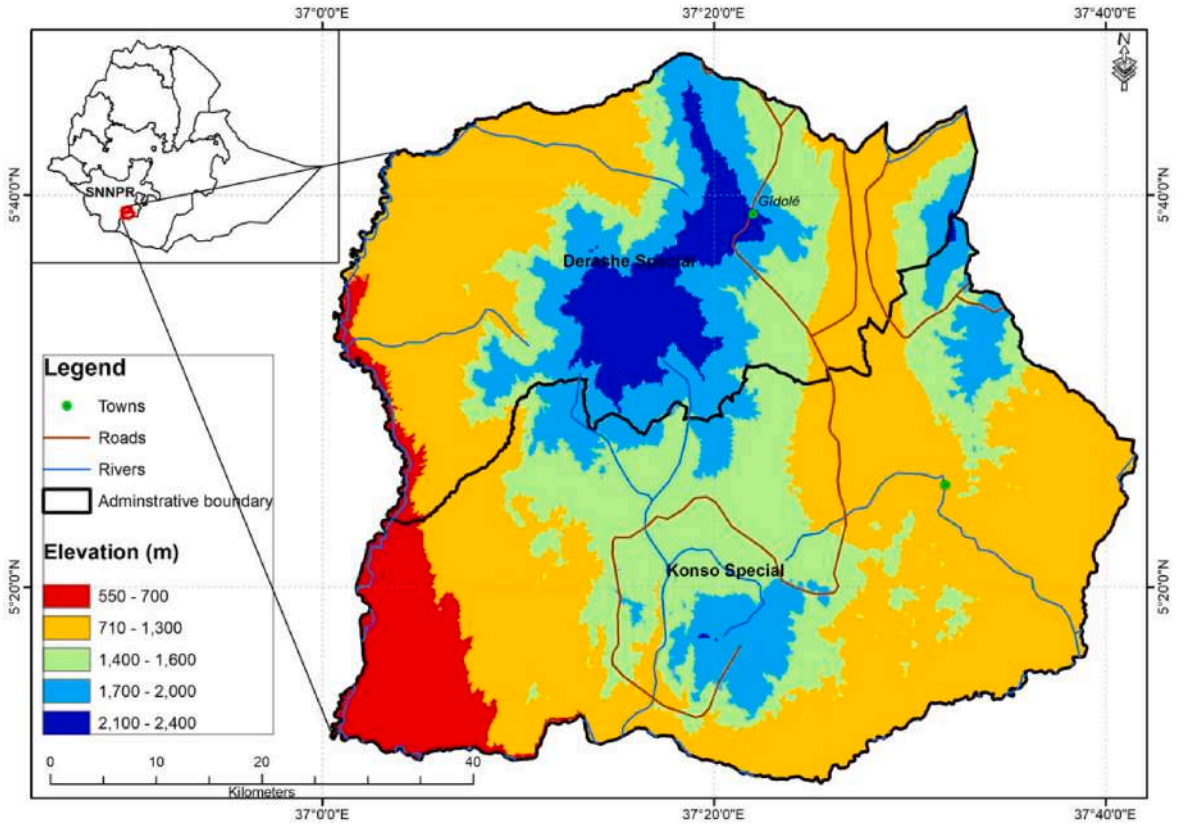

Fig. 1. Map of the study districts (Derashe and Konso special districts).

Fig. 2. Figure 2a and 2b: Pollarded *M. stenopetala* tree on crop fields (Photo by Berhane Kidane).

Table 1
Ethnic groups' preference of planting materials.

	Means of propagation	Special Districts (Wereda)			
		Konso		Derashe	
		Frequency	Percentage	Frequency	Percentage
1	Seedlings grown from naturally fallen seed	1	1.1	10	11.1
2	Seedlings raised from seed by farmers	13	14.4	29	32.2
3	Cuttings by direct planting	41	45.6	43	47.8
4	Seedlings raised and distributed from Government and NGO	19	21.1	1	1.1
5	Combination of the above methods	16	17.8	7	7.8
		90	100	90	100

by the study ethnic groups is cuttings (Table 1). Their preference may be due to the fact that *M. stenopetala* trees from stem cuttings grow faster compared to trees planted from seed. However, cuttings develop a shallow root system that makes them more susceptible to moisture stress and wind damage (Palada and Chang, 2003).

Similar to this study, the report by Alemayhu et al. (2015) revealed that the common cutting size (length) lies within the indicated range in our study result and was between 0.75 and 1.25 m and the diameter of branch cuttings lie between 5 and 20 cm. Based on the results of the two studies, we suggest using cuttings length of 1m and 10 cm diameter. However, further field research and experiment is required in order to determine the appropriate cutting size (both length and diameter) that could enable better survival, growth and development of *M. stenopetala* plant.

Commonly, seedlings are planted with planting depth (pit) of at least 50 cm and radius depends on the size of the planting material used. If potted seedlings are used for propagation, the radius of planting pit will be greater than 20 cm. In the study area, seedlings are usually protected by maize or sorghum straw from browsing and from heat at early stage to ensure fast growth of the seedlings. Traditionally, the half-moon type water conservation structure is used to conserve moisture and facilitate good survival and growth after planting. Moreover, both ethnic groups usually plant cuttings during the rainy season for better survival and good rejuvenation of cuttings.

3.2. Planting, management and harvesting practices

The study ethnic groups mainly plant *M. stenopetala* in home gardens although they also plant the species in crop fields (Table 2). In crop field, it is usually intercropped with maize or sorghum with the belief that it

Table 2
Frequency and percentage of respondents (N = 180) in site selection for planting *M. stenopetala*.

Site	Frequency	Percentage
Home garden	32	17.8
Crop field	14	7.8
Both home garden and crop field	125	69.4
No Moringa (associated with land shortage)	9	5.0
Total	180	100.0

cannot affect crop production and yield. Similarly, Moana (2018) reported that the practice of planting of Moringa with maize and sorghum as a common practice in southern Ethiopia. Moreover, the author revealed that the presence of a long root system avoids resource competition with understory crops and improve soil fertility through shed leaves. Inconsistent with our survey result, Yisehak et al. (2011) has also reported the importance for alley cropping because it has a long tap root, few lateral root, rapid growth and minimal shade.

Moringa stenopetala, planted in crop fields are pollarded and pruned every year as mentioned by the respondents of the two ethnic groups so as to prevent being a shelter for birds especially in maize and sorghum growing sites (Fig. 2a and b). Alemayhu et al. (2015) also described the practice of pollarding in the moringa growing areas during the dry period. Pollarded trees produce wide and short crown easy for leaf harvesting. Moreover, the survey showed on average the presence of five *M. stenopetala* trees per ha in crop fields and the presence of nine trees per ha in home gardens. The studied ethnic communities (Konso and Derashe) suggested five trees per family could supply sufficient leafy vegetables for a family with average family size of four.

In the study area, usually the first leaf harvest for preparation of local dish of *M. stenopetala* leaf will be started after two years of planting provided cutting is applied for establishment; otherwise, the first reasonable harvest will take up to four years. Alemayhu et al. (2015) also reported similar result for cuttings, but for seedlings they have reported only 3.5 years (which is six months less). In the present study areas, the studied ethnic groups usually do not apply inorganic fertilizers, instead they usually apply cow dung for better survival and growth of seedlings.

Wind also affects the growth of *M. stenopetala* especially at the early growth stage. If the height of a tree is longer (in most cases more than 3 m without branching) it will be easily broken by winds. Therefore, both ethnic groups usually apply pruning at the early growing stage and the pruning height varies from individual to individual and landscape position. However, based on focused group discussion and key informants interview the average preferred pruning height practiced by both ethnic groups is 2.30 m. The indicated pruning height is very important not only to protect against damage by winds but also for ease of harvesting and to avoid birds roosting. However, Palada and Chang (2003) suggested in their study to apply first the apical pruning when the tree is

1.0–2.0 m high. If left to grow without cutting the main trunk, the fast-growing tree will grow straight and tall producing leaves only harvested on the primary stem.

Our study result from focus group discussion and key informant interview showed that *M. stenopetala* tree grown from seedlings will bear the first fruit and thereby seeds after 7–8 years and that will be held every year in the months of November and December. Therefore, local ethnic group and women's associations usually collect seeds in these months every year so as to make ready for sell.

Harvesting of *M. stenopetala* is done throughout the year unless and otherwise it is defoliated by the moth caterpillars. Harvesting is usually accomplished by hand (Fig. 3) or by climbing to the plant and practiced using locally produced wood stick that have hooks at the tip called "**Shankar**" by the Derashe people.

In addition to *Moringa stenopetala,* we also found the introduced *Moringa oleifera* in the home gardens of some families in the study areas. However, it has little use preference by the communities due to its taste and very small leaf size. *Moringa stenopetala* is considered as tastier species with larger leaf biomass production and preferred by both ethnic groups compared to *Moringa oleifera*. In addition, the two species are easily differentiated morphologically by the shape and size of the leaves by the two communities (Fig. 4a and b).

The studied ethnic groups use both clay and steel pots for cooking to prepare local dishes from *M. stenopetala*. They believe that the materials used for cooking affect the taste of the moringa dish and also determine cooking time. Local ethnic groups believe that leaves cooked with clay pot have better taste than those in steel pots. Regarding cooking time, cooking of *M. stenopetala* leaves takes 30 min when a clay pot is used but only 15 min when steel pot is used. However, no information was obtained from both ethnic groups on the effect of cooking media and time on nutrient content. Thus, the effect of different cooking media and time in relation to nutrient retention needs to be studied further.

Locally, the process of cooking its leaves includes, first boiling the water alone, and then adding the leaves to the boiling water and then cooking to the limited minutes based on the material used. Storage duration of a cooked dish is important for both ethnic groups where there is lack of refrigerator and electricity in the rural settings. However, a cooked leaf dish could remain edible for two days without being spoiled provided it is kept untouched by hand after cooking.

Fig. 3. Harvesting the leaves by hand in the study area (Photo by Berhane Kidane).

Fig. 4a. *M. stenopetala* leaf *(Photo by Berhane K.)*.

Fig. 4b. *M. oleifera* leaf (*Photo by Berhane K.)*.

3.3. Traditional utilization (food and medicine)

Moringa stenopetala is considered as important and valuable tree/shrub by the two ethnic groups. It is believed by the ethnic groups that the plant existed and used since ancestral times in the study area. The result of our focus group discussion indicated that *M. stenopetala* is used for different purposes such as preparing the daily local dishes, fallen branches and leaves used for soil fertility improvement, branches serve as fuel, fresh leaves sold for income generation, animal feed, and also for medicinal purpose; and in addition, mature tree crown serves as shade. Moreover, the species is used for the preparation of special food that helps to strengthen lactating women after birth, used also as boundary marker plant between two landholders and also for "Mamma" (a special sitting place on top of pruned branches locally constructed on *M. stenopetala* tree for chasing birds feeding on grains of sorghum, millet or teff crops). Furthermore, both from focus group and key informants, it is found that the plant serves as cultural plant when it is given as gift during marriage for newly married partners, which is locally called "Kolga Wushta" by the Derashe people. In case the plant which was given as gift and planted in the home garden dies, planting another moringa seedling on the same place is an obligation that serves for the same purpose. This type of traditional (cultural) practices contributed to the maintenance/conservation of the species either in home gardens or in the crop fields. These on its own also contributed to lessen hunger and malnutrition.

Almost all part of *M. stenopetala* trees except the wood are edible and these edible portions are believed to be extremely nutritious. Teklemariam et al. (2020) have also reported the importance of the species for humans' food and nutrition. This survey result have shown that *M. stenopetala* dish is believed and considered to be an important component of their daily food by 100 % of the study participants of the two ethnic groups. Fresh *M. stenopetala* leaves can be eaten raw, when

are very young and tender, but can be cooked like cabbage (Tsegu, 2021). It has long been used as a nutritional supplement for famine in Ethiopia (Yisehak et al., 2011). The results of the nutritional analyses were also encouraging and the leaves can supply micronutrients and prevent weight increases from high-fat diets, and the effects (Ye-Jung and Hee-Seon, 2019). *M. stenopetala* has high nutrient contents, so it can be used to develop nutritional supplements where it is abundant. *M. stenopetala* provides multifunction by decreasing hunger, improving health and human nutrition by supplying different food products (Assefa et al., 2015). Moreover, *Moringa stenopetala* is an important source of nutritionally rich food, especially during the dry season, due to its drought resistance and supply of fresh leaves to the household locally with fair affordability to the urban and rural poor (Petr et al., 2020).

The Derashe and Konso ethnic groups in southern Ethiopia cook leaf of the species every day for breakfast, lunch and dinner as local dish. According to our survey result, 87 % of the respondents in Konso and 98% in Derashe eat *M. stenopetala* dish more than two times a day. There are different types of local dish prepared from the species either only from Moringa or prepared mixed with flours of different crops such as sorghum and maize. The most common and used type is locally called "Phossose" (Fig. 5a). Reta (2016) reported "Phossose" as a common dish in his study area (Gofa) and described the process of preparation of "Phossose" from boiled *M. stenopetala* leaf adding semi-wet maize flour. The second most important local dish is called "Kurkufa" (Fig. 5b) and is a local dish type made from the moringa tree leaf mixed with either sorghum or maize flour prepared in small cubes. Kukufa is used by all groups of people in the study area. In some cases, butter is added to "Kurkufa" and prepared as special food for lactating women. This special type of Kurkufa is given to the lactating woman for about six months after giving birth with the strong belief by the community that eating "Kurkufa" mixed with butter for a specified period will enable lactating woman to be fertile again in the shortest time. The leaves of this species can also be cooked alone and be eaten with maize or sorghum bread called "Kita" (Fig. 5c).

In consistent to this survey, Price (2002) has also reported the importance of *Moringa oleifera* leaves and pods for pregnant and breast-feeding women through preserving mother health and through passing on strength to the fetus or nursing child. This cultural thought and experience need to be verified further through advanced research. Dried leaves are also used for the preparation of a local drink called "CHEKA", which is considered not only as a drink but also as food.

M. stenopetala has been in use for centuries for nutritional as well medicinal purposes (Ashfaq al. 2012) and in many parts of the developing world, it is also widely consumed for self-medication by patients affected by diabetes. The survey result in the study area revealed that almost all plant parts of the tree are used for the treatments of different human ailments by the study ethnic groups. The hot soup made from its leaf is used for the treatment of human cough, tonsillitis, and flu. The green leaf juice of *M. stenopetala* is used for the treatment of eye disease. It is usually applied and used when the diseased eye is red and has a burning sensation. Similarly, Eric et al. (2014) from their study demonstrated the use of leaves in the treatment of eyesight problems. The use of the leaves for eyesight is applied by pressing carefully washed and ground leaves on the eye. Kora (2014) found also the use of boiled leaves of the species by the local people as tea to treat malaria, hypertension, stomach problems, expulsion of retained placenta and in some other problems like asthma and diabetes. In our study, we also found its use for the treatment of bloated stomach and "Asthma". On the other hand, the root of the plant chewed and the fluid swallowed serves for the treatment of stomach ache. It is also believed that the plant is used for the treatment of diabetes. Similarly, Yalemtsehay and Amare (1998) showed that regular drinking of the infusion of leaves used for the treatment of diabetes. The root of *M. stenopetala* plant is also used for the treatment of snake bite in our study area. The root is chewed and the liquid (juice) is taken orally by the individuals affected by snake bite. The treatment against snake bites is more effective if it is used together with the root juice of *Terminalia brownii*. The ethnic groups also use water from boiled leaves of moringa for the treatment of Malaria (Bosch, 2004). In the Negelle and Wolayta Sodo areas (Ethiopia) the leaves and roots are similarly used for treatment of malaria (Eyassu, 2014). Moreover, seeds and the roots of *M. stenopetala* can also be used to settle turbid and dirty water (Palada and Chang, 2003).

Although the primary goal of *M. stenopetala* cultivation in the study areas is leaf biomass production for food and medicinal use, but it also has importance in erosion control, as a live fence, as ornamental tree, as a windbreak, for shade and for bee forage as reported by Liyew and Daniel (2015). Fresh Leaves and twigs are used and given as animal feed. Moreover, *M.stenopetala* is a fast-growing species, drought tolerant and is easily adapted to poor soil conditions (Yisehak et al., 2011). Due to its fast growth, able to absorb extremely high levels of CO_2, and exceptionally high content of substances necessary for our health, this species is often grown on plantations (Petr et al., 2020) and has a potential contribution to climate change adaptation.

3.4. Pest and disease

Pest and disease are major constraints for the production of moringa. In our study, we also found that the leaf of *M. stenopetala* is attacked by insect (locally called Shitayta in "Derashiteta" and other beetles (locally called Paneya in "Derashiteta"). The species is believed to be Moringa moth (*Noorda blitealis* Walker) indigenous insect in the region as described by Agena (2009) and reported as defoliator by Moana (2018). The larvae of the insect attack the plant usually on the months of October and April every year. It commonly defoliates the leaves of a standing tree and left exposes the plant naked or uncovered. Branches that are defoliated in October will rejuvenate again in December and the tree that was defoliated in April will also rejuvenate again in June. Insect attack is severe during the rainy season as mentioned by the local ethnic groups. During the period of severe attack by the larva, the whole trees of *M. stenopetala* appear defoliated (Agena, 2009). The leaves that are

(a) *Phososese* (b) *Kurkufa* (c) *Kita* with cooked moringa

Fig. 5. a, b and c Photo by Nina (2012).

affected by insects will not be cooked and used as food because they will have a bad smell as it is experienced by the local ethnic groups. Kumssa et al. (2017) reported that larva foraging on the leaves reduced leaf biomass production and damaged leaves are unappealing for use as human food. Similarly, Taye et al. (2013) indicated that infestation in mature plants results in partial or complete defoliation which in turn causes reduced growth and consequently induces loss in potential of the plant to withstand from other biotic and abiotic stresses. Seeds in the pods bored by larva usually became damaged and not viable for seedling production, and for other uses.

4. Conclusion

The importance of *M. stenopetala* both as food and medicine and its socio-economic and ecological contribution during dry periods is an opportunity for easy promotion and acceptance of the species not only in the study areas but also in new similar agro-ecological zones. Although ethnobotanical studies indicated the food value of *M. stenopetala*, research need to determine the differences in macro - and micro-nutrients of its leaves at different age of the leaves considering different site conditions.

The study result indicated ease of propagation of *M. stenopetala* both by seed and cuttings and is also a good opportunity for promotion and availability of planting materials whenever required. The availability of the planting material facilitates easy promotion of *M. stenopetala* in the study area. Moreover, it also offers the opportunity to promote the species into similar agro ecologies either as a home garden crop or as an agro-forestry species in crop fields. Based on our recent findings, we recommend the use of cuttings with length of between 0.50 and 1.0 m and a diameter between 10 cm–20 cm for planting. But in order to determine the appropriate cutting size (both in length and diameter), it requires further study support for better survival and growth.

Our study result indicated challenges that limit the planting of more *M. stenopetala* trees on crop field that harbor birds in the study areas. Therefore, the local traditional management practice of pruning and pollarding is applied so as to avoid birds that damage crops. Due to shortage of land around homesteads planting of seedlings is carried out at narrow spacing i.e., 1.5m could help to get more leaf biomass yield than wider spacing and which can help the local community in getting additional income to improve and support their livelihood. The traditional use for human medicine should be further studied considering the parts of the plant through laboratory analysis for further utilization of the information. Finally, we also recommend studying the use of different cooking media and time in relation to nutrient retention.

CRediT authorship contribution statement

Berhane Kidane: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Zewdu Yilma:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Abeje Eshete:** Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The Authors declares that there is no conflict of interest.

Data availability

Data will be made available on request.

Acknowledgements

Authors are grateful to Ethiopian Environment and Forest Research Institute (EEFRI) for the financial support and Central Ethiopia Environment and Forest Research Center (CEEFRC) for the provision of necessary logistic facilities for the entire work. Sincere thanks also go to informants in Derashe and Konso Special Districts. We appreciate the efforts of Natural Resource Offices of the two districts for their help during the fieldwork.

References

Aberra, M., Steingass, H., Boguhn, J., Schollenberger, M., Rodehutscord, M., 2012. Effects of elevation and season on nutrient composition of leaves and green pods of *Moringa stenopetala* and *Moringa oleifera*. Agrofor. Syst. 8, 505–518.

Agena, A., 2009. Screening moringa accessions for resistance to moringa moth, Noorda blitealis walker (Crambidae: Nooridae). Indian J. For. 32, 243–250.

Alemayhu, S., Tesfaye, A., Tewodros, T., 2015. Management practices and socio-economic roles of Moringa stenopetala in Kucha District, Southern Ethiopia. Ethiopian J. Nat. Res. 15 (2), 61–76.

Anwar, F., Latif, S., Ashraf, M., Gilani, A.H., 2007. *Moringa oleifera*: a food plant with multiple bio-chemical and medicinal uses- a review. Phytother Res. 21, 17–25.

Ashfaq, M., Basara, S.M.A., Umair, A., 2012. Moringa: a Miracle plant for agro-forestry. J. Agricult. Soci. Sci. 8, 115–122.

Assefa, A., Emiru, B., Tewodros, T., Kiros, M., 2015. Moringa stenopetala tree species improved sele socio-economic benefits in tigray, northern Ethiopia. Sci. Technol. Arts Res. J. 4 (2), 68–78.

Berushka, P., Himansu, B., 2012. An overview of the medicinal importance of Moringaceae. J. Med. Plants Res. 6 (48), 5831–5839. https://doi.org/10.5897/JMPR12.1187.

Bosch, C.H., 2004. Moringa stenopetala (Baker f.) cufod. In: Grubben, G.J.H., Denton, O. A. (Eds.), PROTA (Plant Resources of Tropical Africa/Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands [Internet] Record from PROTA4U.

CSA (Central Statistical Agency). 2013. Population Projections for Ethiopia 2007-2030.

Dechasa, J., Kai, S., Lalisa, A., Yalemtshay, M., Agena, A., 2006. Leaf yield and Nutritive value of Moringa stenopetala and Moringa oleifera Accessions: its potential role in food security in constrained dry farming agroforestry system. In: Proceedings of Moringa and Other Highly Nutritious Plant Resources: Strategies, Standards and Markets for a Better Impact on Nutrition in Africa. Accra, Ghana. November 16-18, 2006.

Eric, E.A., Assogbadjo, Achille E., Gouwakinnou, Gerard, Okou, Farris A.Y., Brice, S., 2014. Ethnobotanical assessment of moringa oleifera Lam. In southern Benin (west Africa). Ethnobot. Res. Appl. 12, 551–560.

Eyassu, S., 2014. Actual and potential applications of moringa stenopetala. Underutiliz. Indigenous Veg. South. Ethiopia: A Rev. Int. J. Agricult. Food Res. 3 (4), 8–19. ISSN 1929-0969.

Fahey, J., 2015. Moringa oleifera: a review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Tree for Life J.

Fuglie, L.J., 1999. The miracle tree: moringa oleifera: natural nutrition for the tropics. Church World Service, Dakar, Senegal.

Kora, G., 2014. Indigenous use of moringa stenopetala by the community of Konso and Hammer. In: Proceeding of Consultative Workshop on Moringa Stenopetala to Maximize its Potential Uses.

Kumssa, D.B., Joy, E.J.M., Young, S.D., Odee, D.W., Ander, E.L., Magare, C., Gitu, J., Broadley, M.R., 2017. Challenges and opportunities for Moringa growers in southern Ethiopia and Kenya. PLoS One 12 (11), e0187651.

Liyew, B., Daniel, F., 2015. Socio-economic, cultural, food and medicinal significance of moringa stenopetala (bak.f) cuf: a case of Konso special Woreda, SNPPRs, Ethiopia. Res. J. Soc. Sci. Manag. 5 (7).

Mekonnen, Y., Gessese, A., 1998. Documentation on the uses of Moringa stenopetala and its possible antileishmanial and ant fertility effects. Ethiopian J. Sci. 21 (2), 287–295.

Moana, U., 2018. Biomass Production and Nutritional Potential of Moringa Steneopetala and Moringa Oleifera. Bachelor Thesis.

Mohammed, A.S., 2013. Medicinal and dietary role of moringa stenopetala(bak.f.) cuf in southern Ethiopia: a review. African J. Agricult. Sci. Tech. 1 (1), 1–6.

Nina, G., 2012. Usage and Acceptance of Moringa Stenopetala in the Diet in Ethiopia. Universitetet i Agder. MSc thesis.

Ntshambiwa, K.T., Eyassu, S., Gaone, M., 2023. Nutritional composition, bioactive components and antioxidant activity of Moringa stenopetala and Moringa oleifera leaves grown in Gaborone, Botswana. Food Product. Proc. Nutrition 5, 7. https://doi.org/10.1186/s43014-022-00124-x.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., Anthony, S., 2009. Agroforestry Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/sites/trees/treedatabses.asp.

Palada, M.C., Chang, L.C., 2003. Suggested Cultural Practices for Moringa. International cooperators guide.

Petr, N., Moana, U., Shiferaw, A., Jaromír, N., Hana, H., 2020. Biomass production of a young plantation of Moringa stenopetala (Baker f.) Cufod. and Moringa oleifera Lam. in southern Ethiopia. South Afr. J. Bot. 129, 463–470. https://doi.org/10.1016/j.sajb.2020.01.018.

Price, M.L., 2002. The Moringa Tree. Echo Technical note.

Reta, A., 2016. Consumption Pattern and Indigenous Processing Practices of *Moringa Stenopetala* (Bak.f.) Cuf. : A Case of Demba Gofa District SNNPR. MSc THESIS.
Taye, M., Surendra, K.S., Thangavel, S., Mulugeta, N., 2013. Distribution and damage status of moringa moth (Noorda blitealis walker) on moringa stenopetala Baker (Cufod.) in southern Rift Valley of Ethiopia. Int. J. Agricult. Tech. 9 (4), 963–985. ISSN 2630-0192.
Teklemariam, A., Zemeda, D., Hadush, H., 2020. Assessing factors affecting moringa production at north-western zone of Tigray, Ethiopia. Agricultural Science 2 (1).
Tsegu, E., 2021. Contribution of moringa tree for food security and management in southern Ethiopia, review. J. Resour. Develop. Manag. 81. ISSN 2422-8397.
Yalemtsehay, M., Amare, G., 1998. Documentation on the uses of *Moringa stenopetala* and its possible antileishmanial and antifertility effects. Sinet 21 (2), 287–295.
Ye-Jung, K., Hee Seon, K., 2019. Screening Moringa species focused on development of locally available sustainable nutritional supplements. Nutr. Res. Prac. 13 (6), 529–534.
Yisehak, K., Solomon, M., Tadelle, M., 2011. Contribution of Moringa (*Moringa stenopetala* , Bac), a highly nutritious vegetable tree, for food security in Southern Ethiopia. Asian J. Appl. Sci. 4 (5).