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Full Length Research Paper

Study on Moringa Germplasm Collection and Screening in Southern Ethiopia

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Abstract
Moringa stenopetala Bac. and Moringa oleifera Lam germplasm collection and screening trial was conducted in three locations at Konso, Arba Minch and Hawassa in SNNPR, Ethiopia. The study was carried out for three consecutive years (2005-2007) to assess natural variability of agronomic yield and to generate germplasm pool for subsequent studies on genetic improvement. Moringa stenopetala seeds were collected from sites in Konso, Arba Minch and Kucha areas whereas the seeds of Moringa oleifera were obtained from ECHO-seed bank. From each site of Moringa stenopetala, 1000 seeds were collected from a random sample of up to 20 trees. The location of each tree accession was recorded with GPS. The experiment comprised 33 Moringa accessions, 28 belonging to indigenous specie of Moringa stenopetala while 5 to exotic Moringa oleifera species. The accessions were compared using Randomized Complete Block Design with four replications after three years of establishment. The data was analyzed with the help of SAS software packages. The results revealed that there were a significant variation in accession Konso Nagayle at three tested sites, with mean values of survival rate, mean height, mean collar diameter, mean number of branches per tree and mean dry leaf biomass per tree were 98.88%, 4.53m, 28.56cm, 96.99 and 47.62kg, respectively. Therefore, the native Moringa accession Konso Nagayle could be recommended for further genetic pool improvement and leaf production at Konso, Arba Minch and, Hawassa areas and

Keywords: Growth, Moringa accession, Natural variability, Southern Ethiopia, Yield

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Introduction

Moringa stenopetala Bac. Indigenous to Southern Ethiopia and Northern Kenya, belongs to the single genus Moringa and family *Moringaceae* (Azene Bekele *et al*., 1993). The tree is popularly known as "Halako" in place where it is commonly grown and "*Shifara" in* Amharic. *Moringa stenopetala* is widely cultivated in Southern Ethiopia especially in Konso, Derashe, Gamo-Gofa and south Omo districts. A German geographer (Nowackw, 1954) observed the use of leaves from M. stenopetala as cabbage in Konso. Moringa grows naturally in riverine forests and Acacia-commiphora woodlands on rocky ground (Edward, *et al*., 2000). Cultivation of the tree in home gardens, on terraces and marketing of the leaves is also practiced by several other tribes of Southern Ethiopia (Kuls, 1958). Even today these leaves are an important vegetable during the dry season, not only for Konso, Gamo, Derashe, Gofa and south Omo districts in Ethiopia but also for minorities from the same tribe in the Marsabit area of Northern Kenya (Gottch, *et. al.,* 1984). *Moringa stenopetala* is also known as vegetable tree. The Njemb tribe, living in Kenya, utilizes this tree as medicinal plant (Berger, *et. al*., 1984). In southern Ethiopia it is used as kale or cabbage for human consumption and as animal feed. Over five million people depend on this plant as a vegetable source. In Gamo-Gofa, immature leaves of *M. stenopetala* are part of the staple diet of the population.

Moringa is drought tolerant and is reported to tolerate an annual precipitation of 500 to1500 mm and annual temperatures from 18.7 to 28.5^{o}C. Moringa grows in a wide range of soil types (pH of 4.5 to 8.0) except heavy clays and prefers a neutral to slightly acidic soil. The tree grows well in altitudes from 0 to 1800 m.a.s.l. (Duke, 1978; Fred, 1992). Moringa is a fast-growing tree which also has fast regrowth after pruning (Foidl *et al.,* 2001) and capacity to produce high quantities of fresh biomass per square meter even at high planting densities. The dry matter (DM) yield is high, from 4.2 to 8.3 tons ha^{-1} when harvested every 40 days and fresh leaves contain19.3% to 26.4% crude protein in dry matter (Makkar and Becker, 1996; Makkar and Becker, 1997; Foild *et al*., 1999; Aregheore, 2002). Moringa leaves have a negligible content of tannins, saponin content similar to that of soybean meal and no trypsin and amylase inhibitors or cyanogenic glucosides (Makkar and Becker, 1996; Makkar and Becker, 1997). Currently, Moringa is used for various purposes, viz., the young leaves and pods are used as vegetables, the oil extracted from kernels for culinary and industrial purposes, the water extract of the kernels as water purifying agent, the seed cake as fertilizer, and various parts of the tree in traditional medicine (Foidl *et al*., 2001).

Besides its fast growing and; drought resistant nature it offers many advantages to subsistence farmers (John, 1979). One tree of *M. stenopetala* is able to support a large family for several years. Apart from being cultivated traditionally as cabbage tree and planted as ornamental tree, unripe and mature seeds of the *Moringa species* are used as foodstuff and spice in many Asian and African countries and also consumed in drinks prepared in folk medicine (John, 1979). *Moringa stenopetala* leaves can also be eaten in salads and are important in regions where vegetables are scarce. Seeds of the *Moringaceae* family contain 40% by weight of high quality oil that is equal in value of both cooking oil and as the main ingredient for soap manufacturing (Ibrahm, *et. al.,* 1974). Moringa leaves are free from anti-nutrients except for saponins and phenols. The concentration of phenol is much below the toxic threshold levels for animals (Makkar and Becker, 1997).

According to Fuglie, L.(1999), the many uses for Moringa include: alley cropping (biomass production), animal forage (leaves and treated seed-cake), biogas (from leaves), domestic cleaning agent (crushed leaves), blue dye (wood), fencing (living trees), fertilizer (seed-cake), foliar nutrient (juice expressed from the leaves), green manure (from leaves), gum (from tree trunks), honey and sugar cane juice-clarifier (powdered seeds), honey (flower nectar), medicine (all plant parts), ornamental plantings and; bio-pesticide (soil incorporation of leaves to prevent seedling damping off disease), pulp (wood), rope (bark), tannin for tanning hides (bark and gum), water purification (powdered seeds). Moringa seed oil (yield 30-40% by weight), also known as Ben oil, is a sweet non-sticking, non-drying oil that resists rancidity. It has been used in salads, for fine machine lubrication, and in the manufacture of perfume and hair care products (Terra, 1966). In the West, one of the best known uses for Moringa is the use of powdered seeds to flocculate contaminants and purify drinking water (Berger, *et. al.,* 1984; Gassenschmidt, *et. al*. 1995; Olsen, 1987), but the seeds are also eaten green, roasted, powdered and steamed for tea or used in curries (Gassenschmidt*, et. al.,* 1995). This tree has in recent times been advocated as an outstanding indigenous source of highly digestible protein, Ca, Fe, Vitamin C, and carotenoids suitable for utilization in many of the so-called “developing” regions of the world where undernourishment is a major concern. The high true protein content of leaves (23 per cent in DM, Makkar and Becker, 1997), the high proportion of this protein potentially available in the intestine (Makkar and Becker, 1997), the presence of adequate levels of essential amino acids (higher than the levels present in the FAO reference protein), and low levels of anti-nutrients indicate their high nutritional quality. The high pepsin soluble nitrogen (82-91 per cent) and the low acid detergent insoluble protein (1-2 per cent) values for the meal suggest that most of the protein in the meal is available to most animals (Makkar and Becker, 1997). Moringa is especially promising as a food source in the tropics because the tree is in full leaf at the end of the dry season when other foods are typically scarce. Despite all these facts the indigenous *Moringa stenopetala* is poorly studied. Hence, screening trial was conducted to assess the natural variability in agronomic yield and to generate a germplasm pool for subsequent studies on genetic improvement.

Materials and Methods

Study sites and climate

Collected Moringa accessions were screened at three locations viz. Konso, (semi-arid lower altitude), Arba Minch (semi-arid lower altitude) and Hawassa (sub-humid lower altitude) of Southern Ethiopia. While Konso and Arba Minch are the well known traditional *Moringa stenopetala* growing belts Hawassa is non-traditional area of this species.

Seed collection

Moringa stenopetala seeds were collected from 28 sites in Konso, Arba Minch and Kucha areas whereas the seeds of *Moringa oleifera* were obtained from ECHO-seed bank. From each site of *Moringa stenopetala*, more than 1000 seeds were collected from a random sample of up to 20 trees. The location of each tree accession was recorded with GPS (Table 1). Seed collection was carried out based on the farmers' indigenous knowledge and their preferences for reduced leaf bitterness which was identified by less unpleasant or more pleasant smell of the fresh leaf stalk sap that exudes after crushing.

Table 1. GPS data of Moringa accessions

No.	Accessions	Lat	Deg	Min.	Sec	Lon	Deg	Min.	Sec	Altitude(m)
1	Lasho	N	6	35	21	E	37	50	13	1273.1
2	Wajiffo	N	6	27	50	E	37	44	54	1224.4
3	Yayke	N	6	23	49	E	37	44	52	1266.4
4	Kerber-O	N	6	17	43	E	37	46	3	1244.5
5	Lante	N	6	8	12	E	37	39	7	1222.7
6	Arba Minch Unv.-O	N	6	3	55	E	37	33	41	1267.1
7	Arba Minch Unv.	N	6	3	55	E	37	33	41	1267.1
8	AM. Shekela	N	6	1	56	E	37	33	26	1285.9
9	Konso Dokatu	N	5	19	56	E	37	25	15	1629.8
10	Konso Dokatu	N	5	20	20	E	37	25	34	1538.0
11	Gofa(Sawla)	N	6	-	-	E	37	-	-	-
12	Konso Gamolle	N	5	20	10	E	37	24	31	1609.4
13	Konso Gamolle	N	5	20	10	E	37	24	31	1609.1
14	Konso Karate	N	5	20	14	E	37	26	21	1495.2
15	Konso Kube	N	5	20	10	E	37	27	38	1295.5
16	Konso Dera	N	5	19	55	E	37	26	41	1415.9
17	Konso Gerssale	N	5	21	17	E	37	27	4	1285.2
18	Konso Gerssale	N	5	21	17	E	37	27	4	1285.2
19	Konso Negayle	N	5	22	34	E	37	26	34	1287.8
20	Derahse Gatto	N	5	33	21	E	37	24	51	1259.4
21	DerasheDnota Minder	N	5	38	32	E	37	26	46	1171.5
22	Arba Minch Wosseka	N	5	43	32	E	37	25	49	1186.6
23	Shele	N	5	51	55	E	37	28	41	1129.2
24	Shele	N	5	51	55	E	37	28	41	1129.2
25	Secha	N	6	0	36	E	37	32	15	1414.7
26	ArbaMinch Kolashara	N	6	5	26	E	37	33	56	1245.7
27	ArbaMinch Kolashara	N	6	5	26	E	37	33	56	1245.7
28	Molle	M	6	16	3	E	37	46	20	1232.8
29	Wacha	N	6	19	43	E	37	18	17	1244.5
30	Selambire	N	6	28	20	E	37	27	30	1334.7
31	Nicaragua-O	N	-	-	-	E	-	-	-	-
32	Ex. Mbolo-O	N	-	-	-	E	-	-	-	-
33	Ex. Baringo-O	N	-	-	-	E	-	-	-	-

Legend: AM = Arba Minch; Deg= Degree; E=East; Ex = Exotic; Lat = Latitude; Lon = Longitude Min= Minute; N=North; O = *Moringa oleira;* Sec = Second

Experimental Design
All collected accessions were screened at Konso; Arba Minch and Hawassa; at each location experiment was executed in a Randomized Block Design (RBD) with four replications. Please see the experimental field at Hawassa (Photo 1).

Photo 1. Moringa accessions screening experimental field at Hawassa

Survival rate
Survival rate was computed referring to number of established seedlings divided by total number of seedlings planted minus number of seedlings lost times hundred and expressed in percentage. In forestry the survival rate of the seedlings is recorded after one year of planting.

$$Survival\ rate = \frac{\text{Number of seedlings planted} - \text{Number of seedlings lost}}{\text{Number of seedlings planted}} * 100$$

Collar diameter
The collar diameter of the tree was measured with the help of tree caliper at ground level of stem in centimeters (cm). This parameter was recorded at the end of growing/vegetative season at a given period of time to quantify radial increment of the tree.

Height growth
Height growth of tree was measured with Hypsometer. Time of recording was the end of vegetative growth and expressed in terms of meter.

Number of branches
Number of branches per tree was obtained by counting the total number of branches. The right time of counting the tree branches was just before collection of leaves for recording of dry leaf biomass at the end of growing season.

Dry leaf biomass
The collected leaf sample was dried in the oven for 48 hours at 65°C of temperature to constant weight and then weighed with the help of weighing balance and expressed in terms of kilo gram per tree.

Data analysis
Collected data were analyzed with the help of SAS software packages.

Results and Discussion
Survival Rate
Accession Konso Nagayle revealed the highest survival rate with the mean value of 98.88% at Ariba Minch site. On the other hand the minimum value of survival rate was observed on accession no. 41 (Baringo seed source) with mean value of 69.66%. Hawassa was not a traditional Moringa growing area even though it survived better than its native home of Konso. This study suggests that the Arba Minch area is a best site to undertake huge commercial or industrial plantation of Moringa species since the mean survival percentage was much greater than 80%. The survival rate of the tree species is an indicator of site suitability or the adaptation capability of species to the particular site conditions. Among all screening sites the best survival rate or establishment performance of entire Moringa

accessions were recorded at Arba Minch (Fig.1).

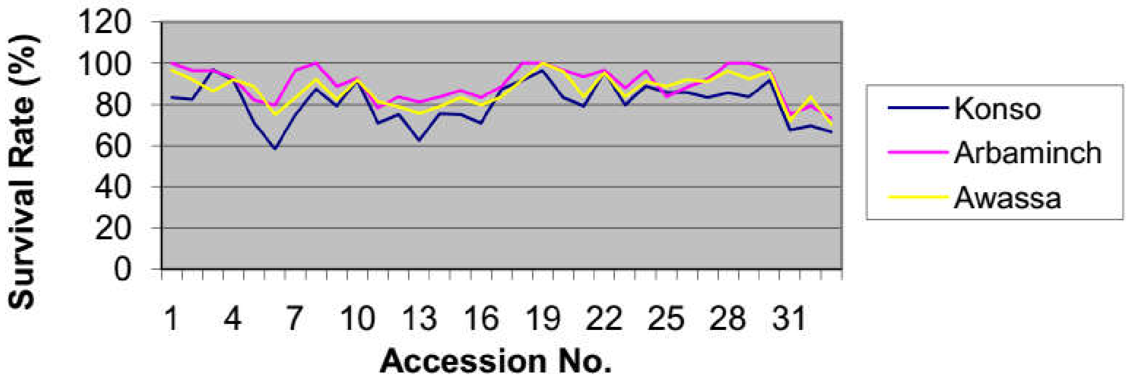

Figure 1. Mean survival rate of moringa germplasm collection across the sites

Collar diameter

The mean value of collar diameter was significantly influenced by natural genetic variability of Moringa accessions across locations (Table 2).The maximum collar diameter was observed in accession Lasho (28.56cm), which was followed by accession Konso Nagayle (28.37cm). The minimum collar diameter was recorded for accession Boringo (20.62cm). All accessions of *Moringa stenopetala* have shown better collar diameter increment than *Moringa oleifera* accessions in all testing sites.

Height Growth

The height growth of three years old Moringa accession was significant across locations which in turn implies the natural variability among accessions and used as one of the characteristics to screen well performing grermplasm (Fig. 2). The plant growth is the cumulative effect of genetic potential and environment of the tree species. Moringa accessions were exhibited the maximum height growth at Ariba Minch site.. In contrary the minimum height growth was observed in Konso due to harsh environmental conditions of the site. Height growth of exotic *Moringa oleifera* accessions was better than indigenous *Moringa stenopetala* across all tested locations. Konso Nagayle was the only indigenous Moringa accession that has shown significant height growth out of the natives. The tree height may not be a good trait to screen tree species for leaf yield. Height growth of exotic accessions was double of *Moringa stenopetala* but the diameter/radial growth of *Moringa oleifera* was significantly lesser. The natural height increment variability among accessions is a good distinguishing trait of the Moringa species.

Table 2. Mean collar diameter (cm) of Moringa accessions across locations

Acc. No.	Konso	A/Minch	Hawassa	Mean
1	27.33	29.8	28.56	28.56
2	24.82	27.6	25.39	25.93
3	26.47	28.51	27.63	27.53
4	25.31	26.93	25.80	26.01
5	23.18	25.22	24.67	24.35
6	17.50	20.38	18.40	18.76
7	25.66	28.40	27.53	27.19
8	23.29	25.86	23.90	24.35
9	24.70	27.00	26.35	26.01
10	22.45	26.58	24.37	24.46
11	23.34	26.61	25.89	25.28
12	25.32	26.14	25.92	25.96
13	23.59	25.33	23.85	24.25
14	24.76	27.55	26.61	26.30
15	23.64	26.47	25.50	25.20
16	24.95	25.40	24,76	25.03
17	25.81	27.62	26.19	26.54
18	24.47	26.30	24.95	25.24
19	25.22	30.25	28.41	28.37
20	26.53	29.57	26.30	27.03
21	22.70	24.46	24.25	23.80
22	27.69	26.80	25.74	25.41
23	22.44	25.53	22.92	23.63
24	23.87	26.36	25.54	25.25
25	24.51	25.53	24.87	24.97
26	25.39	27.78	25.94	26.36
27	24.27	26.40	25.38	25,35
28	23.62	25.91	24.70	24,74
29	25.40	27.15	25.66	26.07
30	22.79	24.33	23.58	23.56
31	20.58	21.24	20.96	20.92
32	20.90	22.59	21.35	21.61
33	20.41	20.85	20.60	29.62
Loc.Mean				**26.35**
CV.			**2.97%**	

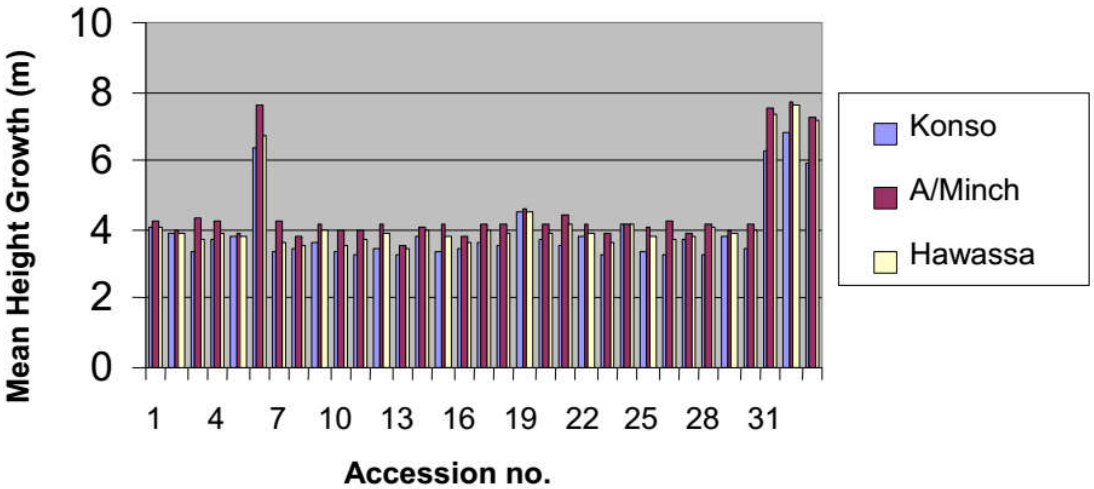

Figure 2. Mean height growth value of Moringa germplasm across locations

Number of Branches

Most of the time number of branches has direct correlation with leaf yield of the tree species. The mean number of branches per tree were the highest in Konso Negayle (96.99 branches per tree) followed by Arba Minch Kolashara (82.09 branches per tree). Number of branches was lower in exotic accessions as compared to indigenous Moringa accessions. The trend of number of branches across sites was shown identical genetic trait for all accessions irrespective of the seed origin. But the number of branches was revealed natural variability among accessions (Figure 3). Branching habit of indigenous accessions was erect and horizontal for exotic. *Moringa stenopetala* has strong and long branches than *Moringa oleifera* accessions. Figure 3 shows the separate trend of mean number of branches per tree across locations, which is similar among the accessions but the variability in number of branches, was due to site factor or environment.

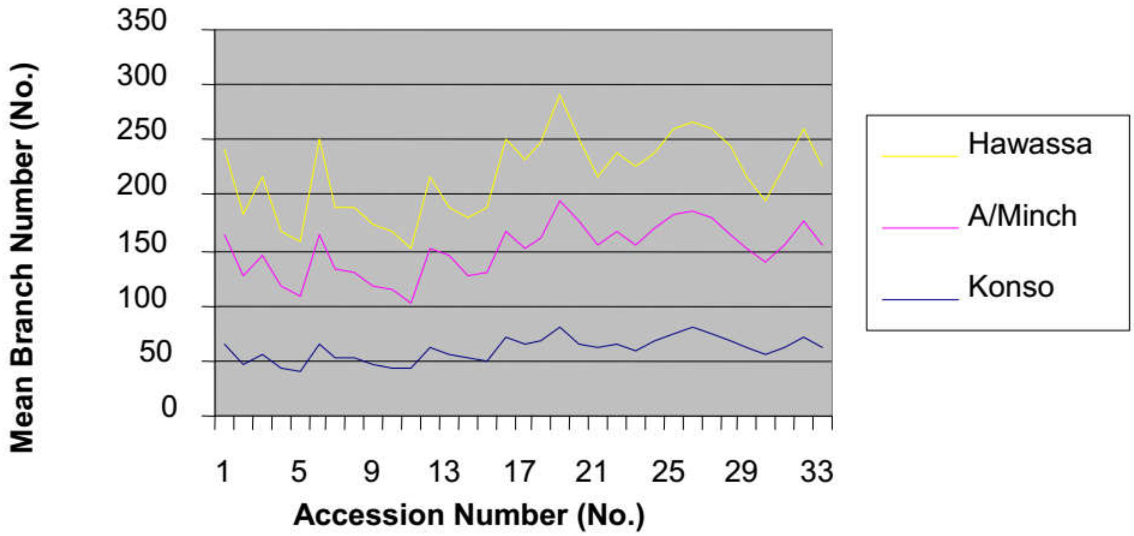

Figure 3. Trend of mean branch number of Moringa accessions across locations

Dry Leaf Biomass

Dry leaf biomass per tree was the highest in Konso Negayle (47.62 kg/tree) and the lowest in exotic accession Nicaragua-O (22.22 kg/tree) in Table 2 and figure 4.The dry leaf biomass is very important selection criteria for Moringa accessions since the leaves are food for human beings and feed for animals. The exotic accessions gave the lowest dry leaf biomass than indigenous Moringa accessions, which implies a better leaf yield potential of the native germplasm. Currently *Moringa stenopetala* is primarily grown for home consumption of the leaf and the surplus for sale in the markets to generate cash income to the family

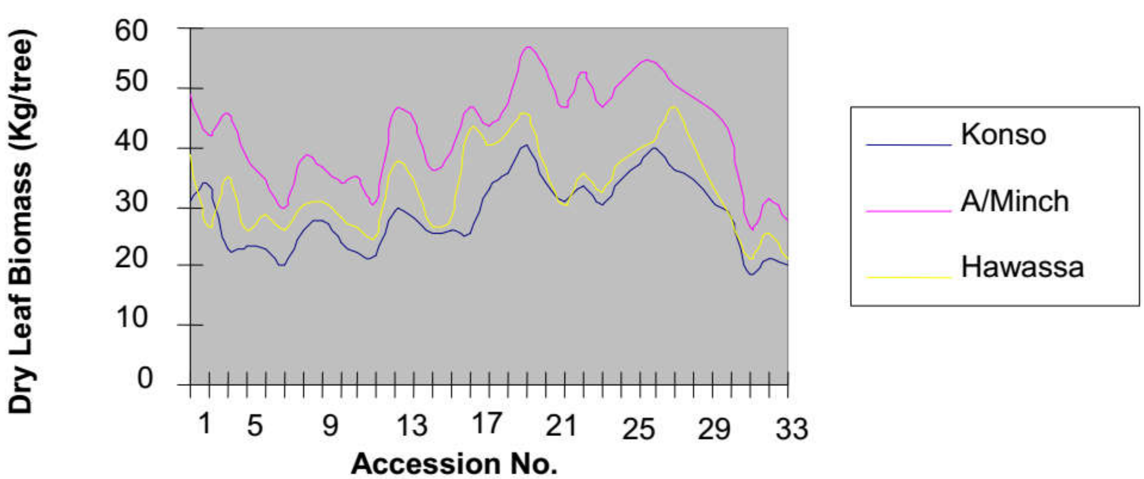

Figure 4. Mean dry leaf biomass value of Moringa accessions across locations

The reasons for the reduced dry leaf biomass per tree of *Moringa oleifera* was due to smaller leaf size and lesser number of branches compared to *Moringa stenopetala*. The lowest dry leaf biomass was obtained at Konso sites (Figure 4). Indigenous accessions have shown genetically superiority over the exotic *Moringa oleifera*, which implies that it is very advisable to improve the native germplasm rather than introducing the exotic accessions.

Conclusion and Recommendation

The result of the trial on Moringa germplasm collection and screening indicated that there was significant difference between accessions for yield. Konso Negayle accession performing better than others is recommended for leaf production at Konso, Arba Minch, Hawassa and in places with similar agro ecologies. This accession is also recommended for further tree improvement research.

Conflict of Interest

I am declaring that the original research article entitled "Study on Moringa Germplasm Collection and Screening in Southern Ethiopia" is my own work. Therefore, there will not be any conflict of interest in publication of it in your journal.

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