E-ISSN: 2346-7290

Effect of mineralized organic manures as soil amendments on the growth performance of *Gambeya albida* (G. Don)

Egwunatum, A.E.*, Anozie, E.L. and Unuebgu E.

Department of Forestry and Wildlife, Nnamdi Azikiwe University, Awka, Nigeria.

*Correspondence author (Email: ae.egwunatum@unizik.edu.ng; Phone: +2348026083345)

ABSTRACT

This study examined the effect of different organic amendments on growth variables of *Gambeya albida*. Organic amendments were mineralized from cow dung (T2), goat dropping (T3) and poultry dropping (T4) following standard procedures in ratio of 1: 2: 1 topsoil and river-sand to produce soil media respectively in comparison with control topsoil (T1) and used to assess growth variables of *G. albida* in a Completely Randomized Design (CRD). Mineralized soil media were analyzed for pH (H_2O), exchangeable cations - calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}), exchangeable acidity (H^{+} +Al), Cation Exchange Capacity (CEC) and moisture content. Early growth data were collected at 6 weeks after transplant and analyzed using analysis of variance (ANOVA), while significant means were separated with the Duncan Multiple Range Test ($P < 0.05$). The results showed that CEC was T4>T3>T2>T1 while Ca/Mg ratio was T2<T1<T3<T4. T2 recorded significantly ($p < 0.05$) the highest mean moisture content (28.81%), pH (7.8) and stem height (69.6mm), while T4 had the maximum leaf production. The study therefore recommended that T2 and T4 could be used as potential amendments for the growth of *Gambeya albida*.

Keywords: Mineralized amendment**;** Cation Exchange Capacity (CEC); Ca/Mg ratio

INTRODUCTION

Gambeya albida (G. Don) is an important fruit tree species that is highly cherished as a means of sustainable livelihood option due to multiple benefits as an excellent source of vitamins, irons, flavor to diets and raw materials to some manufacturing industries (Bada, 1997; Unelo, 1997). The bark is employed in folk medicine for the treatment of yellow fever and malaria (Florence *et al*., 2015). Its roots, barks and leaves are widely used as an application to sprains, bruises and wounds in Southern Nigeria while extracts from seeds and roots were reportedly engaged to arrest bleeding from fresh wounds and to inhibit microbial growth of known wound contaminants in the course of enhancing wound healing process (Okoli *et al*., 2010). The wood of the matured tree, that could reach 40 m in height and 2 m in girth, is often sawn as timber for utilization in the construction of houses and hut especially after harvest of its berry fruit between the months of January to April (Oboho, 2014). Despite of these benefits, the increasing threat by deforestation and other anthropogenic activities coupled with the poor traditional belief system of the local communities that natural forest regeneration can take place irrespective of degradation state has in no small way militated against regenerating itself after exploitation (Anozie and Oboho, 2019). This is even worsened by the long gestation period of tree species that shift attention and interest on arable crops with early maturing and short gestation periods for the perceived economic gains. Consequently, there is a neglect of this fruit tree with respect to cultivation particularly attempts at its domestication in the light of perceived utilitarian values. Although being a forest tree that is common in the tropical Central, East and West Africa regions especially in Nigeria and other parts of the world (Amusa *et al*., 2013), its special adaption to the wild have severely led an inclination to luxuriant forest soil nutrient. Hence, the inability to domesticate with a view to complimenting its enhanced sustainability in the wild has currently enlisted *G. albida* as an endangered tree species. Therefore with the soil perceived as the major silvicultural challenge to domesticating Gambeya and its poor natural regeneration capacity (World Agroforestry Centre, 2007), there is the need to search for probable soil amendments that compare favorably with the rich forest soils in the wild. The use of soil amendments in pursuit of domesticating Gambeya with a view to shortening its gestation period either at the germination or vegetative stages could go a long way in eliciting the needed interest among the locals to combat the threat. But the unavailability and cost implications of inorganic amendments besides its environmental pollution capacity undermine its choice in favor of organic alternatives (Okwonomo *et al*., 2006). Further potential threat of increase in soil acidity negative influence on the phosphorus availability, decimation of microbial activities owing to decrease in soil organic matter content have been well documented as critical demerits of increasingly applying inorganics for sustainable agricultural attainments (Nakhro and Dhar, 2010; Kelly *et. al.*, 2010).

Organic amendments of plant and animal origins have been reported to enhance plant growth through regulation of the soil biophysical structure for appropriate nutrient use efficiency especially in light soils (Pandey *et al*., 2007; Oso, 1995). However, the state of organic materials at the time of its application have been shown to be of significance due to surrounding environmental conditions that influence either the impedance of inherent nutrients in the soils. This is because the dual potency of several organic amendments have been reportedly lost either in part or completely as a result of direct use of such materials without adequately initiating mineralization process that could sustain inherent nutrient potential before application. Even the direct application of large amounts of poultry manures in pursuit of optimum plant growth has been reported to cause severe pollutions (Belay *et. al.,* 2001). It is against this backdrop that component nutrient mineralization of the organic materials which is a microbial-mediated action becomes essentially important to reducing the economic waste, biochemical pollution and nutrient supply inefficacies often associated with direct use of such organic materials as amendments for the growth of plant species, particularly tree species that place greater demand on available nutrients. Microbial-mediated actions at composting different organic materials within various ages have been shown to confer varying degrees of potencies and durability in service as sources of nutrients for managing anemic and degraded soil related issues (Egwunatum *et al*., 2009; Egwunatum *et al.*, 2014). Cooke (1975) reported that plant growth with soil amendment grow faster and produce in a shorter time because of improved soil structure through good soil water holding capacity, aeration and drainage. Hence this study engaged the search for organically soil improving materials which are readily affordable and available that could be most suitable for the early growth performance of *G. albida* for possible augmentation of declining forest soils in pursuit of domestication of forest tree species amidst deforestation crisis in the tropics.

MATERIALS AND METHODS

Description of study Area

This study was carried out in Professor Nabuife screen house of the Department of Forestry and Wildlife, Nnamdi Azikiwe University, Awka, Anambra State. Nigeria. The university is located in the Eastern part of Nigeria and lies between the Latitude 6.2485^o N and Longitude 7.1154^o E. The climatic condition of the area is tropically with an annual rainfall range of 1828 mm – 2002 mm and average temperature of approximately 26.30^o C (Ezenwaji *et al*., 2013).

Media procurement and preparation

The cow dung and goat dropping used for this experiment were gotten from slaughter house, Amansea, the poultry dropping was purchased from the Department of Animal Science and Technology, while the top soil was also gotten from the degraded *Gmelina arborea* plantation in the premises of Nnamdi Azikiwe University Awka, Anambra State, Nigeria.

The cow dung, goat dropping and poultry dropping were mineralized for 14 days based on recommended composting age of 2 weeks (Egwunatum *et. al.,* 2014) by mixing each of the sieved organic waste materials with the *G. arborea* plantation top soil and river sand in the ratio 1:2:1 of the top soil, organic waste material and river sand respectively in 3 replicates. The resultant individual mixture types were then moistened with 500 ml of water and covered with black nylon to ensue for microbial activities on the media and in the process liberate the nutrient for 14 days. The mineralized media were then filled into 20 x 10 x 10 cm^3 polythene bags each in eight replicates per treatment. A control treatment of sieved *Gmelina* plantation top soil and river sand in ratio 1:1 was filled into 20 x 10 x 10 cm^3 polythene bag dimension using a hand trowel. Growth media samples were taken and analyzed for pH, cation exchange capacity, exchangeable acidity and exchangeable cations (Ca, Mg, Na and K), exchangeable acidity and moisture content. The pH was measured in 1:2.5 soil: water suspension using glass electrode digital pH meter. Exchangeable bases: Ca, Mg, Na, K were extracted using normal ammonium acetate (Thomas, 1982). The exchangeable K and Na were determined by flame photometer while Ca and Mg were determined by atomic absorption spectrophotometer. The exchangeable acidity and exchangeable aluminum (Al) were determined by titrate as described by Thomas (1996). The exchangeable hydrogen was obtained by subtracting exchangeable acidity (Al^{3+} + H) – Exchangeable Al.

Experimentation and Treatments

A total of 100 ripe fruits of *G. albida* was procured from the Anambra State Ministry of Environment, Forestry Department. These were de-pulped and seeds extracted manually before washing with water and then dried at the screen house temperature of 25-36^{o}C for 5 days. Eighty (80) viable seeds were carefully selected through viability test using the flotation method and carefully sown on different mineralized media in 4 m x 2 m perforated wooden germination troughs at the rate of 20 seeds per media trough in the Professor Nabuife screen house. These were monitored for epigeal germination for 5 weeks after which 40 healthy seedlings were selected and picked from the respective troughs into polythene bags already filled with the various media at 10 replicates per treatment in the screen house. The treatments constituted control top soil (T1) and mineralized cow dung (T2), goat dung (T3) and poultry dropping (T4). These were watered with 2 litres of water by sprinkling using a watering can for 2 days and the growth variables were assessed weekly for 6 weeks.

Data Collection and Analysis

The experiment was laid out in Completely Randomized Design (CRD). There were four treatments in eight replicates making a total of thirty-two potted seedlings of *G. albida*. The parameters that were assessed include; leaf count, collar diameter and plant height. The parameters were assessed weekly using ocular estimation for leaf count by counting the number of leaves per plant, while the vernier callipers was used to determine the collar diameter and the meter rule for stem height of seedlings by measuring from soil surface to the apical of individual plant. Data were analyzed using analysis of variance (ANOVA) in SAS and significant means were separated using Duncan Multiple Range Test (Duncan, 1955) at 0.05 level of probability test.

RESULTS

Effect of Mineralized Organic Materials on Soil

The nutrient potential of mineralized animal waste organic matters after 14 days showed that there was no significant difference in the mean calcium contents of T1 and T3 at the end of 14 days mineralization period. T4 recorded the mean significantly higher values (26.90 cmol/kg, 0.24 cmol/kg and 35.47 cmol/kg) in calcium, sodium and cation exchange capacity respectively. However, T3 was also noted to have significantly higher values (0.22 cmol/kg, 2.00, 9.50 and 2.25) in sodium, hydrogen ion (H^+), pH and aluminum ion (Al^{3+}) among other treatments respectively. T2 experienced significantly higher values (9.20 cmol/kg, 0.18 cmol/kg and 28.81 %) in magnesium, sodium and moisture content (%) respectively. Meanwhile, T1 also observed significantly higher values (0.15 cmol/kg, 0.46 cmol/kg and 8.04 cmol/kg) in calcium to magnesium ratio respectively (Table 1).

Table 1: Mineralization potential of organic material**s** used in the study

Soil parameter	T1	T2	T3	T4
Calcium (cmol/kg)	18.50^{b}	16.60^{c}	18.80^{b}	26.90^{a}
Magnesium (cmol/kg)	2.30^{d}	9.20^{a}	6.50^{b}	4.80^{c}
Sodium (cmol/kg)	0.15^{a}	0.18^{a}	0.22^{a}	0.24^{a}
Potassium (cmol/kg)	0.46^{a}	0.38^{b}	0.31^{c}	0.28^{c}
H^+	0.35^{d}	0.50^{c}	2.00^{a}	1.50^{ab}
Al^{3+}	1.00^{c}	0.25^{d}	2.25^{a}	1.75^{b}
CEC (cmol/kg)	22.76^{b}	27.11^{c}	30.8^{b}	35.47^{a}
pH (H_2O)	5.80^{d}	7.80^{c}	9.50^{a}	8.60^{b}
Moisture content (%)	25.30^{b}	28.81^{a}	21.40^{c}	24.51^{b}
Ca/Mg ratio	8.04^{a}	1.80^{d}	2.39^{c}	5.60^{b}

Means with the same superscript and on the same row are not significantly different ($P<0.05$)
Key: T1= Topsoil; T2=Mineralized cow dung media; T3= Mineralized goat dropping media;
T4= Mineralized poultry dropping

Effect of Soil Amendments on Stem Height

The result of the descriptive analysis on the stem height of *G. albida* seedlings under the different media are as shown in Table 2. T2 mineralized media had the highest mean stem height of 6.96 cm with a maximum of 8.90 cm followed by seedlings raised under T3 with mean value of 6.56 cm with a maximum of 7.60 cm. Seedlings raised with control (T1) treatment gave the least mean stem height (5.76 cm). The least mean stem height (5.76) with maximum height of 7.10 was recorded by the control.

Table 2: Descriptive analysis on stem height of *G. albida* seedlings under different media

Growth media	Mean	±Std. Deviation	Std. Error	Min	Max
T1	5.76	±0.66	0.10	4.50	7.10
T2	6.96	±1.01	0.16	5.00	8.90
T3	6.12	±0.70	0.11	5.00	7.60
T4	6.56	±0.96	0.15	5.00	8.50
Overall Mean	6.35	±0.95	0.08	4.50	8.90

The result of the one way analysis of variance (ANOVA) for stem height of seedlings under different potting mixtures (Table 3). The results revealed that there were significant differences in mean stem heights among the mineralized treatments and control ($p < 0.05$).

Table 3: ANOVA for the *G. albida* seedlings height under different organic manure amendments

SV	Sum of Squares	Df	Mean Square	F	P-Value
Treatment	32.937	3	10.979	15.311	0.000^{s}
Error	111.862	156	0.717		
Total	144.799	159			

Means ±Standard deviation under the same alphabet and column are not significantly the same (p< 0.05)

s = significant at p < 0.05

Key: T1= Topsoil; T2=Mineralized cow dung media; T3= Mineralized goat dropping media; T4= Mineralized poultry dropping

The seedlings which were raised with T2 produced the highest mean stem height of 6.96 cm and mineralized poultry floor waste produced seedlings with mean stem height of 6.56 cm. Seedlings raised with the control top soil produced the least mean stem height (5.76 cm). The result further revealed that there were significant differences in height among control top soil, mineralized cow dung and mineralized poultry dropping. However, the result indicated that no significant difference was observed between stem heights of control top soil (T1) and mineralized cow dung (T2) respectively (Table 4).

Table 4: Mean separation for seedling height under different media

Growth media	Subset for alpha = 0.05		
	A	B	C
T1	5.76 ±0.66		
T2	6.96±1.01		
T3	-	6.12 ±0.96	
T4	-		6.56±0.96
Sig.	0.061	1.000	1.000

Effect on Collar Diameter

The result of the one way analysis of variance (ANOVA) for the effect of organic amendments on collar diameter are presented in Table 5. The result revealed that the mean seedling collar diameter had P value of 0.133 which is not significant.

Table 5: ANOVA on seedling collar diameter under different treatment

Source of Variation	Sum of Squares	Df	Mean Square	F	P-Value
Treatment	0.199	3	0.066	1.893	0.133**
Error	5.476	156	0.035		
Total	5.675	159			

**significant at P < 0.05

Effect on Leaf Production

The mineralized poultry dropping (T3) recorded the highest mean leaf number (2.70) with the maximum leaf number of 5, while the control top soil (T1) recorded mean value of 2.43 with least leaf number of 4. Seedlings raised with the mineralized goat dropping (T3) recorded the least mean leaf number (2.33) having the same leaf number of 4 as in T1 and T2 respectively (Table 6).

Table 6: Descriptive analysis on leaf production of seedlings under different media

Growth media	Mean±	Std. dev.	Std. Error	Minimum	Maximum
T1	2.43	±0.59	0.09	2.00	4.00
T2	2.38	±0.59	0.09	2.00	4.00
T3	2.33	±0.53	0.08	2.00	4.00
T4	2.70	±0.85	0.14	2.00	5.00
Total	2.46	±0.66	0.05	2.00	5.00

The results revealed that there was no significant difference in the mean leaf production (P = 0.051) of Gambeya seedlings (Table 8).

Table 8: ANOVA of leaf production under different treatment

Source of Variation	Sum of Squares	DF	Mean Square	F	P-Value
Treatment	3.369	3	1.123	2.641	0.051^{ns}
Error	66.325	156	.425		
Total	69.694	159			

ns- not significant at P > 0.05

DISCUSSION

The highest mean stem height of seedlings recorded by T2 may not be unconnected with its moisture content and the capacity to release nutrient as depicted by the high magnesium content in the soil amendment. This is because, the high moisture content in cow dung allows for a better aeration of roots (Ajah, 2017). This is also in line with the findings of Falana *et al.* (2017) that, cow dung greatly influenced the plant stem height, diameter, and leaf production as a result of higher moisture content to produce better, healthy and vigorous seedlings within a shorter period compared to other treatment applications with lower moisture content. T4 equally influenced stem height significantly probably due to the high CEC value. This finding is in line with the study of Anderson (2008) that poultry droppings performed better than inorganic NPK, even with higher CEC on the growth of *Khaya senegalensis.* This observation may not be unconnected with the Ca/Mg ratio which was least for T2 indicating a better capacity to manage nutrient loss than the T1, T3 and T4. But, for the compensating higher CEC of T4, it influenced stem height compared to T1 with the widest Ca/Mg ratio.

The pH of T1 was moderately acidic (pH 5.6-6.0), while that of T3 and T4 ranged from moderately alkaline (pH 7.9-8.4) to very strongly alkaline (pH > 9.00) respectively. These conditions may have invariably affected the nutrient release especially T1 because acidity tends to immobilize essential nutrients for plant growth. This supports the findings of Pandey *et al*. (2007) that organic amendments improved the soil physical, chemical and biological properties and also increase the efficiency of the applied nutrients especially in light soils. Also, Merino *et al*. (2004) and Grace *et al*. (2006) equally agreed that soil organic matter determines the physical, biological and chemical properties of soil. Khan *et al*. (2006) also joined the opinion that addition of organic potting media is important because it supplies essential nutrients required by plants or seedlings.

The T3 had the best performance in collar diameter, this high performance concurs with the findings of Haruna *et al*. (2015) and Elias *et al*. (2009) that the application of goat manure to the soil enhanced the availability of phosphorus in the soil through enhanced biological cycling of soil, thereby making essential nutrients readily available for plant uptake.

Although, the collar diameter of seedlings raised under T1, T2, T3 and T4 were not significantly different, seedlings raised with T3 had the highest mean collar diameter. This supports the work of (Hue, 1992) and Iyamuremye *et al*. (1996) that application of goat manure to soil could also improve the availability of enhanced biological cycling of soil nutrients through internal moisture regulation. Hence, the slight differences in the collar diameters among the treatments might be due to some physiological processes like the reallocation of plant resources and the variation in mineralization rate, especially during the early germination period where food storage for growth is distributed.

CONCLUSION

G. albida seedlings can be raised with mineralized organic materials most especially the use of mineralized cow dung as it performed excellently well in raising its seedlings in terms of stem height and other measurable parameters. It is therefore recommended that mineralized cow dung be adopted for raising *G. albida* seedlings in order to increase early growth and development of the plant.

REFERENCES

Adewusi, H.A. 1997. The African Star Apple (*Chrysophyllum albidum*) Indigenous Knowledge from Ibadan, South Western Nigeria. *In Proceedings of a National Workshop on the potentials of the Star Apple in Nigeria* (eds) Denton, O.A, Ladipo, D.O.,Adetoro, M.A.,Sarumi, M.B.,pp 25-33.

Ajah, A.M.R. 2017. Effective Use of Cow Dung Manure for Healthy Plant Growth. *International Journal of Advanced Research and Development*, 2 (5), 218-221.

Amusa, N.A., Adiaha, A.H. and Oladopo, M.O. 2013. Biodeterioration of African Star Apple (*Chrysophyllum albidum)* in Storage and the Effect on its Food Value. *African Journal of Biotechnology*, 2, 56-59.

Anozie, E.L. and Oboho, E.G. 2019. The Effect of Seed Source and Pre-sowing Treatment on Germination of *Canarium schweinfurthii* [Eng1]

Seeds. *Asian Journal of Research in Agriculture and Forestry*, 4 (4), 1-11.

Bada, S.O. 1997. Preliminary information on the ecology of *Chrysophyllum albidum* G. in west and central Africa In: *Proceedings of a National workshop on the potentials of the star Apple in Nigeria* (eds) Denton OA, Ladipo DO, Adetoro MA, Sarumi MB,pp.16-25.

Belay, A., Classen, A.S., Wehner, F.C. and Bee, J.M. (2001). Influence of residential manure on selected nutrient elements and microbial composition of soil under crop rotation. *South African Journal of Plant and Soil*. 18, 1-6

Centrad, 1999. Center for Environmental and Renewable Natural Resource Management, Research and Development. Jericho, Ibadan Publication Number CEN/011/1999'

Elias, M.G., Pearson, N.S.N., Philip, C.B. 2009. Effects of Goat Manure and Inorganic Phosphate. Addition on Soil Inorganic and Microbial Biomass Phosphorus Fraction under Laboratory Incubation Conditions, *Soil Science and Plant Nutrition*, 55 (6), 764-771.

Ezenwaji, EE, Okoye A.C., Awopeju A.K. 2013. The Relative Contributions of Climatic Elements and Environmental Factors to Flooding in Awka Urban Area. *Journal of Environmental Science and Technology*, 7 (8), 808-814.

Egwunatum, A.E. and Lane, S. 2009. Effect of compost age on the suppression of *Armillaria mellea* with Green waste compost Tea. *Compost Science and Utilization*, 17 (4), 237-240.

Egwunatum, A.E., Uyovbisere, E.O. and Akparobi, S.O. 2014. Bioremediation of crude oil contaminated soil with variegated compost formulations. *Nigerian Journal of Soil and Environmental Research*, 12, 141-146.

Falana, A.R., Musa, F.B., Ogidan, O.A. and Aderounmu, A.F. 2017. Effect of *Gliricidia sepium* leaves and cow dung on the Growth of *Khaya senegalensis (*A. Juss) seedlings. *Journal of Forestry and Management*, 14 (1), 37-48.

Florence, A.B., Adiaha, A.H. 2015. Storage Effect and the Post-harvest Quality of African Star Apple Fruits (*Chrysophyllum albidum*) Under Ambient Conditions. *African Journal of Food Science and Technology*, 6 (1), 35-43.

Grace, C.M., Colunga-Gracia, Gage, S.H., Robertson, G.P. and Safir, G.R. 2006. The Potential Impact of Agricultural Management and Climate Change on Soil Organic Carbon Resources in Terrestrial Ecosystems of North Central Region of the United States. *Ecosystems*. 9, 816-827.

Harun, I.G., Benson, E. M. and Benjamin, O.D. 2015. The Effect of Lime and Goat Manure on Soil Acidity and Maize Growth Parameters at Kavutiri, EMBU Country –Central Kenya. *Journal of Social Science and Environmental Management*, 6 (10), 275-283.

Hue, N.V. 1992. Correcting soil acidity of a highly weathered Ultisol with chicken manure and sewage sludge. *Communication in Soil Science and Plant Analysis*, 23, 241–264.

Iyamuremye, F., Dick, R.P., Baham, J. 1996. Organic amendment and phosphorus dynamics: II. Distribution of soil phosphorus fractions. *Journal of Soil Science*. 161, 436–443.

Keay, R.W.J. 1989. *Trees of Nigeria*. Claredon Press, Oxford.

Kelly, S.R., Joseph, M.C. and Noah, F. 2010.

Nitrogen fertilization inhibits soil microbial respiration regardless of the form of nitrogen applied. *Soil Biology and Biochemistry*, 42, 2336-2338

Khan, M.M., Khan, M.A., Mazhai, A., Muhammed, J.M.A. and Abbas, H. 2006. Evaluation of Potting Media for the Production of Rough Lemon Nursery Stock. *Pak. Jour.Bot*. 38(3), 623-629.

Oboho, E.G. 2014. *Silviculture for Beginners*, Uniben Press, Ekahuan Campus, Benin-City, Nigeria. 263 pp.

Nakhro,N. and Dhar, M.S. 2010. Impact of organic and inorganic fertilizers on microbial populations and biomass carbon in paddy field soil. *Journal of Agronomy*, 9, 102-110.

Okafor, J.C. and Fernandes, E.C.M. 1987. Compound Farms of South-east Nigeria: a predominant Agroforestry Homegarden system with crops and small livestocks. *Agroforestry Systems*, 5, 154-168.

Okoli, B.J. and Okere, O.S. 2010. Antimicrobial Activity of the Phytochemical Constituents of *Chrysophyllum albidum* G.Don-Holl (African Star Apple). *Journal of Research in National Development*, 8 (1), 1-8.

Okunomo, K., Ureigho, U.N. and Oputa, H.O. 2006. The Effect of Soil Amendment on the Performance of *Gambeya albida* (Linn) seedlings. *Agricultural Journal*, 1 (4), 262-265.

Oso, B.R. 1995. Potentials *of Hyacuth azola and other weeds as organic fertilizer*. University of Ibadan 78 pp.

Pandey, N., Verma, A. K. and Gopalaswamy, A. 2000. Effect of organic and inorganic nitrogen combination on rice yield and N uptake. *Journal of Indian Society of Soil Science*, 48(2), 398-400.

Thomas, G.W. 1982. Exchangeable Cations. In: Page, A.L. (eds). Methods of Soil Analysis 2. *Agronomy Monograph*. 9: 159-165. Madison, WI., USA.

World Agroforestry Centre 2007. *Chrysopyllum albidum- Technical Report*, 3 pp.