GENERAL VARIABILITY OF SOILS UNDER VETIVER GRASS STRIPS: FOCUS ON COMBATING LAND AND ENVIRONMENTAL DEGRADATION.

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ABSTRACT

The general variability of soils on runoff plots under the influence of vetiver grass strips (VGS) was studied using conventional "Fisher" statistics. The focus was on safe use of vetiver system (VS) for combating land degradation in view of its various advantages. The overall objective was to quantify the variability in relation to VGS effects on the soil and its influence on other plants. The VGS was established at 20m spacing two years earlier hence some soil had accumulated on the upper slope side at a mean rate of 71.0mm per year. There were greater faunal activities around the VGS. Static soil properties such as total sand (ranged 712 to 866 gkg^{-1}) and bulk density (1.24 to $1.51gcm^{-3}$) had low coefficient of variation (CV) values (CV<15%) and dynamic soil properties which could easily be influenced by management (such as available phosphorus and silt; ranging from 2.85 to 13.2mg kg^{-1} and 64 to $174gkg^{-1}$ respectively) had high CV values (CV = 35 to 70%). All the parameters analysed followed a normal frequency distribution.

The results of the effects of VGS on properties of soils bounded by it showed that clay and bulk density were lesser with VGS than without; $83.83kg^{-1}$ clay with VGS and $90.5gkg^{-1}$ without VGS at 0-5cm depth. The reverse was observed for sand content, though their effects were linked to slope, erosion and pedogenic factors rather than VGS. Among the chemical properties, organic carbon (OC) and total nitrogen (TN) were higher in parcels of land in order bounded by VGS than those without. The use of the VGS technology in combination with mechanical measures along water-ways, gully embankments, roadsides and sloppy farm-lands to protect and rehabilitate marginal lands to facilitate crop production, and the integration of soil variability with problem solving were recommended. It was concluded that since the VS did not cause any significant difference in the soil physical properties it can be safely used as an environmentally-friendly natural resource to improve and protect farmlands and infrastructures.

Keywords: *Vetiver Grass, Variability, Land degradation, Soils, Rehabilitation, Environmental protection.*

INTRODUCTION

Soil degradation and declining productivity of the previously productive agricultural lands are what the resource-poor small farmers have to grapple with in order to make a living. The implication is that as the negative trend progresses, the farmers mine the land ignorantly until complete exhaustion and productivity breaks down. They are then forced to look elsewhere in the ecosystem to make a living: Exploitation of virgin forests for all what it can afford; the water-shed is no more protected; adding municipal waste and effluents from septic tanks can be hazardous as there are dangers of heavy metals pollution. Generally, the relationship between environmental degradation and poverty is cyclic and complicated as reported by Pinstrup-Andersen and Pandya-Lorch (2001), "one of the major causes of environmental stress in the developing world is poverty, and one of the major causes of poverty is environmental stress". Besides affecting aggregate food supply, soil degradation also diminishes agricultural income and economic growth (Scherr, 1999). And because the poor are particularly dependent on agriculture, soil degradation poses particular problems. Leaving them with no apparent alternative livelihood options than to continue to cultivate the marginal lands. Details on land degradation, use and extent of marginal lands, definitions and criteria for soil marginality have been reported in the literature (Agboola *et al*, 1977; Babalola and Zagal, 1999; GEO-

3, 2002; Scherr, 1999; Pinstrup-Andersen and Pandya-Lorch, 2001; among others). But the major problem that still lingers is how to rehabilitate lands sustainably with less cost and low-external inputs to benefit the poor.

Combating or reversing land degradation is no mean task; it is an herculean task especially as land degradation monitoring devises are yet to be put in place (GEO-3, 2003). Soil degradation, a major component of land degradation can be checked. And this can be easily done factor by factor. Soil erosion is a major factor in land degradation and has severe effects on soil functions. The main types of soil degradation are water erosion (56 per cent), wind erosion (28 per cent) and chemical degradation (12 per cent) (GEO-3, 2002). And there is one grass known and proven (Greenfield, 2002; Okorie, 2002 and TVN, 2002) to be very useful and effective in combating the three main types of degradation (96 percent) mentioned above. The plant can prevent degradation and at the same time heal land that have already been degraded and/or polluted. The grass is called vetiver (*Vetiveria zizaniodes* (L.) Nash.). It is a cheap, reliable and living resource material that has been described variously as “a hedge against erosion”, “a trickle filter” against surface run-off, “a nurse plant” in stabilizing contaminated land fills, and “a barrier” in disaster mitigation and vulnerability reduction. Vetiver grass has been used in various countries for various land recovery purposes. It offers one of the best, new, and low-external-input technology for effectively rehabilitating eroded and marginal lands and for removing toxic heavy metals and other contaminants from polluted agricultural lands, with great potentials for purifying eutrophic water. However, its application in Nigeria is very limited due to ignorance about what it can effectively do.

Because of the various uses of the vetiver grass, a close scientific study of the general variability of soils under the already established vetiver grass strips was undertaken. The main objectives were to: (i) quantify the general and spatial variability of the soils under vetiver grass strips (VGS) in relation to its effects on the soil and on other plants; (ii) investigate, quantify and evaluate the variability (of the physico-chemical properties); (iii) contribute to knowledge of on-farm environmentally-friendly soil and water conservation technology using vetiver grass system.

MATERIALS AND METHODS

The study area was located along Parry-Road in the University of Ibadan, Ibadan – Nigeria; on Lat. $7^{0}25^{l}$ to 31^{l} N and Long. $3^{0}5^{l}$ to 56^{l} E; on altitude of 228m above sea level with a mean annual rainfall of 1289.2mm (Alabi and Ibiyemi, 2000) and in sub-humid agro-ecology. The Vetiver Grass Strips (VGS) field was made up of 6 plots each measuring 40m x 3m. Three plots had VGS while three were bare (control). The surface distance between the VGS were 20m. The slope of the plot is 5% while the area of farmland is $720m^2$, that is 0.072 hectare. The soil order is Alfisol, Ibadan soil series. The area had been cropped with arables, with the VGS in place, for two seasons under rain-fed system.

For field sample collection, systematic sampling using soil anger was carried out on grids 5m x 3m. Samples were collected at 015cm and 5 to 10cm depths, at a lag of 5m apart. A total of 120 samples were collected (including the 24 samples of accumulated materials on the upper slope of the VGS) air-dried and passed through 2.0mm and 0.210mm sieves for relevant laboratory analyses. Generally, the physico-chemical properties were determined using methods described by Black (1965), IITA (1979), Udo (1986) and Hesse (1971).

The classical "Fisher" statistics was carried out to determine levels of significance and used to show the general variation as characterized by the analysis of variance (ANOVA) - using randomized complete block design; mean; standard deviation; coefficient of variation (CV); range and frequency distribution. The computer software used for the analysis was "The SAS system" (SAS Institute, 1989). The statistical model used in computing the frequency distribution was defined (Kutilek and Nielsen, 1994) as the probability density function (pdf):

$$pdf = \frac{1}{\delta\sqrt{2\pi}} \text{ exp. } [-(x-\mu)^2/2\delta^{-2}]$$

RESULTS AND DISCUSSION

General variability: The average values of some soil physico-chemcial properties of the vetiver grass strips (VGS) plots; their standard deviations and CV are presented in Table 1. Subjecting the eleven variables considered to ANOVA (The SAS system), no significant difference (at P = 5%) was observed among the properties. This implies the parameters were somehow uniform throughout the whole field, thus indicating that VGS generally did not have any adverse effect on soil physical properties. However, some rather dynamic properties which can easily be influenced by management [such as total nitrogen (TN); pH; organic carbon (OC); clay] either at 0 to 5cm or 5 to 10cm depths. Clay was found to be unusually dynamic perhaps due to its size and mobile nature in the tropical rains run-off (during erosion). It is note-worthy to report here that from visual observations, there were more faunal activities around the VGS than anywhere else in the field. Earthworm casts and termites were prominent under the VGS. Greater root content was found at 5 to 10cm depth explaining the reason for significant difference in OC at this depth.

At the 0 to 5cm depth, available P ranked highest in variability (CV = 46.28%) while total sand was the least variable (CV = 4.74%) property (Table 1) in the field. A summary and grouping of these variabilities into low, medium and high, after Wilding (1985) and Ojetade (1999) is presented in Table 2. The result in Table 2 will help us understand static and dynamic soil properties of soils under the influence of VGS. The properties with low variability were somehow static and could be said to be less influenced by the VGS while those with high variability were dynamic. From ANOVA, only three variables: clay, soil pH and TN indicated significant differences at both depths in the field. Clay content at 5 to 10cm depth were significantly higher ($P < 0.01$) in lags without VGS than in lags with VGS and this with a lower CV (CV = 9.23%). This difference is an important contribution by VGS to clay absence at the lower depths in the field, thus explaining why rain water percolates VGS field more readily than in control. In Table 3, the effects of vetiver grass strips were compared with control plots at both depths. Only clay, soil pH, OC and TN contents showed significant differences between lags and plots in the main field. The soil pH of plots A and C were significantly higher than plot E and control at both levels. Total N at 0-5cm depth showed significant differences both among plots and at different lags.

Figures 1 and 2 show the frequency distribution referred to as the probability density function (pdf) of some of the soil properties in the VGS field. The field and the parameters were considered only along North-South transect, and their frequencies all followed normal distribution pattern.

Effects of VGS on properties of soil-block bounded by VGS on both ends were compared with the properties of soil-block without VGS on both ends. The results at 0 to 5cm depth is presented in Table 4. The control (bare plots without VGS) were equally evaluated as a check. Clay was generally lower in the parcel of land (lags) bounded by VGS than those not bounded by VGS. For instance, clay was 83.83gkg^{-1} with VGS and 90.5gkg^{-1} without. Similar trends were followed in their controls; 89gkg^{-1} with VGS compared with 103.5gkg^{-1} clay without VGS (Table 4). There was a reversal of this trend with total sand content. The results obtained here for soil physical properties revealed that the observed effects may not be due to VGS but rather to slope, erosion and pedogenic factors as the trends were equally similar in the control plots or lags. The chemical properties of the filed revealed that soil pH, organic carbon and total nitrogen were generally higher in parcels of land bounded by VGS than those without VGS. In contrast, available phosphorus (P) indicated a reversal (and lower).

ENHANCED DISCUSSION

In the study, the dynamic physical particles sizes were silt and fine sand possibly due to their sizes. Ojetade (1999) obtained similar results for silt. Silt can be used as a modal parameter to detect soil erodibility because they are predominantly spherical in shape, hence cohesion, surface area and aggregation are much less in silt than clay. Since its size fraction is smaller than sand, it is more easily eroded than the two extreme particles. The high variability of silt in this study could be linked to the “movement-retarding” effect of the VGS, which spreads out the runoff water and retains more of large-sized particles; and were those materials that accumulated on the upper slope side of the VGS. The accumulation ranged from 59.54 to 91.85mm per year and was significantly sand (Table 3).

From these results, vetiver does not have any negative impact on the soil physico-chemical properties rather it enhances erosion control by retarding movements of highly variable and dynamic particles, hence VGS can be cheaply and safely used alongside crops for on-farm land and environmental rehabilitation/protection without danger or harm. In Australia, Troung and Hengchaovanich (1997) found that the VGS had a significant role in slope stabilization and flood mitigation. They particularly showed that its incorporation into strip cropping provides good protection from floodwater over 90m spacing and 0.20 to 0.35per cent slopes. Based on studies carried out at Umudike, Southeastern Nigeria, Okorie (2002) has recommended some cultural techniques for use of vetiver in farmlands in the region. Research work in China showed that VGS reduced toxic heavy metal in contaminated landfills, protected soil from wind erosion and plants from sand-drift and sand-blasting. Technical uses for bio-remediation of VS include bio-engineering of farms, highways and embankments (Greenfield, 2002; TVN, 2002).

CONCLUSION/RECOMMENDATIONS

Soils continuously vary in space and time. The study serves as an encouragement and guide to intensify use of VGS on landscapes for protection against natural hazards and weather extremities. It can therefore be concluded that one of the most effective ways of controlling soil erosion and surface runoff is to design and apply strategies that combine mechanical practices with this biological "living-vegetative-hedge" (vetiver system) approach. The vetiver system (VS) is both environmentally-friendly and less harsh to soils as it did not cause any significant difference in the soil physical properties. It allowed complementary crop production, which is what the farmer with limited or marginal lands need, and promoted faunal activities around the VGS; thereby using natural resource and cheaply too, to improve standards of living without destroying the environment as obtainable with expensive soil-mechanical structures. It is recommended that this relatively new VGS technology be used in combination with mechanical measures and that to help decide the best choices of management, variation in soil physical parameters should be integrated with problem solving to give the grower answers to his specific set of problems.

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