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Emergence of Cocoa (*Theobroma cacao* L.) Seedlings as Influenced by Soil Remineralization using Rock Dusts

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Abstract:

Cocoa(*Theobroma cacao)* are opted for undergoing extensive nursery preparations, spending nothing less than 4-6months before transplanting to the field. This is due to late emergence that occur in the raising of cocoa seedlings thereby incurring additional expenses during and after nursery stages. Evaluationof the effects of soil remineralization by rock dusts on the emergence of cocoa was therefore carried out using granite and basalt rock dusts to determine the effect of remineralization of soil on the emergence of cocoa.Pots experiment was used with seven treatments including controland 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) anddata were collected on days of emergence. Data collected were subjected to Analysis of Variance (ANOVA) and no significance means among the treatment. The result however showed that T_6 and T_1 (1.5tons/ha and 0.5tons/ha of basalt and granite) had the best mean days to emergence of (8.75) while T_7 (control) had the least mean performance for emergence (10.25). 1.5 ton/ha of basalt rock dust performed best in the percentage of emergence giving a 100% emergence. However, there were no significant differences among the treatment at 0.05 level of significance.This showed that soil remineralization by rock dust should be encouraged to enhance the early emergence *Theobroma cacao* seedlings, judging with the best performance from the parameter assessed using the treatments including control. Compared to mineral or organic fertilizers, rock dusts are environmentally safe and are readily available mostly in quarries.

Keywords: Cocoa, Granite, Basalt, Emergence, Remineralization

INTRODUCTION

Cacao residues on pottery in Ecuador suggest that the plant was consumed by humans as early as 5,000 years ago. The tree was likely domesticated in the upper Amazon region and then spread northward. It was widely cultivated more than 3,000 years ago by the Maya, Toltec, and Aztec peoples, who prepared a beverage from the bean (sometimes using it as a ceremonial drink) and also used the bean as a currency.Cocoa trees grow in hot, rainy tropical areas within 20° of latitude from the Equator. Cocoa harvest is not restricted to one period per year and a harvest typically occurs over several months. In fact, in many countries, cocoa can be harvested at any time of the year. Pesticide are often applied to the trees to combat capsid bugs, and fungicides to fight black pod disease. The pods on a tree do not ripen together; harvesting needs to be done periodically through the year (Fawusi, 1983; Hawksley, 2001 and Hui, 2006).

In Nigeria cocoa production has steadily grown from 165,000 tons in 1999-2000 to 250,000 tons in 2013-2014, mainly as a result of high grower prices and to a limited extent also to the government support as outlined in the 2011 Cocoa Transformation Action Plan (Nzeaka 2014). The total harvested area amounts to 640,000 ha and the average yield is about 400 kg per ha (Lass 2000). Yield improvement is constrained by the age of the farmers (most of them are over 60 years old), a lack of proper farm management, low farm input use, inadequate supply and high costs of recommended chemicals, poor access roads to the major cocoa production areas and an inadequate extension service. Many cocoa fields are old and there is an urgent need for replanting of old farms. The Cocoa Transformation Action Plan envisages to improve this situation and to raise the production to 500,000 tons by 2015.

Many factors lead to low yield of cocoa, some of these factors include low input use, inadequate maintenance and pest and disease control, late or no emergence of cocoa seedlings, poor shade management, little or no fertilizer use and old age of cocoa farms. Also farm gate cocoa price, high input prices, no access to loans and credits and the small farm size are considered as external factors beyond the control of the individual farmer (Asare 2006). They affect the general conditions for cocoa production but have no direct effect on yield.

Efforts must be made to mitigate and counter the negative impact of agriculture on soil quality which also accelerates soil erosion and reduce biota activities in the soil. Application of rock dust to soils, being a natural source remineralization practice, has been considered to have little or no negative effect on soils and the environment, making all kinds of claims for growing bigger plants, producing higher yields, increasing disease resistance, eco-friendly, etc making it an important part in an overall strategy for a more sustainable agriculture (Egli *et al.,* 2010, Imaya *et al.,* 2010). However, a dearth of information on the effect of remineralization by rock dusts for the emergence of cocoa seedlings is known. Hence, this study seeks to document the effect of remineralization by rock dust on the emergence cocoa (*Theobroma cacao*).

MATERIALS AND METHODS

The experiment was carried out on the experimental plot of Crop Production Technology department at Federal College of Forestry, Jericho, Ibadan, situated at Jericho Hill under Ibadan Northwest Local Government area of Oyo state. The area is situated in the rain forest agro ecological zone of Nigeria which lies at latitude7^0 54^1 N and longitude 3^0 34^1 E. The average annual rainfall range and temperature are 1400mm-1500mm and 32^0C respectively with an average humidity range of 80-85% with two distinct seasons of wet (April – October) and dry season from November- March (FRIN, 2019).The granite rock dust and basalt rock dust were collected from the commercial quarries along Ibadan-Lagos express way. The rock dusts (residual minerals fines) were collected manually from the ground underneath the rock crushers where the finest dust tends to accumulate. After collections, the rock dust was taken to Forestry Research Institute of Nigeria (FRIN) soil laboratory to determine its physical and chemical composition.The seed of cocoa (*Theobroma cacao*) was procured from Oyo State Agricultural Development Project (OYSADEP), Ibadan.

The pot experiment consists of 28 polythene pots which were filled with topsoil and placed on the experimental field. Granite and basalt rock dust were added to 24 polythene pots filled with topsoil at different application rates (Boland and Baker 2000), as shown in the experimental layout key below. The granite and basalt dusts were agitated to incorporate them with the top soil and left for a day prior to planting. The remaining four top soil filled polythene pots were left undisturbed and these serve as control. The experimental layout was Completely Randomized Design (CRD), with four (4) replicates.The

Parameters assessed are mean days of emergence which was the mean of the number of days between planting and emergence; the percentage emergence which was done by counting the number of seedlings that emerge per treatment divided by the total number of seeds planted for each treatment and then multiplied by 100 percent. Watering was done twice a day (early in the morning and evening). Regular weeding was also carried out as when necessary.

Experimental layout

T_1R_1	T_3R_3	T_5R_3	T_2R_1
T_6R_1	T_4R_1	T_6R_3	T_4R_2
T_5R_4	T_1R_2	T_2R_2	T_3R_4
T_3R_2	T_7R_4	T_4R_4	T_7R_2
T_7R_3	T_2R_3	T_1R_3	T_6R_4
T_4R_3	T_5R_1	T_7R_1	T_5R_2
T_2R_4	T_6R_2	T_3R_1	T_1R_4

Where

T_1 = Topsoil + 0.5tons/ha of granite dust (85g of granite dust per 2kg of top soil).

T_2 =Topsoil + 0.5tons/ha of basalt dust (85g of basalt dust per 2kg of top soil).

T_3 =Topsoil + 1.0tons/ha of granite dust (170g of granite dust per 2kg of top soil).

T_4 =Topsoil + 1.0tons/ha of basalt dust (170g of basalt dust per 2kg of top soil).

T_5 =Topsoil + 1.5tons/ha of granite dust (255g of granite dust per 2kg of top soil).

T_6 = Topsoil + 1.5tons/ha of basalt dust (255g of basalt dust per 2kg of top soil).

T_7 = Top soil (Control).

All data collected were statistically analysed using Analysis of Variance (ANOVA). Differences between means were determined using the Least Significant Difference (LSD) test at 5% level of significance.

RESULTS AND DISCUSSIONS

Table 1: Typical 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 ($mgkg^{-1}$)	3.0
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 (gkg^{-1})	
Sand	884
Silt	68
Clay	48
Textural Class	Loamy sand

Source: Soil & Tree Nutrition Laboratory, FRIN.

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 (3.62g/kg) are also said to be 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 (0.3cmol/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 (96mgkg^{-1}), Fe (81 mg/kg^{-1}) and Cu (2mgkg^{-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 (7mgkg^{-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

Source: Soil and Tree Nutrition lab, FRIN

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 230mgkg^{-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) 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: Cocoa Seed Emergence as Affected by Basalt and Rock Dusts at Planting.

Treatment	Application Rate (tons/ha)	Means of Emergence	Percentage of Emergence (%)
Basalt	0.5	9.25[a]	96[a]
	1.0	9.25[a]	96[a]
	1.5	8.75[a]	100[a]
Granite	0.5	8.75[a]	98[a]
	1.0	10.00[a]	93[a]
	1.5	9.50[a]	95[a]
Control	0	10.25[a]	92[a]
Sig	App rate	Ns	Ns
	Trt	Ns	Ns
	Trt&App	Ns	Ns

In the mean analysis of the emergence, there was no significant difference among the treatment application rates and in the interaction effect. In the mean performance, the least was recorded in 1.5tons/ha of basalt and 0.5tons/ha of granite having 8.75days indicating the earliest days of emergence while the longest emergence was recorded in control having 10.25 mean days of emergence indicating late day of emergence.

The percentage emergence of more than 90% recorded was an improvement when compared with Adenikinju (1975a) who reported percentage of 34-60 percent within 14 days after planting but in agreement with Olaiya (2016) who also reported more than 90% percentage emergence using mucilage removal with sawdust and washing before planting.

CONCLUSION

It is apparent from this study that planting of cocoa with re-mineralized soil using rock dust is the best for early emergence of cocoa seedlings before transplanting on the field. The parameters studied shows that basalt and granite dust performed better than the control when considering the mean days of emergence and percentage of emergence. Application rate of 1.5 tons/ha of basalt rock dust is observed to be the best eventhough it has same mean day of emergence with granite 0.5 tons/ha, but the percentage of emergence is better. In order to improve emergence of cocoa seedlings, it is thus recommended that rock dust being a natural remineralization agent has the essential nutrient in enhancing the early emergence of *Theobroma cacao* at the nursery stage before transplanting to the field.

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