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Effect of harvesting frequency on leaf biomass production of three *Moringa stenopetala* (Bak.f) provenances grown in Dello-menna district of Bale zone, Southeast Ethiopia

Wondmagegn Bekele[1]*, Bikila Mengistu[2] and Zerihun Dibaba[1]

[1]Sinana Agricultural Research Center, Oromia Agricultural Research Institute, Bale - Robe, Ethiopia.
[2]Fitche Agricultural Research Center, Oromia Agricultural Research Institute, North-Shewa, Ethiopia.

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Many parts of *Moringa stenopetala* are edible, providing a highly nutritious food for both humans and animals. Above all, the leaves of *Moringa* have exceptional nutritional value containing a variety of vitamins and minerals. Harvesting frequency had effect on leave biomass production of *M. stenopetala* provenances. This study was conducted to examine the effect of harvest frequency on *M. stenopetala* provenances grown at Sinana Agricultural Research sub site located in Dello-menna district of Bale zone, Southeast Ethiopia. To do so, three levels of *M. stenopetala* provenances (Abay-filiklik, Konso and Bale) were combined with three levels of harvesting frequency (2, 4 and 6 months) in factorial Randomized Complete Block Design. The result has shown that, the amount of leaf biomass yield recorded was considerably variable due to the effect of treatments employed in the study. Among the three frequent harvest intervals, 4 months interval had produced the highest fresh (3566.33 g/plant), air-dried (761.91 g/plant) and oven-dried (684.23 g/plant) leaves yield. In terms of provenances, Konso provenance had produced the highest fresh (4150 g/plant), air-dried (994.10 g/plant) and oven-dried (785.66 g/plant) leaves biomass yield throughout the frequent harvest cycles. While, Bale provenance had produced the least air-dried (466.23 g/plant) and oven-dried (394.76 g/plant) leaf yield. Therefore, for higher leaf biomass production harvest at 4 months interval from Konso provenance would be more advisable, followed by Abay-filiklik. This in turn infer, the possible and optimum leaf yield harvesting frequency within a year for the provenances would be 3 times. However, the nutritional content of the provenances along with their different harvesting stages needed to be investigated further in the future.

Key words: Abay-filiklik, Air-dried biomass, fresh biomass, Konso, leaf yield, oven-dried biomass.

INTRODUCTION

Moringa is a genus that represents the family Moringaceae. It is represented by 13 to 14 species and 2 of them namely *stenopetala* and *oleifera* are popularly the known species in different parts of the world. *Moringa stenopetala* often referred to as East African *Moringa* tree because it is native to Southern Ethiopia, Eastern Somali

*Corresponding author. E-mail: wondmagegnb2004@gmail.com.

and Northern Kenya, while India is a center of endemism for *Moringa oliefera (*Ashfaq and Basra, 2012; Mitiku et al., 2023). *M. stenopetala* is known for its characteristics as a highly resilient tree that grows very fast and is easy to propagate. It grows best in semi-arid to arid conditions and has very low requirements in terms of nutrients, water and management (Isah et al., 2014; Bekele et al., 2022). This implied the tree could be grown over a wide range of climatic conditions, even in drought prone areas and being promoted across African country as a fast growing multipurpose tree.

In Ethiopia, *M. stenopetala* is grown by smallholder farmers as a tree or "perennial vegetable" at homestead level for its nutritional, economic and medicinal values (Mengistu and Soboka, 2023). Many parts of the tree are edible providing a highly nutritious food for both humans and animals. Above all, the leaves of moringa have exceptional nutritional value containing a variety of vitamins and minerals (Dechasa et al., 2006; Ashfaq and Basra, 2012; Mengistu and Soboka, 2023). It contains nutrients such as calcium, iron, vitamin A and vitamin C, and makes a significant contribution to nutritionally poor diets. When used for human consumption leaves could be cooked freshly and eaten like cabbage. The dried leaves of the *Moringa* could be grinded into powder and used as a supplementary food (Seifu, 2014). Additionally, parts of the plant such as root, bark, leafs and fruits have medicinal value and are used as drug for the treatment of several diseases (Savitha et al., 2014). Due to all these facts, *Moringa* is attracting more unemployed youth and women to involve in income generating activity through growing, processing and marketing of the tree and its product (Kaleb and Busha, 2013; Abay et al., 2015).

Recently, three *M. stenopetala* provenances were introduced for multitude benefits in the midland area of Bale, Southeastern Ethiopia (Bekele et al., 2022). Despite their introduction knowledge on leave biomass production along with different leaf, harvest cycle is not studied. Harvesting frequency provides a baseline information on leave biomass production potential of the provenances. On the other hand, it also insights the possible optimum leaf yield harvest frequency and increases its contribution to food security. Therefore, this study was planned and conducted to examine the effect of harvesting frequency on leave biomass production potential of three *M. stenopetala* provenances grown in Dello-menna district of Bale, Southeast Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Dello-menna district of Bale zone, Oromia Regional State, Southeast Ethiopia. Dello-Menna is 544 km South of Addis Ababa. It is found between 6° 40` to 7°10` N latitude and 39° 30` to 40° E longitude (Figure 1). The experiment was conducted at the research sub-station of the Sinana Agricultural Research Center located in Burkiti kebele of Dello-menna district. The research station is about 2.5 km the North of the administrative town of the Dello-Menna district, lying 6° 24' 42.45" N and 39° 49' 55" E with an altitude of 1450 m above sea level.

The area characterized by bimodal rainfall, with a rainy season from the middle of March through June and early September through November. The mean annual precipitation is 986.2 mm, with mean annual temperatures of 22.5°C. In the area, Niti-sol is the dominant soil characterized by its color of reddish-brown clay towards the higher altitudes and tends to red-orange sandy soil toward the lower altitudes (Fayera and Manfred, 2006; Bekele et al., 2020).

Experimental procedure and treatments

In the study, five years old *M. stenopetala* provenances plantation grown at Sinana Agricultural Research sub site located in Dello-menna district of Bale zone was used. The plantation was established by 2 × 2 m spacing consisting of nine plants per provenance with three replications. The plantation was pollarded at 1 m above the ground to promote multiple branch regeneration prior harvest, and then 60 days duration allowed for hardening-off the shock of pollard. In the study, three levels of *M. stenopetala* provenance (Arba-minch, Abay-filiklik and Bale) and three levels of leaf biomass harvest frequency (2, 4 and 6 months) were combined with factorial Randomized Completed Block Design. With this, the levels of provenance were considered as main plot factors whereas harvesting time intervals were used as sub-plot factors.

Data collection and statistical analyses

Three *M. stenopetala* mother plants with three replications have been used for the harvest and determination of leave biomass yield of the provenances. In the course, 70% leaf biomass of the plants was harvested while 30% left for the enhancement of photosynthetic process. The estimation was conducted by counting and grouping the number of branches found on the mother plants prior to harvest. The fresh weight of leaves harvested per plot was determined using a weighing scale immediately after harvest in the field. While, the air and oven-dried leaf biomass of the provenances were determined using an electric beam balance at Sinana soil laboratory. Thereafter, the frequent leaf biomass of each harvest cycles (2, 4 and 6 months) were added and recorded as yield per plant in grams for a year. Finally, the collected data was summarized and analyzed by using *R x64 4.1.0* computerized software program.

RESULTS AND DISCUSSION

The effect of harvesting frequency on fresh leaf biomass yield of the provenances

The fresh leaf biomass yield of the provenances harvested at different time interval was summarized (Table 1). The effect of the provenances and harvesting time on fresh leaf biomass yield was found statistically significant ($p<0.05$). Accordingly, the highest leaf yield was recorded at 4 months for Konso provenance whereas the lowest was reported for Abay-filiklik provenance at 6 months interval harvest time.

The amount harvested from Bale and Abay-filiklik provenances did not significantly varied with each other while the one harvested from Konso was the highest

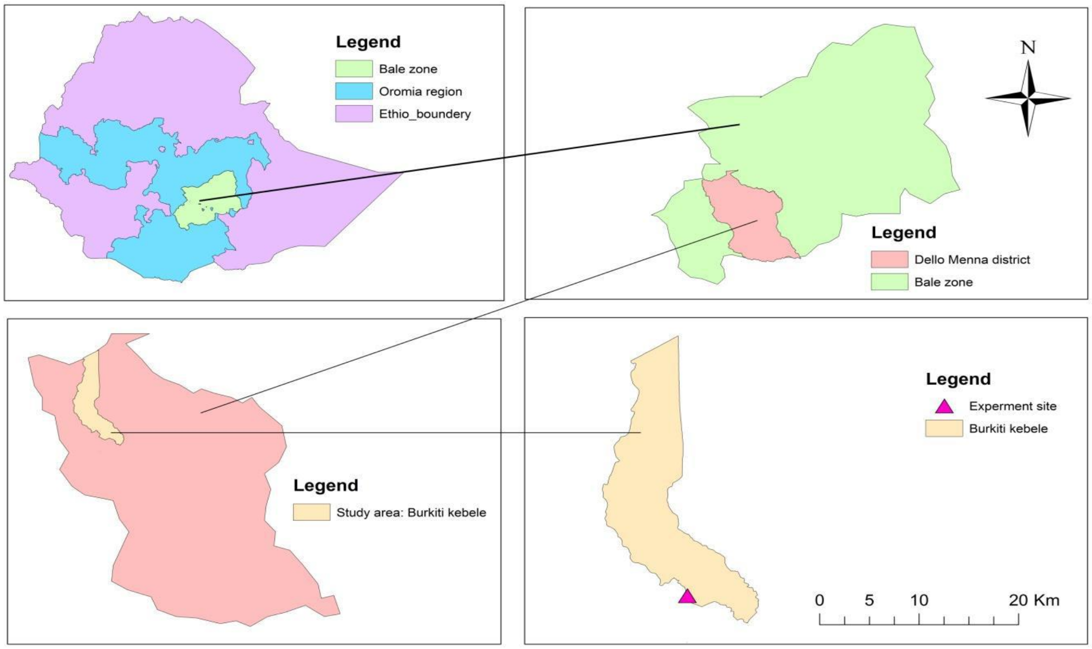

Figure 1. Location of the study area.

Table 1. The amount of fresh leaves biomass recorded at different harvesting times.

Provenance	Amount recorded (g/plant) at different time intervals (months) within a year			
	2 months	4 months	6 months	Mean
Konso	3917.00[ab]	5033.00[a]	3500.00[abc]	4150.00
Abay-filiklik	2283.00[cd]	2933.00[bcd]	1487.00[d]	2234.33
Bale	2133.00[cd]	2733.00[bcd]	2217.00[cd]	2361.00
Mean	2777.67	3566.33	2401.33	2915.11
CV (%)	32.00			
LSD (p<0.05)	1613.5			

Values within the same columns with the same letters are not statistically different. CV = Coefficient of variation, LSD=least significant difference.

throughout the harvest cycles. This implied that, the harvest intended for fresh leaves production purpose harvesting at 4 months interval from Konso provenance would be more advisable.

The effect of harvesting frequency on air-dried leaf biomass yield of the provenances

The air-dried leaf biomass mean values of the provenances are shown in Table 2. There were significant ($P < 0.05$) differences for air-dried leaf biomass production among provenances at 2nd and 4th month harvesting cycle. The values among the provenance ranged from 385 to 1132.30 g at 2nd and 4th month harvesting time, respectively. At 6th month, the amount recorded ranged from 451 to 867.30 g with non-significant variation among the provenance (Table 2). The values have pointed that the maximum air-dried leaf yield was recorded during 4 months harvest time for the entire tested provenances. Among the three provenances, Konso had produced the highest leaf yield closely followed by Aby-filiklik.

The effect of harvesting frequency on oven dry leaf biomass yield of the provenances

The analysis has confirmed that the amount of oven-dried leaves biomass recorded at 4th month harvest time was considerably variable among the provenances (Table 3). At this moment, the amount harvested from Konso (1031.70 g/plant) found the highest followed by Abay-filiklik (673.30 g/plant) and Bale (347.70 g/plant) provenances, respectively.

Table 2. The amount of air-dried leaf biomass recorded at different harvesting times.

Provenance	Amount recorded (g/plant) at different harvesting times within a year			
	2 months	4 months	6 months	Mean
Konso	982.70[ab]	1132.30[a]	867.30[abc]	994.10
Abay-filiklik	523.30[bc]	738.30[abc]	451.00[bc]	579.87
Bale	385.00[c]	415.30[c]	598.40[abc]	466.23
Mean	630.33	761.91	638.90	680.06
CV (%)		26.70		
LSD(p<0.05)		511.80		

Values within the same columns with the same letters are not statistically different. CV=Coefficient of variation, LSD=Least significant difference.

Table 3. The amount of oven-dried leaves biomass recorded at different harvesting times.

Provenance	Amount recorded (g/plant) at different harvesting time within a year			
	2 months	4 months	6 months	Mean
Konso	628.30[ab]	1031.70[a]	697.30[ab]	785.66
Abay-filiklik	393.70[b]	673.30[ab]	387.30[b]	484.76
Bale	301.30[b]	347.70[b]	535.30[b]	394.76
Mean	441.10	684.23	539.97	555.06
CV (%)		24.10		
LSD (p<0.05)		423.50		

Values within the same columns with the same letters are not statistically different. CV=Coefficient of variation, LSD=least significant difference.

However, at 2 months harvest the least oven-dried leaf yield (301.30 g/plant) biomass was reported for Dello-menna provenance. This is consistent with the observation made for fresh and air-dried biomass yield, the higher amount of oven-dried yield was harvested at 4 months interval against to 2 and 6 months harvest cycles within a year. Other related study conducted by Savitha et al. (2014) in India also reported that higher amount of *M. oleifera* leaf biomass yield was recorded at 4 months harvest interval than 2, 6 and 8 months. Furthermore, in the current study the lower fresh, air-dried and oven-dried leave biomass production at the 6 months harvest time might be linked to the leaves defoliation and/or development to small stems.

CONCLUSION AND RECOMMENDATION

Many parts of *M. stenopetala* are edible providing a highly nutritious food for both humans and animals. Above all, the leaves of *Moringa* have exceptional nutritional value containing a variety of vitamins and minerals. However, harvesting frequency and provenance variability have an effect on leave yield and health of mother plants. Thus, the study was planned and conducted to understand the effect of harvesting frequency on leave biomass yield of *M. stenopetala* provenances grown in Dello-nenna district of Bale zone, Southeast Ethiopia.

As regards the finding, the amount of fresh leaf biomass harvested at 4 months interval was found to be significantly the highest (3566.33 g/plant) followed by 2 months (2777.67 g/plant) and 6 months (2401.33 g/plant) harvest cycles, respectively. Not only this, the highest amount of air-dried and oven-dried leaf biomass had also been produced at 4 months harvesting time whereas the least was at 2 months. This has confirmed, harvest at 4 months interval was found optimum for getting high leaf biomass yield for the tested provenances and this possibly suggested harvesting frequency within a year would be 3 times. The amount of leaf biomass yield recorded among the provenances varied as well. In this respect, the frequent leaf biomass (fresh, air and oven-dried) yield recorded from Konso provenance was the highest. However, against the fresh leaf biomass, the least dried (air and oven) leaf biomass yield was recorded from Bale provenance. This implied if growers intended for optimum *M. stenopetala* leaf yield, harvest at 4 months interval from Konso provenance is more preferable than the others. However, the nutritional content of the provenances along with their different harvesting stages need further investigation in the future.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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