Global Scientific JOURNALS

GSJ: Volume 8, Issue 9, September 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

ASSESSMENT OF MINERAL NUTRITION OF *Albizia lebbeck* SEEDLINGS ON ORGANIC MEDIA ENRICHED SOIL

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ABSTRACT

Forest soil is the growth media used in raising seedlings in Nigeria. Poor growth media in tree nursery establishment has been reported as the major cause of poor seedling establishment in nurseries. This research evaluated the potential of forest soil and organic materials as potting media for seedlings establishment. The experiment was laid out in a completely randomized design with five treatments comprising of: Forest soil (Medium A); Sawdust with cattle manure in the ratio of 1:1 by weight (Medium B); Forest soil with cattle manure - sawdust mixture (1:1) in the ratio of 1:1 (Medium C); Forest soil with cattle manure - sawdust (1:1) mixture in the ratio of 1:2 (Medium D); and Forest soil with cattle manure - sawdust (1:1) mixture in ratio of 1:3 (Medium E). The treatments were replicated three times in research plots of 100 seedlings per treatment. Seedlings were allowed to grow for 24 weeks while growth parameters and nutrient concentration were monitored. Enrichment of Forest soil with Sawdust and Cattle manure at different ratios increased nutrient concentrations in the media and dry matter biomass compared to those with only forest soil. There is urgent need to develop strategies for mixing organic materials with forest soil which will improve the growth of tree seedlings.

Key words: Growth Medium, Cattle manure, Forest soil, Sawdust, Tree seedlings, Nutrient uptake

Introduction

Soils collected from forest floor have been reported to be deficient in essential plant nutrients such as nitrogen and phosphorus (Vitousek and Sanford 1986). Nutrients in forest soils have declined due to pollution, agricultural activities, and tree harvesting (Binkley and Fisher, 2012). Due to this decline, seedlings raised in such soils suffer from poor growth and survival in the nursery. Evans, (1983), recommends addition of small quantities of essential macro elements to supplement nutrient deficiency in the soils during preparation of potting media. No standard tree seedlings potting media is applied in most tree nurseries in Nigeria. Studies by Kungu *et al.* (2008) showed that compost-based nursery media gave the highest seed germination percentage as compared to farm soil which gave the lowest seed germination percentage. Studies done by Depardieu *et al*., (2016), have shown that sawdust, despite being an inert media, when mixed with other substrate, can form a soilless growing system for producing bare-root seedlings, due to its ability to retain nutrients. Forest soil with organic matter has also been shown to enhance water retention in media leading to enhanced growth of seedlings (Oades, 1988). Saw dust has largely been considered as a waste product in forestry system (Onchieku *et al*., 2013), though it does not harbor microorganisms due to its low nutrient content (Okalebo *et al.*, (2002), it can provide nutrients over a long period if decomposition is managed

appropriately by mixing with nutrient rich medium. Cattle manure is an ideal component for mixing with sawdust to enhance its decomposition. High concentration of macro nutrients in cattle manure can provide initial nutrients required for decomposition of sawdust and for growth of seedlings (Tanimu *et al*., 2013). Since chemical, physical and composition nature of nursery media regulate seedling growth, and affect rates of organic matter decomposition, it affects survival of the seedlings and productivity. There are minimal data on alternative nursery potting media of tree seedlings other than the convectional growth media comprising of forest soil. This study sets out to evaluate alternative nursery media with comparative assessment of *Albizia lebbeck* seedlings performance using forest soil and organic mixtures of sawdust and cattle manure as potting media.

Materials and Methods

Nursery potting media

The potting media were prepared by mixing forest soil and organic materials. The five mixtures of soil and organic materials used are described in detail in Table 1. Forest soil was collected from the surface layer of 0-15cm depth from the natural forest stands of *Terminalia superba*. The soil was mixed thoroughly, air dried under shade and sieved to pass through 8mm sieve to remove large plant materials, then weighed for media preparation.

Sawdust was collected from nearby timber processing sawmills and sorted to remove wood debris. Cattle manure was collected from different cattle rearing farms, mixed together to obtain a homogenized sample. The sawdust, forest soil and cattle manure were weighed according to treatment mixtures based on weight ratios. The treatment mixtures were covered with polythene sheet and allowed to decompose for three months under shade. After three months, 200g each of the media was weighed into polythene bags measuring 3'by 4'and planted with *Albizia lebbeck* seedlings pricked from germination bed.

Table 1: Treatment description showing the growth media mixtures and ratios used in the study

Treatment Code	Treatment Description	Mixture Ratios		
		Farm Soil	Cattle Manure	Sawdust
MA	Forest soil	1	-	-
MB	Sawdust + cattle manure in the ratio 1:1 by weight	1	1	-
MC	Forest soil + (cattle manure + sawdust) (1:1) in the ratio 1:1 by weight.	1	0.5	0.5
MD	Forest soil + (cattle manure + sawdust) (1:1) in the ratio of 1:2 by weight	1	1	1
ME	Forest soil + (cattle manure + sawdust) (1:1) in ratio of 1:3 by weight	1	1.5	1.5

MA-Medium A, MB-Medium B, MC-Medium C, MD-Medium D, ME-Medium E.

Tree seedling

Fifty (50grams) of *Albizia lebbeck* seeds were acquired from Forestry Research Institute of Nigeria. The seeds were sown in a seed bed of sand a week before the completion of decomposition period of the nursery growth media. After germination the seedlings were allowed to grow for 14 days and on the 15thday after germination, they were

pricked out, into polythene bags. Three hundred (300) polythene tubes of size 3'by 4' were filled with the growth media (200g) for each of the treatment described in Table 1 and arranged in an experimental unit of 100 seedlings per replicate. The layout comprised of seedlings established in a completely randomized design with three (3) replicates each. Seedlings were allowed to grow for 24 weeks and watering was done once daily. The removal of weed was performed manually. Seedlings growth parameters including height and root collar diameter and biomass accumulation were measured at interval of four-weeks.

Assessment of Parameters

Seedling shoot height, root collar diameter and biomass were measured at an interval of 4 weeks for a period of 24 weeks. A total of 75 randomly sampled seedlings treatment (5 from each replicate) was sampled during each sampling period, whereby 15 seedlings were selected randomly from each treatment for destructive sampling. The seedlings height and root collar diameter were measured. The seedlings biomass above ground was cut and oven dried at 70°C for 24 hours for biomass determination and nutrient concentration in the tissue.

Nutrient Analysis

For determination of nutrient content in the potting media, 500g sample of each of the potting media treatments was taken for qualitative analysis. The media were divided into three portions, air-dried, sieved through a 2 mm sieve and oven dried at 800^{o}C before elemental analysis. PH was determined in water (Anderson and Ingram 1993), while total nitrogen and carbon were determined using a Carlo Erba CNHS analyzer. Available Potassium was determined calorimetrically after extraction with Melich's reagent. Exchangeable cations K, Mg and Ca were determined after extraction by shaking for 2hours with ammonium acetate (5 g in 100 ml) (Anderson and Ingram 1993). Available K was determined by flame photometry, while Mg and Ca were determined by atomic absorption spectrophotometry.

Plant Tissue Nutrient Analysis

Dried leaves and stems from the 8 weeks and 24 weeks harvests were ground and analyzed for concentrations of N, P, K, Ca, Mg. Nitrogen was determined by Auto analyzer, and for other elements P, K, Ca and Mg, plant material was wet-ashed with concentrated H_2SO_4 solution and nutrients were determined as for the potting media.

Statistical Analysis

The nutrient uptake of plant tissue was calculated from nutrient concentrations and corresponding tissue dry weights for each treatment. Since the experiment was laid out in complete randomized design, variations over treatment were studied using one-way ANOVA model with average growth parameters as the dependent variable. Treatments were considered as the fixed effect and within treatment variation as the error term. Critical value of $P>0.05$ was used to determine statistical significance.

RESULTS

Fertility of the Potting Media

The mixture of forest soil, cattle manure and sawdust had the highest amount of total nitrogen content of 5.7g/kg, while the lowest amount of total nitrogen of 5.4g/kg was recorded in Medium B (Table 2). Percentage total carbon ranged between 17.52 g/kg to 35.5g/kg in Medium C and Medium B respectively. PH (in water) of the media was acidic (pH 4.85) in Medium A while in Medium E, the media was a weak base (pH8.07).

Table 2: Characterization of the nursery potting media at the start and the end of the nursery experiment

At Start of Experiment Baseline						
Treatment	PH(Water)	Org C g/kg	Nitrogen g/kg	Phosphorus g/kg	Exch. K ppm	Exch. Ca ppm
MA	4.85	18.02	5.6	0.31	0.89	1.76
MB	5.02	35.50	5.4	0.81	6.90	3.52
MC	5.20	17.52	5.7	0.49	4.92	2.77
MD	6.25	19.21	5.5	0.38	5.28	2.83
ME	8.07	18.20	5.5	0.83	6.77	3.19
LSD (P<0.05)	*	ns	Ns	Ns	Ns	Ns

At the end of the Experiment (24 weeks)						
Treatment	PH(Water)	Org C g/kg	Nitrogen g/kg	Phosphorus g/kg	Exch. K ppm	Exch. Ca ppm
MA	5.17	09.99	6.6	0.17	0.19	1.79
MB	5.92	8.76	7.7	0.29	1.16	3.26
MC	6.22	11.25	7.8	0.29	1.04	3.86
MD	6.35	12.29	7.8	0.53	0.87	4.65
ME	6.49	24.55	09.9	0.87	0.59	5.72
LSD(P<0.05)	*	ns	Ns	Ns	Ns	Ns

*indicates significant at P<0.05; ns indicates not significant.

Determination of Seedling Growth Parameters

Height of seedlings grown in different potting media during the growing period is shown in Table 3. Shoot height of the seedlings at the end of the growing period was highest in Medium 2 followed by Medium 3 and Medium 1 with height values of 12.25cm, 10.78cm, and 10.35cm respectively. All seedlings at week 24 had reached transplantable height of above 10cm which is recommended by Lamprecht, (1989). Growth increased steadily reaching a diameter above 5.0 mm in all treatments at week 24 as shown in Table 3. Medium 5 which comprised of forest soil mixed with cattle manure - sawdust (1:1) mixture in ratio of 1:3 had the fastest growth as compared to other treatments recording a root collar diameter of 8.55mm at week 24.

Seedling growth and biomass was enhanced by mixing forest soils with sawdust and cattle manure. The highest biomass yield at the end of the experimental period was recorded in Medium 5 and Medium 2 with 18.89g and 17.57g dry biomass respectively. However, these differences were not statistically different among the potting media treatments at 5% level with respect to biomass, shoot height and root collar diameter.

Table 3: Effect of different potting media on biomass, height and root collar diameter of seedlings

Treatment	Height (cm)		Root collar diameter (mm)		Dry Biomass (g)	
	4 Weeks	24 Weeks	4 Weeks	24 Weeks	4 Weeks	24 Weeks
MA	1.39	10.35	0.2	4.19	0.58	16.76
MB	0.25	12.25	0.21	5.25	0.56	17.57

MC	0.28	10.78	0.20	6.70	0.12	15.86
MD	0.28	09.76	0.21	6.87	0.08	15.67
ME	0.21	09.03	0.20	8.55	0.22	18.89
LSD(P<0.05)	Ns	Ns	Ns	Ns	Ns	Ns

DISCUSSION

Nutrient Concentration of the Potting Media and its Effect on Seedling Growth

The results of analysis of the potting media prior to and after the experimental period showed that the content of percentage organic carbon and nitrogen were quite moderate and above the critical level of 0.2% as reported by Okalebo *et al*., (2002), and Landon, (2014). There was a general increase in the contents of total nitrogen in potting media during the study period. Treatments with cattle manure in the mixture had high levels of nitrogen compared to those with forest soil alone. However, the available P content was lower than the critical levels considered optimum by Okalebo *et al*., (2002).

The low levels of P and Mg reported in this study are similar to the findings of Singh and Bhati (2003) on Eucalyptus seedlings when irrigated with municipal effluent in Indian deserts. This is attributed in part to P fixation which is common in tropical soils and partly due to the partial sterilization of soil during preparation of the nursery media which increased microbial activities thereby favoring increased microbial degradation of soil organic matter for more release of nutrients (Fabião, *et al*., 2002).

The slow effect of N at the start of the experiment is mainly found with recalcitrant organic matter with a high C: N ratio as was the case with Medium 4 which had forest soil mixed with sawdust and cattle manure in the ratio of 1:2 by weight. This could be attributed to immobilization, which causes loss of N from the system and a reduction in the soil ability to mineralize N (Mendham *et al*., 2003).

Organic residue impact on soil fertility will depend not only on the quality (Parton *et al*, 1994) and quantity of the residues (Tian *et al*., 1992) and the prevailing climatic conditions (Vanlauwe *et al*., 1995) but also on the way they are managed from different sources (Adetunji, 1996, Cadisch and Giller, 1997).

Nutrient Uptake of Seedlings

Treatments amended with cattle manure and sawdust, organic manure additions are known to release large amounts of exchangeable bases which improved the soil reaction thereby affecting the changes in PH of the potting media as observed in this study (Hargrove and Thomas 1981; Keeler *et al*., 2009).

There was increased plant uptake of N in treatments that were enriched with cattle manure and sawdust. The higher production of dry matter though not significantly different in the forest soil and cattle manure treatments compared to forest soil alone would be due to the higher levels of soil available N and P in the media. Calcium and Magnesium availabilities were not affected by microbial decomposition and therefore their level in this study was shown to decline during the experimental period. Soil calcium is one of the macronutrients adversely affected in tropical forest soil. High rainfall amount encourage leaching of the basic cations, such as calcium from upper horizons thereby making them unavailable to plants. Similar findings showing decline in exchangeable calcium were reported in forest soils (Thimonier *et al*., 2001 and Lawrence *et al*., 1997). From these results, the enrichment of forest soil with sawdust and cattle manure enhanced nutrient uptake by the seedlings and hence growth and dry matter yield. However, the optimum ratio of mixing sawdust and other organic amendments ought to be determined before

addition to forest soil. The ratios of the organic mixtures would depend on the C: N ratio of the materials. Organic residues with high wide C: N ratios such as sawdust should be applied at lower ratios, while other materials with medium to low C: N ratios such as cattle manure could be incorporated at higher ratios (Cadisch and Giller, 1997).

The research work has shown that seedlings growth parameters were enhanced when forest soil was mixed with other organic materials at various ratios. Slow growth at the initial growth (0-8 weeks) could be regarded as establishment stage where roots start to grow and new leaves start to develop. From week 8 to week 24, seedlings showed rapid growth of beyond 10cm in all treatments. Rapid growth could be associated with uptake of available nutrients in the growth media thus attaining a height of 10cm height, which according to Lamprecht (1989) was ideal height for out planting. Mortality rate of the seedlings was low in this study possibly due to enhanced nursery management practices and low seedbed and pot density. Therefore, there was improvement in growth and survival of seedlings after pricking out. Better understanding and implementation of nursery cultural practices to improve seedling quality should enable establishment of quality seedlings after transplanting and improved future growth of forest stands.

The application of plant nutrient testing in forest and conservation nurseries is meant to assist in determination of seedling quality and out planting success. Seedling height, root collar diameter and biomass are special attributes in determination of seedling quality that can be used to predict survival in the field. The positive correlation between the parameters with foliar nutrient concentration indicated that seedlings responded to enhanced nutrient supply in the potting media and thus these results demonstrate the potential for developing new strategies for growing seedlings in the nursery.

CONCLUSION

Application of appropriate ratios of nursery growth media is very important in enhancing establishment of seedlings in the nursery. Thus mixing forest soil with cattle manure with or without sawdust gave the best results on seedlings performance in the nursery as per growth parameters measured and enhanced their nutrition, therefore it could be considered as good predictor of survival and performance in the field.

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