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BIOMASS ACCUMULATED BY *Mansonia altissima* A CHEV. SEEDLINGS UNDER THE EFFECT OFARBUSCULAR MYCORRHIZA, FERTILIZER APPLICATION AND MOISTURE SUPPLY

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ABSTRACT

Mansonia altissima is an indigenous hard wood species, which of great use both locally and internationally, this has led to much pressure being put on them, which in turn caused over-exploitation. This study investigated the effect of mycorrhiza, fertilizer and moisture supply on the biomass accumulation of M. altissima seedlings. Seedlings were monitored under these three factors at 3 levels each mycorrhiza (0g, 10g and 20g), fertilizer (0g, 1g and 2g) and water supply ((once in a week, twice in a week and everyday, 1/7, 4/7, and 7/7 respectively). The study was conducted in 3x3x3 factorial experiment in completely Randomized Design (CRD) and subjected to ANOVA. The study revealed that mycorrhiza does not have significant effect on the dry matter of M. altissima seedlings while fertilizer and watering regime had significant effect at (p>0.05) on leaf dry weight, (LDW), stem dry weight (SDW), root dry weight (RDW) and total dry weight (TDW). It was observed that seedlings LDW ranged from 1.22g to 2.42g, SDW ranged 0.39g to 0.81g, RDW ranged from 0.23 to 0.49 and TDW ranged from 11.83g to 3.67g respectively after 24 weeks. The biomass accumulated by M. altissima under the interaction of three factors revealed that M2F2W3seedligs treated with 10g mycorrhiza, 1g of N P K fertilizer and watering everyday was higher compared to other interactions, this implies that M. altissima preferred little fertilizer application and watering everyday for optimum biomass production

Key Words: Indigenous, biomass accumulation, mycorrhiza, fertilizer, and *Mansonia altissima*

INTRODUCTION

With the advent of plantation forestry and its expansion to soil of relatively low fertility, increasing attention is being paid to the nutrition of forest trees and correction of nutritional disorders through fertilizer application. The success and value of forest fertilization, however, depends on accurate diagnosis of soil nutrient deficiencies.

FAO (2003) showed that the indigenous timber tree species are fast disappearing from Nigeria forest due to over exploitation without replenishment. In recent times, mature fruiting trees of indigenous hard wood species are hard to come by limiting seed supply to foresters. *Mansonia altissima is* among the most highly priced timber species in the local and international markets (FAO, 2005). Nigeria earned millions of naira worth of foreign exchange from sales of this hard wood species between 40's and 70's (FA0, 2005).

The significant contribution of Mycorrhiza to plant is the symbiosis relationships, which are characterized by bi-directional movement of nutrients where carbon flows to the fungus and in-organic nutrients move to the plant, thereby providing a critical linkage between the plant root and soil (Garbaye, 1994). In infertile soils, nutrients taken up from the mycorrhiza fungi can lead to improved plant growth and reproduction, as a result, mycorrhiza plants are often more competitive and better able to tolerate environmental stresses than non- mycorrhiza plants.

Arbuscular mycorrhiza fungi belong to the order Glomales and form highly branched structures called arbuscules, within root cortical cells of many herbaceous and woody plant species. Arbuscular mycorrhiza fungi (AMF) can be found in almost all habitats and climates (Barea *et al.*, 1997) and at different depths of soil (Michelsen and Rosendahl, 1990).Although the occurrence and efficiency of AMF have been widely examined in most valuable undomesticated fruit trees (Mathur and Vyas, 2000), little is known of the mycorrhiza status and responsiveness of inherently slow growing indigenous timber tree species such as *Mansonia altissima*

Hence, this study is necessary to understand the role of arbuscular mycorrhiza inoculation, fertilizer application and watering regime on biomass accumulation of *Mansonia altissima* seedlings in the tropical environment.

MATERIALS AND METHOD

Seed procurement

Mansonia altissima seeds were collected from seed store in Forestry Research Institute of Nigeria, headquarters Ibadan.

Experimental site

The study was carried out in the West African Hardwood Improvement Project (WAHIP) nursery, Forestry Research Institute of Nigeria Headquarters, Ibadan. The area lies between latitude 7^0N and 7.2^0N and longitude 26 ^{o}E and 27^oE. The climate is mainly tropical with rainfall patterns ranging between 1000mm and 14500mm, the average temperature is about 30^0C while relative humidity is about 65%. There are two different climatic seasons which are the dry (November - March) and the rainy season (April - October).

Experimental design and treatment

Seeds of *Mansonia altissima* were sown directly into poly pots filled with top soil collected from Forestry Research Institute of Nigeria arboretum. The mycorrhiza used was supplied by Agronomy Department, University of Ibadan. The inoculations were carried out according to the method of Carling *et al*., 1978, Fagbola *et al*., 2005 and Kareem *et al* 2012., Also N:P:K fertilizer was added. Three (3) seeds each were sown directly into the polypots and were arranged in screen house of Forestry Research Institute of Nigeria. After germination, thinning was carried out to reduce the number of seedlings to one plant per poly pot. A 3 X 3 X 3factorial experiment was used for the study. The treatments were replicated five times. The factors were mycorrhiza, N:P:K fertilizer and water supply. While N:P:K fertilizer and water supply had three levels(N:P:K 0g, 1g, and 2g and the water supply was once in a week, twice in a week and every day(1/7, 4/7 and 7/7 respectively), mycorrhiza (*Glomus deserticola*) also had three levels (myco 0g,10g and 20g. The seedlings were watered regularly for six weeks to allow proper establishment before the drought stress treatment commenced.

M. altissima seedlings under each treatment were used to examine biomass accumulation. The experiment was monitored for a period of 24 weeks. For biomass estimation, mean height of the seedlings under each mycorrhiza, fertilizer and moisture supply was calculated and three seedlings with heights closest to the mean were selected for destructive sampling. The selected seedlings from each treatment were carefully uprooted by separating the seedlings from soil, washed and sectioned into root, stem and leaves. A sensitive weighing balance was used to obtain the initial (fresh) weight of leaves, stem and root

After taking the fresh weight, seedling components (leaves stem and root) were taken to the analytical laboratory of the Bio-science Department, FRIN and placed in the oven and dried at 70^oC for 24 hours until a constant weight was obtained. Since 100% of each component was taken as their biomass. Seedling total biomass was then obtained by summing the biomass of each of the various components.

Data collection and analysis

Leaf dry weight (LDW), stem dry weight (SDW), root dry weight (RDW), and total dry weight (TDW) were taken after 24 weeks. The data were then subjected to analysis of variance to compare the effects of mycorrhiza, fertilizer application and moisture supply on the biomass accumulated by *M. altissima* seedlings.

RESULTS

Effect of mycorrhiza on seedling biomass of *M.altissima*

Leaf dry weight

There was variation in the mean LDW which was between 1.76g and 2.00g. The highest mean value was observed in M2 while M3 had the least value. However, ANOVA revealed that there were no significant differences among the mycorrhiza level but there was significant difference in the interaction of mycorrhiza and watering regime.(Appendix 1)

Stem dry weight

Variations were observed in the stem dry weight of the seedlings subjected to different mycorrhiza level. M2 had the highest mean value of 0.60g while M1 had the least mean value 0.57 g. However, ANOVA reveals that there was no significant difference in stem dry weight with respect to mycorrhiza as a factor. (Appendix 2).

Root dry weight

Weight of non-inoculated, 10 g inoculated and 20g inoculated are not significantly different from one another. Although, M2 had the highest mean value of 0.37 g while M1 had the least with 0.32g. (Table 1).

Total dry weight

Variations were observed in TDW produced by the seedlings subjected to different mycorrhiza level. M2 had the highest mean value of 2.96g while both M1 and M3 had the same mean value 2.68g. (Table 1).

Table 1: Effect of Mycorrhiza on Dry Weight of *M. altissima* seedlings

Mycorrhiza	LDW(g)	SDW(g)	RDW(g)	TDW(g)
M1	$1.80{\pm}0.23^{b}$	$0.57{\pm}0.06^{b}$	$0.32{\pm}0.04^{b}$	$2.68{\pm}0.30^{b}$
M2	$2.00{\pm}0.18^{a}$	$0.60{\pm}0.04^{a}$	$0.37{\pm}0.06^{a}$	$2.96{\pm}0.36^{a}$
M3	$1.76{\pm}0.20^{b}$	$0.59{\pm}0.06^{b}$	$0.34{\pm}0.08^{b}$	$2.69{\pm}0.28^{b}$

Means with same superscript in each column are not significantly different from each other (p>0.05)

Effect of fertilizer on seedling biomass of *M.altissima*

Leaf dry weight

The highest mean value of leaf dry weight under fertilizer treatment was observed with seedlings treated to 1g of NPK(F2) while the least was observed under seedlings without fertilizer(F1) with value2.39g and 1.22g respectively (Table 2). Result shows that there was no significant difference in weight between F2 and F3 with 2.39g and 1.94g respectively.

Stem dry weight

Seedlings treated with 1g of NPK (F2) had the highest mean value of stem dry weight (0.81g) while seedlings without fertilizer (F1) had the lowest value of 0.39g (Table 3).ANOVA reveals that effect of fertilizer on seedling biomass had significant difference on fertilizer and on interaction between fertilizer and watering regime of stem dry weight at $P<0.05$ (Appendix 2).

Root dry weight

The mean seedlings RDW for fertilizer application ranged between 0.23g to 0.42g with the highest value recorded in seedlings treated to 1g of NPK (F2) and least in seedlings without fertilizer (F1), (Table 4) ANOVA shows that root dry weight of seedlings subjected to effect of fertilizer were significantly different at $P<0.05$ (Appendix3).

Total dry weight

Result showed variations in the mean total dry weight of the seedlings treated with NPK fertilizer. The highest mean total dry weight was observed in the seedlings treated with 1g of NPK fertilizer (F2) which had a mean total dry weight of 3.62g while seedlings without fertilizer(F1) had the least value of1.83g. (Table 5).There was significant effect of fertilizer, and interaction between fertilizer and watering regimes on total dry weight of seedlings as shown in (Appendix 4).

Table 2: Effect of Fertilizers on the Leaves Dry Weight of *M. altissima* seedlings

Fertilizer	Mean	P- value
F1	$1.22{\pm}0.18^{b}$	0.00*
F2	$2.39{\pm}0.24^{a}$	0.12ns
F3	$1.94{\pm}0.28^{a}$	0.12ns

*ns- not significant (p>0.05)*significant at (p≤0.05)*

Table 3: Effect of Fertilizers on the Shoot Dry Weight of *M. altissima* seedlings

Fertilizer	Mean	P- value
F1	0.39±0.06[c]	0.08ns
F2	0.81±0.09[a]	0.08ns
F3	0.55±0.05[b]	0.01*

*ns- not significant (p>0.05)*significant at (p≤0.05)*

Table 4: Effect of Fertilizers on the Root Dry Weight of *M. altissima* seedlings

Fertilizer	Mean	P-value
F1	0.23±0.06[b]	0.00*
F2	0.42±0.06[a]	0.56ns
F3	0.38±0.06[a]	0.56ns

*ns- not significant (p>0.05)*significant at (p≤0.05)*

Table 5: Effect of Fertilizers on the Total Dry Weight of *M. altissima* seedlings

Fertilizer	Mean	P - value
F1	1.83±0.38[b]	0.00*
F2	3.62±0.46[a]	0.08ns
F3	2.87±0.42[a]	0.08ns

*ns- not significant (p>0.05)*significant at (p≤0.05)*

Effect of watering regimes on seedling biomass of *M.altissima*

Leaf dry weight

Mean separation table showed that seedlings under W3 (which is daily watering)had the highest value with 2.42g while once in a week watering W1 had the least leaf dry weight with 1.49g.(Table 6). It also revealed that there was no significant difference between W1 and W2.ANOVA reveals that there were significant differences among the watering regime and the interaction between fertilizer and watering regimes.(Appendix 1).

Stem dry weight (SDW)

Result showed that W3 had the highest mean stem dry weight value of 0.76g while W2 had the least with 0.48g (Table 7). while W1 and W2 are not significant from each other. ANOVA reveals that watering regime had significant effect on stem dry weight at (P<0.05) (Appendix 2).

Root dry weight

RDW under watering regime reveals that seedlings treated to daily watering(W3) had the highest mean value while seedlings watered three times a week at pot capacity (W2) had the least value of 0.49gand 0.24g respectively (Table 8).ANOVA shows that root dry weight of seedlings subjected to effect of watering regime were significantly different at (P<0.05) .(Appendix 3)

Total dry weight

The least value of total dry weight among watering regimes was once a week watering (W1) with 2.29g while the highest was observed for everyday watering (W3) with 3.67g (Table 9). There was significant effect of watering regime and on total dry weight of seedlings (Appendix 4).

Table 6: Effect of Watering Regimes on the Leaves Dry Weight of *M. altissima* seedlings

Watering Regime	Mean	P - value
W1	1.49±0.24[b]	0.61ns
W2	1.64±0.22[b]	0.61ns
W3	2.42±0.28[a]	0.01*

*ns- not significant (p>0.05)*significant at (p<0.05)*

Table 7: Effect of Watering Regimes on the Shoot Dry Weight of *M. altissima* seedlings

Watering Regime	Mean	P - value
W1	0.50±0.07[b]	0.82ns
W2	0.48±0.06[b]	0.82ns
W3	0.76±0.09[a]	0.01*

*ns- not significant (p>0.05)*significant at (p≤0.05)*

Table 8: Effect of Watering Regimes on the Root Dry Weight of *M. altissima* seedlings

Watering Regimes	Mean	p - value
W1	0.29±0.08[b]	0.40ns
W2	0.24±0.06[b]	0.40ns
W3	0.49±0.16[a]	0.00*

*ns- not significant (p>0.05)*significant at (p≤0.05)*

Table 9: Effect of Watering Regimes on the Total Dry Weight of *M. altissima* seedlings

Watering Regime	Mean	P-value
W1	2.29±0.30[b]	0.87ns
W2	2.36±0.36[b]	0.87ns
W3	3.67±0.42[a]	0.00*

*ns- not significant (p>0.05)*significant at (p≤0.05*

Interaction Effect of Mycorrhiza, Fertilizer and Watering Regimes on Dry Weight of *M. altissima* seedlings

The interactive effect of mycorrhiza, fertilizer and watering regimes on dry weight revealed that seedlings treated with 10g of mycorrhiza, and watering everyday and 1g of N.P.K ($M_2F_2W_3$) had the highest mean LDW of 4.72g while the least was seedlings treated with 10g mycorrhiza, without fertilizer and thrice watering ($M_2F_1W_2$) had the least value of 0.59g. $M_2F_2W_3$ had the highest mean value for SDW with 1.67g, RDW with 0.88g and TDW of 7.27g respectively. (Table 10).

Table 10: Interactive Effect of Mycorrhiza, Fertilizer and Watering Regimes on Dry Weight of *M. altissima* seedlings

M*F*W	LDW(g)	SDW(g)	RDW(g)	TDW(g)
M1F1W1	1.83±0.60^{hi}	0.52±0.92^{f}	0.36±0.13^{de}	2.72±0.89^{f}
M1F1W2	2.05±0.58^{g}	0.52±0.87^{f}	0.25±0.11^{g}	2.82±0.86^{f}
M1F1W3	1.67±0.62^{i}	0.49±0.90^{fg}	0.28±0.12^{f}	2.44±0.80^{f}
M1F2W1	1.33±0.56^{k}	0.48±0.91^{fg}	0.33±0.11^{e}	2.14±0.78^{fg}
M1F2W2	1.97±0.54^{gh}	0.77±0.93^{d}	0.25±0.16^{g}	2.99±0.75^{f}
M1F2W3	3.01±0.62^{c}	0.94±0.93^{c}	0.40±0.14^{d}	4.35±0.86^{c}
M1F3W1	1.13±0.44^{k}	0.38±0.94^{h}	0.23±0.11^{g}	1.74±0.89^{h}
M1F3W2	1.34±0.52^{k}	0.40±0.92^{fg}	0.42±0.15^{d}	2.15±0.89^{fg}
M1F3W3	1.85±0.63^{hi}	0.63±0.88^{e}	0.32±0.13^{e}	2.80±0.85^{f}
M2F1W1	0.72±0.48^{lm}	0.29±0.91^{hi}	0.15±0.08^{i}	1.16±0.82^{j}
M2F1W2	0.59±0.64^{m}	0.22±0.93^{j}	0.13±0.09^{i}	0.93±0.85^{k}
M2F1W3	0.92±0.59^{l}	0.41±0.86^{fg}	0.22±0.11^{g}	1.55±0.82^{h}
M2F2W1	1.49±0.60^{ij}	0.46±0.78^{fg}	0.23±0.12^{g}	2.19±0.83^{fg}
M2F2W2	2.51±0.68^{e}	0.53±0.82^{f}	0.27±0.10^{f}	3.31±0.86^{de}
M2F2W3	4.72±0.74^{a}	1.67±0.94^{a}	0.88±0.12^{a}	7.27±0.82^{a}
M2F3W1	2.53±0.69^{d}	0.72±0.90^{d}	0.60±0.14^{b}	3.84±0.80^{d}
M2F3W2	1.99±0.62^{h}	0.54±0.91^{f}	0.28±0.15^{f}	2.81±0.78^{f}
M2F3W3	2.50±0.65^{e}	0.52±0.89^{f}	0.56±0.10^{c}	3.58±0.89^{de}
M3F1W1	0.95±0.56^{l}	0.30±0.79^{i}	0.21±0.16^{g}	1.46±0.82^{hi}
M3F1W2	0.93±0.57^{l}	0.36±0.88^{h}	0.18±0.11^{g}	1.47±0.85^{hi}
M3F1W3	1.31±0.46^{k}	0.38±0.86^{h}	0.28±0.13^{f}	1.97±0.86^{h}
M3F2W1	1.86±0.55^{hi}	0.90±0.95^{c}	0.29±0.13^{f}	3.05±0.82^{e}
M3F2W2	1.13±0.70^{k}	0.35±0.94^{h}	0.20±0.12^{h}	1.68±0.89^{gh}
M3F2W3	3.53±0.63^{b}	1.19±0.98^{b}	0.88±0.21^{a}	5.60±0.84^{b}
M3F3W1	1.59±0.61^{ij}	0.47±0.90^{fg}	0.25±0.09^{g}	2.32±0.87^{g}
M3F3W2	2.26±0.57^{f}	0.64±0.93^{e}	0.20±0.10^{h}	3.10±0.86^{e}
M3F3W3	2.29±0.66^{f}	0.61±0.91^{e}	0.56±0.11^{c}	3.46±0.89^{de}

Means with same superscript in each column are not significantly different from each other (p>0.05)along with the results but should follow the results immediately.

DISCUSSION

In this study, inoculation of *M. altissima* with *G. deserticola* species of AM had no significant effect on the biomass accumulation assessed, which is in line with findings of (Manjunath and Habte, 1990), this contradiction maybe due to lower physiological compatibility of *G. deserticola* with *Mansonia altissima* since variability in compatibility has been reported for various A.M symbiosis (Krishma *et al.*, 1985, Rajapakse and Miller 1987, Rao *et al.*, 1990 and Mercy *etal* .,1990).

The application of N.P.K fertilizer significantly affected biomass accumulation in seedlings of *Mansonia altissima.* This might be due to the fact that Nitrogen is a major nutritional element required for tissue differentiation and its role in increasing plant growth and development which are well documented by various researchers (Shedeed *et al.*, 1986, Aziz, 2007). Like Nitrogen, Phosphorus is an essential constituent of the genetic material and augments cell division (Aziz, 2007). The increased growth and development in the present study in respect to phosphorus treatment might be due to increased rate of new cell formation.

The study clearly demonstrates the nutritional importance of N.P.K supply to *M. altissima* seedlings for better growth and development and the results revealed application of N.P.K at 1g/seedling to be beneficial and therefore enhanced seedlings performance under tropical agroclimatic condition. The optimum level of fertilizer requirement for a tree species like *M. altissima* is dynamic and changes with the age of plant. Therefore, the fertilizer requirement studies need further long term evaluation for different agro-ecological regions.

Water is a significant factor in tree growth and development in the tropics (Awodola and Nwoboshi, 1993). Water is required by plants to manufacture carbohydrate and as a means for transportation of food and mineral elements. Various vital processes in plants such as cell division, cell elongation stem as well as leaf enlargement and chlorophyII formation depends on plant water availability (Price *et al.*, 1986).

The finding from this study revealed that watering regimes applied to the seedlings of *M. altissima* had significant effect on biomass assessment. The highest value for leaf dry weight, stem dry weight, root dry weight and total dry weight were observed in seedlings watered everyday to pot capacity. This is in agreement with the previous studies (Akinyele, 2007 and Ogunwande, 2014). The seedlings of *M. altissima* were able to utilize the different watering regimes for biomass accumulation. The different watering regimes favoured the biomass accumulation of the seedlings which corobrate the findings of Agbo-Adediran, (2014). *M. altissima* is adapted to the tropical environment, so excessive moisture was not detrimental to the seedlings. It is widely reported that soil drying stimulates root growth and proliferation deep into the soil profile (Khalil, 1993).

CONCLUSION

Interaction between mycorrhiza, NPK fertilizer and drought stress resulted in enhancement of biomass accumulation of *M. altissima* seedlings indicating that arbuscular mycorrhiza was not parasitic. However, fertilizer was found to excerpt more influence than mycorrhiza in respect of biomass accumulation in *M. altissima* seedlings.

REFERENCES

Agbo-Adediran, A.O. (2014). Effect of light intensity and watering regimes on the seedlings growth of *Entradrophragma angolense.* M.Sc. Thesis submitted to the Department of Forest Resources Management, University of Ibadan, Nigeria. Pp 12-49

Akinyele, A.O. (2007). Silvicultural requirements of seedlings of *Buchholzia coriacea* Engl. Ph.D thesis submitted to the Forest Resources Management, University of Ibadan. pp. 179

Awodola, A. M., and Nwoboshi, L. C. (1993). Effect of source of potassium and frequency of moisture application on growth and macronutrient distribution in seedlings of *Parkia biglobosa* (R. Br.ex.G.Don). *Nigeria Journal of Forestry*, 23 (2) 98- 108.

Aziz, N. G. A (2007), Stimulatory effect of NPK fertilizer and benzyladenine on growth and chemical constituents of *Cordiaeum variegatum* L. Plant. American. Evasion *J. Agric and Environ Sci* 2 (6): 711-719

Barea, J. M., Azcom–Aguilare, C. and Azcon, R. (1997). Physiological and nutritional response by *Latuca sativa* L.to nitrogen sources and Mycorrhiza fungi under drought condition. *Boil fsertil soils* 22:156: 161.

Carling D.E Riehle W.G, Broom M.F and Johnson D.R. (1998). Effect or a vesicular – arbuscular mycohhiza fungus on nitrogen reduyctase and nitrogen activities in modulating and non-modulating soybeans. *Phytopathol* 68:1590-1596.

Fagbola, O., Oyetunji, O.J, Osonubi, O and Mulongoy, K. (2005). Greenhouse evaluation of two woody hedgerows as affected by arbuscular mycorrhiza fungus (AMF), soil quality and moisture.*journal of Archives of Agronomy and soil science* Vol 51 No3 pp 335-349

FAO (2003) State of the world's forest (2003) FAO of the united Nations Rome pp151

Food and Agricultural Organization (2005). Revises figures Rhett A. Butler (November 17, (2005): Nigeria has worst deforestation rate, mongabay. Com.

Garbaye, J. (1994). Helper bacteria: A new dimension to the mycorrhiza symbiosis. *New Phytol* 128:179 – 210.

Kareem, A.A., Akinyele, A.O., Adio, A.F., and Iroko, O.A., (2012). Preliminary Investigation of the effect of Arbuscular mycorrhiza and water stress on *Afzelia* *africana* (Smith) In different soil Media, *Journal of Sustainable Environment Management*, 4: 56 - 62

Khalil, A.A.M. (1993). Water relations of young trees Ph.D. Thesis University of Edinburgy pp240.

Krishna, K.R. Shetty, K.G. Daft, P.J and Andres, D.J. (1985). Genotype dependent variation in mycorrhiza colonization and respond to inoculation of pearl millet. *Plant Soil* 86. 113-125

Manjunath, A., and Habte, M.(1990). Establishment of soil solution phosphorus for studies involving vesicular- arbuscular mycorrhiza symbiosis. *Commum.soil.sci.plant Anal*.21: 556 – 557.

Mathur, M. and Vyas, A. (2000). Influence of arbuscular mycorrhiza on biomass production, nutrient uptake and physiological changes in *Ziziphus mauritiana Lam.* under water stress. *J. Arid Environs*, 45,191-195

Mercy, M.A, Shivashankar, G. Bagyaraj, D.J. 1990. Mycorrhiza colonization in cowpea is host dependent and heritable. *Plant Soil* 121:292-294.

Michelsen, A. Rosendahl, S. (1990). The effect of Vesicular arbuscular mycorrhiza fungi, phosphorus and drought stress on the growth of *Acacianilotica* and *Leucaena leucocephala* seedlings. *Plant Soil* 124: 127-134

Ogunwande, O.A (2014). A PhD Thesis submitted to Department of Forest Resources Management, University of Ibadan, Nigeria. Pp178.

Price, D.T., Black, T.A. and Kelliher, F.M (1986). Effects of salaunderstorey Removal on photosynthesis rate and stomata conductance of young Douglas-Fir Trees Canadian Journal of Forest Resources. 16: 90 – 97

Rajapakse, S. and Miller J.C. (1987). Intraspecific variability for V.A mycorrhiza sysbiosis in cowpea (*Vigna unguiculata* LWalp.). In: Gabelman W.H. Loughman B.C (eds) Genetic aspects of plant mineral nutrition. Nijhoff.Dordrechi. Pp 523-536

Rao, P.S.K, Tilak, K.V.B.R. and Arunachalam, V. (1990). Genetic variation for V.A mycorrhiza formation and root development in Medicago.in Smith J.H. Russel RS (eds) The soil root interface Academic Press London. PP 211-219.

Shedeed M. R., Hashim M.E., Hagag A.A (1986). Effect of different fertilization treatment on the growth of *Ficus elastic* Var. decora plant. *Annals of Agricultural Sciences*: 717 – 725

Appendix 1: ANOVA Result for the Effect of Mycorrhiza, Nutrient and Watering regimes on the Leaves Dry Weight of *M. altissima* seedlings

Variable	SV	df	SS	MS	F	Sig.
LDW (g)	Mycorrhiza (M)	2	0.86	0.43	0.41	0.67ns
	Fertilizer (F)	2	18.99	9.49	8.93	0.00*
	Watering Regime (W)	2	13.47	6.74	6.34	0.00*
	M * F	4	12.36	3.09	2.91	0.03*
	M * W	4	1.14	0.29	0.27	0.90ns
	F * W	4	12.99	3.25	3.06	0.02*
	M* F * W	8	5.05	0.63	0.59	0.78ns
	Error	54	57.40	1.06		
	Total	80	122.27			

ns- not significant (p>0.05)*significant at (p≤0.05)

Appendix 2: ANOVA Result for the Effect of Mycorrhiza, Nutrient and Watering regimes on the Stem Dry Weight of *M. altissima* seedlings

Variable	SV	Df	SS	MS	F	Sig.
SDW (g)	Mycorrhiza (M)	2	0.01	0.01	0.04	0.96ns
	Fertilizer (F)	2	2.46	1.23	11.30	0.00*
	Watering Regime (W)	2	1.30	0.65	5.96	0.01*
	M * F	4	0.40	0.10	0.92	0.46ns
	M * W	4	0.29	0.07	0.66	0.62ns
	F * W	4	1.58	0.40	3.63	0.01*
	M* F * W	8	1.32	0.17	1.51	0.18ns
	Error	54	5.88	0.11		
	Total	80	13.24			

ns- not significant (p>0.05)*significant at (p≤0.05)

Appendix 3: ANOVA Result for the Effect of Mycorrhiza, Nutrient and Watering regimes on the Root Dry Weight of *M. altissima* seedlings

Variable	SV	df	SS	MS	F	Sig.
RDW (g)	Mycorrhiza (M)	2	0.04	0.02	0.37	0.69ns
	Fertilizer (F)	2	0.52	0.26	5.02	0.01*
	Watering Regime (W)	2	0.90	0.45	8.62	0.00*
	M * F	4	0.28	0.07	1.35	0.27ns
	M * W	4	0.37	0.09	1.75	0.15ns
	F * W	4	0.55	0.14	2.63	0.04*
	M* F * W	8	0.34	0.04	0.82	0.59ns
	Error	54	2.82	0.05		
	Total	80	5.82			

ns- not significant (p>0.05)*significant at (p≤0.05)

Appendix 4: ANOVA Result for the Effect of Mycorrhiza, Nutrient and Watering regimes on the Total Dry Weight of *M. altissima* seedlings

Variable	SV	df	SS	MS	F	Sig.
TDW (g)	Mycorrhiza (M)	2	1.40	0.70	0.30	0.75ns
	Fertilizer (F)	2	43.31	21.66	9.10	0.00*
	Watering Regime (W)	2	32.52	16.26	6.83	0.00*
	M * F	4	20.80	5.20	2.18	0.08ns
	M * W	4	4.20	1.05	0.44	0.78ns
	F * W	4	31.00	7.75	3.26	0.02*
	M* F * W	8	13.09	1.64	0.69	0.70ns
	Error	54	128.52	2.38		
	Total	80	274.84			

ns- not significant ($p>0.05$)*significant at ($p\leq0.05$)