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EFFECTS OF SOIL REMINERALIZATION BY ROCK DUST ON THE EMERGENCE AND EARLY GROWTH OF BANANA (*MUSA ACUMINATA*)

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ABSTRACT

The study evaluated the effects of soil remineralization by rock dust on the emergence and early growth of Banana (*Musa acuminata*). Pot experiments were conducted to determine the effect of remineralization of soil using granite and basalt rock dusts as soil remineralizers. There were seven treatments including control used for the experiment and these were replicated four times. The treatments were T_1 (0.5tons/ha of granite dust per 2kg of top soil), T_2 (0.5tons/ha of basalt dust per 2kg of top soil), T_3 (1.0tons/ha of granite dust per 2kg of top soil), T_4 (1.0tons/ha of basalt dust per 2kg of top soil), T_5 (1.5tons/ha of granite dust per 2kg of top soil), T_6 (1.5tons/ha of basalt dust per 2kg of top soil), T_7 (Control). The experiment was laid out in Completely Randomized Design (CRD). Data were collected on days of emergence, number of leaves, plant height (cm) and stem girth (cm) for 5 weeks. Watering was done twice daily both in the morning and evening. Data collected were subjected to Analysis of Variance (ANOVA) and no significance means among the treatments except for number of leaves at 0.05 level of significance. The results showed that T_6 (1.5tons/ha basalt) had the best mean days to emergence (16.75) while T_7 (control) had the least mean performance for emergence (33.50). For plant height T_2 (0.5tons/ha basalt) had the best mean performance (15.90cm) and T_7 (control) had the least mean performance of (10.70cm), for number of leaves, significance difference occurred among the treatments but none in the application rate. T_6 (1.5tons/ha basalt) had the best mean performance (8.75) and T_5 (1.5tons/ha granite) had the least mean performance (4.25), for stem girth, T_2 (0.5tons/ha basalt) had the best mean performance of (7.63cm) while T_7 (1.5tons/ha granite) had the least mean performance of (5.28cm), at 10 weeks after planting. Observing the best performance from the parameter assessed using treatments including control, soil remineralization by rock dust should be encouraged to enhance the emergence and early growth of *Musa acuminata.* These rock dusts are readily available at quarries and are environmentally safe.

INTRODUCTION

Banana is a common name for the herbaceous plant of the genus Musa. There is no formal botanical distinction between banana and plantain and the use of either term is based purely on how the fruits are consumed (Oke *et al.*, 2000). The word "banana" is sometime used to describe other plantain cultivars and names may reflect local uses or characteristics cultivars, such as cooking plantain, banana plantain, *bocadillo* plantain etc. Almost all modern plantain was derived from the hybrid between two wild species *Musa acuminata* and *Musa balbisiana*. The scientific name of the hybrid is *Musa paradisiaca* (Randy *et al.*, 2007).

Banana is traditionally propagated by planting corms and suckers. Suckers are traditionally used by farmers as planting materials coming from their own plantations. These suckers are most of the time affected by pests (e.g. weevils) and diseases (e.g. nematodes, viruses such as banana bunchy top, banana streak). The sucker production ability of banana is very low with an average of about 3 suckers per year per plant depending on agro-climatic conditions and cropping practices (Joab, 2004). The quantity and quality of the planting material are major factors for successful crop production (Tenkouano *et al.*, 2006]. This could be achieved through clonally planting materials obtained through the in vitro micro-propagation or in vivo macro-propagation techniques. In vivo macro propagation is an alternative technique for mass production of banana planting materials under in-vivo conditions (KWA, 2003). Compared to the in vitro one, this technique is relatively simple, less expensive and provides in a short period pest-free and genetically identical plantlets.

Soil fertility and the amount of arable land continue to be diminished by mismanagement of soil resources and bad agricultural practices (Pimentel *et al.* 1995). A key parameter of soil fertility is the amount of humus and less decomposed organic matter present in the soil. This soil organic matter beneficially influences soil structure, water holding capacity and aeration, and confers pH buffering capacity and improved nutrient retention (Parikh and James, 2012). The advent of chemical fertilizers in the second half of the 20th century greatly contributed to the degradation of soil fertility, partly due to the fact that application of notably inorganic nitrogen greatly accelerates decomposition rates of organic matter which becomes rapidly depleted (Khan *et al.* 2007). Furthermore, most nitrogen fertilizers (ammonia-based) cause the soil to acidify, significantly affecting soil biota as well as plant nutrient availability (Parikh and James, 2012). Also, fertilizer-induced soil acidification increases output fluxes of nutrients, releasing major cations from the soil system by processes of soil ion-exchange leaching as well as weathering of soil and rock (Pierson-Wickmann 2009). Use of phytosanitary chemicals and other biocidal practices also greatly affect soil fertility. The role of soil organismal interactions in the maintenance of healthy soil through nutrient cycling and structure amelioration is often undermined (Kibblewhite *et al.* 2008), as the mutualistic relations that benefit crop growth. For example, chemical fungicides can destroy beneficial soil fungi that aid plants in absorbing minerals, and pesticides greatly affect soil microbial populations that contribute to soil health (Ekundayo, 2003).

One very important and often overlooked aspect of soil degradation is that of soil demineralization. Agriculture effectively mines the soil of plant nutrients and minerals by intensive cultivation and harvesting of crops, altering the natural cycling of nutrients in the soil (Parikh & James 2012). The rate of demineralization of agricultural soils is alarming. The official report of the Rio Earth Summit of 1992 raised deep concerns on this issue, based on data showing that over the last 100 years average mineral levels have fallen by 72% in Europe, 76% in Asia, 85% in North America, 74% in Africa, 55% in Australia, and 76% in South America.

Rock dusts referred to as mineral fines, are in many cases regarded as waste by the quarrying industries. They have been applied to a range of natural materials, some of which are true wastes while others are products specifically manufactured to a particular standard (Robin *et al.*, 2004). In some cases the term is also applied to other recycled materials, for instance from construction / demolition industries. The use of rock dusts as a means of enhancing plant growth and therefore crop quality through improving soils in which they grow has been proposed by a number of groups and individuals. A wide range of claims have been made, extending from specific plant-growth improvement to more strategic benefits, notably through enhanced soil-carbon sequestration and therefore a contribution to ameliorating global warming and its effects (Rajib *et al*., 2016). These claims are by no means widely accepted and yet if validated would offer a potentially powerful tool for positively influencing global environmental change. For claims to be accepted by mainstream industries such as agriculture they need to be supported by robust technical and scientific evidence.

It is thus evident that measures need to be taken to decelerate and counter soil demineralization around the world. One such measure is the application of (volcanic) rock dust to mineral deficient crop fields and pastures. Rock dust contains many of the nutrients essential to plant growth, with the exception of nitrogen and generally only limited amounts of phosphorous. Grinded volcanic rock also improves soil structure and increases water holding capacity and cation exchange capacity (von Fragstein 1987). Moreover, the grinded rock is naturally alkaline which might constitute an effective alternative to traditional liming materials for correcting the pH (Silva, 2012). Rock dust helps stabilize soil organic matter (Egli *et al.* 2010; Imaya *et al.* 2010), and its paramagnetic characteristics may aid plants in taking up water and nutrients. The release of nutrients from the rock dust is directly related to weathering, therefore nutrient oversupply and leaching are limited (von Fragstein 1987). Soil biota (from microbes to vascular plants) obtain a significant proportion of their nutritional requirement from the weathering of soil minerals, predominantly secondary minerals (Killham 1994), and accelerate chemical weathering by producing organic acids (Schwartzman 1989). These biotas thus play an essential role in liberating minerals from rock dust, making them available to plants. For example, mycorrhizal fungi have been shown to significantly dissolve soil minerals through their exo-enzymatic activity, as have other microorganisms mutualistically living in the rhizosphere (Balogh-Brunstad *et al.* 2008). Since chemical fertilizers have been noticed to contribute to the degradation of soil fertility (Khan 2007), rock dust can be used as a possible alternatives preventing soil fertility degradation and help to stabilize soil nutrients.

A key parameter of soil fertility is the amount of humus and less decomposed organic matter present in the soil. Chemical fertilizers are known to affect soil biota which induces the metabolic activities in the soil, (Parikh *et al*. 2012) which makes the use of top soil only as a conventional practice. Banana suckers are opted for undergoing extensive nursery preparations, spending nothing less than 2-3 months before transplanting to the field; this incurs additional expenses during and after nursery stages (Lule *et al.*, 2003). Chemical fertilizers (which affect soil fertility after harvesting) have been used all to no avail in solving the extensive nursery preparation but there is a dearth of information on the effect of remineralization by rock dusts for the production of good quality of sucker. However, this study seeks to document the effect of remineralization by rock dust on the emergence and early growth of Banana (*Musa acuminata*).

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METHODOLOGY

The experiment was carried out at the experimental plot of Crop Production Technology Department in Federal College of Forestry Jericho Ibadan, under Ibadan Northwest local government area of Oyo state. The area is situated in the rainforest agro ecological zone of Nigeria and lies on latitude 7^{o} 54^{I}N and longitude 3^{o} 34^{I}E. The average annual rainfall range between 1400mm-1500mm and average temperature is about 32^{0}C with average relative humidity of 80-85%. The following materials were used during the course of the study: Granite rock dust, basalt rock dust, banana suckers, polythene pot, hoe, hand trowel, watering can, paper tape, cutlass, tape rule, hand gloves, and nose cover.

The granite and basalt rock dust was collected from the commercial quarries along Ibadan-Lagos express way. The rock dusts which are residual mineral fines were collected manually from the ground underneath the rock crushers where the finest dust tends to accumulate. After collection, they were taken to Forestry Research Institute of Nigeria (FRIN) soil laboratory to determine its physical and chemical composition. The sword suckers which were used for the experiment was procured from International Institute of Tropical Agriculture (IITA) Moniya, Ibadan. They were adjudged to be free from infection through visual observation.

A total of 28 Polythene pots were filled with topsoil and placed on the experimental field. Granite and basalt rock dust were added to 24 polythene pot filled with topsoil at different application rates (Boland *et al.*, 2000), as shown in the experimental layout key below. The granite and basalt was agitated to incorporate them with the topsoil and left for a day prior to planting. Four polythene pots of topsoil without rock dust serves as control. The banana suckers was cut into bit sizes ranging between 100-150g and dipped into 5litres of water containing fungicide; this is to prevent transfer of fungi infection from the mother plant to the emerging sucker. The bits were allowed to stay in the solution for about 2-3 minutes after which the bits were removed and air-dried under shade for 24 hours before planting. The bits were buried 5cm deep to each of the polythene pot. One bit was planted per polythene pot. Watering was done twice in a day to allow the bit get access to the required quantity of water necessary for proper development. And regular weeding was carried out as at when necessary.

The experiment was laid out in Complete Randomized Design (CRD), with four (4) replicates. The treatment are as follows;

T_1 = Topsoil + 0.5tons/ha of granite dust (85g of granite dust per 2kg polythene pot).
T_2 = Topsoil + 0.5tons/ha of granite dust (85g of basalt dust per 2kg polythene pot).
T_3 = Topsoil + 1.0tons/ha of granite dust (170g of granite dust per 2kg polythene pot).
T_4 = Topsoil + 1.0tons/ha of basalt dust (170g of basalt dust per 2kg polythene pot).
T_5 = Topsoil + 1.5tons/ha of granite dust (255g of granite dust per 2kg polythene pot).
T_6 = Topsoil + 1.5tons/ha of basalt dust (255g of basalt dust per 2kg polythene pot).
T_7 = Top soil (Control).

The growth parameters were assessed once every week commencing from third week after planting (WAP). The assessed growth parameters were days to emergence, numbers of leaves, plant height (cm), stem girth (cm). Data collected were statistically analyzed using System Analysis Software (SAS) and subjected to Analysis of Variance (ANOVA). Mean differences were separated using Least Significance Difference (LSD) at 5% level of significant.

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RESULTS AND DISCUSSION

Table 1: Pre-planting physical and chemical properties of the soil used.

Soil parameters	Content in soil
pH (H_2O 1:1)	6.2
Organic Carbon (gkg^{-1})	3.62
Total Nitrogen (gkg^{-1})	0.64
Available Phosphorus ($mgkg^{-1}$)	3
Exchangeable cations ($Cmolkg^{-1}$)	
Na	0.4
K	0.1
Mg	0.3
Ca	3.0
Extractable Micronutrients ($mgkg^{-1}$)	
Mn	96
Fe	81
Cu	2
Zn	7
Particle size distribution ($mgkg^{-1}$)	
Sand	884
Silt	68
Clay	48
Textural Class	Loamy sand

Pre planting soil analysis showing the physical and chemical properties of the soil is presented in table 1 above. From the analyzed result, the soil pH is slightly acidic (6.2), this is based on soil fertility classification established for Nigeria soil by Esu (1991). The total Nitrogen is low (0.64 gkg^{-1}) which is below the critical value of 1.50gkg^{-1}. The available phosphorus (3$mgkg^{-1}$) and organic carbon is low when compare to their respective critical value of 7.0mg/kg and 10mg/kg respectively (Agboola and Ayodele, 1985, F M A N R, 1990). The exchangeable cations of Na and K are also low while that of Mg (0.3$cmol/kg^{-1}$) can be said to be moderate using the critical value of Mg which is (0.28 $cmol/kg^{-1}$). The extractable micro nutrients analysis shows that Mn (96$mgkg^{-1}$), Fe (81 mg/kg^{-1}) and Cu (2$mgkg^{-1}$) in the soil were within the critical value of 5-100 $mgkg^{-1}$, 5-200 $mgkg^{-1}$ and 1.2 - 2.0 $mgkg^{-1}$ respectively . Zn (7$mgkg^{-1}$) was found to be higher than the critical value of 1-5 $mgkg^{-1}$ (Agboola et al, 1976).

Table 2: Typical Physical and Chemical properties of rock dust used.

Parameters	Content in Granite dust	Content in Basalt dust
pH (H_2O 1:1)	5.7	8.1
Organic Carbon (gkg^{-1})	2.99	3.82
Organic matter(gkg^{-1})	5.15	6.04
Total Nitrogen (%)	0.26	0.28
Available Phosphorus ($mgkg^{-1}$)	3.22	4.41
Exchangeable cations($Cmolkg^{-1}$)		
Na	0.98	1.01
K	0.45	0.30
Mg	0.35	0.71
Ca	4.09	8.11
Extractable Micro Nutrients ($mgkg^{-1}$)		
Mn	4.02	4.02
Fe	180	230
Cu	2.6	2.8
Texture	Phaneritic	Aphanitic

Analysis showing the physical and chemical properties of the rock dust is shown in table 2 above. The pH of the granite dust is 5.7 which are acidic and this is tantamount to the acidic nature of granitic rocks while the pH of the basalt dust is 8.1 which are also tantamount to the basic nature of basaltic rocks. Both rock dusts have a high iron (Fe) content (180 and 230$mgkg^{-1}$) because of the present of amphibole which is a mineral present in both granite and basalt rocks. In the exchangeable cations, the Mg content which is from pyroxene (a mafic minerals found in igneous rocks) can be said to be higher in basalt dust (0.71Cmol/kg^{-1}) than the Mg content in granite dust (0.35Cmol/kg). The Na and the Ca contents are from the plagioclase feldspar minerals found in igneous rocks also. The Na content is higher in basalt dust (1.01Cmol/kg^{-1}) than in granite dust (0.98Cmol/kg^{-1}), also the Ca content is also higher in basalt dust (8.11cmol/kg^{-1}) than in granite dust (4.09cmol/kg^{-1}). The potassium content found in the dust are from orthoclase mineral (k-feldspar). The K content can be found to be higher in granite dust (0.45Cmol/kg^{-1}) than in basalt dust (0.30Cmol/kg^{-1}). Nitrogen is known to be of little content in rock dusts generally and in some cases are not found in them. This contributes to the little content of the total Nitrogen in the analysis of both rock dusts (0.26% and 0.28%). The organic matter content in the rock dust is found to be from the vegetation found on the rock which can be said to have affected few parts of the rock. The organic matter content of basalt dust (6.04%) is found to be higher than organic matter content of granite dusts (5.15%). The texture of the granite dust is phaneritic indicating coarse texture while the texture of the basalt dust is aphanitic indicating fine texture.

Table 3: Effect of Rock Remineralization by Basalt and Granite Dust on Days to Emergence of *Musa acuminata*.

Treatments	App rate (tons/ha)	Means of Emergence
Basalt	0.5	24.00[ab]
	1.0	26.75[ab]
	1.5	16.75[b]
Granite	0.5	27.75[ab]
	1.0	30.50[a]
	1.5	31.25[a]
Control	0	33.50[a]
Sig	Trt	Ns
	App rate	Ns
	Trt*App	Ns

The mean analysis of emergence showed that there was no significant difference among the treatments application rate and the interaction effect. The result obtained showed that 1.5tons/ha of basalt had the earliest days of emergence at 16.75 days and this is higher when compared with mean of 15.28 days of Jules (2017) in Congo, while the 1.5tons/ha of granite had the longest days of emergence of 31.25days which is earlier than the control treatment having 33.50days. The basalt treatments have earlier days of emergence ranging 16.75 - 26.75 days than the granite treatment at 27.75 - 31.25days.

Table 4: Effect of Rock Remineralization by Basalt and Granite Dust on Plant Height of ***Musa acuminata.***

		Weeks after planting (WAP)				
Treatments	App rate (tons/ha)	7	8	9	10	11
Basalt	0.5	10.80[a]	12.73[a]	13.60[a]	15.05[a]	15.90[a]
	1.0	1.70[b]	4.15[b]	5.83[a]	8.13[a]	11.05[a]
	1.5	10.75[a]	11.73[ab]	12.98[a]	14.38[a]	15.47[a]
Granite	0.5	5.65[ab]	7.65[ab]	9.23[a]	10.70[a]	12.50[a]
	1.0	3.53[ab]	4.95[ab]	6.98[a]	8.95[a]	11.65[a]
	1.5	2.90[b]	4.48[b]	5.60[a]	9.35[a]	11.65[a]
Control	0	4.20[ab]	5.80[ab]	7.40[a]	9.80[a]	10.70[a]
Sig	Trt	Ns	Ns	Ns	Ns	Ns
	App rate	Ns	Ns	Ns	Ns	Ns
	Trt*App	Ns	Ns	Ns	Ns	Ns

The mean plant height analysis shows that there was no significant different among the treatment (basalt and granite dusts) at application rates of 0.5ton/ha, 1.0ton/ha 1.5tons/ha and 0 (control), and also no significant difference in the interaction effect at weeks 7 to 11 after planting. The 0.5tons/ha of basalt application rates produced the highest mean height at weeks 7 to 11 with a height of 15.90cm at 11 weeks after planting (WAP) and this is higher when compared with mean of cocoa plant height (4.28cm) of Olagorite and Gbenga (2012) in Ayetoro. The application rate of 1.0ton/ha of basalt had the least mean height at 7 to 11 WAP with 11.05cm at 11 WAP. However the application rate of 1.0ton/ha of basalt and 1.5tons/ha of granite produced lower mean plant height than the control application at 7 to 10 WAP while at 11 WAP all the treatment have higher means than the control 10.70cm.

Table 5: Effect of Rock Remineralization by Basalt and Granite Dust on Number of Leaves of *Musa acuminata*.

		Weeks after planting (WAP)				
Treatments	App rate (tons/ha)	7	8	9	10	11
Basalt	0.5	3.50^{ab}	5.00^{ab}	6.25^{ab}	7.00^{ab}	7.25^{ab}
	1.0	2.00^{b}	3.00^{b}	3.75^{bc}	4.75^{bc}	5.00^{bc}
	1.5	6.00^{a}	7.00^{a}	7.75^{a}	8.25^{a}	8.75^{a}
Granite	0.5	1.75^{b}	3.25^{b}	3.75^{bc}	4.50^{bc}	5.25^{bc}
	1.0	1.00^{b}	2.50^{b}	3.25^{bc}	4.00^{c}	4.75^{bc}
	1.5	0.75^{b}	2.00^{b}	2.50^{c}	3.75^{c}	4.25^{c}
Control	0	1.25^{b}	2.25^{b}	2.75^{c}	3.50^{c}	4.25^{c}
Sig	Trt	*	*	*	*	*
	App	Ns	Ns	Ns	Ns	Ns
	Trt*App rate	Ns	Ns	Ns	Ns	Ns

The mean analysis of the number of leaves showed that there were significant different among the treatment of basalt and granite while there was no significant different among the treatment application rate and their interaction effects at 7 to11 weeks after planting (WAP). The application rate of 1.5tons/ha of basalt produced the highest number of leaves in 7 to 11 WAP and having 8.75 and this is higher when compared with mean of plant height (7.30cm) of Navaneentha krishnan *et al.*, 2012 in Indian. The lower mean number of leaves was recorded in the granite treatment application rates with 1.5tons/ha having the least at 11 WAP of 4.25 and the same with the control treatment.

Table 6: Effect of Rock Remineralization by Basalt and Granite Dust on Stem Girth of *Musa acuminata.*

		Weeks After Planting (WAP)				
Treatments	Apprate (tons/ha)	7	8	9	10	11
Basalt	0.5	4.85[a]	5.98[a]	6.70[a]	7.18[a]	7.63[a]
	1.0	3.23[ab]	4.60[a]	5.25[a]	5.80[a]	6.25[a]
	1.5	4.33[ab]	5.18[a]	5.85[a]	6.43[a]	7.08[a]
Granite	0.5	3.23[ab]	4.23[a]	4.78[a]	5.40[a]	5.78[a]
	1.0	2.04[b]	3.45[a]	4.15[a]	4.90[a]	5.30[a]
	1.5	2.78[ab]	4.10[a]	6.65[a]	5.10[a]	5.55[a]
Control	0	2.68[ab]	3.78[a]	4.18[a]	4.68[a]	5.28[a]
Sig	Trt	Ns	Ns	Ns	Ns	Ns
	App rate	Ns	Ns	Ns	Ns	Ns
	Trt*App rate	Ns	Ns	Ns	Ns	Ns

The mean analysis result of the stem girth (table 6) show that there were no significant difference among the treatment, application rate and the interaction effect. The result obtained showed that 0,5tons/ha of basalt application rate produced the highest stem girth from 7 to 11 WAP having 7.63cm and this lower when compared with mean of cocoa stem girth (8.19cm) of Olagori *et al.*, 2012 in Ayetoro, while the control treatment produced the least stem girth in all the weeks assessed and having 5.28cm at 11 WAP. The granite application had lower stem girth mean with a range at 5.30-5.78cm than the basalt application with a range of 6.25-7.63cm at 11 weeks after planting (WAP).

Conclusion

Musa acuminata splitted suckers were planted using rock dusts (granite and basalt dusts) as soil amendments; different parameters were thus studied. The emergence parameters studied and analyzed shows that 1.5tons/ha of basalt gave the earliest emergence (16.75) followed by 0.5tons/ha of basalt 24.00. It can thus be concluded that for emergence, basalt dust perform best of all the other treatments (granite dust and control). For the other parameters measured, the plant height, 0.5tons/ha of basalt gave a better mean (15.90) compare to other treatment while T7 (control) gave the least mean figure of 10.70. For number of leaves, 1.5tons/ha of basalt gave a better mean of 8.75 while 1.5tons/ha of granite gave the least mean value of 4.25. For stem girth, 0.5tons/ha of basalt gave a better mean of 7.63 while 1.0tons/ha of granite gave the least mean figure of 5.30. From the analyzed results, it can be concluded that basalt and granite dusts performs better than the control, with basalt dusts performing best.

In order to improve emergence and early growth of *Musa acuminata* (banana) it is thus recommended that rock dust as an amendment has the essential nutrient in enhancing the cultivation of *Musa acuminata*. The significance difference between the number of leaves and the treatments shows rock dusts can also be used to enhance vegetables cultivation. In choosing rock dusts as amendments, it is also recommended that basalt dusts are a better remineralization of soil alternative than granite dusts.

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