Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Effects of Soil Sources on the Early Growth and Biomass Accumulation of Mansonia Altissima A. Chev

[1]Adenuga, D. A., [1]Agbo-Adediran, A.O, [1]Odeyale, O. C., [2]Musa, F. B. and [1]Odede, L. A.

[1]Forestry Technology Department, Federal College of Forestry, Ibadan

[2]SustainableForest Management Department, Forestry Research Institute of Nigeria

Corresponding author Email: denakins4ever@gmail.com

Abstract

Soil serves as an anchor for plant roots and as a water holding tank for needed moisture, it provides a hospitable place for a plant to take root. This paper describes a case study of four selected soil sources- Natural forest soil, Plantation soil, dumpsite soil and baresoil in raising *Mansonia altissima* seedlings. The natural forest soil was collected from J1 forest area Ijebu-Igbo, Ogun State, the plantation soil, dumpsite soil and the bare soil were collected at different places within Ibadan, Oyo State. The soil from different sources was analyzed to ascertain their state before use. Seeds of *M. altissima* collected from Forestry Research Institute of Nigeria were sown into germination basket containing sterilized river sand. After germination, eighty (80) uniform and vigorous seedlings were transplanted into polythene pots containing different sources of soil and this served as treatments. The experiment was monitored for fourteen weeks.

The results revealed that the seedlings of *M. altissima* raised in natural forest soil had the best performance in term of height (12.82cm) while bare soil recorded the least height growth (10.38cm). In leaf production, the lowest value was also recorded in bare soil with a mean number of leaves of 6.75. The forest soil and bare soil had the best and the least performance with 3.63mm and 3.13mm in stem diameter respectively. It was also revealed that all the results from biomass accumulation shows that bare soil had the highest values- stem (2.89g), leaf (3.1g) and root (1.87g). Significant differences exist in stem, leaf and root biomass accumulation among the soil sources ($P \leq 0.05$). It is therefore concluded that degraded soil, especially those with similar characteristics with the soil of this study can still be used when the mostly used natural forest soil is unavailable for raising seedlings

Keywords: *Mansonia altissima,* biomass accumulation, soil sources, seedlings

Introduction

Forests are essential elements for life on earth and provide a vast array of resources. Millions of people in the world depend on forests for timber and non-timber forest resources and soil plays a significant role in the productivity of the forest. Trees such as *Mansonia ultissima* form an important component of the forest. *M. altissima* belongs to the family *Sterculiaceae* (Irvine, 1961). Mansonia is classified as a non – pioneer light demander (Gyimah, *et al*, 2003). It is a semi – deciduous forest species that can grow up to 37m high. The stem girth can be up to $2^{1}/_{2}$m. it is cylindrical to tapering with plank buttresses of up to 2⅔m. It has a dense crown, but deciduous in the dry season (Maku *et al*, 2014). *M. altissima* is highly demanded for its economic, social, cultural, medicinal and pharmacological uses (Ogbamgba and Wekhe, 2006). However, it requires urgent attention in term of conservation.

Soil is one of the most important natural resources and a major factor in global food production (Den Biggelaar, 2003). The capacity of soil can only be fully exploited when land use decisions incorporate knowledge of soil properties. Forest soils are predominantly complex basement soil which comprise of the original geologic mineral substrate that has been deposited across the topography of the landscape, acted upon by various biotic organisms, and over time weathered by the climate conditions of the region. The most biologically active portion of any soil is near the surface, where the levels of oxygen and water are most conducive for plant root growth and microorganism activity. For this reason approximately 90% of all forest tree roots occur within the upper 15.24cm of soil. The uppermost soil layer is most heavily influenced by the incorporation of organic matter – mostly from grass, forb and shrub fine root turnover and decomposition, but also the deposition of woody debris on the soil surface (FAO, 2007). Ferric luvisols soils have a medium to high storage capacity for water and nutrients and are well aerated. The greater humus and clay contents in the topsoil give luvisols (para-brown soils) a distinctively greater nutrient supply. The pH values of topsoil in forest plantation areas are usually low at 3 - 4; with soil acidification by humic acids and acid rain (Soil Association, 1990). The nutrient supply of forest plantation soils in the shallow root zone down to 0.3 m depth is low to moderate. The nutrient supply in the deep root zone down to 1.5 m depth is medium to high because of the increase in pH (Soil Association, 1990)

In most West African countries, the demand for indigenous tropical hardwoods such as *M. altissima* for domestic consumption and export is increasing. It is one of the few species used for building, furniture work, and construction. However it has suffered a lot of exploitation due to the anthropogenic activities. Nigeria forest land has been degraded for the purpose of agriculture, human settlement and road construction and due to poor management. There is a great need to better understand the biology of indigenous species so that their adaptive advantage for use in local condition can be promoted and sustained. Therefore, the need to raise the seedlings of *M. altissima* for its plantation to replenish the exploited areas necessitated this study. The main objective of this study therefore was to examine which soil media is best suitable for raising the seedlings of *M. altissima* at the nursery stage and also give best yield in terms of biomass accumulation.

Materials and Methods

Experimental site

The experiment was carried out at the nursery of Federal College of Forestry, Ibadan, located within the Government Reservation Area (GRA), Jericho in Ibadan North-West Local Government Area of Oyo State, Nigeria. The area lies at latitude7^0 26^1N and longitude $3^0 51^1$E with the annual rainfall ranging from 1,300-1,500mm. The average relative humidity is about 65% and the average temperature is about 26^0C. The eco-climate of the dry season usually commence from November to March while the raining season is usually from April to October (FRIN, 2016).

Procurement of *Mansonia altissima* seeds

The seeds of *M. altissima* were obtained from Seed section of the Forestry Research Institute of Nigeria (FRIN), Jericho Ibadan, Nigeria. The soil sources that were considered for this study are Forest soil, Plantation soil, dumpsite soil and bare soil. The natural forest soil was collected from J1 forest area Ijebu-Igbo, Ogun State, the Plantation soil was collected at Teak plantation within the College premises while dumpsite soil was collected from Ajakanga area within Ibadan and bare soil was collected at Idi-Ishin area Ibadan. All the soil samples were collected at the centre of each collection point and at the depth of between 5 and 15cm.

Methods

The seeds were sown into germination trays containing sterilized river sand and watered daily. Germination was first noticed 14 days after sowing. At the end of the germination period, eighty uniformly growing seedlings of *M. altissima* were transplanted into polythene pots filled with soils collected from the different sources. There were four treatments, replicated twenty times and arranged in a Completely Randomized Design (CRD).

Data Collection

Selected morphological variables, namely plant height, collar diameter, number of leaf produced were assessed. Seedling height was measured with the aid of meter rule and stem diameter using vernier calipers. Dry weight of leavesand roots were determined after oven drying at 80 ºC till constant weight was achieved.

However, in order to further understanding *M. altissima* growth responses to different soil sources, the following physiological characteristics were measured:

a. Leaf Area Ratio (LAR) – this expresses the ratio between the area of leaf lamina to the total plant biomass. It is the leafiness of a plant or the amount of leaf area formed per unit of biomass and expressed in cm^{-2} g^{-1} of plant dry weight (Radford, 1967).

$$LAR = \frac{\text{Leaf Area per Plant}}{\text{Plant Dry Weight}} \ldots\ldots 1$$

b. Leaf Weight Ratio (LWR) - this is expressed as the dry weight of leaves to whole plant dry weight and is measured in g^{-1} (Kvet *et al.,* 1971).

$$LWR = \frac{\text{Dry weight of leaf}}{\text{whole plant dry weight}} \ldots\ldots 2$$

a. Specific Leaf Area (SLA) - this is a measure of the leaf area of the plant to leaf dry weight and expressed in cm^2g^{-1} (Kvet *et al.*, 1971).

$$SLA = \frac{\text{Total leaf area}}{\text{Total leaf dry weight}} \ldots\ldots 3$$

b. Specific Leaf Weight (SLW) – this is a measure of leaf weight per unit leaf area. Hence, and implies that high SLW indicates more biomass and a positive relationship with yield can be expected (Pearce *et al.,* 1968).

$$SLW = \frac{\text{Leaf Weight}}{\text{Leaf Area}} \ldots\ldots 4$$

Data Analysis

Data collected were subjected to one-way Analysis of Variance and where there was a significant difference, means were separated using LSD. The biomass accumulation was determined by the dry weight method.

Results and Discussion

Table 1: Physical and Chemical Composition of the Soil Used

Sample Description	Forest soil	Plantation soil	Dumpsite	Bare soil
%O.C	2.79	2.04	2.02	2.63
%O.M	4.82	3.51	3.47	4.54
%N	0.21	0.26	0.20	0.21
P (mg/kg)	2.33	5.04	4.59	5.89
Mn (mg/kg)	1.8	23.7	10.6	16.6
Fe (mg/kg)	4.0	26.0	2.0	20.0
Cu (mg/kg)	1.0	5.3	2.6	16.5
Zn (mg/kg)	4.2	2.2	11	76
Na (cmol/kg)	2.1	1.9	3.0	2.2
K (cmoll/kg)	0.08	0.05	0.14	0.08
Mg (cmol/kg)	3.9	3.0	6.5	4.1
Ca (cmol/kg)	10.8	7.8	18.6	4.5
Sand (%)	85.5	87.4	89.4	83.4
Clay (%)	9.1	9.1	7.1	11.1
Silt (%)	5.5	3.5	3.5	5.5
Textural Classes	(Sandy loam)	SL	SL	SL

Table 2 presented the effect of different soil sources on early growth of *Mansonia altissima* with respect to Plant height, leaf production, stem diameter, and leaf area. The mean values of *M. altissima* height, leaf production, stem diameter, and leaf area ranged between 10.38-12.82cm, 6.75-7.13, 3.13-3.63mm and 97.21-105.03cm^2 respectively. The seedlings of raised in natural forest soil had the best performance in term of height with 12.82cm while bare soil recorded the lowest with 10.38cm. In term of leaf production, the seedlings raised with dumpsite soil had the highest mean value of 7.16 and the lowest with 6.75 (Bare soil).

The highest mean value of stem diameter 3.63mm was also recorded in seedlings raised with natural forest soil while the least value of 3.13mm was recorded in seedling raised with baresoil. For leaf area 105.03cm^2 was recorded as the highest and 97.21cm^2 as the least mean values for seedlings raised with natural forest soil and baresoil respectively..

The result obtained from the soil analysis reveals that both organic carbon and organic mineral contents in forest soil had higher values than the other soil sources, This accounted for their performance in height, leaf production and leaf area. This corroborates the findings of Jawayria *et al* (2018) that the availability of suitable mineral nutrient played an important role in the seedling development and growth.

Susan *et al* (2010) also reported that soil nutrient will influence the growth of indigenous species. The influence of the different soils on the growth response, height, stem diameter and leaf area of *Mansonia altissima* in this study agreed with the work of Saikou, *et, al* (2010). They reported that natural soil increased the growth potential of young plants.

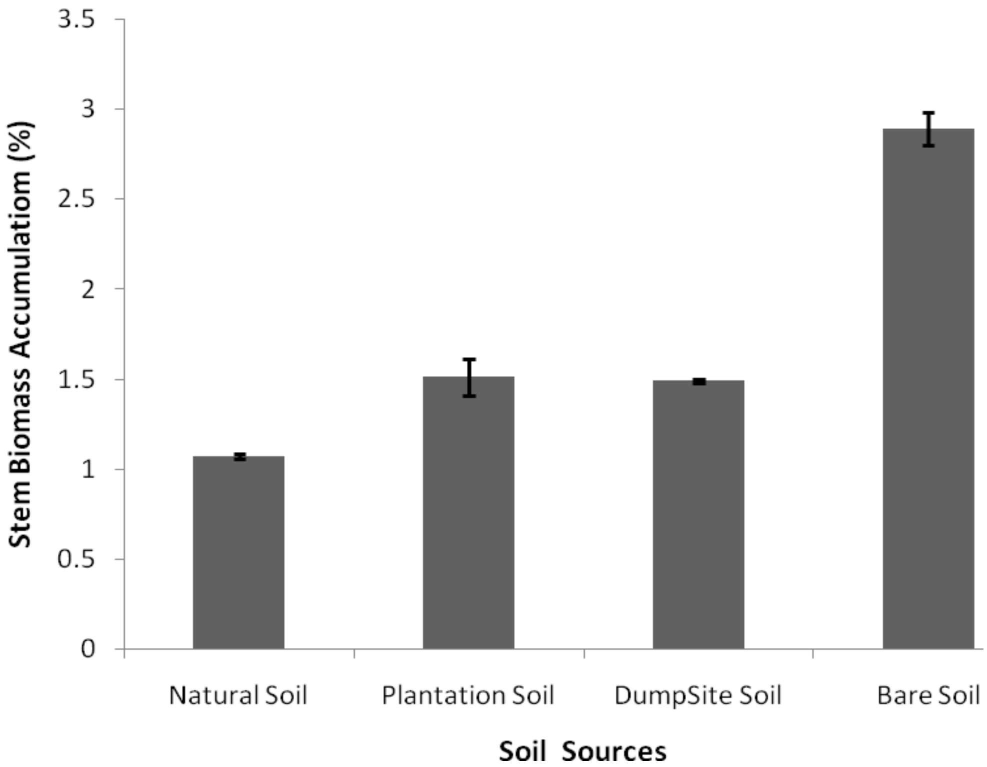
The Analysis of Variance conducted shows that significant differences exist within all the soil sources at P≤0.05. The result in Table 1 indicates that selected soil sources have influence on plant parameter of *M. altissima*. This might be as a result of the composition of the soil sources used for the experiment.

Table 2: Effect of the Different Soil Sources on the early growth of *Mansonia altissima*. Effect of Different Soil Sources on the *Mansonia altissima* Seedlings

Soil Sources	Plant Height (cm)	Leaf Production	Stem Diameter(mm)	Leaf Area(cm^2)
Natural forest Soil	12.82±0.21	7.13±0.08	3.63±0.06	105.03±1.90
Plantation Soil	12.07±0.17	6.82±0.06	3.39±0.05	101.67±2.06
DumpSite Soil	11.69±0.12	7.16±0.08	3.38±0.03	100.74±1.96
Bare Soil	10.38±0.13	6.75±0.05	3.13±0.05	97.21±3.55
LSD Value	0.45	0.19	0.13	NS

*NS-Not-significant

Biomass accumulation of stem for seedlings raised with forest soil was 1.07 while 1.51, 1.49 and 2.89g/m^2 were recorded for plantation, dumpsite and bare soil respectively. However, bare soil (T_4) had the highest value of 2.89g and forest soil (T_1) with 1.07g as least value. There is a significant difference in the stem biomass accumulation among the soil sources (P≤0.05).



Soil sources

Figure 1: Stem biomass accumulation

Leaf biomass accumulation revealed that seedlings raised with natural soil had 1.29 as its mean value, while seedlings raised with plantation soil, dumpsite soil and baresoil had 1.97, 2.5 and 3.1g/m^2 respectively, indicating that baresoil had the highest value of 3.1g as the highest while forest soil (T_1) with 1.29g as least value. There is significant difference existing in stem biomass accumulation among the soil sources ($P \leq 0.05$).

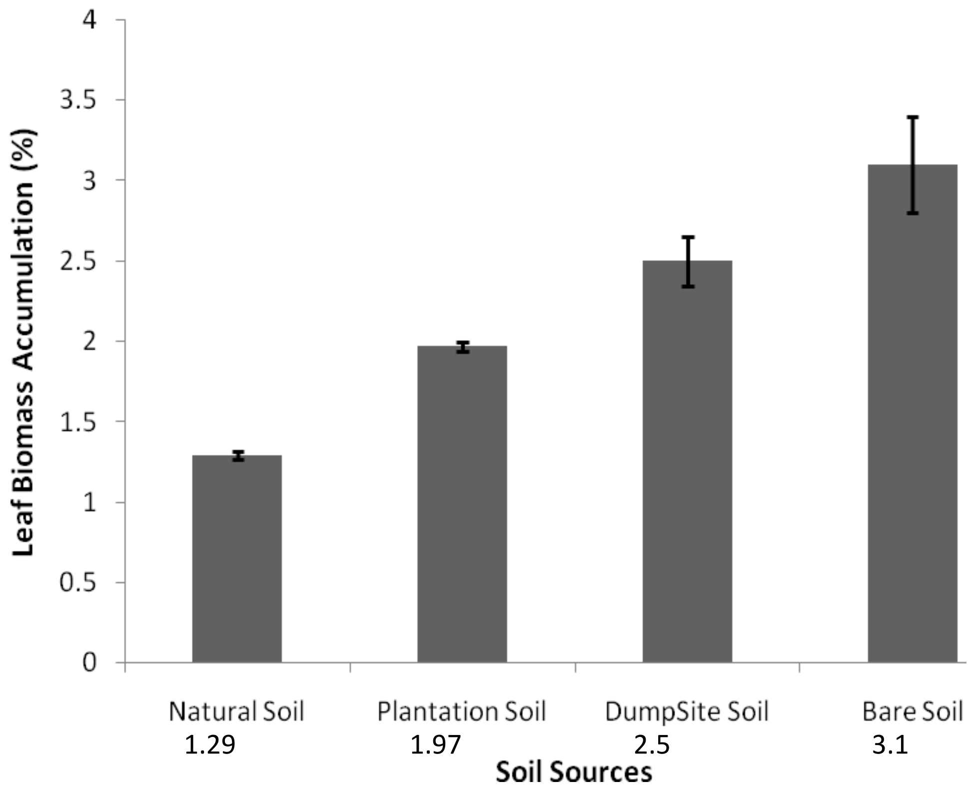


Figure 2: Leaf biomass accumulation

Bare soil had the highest value of 1.87g and forest soil with 0.25g as least mean in root biomass accumulation, while plantation soil raised seedlings and dumpsite had 0.39 and 0.7 respectively. There is significant difference existing in root biomass accumulation among the soil sources (P≤0.05).

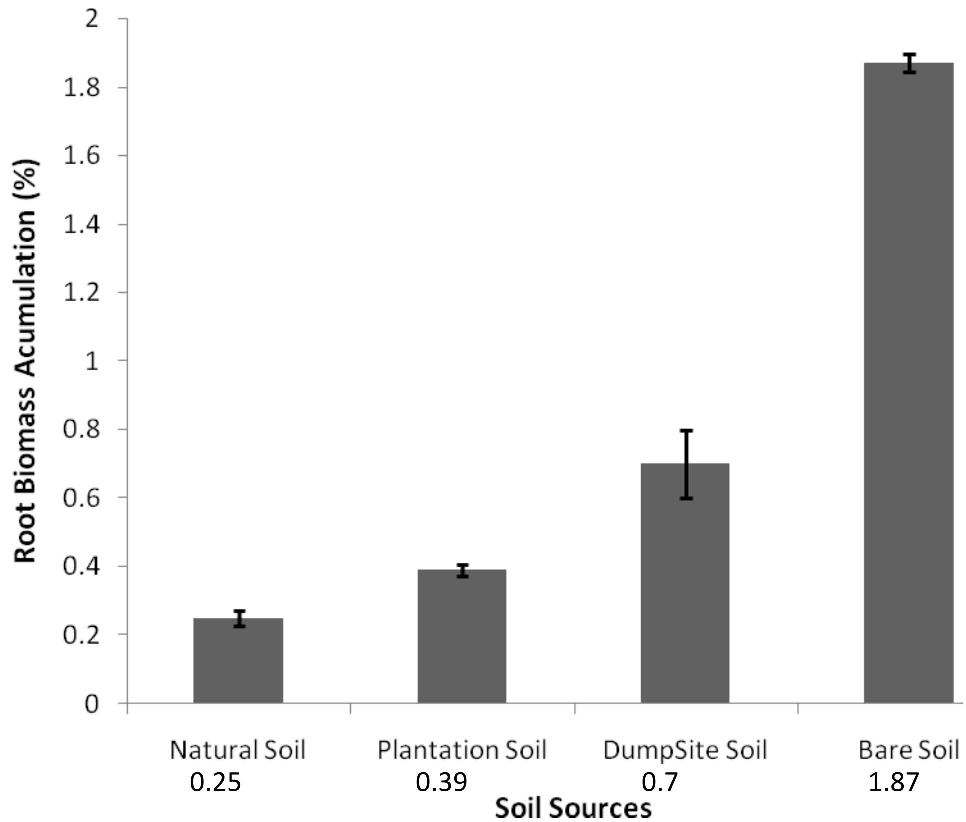


Figure 3: Root biomass accumulation

Table 3 reveals growth response of *M. altissima* as affected by different soil sources. Seedlings raised with the plantation soil had a leaf area ratio of 47.61 as the highest while the lowest (13.21) was obtained from seedlings raised with the degraded soil. For leaf weight ratio (LWR), the seedlings that were raised with dumpsite soil had 0.95 as the highest value and forest soil raised seedlings had 0.35 as the lowest value. Meanwhile, specific leaf area (SLA) had its highest value of 357.81cm^{2}g^{-1} in seedlings raised with plantation soil and the least value of 213.43cm^{2}g^{-1} was recorded in seedlings raised with baresoil. The specific leaf weight (SLW) had 0.09g/cm^2 and 0.04g/cm^2 as the highest and least values from baresoil and dumpsite soil raised seedlings respectively. The different soil sources shows significant different on selected physiological characteristics (growth response).

Table 3: Effect of Soil Sources on Physiological Characteristics of *M. altissima*

Soil Sources	Leaf Area Ratio	Leaf Weight Ratio	Specific Leaf Area(cm^2g^{-1})	Specific Leaf Weight(g/cm^2)
Forest	30.02±6.26	0.35±0.06	335.06±6.91	0.061±0.01
Plantation	47.61±23.15	0.93±0.49	357.81±55.18	0.06±0.01
Dumpsite	39.93±13.23	0.95±0.37	306.27±7.07	0.04±0.02
Baresoil	13.21±2.84	0.44±0.11	213.43±6.01	0.09±0.02
LSD Value	21.21	0.49	43.43	0.00

The pattern observed was degraded soil > dump-site soil > plantation soil > forest soil in all the biomass components. The high biomass attributed to the degraded soil maybe as a result of high specific leaf weight recorded for seedlings raised in them as noted in figures 1-3 and table 3 (Pearce *et al.,* 1968). The physiological parameters did not show a clear pattern and this may be due to the short duration of the experiment because the exposure period may not have been enough to allow clear differentiation in the growth rate of the seedlings as suggested by Olajuyigbe and Agbo- Adediran (2015).

Conclusion and Recommendation

This study revealed that *Mansonia altissima* seedlings grow better in forest soil as this could be observed in plant height; stem diameter; leaf area while dumpsite soil had the best performance in leaf production. In addition, it also indicated that the rate at which plants grow is highly determined by the type of soil the species was planted on. Natural forest soil increases growth potential of plants and it can be deduced from the soil analysis that both organic carbon and organic mineral contents in the forest soil had higher values than the other soil sources. Therefore, as a means of improving the growth of *Mansonia altissima* seedlings, it is recommended that forest soil should be adopted for raising the seedlings.

References

Den Biggelaar, C., Lal, R., Wiebe, K., Eswaran, H., Breneman,V. and Reich, P. (2003): The global impact of soil erosion on productivity: II: Effects on crop yields and production over time. *Advanced Agronomy*, 81: 49-95pp

FAO, (2007): State of the World's Forests 2005. FAO, Rome, Italy

FRIN, (2016): Annual Meteorological Report, Forestry Research Institute of Nigeria

Gyimah, R.,Nakao, T. and Min (2003): Effect of light intensity and nutrient on growth and electron transport of tropical tree found in Ghana, Faculty of Agriculture, Miyazaki University, Japan. 40pp.

Irvine, F. A. R. (1961): Woody plants of Ghana with special reference to their uses. Oxford Univ. Press London 146p

Jawayria, A. R., Muhammad, Z. I., Muhammad, S. and Mohammad A. (2018): Effect of Different soil types on seedling growth of *Pisum sativum* L. *Insight Botany*, 8: 1-5

Kvet, J., Ondok, J.P., Necas, J. and Jarvis, P.G. (1971): Methods of growth analysis. In: Sestak, Z., Catsky, J. Jarvis, P.G. (eds.), Plant Photosynthetic Production: manual and methods. The Hague: The Hague Publisher. Pp.343- 384.

Maku, J. O., Gbadamosi, A. E. and Fadoju, O. A. (2014): Germination and Seedling Growth of *Mansonia altissima* (A. Chev) in Response to Hormonal Treatment. *International Journal of Agriculture and Forestry*, 4 (4), 269-274

Ogbamgba, K. O. and Wekhe, S. N. (2006): The effect of dietary inclusion of *Mansonia altissima* on feed intake, efficiency and feed conversion of laying birds and cocks. *African Journal of Biotechnology*, 5(10), 1022-1024

Pearce, R. B., Brown, R. H. and Balster, R. E. (1968): Photosynthesis of alfalfa leaves as influenced by age and environment. *Crop Science*. 6:677-680

Radford P. J. (1967): Growth analysis formulae—their use and abuse. *Crop Science.* 7:171-5, *Sensing Reviews* 10: 105–125

Soil Association (1990): Map description, Environmental Atlas, Berlin.

Susan, G. W. L., William, F. L., Ana, A., Philip, M. F., Kyle, E., Harms, A. V. and Regina, C. C. (2010): Influence of soils and topography on Amazonian tree diversity: a landscape-scale study. *Journal of Vegetation Science* 21: 96–106

