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Quarry dust effects on soil physico-chemical properties and early growth of *Gmelina arborea* (Roxb) and *Terminalia ivorensis* (A. Chev.)

F.T. Omosebi[1,]* and V.A.J. Adekunle[2]

[1]National Environmental Standards and Regulations Enforcement Agency (NESREA), Ondo State Field Office, Akure, Nigeria
[2]Department of Forestry & Wood Technology, Federal University of Technology, Akure, Nigeria

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⌧*Corresponding author:
Funmilayo Omosebi,
National Environmental Standards and Regulations Enforcement Agency (NESREA), Ondo State Field Office, Akure, Nigeria
Email: afunny500@yahoo.com

Abstract

Forests ecosystems are among the most productive terrestrial ecosystems for rural livelihood and environmental conservation. Thus, this study examined the effects of quarry dust on soil properties and on early growth of two hardwood tree species (*Gmelina arborea* and *Terminalia ivorensis).*The rock dust was collected from three randomly selected quarry sites in Ondo State, Nigeria at the crushing point while topsoils were collected at 50m and 100m away from the crushing point and from the adjoining forests for laboratory analyses. Ten seeds of each species were procured and planted using four different mixing ratios of the topsoil and quarry dust (0:100, 25:75, 50:50, 75:25, 100:0). The seedlings were nurtured for three months but measurement of stem height, number of leaves and stem diameter commenced at the fouth week. Dry biomass and its carbon and carbon dioxide equivalent were also obtained. The results showed that the samples had high proportion of sand and silt but small amount of clay. Their pH varied between 4.86 and 7.33. The sodium (Na), phosphorus (P), organic carbon, organic matter and nitrogen (N) concentrations were lower at the crushing point than the samples from 50 and 100m away. But the potassium (K) and calcium (Ca) concentrations were higher at the crushing point. Significant differences were observed among the sowing media with regards to seedling growth characteristics. For seed germination, 25:75 rock dust: topsoil was the best medium as it produced mean seed germination of 80%. The 100% rock dust gave the least seed germination potential. The highest numbers of leaves (21 and 6), stem diameter (5mm and 0.6mm) and stem height (32.3cm and 5.7cm) for *G. arborea* and *T. ivorensis* respectively, were recorded in 50% rock dust. The growing media significantly influenced the early growth of these two species. Therefore, rock dust could be used for soil amendment management.

1. INTRODUCTION

Given the dynamic nature of global ecosystem, environmental change driven by man-made natural cause is inevitable. One of the most widely discussed environmental issues nowadays is the prospect of global climate change. Quarrying, a process of getting useful stone from quarry is also suspected to contribute to the increase in air pollution. Rock quarrying and stone crushing is a global phenomenon, and has been the cause of concern everywhere in the world, including the advanced countries (Effiong, 2012). Different quarrying activities have different impacts on air quality and cause significant impact on the environment (Okafor, 2006; Babatunde *et al*. 2012). One of the biggest negative impacts of quarrying on the environment is damage to biodiversity (Anand, 2006).

The major environmental hazard from quarry operation is the effect of dust and this will be dependent on the concentration of the dust particles in the ambient air and its rate of deposition. According to Ademola (2008), dust is one of the most visible, invasive and potentially irritating impacts associated with quarrying. Dust from quarrying has been reported to stall the growth and flowering of crops (Iqbal and Shafig, 2001).

Forests ecosystems are among the most productive terrestrial ecosystems. *Gmelina arborea* and *Terminalia ivorensis* are unarmed, large deciduous forest trees. Good colonizers of abandoned farmlands. Wood of T. ivorensis resists fungi and is moderately resistant to termites. It is an ideal choice for large-scale afforestation programmes. *Gmelina arborea* and *Terminalia ivorensis* among other forest trees grow fast and can tolerate a wide variety of soil types thus make them attractive both for climate change mitigation and agricultural uses (Watson *et al*., 2000). Trees are considered one of the most sensitive indicators of the environmental condition from all life forms. They are most suitable for the evaluation of environmental challenges (Erlickyte *et al*. 2008). Trees integrate the impact of climate and pollution (Stravinsklene 2002, 2005). The test crop used are.

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In spite of dangers of the dust emission resulting from quarrying, there has not been a concrete finding on the effects of quarry dust on the forest ecosystem. Effect of quarry dust on plant cover, height and number of leaves need to be ascertained. While quarrying can cause significant impact to the environment, with the right planning and management, many of the negative effects can be minimized or controlled.

This study examined the effect of quarry dust on quarry sites surrounding soil and on seed germination and seedling growth of *G. arborea* and *T. ivorensis*. This was achieved by examining the nutrient content of quarry dust and the physico-chemical properties of the surrounding soil. The effect of quarry dust on early growth of tree species was examined.

2. MATERIALS AND METHODS

2.1. The study area

Data for this study was collected from three randomly selected quarry sites in Ondo State, Southwest Nigeria. The sites are Ondo State Asphalt Company (OSAC), Ebenezer Mining and Ceramic Ind. LTD and Dortmund and Company Nig LTD Iju-Itaogbolu. The sites are on longitude +005.0500 and 005.079584 and latitude +007.22082 and 007.198515; longitude + 005.1311 and +005.1501 and latitude +007.2315 and +007.2031; and longitude +005.22519 and 005.24660 and latitude +007.29082 and 007.27656 respectively (Fig. 1).

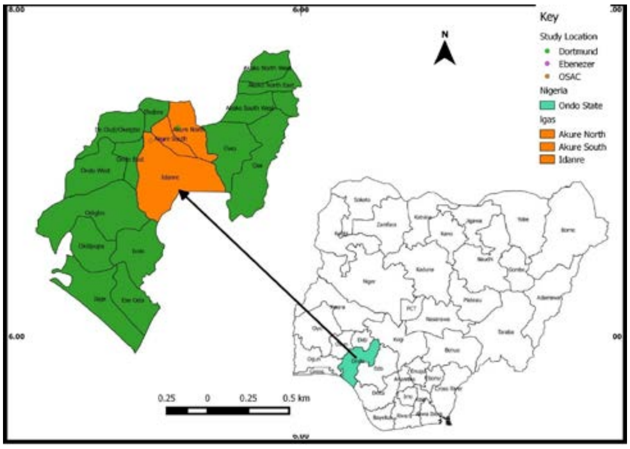

Figure 1: Map Showing Quarry Locations

2.2. Methodology of data collection and Laboratory Analyses

Field data collection, laboratory works and data analyses were done in phases to achieve each of the objectives of the project. To determine the impacts of quarry activities on soil properties and soil fertility, the rock dust samples were collected at the crushing point and at the radius of 120m away from the crushing site of the radii 50 and 100m into the adjoining forest to each of the site with soil auger. Soil samples were air-dried and ground using agate mortar. They were sieved using nylon sieve with 0.5 mm mesh size and taken to the laboratory for analyses. The laboratory analyses of the dust was carried out to study the essential nutrient elements such as carbon (Titration method), nitrogen (Kjeldahl digestion method), phosphorus (Bray P-1), potassium (Flame photometry), and calcium (Flame photometry) and the dust particle size (Hydrometer method).

For tree seeds propagation, the test crops are Gmelina arborea and Termilina avorensis. 260 seeds (10 seeds per treatment) were planted using quarry dust and top soil ratios of 50:50, 30:70, 70:30, 100:0, 0:100 as sowing media. The following parameters were studied: Tree seeds germination periods, Seedlings' growth parameters - height of stem, number of leaf, stem diameter from the 4th week to 12th week, Dry biomass, Equivalent carbon and Carbon dioxide.

3. RESULTS AND DISCUSSION

3.1. The Samples Physical Properties Analysis

The results of the physical properties of rock dust and topsoil in Table 1 show that the rocks from the three site locations (OSAC, Ebenezer and Dortmund) have higher percentage proportion of sand compared to reference topsoil. The highest percentage (84.91±1.3) is recorded in rock dust from OSAC. This is followed by the rock dust from Ebenezer (76.91±1.8) and next to it is the rock dust from Dortmund (73.57±1.3). The least percentage proportion of sand (71.12 ± 1.3) is from reference topsoil.

The percentage proportion of silt is greater (16.56 ± 1.2) in reference topsoil compare to rock dust from Dortmund (14.72±0), Ebenezer (12.05±0.7) and OSAC (6.72±1.2) respectively. The percentage proportion of clay is the least recorded from these three properties with the exception of clay and silt proportion from OSAC (8.37±2.4: 6.72±1.2). The percentage proportion of clay for reference topsoil is 12.32 while the percentage proportion for Dortmund is11.71±1.3.

Table 1: Physical Properties of Rock Dust and Topsoil

Site Location	Clay (%)	Silt (%)	Sand (%)
Osac	8.37±2.4	6.72±1.2	84.91±1.3
Ebenezer	11.04±2.0	12.05±0.7	76.91±1.8
Dortmund	11.71±1.3	14.72±0	73.57±1.3
Reference Topsoil	12.32 ± 0.5	16.56 ± 1.2	71.12 ± 1.3

Nursery sowing media influence quality of seedlings produced (Agbo and Omaliko, 2006). Seed germination is affected by many factors, which include type of substrate used, environmental factors such as

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oxygen, water, temperature and some plant species, light (Hartmann *et al.*, 2001). In heavy soil without drainage, the development of root system is suppressed and plants are more susceptible to soil borne diseases (Beattie and White, 1992). Media composition used influences the quality of seedlings as also reported by Wilson et al., (2001). The results of the physical properties of rock dust and topsoil in Table 1 shows that it has higher percentage proportion of sand, followed by percentage proportion of silt and least percentage proportion of clay which is similar to the results of the physico-chemical analyses of rock dust carried out by Chaturvedi et al. 2012.

3.2. The Samples Chemical Properties Analysis

The mean chemical properties of topsoil and rock dust in the selected site locations are summarized in Table 2. The mean pH values of quarry site topsoil range from 5.86 to 6.37 and rock dust pH value is 7.04 (slightly alkaline) meanwhile the reference soil has mean pH valueof 5.57. This implies that rock dust has significant effect on the pH of quarry site topsoil. The mean Na values range from 30.67ppm to 40.44ppm while the mean values

of phosphorus range from 0.17ppm to 0.54ppm implying that Na and P are lower in the quarry site soil compared to reference soil value of 71.67ppm and 1.71ppm respectively. The mean values of K ranges from 58.0ppm to 64.67ppm, the values which are higher than that of reference soil value of 18.33ppm. The mean Ca values range from 1.36ppm to 1.92ppm, these are in close range with the reference soil Ca mean values. The mean values of N range from 0.50% to 0.63% while that of Organic carbon (Oc) range from 0.36% to 1.27% and that of Organic matter range from 0.61% to 2.20%. These values are obviously small indicating low organic content in the soil and this is similar to the N, Oc and Om of reference soil with mean values of 0.62%, 1.73% and 2.98% respectively.

Table 2: Summary of mean chemical properties of topsoil and rock dust in the selected site locations

Sampling Point	pH	Na(ppm)	K(ppm)	Ca(ppm)	P(ppm)	N%	Oc%	Om%
Crushing Point	6.3700^{d}	37.6667^{b}	62.8889^{d}	1.6444E2^{bc}	0.1689^{a}	0.6277^{c}	0.3556^{a}	0.6144^{a}
50m	5.8611^{b}	30.6667^{a}	58.0000^{c}	1.6089E2^{b}	0.3333^{b}	0.5040^{b}	1.0667^{b}	1.8411^{b}
100m	6.1600^{c}	31.0000^{a}	64.6667^{d}	1.9222E2^{c}	0.2778^{ab}	0.5266^{b}	1.2744^{b}	2.1967^{b}
Rock Dust	7.0411^{e}	40.4444^{b}	35.0000^{b}	1.3589E2^{a}	0.5456^{c}	0.4457^{a}	0.4411^{a}	0.7611^{a}
Topsoil-Control	5.5700^{a}	71.6667^{c}	18.3333^{a}	1.6333^{b}	1.7100^{d}	0.6233^{c}	1.7267^{c}	2.9767^{c}

The summary of mean chemical properties of samples from different sampling points in table 2 shows that pH of all samples from different sampling points are significantly different. Klinger (2007) reported that acidification leads to a departure from the chemically balanced soil, neutral pH state is preferred by most living systems, around pH 7. Oldfield, (1997) recorded that there is no significant pH effect in rock dust-soil amendment. For sodium (Na), 50m and 100m are not significantly different but there are significant differences among them and other sampling points, and it is the same trend for rock dust and crushing point. Crushing point and 100m potassium (K) are not significantly different but significant differences exist among other sampling points. Topsoil and 50m calcium (Ca) are not significantly different but other sampling points varied significantly. Phosphorus (P) varied significantly among sampling points. For Nitrogen (N), there is no significant difference between 50m and 100m and also no significant difference between crushing point and topsoil. Variability exists among sampling points. For Organic carbon (Oc), 50m and 100m are not significantly different and crushing point and rock dust are also not significantly different but vary significantly among themselves. Sodium (Na), Phosphorus P, Organic Carbon (C), Organic Matter (OM) and Nitrogen (N) (except in crushing point sample) concentrations are lower in the other sampling points than in the control sample. The Potassium (K) and Calcium (Ca) concentrations are higher in the other sampling points than in the control sample. Sodium (Na), Phosphorus (P), Nitrogen (N), Organic Carbon (C) and Organic Matter (OM) (except in 100m sample) concentrations are lower in the other sampling points than in the reference topsoil because reference soil source has dense vegetation. Alkaline soils normally contain higher calcium levels than potassium (Ujwala Ranade-Malvi, 2010). It is possible that, especially at the nutrient poor sites, growing trees need extra K and P. Rock dust improves soil hydrology, it tends to buffer acid soils, and can provide potassium to plants on demand as reported by Oldfield, (2001). Potassium is also known to leach out easily, especially from poor sites (Demeyer et al. 2001, Piirainen et al. 2013). The Nitrogen (N) concentration of the topsoil sample at the crushing point and 100m topsoil samples are the same as that of control sample while the

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Nitrogen level in rock dust sample and 50m topsoil samples are lower in concentrations than the control sample.

3.3. Seedlings Growth Parameters Percentage Seed Germination Rate

The mean germination percentage at six weeks according to the sowing media is summarized in Table 3. The result reveals that the mean germination rate varied considerably among the seed species and the sowing medium. For *G. arborea*, the sowing medium of 25% rock dust records eighty percent mean germination. This is followed by seventy-three percent mean germination in the 75% and 50% rock dust and the least mean germination of sixty percent is recorded in 100% rock dust. The sowing medium of 100% Topsoil, that serves as control records sixty percent seeds germination.

Table 3: Summary of Germination percentage according to the sowing media at 6 weeks

Seed Species	100% Rock dust	75% Rock dust	50% Rock dust	25% Rock dust	100% Topsoil
G. arborea	60.00± 17.32	73.33±1 2.02	73.33±1 4.53	80.00±1 5.28	60.00± 0.00
T. ivorensis	26.67± 12.02	20.00±5 .77	13.33±3. 33	16.67±8. 82	10.00± 0.00

For *T. ivorensis*, the sowing medium of 100% rock dust has approximately twenty-seven percent mean germination. This is followed by twenty percent mean germination in the 75% rock dust and the sowing medium of 25% rock dust records approximately seventeen percent mean germination. The least mean germination of thirteen percent is recorded in 50% rock dust. 100% Topsoil sowing medium that serves as control records ten percent seed germination.

In addition, the results also revealed that the growing media have beneficial effect on the early growth of *G. arborea*. 25% rock dust mixed with 75% topsoil is the best media as it produced one hundred percent seed germination. The 100% rock dust produced the least seed germination percentage.

The reason for the best performance of 25% rock dust mixed with 75% topsoil are high organic content which increases the water and nutrient holding capacity of the medium. Rock dust mixed with topsoil affects properties of soil physics, chemistry and biology, since organic matter acts as glue for soil aggregate and source of soil nutrient (Soepardi, 1983). Soil aggregation will improve permeability and airflow in the poly bags. Furthermore, seed germination and root growth become easier so that plant grows well and may absorb more water and nutrient (Jo, 1990). All these factors are favorable for seed germination and ultimately increase seed germination (Bhardway, 2014).

The results of the mean tree growth variables for all the three sites are summarized in Tables 4 for *G. arborea*.

Table 4: Summary of tree growth variables with the sowing media for all the sites (*G. arborea*)

Sowing media	Height (cm)	Diameter (mm)	Wet biomass	Dry biomass	Germination rate (%)	No of leaves
100% Rock dust	2.2100^{a}	0.3233^{a}	9.3400^{a}	2.99^{a}	50.7700^{a}	6.4667^{a}
75% Rock dust	3.1200^{a}	0.4867^{a}	15.1900^{ab}	5.14^{ab}	51.8467^{a}	8.1267^{ab}
100% Topsoil	3.1600^{ab}	0.4867^{a}	15.9933^{ab}	5.54^{ab}	60.0000^{a}	9.5733^{bc}
50% Rock dust	3.6600^{bc}	0.5100^{a}	21.0900^{b}	6.67^{b}	63.9300^{a}	11.5400^{c}
25% Rock dust	4.5033^{c}	0.5300^{a}	21.5067^{b}	7.28^{b}	68.8533^{a}	11.5833^{c}

The result showed that all the tree growth variables increase as the rock dust percentage reduces in the sowing media from 100% to 25%. The mean stem height increases from 2.21cm in 100% rock dust sowing medium to 4.50cm in 25% rock dust sowing medium. The stem diameter has the same sequence of 0.32mm to 0.53mm as well as wet biomass and dry biomass in the order of 9.34 to 21.51 and 2.99 to 7.28 respectively. The mean germination percent increases from 50.77 in 100% rock dust sowing medium to 68.85 in 25% rock dust sowing medium. The mean values for the number of leaves in the experiment followed the same increasing order of the above growth variables from 6.47 to 11.58. The tree growth variables gotten from the reference soil (100% Topsoil) are generally lower than the tree growth variables from 25% rock dust sowing medium. This implies that rock dust influences the germination and early growth of the test crop.

The summary of tree growth variables with the sowing media for *G. arborea* shows that stem diameter and seed germination rate are not significantly different among sowing media. Dry and wet biomass for 75% and 100% Topsoil are not significantly different. Also, dry and wet biomass for 50% and 25% Rock dust are not significantly different. Meanwhile, stem height and number of leaves showed significant variability among sowing media.

Combined application of rock dust and topsoil shows significant effect on stem height and number of

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leaves of *G. arborea* and also there are significant differences in stem height, stem diameter and number of leaves of T. ivorensis. This is due to the synergistic combination of both factors in improving physical and chemical condition of the media and nutritional factors (Sahni et al., 2008; Barrie Oldfield, 2001).

The results of the mean tree growth variables for all the three sites are summarized in Tables 5 for Terminalia ivorensis. The result showed that all the growth variables increase as the rock dust percentage reduces in the sowing media.

The mean stem height increases from 0.46cm in 100% rock dust sowing medium to 0.96cm in 25% rock dust sowing medium.

The stem diameter has the same sequence of 0.04mm to 0.11mm as well as wet biomass and dry biomass in the order of 0.35 to 0.94 and 0.15 to 0.39 respectively.

Table 5: Summary of tree growth variables with the sowing media for all the sites (*T. ivorensis)*

Sowing media	Stem height	Stem diameter	Wet biomass	Dry biomass	Germination rate	No of leaves
100% Rock dust	0.4600[a]	0.0433[a]	0.3500[a]	0.1500[a]	18.4400[a]	0.4200[a]
75% Rock dust	0.7467[b]	0.0600[ab]	0.3967[a]	0.1733[a]	19.9233[a]	0.8567[b]
100% Topsoil	0.8000[b]	0.0733[b]	0.4633[ab]	0.1867[a]	21.1467[a]	0.9700[b]
50% Rock dust	0.8800[b]	0.0767[b]	0.5167[ab]	0.2000[a]	26.0700[a]	1.0167[b]
25% Rock dust	0.9633[b]	0.1067[c]	0.9400[b]	0.3900[b]	30.0000[a]	1.0333[b]

Means followed by the same alphabet in the column are not significantly different (P>0.05)

The mean germination percent increases from 18.44 in 100% rock dust sowing medium to 30.00 in 25% rock dust sowing medium. The mean values for the number of leaves in the experiment followed the same trend of 0.42 in 100% rock dust to 1.03 in 25% rock dust. The tree growth variables gotten from the reference soil (100% Topsoil) are generally lower than the tree growth variables from 25% rock dust sowing medium. This implies that rock dust influences the germination and early growth of the test crop.

The summary also shows that stem height and number of leaves are not significantly different among sowing media with the exception of 100%Rock dust. Dry biomass is not also significantly different among sowing media with the exception of 25%Rock dust. There is no significant difference in germination rate among sowing media. Stem diameter and wet biomass varied among the sowing media ($P<0.05$). This result is akin to the findings of Campos Mota et al., (2009) and Abirami et al. (2010) that used coir dust with vermicompost to get a better growing medium for plant establishment. Bruck, (1998) also had increase in plant height of Mahogany with rock dust amendment.

3.4. Plant Biomass and its Carbon Derivative

The estimates of the total above-ground biomass in forest ecosystems are critical for carbon dynamics studies, as plant biomass is an important indicator in carbon sequestration (Adekunle et al. 2014). The amount of carbon sequestered can be inferred from the biomass change since 50% of the forest dry biomass is approximately carbon (Losia et al. 2003; Montagu et al. 2005). The carbon content was estimated as 50% of the dry weight or biomass (Penman 2003; and IPCC 2006). The relationship between carbon content and carbon dioxide was used to convert carbon in the seedling to CO2. This represents the amount of carbon the seedling could sequestrate if they have not been uprooted or theamount of CO_2 to be released into the atmosphere if they act as carbon source. The relationship is given as follows:

1tC = 3.67 t CO2 (NIACS 2008; Renasingbe and Abasayari 2008).

Table 6 shows the summary of mean biomass (wet and dry weight), carbon and carbon dioxide of the seedlings for different sowing media from the three locations for *G. arborea*. The mean wet weight from all the sowing media ranges from2.99mg to 21.51mg, while the mean dry weight ranges from 5.14mg to 7.28mg. The mean derived carbon and carbon dioxide range from 1.49 to 3.34 and 3.20 to 10.55 respectively.

Table 6: Summary of Mean Biomass (wet and dry weight), Carbon and CO_2 of the seedlings with the sowing media for all the sites (*G. arborea)*

Sowing media	Wet Weight(mg)	Dry Weight(mg)	Carbon	CO_2
100% Rock dust	2.9867[a]	5.7500[a]	1.4933[a]	10.5533[b]
75% Rock dust	21.5067[c]	6.6733[a]	3.3400[a]	3.3367[a]
50% Rock dust	15.1900[b]	5.1400[a]	2.5700[a]	8.4033[b]
25% Rock dust	20.1567[bc]	6.3933[a]	2.5767[a]	3.1967[a]
100% Topsoil	21.0900[bc]	7.2800[a]	3.1567[a]	3.6400[a]

Means followed by the same alphabet in the column are not significantly different (P>0.05

Summary of Mean Biomass (wet and dry weight), Carbon and CO_2 of the seedlings with the sowing media for *G. arborea* and *T. ivorensis* in table 6 and 7 shows that dry weight and carbon are not significantly different among sowing media. The wet weight varied significantly among the sowing media. For carbon dioxide, there is no

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significant difference between 75%, 25% rock dust and 100%Topsoil and between 100% and 50% rock dust.

Table 7 shows the summary of mean biomass (wet and dry weight), carbon and carbon dioxide of the seedlings for different sowing media from the three site locations for T. ivorensis.

The mean wet weight from all the sowing media ranges from 0.35 mg to 0.94 mg, while the mean dry weight ranges from 0.15 mg to 0.39 mg. The mean derived carbon and carbon dioxide range from 0.08 to 0.19 and 0.28 to 0.71 respectively. The one-way analysis of variance revealed that the wet weights of the seedlings and CO_2 are significantly different among the sowing media while the dry weights and carbon are not significantly different among the sowing media.

Table 7: Summary Mean Biomass (wet and dry weight), Carbon and CO_2 of the seedlings with the sowing media for all the sites (*T. ivorensis)*

Sowing media	Wet Weight	Dry Weight	Carbon	CO_2
100% Rock dust	0.3500[a]	0.1733[a]	0.0833 [a]	0.3167[b]
75% Rock dust	0.3967[a]	0.1500[a]	0.0767 [a]	0.2767 [a]
50% Rock dust	0.4633[ab]	0.2000[a]	0.1000 [a]	0.3667[b]
25% Rock dust	0.5167[ab]	0.1867[a]	0.0933 [a]	0.3467 [a]
100% Topsoil	0.9400[b]	0.3900[b]	0.1900 [a]	0.7100 [a]

Means followed by the same alphabet in the column are not significantly different (P>0.05)

The one-way analysis of variance revealed that the wet weights, dry weights, carbon and CO_2 are significantly different among the sowing media.

Figure 1- 6 show the weekly averages of the rate of the growth variables (stem diameter, stem height and number of leaves) of seedlings using the five treatments (sowing media) from three different locations (OSAC, Ebenezer and Dortmund). From the result it is observed that the responses of the growth variables of the seedlings to the sowing media differ also with the site locations. From figure 1, *G. arbore*a planted with the sowting media from OSAC, 75% rock dust produced the highest stem diameter of 4.86mm, while 25% rock dust produced the highest stem height of 35.7cm and 50% rock dust produced the highest number of leaves of 40.

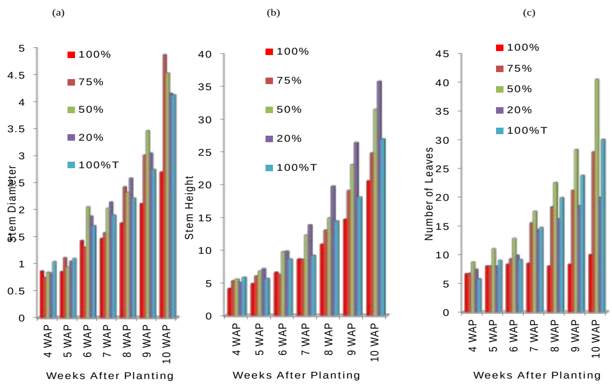

Figure 1: Growth rate of *G. arborea* Seedling using the planting media from Osac quarry site (a – stem diameter, b – stem height & c – no of leaves)

Figure 2 presented *T. ivorensis* planted with the sowing media from OSAC, 100% top soil did better than all other media for the growth variables and it is followed by 25% rock dust with stem diameter 0.7mm, stem height 6.53cm and number of leaves 7.

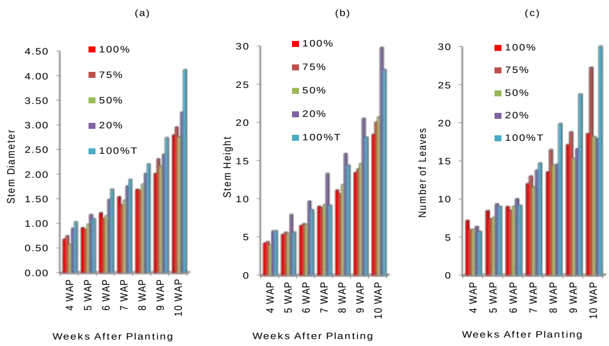

Figure 2: Growth rate of *T.ivorensis* Seedling using the planting media from Osac quarry site (a – stem diameter, b – stem height & c – no of leaves)

Figure 3 shows the results of *G. arborea* planted with the different rock dust used as sowing media from Ebenezer site. The stem diameter of 3.25mm is obtained for 25% rock dust. This is next to the value obtained for the 100% topsoil (4.11mm). While 25% rock dust produced the highest stem height of 29.77cm, 75% rock dust produced the highest number of leaves (27) that is next to the value for the topsoil (30.0).

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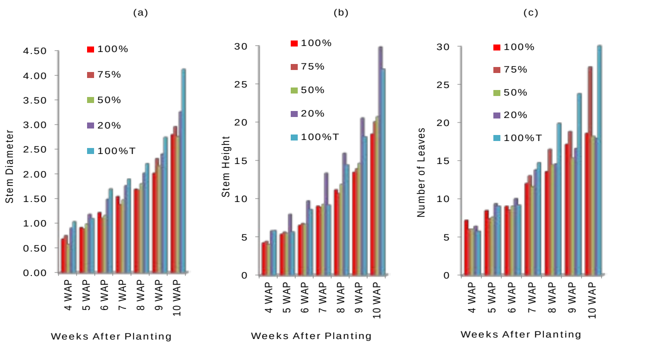

Figure 3: Growth rate of *G. arborea* Seedling using the planting media from Ebenezer quarry site (a – stem diameter, b – stem height & c – no of leaves)

Figure 4 presented the results of T. ivorensis planted with the sowing media from Ebenezer. It is observed that the 100% topsoil has the highest stem diameter of 0.99mm. This is followed by 100% rock dust of 0.64mm and the least diameter is recorded in 75% and 25% (0.33mm). For the stem height, the 75% rock dust sowing media has the highest height of 7.7cm. This is followed by the topsoil of 7.18cm. For the number of leaves, 100% topsoil has the highest number of leaves of 9. This is followed by 75% and 50% rock dust of equal value of 8 and the least value of the number of leaves is found in 25% rock dust (4).

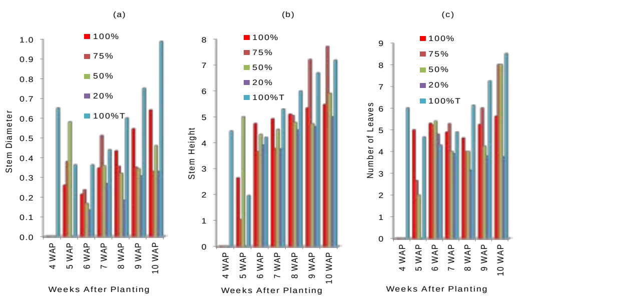

Figure 4: Growth rate of *T.ivorensis* Seedling using the planting media from Ebenezer quarry site (a – stem diameter, b – stem height & c – no of leaves)

Figure 5 shows the results of *G. arborea* planted with the sowing media from Dortmund, 50% rock dust produced the highest stem diameter of 4.52mm, followed by 100% topsoil of 4.11mm. 25% rock dust has the highest stem height of 35.7cm while 100% rock dust has least value of 14.08cm. For the number of leaves 50% rock dust records the highest value of 40, followed by the value from topsoil which is 30 and the least value of 12 is found in 100% rock dust.

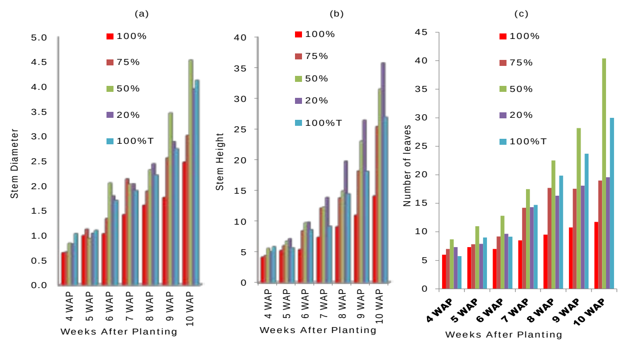

Figure 5: Growth rate of *G. arborea* Seedling using the planting media from Dortmund quarry site (a – stem diameter, b – stem height & c – no of leaves)

Figure 6 presents T. ivorensis planted with the sowing media from Dortmund, they all have the same trend of highest value for topsoil and lowest value for 50% rock dust. The highest and lowest values for stem diameter, stem height, and number of leaves are: 0.99mm and 0.37mm, 7.18cm and 4.4cm, and 8.5 and 4.6 respectively.

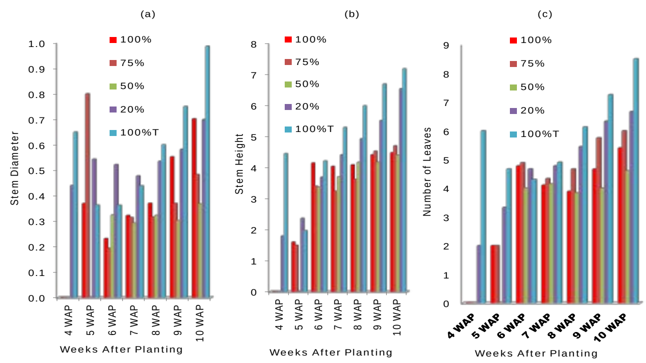

Figure 6: Growth rate of *T. ivorensis* Seedling using the planting media from Dortmund quarry site (a – stem diameter, b – stem height & c – no of leaves)

However, the estimates of these variables were found to be significantly higher in 25% rock dust when compared with the other sowing media. According to the mean separation results, there was significant difference ($p<0.05$) in some these variables as shown in Table 8 and 9.

Finally, the result reflects that in terms of plant growth, there is substantiated evidence of seed germination improvement following soil/rock dust-enhancement. In general, rock dust had a beneficial effect on germination rates similar to the effects of compost, but in a well-balanced soil may have an inhibitory effect. This suggests

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that rock dust, while potentially valuable as a soil amendment, has less worth in high-nutrient soils and may be appropriate for use only in preparation of soils prior to other amendments or in the reinstatement of poor quality sites such as land restoration (Szmidt, 2004, 1998).

4. CONCLUSION

The result shows that rock dust mixed with topsoil in appropriate mixture proportion can be used successfully in preparation of *G. arborea* seedling due to its physical and chemical properties. On the basis of results obtained from this study, it is concluded that sowing media significantly influenced the seed germination and the growth parameters of *G. arborea* seedling in which medium of rock dust + topsoil (50:50) is the best medium. This is because the number of germinated seeds and the seedling growth parameters are higher in this medium than in the other media.

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