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Full Length Research Paper

Evaluation of the effect of provenance on survival and growth performance of *Moringa stenopetala (Bak.f)* intwo districts of Bale zone, Oromia, southeast Ethiopia

Wondmagegn Bekele[1*], Bikila Mengistu[2], Hirpa Abebe[1], Zerihun Dibaba[1] and Fikru Ameyu[1]

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

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In Ethiopia study on provenance variability effects on survival and growth performance of Moringa stenopetala is very scarce despite it is one of the most exciting plants that we have to see closely for its conservation and genetic improvement. Study was undertaken to evaluate the effect of provenance on survival and growth performance of M. stenopetala at Dello-menna and Goro research sites of Sinana Agricultural Research Center of Bale, Southeast Ethiopia.The tested provenanceswere Konso, Abay and Bale collecting their planting materials from the respective Arbaminch, Filiklik and Dell-menna locations. The experiment laid out in RCBD design with three replications.In study,the necessary data parameters(survival rate, plant height, root collar diameter and diameter at breast height) were recorded and analyzed by using R software. As to resultsprovenance effects on theseparameteris considerably($p < 0.05$) varied. Accordingly, survival rate at Dello-mennaresearch sub site reported within a rangeof70.30% to 85.19%.While at Goro, it ranges from 33.33% to 73.5% amongthe provenance. Height growth ranged 121.3 cm to 251.3cm at Dello-menna site, and from 46.4cm to 117.9cm at Goro. Besides, rootcollar diameter at Dello-menna site reported within a rangeof 2.59 cm to 7.17 cm among provenances, and 3.83 cm to 5.90 cm at Goro.The result pointed thatoverboth sites the survival and growth of Konso provenance had showed good performance followed by Abay and Bale, respectively. Thus, at the sites maximum M. stenopetala production can be achieved if Konso provenance majorly used as seed source for further plantation.Besides, Abay provenance at Dello-menna and Bale at Goro sites alternatively can be considered in some cases. However, to make a firm conclusion as to the genetic variability among provenances the continued observation strongly recommended.

Keywords: Abay-provenance, Bale-provenance, Diameter at breast height, Konso-provenance, Plant height, Root collar diameter.

INTRODUCTION

Background and justification

Moringa is a genus that represents the family Moringaceae. It is represented by 13 to 14 species, of these, *Moringa stenopetala* and *Moringa oliefera* species are the major ones (Wubalem *et al.,* 2012; Hailie *et al.,* 2015).

Moringa stenopetala considered as *''East African Moringa tree''* as it is native only to southern Ethiopia and northern Kenya (Alelegne, 2016; Tagay and Yemiru, 2021). Current global developments on Moringa agree for addressing the global issue of poverty and environmental crises. Today the plant is being used to solve poverty among rural dwellers by promoting income generation through rational utilization of vegetation, application of the seed in water treatment, plantation/nursery development/, as well as food supplement to combat malnutrition, supply of the leaf powder, oil and many other (Mamuye *et al.,* 2020). Not only this, it has the

*Corresponding author Email: wondmagegnb2004@gmail.com

highest nutritional content of ever plant tested, and it is named as God's abundant resource.

Environmentally *Moringa stenopetala* has a low demand for soil nutrients and water making its production and management easy (Isah *et al.,* 2014; Chris *et al.,* 2015). Indeed, it is drought tolerant and easily adapted plant to poor soil and arid conditions. This shows that, the species can be easily cultivated on marginal lands where food crop production is not possible. In southern part of Ethiopia *M. stenopetala* tree has long been grown by Konso people for the management of marginal dry lands. Additionally, *M. stenopetala* leaves are the staple food of Konso people. Studies have shown *M. stenopetala* leaves to be an excellent source of vitamins, minerals and protein: perhaps more than any other tropical vegetable (Ashfaq *et al.,* 2012; Diriba *et al.,* 2017). Therefore, it is a strategic plant in being a unique food tree in drought prone areas and need a special attention for its conservation.

In Ethiopia, knowledge on genetic variability and proper management of this valuable multipurpose tree species is very limited. Above all, provenance variability response on its survival rate and growth performance not yet investigated. Provenances of the same tree/shrub species could react differently to different environmental situations (Negash and Mebrate, 2005; Girma *et al.,* 2012; Edward *et al.,* 2014) and the hypothesis is likely true for *M. stenopetala* species. Knowledge on tree provenance variability enables to identify the best performing planting material source to sustain and maximize the productivity of the species in general. Thus, study is conducted to evaluate provenance variability effects on survival and growth of *M. stenopetala* grown at Dello-menna and Goro districts of Bale, southeast Ethiopia.

MATERIALS AND METHOD

Description of the Study area

The study was carried out at Dello-menna and Goro research sub sites of Sinana Agricultural Research Center, Bale zone of Oromia regional state, southeast Ethiopia. Dello research sub site is located at 6^0 24' 42.45" N and 39^0 49' 55" E while Goro sub site lieat 6°59'20.97" Nand $40^0$29'45.16'' E. The rainfall pattern for both areas is bimodal type, which divide the year into two rainy seasons. Accordingly, Dello attain main rainy season middle of March through June and short rainy seasons early September through November. The mean annual rainfall of Dello-menna district about 986.2 mm with mean annual temperature of 22.5 ^oC. Its altitude ranges from 1000 to 2500 meters above sea level with reddish brown clay soil type towards the higher altitudes and tending red-orange sandy toward the lower elevations (Bekele *et al.,* 2021).

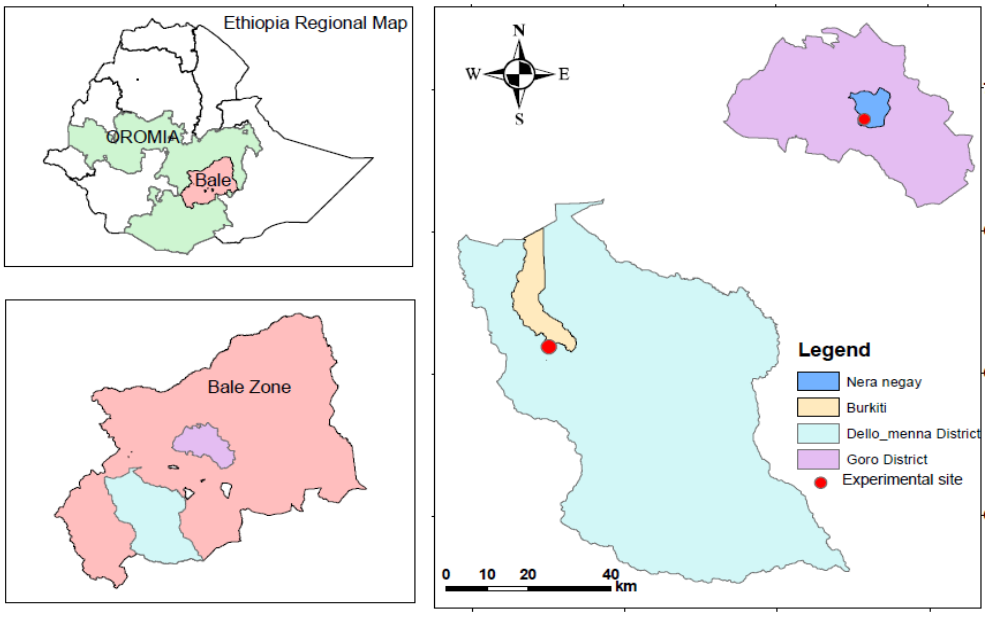

Figure: 1 Location of the study area.

Goro district attain the main rainy season June to October and short rainy season March to May. The mean annual rainfall for Goro is between 800 and 1000 mm with Mean maximum annual temperature 26.5°C and mean of minimum temperature 12.4°C (Chimdessa *et al.,* 2019).

Treatments and experimental layout

Three Moringa stenopetala provenances namely; *Abay, Konso and Bale* had been used. Seeds of Bale provenance from Dello-menna district of Bale zone, Konso provenance from Arba-minch zuria district and Abay provenance from

Abay filiklik area collected. Thereafter, seedlings of the provenances produced following the standard tree nursery seedling production techniques. The experiment installed by RCBD design with three replications with a plot size of 8 m x 6 m for each provenance type. The spacing between plants was 2 m x 2 m consisting of 12 plants per plot.

Data collection and statistical analyses

Survival count, root collar diameter, and height data collected at the age of one year after planting and continued for the subsequent years of study period. Diameter at breast height (DBH) measurement obtained starting at the 2nd year of experimental period. Survival count was made for the whole tree/shrub species found in a plot whereas for other parameters about six plants sampled randomly. Root collar diameter and DBH were measured using calipers whereas height was measured using graduated pole and/or measuring tape. The collected data is summarized and analyzed by Microsoft excel and R software computerized programs, respectively. Finally, the existence of relationship among growth performance traits (height, root collar diameter and DBH) examined by Pearson's correlation coefficient.

RESULTS AND DISCUSSION

Survival rate

Result has shown that, except during the first year of study period at Dello-menna site a significant difference ($p<0.05$) was reported for the survival rate of tested provenance's (table 1). During the years, the survival rate of Konso provenance found relatively higher over both experimental sites ranging with mean values 73.50% to 88.90%.
Provenances grown at Dello research sub site showed good survival rate having more than 70% compared to Goro.
At Goro sub site the subsequently reported survival rate ranged from 33.33 to 74.83% among provenances. The lower survivingrate of provenances at Goro may attribute to Moringa species intolerance to the slight waterlogged soil condition of Goro site. This is because

Table: 1 Means of survival rate (%) as influenced by provenance's over the years of study period and locations.

Provenances	Dello-menna			Goro		
	1st year	2nd year	3rd year	1st year	2nd year	3rd year
Abay	85.19[a]	77.78[ab]	74.08[a]	41.44[a]	41.11[a]	33.33[a]
Konso	88.90[a]	88.89[b]	85.19[b]	74.83[b]	74.83[b]	73.5[b]
Bale	81.49[a]	70.34[a]	70.34[a]	74.67[b]	70.56[b]	66.45[ab]
CV (%)	14.10	7.40	4.80	20.00	20.10	26.00
LSD ($p < 0.05$)	27.21	13.27	8.40	28.86	25.35	34.10

N/B: Means in columns with the same letters are not significantly different, CV = Coefficient of variation, LSD= Least significant difference.

Moringa species grow best in well-drained soils than waterlogged soil conditions (Edward *et al.,* 2014).

Height growth (H)

Except during the first year of study period, a provenance effect on height is statistically significant ($p < 0.05$) over both locations (table 2).
Accordingly, height growth at Dello site ranged 62.57 cm to 121.3 cm and 73.96 cm to 251.3 cm for Bale and Abay provenances, respectively. At Goro, height growth among provenance reported 31.58 cm for Bale provenance to 117.99 cm for Konso.

The resulthas showed at Dello-menna site, superior height growth reported for Abay provenance followed by Konso provenance. However, at Goro, Konso provenance showed superior height growth throughout the years of study period. The differences in height growth within a site attributed to variations in adaptability potential among provenances while between the sites may link to the environmental factors.

Root collar diameter growth (RCD)

Results of provenance effect on RCD growth of *M. stenopetala* planted for both sites reported (table4). At Dello

Table: 2 Means of plant height (cm) as influenced by provenancesover the years of study period and location.

Provenances	Dello-menna			Goro		
	1st year	2nd year	3rd year	1st year	2nd year	3rd year
Abay	73.96[a]	143.3[b]	251.3[b]	30.58 [a]	41.37 [a]	46.40 [a]
Konso	69.47[a]	94.0[ab]	221.0[ab]	38.33[a]	91.09[b]	117.99[b]
Bale	62.57[a]	83.0[a]	121.3[a]	31.58 [a]	59.97 [ab]	79.50 [ab]
CV (%)	14.80	23.00	27.20	6.80	22.50	24.90
LSD (p < 0.05)	23.0	55.58	121.9	5.19	32.7	45.94

N/B: Means in columns with the same letters are not significantly different, CV = Coefficient of variation, LSD= Least significant difference.

Table: 3 Means of root collar diameter (cm) as influenced by provenance over the subsequent years of study period and location.

	Dello-menna			Goro		
Provenances	1st year	2nd year	3rd year	1st year	2nd year	3rd year
Konso	3.41 [b]	6.00 [b]	7.17 [bc]	2.62 [a]	4.40[a]	5.90[a]
Abay	2.89 [a]	4.42 [ab]	5.82 [b]	2.42 [a]	2.44[b]	3.83[a]
Bale	2.87 [a]	3.63 [a]	2.59 [a]	2.67 [a]	3.51 [ab]	4.67[a]
CV (%)	10.10	23.00	29.70	16.50	22.90	28.50
LSD (p < 0.05)	0.47	1.92	2.84	0.59	1.80	3.08

N/B: Means in columns with the same letters are not significantly different, CV = Coefficient of variation, LSD= Least significant difference

Research sub site variation in RCD development was statistically significant (P<0.05) in the whole assessment period. At the study site, the superior RCD development was reported for Konso provenance followed by Abay and Bale, respectively. Furthermore, at Goro site the variability in RCD growth within the provenance is non-significant except during the 2nd year of study period. In spite of non-significance variability, the better RCD development with a grand mean of 3.97 cm reported for Konso provenance closely followed by Bale and Abay, respectively.

The result revealed, provenances grown at Dello research sub site had showed good performance in RCD development than provenances grown at Goro.

Diameter at breast height (DBH)

Similar to other growth performance traits, diameter at breast height growth reported for the studied provenances over both study sites.

At the sites, relatively superior Dbh (cm) growth was reported for Konso and Abay provenances with non-significant (p< 0.05) variation between themselves (table 4). Oppositely, poor Dbh development reported for provenance obtained from Bale at both study sites.

Table 4: Means of diameter at breast height (cm) as influenced by provenances over the years of study period and locations.

Provenances	Dello-menna		Goro	
	2nd year	3rd year	2nd year	3rd year
Konso	3.463[b]	6.573[b]	3.400 [b]	4.447[a]
Abay	2.896[b]	5.477[ab]	2.410[ab]	3.717[a]
Bale	1.723[a]	3.137[a]	2.103[a]	2.880[a]
CV (%)	15.60	23.00	16.80	27.30
LSD (P < 0.05)	1.145	2.952	1.030	2.235

N/B: Mean values in columns with the same letters are not significantly different, CV = Coefficient of variation, LSD= Least significant difference.

Provenances that showed the highest height and root collar diameter growth also recorded the highest DBH values. Thesynthesis examined by Pearson's correlation coefficients and substantiated by theresults reported during the study (table5). As to results mean DBH growth positively correlated with height (r = 0.8675), and with RCD (r = 0.9355) and mean height growth positively correlated with RCD (r = 0.9164).

Table: 5 Correlation coefficient (r) between different growth performance traits.

	Mean Height	Mean RCD	Mean DBH
Mean Height	1.0000	0.9164*	0.8675*
Mean RCD	0.9164*	1.0000	0.9355**
Mean DBH	0.8675*	0.9355*	1.0000

Note: ns = non-significant at p = 0.05, * = significant at p = 0.05, **= significant at p < 0.01

This has implied provenance with the largest DBH and RCD is the tallest, and the observation is in line with other's finding stating woody perennial growth performance trait exhibit a positive association each other (Bekele *et al.,* 2021).

CONCLUSION AND RECOMMENDATION

Moringa stenopetala is one of the most exciting plant that we have to see very closely for its genetic improvement and conservation. In Ethiopia, knowledge on provenance variability effect on survival and growth performance of M. stenopetal is very scarce. Study was planned and undertaken to test the existence of variability within three provenances of *M. stenopetala* depending up on their survival rate, height, RCD and DBH traits. The Study was conducted at Dello-menna and Goro research sub sites of Sinana Agricultural Research Center of Bale, Southeast Ethiopia. Asto results provenances effect on survival rate, height, RCD and DBH is statistically considerable over both experimental sites. Survival rate at Dello-menna sub site ranged from 70.30% for Bale provenance to 85.19% for Konso. At Goro, the mean value of survival rate ranged from 33.33% for Abay to 73.5% for Konso. Height growth ranged 121.3 cm to 251.3 cm at Dello-menna site and 46.4 cm to 117.9 cm at Goro. Root collar diameter ranged from 2.59 cm for Bale to 7.17 cm for Abay at Dello-menna study site and 3.83 cm for Bale to 5.90 cm for Konso at Goro.

The results showed that at both experimental sites the survival rate and growth of Konso provenance had showed good performance followed by Abay and Bale, respectively. Furthermore, provenance grown at Dello-menna study site had showed good performance compared to Goro. The difference within a site could be attributed to variations in adaptability among provenances while between the sites might be linked to the soil condition. Indeed, the lower performance of provenances grown at Goro sub site attributed to Moringa species intolerance to the slight waterlogged soil condition of Goro site of than Dello-menna. Despite the variability, maximum *M. stenopetala* production can be achieved if Konso prove-

nance used as seed source for further plantation over both locations. However, in order to make a firm conclusion to the genetic variability among provenances, the continued observation is strongly recommended.

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