GROWTH PERFORMANCE AND FORAGE NUTRIENT CONTENT OF MORINGA (*MORINGA OLEIFERA LAM)* PROVENANCES UNDER LUYENGO CONDITIONS, SWAZILAND CONDITIONS

N.P. Gamedze, J. F. Mupangwa*, E. Bhebhe and B. J. Dlamini
Department of Animal Science, University of Swaziland, P. O. Luyengo, Swaziland
Phone: +26825170583, *E-mail: mupangwa@uniswa.sz

ABSTRACT

The incorporation of tree and shrub species in animal production systems is a viable alternative to improve the utilisation of land and at the same time improve the diet of livestock. Scarcity of animal feed resources, particularly during the dry season, is a major constraint to livestock production in Swaziland. Therefore, alternative feed resources need to be investigated. Moringa oleifera (Lam) leaves can be used as animal feed. Its growth performance and nutritive value has not been documented in the country. The objective of the study was to determine the growth performance and chemical composition of three provenances of Moringa. The three provenances evaluated were Mayiwane, Malawi and Binga in a completely randomised design with three replications. The Moringa was measured for growth performance for 12 weeks and harvested after 16 weeks for chemical analysis. The plant height for Mayiwane provenance ranged from 8.86 cm to 51.25 cm, Malawi provenance ranged from 6.61cm to 40.79 cm and Binga provenance ranged from 2.71cm to 40.79 cm. Root collar diameter for Mayiwane provenance ranged from 0.196 cm to 0.625 cm, Malawi provenance ranged from 0.144 cm to 0.526 cm and Binga provenance ranged from 0.065 cm to 0.531. The three provenances had significant ($P<0.05$) differences in the number of leaflets produced. Mayiwane provenance had leaflets ranging from 15 to 236, Malawi provenance from 9 to 213 and Binga provenance from 3 to 190. Chemical analysis of Moringa showed that there were no significant ($P>0.05$) differences in CP, CF, OM and ash content among the provenances. Mayiwane provenance had the highest DM value of 21.22% and was not significantly different ($P > 0.05$) from Binga provenance which was 20.72%. It is concluded that Mayiwane provenance can be utilised for its fast growth rate and its adaptability to Luyengo for large scale forage production.

Key words: *Moringa oleifera,* seedlings, growth performance, nutritive value, Swaziland.

INTRODUCTION

The moringa tree (*Moringa oleifera* (Lam) belongs to the Moringaceae family with 14 known species and is a perennial tree that originated from India and is found in most tropical countries in Africa, Asia and America (Emongor, 2009; Kelly, 2009). This fast-growing tree can reach up to 7-12m and is grown throughout the tropics for human food, fodder, medicine, dye, and water purification (Makkar and Becker, 1997). Moringa can be propagated either by using seeds or cuttings. Environmentally it has a low demand for soil nutrients and water making its production and management easy. Moringa can grow in all types of soil, from acid to alkaline (Duke, 1983) and can tolerate up to 6 months of dry season reasonably well. The tree grows well at altitudes from 0 to 1800 m above sea level and rainfall between 500 and 1500 mm per year (Makkar and Becker, 1997).

Moringa oleifera is a non-leguminous multipurpose tree with high crude protein content in the leaves (251g/kg DM) and therefore offers an alternative source of protein for livestock (Foidl *et al.,* 2001). Moringa leaves have a negligible content of tannins, a saponin content similar to that of soybean meal and no trypsin and amylase inhibitors or cyanogenic glucosides (Makkar and Becker, 1997). As part of global efforts to improve animal nutrition, attention is being shifted to the evaluation of multi-purpose tree species (MPTS). Some MPTS produce a new flush of leaves while others retain theirs in green form through the dry season thereby making them a good source of supplementary forage feed during this critical period (Aregheore, 2002). Moringa leaves are readily eaten by cattle, sheep, goats, pigs, chickens and rabbits and can also be used as feed for fish. Several studies have demonstrated that significant proportions of traditional fodder can be replaced with Moringa leaf (Manh *et al*., 2005; Sanchez, 2006; Radovich, 2009). Research has shown that introducing the foliage into the diet of dairy cows can increase milk production by as much as 30% and increase the daily weight gains of beef cattle by 32% and birth weights of cattle by 3-5kg (Joubert, 2010).

In Swaziland, Moringa was introduced and naturalised as an ornamental tree and was also used as a live fence and windbreak. Recently it has generated a lot of interest among farmers as a potential fodder crop for use as livestock feed (Onwuka, 2011). However, there is lack of information in Swaziland on Moringa growth performance, and the nutritional content of Moringa fodder. This study aimed at contributing towards addressing the seasonal shortages in quantity and quality of forages in Swaziland through the assessment of the potential of *Moringa oleifera* through its establishment, growth and nutritive quality under Luyengo, Swaziland, conditions.

MATERIALS AND METHODS

Description of study site

The experiment was carried out at the University of Swaziland, Faculty of Agriculture, Luyengo, located 26^0 32`0`` South, 31^0 14`0` East which lies at 638 m above sea level. There is a wet season between November and April with a mean annual rainfall of 1200 mm and a dry season between May and October. Mean annual temperature is 27.3 ^{0}C, with the highest temperatures occurring towards the end of the dry season. The soil is mainly sand-loam soil with a pH of 5.4 (Dlamini, 2010). The nursery study was carried out from November 2011 to April 2012.

Experimental design

The seedlings were grown in the lath-house permitting 70% solar irradiation. A completely randomised design was used and replicated three times. Each Moringa provenance consisted of 20 seedlings within a replicate. The three provenances of Moringa that were used in the study were from Mayiwane (Swaziland), Malawi and Binga (Zimbabwe).

Moringa establishment and management

The seeds were sown in five litre plastic bags filled with 5kg of mixture of nursery compost and sandy loam soil in a ratio of 1:4, respectively. The seeds were sown at a depth of 3cm. The Moringa seedlings were then spaced 30cm between rows and 15cm between plants after eight weeks of their emergence to give them enough space for growth. The plants were grown for a period of 16 weeks during which all the parameters of growth were measured. The seedlings were watered twice a week. The sandy loam soil was hand cultivated using a hand fork to promote aeration and water penetration. Weed control was done manually during the growing period. The control of cutworms was by use of cutworm bait which was applied twice within the growth period of Moringa.

Growth performance measurements
The growth performance variables that were determined included: percentage emergence, days to emergence, plant height, root collar diameter and number of leaflets. The number of leaflets was counted on all the plants in each replication at fortnightly intervals up to 12 weeks after emergence. Plant height was determined by measuring shoot length on all the plants in each replication using a 1m ruler. The root collar diameter was measured using a veneer calliper fortnightly after emergence on all the plants in each replication.

Forage sampling
The leaf forage samples for nutrient analysis were collected at 16 weeks post-emergence. The leaves were harvested from the top of the plant to the end of the soft stem part (20 cm above ground) from all the plants because they were considered as potential feed and also to allow regrowth of the plant. The fresh leaves were put in brown paper bags for subsequent laboratory analysis.

Laboratory analysis
All the provenances were analysed for chemical composition using the AOAC (1990) procedures. All samples were dried in a forced draft oven at 65 ºC for 48 hours. Dried samples were ground to pass through a one mm sieve for quality evaluation. Dry matter (DM) was determined by oven drying samples at 105 ºC for 6 hours and ash determination was done at 550 ºC for 8 hours. Total N was determined by the Kjeldahl procedure and CP calculated as N x 6.25. The organic matter (OM) was determined by subtracting the ash content from the dry matter weight of Moringa. Crude fibre (CF) of the forage was determined using the fibretec hot extractor method (AOAC, 1990).

Data analysis
Data were subjected to analysis of variance (ANOVA) using Statistical Package for Social Sciences for Windows version 15.0 (SPSS, version 15.0) (SPSS, 2006) fitting the following model:
$Y_{ij} = \mu + P_i + e_{ij}$
Where: Y_{ij} is the dependent variable (e.g. days to emergence, percent emergence, plant height, root collar diameter, DM, CP, Ash, Organic matter (OM), Crude fibre (CF)), μ is the overall mean, P is provenance effect (i =1, 2, 3), and e_{ij} is the residual error. Mean separation for significant effects was performed using the Least Significant Differences (LSD) test of SPSS version 15.0 (SPSS, 2006).

RESULTS AND DISCUSSION

Seed emergence
The Moringa seeds took between 8 and 16 days to emerge at a mean temperature of 30^0C under lath house conditions. The Mayiwane provenance emerged after 8 days, while the Malawi and Binga provenances emerged after 10 and 16 days, respectively. The storage duration and conditions of the seeds can contribute to variations in emergence of the three provenances. According to Sauveur and Broin (2010) seeds should not be stored over long periods as they lose viability (germination capacity) after about one year. In this study the Mayiwane provenance had fresh seed from pods whilst the Malawi provenance seed had been stored one year from harvest and the Binga provenance were more than 24 months old at room temperature. Seed that is one year old and more have been reported to lose viability if stored at room temperature (Emongor, 2009) resulting in low emergence percentage. The emergence percentage was statistically different (P<0.05) with Mayiwane provenance having the highest emergence percentage of 89% as compared to Malawi, 56%, and Binga, 30%, provenances. All other factors being

equal, genetic differences between Moringa seed has been reported to have a significant effect on germination percentage (Emongor, 2009).

Growth performance

The seedling plant height of the provenances is presented in Figure 1. There were significant (P < 0.05) provenance and week interaction in the height of the seedlings during the 12 weeks. At two weeks of growth the Mayiwane provenance had significantly (P < 0.001) greater seedling height (16.22 vs 14.02 cm) than that of the Binga provenance. However, the seedling height for the Mayiwane provenance was similar (P > 0.05) to that of Malawi provenance, whilst that of Malawi provenance was not different from that of Binga provenance (15.57 vs 14.02 cm). A similar trend was observed at 4 weeks of growth among the provenances.

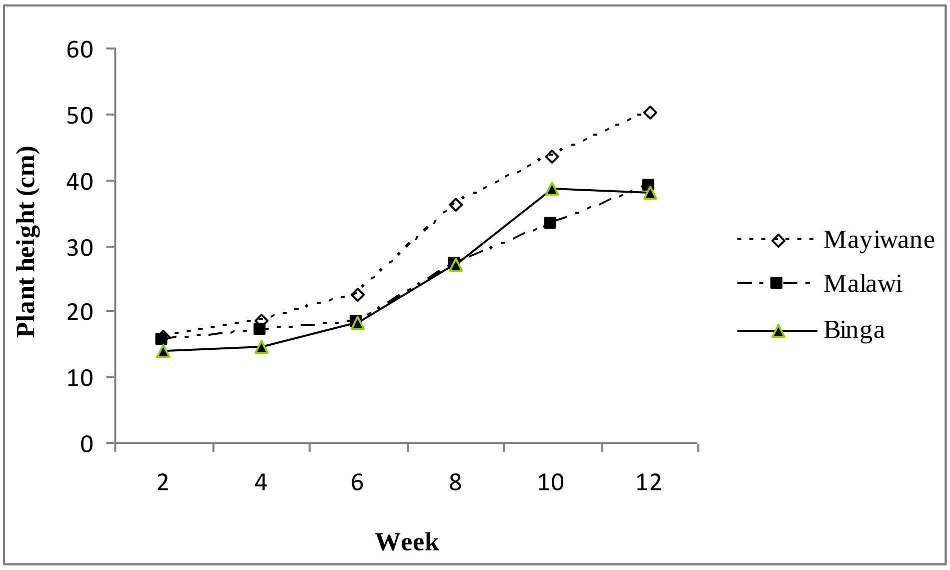

Figure 1: Plant height of Moringa provenances grown at Luyengo.

At 6 weeks of growth, the Mayiwane provenance had a greater (P < 0.05) seedling height than that of both Malawi and Binga provenances which themselves were not significantly different (P > 0.05). The provenances showed the same trend as at week 6 during week 8 of growth with Mayiwane provenance having greater (P < 0.001) seedling height than the other provenances. During the tenth week of growth, the Mayiwane provenance seedlings had greater (P < 0.01) height (43.59 cm) than that of Malawi (32.95 cm) and Binga (38.75 cm). Mayiwane provenance at 12 weeks of growth maintained a greater (P < 0.05) seedling height compared to that of Malawi and Binga provenances which where similar (P > 0.05). The findings of this study are consistent with the results that were obtained by (Emongor, 2009; Amaglo *et al*., 2006) where the local provenance always had better performance compared to introduced provenances. Although Moringa is a fast growing tree it only reached 51.25 cm as the maximum mean height at 12 weeks of growth which is in contrast with findings of Emongor (2009), who reported that Moringa provenances reached a height of 80cm in a space of 8 weeks. The relatively wide plant spacing might have contributed to the slow stem extension resulting in reduced plant height of the Moringa trees. Amaglo *et al*. (2006) reported that increasing plant density accelerates the rate of plant growth hence plant height.

The root collar diameter of the provenances is presented in Figure 2. There were significant ($P < 0.001$) differences in root collar diameter among the three provenances. The mean root collar diameter for the Mayiwane provenance ranged from 0.332 cm at the end of week 2 to 0.602 cm at the end of week 12. The Malawi provenance had a mean root collar diameter of 0.307 cm at the end of week 2 and 0.501 cm at the end of week 12 while that of the Binga provenance ranged from 0.291 cm to 0.525 cm, at week 2 and 12, respectively. The root collar diameter of Mayiwane provenance was greater than that of Malawi and Binga provenances at all stages of growth. The Malawi and Binga provenances root collar diameters did not differ during the 12 week growth period. According to Amaglo *et al.* (2006) plant height is directly related to root collar diameter and this explains the observations made in this study with the Mayiwane provenance having the highest plant height and root collar diameter.

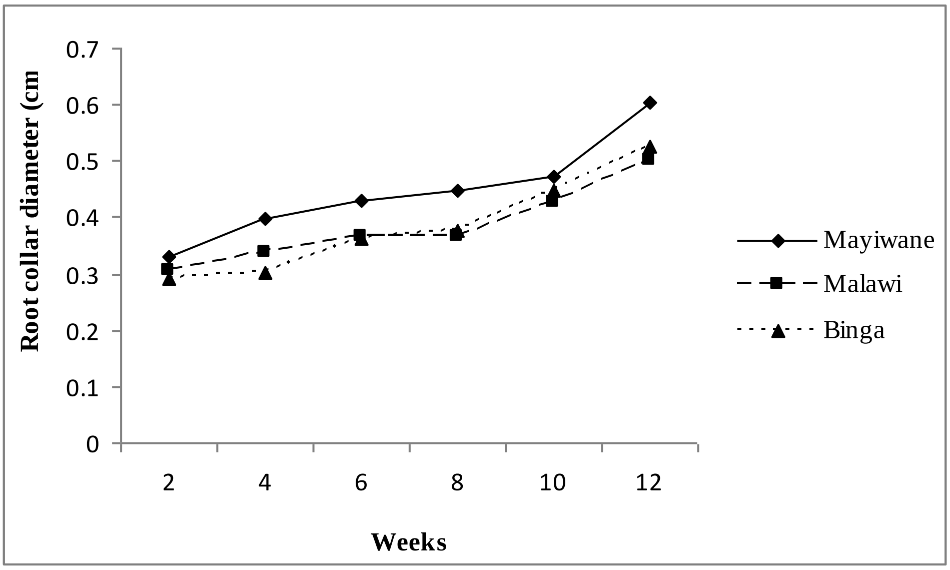

Figure 2: Root collar diameter of Moringa provenances grown at Luyengo.

The number of leaflets of the provenances is presented in Figure 3. There was a significant ($P < 0.05$) provenance and week interaction on the number of leaflets recorded per seedling plant. The mean number of leaflets for the three provenances were not significantly different ($P > 0.05$) at 2 weeks of growth. However, at week 4 the Mayiwane and Malawi provenances had similar ($P > 0.05$) number of leaflets. Similarly, Malawi and Binga provenances did not differ in their leaflet numbers at 4 weeks of growth, but the number of leaflets for Binga provenance was smaller ($P < 0.05$) than that of Mayiwane provenance. At 6 weeks of growth, Mayiwane and Binga provenances and Malawi and Binga provenances had similar ($P > 0.05$) leaflet number. However, the leaflet number of Mayiwane provenance was greater ($P < 0.01$) than that of Malawi provenance. Between week 4 and 6 all the provenances lost some leaflets due to red spider mite and cutworm attack. This is in agreement with Amaglo *et al.* (2006) who reported that pest and disease can also reduce the number of leaves per plant as they cause damage and destruction to plant growth. At week 8 Mayiwane provenance had a higher ($P < 0.05$) number of leaflets compared to Malawi and Binga provenances that did not differ ($P > 0.05$) in their number of leaflets. At week 10 there was no significant difference (P > 0.05) in their number of leaflets in all the three provenances of Moringa. Since Moringa is a deciduous tree, in week 10 all the three provenances were losing some of their leaves. Despite the plant losing their leaves, the root collar diameter and plant height were continuously increasing. This is in agreement with Anele *et al.* (2007), who reported that Moringa is a deciduous tree and can lose their leaves without affecting subsequent plant growth. At week 12, Malawi and Binga provenances were not significantly different (P > 0.05) and they both had fewer (P < 0.05) leaflet number compared to Mayiwane.

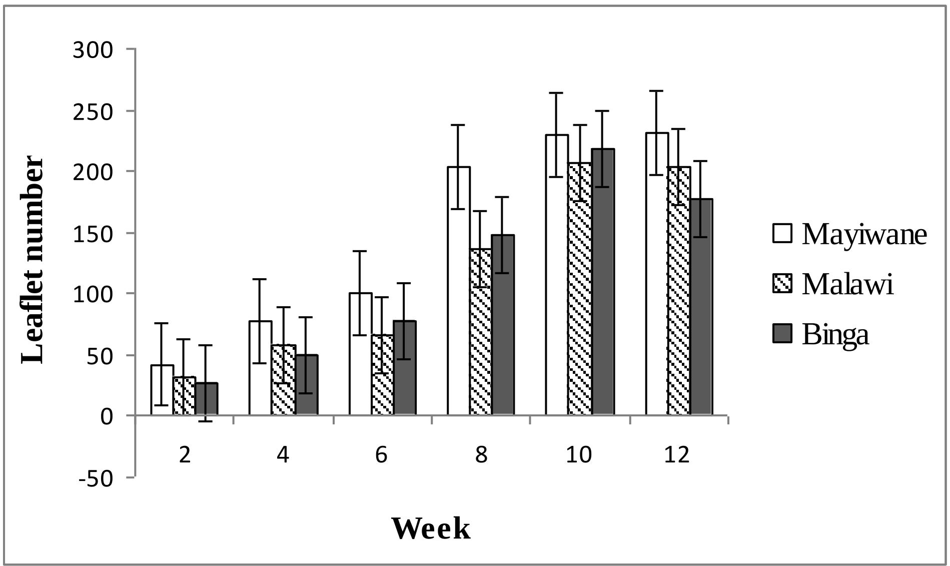

Figure 3: Leaflets of Moringa plant provenances grown at Luyengo.

Chemical composition

The chemical composition of the forage from the three provenances is presented in Table 1. The dry matter (DM) contents of the Mayiwane and Binga provenances were not significantly (P > 0.05) different but Mayiwane provenance and Malawi provenance were significantly (P < 0.05) different, while Binga provenance and Malawi provenance did not differ (P > 0.05). The dry matter (DM) content of the three provenances were within the range of 185.4 to 228.3 g/kg reported in literature (Sanchez *et al*., 2006; Anele *et al*., 2008). However, the findings of this study are in contrast with findings of Emongor (2009), who reported that there were no significant difference in the dry matter content of different Moringa provenances that were grown under the same conditions. According to Sauveur and Broin (2010), DM of different Moringa plants varied and they depended upon the time of harvesting, stage of growth and conditions on which the plant was cultivated.

Table 1. Nutrient composition (g/kg DM) of Moringa provenances (DM% basis).

Provenance	DM	OM	CP	CF	Ash
Mayiwane	212.2^{a}	918.4^{a}	223.5^{a}	147.5^{a}	81.7^{a}
Malawi	196.5^{b}	893.2^{a}	221.8^{a}	168.6^{a}	108.5^{a}
Binga	207.2^{ab}	936.9^{a}	229.0^{a}	143.9^{a}	63.2^{a}

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

The organic matter (OM) content ranged from 893.2 to 936.9 g/kg DM and was not significantly (P > 0.05) different among the three provenances. The crude protein (CP) content of the three provenances did not differ (P > 0.05) and ranged from 221.8 to 229.0 g/kgDM and falls within the range reported in earlier studies (Sanchez *et al*., 2006; Gadzirayi *et al*., 2012) for Moringa forage. The CF content ranged from 14.39 ± 0.39% to 16.86 ± 2.86%. Among the provenances Malawi had a higher CF content followed by Mayiwane then Binga. The ash content ranged from 63.2 to 108.5 g/kg DM with Malawi having a highest value followed by Mayiwane provenance and then Binga provenance. The ash content of the three provenances where not significantly (P > 0.05) and were within the range of findings of Sauveur and Broin (2010) who reported an ash content ranging from 80 to 110 g/kg DM in Moringa forage. The crude fibre of Moringa was low for all the provenances of Moringa and it imply that Moringa forage is easily digested by the animals (McDonald *et al*., 2002).

CONCLUSION

The results of the study showed that Moringa has the potential to be grown as a livestock feed resource in Swaziland. The protein content of Moringa indicated its suitability as a potential protein supplement in livestock diets especially during the dry season when protein is a limiting nutrient in livestock diets. The Mayiwane provenance can be utilised for its fast growth rate and its adaptability to the country for large scale forage production. However, agronomic evaluation of a wider range of Moringa provenances is required in order to determine their suitability in different agro-ecological zones of the country.

ACKNOWLEDGEMENTS

The authors are grateful to the University of Swaziland for funding this research project. We also acknowledge the support and cooperation of World Agroforestry Centre and the Mayiwane Community, Swaziland, in providing the Moringa seeds.

LITERATURE CITED

Amaglo, N.K., Timpo, G.M., Ellis W.O. and Bennett, R.N. (2006). Effect of spacing and harvest frequency on the growth and leaf yield of Moringa (*Moringa oleifera* Lam), a leafy vegetable crop. *Ghana Journal of Agriculture* 33:78-83.

Anele, U.Y., Arigbede, O.M., Olanite, J.A., Adekunle, I.O., Jolaosho, A.O., Onifade, O.S. and Oni, A.O. (2008). Early growth and seasonal chemical composition of three indigenous multipurpose tree species (MPTS) in Abeokuta, Nigeria. *Agroforestry Systems 73:89–98*.

AOAC (1990). Official Methods of Analysis. 16th Edition. Association of Official Analytical Chemists (AOAC), Washington, DC.

Aregheore, E.M. (2002). Intake and digestibility of *Moringa oleifera*-batiki grass mixtures for growing goats. *Small Ruminant Research 46: 23–28.*

Dlamini, N. G. (2010). Effect of kraal manure on dry matter yield and nutritive value of napier grass grown at Luyengo. B. Sc. Research Project Report, Faculty of Agriculture, Luyengo, Swaziland.

Duke, J.A. (1983). Handbook of energy crops (*Moringa oleifera*). Center for new crops and plant products. Purdue University, Indiana, US. http://www.hort.purdue. edu/newcrop/ duke_energy/Moringa_oleifera.html. 14/06/12.

Emongor, V.E. (2009). Growth of moringa *(Moringa oleifera Lam)* seedling provenances under Botswana conditions. *Botswana of Agricultural and Applied Science* 5 (2): 56-63.

Foidl, N., Makkar, S. and Becker, K. (2001). The potential of *Moringa oleifera* for agricultural and industrial uses. In Proceedings of International Workshop on what development potential for Moringa products, Tanzania, October 29th to November 2nd 2001. http://www.moringanews.org/actes/foild_en.doc.14/06/12.

Joubert, R. (2010). A tree for all seasons. *Farmer's weekly.* April 16, 2010. Kwazulu-Natal, South Africa. p.72-74.

Kelly, S.A. (2009). *Moringa oleifera* a multipurpose tree: Amandla resources. Unpublished Ph.D. Dissertation, University of KwaZulu-Natal, South Africa.

MacDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A. (2002). Animal Nutrition.6th Edition. Pearson. Prentice Hall, London.

Makkar, H.P.S. and Becker, K. (1997). Nutrients and antiquality factors in different morphological parts of the *Moringa oleifera* tree. *Journal of Agriculture Science 128: 311–332.*

Manh, L.H., Xuan Dung, N.N. and Phung Ngoi, T. (2005). Introduction and evaluation of *Moringa oleifera* for biomass production and as a feed for goats in the Mekong Delta. *Livestock Research for Rural Development* 23: 83-85.

Onwuka, J. (2011). Pilot project to test all-purpose tree in Swaziland. *Times of Swaziland.* July 20, 2011. Mbabane, Swaziland. p.12.

Radovich, T. (2009). Farm and forestry production and marketing profile for moringa (*Moringa oleifera*). http://www.agroforesty.net/scps.13/10/11.

Sanchez, N.D. (2006). *Moringa oleifera* and *Cratylia argentea*: Potential Fodder Species for Ruminants in Nicaragua. Unpublished Ph.D. Dissertation, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Sanchez, N. R., Ledin, S. and Ledin, I. (2006). Biomass production and chemical composition of Moringa oleifera under different management regimes in Nicaragua. *Agroforestry Systems (2006) 66: 231–242*

Sauveur, A.S. and Broin, M. (2010). Growing and processing moringa leaves. http://www.moringaweb.EN.pdf 14/10/11.

SPSS (Social Statistical Package for Social Sciences), 2006. SPSS Inc. SPSS 15.0 Command Syntax Reference 2006, SPSS Inc., Chicago, USA.