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EFFECT OF SAW DUST BIOCHAR AND NPK 15:15:15 INORGANIC FERTILIZER ON *moringa oleifera* SEEDLINGS GROWN IN AN OXISOL

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ABSTRACT

A factorialexperiment was conducted in the screen house of Bowen University, Iwo, Nigeria to examine the response of Moringa oleifera Lam. seedlings to saw dust biochar and NPK 15:15:15 inorganic fertilizer amendments. The plants were grown for twelve weeks in top soil (0-30cm) collected from an Oxisol in the University Research Farm. Biochar and NPK inorganic fertilizer were applied at four levels, viz 0, 5, 10 & 20 t C ha^{-1} and 0, 22.5, 45 & 90 kgNha^{-1} respectively. The results indicated that the tree species responded positively to sole application of either inorganic fertilizer or saw dust biochar. Tree height, stem diameter and dry matter yield increased, in all cases, over the non-treated control. The higher the application rate of either NPK inorganic fertilizer or saw dust biochar, the more beneficial their effects were on all the plant parameters considered except for the number of branches produced which did not appear to be affected. No significant positive correlation was established between application rates of inorganic fertilizer and tree parameters. However, rates of application of saw dust biochar were significantly and positivelycorrelated with tree height (r= 0.98), stem diameter (r=0.99**) and dry matter yield (r=0.96*). Interaction between biochar and inorganic fertilizer was not statistically significant for tree height, stem diameter and number of branches but it was significant for dry matter yield and root: shoot ratio. The combined effects of biochar (20t Cha^{-1})and NPK inorganic fertilizer (90kgNha^{-1}) resulted in the production of seedling that was superior in dry matter yield to any other seedlings produced at any biochar inorganic fertilizer combination level. Therefore, complementary use of inorganic fertilizer and saw dust biochar at the highest application level of each gave the best result in producing healthy Moringa seedlings in this study.*

Keyword: Biochar, *Moringa oleifera*, nursery, saw dust

INTRODUCTION

There is an increasing national and international interest in the planting of *Moringa oleifera* as a non-timber tree species because of its nutritional, medicinal and economic value (Jahn and Dirar, 1979; Duke, 1983; Foidl et al, 2001; Fahey, 2005; Maroyi, 2005; Hsu et al, 2006; CTA, 2008). Consequently, it is being planted as a court-yard home garden tree, multi-purpose tree on agricultural farm land and as a plantation tree species to provide the much needed products for consumption by individuals and as raw materials for industries.

Research results have however convincingly shown that one of the plant characteristics that affect growth rate and biomass production of trees in plantations is the quality of the planting stock (Fagbenro, 2001b). An important factor that has direct influence on the quality of the planting stock is the nature and component of the potting mixture used in the nursery for their production.

Inorganic fertilizer is rarely used in Nigeria to raise tree seedlings partly because of its economic cost and partly because it can only supply the specific nutrients it contains to the soil, but cannot provide the additional effects of organic matter for the prevention of erosion, run-off and leaching, improvement of cation exchange capacity and water-holding capacity of the soil. So, over the years, the productivity of permanent forest nurseries has become dependent upon the supply of organic materials such as poultry droppings, cow dung or horse dung to improve the quality of the nursery potting mixture (Olagunju and Ekwebelam, 1985). However, these animal manures are at present not easily available in every locality and, where available, their supply is becoming increasingly costly for use in forest nurseries (Fagbenro et al, 2012a). But there are other organic materials that are more abundant in the environment and which can be processed to improve their effectiveness as organic soil conditioners or fertilizers. One of such materials is saw dust which at present constitutes an environmentally unacceptable organic waste in our towns and cities (Fagbenro, 2000b).

In this study, our aim was to investigate effect of saw dust biochar on the growth of Moringa seedlings when applied alone and in combination with NPK inorganic fertilizer. Biochar is a term used to designate a carbon-rich product obtained when a biomass like saw dust is heated in a closed container with little or no oxygen (Lehmann and Joseph, 2009a). The stimulus for the study emanated from the reported beneficial effects of biochar and its combination with inorganic fertilizers on crop (Uzoma et al, 2011; Fagbenro et al, 2012b).

MATERIALS AND METHODS

Bulk surface soil (0-30cm) was collected from an unfertilized agricultural farm previously grown to maize and cowpea during previous year's planting season from Bowen University teaching and research farm. The soil is grouped as Oxisol (Aubert and Tavenier, 1972; FAO/UNESCO, 1977). It was air - dried and sieved through 2-mm sieve. Some physical and chemical properties of the soil were determined and are presented in Table 1.

Viable seeds of *Moringa oleifera* were procured and pre- treated by soaking in cold water for 18 hours and germinated in a germination box containing a mixture of topsoil and sand (1:1, w/w).The saw dust feedstock was collected from Oluwaloseyi saw mill in Iwo and then converted to biochar by heating, using the traditional earthen mound kiln method without energy capture.

Table 1: Some properties of soil (0-30cm) sample used for the pot experiment

Property	Value
Texture: Sand	Sand (g/kg) 872
	Silt (g/kg) 40
	Clay (g/kg) 88
pH (H_20)	6.2
Total N (g/kg)	2.3
Organic C (g/kg)	19.9
AV.P (mg/kg)	16.5
K (cmol/kg)	0.24
Na (cmol/kg)	0.60
Mg (cmol/kg)	1.35
Ca (cmol/kg)	13.50
Cu (mg/kg)	2.36
Zn (mg/kg)	5.69
Fe (mg/kg)	78.30
Mn (mg/kg)	79.60

The temperature inside the kiln was about 350°C. Some selected properties of the biochar are as indicated in Table 2.

Table 2: Selected properties of saw dust biochar used for the experiment

Property	Value
pH (H_2O)	8.1
pH ($CaCl_2$)	7.8
NO_3- N (g/kg)	1.7
NH_4- N (g/kg)	0.8
Total organic C (g/kg)	908.7
Total N (g/kg)	11.3
C / N ratio	80.4
Total P (g/kg)	3.8
K (g/kg)	5.4
Mg (g/kg)	1.9
Ca (g/kg)	1.5
Na (g/kg)	1.8
S (g/kg)	0.88
Ash (g/kg)	38.9
HA (g/kg)	80.9
FA (g/kg)	49.0
HA: FA Ratio	1.65
Mn (mg/kg)	17.6
Cu (mg/kg)	2.4
Zn (mg/kg)	479.8
Fe (mg/kg)	23.1
Exch. Acidity (cmol/kg)	0.65
CEC (cmol/kg)	106.38

HA = Humic acid; FA = Fulvic acid.

Four levels of saw dust biochar, namely 0,22, 44 and 88g biochar, equivalent rates of 0.5, 10 and 20 $tCha^{-1}$ in that order, and 4 levels of NPK inorganic fertilizer, 0. 0.6, 1.2 and 2.4g equivalent rates of 0, 22.5, 45, and 90 kg Nha^{-1} respectively were added to 10kg soil. Each of the resulting 16 treatments was thoroughly mixed and put in a 15-litre black plastic pot with drainage holes at the bottom. The holes were lightly plugged with non- absorbent cotton wool to prevent loss of soil and leaching of nutrients. The mixture in the poly pot was moistened to 50% water holding capacity and left in the screen- house for 7 days to equilibrate.

Moringa oleifera seedlings of similar height were transplanted at 2-leaf stage (approximately 1 week after germination) into the polypots at one per pot. The design was a 4 x 4 factorial combination replicated three times. The pots were left in the screenhouse for 7 days after transplanting to overcome initial shock. Thereafter, the pots were moved outside the screen house and lined upon black plastic sheet to prevent plant roots getting into the ground. Random numbers were used to determine the position of each pot on the plastic sheet. Watering was done once a day or as necessary when it did not rain. The plants were grown outside to simulate nature.

At the end of 13 weeks of plant growth, the experiment was terminated. A day before harvesting, seedling height was measured with a long ruler from the soil surface to the seedling tip while the stem diameter was measured with a micrometer at the crown line to the nearest mm. The number of branches produced was also recorded. The fresh shoot (leaf+stem) and root were harvested, weighed, and then oven-dried separately at 70^{0}Cto constant weight to determine dry matter yield.

Particle size analysis of the soil sample was determined by the improved Bouyocous hydrometer method (Bouyocous, 1962) while soil and biochar chemical analyses were done using routine procedures (IITA, 1982). Extractable humic substances (humic acid and fulvic cid) were exhaustively extracted with 0.1MNaOH and fractionated according to Fagbenro (1988).

Analysis of variance was carried out. Duncan's Multiple Range Test was used for means separation where significant effects were obtained. Seedling growth parameter data obtained from main effect of each of the two factors were subjected to simple correlation analysis to determine the extent application rates of each factor was related to the growth variables.

RESULTS AND DISCUSSION

Main effect of NPK inorganic fertilizer and saw dust biochar

Table 3 gives the result of Moringa seedling's performance when fertilized with NPK inorganic fertilizer alone. The tree seedlings responded positively to inorganic fertilization, with the seedlings grown in treatments having fertilizer performing significantly better than those in the non-treated control. The higher the rateof the fertilizer applied, the more beneficial its effect on the plant growth. The fertilizer was highly significant in its effect on plant height, stem diameter, dry matter yield and root: shoot ratio but had no significant effect on the number of branches formed. There wasno significant positive correlation between rate of application of the fertilizer and the plant parameters considered in this study as indicated in Table 4.

This result is similar to the finding of Aluko (1982) on the positive response of *Terminalia superb* and *Terminalia ivorensis*to mineral fertilization. Fagbenro (2001b) also reported positive response of *Ceiba pentandra*, *Parkia biglobosa* and *Gmelina arborea*plantsto the application of NPK 15:15:15 inorganic fertilizer.

The result further confirms the fact that, Moringa, like any tree species, requires nutrient elements for adequate growth particularly in low-nutrient and low organic matter soils (Fagbenro and Aluko, 1987).

Table 3: Main effects of NPK 15: 15: 15 inorganic fertilizer and saw dust biochar on 13-week old *Moringa oleifera* seedlings grown in an Oxisol

Fertilizer level ($KgNha^{-1}$)	Height (cm)	Stem diameter (mm)	No of branch	Dry matter (g)	Root : Shoot Ratio
0	32.7c	11.0b	9	11.0c	2.6c
22.5	37.8b	11.6b	9	22.3b	3.5b
45	41.2ab	11.9b	9	22.8b	4. 1a
90	43.2a	13.1a	9	25.6a	3.6b
Biochar level ($t\ C\ ha^{-1}$)	Height (cm)	Stem diameter (mm)	No of branch	Dry matter (g)	Root : Shoot Ratio
5	36.3b	11.0c	9	21.2b	4.3a
10	41.1a	12.5b	9	22.3b	4.5a
20	43.1a	13.8a	9	35.2a	4.5a

Foot note: in this and other tables, values in one column followed by the same letter are not significantlydifferent at $p \leq 0.05$.
NS: Not significant

Table 3 also shows the effect of sole application of saw dust biochar on Moringa seedlings. Response trend in the tree seedlings to biochar amendment was similar to that of inorganic fertilizer. Biochar had significant effect on plant height, stem diameter, dry matter yield and root: shoot ratio but no significant effect on branch production. Compared to response to inorganic fertilizer, it may be concluded that the seedlings responded more positively to biochar amendment than to inorganic fertilizer. This is likely to be the case as the application rates of saw dust biochar were significantly positively correlated with tree height (r=0.98*), stem diameter (r=0.99**) and dry matter yield (r=0.96*) as shown in Table 4.

The significant response of Moringa seedlings to saw dust biochar confirms the reported stimulating effect of biochars on tree growth (Chidumayo, 1994; Hoshi, 2001). The high significant positive effect of saw dust biochar may be due to the nutrients contained in it and the presence of high amount of humic substances (humic acid and fulvic acid in Table 2). Humic substances have hormonal properties that have been reported to stimulate plant growth (Freeman, 1978; Fagbenro and Agboola, 1993, Fagbenro, 2001b). According to Flaig (1975), the effect of physiological active substances, such as humic substances, is to improve plant yield if one or several growth factors are in deficit or in excess. It could also be due to the nutrient transforming property of biochars in the soil system (Gundale and DeLuca, 2006; Liang et al, 2006). Alternatively, it could be due to the characteristic beneficial effects of biochars on a variety of agriculturally important soil micro-organisms (Ogawa et al, 1983).

The observed significant positive correlations between biochar application levels and seedling parameters in Table 4 further confirm the beneficial effects of the organic material on the growth of Moringa plant.

Table 4: Relationship between NPK 15: 15: 15 inorganic fertilizer and saw dust biochar application levels and height, stem diameter and dry matter yield of *Moringa oleifera* seedlings.

Source of Comparison	Correlation Coefficients (r)	
	Fertilizer	Biochar
Application Level versus Height	0.80	0.98*
Application Level versus Stem Diameter	0.86	0.99**
Application Level versus Dry matter	0.83	0.96*

* Significant at 5% probability level;
** Significant at 1% probability level.

Interaction effect of NPK inorganic fertilizer and saw dust biochar

Data on the complimentary use of NPK inorganic fertilizer and saw dust biochar are presented in Tables 5 and 6. The analysis of variance data in Table 5 indicated that the combination of inorganic fertilizer and saw dust biochar did not significantly affect height, stem diameter and branch production by Moringa seedlings (hence data not presented in Table 6).

Table 5: Complete analysis of variance (ANOVA) for the main effect and interaction of saw dust biochar with NPK 15: 15: 15 inorganic fertilizer on 13-week old *Moringa oleifera* seedlings grown in an Oxisol

Source	DF	Anova SS	Mean Square	F-Value	Pr > F
	Height				
Biochar	3	584.7656250	194.9218750	8.33	0.0003
Fertilizer	3	759.1406250	253.0468750	10.82	<0.0001
Biochar & Fertilizer	9	168.5885417	18.7320602	0.80	0.6183
	Stem Diameter				
Biochar	3	89.04166667	29.68055556	16.01	<0.0001
Fertilizer	3	28.0416667	9.34722222	5.04	0.0057
Biochar & Fertilizer	9	9.25000000	1.02777778	0.55	0.8234
	No. of Branches				
Biochar	3	3.89583333	1.29861111	2.01	0.1322
Fertilizer	3	0.22916667	0.07638889	0.12	0.9487
Biochar & Fertilizer	9	4.18750000	0.46527778	0.72	0.6866
	Dry Matter Yield				
Biochar	3	1318.175000	439.391667	59.11	<0.0001
Fertilizer	3	437.461667	145.820556	19.62	<0.0001
Biochar & Fertilizer	9	307.253333	34.139259	4.59	0.0006
	Root: Shoot Ratio				
Biochar	3	2.76562500	0.92187500	5.31	0.0044
Fertilizer	3	0.39895833	0.13298611	0.77	0.5219
Biochar & Fertilizer	9	7.87854167	0.87539352	5.04	0.0003

The interaction was however significant for dry yield and root matter: shoot ratio. The data presented in Table 6 indicated that increased addition of biochar to a given level of inorganic fertilizer resulted in increase in seedling dry matter production, thus enhancing the use of efficiency of the fertilizer. The combined effect of inorganic fertilizer (90 kg Nha^{-1}) and saw dust biochar (20 t Cha^{-1}) produced the highest seedling dry matter when compared to any other inorganic fertilizer-biochar combination level. At this level of inorganic fertilizer biochar combination, seedling dry matter yield was more than 60% of the yield when inorganic fertilizer was applied alone at this level. Therefore, for full realization of Moringa plant growth potentials, complimentary use of inorganic fertilizer and saw dust biochar is recommended. A look at Table 6 also shows that dry matter yield at the maximum biochar application level of 20 t Cha^{-1} (35.2g) was close to the yield recorded at the combined maximum application level of biochar (20 t Cha^{-1}) and inorganic fertilizer (20kgNha^{-1}) (41.6g), implying a possibility of biochar displacing or greatly reducing requirement for mineral fertilizers in tree seedling production.

Nursery tree seedlings having root: shoot ratios of 1 or higher are to be preferred as they are believed to withstand drought better when planted than the ones with lower ratios (Wilde et al, 1972). Review of literature has shown that root: shoot ratioof most tree seedlings produced with inorganic or organic fertilizer, even those in the untreated control, are usually lower than 1 due to the production of higher shoot at the expense of root (Fagbenro and Agboola, 1993; Fagbenro et al, 2011).Table 6 has however shown that the root: shoot ratio of Moringa seedling was greater than 2 for the untreated control and about 4 for the fertilized ones.

Table 6: Interaction effects of saw dust biochar and NPK 15:15:15 inorganic fertilizer on dry matter yield and root: shoot ratio of 13-week old *Moringa oleifera* seedlings grown in Oxisol.

Fixed Biochar Level (t Cha^{-1})	Levels of NPK (KgNha^{-1})	Dry Matter (g)	Root: Shoot Ratio
0	0	11.0c	2.6c
0	22.5	22.3b	3.5b
0	45	22.8b	4.1a
0	90	25.6a	3.6b
5	0	21.2d	4.3a
5	22.5	24.4c	3.8b
5	45	26.0b	4.4a
5	90	27.4a	3.5b
10	0	22.3c	4.5a
10	22.5	27.7b	3.6b
10	45	28.9a	3.5b
10	90	29.0a	4.0a
20	0	35.2b	4.5a
20	22.5	30.3c	3.9b
20	45	32.2c	3.6b
20	90	41.6a	4.1a
	SE	2.9	0.5

Table 6 has however shown that the root: shoot ratio of Moringa seedling was greater than 2 for the untreated control and about 4 for the fertilized ones. This is a departure from the norm. This result is probably due to the fact that Moringa seedling has a bulbuous (tuberous) root that tends to be heavier than its shoot. This rooting system probably explains why Moringa survives better in soils where nutrients or water may be inadequate. Further research is certainly needed to throw more light on the ecological importance of the peculiar rooting system of Moringa.

CONCLUSIONS

The application of either saw dust biochar or NPK 15:15:15 inorganic fertilizer significantly stimulated the growth of Moringa seedlings and can therefore be used complimentarily to produce vigorous Moringa seedlings. Saw dust biochar is capable of rendering a near maximum dry matter productivity with or without NPK inorganic fertilizer. Taken from the point of view of cost and efficiency, biochar therefore constitutes an organic amendment which could be considered as an organic fertilizer in tree nurseries when compared to the costly inorganic fertilizer and the traditional organic materials such as animal manures that are now becoming increasingly more scarce and costly in the country. However, further systematic studies are required on the response of Moringa to biochar and inorganic fertilizer amendments in different soils.

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REFERENCES

Aluko, A. P. (1982) "Mineral nutrition of *Terminalia ivorensis* and *Terminalia superba* seedlings grown in a typical forest soil of Southwestern Nigeria".*M.Phil. Thesis,* University of Ife, Nigeria.

Aubert, G. and Tavenier, R. (1972) "Soil survey". In: *Soils of the Humid Tropics*. Washington D.C, National Academy of Sciences, p. 17-34.

Chidumayo, E. M. (1994)"Effects of wood carbonization on soil and initial development of seedling in miombo woodland, Zambia".*Forest Ecol. Management*. 70: 353-357.

CTA (Technical Centre for Agricultural and Rural Cooperation) (2008) "Moringa on two wheels".*Spore Magazine*, No. 135, June 2008: 5.

Duke, J. A. (1983). *Handbook of Energy Crops*.Unpublished Retrieved from http://www.hort.purdue.edu/new/crop/duke_energy/Moringa_oleifera.htmlon19 November, 2009.

Fagbenro, J. A. (1988) "Studies on the extraction of soil organic matter and the effect of humic acid on the growth of Teak (*Tectona grandis* Linn.F) seedlings". *Ph.D. Thesis*, University of Ibadan, Nigeria.

Fagbenro, J. A. (2000b) "Analysis and use of organic materials".In : *Proceedings of the 26th Ann. Conf. of the Soil Science Soc. of Nigeria* (c-ed Babalola, Akinlolu), p. 141-154.

Fagbenro, J. A. (2001b) "Effect of inorganic and organic NPK fertilizers on the growth of three tropical hardwood seedlings grown in an Ultisol". In: *Proceedingof an International Conference on Nursery Production and Stand Establishment of Broad-leaves to Promote Sustainable Forest Management*(ed (s) Ciccarese, L. and Finno, A.) Rome, Italy. International Union of Forest Research Organization (IUFRO), Italian Environmental Protection Agency (ANPA) and Dalarna University (Sweden), p. 79-91.

Fagbenro, J. A. and Aluko, A. P. (1987) "Fertilizer use in the production of trees in Nigeria". In: *Proceedings of a National Fertilizer Seminar: Towards efficiency of fertilizer use and development in Nigeria*, Port Harcourt, October 28 -30, 1987, p. 202-215.

Fagbenro, J. A. and Agboola, A. A.(1993)"Effect of different levels of humic acid on the growth and nutrient uptake of Teak seedlings".*Journal of Plant Nutrient*. 16(ISS.8): 1465-1483

Fagbenro, J. A., Banjo, A. O. and Oshunsanya, S. O. (2012a) "Effect of amended composted saw dust on the growth of Gmelina arborea seedlings". *Environtropica Journal*, 8: 81-89.

Fagbenro, J. A., Salami, B. T., Oshunsanya, S. O. and Aduayi, E. A. (2012b)"The potential and promise of biochar, for sustainable soil productivity and crop production". *Environtropica Journal,* 8: 90-111.

Fahey, J. W. (2005) "*Moringa oleifera*: A Review of the Medical Evidence for its Nutritional, Therapeutic and Prophylactic Properties". Part 1.*Trees for Life Journal*, 1:5.

FAO/UNESCO (1997) "Soil Nap of the World 1:5,000,000". Paris: *UNESCO Publication*, Vol. VI, Africa.

Flaig, W. (1975). "Biochemistry of Soil Organic Matter". In: *Organic Materials as Fertilizers*. *FAO Soil Bulletin* 27: 31-69.

Foidl, N., Makkar, H. P. S. and Becker, K. (2001). "The potential of Moringa oleifera for agricultural and industrial uses. In:*The Miracle Tree/The Multipleattributes of Moringa* (ed Lowell, J. Fuglie). New York,Publication of CTA.

Freeman, P. G. (1975) "The effect of some coal-derived humates on the growth of tomato plants in hydroponic culture". *International Bulletin of Coal Research Laboratory*, Bureau of Mines, Grand Forks, ND.

Gundale, M. J. and DeLuca, T. H. (2006). "Temperature and source material influence ecological attributes of Ponderosa pine and Douglas Fir charcoal".*Forest Ecology and Management*. 231: 86-93.

Hoshi, T. (2001). "Growth promotion of tea trees by putting bamboo charcoal in soil". In: *Proceedings of 2001 International Conference on O-cha (Tea): Culture and Science*. Tokyo, Japan: 147-150.

Hsu, R. S., Arbainsyah, Midcap and Witte, L. De (2006)"International Course on Economic Botany", September, 2006. *National Herbarium Leiden*, Netherlands, 18pp.

IITA (International Institute of Tropical Agriculture) (1982) "Automated and semi-automated methods for soil and plant analysis". IITA, Ibadan. *Manual series No. 7*.

Jahn, S. A. A. and Dirar, H. (1979)"Studies on natural co-agulants in the Sudan with special reference to Moringa oleifera seeds".*Water SA*, 5: 90.

Lehmann, J. and Joseph, S. (2009a) "Biochar for Environmental Management: An introduction". In:*Biochar for Environmental Management* (ed (s) Lehmann, J. and Joseph, S.) 416 pp. London: Earthscan Publishers.

Liang, B., Lehmann, J., Solomon, D., Kinyangi, J., Grossman, J., O'Neil, B., Skjemstad, J. O., Thies, J., Luizao, F. J., Petersen, J. and Neves, E. G. (2006)"Black carbon increases cation exchange in soils". *Soil Science Society of America Journal*. 70: 1719-1730.

Maroyi, A. (2005) "The utilization of Moringa oleifera in Zimbabwe". *Trees for LifeJournal*, 1: 5.

Ogawa, M., Yamabe, Y. and Sugiura, G. (1983) "Effects of charcoal on the root nodule formation and VA mycorrhiza formation of soy bean".*The Third International MycologicalCongress (IMC3), Abstract 578*.

Olagunju, F. B. and Ekwebelam, S. A. (1985) "Forest Nursery Practice in Nigeria". *ForestryResearch Institute of Nigeria Research Monograph No. 13.*

Uzoma, K. C., Inoue, M., Andry, H., Fujimaki, H., Zahoor, A. and Nihihara, E. (2011) "Effect of cow dung biochar on maize productivity under sandy soil condition".*Soil Use and Management* 27: 205-212.

Wilde, S. A., Voight, G. K. and Iyer, J. G. (1972) "*Soil and plant analysis for tree culture",*172pp, New Delhi and Oxford. IBW Publishing Co.