THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Land Preparation Methods and Land Use and Their Effects on Soil Fertility in Relation to Cocoa Establishment in an Alfisol in Southwestern Nigeria

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Abstract:
This paper discusses problems of Land preparation methods and land use practices on soil fertility in relation to cocoa establishment and productivity. Physical and chemical analysis of soils collected under different land preparation and land use practices (Bulldozed plot, slashed and burnt plot, un-cleared plot and arable land grown to cassava) were carried out in Ijeun Alagbede in Owode local government area of Ogun state to know their suitability or otherwise for cocoa production. The soil properties studied were soil texture, pH, total N, available P, exchangeable K, Ca, Mg, extractable Zn, Cu, Fe, Mn and organic carbon. Soil under bulldozed plot was very low in nitrogen compared to un-cleared and slashed and burnt plots. Soils collected in the cassava plot had the lowest value of nitrogen. The most commonly observed change in soil following slash-and-burn clearing of tropical forest is a short-term increase in nutrient availability; hence cations were highest in slash and burnt plot. The soils had lower nitrogen and organic carbon compared to the critical values recommended for cocoa.

Keywords: *Land, soil fertility, slash and burn, bulldozed plot, cassava plot, cocoa*

1. Introduction

Land is a basic resource in crop production. The best of crop variety will not express its full potential without the right soil. Cocoa occupies a prominent position among the tree crops of high economic value in Nigeria. The suitability or otherwise of a soil is the major factor to be considered in the production of any crop. The physical and chemical properties of the soils must meet the requirements of the crop in order to get optimum yield.

With the present Nigerian government agricultural transformation agenda, cocoa farmers among other farmers are being supported through provision of inputs such as hybrid cocoa pods and fertilizer with fungicides at subsidized rate through Growth Enhancement Support scheme. Establishment of new plantations is being encouraged. Giving the dearth of virgin lands, most people are left with the option of establishing cocoa on secondary forest, short fallowed land, arable land and rehabilitation of old unproductive cocoa plantations. There seems to be little or no information on the effect of different land preparation methods on the soil fertility of farms in the study area. The aim of this work is to evaluate the physical and chemical properties of the soils under different land preparation methods and assess their suitability or otherwise for the cultivation of cocoa.

2. Materials and Methods

Soil samples were collected from bulldozed plot, slashed and burnt plot, un-cleared plot and plot cropped to cassava at Ijeun Alagbede, Owode local government area, Ogun state (Lat. 07^{o} 04.307 and long. 003^{o} 29. 470.Soil samples were also collected from the heaps of top soil packed at the edges of bulldozed plot. The entire land area was 12 hectares. An area of 3 hectares was marked out for each land preparation type and subdivided into 3 sub-plots of 1 hectare size. Random sampling technique was used and 20 core samples from 0- 20cm soil depths were collected per hectare per land preparation/land use type.


Figure 1: Bulldozed plot


Figure 2: Slash and burn


Figure 3: Cassava plot


Figure 4: Un-cleared plot

The soil samples were labeled, air dried and sieved to pass through 2mm sieve. The 20 core samples /ha/ land preparation method were thoroughly mixed to obtain a composite sample. Three composite samples were obtained per land preparation/land use types. The composite samples were sub-sampled and analyzed for the texture and chemical properties such as pH, organic carbon, nitrogen, phosphorus, potassium, magnesium, copper, iron and manganese.

The soil texture was determined using hydrometer method. The soil pH was determined in soil-water ratio of 1:2 using pH meter. Total N was determined by micro-kjedahl method while available P was by Bray 1 method. The cations were extracted by ammonium acetate and the Ca, Mg, Zn, Cu, Fe and Mn were read through the Atomic Absorption Spectrophotometer, K by flame photometer. The organic carbon was determined by wet dichromate oxidation method.

The three values obtained for each of the element from the three composite samples per land preparation methods were averaged. The average values were then compared with the critical values for cocoa and values obtained in the heap of the top soil at the edges of bulldozed plot.

3. Results and Discussion

The results of the soil analysis indicated highest nitrogen content in the heap of top soils packed at the edge of the bulldozed plot. The nitrogen content in the heap of top soils packed at the edge of the farm that was bulldozed was 80%, 73%, 64%, and 38% higher than N contents in cassava, bulldozed, un-cleared, and slash & burnt plots respectively. The total nitrogen content of 0.23g/kg in the bulldozed plot compared with the N content of 0.86g/kg in the top soil packed at the edge of the bulldozed plot corroborated the reason why bulldozing of farm land is being discouraged in the shallow tropical soils. Mechanical clearing of land using bulldozers on tropical soils with very thin layer of organic matter which is the nutrient reservoir has led to adverse effects of increased soil erosion, increase compaction, increase bulk density, reduced infiltration and poor water holding capacity (Eneji and Ayade, 2000). Montgomery (2008) reported that an inch of soil degraded takes a thousand years to regenerate hence the need to avoid bulldozing of land as a means of land cultivation. Cassava farm has the lowest total nitrogen and organic carbon contents as shown in Table1 which agrees with results obtained by Ufot*et al.,*(2016). Nutrient depleted arable land could be amended to raise its nutrient content and quality if cocoa will be planted. Singh (1997) reported that agricultural potential of a land can be judged by the physical/chemical properties of its soils which provide anchorage, water and nutrients for plant use. Organic carbon contents of the various land preparation methods/land use were higher in heap of bulldozed topsoil(11.4 g/kg) showing similar trends as observed with nitrogen contents. Available Phosphorus contents of the various land preparation methods/land use were grossly below the critical value of 10mg/kg required by cocoa as reported by (Egbe *et al*., 1989).Soil pH in the slashed and burnt plot was the highest compared to other land preparation and land use methods. This was similar to the findings of Babalola(2000) who reported that the ash deposits after burning increase the pH of the soil, and help to fertilize the soil. This is done by immediate release of mineral nutrients such as magnesium, calcium and available phosphorus for crop use. (Christian *et al., 2000*) reported that the most commonly observed change in soil following slash-and-burn, clearing of tropical forest is a short-term increase in nutrient availability but the damage caused on soil is irreparable. Niemeyer et. al,2005 and Brye(2006) reported increased soil temperature after burning, stimulated biological activities and increased organic matter mineralization that enhanced nutrient availability with increased susceptibility of the soil to erosion. Burning has been identified by Hubbert et.al 2006 as one of the soil degrading practices that result in soil structural degradation. Burning exposes to soil surface to rainfall, destroys soil structure and alters soil cation exchange capacity(Kettering et.al 2000). Therefore, soil surfaces exposed by burning tends to be erosion prone compared to original soils because of their low organic matter content as a result of high mineralization and their poor structure. Table 2 shows some critical levels of soil nutrient elements for cultivating cocoa below which yield will reduce.

Properties	Bulldozed plot	Slashed & burnt plot	Un-cleared plot	Cassava plot	Heap of top soil
pH(soil/water1:2)	6.9	7.4	6.91	6.87	7.1
Total N(g/kg)	0.23	0.53	0.31	0.17	0.86
Organic C.(g/kg)	2.67	7.6	4.04	2.45	11.4
Avail. P(mg/kg)	6.21	6.17	5.21	7.09	7.19
Exch.K(cmol/kg)	0.38	0.43	0.21	0.15	0.63
Exch.Ca(cmol/kg)	5.15	9.92	3.65	3.31	6.06
Exch. Mg(cmol/kg)	2.20	3.11	3.02	2.61	3.15
Exch.Na(cmol/kg)	0.17	0.16	0.18	0.24	0.15
CEC(cmol/kg)	7.9	13.62	7.06	6.31	9.99
Sand(g/kg)	790	800	800	780	780
Silt(g/kg)	50	60	60	60	90
Clay(g/kg)	160	140	140	160	130

Table 1: Chemical and physical properties of soils under different land preparation methods in the study area

The calcium levels of the slash and burnt plot was highest due to immediate release of nutrients element into the soil followed by the heap of top soil considering the critical level while un-cleared and cassava plots re list in calcium content. A similar trend was also observed for CEC.

N	P	K	Ca	Mg	Zn	OM	pH
%	mg/kg	Cmol/kg	Cmol/kg	Cmol/kg	mg/kg	%	
0.09	10.0	0.3	5.0	0.8	2.80	3	5.5

Table 2: Critical levels of some soil properties for cocoa cultivation
Source: Egbe et.al 1989

4. Conclusion

Soil under bulldozed plot was very low in nitrogen compared to un-cleared and slashed and burnt plots. Soils collected in the cassava plot had the lowest value of most nutrients(nitrogen). The cations were highest in slash and burnt plot. The soils had lower N and C compared to the critical values recommended for cocoa. Burning increases fertility of soil in a short term, but the damage caused on soil is irreparable. An inch of soil degraded takes a thousand years to regenerate (Babalola, 2000) hence the need to avoid bulldozing of land as a means of land cultivation. Soil amendment will be required if cocoa will be planted on this arable land.

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