EFFECT OF NITROGEN, PHOSPHORUS FERTILIZERS AND MYCORRHIZAL NODULATION ON THE GROWTH AND YIELD OF TREE SEEDLINGS

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Abstract: Soil enrichment in the nursery and established fields are unavoidable. Deforestation and desertification as an agent of edaphic destruction in parts of the country call for the soil and soil restoration. This will assist in improving the yield and growth vigour of seedlings and tree. This study surveyed the effects of nitrogen, phosphorus and nodulation formation on the growth of the seedlings and stands. Fertilizer recommendation for soils and tree seedlings is a dynamic process in view of generation of the new knowledge, changes in the soil nutrient status, changes in plants and planting patterns and associated management practices. Application of nitrogenous and phosphorus fertilizers are more importance practice in nursery establishment. *Faiherbia albida* and *Leucanea leucocephala* observed to fix nitrogen to the soil while mycorrhiza is essential for *Pinus caribea* (Pines) propagation. Training and educative programmes are essential for the forest workers in order to boost productivity and exposed them to nursery techniques. Concerned people and organizations must provide farm inputs, incentives and subsidies to the forest nurseries operators and farmers where and when necessary.

Keywords: Tree seedlings, mycorrhizal nodulation, phosphorus fertilizers, yield

Introduction

Soil nutrient is a substance taken by a cell from its environment and used in catabolic or anabolic reaction with soil to the plant (Patel, 2008). It is the physical properties of forest soils developed under natural conditions by the influence of permanent vegetation over a long period of time. Physical properties of forest soils may be its permanent properties unless modified by harvesting operations, shifting cultivation and forest fires. Important physical properties of forest soils include texture, structure, porosity, density, aeration, temperature, water retention and movement. The physical properties of forest soils affect every aspect of soil fertility and productivity (Osman, 2013). The interaction of numerous physical, chemical and biological properties in soil controls plant nutrient availability. Understanding these processes and how they are influenced by environmental conditions assist in optimizing nutrient availability and plant productivity. Nutrient supply to plant roots is a very dynamic process. Plant nutrients (cations and anion) are absorbed from the soil solution by plant roots which also release small quantities of ions (H^+, OH^- and HCO_3^-). All aqueous solutions (soil water or plant cell water) must be electrically neutral where an equal number of ions with positive (cations) and negative (anions) charges are present (Patel, 2008).

Thus, if there is an imbalance in cation and anion uptake in plant root cells, these cells release cations or anions depending on the imbalance. This process can influence soil solution pH (John *et al*., 2013). Soils also contain minerals that can dissolve to resupply the soil solution. Addition of nutrients or ions through fertilization or other inputs increases ion concentration in the soil solution. Although, some of the added ions remain in solution, some are adsorbed to mineral surfaces or precipitated as solid minerals. As soil microorganisms degrade plant residues, they remove adsorb ions from the soil solution into their tissue. When microbes or other organisms die, they release nutrients back to the soil solution. Microbial reactions are important to plant nutrient availability as well as other properties related to soil productivity (John *et al*., 2013).

Efficient nutrient management programs supply plant nutrients in the adequate quantities to sustain maximum plant growth and yield while minimizing environmental impacts of nutrient. Substantial economic and environmental consequences occur when nutrient availability through effective nutrient management practices requires knowledge of the interactions between the soil, plant and environment (John *et al*., 2013). The objective of the surveyed research is to determine various kinds of nutrient at appropriate level suitable for yield, seedlings growth and stand development.

Impact of mycorrhizal innoculation

Mycorrhiza represents symbiotic association between certain fungi and plant roots which enhances the uptake and nutrients; associated with the hyphae of either an ectotrophic or endotrophic fungus. The ectotrophic fungus forms a sheath or fungal material around rootlets. These are found in the tropics among members of *Dipterocarpaceae* and *Caesalpiniacea* and few tropical representatives of *Fagaceae, Pianaceae* and *Myrtaceae. Theendotrophic* fungi form no sheath but its filaments grow within and between the epidermal and cortical cells and extend to the soil. Another symbiotic association of silvicultural importance is that between the root of most legumes and bacteria. The bacteria derived food, nutrients and water from the legume (Wilson, 1937). Attempts to introduce Pines into region where the soil was not highly fertile and the proper symbiont was lacking have almost in variably ended in conspicuous failure (Daubenmire, 1959). The importance of mycorrhizae to these pines and forest tree species seems to be that they are highly efficient accumulators of nutrient ions which subsequently become available both to the host tree and to the fungus (Melin, 1962). Most mycorrhiza requires carbon for their nutritional obligation and the most favourable carbon source for growth are glucose and other simple sugars. The mycorrhiza depends exclusively on the supply of simple carbohydrate. Since a number of species found to utilize it, particularly if they are supplied with small quantity of glucose and some undoubtedly produce cellulose, hemicelluloses and amylases (Lamb, 1999). The ability to produce this exo-enzyme varies widely with very little exception; product is not as great as that found in free living Basidiomycetes lead litter (Linderberg, 2000). From the result of experiment conducted it could be concluded that, *Faidherbia albida* had greater affinity to form association with Bacteria over *Acacia senegal* and *Leucanea leucocephala*. Thus, *Faiherbia albida* could fix more nitrogen than other nitrogen fixing tree species (Ilu *et al*., 2013).

Table 1: Soil potting mixtures application in some forest nurseries

Location	Soil component (parts per volume)	Fertilizer and insecticides (m^3)
Bukuru (Plateau State)	4 Fine sand; coarse sand , 4 composted cow manure	454 -500 totalfert +1 kg dieldrin, 2% dust +250 borate/m^3
Naraguta (Plateau State)	4 Fine sand , 1 coarse sand , 4 composed cow manure, 1 loamy forest soil	454 – 590 g $(NH_4)_2SO_4$, 590 g Single Super Phosphate, 295 g murate of potash and 2% dieldrin dust
Ibadan (Oyo State)	River sand (1)	1.5-1.7 kg each of Single Super Phosphate (granular) bone meal and horn flakes
Zaria (Kaduna State)	2 River sand , 1 cow manure	2.4 kg totalfert, 1.2 kg (2% dieldrin)
Jakarade (Kano State)	4 Top soil, 3 cow manure	885 g NPK, 590 g dieldrin dust
Kano (Kano State)	4 Top soil, 3 well-rooted pig manure	885 g NPK and 590 kg dieldrin

Source: Nwoboshi (1982); Fagbenro and Aluko (1987)

Effect of nitrogen

Nitrogen is one of the macro-nutrients required by plants for its optimum growth. It is an essential component of protein in a living plant. Nitrogen encourages over ground vegetation growth and also influences the deep green colour of the plant. It also helps in the formation of starch for plant use. The mere fact that Nitrogen is abundant in the atmosphere does not means that it can be taken in directly by plants and brings about the need for fertilizer application. Application of inorganic fertilizers at the rate of 15.0 g of Urea enhanced the production of healthy and vigorous *Enterolobium cyclocarpum* seedlings because it had the highest values for height growth, root length and also stem diameter of *Enterolobium cyclocarpum* seedlings (Salami, 2015). It was also reported that the NPK (15:15:15) 3 – 4 g/pot go a long way to produce very healthy and strong *Treculia africana* shoot height as a parameter (Salami *et al.,* 2018). According to (Fagbenro and Aluko, 1987) observed that shoot height, dry matter production, leaf size and number as well as chlorophyll contents were best for *Dalbergia latifolia*, *Terminalia ivorensis*, *Gmelina arborea* and *Terminalia superba* when Ammonium nitrate was the source of Nitrogen (Table 3). This was followed by calcium nitrate and potassium and potassium and nitrate than Ammonium sulphate while the least response was observed from the Nitrogen Free Source (control). Application of six fertilizers with ratio of NPK (3:2:1): Nitrogen application at 480 mg/plant, Phosphorus application at 320 mg/plant and Potassium application at 160 mg/plant was the most suitable fertilization method for plant growth (Shixin *et al.,* 2019). Based on his observations, Adebagbo (1981) suggested that adequate Nitrogen fertilization be developed on extensive soil test and knowledge of the nutrition requirement of the individual plant species. Jose (2003) also reported high loses of phosphorus and mineral uptake may lead to poor cell differentiation and multiplication. There were no significant differences in stem diameter produced by seedlings during the experiment. However, the best treatment combination recorded was NPK 10 g. This indicates that nitrogen and phosphorus play important roles in stem diameter formation. Pinkard *et al.* (2007) working with reported for *Eucalyptus globules*, reported that seedling collar diameter increment did not show significant differences (P>0.05) with nitrogen application. Seedling collar diameter increments for fertilized seedlings were generally better than those of the control experiment. Burslem *et al.* (1995) and Gbadamosi, (2006) also reported similar results for tree seedlings. Table 2 presented data of the effect of sources on the growth of the four tree seedlings. Aluko and Aduayi (1984) have carried out pot culture experiments for predicting fertilizer requirements of *Terminalia ivorensis* and *Terminalia superba*. They found that application of 100 and 200 ppm Nitrogen for *Terminalia ivorensis* and 200 and 400 ppm Nitrogen for *T. superba* increased shoot height, stem diameter, leaf production and induced healthy growth of the seedlings in an alfisol, *Terminalia superba* was found to be tolerant to high Nitrogen application while *T. ivorensis* was not. Similarly, the best response in terms of morphological growth was obtained at 100 ppm phosphorous applied in the form of single super phosphate. Xiankai, (2010) observed that low-to-medium levels of N addition (100 $kgNha^1yr^1$) generally did not alter plant diversity through time, high levels of N addition significantly reduced species diversity. Emerhi and Nwiisuator (2014) observed that mean values of nitrogen content of wood, bark and leaves were 0.5743 and 1.02668. The effect of sites on nitrogen content of wood and bark of the mangrove species was significant (P<0.05) but not significant (P>0.05) in the leaves. This agrees with results found by Orman and Will (1960).

Table 2: Mean performance of selected species at the seedling stage

Species name	Germination (%)	Shoot-length (cm)	Root length (cm)	Nodule form
Faiherbia albida	60	30.9	21.2	14
Leucanea leucocephala.	45	30.2	20.2	12
Acacia senegal	40	26.4	19.4	14

Source: Ilu *et al*. (2013)

However this was not consistent in all the samples drawn. Wood nitrogen content was not significantly affected by tree size. The nitrogen content of trees of the same species within the same diameter class (a) varied significantly in bark and leaves. Nitrogen contents for sapwood and heartwood were not significantly different. Nitrogen contents did not vary significantly along the bole in both wood and bark. The nitrogen contents of leaves sampled from different position within the crown were not significantly different (P>0.05). Salami *et al.* (2019), also observed that the results of growth performance showed that there was significant difference (P=0.05) across all level nitrogenous fertilizers applied in the early growth performance of *Balanities eagyptiaca*. The shoot height showed that the seedlings performed better in NPK (10 g) followed by NPK (5 g), control (soil application), Urea (5 g) and Urea (10 g). Leaf area also showed that there was significant difference (P=0.05) across all fertilizers applied.

Table 3: Effect of different sources of Nitrogen on various growth characters of selected species treated for twelve (12) weeks

Species	Leaf numbers at final harvest	Leaf area (cm^2)	Leaf dry weight (g)	Shoot dry weight (g)	Root dry weight (g)	Shoot root Ratio
		Control(nil N)				
Dalbergia latiofolia	11	68.66	0.317	0.240	0.278	0.86
Terminalia ivorensis	10	68.47	0.242	0.142	0.519	0.27
Gmelina arborea	13	85.68	0.391	0.343	0.992	0.34
Terminalia superb	6	47.31	0.150	0.207	0.347	0.60
Means	**10**	**67.53**	**0.275**	**0.233**	**0.534**	**0.52**
	Potassium nitrate		**KNO_3**			
D. latifolia	10	65.03	0.247	0.246	0.312	0.79
T. ivorensis	31	963.39	4.270	2.113	3.874	0.55
G. arborea	15	830.36	5.191	4.256	7.234	0.59
T. superb	13	481.97	1.949	1.207	1.776	0.68
Means	**17**	**585.19**	**2.914**	**1.956**	**3.299**	**0.65**
	Calcium nitrate		**$Ca (NO_3)$**			
D. latifolia	8	59.94	0.575	0.314	0.189	1.66
T. ivorensis	28	702.74	2.519	0.998	1.725	0.58
G. arborea	37	1758.00	7.294	7.346	8.662	0.85
T. superb	14	660.09	2.678	1.775	2.018	0.88
Means	**22**	**795.19**	**3.266**	**2.608**	**3.149**	**0.99**
	Ammonium nitrate		**$(NH_4)_2SO_4$**			
D. latifolia	8	70.98	0.329	0.237	0.218	1.09
T. ivorensis	27	776.38	2.740	1.392	1.602	0.87
G. arborea	17	282.59	1.233	0.999	1.660	0.59
T. superb	14	410.81	1.787	0.887	1.174	0.76
Means	**17**	**385.19**	**1.522**	**0.874**	**1.164**	**0.83**
	Ammonium nitrate		**$(NH_4)_2SO_3$**			
D. latifolia	16	180.66	0.738	0.334	0.287	1.16
T. ivorensis	30	1063.70	3.459	1.356	1.664	0.82
G. arborea	31	1667.20	9.342	3.819	8.235	0.46
T. superb	15	776.27	3.969	1.862	1.966	0.95
Means	**23**	**921.96**	**4.377**	**1.843**	**3.038**	**0.85**

Source: Fagbenro and Aluko, (1987)

Table 4: Level of nutrient applied

Commercial fertilizers	Elements	0 kg/ha Level 1	50 kg/ha Level 2	175 kg/ha Level 3	300 kg/ha Level 4
Urea 46% of Nitrogen	N	0	0.1683	0.6416	1.100
TSP 48% of P_20_5	P	0	0.1733	0.6300	1.0797

Source: Rafiqul Hoque *et al.* (2004)

Application of N significantly affected survival percentage, collar diameter fresh root, fresh shoot weight, total leaf area, dry matter production (root, shoot and leaf) and total biomass of the seedlings. Different levels of N and P applied are given in Table 4. The effect of P was generally not significant. Though there were some differences due to different fertilizer doses the interaction effects of both N and P were not significant on any parameter measured with *Antho cephalus* Chinensis (Rafiqul Hoque *et al.,* 2004)

Impact of phosphorus

Phosphorus is relatively immobile with little leaching to ground water in most mineral soils; P in poultry waste is rapidly hydrolyzed and chemically precipitated or adsorbed. Phosphorus management for high applications should be based on the chemical, physical and biological reactions of P in soil (Edwards and Daniel, 1992; Reddy *et al.,* 1978). The amount of p in the soil depends on precipitation/adsorption reactions, mineralization have shown little focus on p as compared with N transformations in poultry waste amended soils (Edwards and Daniel, 1992; Sharpley *et al.,* 1994). Phosphorus is found in Organic and inorganic soluble and insoluble forms. In some soils water soluble inorganic P is rapidly converted into water insoluble P (Reddy *et al.,* 1980). Total phosphorus (p) in surface soil varies from 0.005 to 0.15% and decreases with increasing weathering intensity. This total soil p is much lower in humid and tropical region soil. Unfortunately, the quantity of total soil P has little or relationship to P availability. Therefore, understanding the relationships and interactions of p in the soils and the factors that influence availability to plant is essential for efficient p management and protection. The most common visual symptoms include overall stunting of the plant and a darker green colouration of leaves. With increasing p deficiency the darker green colour changes to a greyish green to bluish green metallic luster. Emerhi and Nwiisuator (2014) who observed that overall mean values phosphorus contents for wood bark and leaves in the mangrove species were 0.04088, 0.06215 and 0.06928% dry weight of wood, respectively. There was no significant differences ($P<0.05$) between the species and tree sizes (Table 1). There was also significant difference ($P<0.05$) between the wood in radial and axial direction.

Problems with use of fertilizers in forestry

Despite the fact that inorganic fertilizers are generally recognized and acceptable as a means of improving the soil fertility, some limitations come into focus and this discourages its usage in both agricultural and forest tree production. Even with positive responses observed, no government or private organizations in Nigeria are committed to investment in forest development. More than any other consideration, the problems with forest fertilizer is economic. From all indication inorganic fertilizers are likely to become increasingly more expensive. Another gap is that illiterate farmers and nursery workers find inorganic fertilizers most difficult to apply correctly. Leaf deformation and complete cutting up of tree seedlings can be negatively affect the increment in acidity of the soil which is due to application of inappropriate quantity and wrong inorganic fertilizers (Salami *et al.,* 2018). In the circumstances, the judicious utilization of locally available organic materials for tree seedlings production will more than complement the use of chemical fertilizers. The Increased in the use of organic materials such as poultry manure, cow dung, saw dust and municipal refuse which are abundant in the country offers a possibility for effectively supplementing soil nutrients for plant requirements (Fagbenro and Aluko, 1987).

Conclusion

Positive responses have been obtained in a number of fertilizer experiment works. The responses to nitrogen and phosphorus fertilizers and some trace element fertilizers lead to the belief that significant success can be achieved in improving site quality through their uses. Therefore, for substantial increased in the tree seedlings and stands yield. Nitrogen and Phosphorus are needed in all the soils. Soils and leaf analyses are important tools in the rational and belief of the seedlings and tree. Agrochemicals and other agricultural inputs are expensive and have not always been available in good time for the best results. Also, Agrochemical industries should be accessible to forest nurseries with less expensive rate to reduce production cost. State government should accede to request of entrepreneurs with good industrial outreach programmes by subsidizing raw materials for industrial use. Provision of more fertilizer warehouses is inevitable. Federal Government through Forestry Research Institute of Nigeria must able to discharge their duties by providing awareness and training on importance of chemical fertilizer. State government, agricultural banks and Non-Governmental Organization should assist foresters and farmers with interventions such as provision of agrochemicals, other farm inputs and subsidize.

Conflict of Interest

Authors declare there is no conflict of interest related to this study.

References

Aluko AP & Aduayi EA 1983. Response of forest tree seedlings (*Terminalia ivorensis*) to varying levels of nitrogenous and phosphorus. *Journal of Plant Nutrient.* 6(3): 219-237.

Burslem DF, Grubb PJ & Turner IM 1995. Responses to nutrient addition among shade tolerant tree seedlings of lowland tropical rain forest in Singapore. *Journal Tropical Ecology,* 83: 113-122.

Daubenmire RF 1959. *Plants and Environment. A Textbook of Plant Autecology*. John Wiley and Sons Inc 422pp

Edwards DR & Daniel TC 1992. Environmental impacts of on-farm poultry waste disposal – A review. *Biol. Reso. Techn.,* 4(41): 9-33.

Emerhi EA & Nwiisuator D 2014. Evaluation of Phosphorus and total Nitrogen contents of mangrove species in Niger delta. Proceedings of the 37th Annual Conference of Forestry Association of Nigeria held in Minna, Niger State 9th- 14th November 2014. Pp -57

Fagbenro JA & Aluko AP 1987. Fertilizer use in the production of forest trees in Nigeria. Proceedings of the National fertilizer seminar, held at Port-Harcourt. October 28-30. Theme: Towards efficiency of fertilizer use and development in Nigeria.

Gbadamosi AE 2006. Fertilizer response in seedlings of medicinal *Enantia chlorantha* Oliv. *Tropical Subtropical Ecosystem,* 6: 11-115.

Ilu, K.J, Sani MS, Yau IA & Imam M 2013. Germination, Growth and Nodulation studies in three nitrogen fixing tree species, proceedings of the 36th Annual Conference of the Forestry Association Nigeria held in Uyo, Akwa Ibom State Nigeria, pp. 436-439.

John LH, Samuel LT, Weiner LN & James DB 2013. Soil fertility and fertilizers: Introduction of Nutrient Management 8th edition, pp. 185-221Melin, E, 1962.

Jose LM 2003. Nitrogen and Phosphorus reabsorption in tree of Neo-tropical rain forest. *Journal of Tropical Ecology,* 19: 465-468.

Lamb RJ 1999. In C Roderic(ed). The Biology of Symbiotic Fungi, pp. 253-255.

Lindeberg G 2000. Tran Elr Mycological society, 63:295-306.

Nwobochi LC 1982. Tropical Silviculture. Principles and Techniques. Ibadan University Press Publishing House University of Ibadan, Ibadan, Nigeria.

Orman HR and & Will GH 1960. The nutrient content of *Pinus radiate* trees. *NZJ Science,* 3: 510-522.

Osman KT 2013. Forest Soils, DOI 10.1007/978-3-319-02541-4_2, © Springer International Publishing Switzerland.

Patel SV, Golakiy A, Savalia SG & Gajera HP 2008. A Glossary of Soil Sciences. International Book Distributing Co., p. 330.

Pinkard EA, Ballie C, Patel V & Mohammed CL 2007. Effects of fertilizing with Nitrogen and Phosphorus on growth and crown condition of *Eucalyptus globolus* Labill. experiencing insect defoliation. *Forest Ecology Management,* 4(231): 131-137.

Rafiqul Hoque ATM, Hossain MK, Mohiuddin M & Hoque MM 2004. Effect of inorganic fertilizers on the initial growth performance of *Anthocephalus chinensis. J. Appl. Sci.. Asian Network for Scientific Inform.,* 4(3): 477-485.

Reddy KR, Overcash MR, Khalel R & Westerman PW 1980. Phosphorus adsorption description characteristics of two soils utilized for disposal of animal wastes *Journal Environment,* 7(9): 86-92.

Salami KD 2015. Comparative effect of Nitrogenous and Phosporous fertilizers on the Growth of *Enterolobium cyclocarpum* Jacq Seedlings. Nigeria Tropical Biology Association (NTBA) 2015. Conservation in 21st Century Nigeria: Transcending Disciplinary Boundaries, Vol 2. 5th Annual Biodiversity Conference held at Federal University of Technology, Akure (FUTA) from 19 – 20 May, 2015, pp. 265-268

Salami KD, Jibo AU & Lawal AA 2018. Effects of Organic and Inorganic Fertilizer on the Early Growth Performance of *Treculia africana*. LINN (AFRICAN BREAD FRUIT). *Dutse J. Agric. and Food Security* (DUJAFS), 5(2): 28-36.

Salami KD, Odewale MA, Gidado AH & Adam ZA 2019. Pre-germination treatments on seeds of *Balanites aegyptiaca* (L) Delile and influence of potting mixtures on the early growth. *J. Forestry Res. and Mgt.,* 16(1).107-117; www.Jfrm.org.ng

Sharplay AN, Chapra SC, Wedepoli R, Sims JT Daniel TC & Reddy KR 1994. Managing agricultural phosphorus for protection of surface waters. issue and options. *Journal Environmental Quality,* 5(23): 437-451.

Shixin Deng, Kankan Shi, Jian Ma, Lili Zhang, Luyi Ma & Zhongkui Jia 2019. Effects of fertilization and frequencies on the growth and Nutrient uptake of *Magnolia wufengensis* (Magnoliacea). *Forests* 2019(10): 65, doi 10.3390/f10010065.

Xiankai LU, Jiangming MO & Frank SG 2010. Effects of experimental Nitrogen additions on Plant Diversity in an Old-growth Tropical Forest. Marshall University Marshall Digital Scholar Biological Sciences Faculty Research.