Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 18, Issue 3, 2018
PRINT ISSN 284-7995, E-ISSN 2285-3952

EFFECT OF BAHIAGRASS COVER ON THE CHEMICAL PROPERTIES OF AN ULTISOL AT DIFFERENT LEVELS OF SLOPE IN UMUDIKE, NIGERIA

Ojimgba ONWUCHEKWA, Mgbeahuru CHIBUIHEM

Abia State University, Uturu, Nigeria, Department of Soil Science, Phone: +2348030846974; Emails:onwuchekwao@yahoo.com; ojimgbachekwas59@gmail.com

Corresponding author: onwuchekwao@yahoo.com

Abstract

The effect of Bahia grass (Paspalum notatum) on the chemical properties of an ultisol at different levels of slope was carried out in Umuahia, Southeastern Nigeria. The use of Paspalum notatum has attracted considerable research attention with respect to forage production and erosion control. Little information is available on the influence of this grasscover management on soil chemical properties. This research work was carried out at different levels of slope planted with Paspalum notatum (4%, 20% and 33%) and also on bare soil. The study has shown that the slopes planted with Paspalum notatum gave significantly higher results of the chemical properties than the open adjacent bare soil. In all the parameters considered in this study, the values obtained in 4% slope was higher than those obtained in 20% as well as 33% and the bare soil, in the following significant order: 4%> 20% > 33% > Bare soil. However, 4% slope had higher values of phosphorus (P) than the similar values of 33% and 20%, while Bare soil gave the least value in the order: 4%> 33% = 20% > Bare soil. Also, the exchangeable acidity (H^+ and Al^{3+}) values were significantly ($P<0.05$) higher in bare soil than in those slopes planted with Paspalum notatum. This result also pointed to the fact that the pH of the soils planted with Paspalum notatum gave higher values than the corresponding bare soil. Therefore, Paspalum notatum improved very highly the chemical properties of the tropical soils, whereas bare soil had no such effect.

Key words: *bahia grass, chemical properties, ultisol, slope levels*

INTRODUCTION

Bahia grasscover (*Paspalum notatum),* a perennial grass has the characteristics of rapid growth, strong resistance to stress and high biomass yield. The grass has been widely grown in the tropics and subtropics for the purposes of lawn establishment, forage crop growth, erosion control and slope stabilization. The plants develop an extensive root system that plays a crucial role in the protection of both soil and water [37], [34], [38]. In recent years, this grass has been found effective in revegetation of mined lands, uptake of heavy elements e.g. Cs and Sr. [8],[28],[35]. Previous studies showed that *Paspalum notatum* was one of the suitable grasses for restoring an oil shale waste dump due to its good adaptability to the waste [35],[12]. The change from agricultural to grassland which is referred to as land use conversion influences change in production of biomass as well as nutrient cycling have influence on soil properties [5],[36]. This particular change in land use from agriculture to grassland/ forest, brought the development of a longer tree biomass [31] and increased the availability of plant nutrients [17]. This also increases soil organic carbon, microbial biomass and potential nitrogen mineralization rate, reducing the soil bulk density [17]. Soils under grass cover have shown better chemical properties than soils under forest cover and also bare soils [23].

Soil landscape relationships due to anthropogenic and natural activities can also influence the properties of soils through the summits to the foot slopes and in most cases, Soil organic matter (SOM) and nutrient reserves are really affected. Thus, soil properties which include morphological, physical and chemical as well as depths for crop production often vary among landscape position and which potentially limit Crop production [29].

Fallow/grassland have higher soil organic carbon values than cropland, but lower values than forest for different depths which was consistent with the results of [9] and [11]. The relatively low vegetative cover, especially at the upper and mid-slope, may also account for low organic carbon values as well as soil total nitrogen. However, relatively high vegetation coverage and thick litter fall and animal tissue in the forest are helpful to reduce soil erosion as well as accumulate soil organic carbon, total nitrogen, available phosphorus, and cation exchange capacity as stated by [9] and [33].

However, increased organic carbon values of the soils at lower slopes may be due to organic matter accumulation resulting from litter falls. [16] found that soil organic carbon content increases with slope because of the stronger soil erosion at high slopes. On the other hand, relatively high soil organic matter (SOC) (11.2%) at the uplands than mid slope position maybe due to its flatness. [15] also reported that SOC may be a direct product of mineralization rates rather than being more strongly related to material deposited and eroded due to enhanced erosion process on disturbed hill slope. The orientation of the study area in terms of the upper, middle and bottom slope positions, relate the properties of the soil in different landscape positions. [3] however, studied the properties of the soil in relation to land form positions and found significant differences among soil properties of sand, silt, pH and exchangeable calcium and magnesium mostly decreased down the slope.

Land use and slope affect soil properties. Pearson coefficients of interaction between land use and slope position to soil properties (0 – 20cm depth) revealed that overall degree of correlations is highly dependent on environmental variables. Total Organic Carbon (C), Nitrogen (N) and Phosphorus (P) in the middle slope soils were the lowest among the soils in the three topographic positions [4]. According to the findings of [28], organic carbon, available nitrogen (N), available potassium (K), extractable iron (Fe) and exchangeable sodium (Na), were highest on the summit, while pH, available phosphorus, exchangeable calcium (Ca), and Magnesium (Mg) were significantly higher on the foot slope at surface soils [29].

[14] used slope position and aspect to estimate N- Cycling rate in Minnesota Prairie, USA, but found small variation with the subtle topography. [6] found slope to be controlling factor for soil pH in mountainous areas of Eastern Taiwan. Appropriate soil management practices like grass cover could increase the (SOM) content to become a source of slow release of nutrients to the soil [13]. The major objective of this research work was to determine the effect of *Paspalum notatum* on the chemical properties of an Ultisol at different levels of slope.

MATERIALS AND METHODS

Location

The experiment was conducted within the premises of Abia State University, Umuahia Campus. The area is located in Umudike, Umuahia, South Eastern Nigeria which lies at latitude 05^0 29^0 North, longitude 07^0 33^0 East and is at 122m (400 feet) above sea level. This falls within the humid rainforest zone of West Africa which is characterized by long duration of rainfall and a short period of dry season.

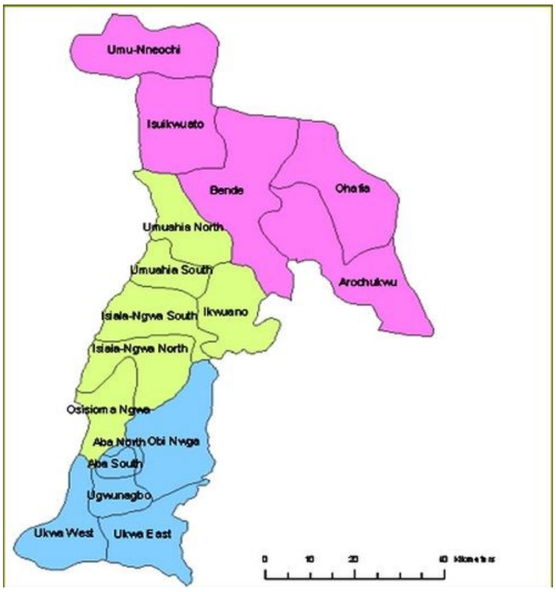

Fig. 1. Map of Abia State showing Umuahia the Project Site [Abia State University, Umuahia Campus Nigeria]

The vegetation predominant in the study site is tropical rainforest in which medium size trees (8.29 m) long, such as *Terminalia spp*, *Milicius spp*., etc are predominant. Below the trees are grasses and shrubs.

The predominant soils of the study area as in other parts of Nigeria are classified as ultisols [21]. These soils have a number of soil related constraints to agricultural productivity, poor structural stability and high susceptibility to soil erosion and drought trees [21].

It is notable with very little rainfall, hotter days, cooler nights and lower humidity ending in February. It has an average rainfall of 2000 mm, ambient temperature of 26^0C with maximum temperature of 33^0C and minimum temperature of 22^0C. Relative humidity ranges from 50-95%.

Soil Slope

Soil slope is particularly important in terms of its effect on erosion. Slope can be measured in percent (rise/run) 100 degrees. The amount of surface residue required reducing erosion increases with slope and as soil texture gets finer.

To convert percent slope to slope in degrees;
"Angle in degrees" = cotangent.
(Percent slope/100) = cotangent (Rise/Run)
Percent slope = tangent (percent slope/100).

Soils in low-lying areas have higher water content, more weathering, thicker soils and vegetation.

Therefore, slope gradient is referred to as the angle of inclination of the soil surface from the horizontal. It is however expressed in percentage, which also is the number of feet rise or fall in 100ft of horizontal distance.

Table 1. Slope Description, Percentage and Class

Percent slope	Slope class	Description
0 – 2	A	Nearly level
3 – 6	B	Gently sloping
7 – 12	C	Moderately sloping
13 – 18	D	Strongly sloping
19 – 25	E	Moderately steep
26 – 35	F	Steep
>35	G	Very steep

Source: Purdue University. March 2010-Soil Slope [25]

This is important because it influences the rate at which runoff flows on the soil surface and erodes the soil.

Slope shape either straight, concave or convex and slope length are also important properties of soil surfaces.

Steep slope encourages accelerated erosion, reduces the amount of water percolation through the soil and decreases the upper portion of the soil.

Soil Sampling

Twelve (12) soil samples were collected for the experiment from three different locations at the depth of 0-20cm. Three soil samples were collected from bare soil or open adjacent sites to where *Paspalum notatum* was established by the University. However, three (3) other samples were collected from the slopes of 4, 20 and 33% which were planted with *Paspalum notatum* at three locations A, B. and C. The samples were transferred to the laboratory for routine analysis; therefore, these soil samples collected were air-dried and passed through a 2mm sieve to remove large particles, debris and stones. A total of twelve soil samples were collected.

Laboratory investigation

The dried and sieved samples of soil were used to analyzed for pH, ECEC, Organic Carbon/ organic Matter, Base saturation, exchangeable acidity, available phosphorous, total nitrogen and exchangeable bases.

Soil Reaction

The pH of the soil was determined in both distilled water and salt (potassium chloride-KCl) at the ratio of 1:2.5 (soil sample to distilled water/KCl ratio).

Organic Carbon

The organic carbon content of the soil was determined using the method of [32]: while the soil organic matter was determined by multiplying % organic carbon with 1.724 (Van Bermeleen factor - carbon comprises 58% organic matter). The soil organic carbon was oxidized using 1N potassium dichromate solution and concentrated sulphuric acid. The percentage Organic Carbon was determined by titrating with 1N ferrous ammonium sulphate liquid.

Effective Cation Exchange Capacity

In addition, the effective cation exchange capacity (ECEC) was determined using the summation method, which implies the addition of the exchangeable cations and total exchangeable bases.

Total Nitrogen

This was determined using the fractionation method; the wet oxidative digestion by Kjeldahl.

Exchangeable Acidity

Exchangeable acidity (H^+ and Al^{3+}) was determined using the titration method of [18].

Base Saturation

Base saturation was determined by calculation. Base saturation equals total exchangeable bases divided by Effective Cation exchange capacity, multiplied by hundred i.e.

$$BS = \frac{TEB}{ECEC} \times 100$$

It is the amount of basic cations that occupy the cation sites.

Available Phosphorus

This was determined by the [2]. Brays method 2 (0.3N ammonium fluoride x 0.1N HCl). The phosphorus with the unit part per million (ppm) was determined using a photo electric calorimeter and converted to Kilogramme by multiplying by 2.24.

Exchangeable Bases

The complex metric titration method was used to determine the values of Calcium (Ca) and Magnesium (Mg) predominant in the soils of the study site. Also, sodium (Na) and Potassium (K) were determined by the Flame-photometric method. The soil sample was leached with ammonium chloride and ammonium hydroxide buffer 10 solutions.

RESULTS AND DISCUSSIONS

Effect of *Paspalum notatum* on soil chemical properties different slope levels.

pH, Organic Carbon/ Organic Matter, Nitrogen, Available Phosphorus.

The results in Tables 2 and 3 summarized the effect of *Paspalum notatum* on the organic carbon, total nitrogen, pH as well as available phosphorus of soils at different slope levels. The results also show there were significant changes ($P < 0.05$) in organic carbon, total nitrogen, pH and available phosphorus due to influence of *Paspalum notatum.* Generally, the tables also show that there were significant changes in all the parameters as follows: 4%> 20%> 33%> bare soil, except in exchangeable acidity where bare soil had the highest values in the following order: bare soil >33% >20% >4% and in available phosphorus where 4%> 33% = 20%> bare soil. However, *Paspalum notatum* gave significantly higher values than the bare soil as a result of increased root activities by microbes due to high organic carbon and organic matter contents of *Paspalum notatum*.

Soil Reaction (pH)

Some increase in pH of the soils planted with *Paspalum notatum* was observed in the various slopes. For example, the pH in water of the bare soil was raised slightly from 4.9 to a mean of 5.5, 5.2 and 5.1 for 4, 20 and 33% slopes, respectively. Also, the pH in KCl was raised from 3.7 to 4.3, 4.1 and 4.0 for 4, 20 and 33% slopes, respectively. The relative improvement was in the order: Bare soil < 4% > 20% = 33% for pH in water. The very acidic nature of the bare soil according to [20] is as a result of a problem of exposure of very acidic subsoil due to erosion. They attributed this low values partly because the soils are heavily leached of the basic cations due to very heavy rainfall associated with the rainforest zone.

Organic Carbon

Also, the results obtained from Tables 2 and 3 show that the percentage organic carbon content of the bare soil ranged from 1.04 to 1.06 with mean of 1.05%. Then, the organic carbon content of *Paspalum notatum* at 4% slope ranged from 2.18 to 2.20% with mean of 2.19%, while that of 20% slope is 2.14 to 2.16 with mean of 2.15%, and 33% slope ranged from 1.71 to 1.74% with mean of 1.72%.

Similarly, Tables 2 and 3 show that organic matter values derived from organic matter of bare soil had significantly the same trend and ranged from 1.79 to 1.83% with mean of 1.81%. In addition, the organic matter values of *Paspalum notatum* at 4% slope ranged from 3.76 to 3.79% with mean of 3.78% while 20% slope gave a range value of 3.69 to 3.72% with mean of 3.71% and 33% slope ranged from 2.95 to 2.99% with mean of 2.97%. The organic carbon/organic matter contents were highest at 4%, followed by 20%, and 33%, while the least value was obtained in bare soil, that is O% slope (4%> 20> 33%> bare soil). All levels of slope as well as the bare soil were significant at $P < 0.05$. The tables pointed to the fact that *Paspalum notatum* (grass cover) significantly increased the percentage organic carbon as well as organic matter content of the soils on the slopes than the bare adjacent soil. Therefore, these soils contain the largest terrestrial carbon pool and thus play a crucial role in the global carbon cycle.

Also, high organic carbon (OC) stocks are predominant in grassland soils. Hence, [19] concluded that grasslands have high inherent soil organic matter values that supplies plant nutrients and increases cation exchange capacity. This high level of organic carbon and organic matter contents could be attributed to the presence of vegetation, utilization of carbon in photosynthesis and organic matter decomposition through litter fall and decomposition processes [24].

Table 2. Effect of *Paspalum notatum* on Organic Carbon, Total nitrogen, pH and Available phosphorus at different slope levels in Umudike, Umuahia, Nigeria

Slope %	**Location**	**Attribute**						
		pH		**OC**	**OM**	**N**	**Avail.P**	
		H$_2$0	**KCl**	**(%)**	**(%)**	**(%)**	**(Mg/kg)**	**C:N**
0	A	5.0	3.9	1.06	1.83	0.090	18.60	11.78
Bare	B	4.9	3.9	1.04	1.79	0.089	18.00	11.69
Soil	C	4.9	3.5	1.05	1.81	0.091	17.50	11.54
	Mean	4.9*	3.7*	1.05*	1.81*	0.09*	18.03*	11.67
4	A	5.4	4.3	2.19	3.78	0.181	26.00	12.10
	B	5.5	4.1	2.18	3.76	0.185	27.20	11.78
	C	5.5	4.4	2.20	3.79	0.187	26.80	11.76
	Mean	5.5*	4.3*	2.19*	3.78	0.18*	26.67*	12.17
20	A	5.2	4.2	2.16	3.72	0.178	20.40	12.13
	B	5.2	4.0	2.14	3.68	0.180	20.40	11.89
	C	5.3	4.2	2.15	3.71	0.180	21.80	11.94
	Mean	5.2*	4.1*	2.15*	3.70*	0.18*	21.00*	11.94
33	A	5.1	4.0	1.74	2.99	0.142	22.20	12.25
	B	5.1	4.0	1.71	2.95	0.144	22.00	11.88
	C	5.1	4.0	1.72	2.97	0.140	21.80	12.29
	Mean	5.1*	4.0*	1.72*	2.97*	0.14*	22.00*	12.29
F-LSD **$_{0.05}$**		0.11	0.29	0.01	0.02	0.00	1.26	

OC = Organic carbon; OM = Organic matter; N = Total nitrogen; Avail. P = Available Phosphorus,
*=Significant at $P < 0.05$, a = High significance, b = Higher significance, c = Highest significance,
d = Most significant, Same letters means that they are equal
Source: Own results.

Total Nitrogen

Also, results obtained from Tables 2 and 3 show that total nitrogen in the bare soil (0 slope) ranged from 0.089 to 0.091 with mean value of 0.09%. In *Paspalum notatum* at 4% slope, total nitrogen content ranged from 0.181 to 0.187 with mean value of 0.18%, while at 20%, it ranged from 0.178 to 0.180 with mean of 0.18% and at 33%, it ranged from 0.140 to 0.144 with mean of 0.14%. There was an increase in total nitrogen content of soils planted with *Paspalum notatum* at various slope levels compared with the bare adjacent soil. Comparatively, the results of total nitrogen were in the following significant order: bare soil(0) <4% = 20%> 33%. All levels of slope as well as the bare soil were significant at $P = 0.05$. Tables 2 and 3 pointed to the fact that *Paspalum notatum* on the slopes significantly increased total nitrogen content than in bare soil. Incorporating cover crops into Christmas tree plantations may potentially improve soil fertility, tree growth and quality and be an alternative to commercial nitrogen (N) fertilizers. [26] as well as [10] confirmed that plant community biomass is increased as a result of habitat productivity, this will definitely cause an increase in soil Carbon (C), nitrogen (N) and phosphorus (P) accumulation and storage at different soil depths, especially topsoil layers, mostly due to increased plant C, N and P addition to the soils.

Table 3. Mean values of Organic carbon, Total Nitrogen, pH and Available Phosphorus of soils planted with *Paspalum notatum on different slopes*

Slope (%)	**Attribute**						
	pH		**OC (%)**	**OM (%)**	**N (%)**	**Avail.P (Mg/kg)**	**C:N**
	H_20	**KCl**					
Bare soil (0)	4.9^a	3.7^a	1.05^a	1.81^a	0.09^a	18.03^a	11.67
4	5.5^c	4.3^b	2.19^d	3.78^d	0.18^c	26.67^c	12.17
20	5.2^b	4.1^b	2.15^c	3.70^c	0.18^c	21.00^b	11.94
23	5.1^b	4.0^b	1.72^b	2.97^b	0.14^b	22.00^b	12.29
F-LSD$_{0.05}$	0.11*	0.29*	0.01*	0.02*	0.00	1.26*	

OC = Organic carbon; OM = Organic matter; N = Total nitrogen; Avail. P = Available Phosphorus,
*=Significant at $P < 0.05$, a = High significance, b = Higher significance, c = Highest significance,
d = Most significant, Same letters means that they are equal
Source: Own results.

Available Phosphorus

The results of the available phosphorus in the bare soil ranged from 17.5 to 18.6 with mean of 18.03. In *Paspalum notatum* at 4%, it ranged from 26.0 to 27.2 with mean of 26.67, while at 20%, ranged from 20.4 to 21.8 with mean of 21.00, and 33% slope ranged from 21.8 to 22.2 with mean of 22.00 Mg/kg. There was an increase in available phosphorus content of soils planted with *Paspalum notatum* at various slope levels when compared with the bare soil. The relative increase in the available phosphorus is in the significant order: Bare soil(0) <4% >33% = 20%. All levels of slope as well as the bare soil were significant at $P < 0.05$. Tables 2 and 3 pointed to the fact that *Paspalum notatum* on the slopes significantly increased available phosphorus content than in bare soil. [26] as well as [10] confirmed that grassland causes an increase in soil nutrients (C, P, N) accumulations and storage at different soil depths, especially top soil layers, mostly due to increased plant phosphorus, carbon and nitrogen inputs in the experimental soil.

Effective Cation Exchange Capacity

Therefore, the results in Tables 4 and 5 show an increase in the effective cation exchange capacity of soils planted with *Paspalum notatum* in the various slope levels. Effective cation exchange capacity (ECEC) of the adjacent bare soil was greatly increased from 4.76 to a mean of 6.80, 5.87 and 5.21 cmol/kg for 4, 20 and 33% slopes, respectively. The relative improvement was in the order: Bare soil <4% >20% >33%. All levels of slope as well as the bare soil were significant at $P < 0.05$.

However, planting of *Paspalum notatum* also greatly improved the exchangeable bases of the soils. Generally, the levels of increase in content of these bases were highest in the soils planted with *Paspalum notatum* than in their adjacent bare soil. The increase in cations contributed significantly to the effective cation exchange capacity (ECEC) of the study soils. Also, the ECEC followed the pattern of organic matter values. This trend was expected since in humid tropical soils rich in low activity clays, organic matter is the main contributor to cation exchange capacity (CEC) according to [27].

Exchangeable Acidity (H^+, Al^{3+})

In addition, the results in Tables 4 and 5 indicated a decrease in exchangeable acidity of the soils planted with *Paspalum notatum* which was observed in the various slope levels. According to the Tables, exchangeable acidity in the adjacent bare soil was decreased from 1.84 to 0.82, 1.02 and 1.73 cmol/kg for 4, 20 and 33% slope levels, respectively.

Also, in all levels of slope planted with *Paspalum notatum*, there was no significant increase in aluminum concentration at P <

0.05 was observed, whereas, there was significant increase in their adjacent bare soils. However, the relative decrease in exchangeable acidity was in the significant order: bare soil(0) >33% >20% >4%. [27] stated that on sites that have a tendency to iron or aluminum toxicity, humifying organic matter works to combat toxic metal concentrations by forming complexes with a high molecular weight; where there is absence or little presence of organic matter, aluminum toxicity cannot be combated. This is confirmed with the significant increase in aluminum and hydrogen saturation in adjacent bare soil (Table 4) than in soils planted with *Paspalum notatum*, leading to higher concentration of exchangeable acidity in bare soil than in soils planted with *Paspalum notatum* as in the order above.

Table 4. Effect of *Paspalum notatum* on exchangeable bases and cation exchange capacity of soils on different slopes

Slope (%)	**Location**	**Na^+**	**Ca^{++}**	**Mg^{++}**	**K^+**	**Al^{+++}**	**H^+**	**EA**	**ECEC**	**BS**
		---------------------------------$Cmol(+)kg^{-1}$--							**---------%----------**	
0	A	0.095	1.80	0.80	0.089	0.48	1.40	1.88	4.66	59.69
Bare	B	0.098	2.60	0.80	0.088	0.26	1.60	1.80	4.79	62.34
Soil	C	0.095	1.80	1.60	0.088	0.15	1.70	1.85	4.83	61.76
	Mean	0.10^{a}	1.87^{a}	0.87^{a}	0.09^{a}	0.28^{a}	1.57^{b}	1.84^{d}	4.76^{a}	61.26^{a}
4	A	0.118	3.00	2.60	0.148	0.01	0.92	0.93	6.80	86.30
	B	0.124	3.10	2.80	0.167	-	0.73	0.73	6.92	89.46
	C	0.120	3.00	2.60	0.155	-	0.80	0.80	6.68	87.95
	Mean	0.12^{c}	3.03^{c}	2.67^{d}	0.16^{d}	0.01^{NS}	0.82^{a}	0.82^{a}	6.80^{d}	87.90^{d}
20	A	0.113	2.80	2.00	0.133	0.04	1.00	1.04	6.09	82.85
	B	0.115	2.60	2.00	0.135	0.16	0.84	1.00	5.85	82.90
	C	0.114	2.60	1.80	0.138	0.02	1.00	1.02	5.67	82.04
	Mean	0.11^{b}	2.67^{b}	1.93^{c}	0.14^{c}	0.07^{NS}	0.95^{a}	1.02^{b}	5.87^{c}	82.60^{c}
33	A	0.100	2.00	1.00	0.105	0.40	1.40	1.80	5.01	64.04
	B	0.100	2.00	1.40	0.107	0.80	1.60	1.68	5.29	68.19
	C	0.101	2.00	1.40	0.110	0.22	1.50	1.72	5.33	67.74
	Mean	0.10^{a}	2.00^{b}	1.27^{b}	0.11^{b}	0.23^{NS}	150^{b}	1.73^{c}	5.21^{b}	66.66^{b}
F-LSD $_{0.05}$		0.00*	0.18*	0.31*	0.01*	0.23	0.25*	0.07*	0.34*	2.11*

Na = Sodium; Ca^{++} = Calcium; Mg^{++} = Magnesium; K^+ = Potassium, NS = Not significant, EA = Exchangeable acidity; CEC = Cation exchange capacity; ECEC = Effective cation exchange capacity; BS = Base saturation; Al. Sat. = Aluminum saturation; *=Significant at $P < 0.05$, a = High significance, b = Higher significance, c = Highest significance, d = Most significant, Same letters means that they are equal
Source: Own results.

Base Saturation

Tables 4 and 5 indicated some increase in base saturation of the soils planted with *Paspalum notatum* in the various slopes. Base saturation of the bare soil was raised from 61.26 to a mean of 87.90, 82.60 and 66.66 for 4, 20 and 33% slopes, respectively. The high improvement was in the order: Bare soil < 4% > 20% > 33%. All levels of slope as well as the bare soil were significant at P = 0.05. Addition or planting of *Paspalum notatum* increased the base saturation of the soils. This is so because, a decrease in exchangeable acidity increased CEC, thereby increasing the base saturation and vice versa. Table 3 shows an increase in percentage base saturation in soils planted with *Paspalum notatum*. This result follows the same trend as ECEC. Hence, the addition or planting of *Paspalum notatum* reduced the exchangeable acidity as well as the Al^{3+} and H^+ of the soils according to [27].

Total Exchangeable Bases (Ca^{2+}, Mg^{2+}, Na^+, K^+)

Some increase in the calcium content of the soils planted with *Paspalum notatum* was observed in the various slopes (Tables 4 and 5). Calcium content of the bare soil was raised from 1.87 to 3.03, 2.70 and 2.00 (Cmol/kg) for 4, 20 and 33% slopes, respectively. The high improvement was in the order: Bare soil < 4% > 20% > 33%. All levels of slope as well as the bare soil were significant at $P < 0.05$.

Magnesium content in the soils planted with *Paspalum notatum* increased in the various slopes. Magnesium content was raised from 0.87 to a mean of 2.67, 1.93 and 1.27 for 4, 20 and 33% slopes respectively. The high improvement was in the order: Bare soil < 4% > 20% > 33%. All levels of slope as well as the bare soil were significant at $P < 0.05$ (Table 5).

Table 5. Mean values of exchangeable bases and cation exchange capacity of soils planted with *Paspalum notatum* on different slopes

Slope (%)	**Na^{+}**	**Ca^{++}**	**Mg^{++}**	**K^{+}**	**Al^{+++}**	**H^{+}**	**EA**	**ECEC**	**BS**
	--Cmol(+)kg^{-1}--							**-----------%-----------**	
Bare Soil (0)	0.10^{a}	1.87^{a}	0.87^{a}	0.09^{a}	0.28^{a}	157^{b}	1.84^{d}	4.76^{a}	61.26^{a}
4	0.12^{c}	3.03^{d}	2.67^{d}	0.16^{d}	0.01^{NS}	0.82^{a}	0.82^{a}	6.80^{d}	87.90^{d}
20	0.11^{b}	2.67^{c}	1.93^{c}	0.14^{c}	0.07^{NS}	0.95^{a}	1.02^{b}	5.87^{c}	82.60^{c}
33	0.10^{a}	2.00^{b}	1.27^{b}	0.11^{b}	0.23^{NS}	1.50^{b}	1.73^{c}	5.21^{b}	66.66^{b}
F-LSD 0.05	0.00	0.18	0.31	0.01	0.23	0.25	0.07	0.34	2.11

Na^{+} = Sodium; Ca^{++} = Calcium; Mg^{++} = Magnesium; K^{+} = Potassium, EA = Exchangeable acidity; CEC = Cation exchange capacity; ECEC = Effective cation exchange capacity; BS = Base saturation; Al. Sat. = Aluminum saturation; *=Significant at P = 0.05, NS=Not significant, *=Significant at P = 0.05, a = High significance, b = Higher significance, c = Highest significance, d = Most significant, Same letters means that they are equal
Source: Own results.

Some slight increase in the sodium content of the soils planted with *Paspalum notatum* was observed in the various slopes. Sodium content of the bare soil was slightly raised from 0.10 to 0.12 and 0.11 for 4% and 20% slopes, respectively; it was same with that of 33% slope. The slight improvement was in the order. Bare soil = 33% < 4% > 20%. All levels of slope as well as the bare soil were significant at $P < 0.05$.

Similarly, some increase in the potassium content of the soils planted with *Paspalum notatum* was observed in the various slopes (Table 5). Potassium content of the bare soil was raised from 0.09 to a mean of 0.16, 0.14 and 0.11 for 4%, 20% and 33% slopes, respectively. The slight improvement was in the order: Bare soil < 4% > 20% > 33%. All levels of slope as well as the bare soil were significant at $P = 0.05$. [30] opined that in semi-arid and tropical climates, it is common to find higher soil organic matter and nutrient (Ca, Mg, Na, K, N) contents under grassland and tree canopies than in adjacent open land (bare soil). [1] stated that the inclusion of grassland, trees and other perennials in farm lands can markedly improve soil physical and chemical conditions in the long run. [7] and [22] confirmed that the major recognized ways of adding organic matter and nutrient (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, N, etc) to the soil from the trees and grasses standing on it, is through litter fall and the decay of grasses. This is however confirmed with the high results of the chemical properties of the soils which were planted with *Paspalum notatum*.

In addition, Table 6 shows the relationships between organic matter and some selected chemical properties of the soils which were planted with Bahia grass as well as the soils of the adjacent bare soil. There was Significant correlation at $P < 0.05$ was observed between organic matter and some selected chemical properties except for potassium (K) which had R^2 and r values as 0.119 and 0.345, respectively. Therefore, organic matter influenced these properties positively.

Table 6. Some relationships between Organic matter and some selected chemical properties of the soils

Dependent Variable	**Correlation Coefficient (r)**	**Coefficient of Determination (r^2)**
N	0.998*	0.996
Na	0.787*	0.620
Ca	0.878*	0.771
Mg	0.890*	0.792
K	0.345^{ns}	0.119

* = Significant correlation, ns = No significant correlation
Source: Own results.

CONCLUSIONS

This research on the effect of *Paspalum notatum* on the chemical properties of an ultisol was carried out at Abia State University Umuahia Campus Teaching and Research Farm. It has actually given the results of the chemical properties of soils located at the three (3) different slope levels namely: 4%, 20% and 33%, which however were compared with the open adjacent bare soil.

The results of study have shown that the slopes planted with *Paspalum notatum* gave significantly higher chemical properties than the open adjacent bare soil. In all the parameters considered in this study, the values obtained in 4% slope was higher than those obtained in 20% as well as 33% and the adjacent bare soil in the following significant order: 4%> 20%> 33%> bare soil. However, 4% slope had higher value of phosphorus (P) than the similar values of 33% and 20%, while Bare soil gave the least value in the order: 4%> 33%> = 20%> bare soil. Also, exchangeable acidity (H^+ and Al^{3+}) was highest in bare soil than in the slopes planted with *Paspalum notatum.* This result also pointed to the fact that the pH of the soils planted with *Paspalum notatum* was significantly higher than those of the bare soils. Therefore, *Paspalum notatum* improved very highly the chemical properties of the soils at various slope levels, whereas bare soil had no much affect on the soils.

Recommendations

The following recommendations are made based on the results obtained in this study:

(i)From the results of this study, *Paspalum notatum* had been discovered to be included among the grass cover management that would enhance erosion management because of its high nutrient composition especially organic matter and rooting system.

(ii)It is hoped that *Paspalum notatum* if established on slopes that are prone to erosion could help improve the soil organic matter as well as soil aggregates, reduce run off and encourage infiltration.

REFERENCES

[1]Bayala J., Balesdent J., Marol C., Zapata F., Teklehaimanot Z., Ouedraogo S.J., 2006, Relative contribution of trees and crops to soil carbon content in a parkland system in Burkina Faso using variations in natural C – 13 abundance. Nutry. Cycle Agroecosys 76:193-201.

[2] Bray, R. H. and Kurtz, L. T., 1945, Determination of total, organic and available forms of phosphorus in soils. Soil Sc., 59: 39 – 45.

[3]Brubakar, S.C., Lewis, D.T., Jones, A.J., Frunk, K., 1993, Soil properties associated with landscape position. Soil Science society of America Journal 57(1) 235-239.

[4]Chen, C.R., Condron L.M., Davis M.R., Scerlock R.R., 2002, Effects of afforestation on phosphorous dynamics and biological properties in a New Zealand grassland soil. Plant soil 220: 151-163.

[5]Chen, H.I., 2003, Phosphate activity and Phosphorus fractions in soils of an 18-year- old Chinese Fir plantation. Forest Ecol. Management Vol. 178, Pp. 301-310

[6]Chen, Z.S., Hsieh, C.F., Jiang, F.V., Hsieh, T.H., Sun, T.F., 1997, Relation of Soil properties to topography and vegetation in a Subtropical rainforest in Southern Taiwan. Plant ecology 132(2)229-241.

[7]Cleverland, C.C., Reed, S.C., Townseed, A.R., 2006, Nutrient regulation of Organic matter decomposition in a tropical rainforest. Ecology 87:492-503

[8]Entry, J.A., Watrud, L.S., Reeves, M., 2001, Influence of organic amendments on the accumulation of 137cs and 90si from contaminated soil by three grass species. Water, air and soil pollution 126:385-398.

[9]Fang, X., Xue, Z., Li, B.C., An, S.S., 2012, Soil organic carbon distribution in relation to land use and its storage in small watershed of the loess plateau of China. Catena 88:6-13.

[10]Fornara, D.A., Tilman D., 2008, Plant functional composition influences rates of soil carbon and nitrogen accumulation. Journal of Ecology. 96:314-322.

[11]Hertemink, A.E., Veldkamp. T., Bai.Z., 2008, Land use change and soil fertility decline in tropical regions. Turkish J. Agric and Forestry. 32:195-213.

[12]Huang, J., Kia, H.P., Kong, G.H., 2007, Effects of oil shale waste on growth of plants and benefits of limestone to ameliorate it. Chinese Journal of Ecology. 26:9-15.

[13]Krull, E.S., Skjemstad, J.O., Baldock, J.A., 2003, Functions of soil organic matter and the effects of soil properties.

[14]Lak, D.R., Haviston, A., Curigal, D.F., 1999, Topographic influences on nitrogen cycling within an upland pin oak ecosystem. Forest science. 37(1)45-53.

[15]Li, Y., Zhang, Q.W., Reicosky, D.C., Landstrom, M.J., Bai, L.Y., Li. L., 2007, Changes in Soil organic carbon induced by tillage and water erosion on a steep cultivated hill slope in the Chinese loess plateau from

1898-1994 and 1954-1999. J. Geophysical Res-Biogecosci 12(1).

[16]Liu, Z.P., Shao, M.A., Wang, Y.Q., 2011, Effect of environmental variables on regional soil organic carbon stocks across the Loess Plateau region, China. Ecosystem and Environment. 142:184-94.

[17]Mao, R., Zeng, D.H., Hu, Y.J., Li, I.I., Yang, D., 2010, Changes in soil particulate organic matter, microbial biomass, and activity following afforestation of marginal Agricultural lands in a semi-arid area of North east China. Environmental management. Vol. 46. Pp. 110-116.

[18]McLean, E. O., 1965, Aluminium. In: C. A. Black (ed) Methods of Soil Analysis, Part II. Am. Soc. Agron. **9**: 978 – 998.

[19]Miller, R.W., Donahue, R.I., 1990, Soils Prentice Hall, England Cliffs, New Jersey, USA.

[20]Ojimgba, O., Mbagwu, J.S.C., 2007, Evaluation of the physical and chemical properties of an eroded ultisol and their effects on maize yield. Journ.Sc. Agric., Food Tech and the Env. Vol. 7. No. 1. Pp. 57-64. Fac. Of Agric., Ebonyi State Uni, Abakaliki, Nigeria.

[21]Opara-Nadi, O.A., 2000, Resources and agricultural productivity in Nigeria. In: Food and Fiber production in the 21st century. Nwaigbo, L.C., Ukpabi, U.H., and Anene, A. (Eds). Proceedings of the First Annual conference of the college of Agriculture and veterinary medicine, Abia State University held 10th-13 September, 2000.

[22]Ostertag, R., Silver, W.L., Marin-Spiotta E., Schulten, J., 2008, Litter fall and decomposition in relation to soil carbon pools along a secondary forest chronosequence in Puerto Rice. Springer Science Business Media, USA. Ecosystems 11:701-714.

[23]Pavlu, I., Boruvla, I., Nifodem, A., Rohoskova M., Penizek, V., 2007, Attitude and forest type effects on soils in Lizera mountain regions. *Soil and water Res.* Vol. 2,Pp.35-44.

[24]Poeplau, C., Marstorp, H., Thored, K., Katterer, I., 2016, Effect of grassland cutting frequency on soil carbon storage – a case study on public lawns in three Swedish cities. Soil, 2, 175 – 184. www.soil-journal.net/2/175/2016, Accessed Dec.10, 2017.

[25]Purdue University (March, 2010). Soil slope.

[26]Robin, H.K., 1996, Soil Organic Matter and nutrient availability responses to reduced plant inputs in short grass steppe. Ecology. 77:2516-2527.

[27]Sanchez, P.A., 1976, Properties and management of soils in the tropics. New York.Wiley,618pp.

[28]Shu, W.S, Xia, H.P., Zhang, Z.Q, Lan, C.Y., Wong, M.H., 2002, Use of vetiver and other three grasses for revegetation of Pb/Zn mine tailings field experiment. International journal of phytoremediation. 4:47-57.

[29]Tsui, C.C., Chen, Z.S., Hsieh, C.F., 2004, Relationship between soil properties and slope position in a lowland rainforest of Southern Taiwan. Geoderma. 123, 131,142.

[30]Verinumbe, I., 1987, Crop production on soils under some forest plantations in the Sahel. *Agro forestry Systems*, 5: 185-188.

[31]Vesterdal, I., Ritter, E., Gundersen, P., 2002, Change in soil organic carbon following afforestation of former arable land. Forest ecology and management Vol. 169.Pp.137-147.

[32]Walkley, A., Black, I.A., 1934, Determination of organic carbon in soils. SoilSci.37:29-38.

[33]Wang, Y.Q., Zhang, X.C., Huang, C.Q., 2009, Spatial variability of soil total nitrogen and soil total phosphorus under different land uses in a small watershed on the loess Plateau, China. Geoderma 150: 141-49.

[34]Xia, H.P., Cai, X.A., Liu, S.Z., 2003, Advance in research and application of bahia grass. Grassland of China. 25:44-53.

[35]Xia, H.P., 2004, Ecological rehabilitation and phytoremediation with four grasses in oil shale mined land. Chemophere 54:345-353.

[36]Yang, I.C. Huang, I.H., Pan, Q.M., Tang, I.W., Han, X.G., 2005, Soil phosphorus dynamics as influenced by land use changes in humid tropical, southeast China. Pedosphere, Vol. 15, pp. 24-32.

[37]Ye Chao; Guo, Zhonglu; Li Zhaoxia; Cai, Chonafe, 2017, Effect of bahiagrass roots on soil erosion resistanceof Aquults in Subtropical China.Geomorphology, Volume 285,p.82-93.

[38]Ying Liu, Huawei Song, Juming Zhang, Michael D. Richardson, 2016, Growth characteristics of bahia grass roots treated with micronutrients, rare earth elements, and plant hormones. Hort Technology 26 : 176 – 184.