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BIOMASS PRODUCTION OF MORINGA (*Moringa oleifera* L.) AT VARIOUS SOWING DEPTHS IN A COARSE TEXTURED SOIL

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ABSTRACT

Different parts of Moringa (*Moringa oleifera* L.) plant, especially leaves, pods and flowers, are usually processed for human and animal consumption as these parts have been reported to be rich in nutrient elements that are essential for human and animal health. Consequently, a 19-month field experiment was conducted to determine effect of seed sowing depth on biomass production by moringa plant at the Teaching and Research Farm of the University of Ibadan, Nigeria. Moringa seeds were sown at five sowing depths of 1.5, 3.0, 5.0, 7.0 and 9.0 cm. The results showed that sowing depth significantly ($P \leq 0.05$) affected emergence of seeds 14 days after sowing in the following order: 1.5 > 3.0 > 5.0 > 7.0 > 9.0 cm sowing depths. Also, number of branches, height, canopy cover and dry biomass of the resulting seedlings were significantly influenced by seed sowing depths. Number of branches, heights and dry biomass of seedlings from seeds sown at 1.5 and 3.0 cm depths were at par but were significantly superior to those seedlings from seeds sown at 5.0, 7.0 and 9.0 cm depths. However, canopy cover was not in a definite order. Data obtained in this study seemed to indicate that sowing moringa seeds beyond 3.0 cm depth in the field may not be beneficial to moringa plant for organic biomass production.

Keywords: *Moringa, sowing depth, seed emergence, organic biomass.*

INTRODUCTION

Moringa oleifera L. is one of the most widely cultivated tropical tree species of the monogeneric family Moringaceae (Order Brassicales) which consists of 13 species distributed in sub-Himalayan ranges of India, Sri Lanka, Africa, Madagascar and Arabia (Fahey, 2005), Central America and the Caribbean (Foidl et al., 1999). *Moringa oleifera* tree is a fast growing and drought resistant plant with a tuberous taproot. In the wild, moringa plant ranges in height from 5 to 12 m with a straight trunk (10 - 30 cm thick) with corky whitish bark and umbrella shaped canopy (Fuglie, 2005). It is a perennial tree well known for its multi-purpose attributes, wide adaptability and ease of establishment. Nutritionally, its leaves, pods and flowers which are rich in nutrients, minerals and vitamins are commonly consumed by both humans and animals (Fuglie, 2000). Moringa plant tolerates a wide range of soil type and responds well to mulch, water and fertilizer application (Manh et al., 2005). It thrives in a well-drained sandy or loamy soil with a slightly acid pH of 6.2 to neutral 7.0 (Aregheore, 2005).

Moringa could either be propagated by stem cuttings or seedlings obtained by sowing dry matured seeds (Fuglie, 2000). Seed germination takes up to two weeks. However, sowing depth of Moringa seeds has been reported to affect the emergence of the seeds, and proper anchorage, growth performance, time of flowering, fruiting and harvesting of the resulting plants (Ugese et al., 2010; Karayel et al., 2008; Allah et al., 2012).

Therefore, for optimum crop performance, Moringa seeds must be sown at the appropriate depth (Aikins et al., 2011) where the emerging seedlings could easily access moisture, oxygen and nutrients. The objective of this field study is to determine appropriate seed sowing depth for optimum shoot biomass yield in moringa plant grown on a coarse textured soil.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm of the University of Ibadan, (Latitude 07° 27′ N Longitude 03° 53′ E), Nigeria. The experimental field was cleared mechanically by slashing followed by ploughing and harrowing. The size of the main plot (field) was 36 m x 22 m (792 m^2) that was further sub-plotted, each measuring 6m x 6 m (36 m^2), with a space of 1 m in between each subplot. The experiment was completely randomized with three replications for sowing depths of 1.5, 3.0, 5.0, 7.0 and 9.0 cm. Two seeds were sown per hole with the aid of a calibrated stick at a spacing of 1 x 1 m. The soil was minimally tilled to allow accurate seed placement at the depths calibrated on the stick. After two weeks of complete germination, moringa seedlings were thinned down to one stand per plot.

Soil samples were collected at 0 – 30 cm depth prior to clearing of the site, air-dried, sieved through 2-mm and 0.5-mm sieves for physical and chemical properties respectively. Soil texture was determined using Bouyoucous hydrometer method (Gee and Or, 2002) while bulk density was determined by the core method (Grossman and Reinsch, 2002). Saturated hydraulic conductivity was determined using the Constant Head Permeameter as described by Darcy (1984). Soil pH was determined with the pH meter using a soil/water ratio of 1:1. Organic carbon, total N, available P and exchangeable Na, Mg, K and Ca were determined using routine methods (IITA, 1982) while Fe, Mn, Cu and Zn were determined using Atomic Absorption Spectrophotometer. The selected physico-chemical properties of the experimental soil are presented in Table 1. Data on emergence of Moringa seeds and seedling parameters such as number of branches, stem girth, plant height, and canopy cover were measured from one month after sowing (MAS) to nine MAS. Above-ground total biomass was determined at nineteen MAS by cutting the entire

Moringa tree at 1.5 meter above soil level. The cut portion, which was regarded as the dry matter yield, was then chopped into small bits, packed in a sack and weighed to obtain the fresh weight. The dry weight was determined by drying the chopped bits in the oven for 24 hours at 65 ^{0}C.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA), means were tested and separated by Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984) using PROC. GLM and CONTRAST procedure.

RESULTS AND DISCUSSION

Sowing depth effect on seed emergence

Seeds sown at 1.5 cm depth showed significantly highest mean percent emergence while lowest seeds percent emergence at 5 DAS was noticed at 7.0 cm and 9.0 cm depths (Figure 1). The reason behind this trend could be attributed to the longer distance that needed to be covered by emerging plumule from 7.0 and 9.0 cm before it can appear at the soil surface (Karayel and Ozmerzi, 2008), implying that the deeper the sowing depth, the higher the number of days required to emerge at the surface of the soil. Percent emergence at 7 DAS was in order of 1.5 cm › 5.0 cm › 7.0 cm › 9.0 cm sowing depths. The same trend was maintained at the 10 DAS. Between 5 and 7 DAS, seeds sown at 1.5, 3.0, 5.0, 7.0 and 9.0 cm depths had total percent emergence of 93, 82, 70, 78, and 59%, respectively. This infers that moringa seeds can be sown in the field at depths not more than 5.0 cm if quick emergence of plants between 5 to 7 days is required. In adverse climate conditions such as drought period, moringa seeds can however be sown up to 9.0 cm depth where moisture level is reportedly higher than what is found in the top soil.

Table 1. Analysis of physico-chemical properties of the soil (0 - 30 cm) at the experimental site prior to sowing

Property	Value
pH (H_2O)	6.3
Total Nitrogen (g kg^{-1})	1.38
Organic Carbon (g kg^{-1})	13.3
Available Phosphorus (mg kg^{-1})	10.03
Exchangeable acidity	0.30
Exchangeable Bases (cmol kg^{-1})	
K	0.16
Ca	4.89
Na	0.61

Micro nutrients (mg kg^{-1})	
Cu	3.86
Zn	1.03
Particle Size Distribution (g kg^{-1})	
Fine sand	110.0
Coarse sand	642.0
Silt	80.0
Clay	168.0
Textural Class	Sandy Loam

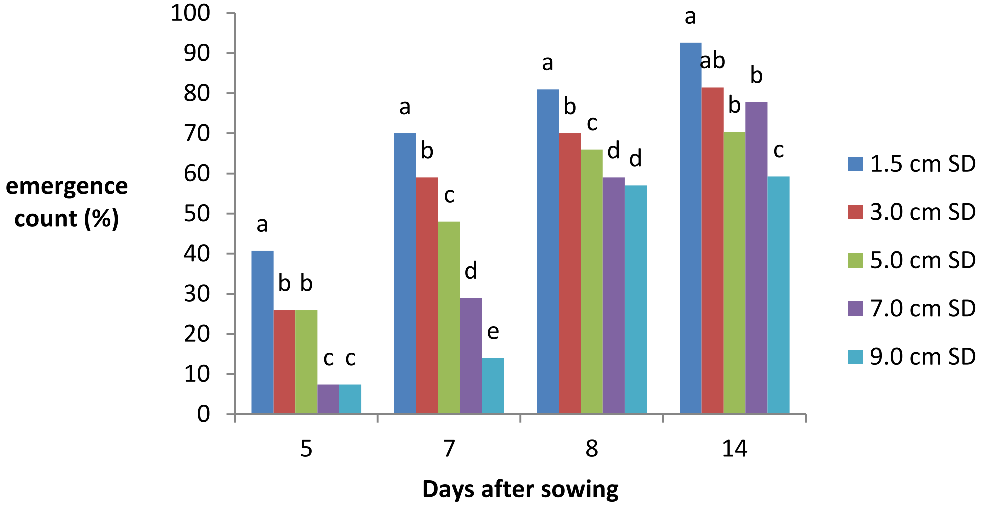

Figure 1. Effect of seed sowing depth on the percent emergence of moringa seeds on the field

Al- Kaisi (2000) reported that deeper sowing depth is preferable in a dry condition to ensure good moisture availability for successful seed germination. At 14 DAS, percent emergence values for seeds sown at 1.5 cm and 3.0 cm depths were significantly higher than seeds sown at other three depths of 5.0, 7.0 and 9.0 cm depths. Liu *et al.* (2007) working in a dry condition discovered that deep sowing might be necessary for crop emergence. This was attributed to the gradual depletion of moisture at the soil surface as the dry season persists. Therefore, sowing depths of 7.0 cm and 9.0 cm might be preferable in dry season while sowing at 3.0 cm is suggested for stand establishment of moringa in wet season.

Effects of sowing depths on plant growth and biomass yield

Sowing depths effect the number of moringa leaves from 2 to 10 WAS (Figure 2). At 2 WAS, seeds sown at 1.5 cm depth showed significant ($p<0.05$) number of moringa leaves produced compared to other sowing depths. Seeds sown at 3.0, 5.0 and 7.0 cm depths were not significantly different ($p<0.05$) for number of leaves produced but significantly different from seeds sown at 9.0 cm depth at 2 WAS. This can directly imply that the deeper the sowing depth, the more the distance needed to be covered by emerging plumule. Therefore, plants that emerge earlier are likely to produce more leaves for photosynthesis. However, sowing depth has no effect on moringa number of leaves from 4 WAS onward.

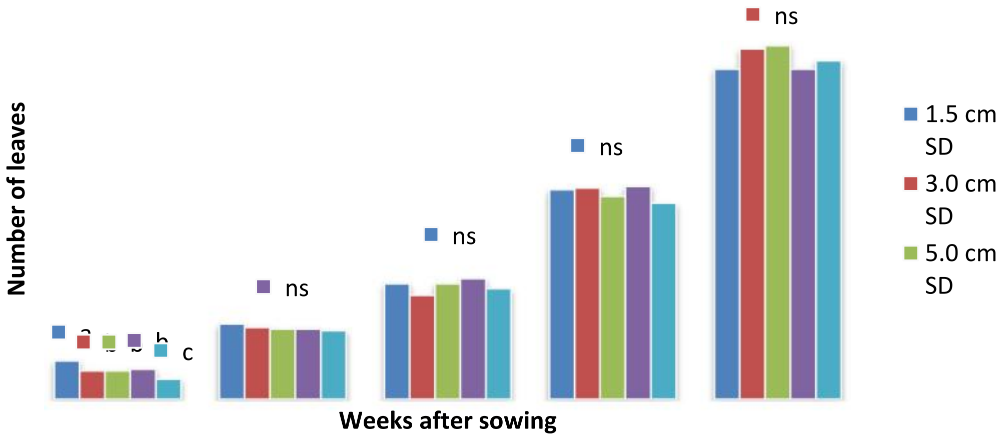

Figure 2. The effect of seed sowing depth on the number of leaves produced by resulting moringa plant

Moringa plant height revealed gradual increase for a period of nine months (Table 2). Between one and two MAS, seeds sown at 1.5 cm and 3.0 cm depth produced taller plants compared to other sowing depths, which implies a faster establishment due to early emergence of moringa seedlings from 1.5 and 3.0 cm sowing depths. Though, there was no significant difference in plant heights among all sowing depths between three and four MAS, seeds sown at 1.5 cm and 3.0 cm depths produced significantly higher plant height than other sowing depths from five to nine MAS.

Table 2. The effect of seed sowing depth on the height (cm) of moringa plant

Seed Sowing depth(cm)	**Months after sowing (MAS)**								
	1	2	3	4	5	6	7	8	9
1.5	6.4	26.8	64.4	98.2	124.0	150.3	205.6	258.7	303.3
3.0	8.1	29.6	68.4	95.8	120.2	147.2	202.8	258.5	303.6
5.0	7.4	31.1	71.5	90.3	104.2	121.3	160.8	201.5	250.3
7.0	5.1	23.9	57.5	80.2	93.5	113.9	163.1	209.3	247.1
9.0	6.2	27.0	64.3	84.9	103.3	130.0	176.0	220.7	263.5
$LSD_{(0.05)}$	2.9*	5.1*	14.3^{ns}	19.4^{ns}	23.0*	27.6*	29.6*	28.3*	44.4*

*= Significantly different at p≤ 0.05; ns = not statistically significant at p≤ 0.05.

However, there was no significant difference in the plant heights obtained from seeds sown at 1.5 and 3.0 cm throughout the study period. This indicates that moringa seeds could be sown at 3.0 cm for proper establishment, stability and anchorage. Seedlings obtained from seeds sown at 1.5 cm and 3.0 cm depths attained higher mean stem circumference values than others sowing depths at one MAS (Figure 3), indicating that nutrient concentration decreases with increase in soil depth. Surface soil had higher nutrient concentrations (C, N, K, P and Mg) than subsoil (Oshunsanya, 2014). However, no significant difference in stem circumference of moringa plants was noticed from two to nine MAS.

The moringa plants branched irrespective of the sowing depth for the first five MAS, after which there was significant difference among the sowing depths from six to nine MAS. Emerging plants from seeds sown at 1.5 cm and 7.0 cm depths branched more than plants emerged from 3.0, 5.0, and 9.0 cm at seven MAS. The same trend was maintained throughout the study period (Figure 4).

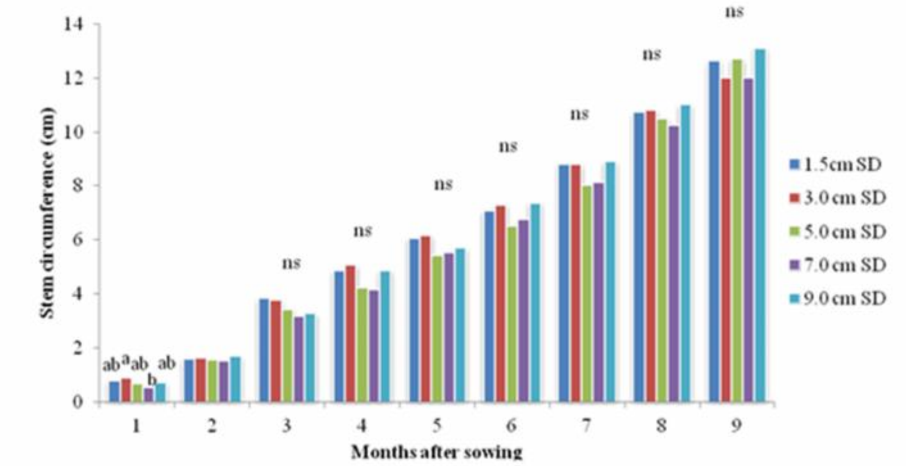

Figure 3. Effect of sowing depth on the stem circumference of Moringa oleifera on the field

*Where: SD = Sowing depth; ns = not significant at p ≤ 0.05

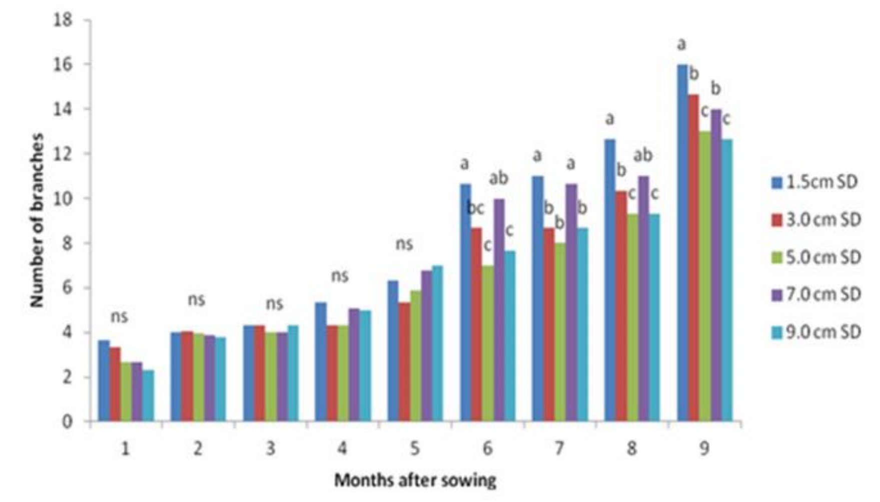

Figure 4. The effect of seed sowing depth on number of branches produced by resulting moringa plant

Moringa plants canopy covers produced from seeds sown at various depths showed significant differences (p≤0.05). However, canopy covers showed no specific trend with respect to sowing depths (Table 3). It is worthwhile that fresh biomass yield was significantly in the order of 1.5 > 3.0 = 5.0 > 7.0 = 9.0 cm sowing depth (Table 4). This trend is similar to the number of branches and plant height exhibition, reflecting the beneficial effect of early emergence exhibited by seeds sown at 1.5 cm and 3.0 cm depths rather than seeds sown at deeper depths. Early emergence could also bring early leaf and branch formation leading to higher biomass production. High fresh biomass of moringa (leaves and stem) could be used for human and animal nutrition (CTA, 2008).

Table 3. The effect of seed sowing depth on canopy cover (cm) of resulting moringa plant

Seed Sowing depth(cm)	**Months after sowing (MAS)**				
	9	10	11	12	13
1.5	351.8	364.9	390.3	446.8	492.0
3.0	310.0	319.9	342.0	390.0	434.8
5.0	326.2	336.7	386.2	441.6	521.1
7.0	322.0	364.6	391.4	468.4	515.4
9.0	346.7	356.3	380.6	437.5	478.3
$LSD_{(0.05)}$	30.0*	30.0*	31.4*	35.8*	39.6*

*= Significantly different at p≤ 0.05; ns = not statistically significant at p≤ 0.05.

Table 4. Effect of seed sowing depth on dry biomass yield (t ha^{-1}) of 19-month old moringa plant

Sowing Depth (cm)	**t ha^{-1}** Dry biomass yield
1.5	7.1
3.0	6.4
5.0	5.4
7.0	5.1
9.0	4.9
$LSD_{(0.05)}$	0.8*

*= Significantly different at p≤ 0.05; ns = not statistically significant at p≤ 0.05.

Moringa seeds sown at different depths showed that seeds sown at 1.5, 3.0, 5.0, 7.0 and 9.0 cm produced 7.12, 6.4, 5.41, 5.07 and 4.90 t ha^{-1} dry biomass yields respectively. It is important to note that dry biomass yields from seeds sown at 1.5 and 3.0 cm depth were not significantly (p≤0.05) different but significantly higher than that of 5.0, 7.0 and 9.0 cm depths. This implies that higher dry biomass content can be obtained from seeds sown between 1.5 and 3.0 cm depths in a coarse textured soil.

CONCLUSION

Sowing depth significantly influenced the field establishment of *Moringa oleifera*. Moringa plant height, number of branches and leaves, fresh and dry biomass yields were highly obtained from seeds sown at 3.0 cm soil depth than 5.0 and 9 .0 cm sowing depths. Therefore, sowing moringa seeds beyond 3.0 cm may not be advisable for quick field establishment and high dry biomass production in a coarse texture soil.

REFERENCES

Aikins, S. H., Afuakwa, J. J., Nkansah, E. O. 2011. Effect of sowing depth on soyabean growth and dry matter yield. *Journal of Agriculture and Biological Science*.3 (6):50 - 53.

Allah, B. G., Altaf, A. D. 2012. Role of soil texture and depths on the emergence of buried weed seeds. *Asian Journal of Agricultural and Biological Science*.7 (4): 223 - 227.

Al-Kaisi, M. 2000. Adjusting planting depth and soil depth for germination of crop production. *Journal of Integrated Crop Management*. 67(8):484

Aregheore, E. M. 2002. Intake and digestibility of *moringa oleifera*-batiki grass mixtures by growing goats. *Small Ruminant Research* 46:11 - 28.

Bhatia, R. K., Chawan D. D., 1983. Effect of sowing depths on the growth performance in Senna.Indian forester. 109:212 - 215.

Chandrasekaran,B., Annadurai, K. and Somasundaram, E. 2010. A textbook of Agronomy P. 13 - 67

Deslauriers, A., Morin, H., Urbinati, C. and Carter M. 2003. Daily weather response of balsam fir (*Abies balsamea* (L.) Mill.) stem radius increment from dendrometer analysis in the boreal forests of Quebec (Canada), tree- structure and function 17 (6): 477- 484.

Fahey, J. W. 2005. A review of the medical evidence of *moringa oleifera* for its nutritional, therapeutic and prophylactic properties.part 1. *Trees Life Journal* 1:5 - 15

Foidl, N., Makkar, H. P. and Becker, K. 2001. The potential of *moringa oleifera* for agricultural and industrial use. p23 - 60

Foidl, N., and Paul, R. 2008. *Moringa oleifera*: the encyclopedia of fruit and nuts. P 50-51

Fuglie, L. J. 2005. The moringa tree: A local solution to malnutrition. P 12-15

Gee, G. W., Or, D., 2002. Particle Size Analysis. In: Dane, J.H., Topp, G.C., (Eds.) Methods of soil analysis. Part 4, Physical Methods, SSSA, Incorporated, Madison, pp. 255 – 294.

Gomez, K. A., and A. A. Gomez, (1984). Statistical procedures for agricultural research. Eds. K. A. Gomez. 464pp.

Grossman, R. B. and Reinsch, T. G. 2002. Bulk density and linear extensibility: Core method. In: J. H. Dane and G. C. Topp (eds.) Methods of soil analysis. Part 4, Physical Methods, SSSA, Incorporated, Madison, 208 – 228.

Hillel, D. 2004. Introduction to soil physics Academic Press Inc, New York, USA. 465pp.

Karayel, D. and Ozmerzi, A. 2008. Evaluation of three depth control components on seed placement Accuracy and Emergence for a precison planter, *Applied Engineering in Agriculture*. 24(3):41- 67

Liu, Z. Yan, Q,Li, X. Ma, J. and Ling, X.(2007). Seed mass and shape, germination and plant abundance in a decertified grassland in northeastern Inner Mongolia. *China Journal of Arid Environments*. 69 (2):198 - 211.

Liu, H. M., Nguyen, N., Xuan, D. and Tran-Phung, N. 2005. Introduction and evaluation of *moringa oleifera* for biomass production and as feed for goats in the Mekong Delta. P 10 - 65

Mahdi, L., Bell, C.J. and Ryan, J. 1998. Establishment and yield of wheat (*Triticum turgidum* L.) after early sowing at various depths in a semi-arid Mediterranean environment, *Field Crops Research*, 58: 187- 196.

Moringa Association of Ghana, 2010. Growing and processing of moringa leaves, p 15- 23 NRCS, 2011. Soil quality for environmental health, p 1

Oshunsanya, S.O. 2011. Soil Physics. First Edition. Debank Publishers, Ibadan, Nigeria 166p.

Oshunsanya, S. O., Fagbenro, J. A., Oyewo, T. O. 2014. Growth performance and mineral composition of *Moringa oleifera* seedlings as affected by soil depth under water stress conditions. *Elixir Agriculture* 70: 23994 – 24000.

Palada, M.C., Chang, L. C. 2003. Suggested cultural practices for moringa. International cooperatives guide. Asian Vegetable Research and Development. (Ed.) by Iowa State University press, (USA) 59pp.

Ramachandran, C, Peter, K. V., Gopalakrishnan, P. K. 1980. Drumstick (*moringa oleifera*): a Multi-purpose Indian vegetable. Bot. 34, 276 - 283.

Smith, K. A., Mullins, C.E. 1991. Soil Analysis: Physical Methods. Marcel Dekker, New York, 620 pp

Tripathi, J.P., Bajpai, S.P. 1985. Effect of depth of sowing on germination of kardan (*Anogeis suspendula*) seeds. Indian Forester 111: 167 - 169.

Ugese, F. D., Baiyeri, K. P., Mbah, B. N. 2010. Effect of sowing depth and mulch application on emergence and growth of shear butter tree seedlings (*Vitellaria paradoxa* C. F. Gaertn.). *African Journal of Biotechnology* 9 (10): 1443 - 1449.