THE GROWTH PERFORMANCE, BIOMASS PRODUCTION AND NUTRITIVE VALUE OF THREE MORINGA PROVENANCES IN LUYENGO, SWAZILAND.

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ABSTRACT

Scarcity of animal feed resources, particularly during the dry season, is a major constraint to livestock production in the tropics and in particular in Swaziland. Commercial animal feed supplement are too expensive for most farmers and alternative resources are needed. Moringa oleifera (Lam) has been used as a protein source in feeding livestock. However, its growth performance, biomass production and chemical composition have not been investigated in Swaziland. The study investigated the field growth performance, biomass production and chemical composition of Moringa provenances under Luyengo condition. The Moringa provenances used were Mayiwane, Malawi and Binga in a randomised complete block design with each provenance replicated twice. The plant height and root collar diameter were measured for 23 weeks after field planting. The data was analysed using Statistix Version 2. The root collar diameter for Mayiwane provenance was greater (P<0.05) than that of Malawi and Binga provenances which themselves did not differ (P>0.05). The increment in root collar diameter followed a similar trend with Mayiwane provenance having an increment of 0.019cm/d compared to 0.012cm/d for Malawi and Binga provenances. Malawi and Binga provenances had similar (P>0.05) plant height which was lower (P<0.05) than that of Mayiwane provenance. Mayiwane provenance had growth rate of 1.81 cm/d which was greater (P<0.05) than that of Binga and Malawi provenances of 1.00 and 1.10 cm/d, respectively. The leaf biomass production of Mayiwane provenance was greater (P<0.05) compared to the other provenances. The leaf fraction dry biomass yield was 5009.13 kg/ha, 3502.27 kg/ha and 2591.32 kg/ha, for Mayiwane, Malawi and Binga provenances, respectively. There was no significant (P>0.05) different in CP, CF and EE content among the provenances. It can be concluded that the Moringa provenances produce substantial forage biomass and can be used as protein supplements to ruminant and non-ruminant diets in Swaziland.

Key words: Moringa provenances, plant height, root collar, biomass, nutrient composition

INTRODUCTION

Livestock have traditionally been an important component of the agricultural industry in Swaziland. However, livestock production in the country is low because of poor nutrition both in terms of quantity and quality of available feeds. Seasonal difference in precipitation causes wide fluctuation in both quantity and quality of the forage available. Low quality, inadequacy of feed and high feed cost, as well as under-nutrition and malnutrition are considered to be the major constraints affecting productivity of farm animals (Aregheore, 2002; Mendieta-Araica, 2011).

In most years farmers rely on the use of crop residues and low-quality standing hay for feeding their animals. However, these crop residues are low in nitrogen and high in lignocellulose, which leads to low digestibility and low voluntary intake (Nurfeta, 2010). The energy and nitrogen intake of animals raised on these feeds can not sustain adequate levels of performance (Sanchez, 2006; Mendieta-Araica, 2011). Hence delayed animal sexual maturity, poor reproductive performance and low milk yield are common observations.

Tree forages can be used as protein supplements to improve livestock performance (Nuhu, 2010). Moringa leaf meal has high protein content ranging from 20 to 29% (Aregheore, 2002, Moyo *et al*., 2011, Gadzirayi *et al*., 2012). The use of Moringa leaf meal as supplements to different basal diets has been associated with improved livestock performance with respect to growth rate, milk production, egg production and quality and reproductive efficiency (Abou-Elezz *et al*., 2011; Mendieta-Araica, 2011; Onu and Aneibo, 2011; Gadzirayi *et al*., 2012). Supplementing low-quality tropical grasses with high protein forages is known to improve intake and digestibility of roughages (Nouala *et al*., Nouala *et al* 2006; Nurfeta, 2010).

Therefore research has increasingly been paying attention to Moringa (*Moringa oleifera* Lam) as a protein source in both non-ruminant and ruminant feeds (Abou-Elezz *et al*., 2011). Moringa is a drought-tolerant tree with negligible amounts of tannins, saponins, trypsin and amylase inhibitors or cyanogenic glucosides (Gidamis *et al*., 2003; Ogbe and Affiku, 2012). Although *Moringa oleifera* is proving to be, a potential protein resource for livestock there is little knowledge about its field growth performance, biomass production and nutrient content under local conditions. Therefore, the objective of the study was to evaluate field growth performance, biomass production and nutrient content of the three Moringa provenances.

MATERIALS AND METHODS

Description of study site

The study was conducted at University of Swaziland (UNISWA), Faculty of Agriculture, Luyengo, located at $26^{0}34'27.42''$ South, $31^{0}10'56.01''$ East and at an altitude of 729 m above sea level (Dlamini, 2010). The farm has a sandy loam soil with a pH of 5.6, Ca content of 0.121 meq/100 g soils, Mg content of 0.701 meq/100g soils and exchangeable acidity of 0.15 meq/100g. The mean annual rainfall for the area is about 980 mm with 75 to 85% coming in October to March and with a peak around December. The mean maximum and minimum temperature is 23.0°C and 11.0°C, respectively (Dlamini, 2010). The rainfall and temperature (Figure 1) recorded during the study period between May 2012 and February 2013 is shown below.

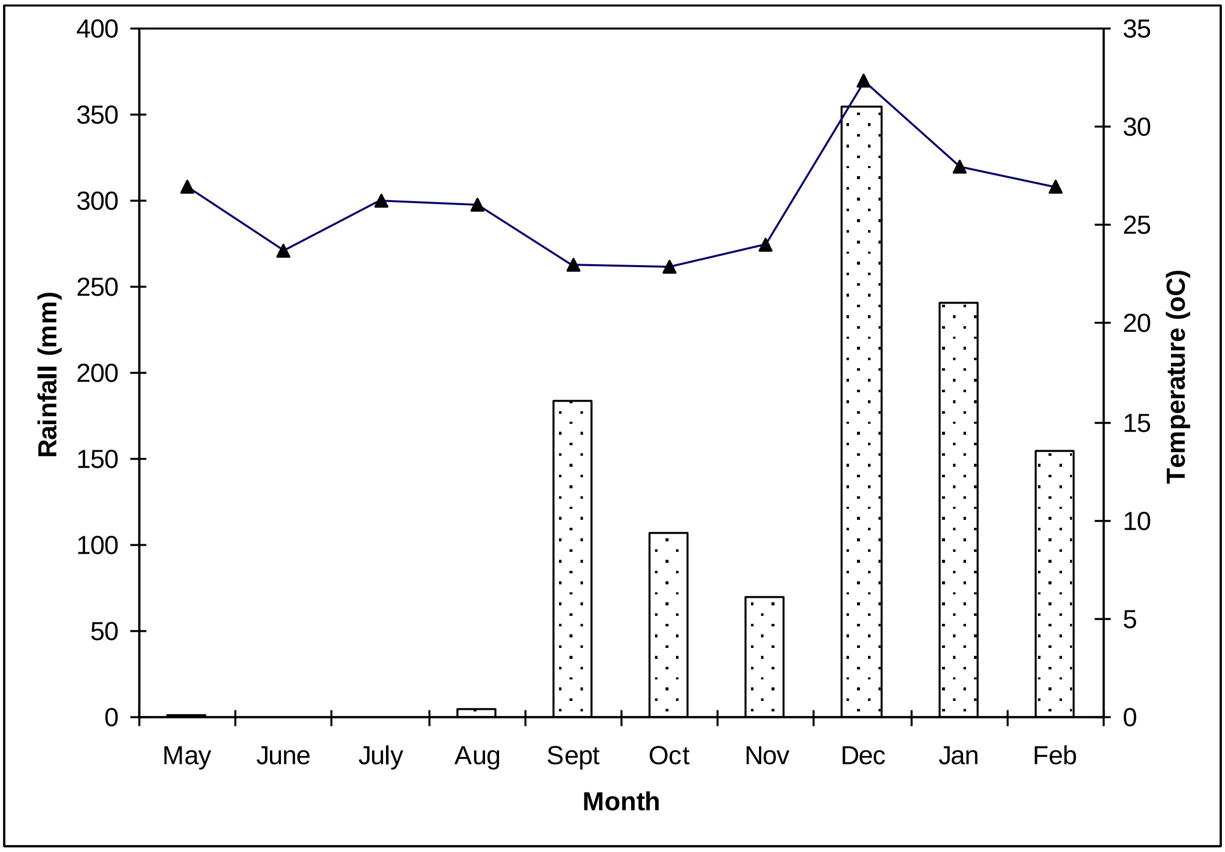

Figure 1: The monthly rainfall and temperature of Luyengo during the study

Experimental design

A randomised complete block design was used. The field was ploughed by a tractor to loosen the soil, and the land was prepared using a garden rake to level the soil. The seedlings, raised in a lathe house for 22 weeks, were planted in 1.5 m × 3 m plots, 1.0 m inter-row and 0.5 m intra-row spacing and 1.0 m path way between plots. The seedlings were planted at a depth of 22 cm. Each plot consisted of 16 seedlings thus a total of 32 per provenance giving a plant population per hectare of 35,556 plants. Weeding was done manually using a hoe when necessary to prevent competition for water and nutrients between the Moringa plant and weeds.

Growth performance

The plant growth performance was evaluated by the survival, root collar diameter and plant height which were measured fortnightly from September 2012. The survival of the provenance was determined by counting the number of trees that died or dried during the course of the experiment expressed as a percentage of the total number of seedlings planted. The plant height was measured fortnightly on 10 randomly selected plants per plot using a tape measure from September 2012 to February 2013. The root collar diameter was also measured at 15 cm of base height on 10 randomly selected plants per plot for 23 weeks using a veneer calipers.

Biomass production & nutrient content

In each block, four plants that were in the middle of the plot were harvested per provenance after 16 months of growth. At harvest the plants were cut at 30 cm above the ground with machete and the material was separated into fine fraction (leaves together with tender twigs) and course fraction (stem) and their fresh weight were taken (grams per plant). The sub samples were dried in an oven at 65°C to constant weight for dry matter (DM) determination. The leaf material was then milled using a hammer mill (Wiley Laboratory mill) through a 2 mm screen for nutrient content determination.

Laboratory analysis

The crude protein content was calculated from the nitrogen content which was determined by the semi-micro Kjeldahl method (AOAC, 1990). The ash content was determined by combustion of a known weight of material at 550°C overnight and weighed the remaining residue. The organic matter was calculated by deducting the weight of the ash from that of the DM of the sample over the weight of the dry feed sample multiply by 100. The crude fibre was determined by the standard procedures of AOAC (1990).

Statistical analysis

The data of growth performance, biomass yield, and nutritive value were subjected to analysis of variance (ANOVA) using Statistix program package (version 2.0, 2006) with the following model:

$Y_{ij} = \mu + P_i + B_j + e_{ij}$

Where:

Y_{ij} is the dependent variable with the i^{th} provenance from the j^{th} block (e.g. growth performance, CP, DM, EE, Ash, Organic matter etc.), μ is the overall mean, P_i= is the effect of the i^{th} provenance (i=1, 2, 3), B_j = is the effect of the j^{th} block effect (j=1, 2), and e_{ij}= the random residual error. The difference between means will be assessed using LSD mean separation test in Statistix (Statistix, 2006).

RESULTS

Growth performance of provenances

Root collar diameter

The root collar diameter of the provenances is presented in Figure 2. Mayiwane provenance was significantly ($P < 0.05$) different in root collar diameter as compared to Malawi and Binga provenances in weeks 1-3 which did not differ ($P > 0.05$) between themselves. In week 5 all the provenances had a root collar diameter that was significantly ($P < 0.05$) different from each other being 0.94 cm, 0.77 cm and 0.58 cm for Mayiwane, Malawi and Binga provenances, respectively. Between weeks 7-23 Mayiwane provenance had a root collar diameter that was significantly ($P < 0.05$) greater than that of Malawi and Binga provenances. The Binga and Malawi provenances had similar root collar diameters between weeks 7 to 23.

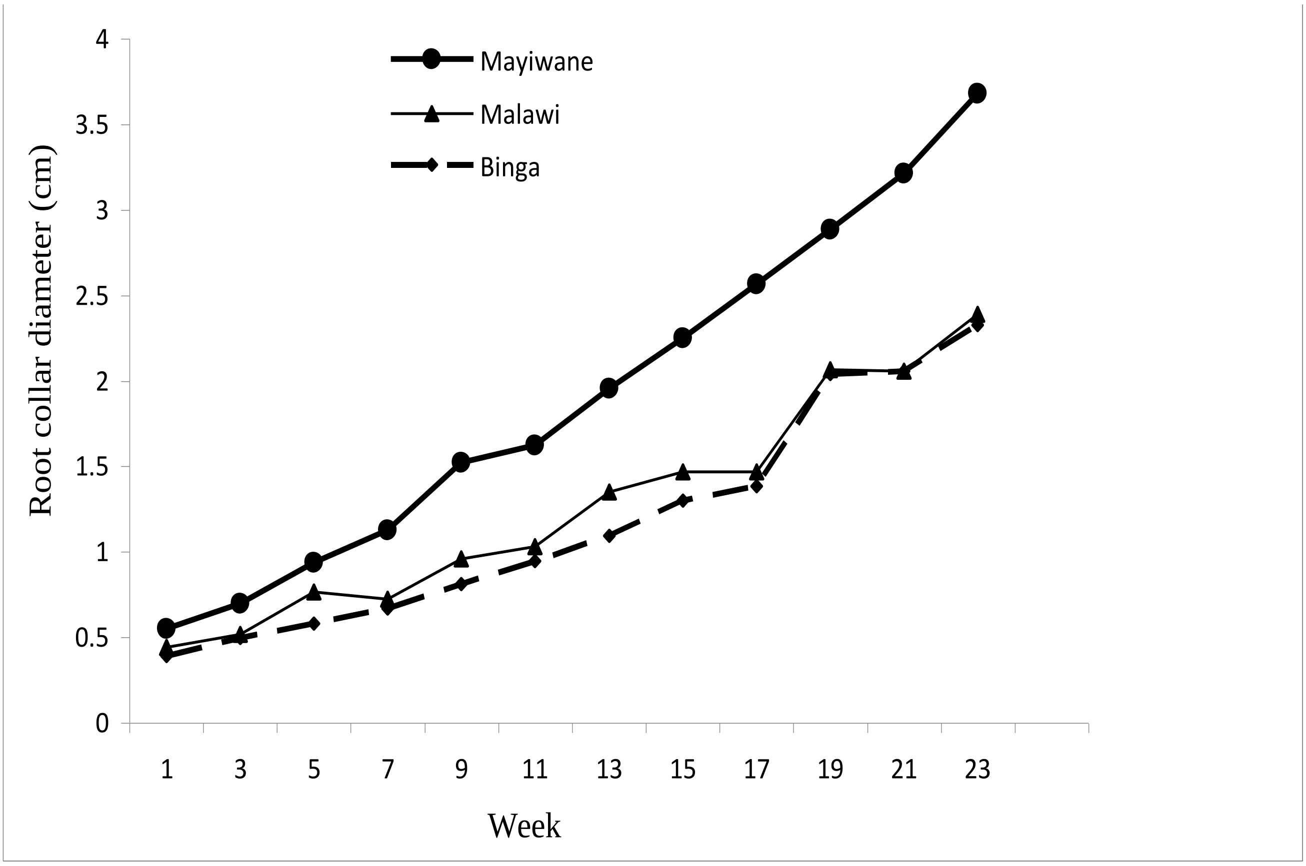

Figure 2: Fortnightly root collar diameter (cm) of *Moringa oleifera* provenances

The root collar diameter increment varied among the three provenances. Mayiwane had the highest root collar diameter increment from 0.55 cm at the 10th month after planting to 3.68 cm at the 16th month after planting with a daily increment of 0.019 cm which was significantly ($P < 0.05$) different than the other provenances. There was no difference ($P > 0.05$) between Binga and Malawi provenances in their root collar increment. Binga provenance had its root collar diameter increased from 0.39 cm to 2.33 cm with a daily increment of 0.012cm compared with Malawi provenance, which had a diameter increment from 0.44cm to 2.39cm with a daily increment of 0.012cm.

Plant height

The plant height for the Moringa provenances is presented in Figure 3. The plant height for Mayiwane provenance ranged from 34 cm to 513 cm from week 1 to week 23, Malawi provenance had its plant height ranging from 18 cm to 473 cm and Binga provenance had its plant height ranging from 20 cm to 423 cm. Binga and Malawi provenances were not significantly ($P > 0.05$) different from each other while Mayiwane provenance had significantly ($P < 0.05$) greater plant height compared to Binga and Malawi provenances.

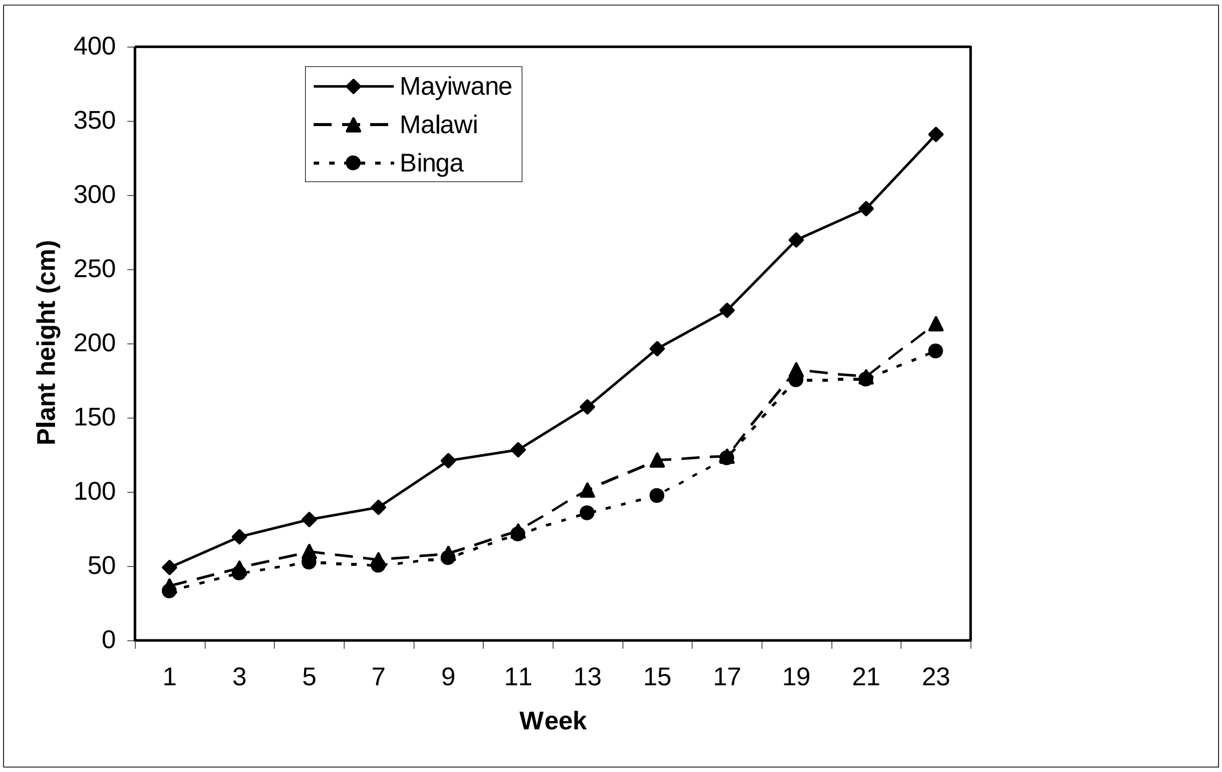

Figure 3. Fortnightly plant height (cm) of *Moringa oleifera* provenances

Mayiwane provenance consistently maintained the highest height increment throughout the evaluation period. Mayiwane provenance height increased from 49.20 cm at 10 months after planting to 340.90 cm at 16 months after planting resulting in a growth rate of 1.81cm per day. In contrast, the Binga provenance height increased form 33.35 cm to 194.85 cm between 10 and 16 months after planting resulting in a growth rate of 1.00 cm per day. Malawi provenance plant height increased from 36.80 cm to 213.55 cm between 10 and 16 months after planting resulting in a growth rate of 1.10 cm.

Biomass production

The fresh and dry matter biomass production of the Moringa provenances at 16 months after planting is shown in Table 1 and Table 2, respectively. There was a significant ($P < 0.05$) difference in the course fraction (stem) and fine fraction (leaves and petioles) of fresh biomass yield among the three provenances. Mayiwane had significantly ($P < 0.05$) the highest course and fine fractions biomass yield among the provenances, followed by Malawi provenance which was intermediate and then Binga provenance with the least biomass yield. The course fraction for fresh biomass yield ranged from 348.63±45.49 grams per plant to 1137.1±45.49 grams per plant, whereas the value for fine fraction ranged from 265.63±11.55 to 518.00±11.55 grams per plant. In fresh biomass yield of the fine fraction, Mayiwane provenance produced 18418.01 kg/ha, Malawi provenance produced 11564.59 kg/ha while Binga provenance produced 9444.74 kg/ha. The biomass dry matter yield followed a trend to fresh biomass. Mayiwane had the highest ($P < 0.05$) dry matter yield, followed by Malawi provenance being intermediate and least was Binga provenance. The dry matter yield of the provenances ranged from 72.88±3.17 to 140.88±3.17 grams per plant of fine fraction. Mayiwane provenance produced DM yield of 5009.13 kg/ha of fine fraction, followed by Malawi provenance by 3502.27 kg/ha then Binga provenance at 2591.32 kg/ha.

Table 1. Fresh biomass yields (g/plant) of Moringa provenances at 16 months after planting

	Provenances		
	Mayiwane	Malawi	Binga
Stem	1137.1±45.49^{a}	525.63±45.49^{b}	348.63±45.49^{c}
Leaf	518.00±11.55^{a}	325.25±11.55^{b}	265.63±11.55^{c}
Total biomass	1655.1±57.20^{a}	850.88±57.20^{b}	614.26±57.20^{c}
Leaf : Stem ratio	0.46	0.62	0.76

^{a,b}Means with different superscripts in the same row differ significantly at *P <0.05*.

Table 2. Dry matter (DM) yields (g/plant) of Moringa provenances at 16 months after planting

	Provenances		
	Mayiwane	Malawi	Binga
Stem	245.50±8.38^{a}	134.75±8.38^{b}	65.16±8.38^{c}
Leaf	140.88±3.17^{a}	98.50±3.17^{b}	72.88±3.17^{c}
Leaf + Stem	386.38±10.63^{a}	233.25±10.63^{b}	138.00±10.63^{a}
Leaf: Stem ratio	0.57	0.73	1.13

^{abc}Means with different superscripts in the same row differ significantly at P <0.05.

Chemical composition

The chemical composition of the three *Moringa oleifera* provenances is presented in Table 3. The dry matter (DM) content of the three provenances varied. Malawi provenance was significantly (P < 0.05) higher in dry matter content as compare to Mayiwane provenance. However, the DM content of Binga provenance was not significantly (P > 0.05) different to both Mayiwane and Malawi provenances. The dry matter content of the provenances ranged from 24.12±0.99 to 27.37±0.99%. There was no significant (P > 0.05) different in the crude protein (CP) content of the three provenances which ranged from 21.26±1.58 to 24.82±1.58% CP. The ash content of the Mayiwane provenance was not significantly (P > 0.05) different from that of Malawi provenances but was significantly (P < 0.05) higher than that of the Binga provenance. The organic matter (OM) of Mayiwane provenance and Malawi provenance were significantly (P > 0.05) similar but significantly (P < 0.05) lower than that of the Binga provenance.

Table 3. Chemical composition (%DM) of *Moringa oleifera* provenances

	Moringa Provenances		
Nutrients	Mayiwane	Malawi	Binga
Dry matter	24.12 ± 0.99^{a}	27.37 ± 0.99^{b}	25.94 ± 0.99^{ab}
Crude protein	24.82 ± 1.58^{a}	21.26 ± 1.58^{a}	22.78 ± 1.58^{a}
Ash	7.55 ± 0.39^{a}	7.23 ± 0.39^{ab}	6.07 ± 0.38^{b}
Organic matter	92.45 ± 0.39^{a}	92.79 ± 0.39^{a}	93.93 ± 0.38^{b}
Ether extract	7.13 ± 2.05^{a}	12.50 ± 2.05^{a}	12.07 ± 2.05^{a}
Crude fibre	15.35 ± 1.31^{a}	17.18 ± 1.31^{a}	14.70 ± 1.31^{a}

^{ab}Means with different superscripts in the same row differ significantly at P < 0.05

The ether extract (EE) was not significantly (P > 0.05) different among the three provenances with values ranging from 7.13±2.05 to 12.50±2.05%. Similarly there was no significant (P > 0.05) difference in the crude fibre content of the three provenances with values ranging from 14.70±1.31 to 17.18±1.31%.

DISCUSSION

Root collar diameter

The highest root collar diameter of Mayiwane provenances can probably be attributed to their high seed quality as evidence to their emergency percentage (Gamedze, 2012). This is in agreement with some reports suggesting sowing sound seeds collected from parents with superior genotypes and phenotype results in a healthy seedling (Nduwayezu *et al*, 2007). Moreover, Mayiwane provenance is from the Highveld part of the country that has almost similar conditions to Luyengo. The findings of this study also confirm earlier reports suggesting that Moringa is a fast growing plant (Nduwayezu *et al.*, 2007 and Anele *et al.*, 2008) as compare to *Leucaena leucocephala*, *Calliandra calothyrsus* and *Gliricidia sepium* commonly used in agroforestry. The variation in root collar diameter of the provenances may be due to the climatic condition, altitude of the study site or genetic variation among the provenances.

Plant height

The growth performances of the Moringa provenances trees as indicated by their plant height at different ages showed their ability to fully establish during the course of the year of planting and could therefore be conveniently incorporated into crop-livestock agroforestry systems to supply early feed resource to animals. The observed statistical differences in the plant height of Moringa provenances indicate that Mayiwane provenance is superior to the other two provenances. The performance of Mayiwane concurred with findings of Nduwayezu *et al*. (2007) who reported greater plant height in locally adapted provenances. The performance of Malawi provenance demonstrates that it does not adapt well in other geographic location as also evidenced in a study in Botswana (Nduwayezu *et al.*, 2007). The higher growth rate recorded by *Moringa oleifera* confirmed earlier reports that it is a fast-growing species (Anele *et al.*, 2007 Nduwayezu *et al.*, 2007) as compare to *Leucaena leucocephala*, *Calliadra calothyrsus* and *Gliricidia sepium* commonly used in agroforestry. However, the results of the current study is in contrast with Fuglie and Sreeja (2001) indicating that Moringa during the first year of establishment can reach a height of 5 m, producing flowers and fruit yet 16 months after planting the Mayiwane provenance was 340.90 cm while Binga and Malawi were 194.85 and 213.55 cm, respectively. This may be because the Moringa provenances were planted during the dry season where there was no rainfall between May and August whereas in the study by Fuglie and Sreeja (2001) the rainfall was 400mm.

Biomass production

Moringa plants are fast-growing and produce high biomass within a short time period when cultivated (Nuhu, 2010). The fresh biomass yield for fine fraction of 18418.01, 11564.59 and 9444.74 kg/ha for Mayiwane, Malawi and Binga provenances, respectively, showed that Mayiwane provenance had the better biomass yield than both Malawi and Binga provenances. In addition, for dry matter production, Mayiwane provenance recorded 5009.13 DM yield kg/ha whereas Malawi and Binga provenances recorded 3502.27 and 2591.32 DM yield kg/ha, respectively. The findings of the study corresponded with other researchers (Makkar and Becker, 1997; Aregheore, 2002; Sanchez *et al*., 2006) who reported, that the total dry matter (DM) production for *Moringa oleifera* is high, from 4.2 to 8.3 tons per ha. Nuhu (2010) reported that a yield of 616.40 kg/ha DM could be obtained at first cut using a planting distance of 1.30 m × 1.30 m.

The planting spacing in this study was 1m × 0.5m contrary to that of Nuhu (2010) hence the DM yield were 4982.46, 3497.64 and 2604.48 kg/ha for Mayiwane, Malawi and Binga provenances, being higher than that reported by Nuhu (2010). The planting density could be the reason the DM varies from that of Nuhu (2010). According to Sanchez (2006) Moringa planted at higher densities (1 million seeds per hectare) gives better yields than at lower densities, when the plantation was irrigated and fertilised. However, Nouala *et al*. (2006) under high density cultivation using a planting density of 15 cm × 15 cm, reported a biomass yields in excess of 15 tons DM per ha in a 60 day growing cycle. The growth performances of the Moringa provenances as indicated by their height and root collar diameter increments at different ages showed their ability to fully establish during the course of the year of planting and could therefore be conveniently incorporated into crop-livestock agroforestry systems to supply early feed resource to animals (Sánchez, 2006).

Chemical composition

The dry matter content (DM) of Malawi provenance was the highest followed by Binga provenance being intermediate and least being that of Mayiwane provenance. The results of this study are comparable to that of Emongor (2009), in Moringa plants that were grown in the same conditions. However, the dry matter value of Moringa leaves of 97.7 %, 87.20 %, and 86% have been reported in studies by Olugbemi *et al*. (2010), Mutayoba *et al*. (2011), Onu and Aniebo (2011), respectively . The variation in the results reported by the other authors and that of this study could be due the time of harvesting, stage of growth and drying process. The fine fraction of this study were harvested in the wet season and they were oven dried immediately after harvesting, whereas in a study by Ogbe and Affiku (2012) the leaves were dried in shade first before oven drying. According to Palada and Chang (2003), DM of different Moringa plants varies and they depend upon the time of harvesting, stage of growth and conditions on which the plant was cultivated.

The crude protein obtained in this study of 24.82, 21.26 and 22.78% for Mayiwane, Malawi and Binga provenances, respectively, was in contrast lower than the crude protein reported by Olugbemi *et al*. (2010) of 27.44 %. However, Mutayoba *et al*. (2011) reported 30.65 % crude protein in Moringa leaves which is higher than the results obtained in the study. The lower value obtained in this study was because the plants were not fertilized, since Moringa does not require a fertilizer (Palada and Chang, 2003). Moreover, Makkar and Becker (1997), Aregheore (2002), and Mendieta-Araica (2011) reported that fresh leaves of Moringa plants contain between 19.3 % and 26.4 % CP in DM which is comparable to that of the Moringa provenances used in this study.

The ash content of *Moringa oleifera* reported by Nuhu (2010), and Mendieta-Araica (2011) ranged between 71 to 194 g/kg DM (7.1 to 9.4%) which is in agreement with the results of this study which were 7.55, 7.23 and 6.07% for Mayiwane, Malawi and Binga, respectively. The ash of *Moringa oleifera* was 98.4 g per kg, 81.4 g per kg DM, and 76.9 g per kg DM during the late, early and mid-dry season, respectively, as reported by Anele *et al*. (2008). The crude fibre and ether extract of the three provenances were greater that those reported by Ogbe and Affiku (2012) of 7.09 and 2.11%, respectively. The higher value obtained in this study may be because the fine fraction comprises of twigs bigger than 5mm, whereas in the other studies twigs more than 5mm were not included in the chemical analyses. The fibre content obtained is satisfactory for ruminant since a satisfactory ration for ruminant should contain 15-20% CF in order to facilitate favourable ruminal physiological function. The ether extract content values of the study of 12.50 and 12.07% for Malawi and Binga provenances, respectively, were in line with that reported by Anele *et al*. (2008) of 13.2%. However, Mayiwane provenance recorded a lower value of 7.13% ether extract as compared to 13.2% reported by Anele *et al.* (2008).

CONCLUSION

The Mayiwane provenance showed greater adaptation to Luyengo conditions and produced higher fresh biomass and dry matter yields as compared to Malawi and Binga provenances. The three provenances however, did not differ in their protein content which is the major limiting nutrient in livestock diets during the dry season. The Moringa provenances have potential to contribute substantially as feed protein supplements to ruminant and non-ruminant animal production in Swaziland.

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