RELATIONSHIP OF LANDSCAPE POSITIONS WITH SOIL PROPERTIES ON MAIZE YIELD IN ULTISOL

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ABSTRACT

Relationship of landscape position and soil properties to maize (*Zea mays* L.) yield was studied in coastal plain soils of Akwa Ibom state. The study aimed at assessing the physico-chemical soil attributes down the geomorphic surface as well as assessing the yield of maize in the respective landscape positions. A total of 3600 plant population (hybrid maize) were planted on 0.072ha in a Randomized complete block design. The traditional land preparation technique was employed with slashing of re-growth vegetation with cutlass. The trashes was left on the sites and allowed to dry for three weeks. Pre-burn soil samples were taken before burning the trashes at the end of three weeks after slashing. The samples collected were analyzed in the laboratory for physico-chemical properties using standard methods. Collected data were statistically analyzed and means of statistically significant parameters were separated using LSD (0.05). The results showed that sand particle of burnt and un-burnt soils were significantly different at 0-15cm of Upper slope (US) but not significantly different in other landscape positions ($p<0.05$). Soil pH in burnt soil was significantly different from the un-burnt soil (both at surface and sub surface) in the three landscape positions. Mean maize yields (with husk) was 0.09 and 0.11kg/ha 'before' and 'after' burning plots of US ; 0.12 and 0.16kg/ha in 'before' and 'after' burning plot of the middle Slope (MS) while the Bottom valley (BV) had 0.14 and 0.16kg/ha in 'before' and 'after' burning plots. Altogether, both husked and de-husked yields were higher in burnt plots than un-burnt plots. Along the slope, husked yield followed the order: BV (0.15kg/ha) > MS (0.14kg/ha) > UP (0.10kg/ha)) while de-husked yield also followed similar pattern but different magnitude.

Key words: maize; toposequence, geomorphic surface; dry matter; soil properties,

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INTRODUCTION

High nutrients fixation along toposequence necessitates vegetation burning and application of high rates of inorganic/organic fertilizers to achieve reasonable crop yields in most of the coastal plain sand. The orientation of the field in terms of the upper, middle and bottom slopes positions, relates soil properties on different landscape positions. Brubakar et al (1993) studied the soil properties in relation with landform positions and found significant differences among soil properties of sand, silt, pH, and exchangeable Ca^{2+} and Mg^{2+} mostly decreased down the slope. Young and Hammer (2000) found that most of these properties and nutrients were similar between ridge and shoulder positions but differences were minimal within the back slope. Tsui *et. al*., (2004) had also reported that the slope aspect and gradient can control the movement of water and soil nutrients on hill slope and hence contribute to the spatial differences of soil properties.

Their results further showed that organic carbon, available nitrogen (N) available K, extractable Fe and exchangeable Na were highest on the summit, while pH, available P, exchangeable Ca and Mg were significantly higher on the foot slope at surface soils. Similar patterns were observed at subsurface such as red colour, moderate to high acidity, lower than 50% base saturation in the argillic horizon, in the sloping landscapes (Bhaskar et al, 2004). Soil of the upper slope positions had higher available Fe, Mn, Cu and Zn. These soils were classified as Ultisols and Entisols, while soils on the valley were of inceptisols order. Soils particle 0.5mm in diameter decreased down the slope and those of 0.05 and 0.5mm formed a larger soils fraction in the middle slope position other than summit or foot slope. Total organic C, N, and P in the middle slope soils were the lowest among the soils in the three topographic positions (Chen et al., 2002).

Considering the uniform plant distribution within the row, along with plant density and its population per plot, row spacing has been another subject that received much attention. An Agronomists and maize producers have assumed that evenly spaced stands of maize have greater yield potentials than unevenly space stands. Duncan (1984) proposed a theoretical basis for plant competition effects on maize grain yield. The yield of a single maize plant is reduced by the presence of it competing neighbors, and amount of yield reduction for a given environment depends on how near and how numerous the neighbor plant are. He also suggested that equidistant spacing must result in the highest yield for any competing plant population.

It is worthy of note that the relationship of landscape positions varies with soil properties and consequently has effect on maize yield due to uni-directional fertility gradient.

Therefore, this study aimed at assessing the variability of soil physico-chemical properties among the landscape positions and how it affects maize yield.

MATERIALS AND METHODS

The study was conducted at the University of Uyo Teaching and Research farm (UUTRF), Use-Offot in humid tropical zone of Nigeria. The region is classified as wet high latitude climate (Ogban and Edem, 2005) with an estimated area of 8,412 square kilometers. Characterized by two seasons, the wet and dry seasons. The wet season lasts from April to October with high annual rainfall range from 2000-3000 mm. the dry season lasts from November to March. The temperature is moderately high varying from 26^{o} C to 30^{o} C throughout the year and high relative humidity. A total of six plots were used in each season measuring 40 x 3 m^2 with a distance of 30 cm between plots. The experiment was laid in a Randomized complete Block Design (RCBD) with three geomorphic surfaces of upper slope, middle slope and valley bottom forming the main treatments.

The experimental site was cleared using local tool (machete) and with minimum tillage. The land was then laid out according to treatments. The maize seeds were sourced from National Root Crop Research Institute, Umudike. The maize seeds were planted in March, 2010 as soon as rain started. The maize according to premier seed classification has the following characteristics:

Variety of maize = Oba 98

Moisture content = Less than 12%

Germination Minimum = 90%

Purity Minimum = 98%, tested on February 2010 by the premier seeds Nigeria Limited.

The germination was almost uniform, two weeks after planting the maize was thinned to 1 seedling per stand.

Weeding was carried out manually using weeding hoe and machete to remove or cut the under growth vegetations. Some weeds were up rooted by hand. Weeding was observed timely and the plots remained weed free through the period. In small scale production systems, which dominate Nigeria agriculture, it has been estimated that weeding alone consumes approximately 30 to 50% of total labour budget depending on the crop and the level of other available resources (Akobundu, 1991; IITA, 1987).

According to Akobundu (1994) in his findings, reported that weed control practices have not changed significantly in the developing countries in the last 25 years despite that more people have been trained in weed science, more research activities have been initiated in these parts of the world, and there has been greater awareness of weed problems than in the past. Many small holder farmers do not use herbicides because of multiple of problems, which have been reviewed by Fadayomi (1991). These include the cost of herbicides which too expensive for the resource-poor peasant farmers. The total number of rows was 5 x 6 = 30 rows while number of maize stands per plot was 600 stands. A total of 1800 stands represented one treatment while 3,600 stands were for the entire plots.

Harvesting

The crop was harvested after 85days from date of planting. Only the husked and de-husked weight was measured from the harvested maize for use in the study.

Soil Sampling Procedure

Soil Samples were collected using soil auger and core cylinder. Bulk samples were collected at 0-15 and 15-30cm depth of both burnt and control plots of the three geomorphic positions while core samples were collect at 0-15cm depth only. A total of 36 bulk samples and 18 core samples were collected for the study. They were taken to the laboratory for determination of physical and chemical properties.

Treatments and Experimental Design

The field was layout in a Randomized complete Block Design (RCBD) with two main treatments (before and after burning). The other treatment was landscape position with three levels namely upper slope, middle slope and valley bottom. The experiment was replicated three times and a total of six plots were used, three for before burning and the other three for after burning effect. Each plot measured 40x3m^2 while distance between plots was 30cm. Trashes were collected from the control plots and deposited on the burnt plot for burning after being allowed to dry for 3 weeks.

Land Preparation

The experimental site was cleared using local tool (machete) and with a minimum tillage. The land was then laid out according to treatment.

Planting of Maize

The maize seeds were collected from National Root Crop Research institute, Umudike, Abia State. They were planted four days after soil sampling have been completed. The maize seeds were planted in late March as soon as rain started. The maize according to premier seed classification has the following characteristics:

Variety of maize = Oba 98

Moisture content = Less than 12%

Germination Minimum = 90%

Purity Minimum = 98%, (tested by the premier seeds Nigeria Limited).

The grains was soaked in water for 3 hours to obtain enough moisture before it was planted, 3 seeds per hole at 60 x 25cm planting distance, and planting was completed in 3 days.

Germination

The germination was almost uniform, two weeks after planting the maize was thinned to 1 seedling per stand.

Weed Control

Weeding was carried out manually using weeding hoe and machete to remove or cut the under growth vegetations. Some weeds were up rooted by hand. Weeding was observed timely and the plots remained weed free through the period. In small scale production systems, which dominate Nigeria agriculture, it has been estimated that weeding alone consumes approximately 30 to 50% of total labour budget depending on the crop and the level of other available resources (Akobundu, 1991; IITA, 1987).

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Laboratory Analysis

Both the physical and chemical properties of the soil were analyzed using starndard methods and procedure. Physical properties analyzed were particle size distribution, bulk density, saturated hydraulic conductivity, and moisture content of the soil, percentage water stable aggregate and total porosity. The chemical properties analyzed included soil pH, organic carbon, total Nitrogen, available phosphorus, exchangeable cautions (Na, Ca, Mg, K) exchangeable acidity and base saturation while Micro nutrient analysed were Cu, Fe, Zn and Mn.

Statistical analysis

The yield and soil data obtained were descriptively analyzed for range, mean and standard deviation while analysis of variance was used to compare treatment means. Pearson Product moment correlation analysis was employed to assess the relationship between soil properties and maize yield while effect of geomorphic position on maize yield was examined using analysis of variance. Mean soil properties and maize yield from burnt and control were also determined and compared using $LSD_{0.05}$. GenStat

Discovery Edition 3 statistical soft ware was used for the analysis of data. Means of significant parameters were separated using Duncan multiple range test of adjacent means.

RESULTS AND DISCUSSION

Mechanical analysis showed soil particles changes in different landscape positions before and after vegetation burning in the surface and subsurface soils (Table 1).

Table 1: Physical properties of the soils in the burnt and un-burnt plots along the slope

		Upper Slope			**Middle Slope**			**Bottom Valley**		
♯Soil Properties	**Depth (cm)**	**First season**	**Second season**	**$LSD_{(0.05)}$**	**First season**	**Second season**	**$LSD_{(0.05)}$**	**First season**	**Second season**	**$LSD_{(0.05)}$**
Sand (gkg^{-1})	0-15	835.97	808.30	19.24*	816.0	829.30	19.88	789.00	817.60	9.24
	15-30	829.30	796.80	22.59*	822.60	917.80	3.82	809.10	814.60	66.17
Silt ((gkg^{-1})	0-15	37.00	51.30	9.94*	50.30	43.60	27.80	70.30	30.30	4.66
	15-30	23.60	43.60	13.90	17.00	4.36	21.83	56.00	24.60	8.79
Clay (gkg^{-1})	0-15	127.00	140.30	9.24	133.60	163.00	9.24	140.30	153.60	91.73
	15-30	147.00	133.60	9.31	160.30	133.60	9.24	147.00	160.30	18.56
Textural Class	0-15	Loamy Sand			Loamy Sand			Loamy Sand		
	15-30	Loamy Sand			Loamy Sand			Loamy Sand		
BD (mgm^{-3})	0-15	1.55	1.55	0.01	1.49	1.65	0.14	1.54	1.58	0.06
TP(m^3m^{-3})	0-15	41.77	41.64	0.35*	43.65	37.74	5.46	42.05	40.75	1.60
Ks ($cmhr^{-1}$)	0-15	19.02	22.18	5.06	17.01	13.45	2.77	20.21	19.07	3.49
MC (m^3m^{-3})	0-15	5.87	6.50	0.71	7.30	6.23	1.45	6.07	6.13	0.70
AWC(m^3m^{-3})	0-15	23.27	22.40	0.04*	22.07	22.83	2.15	22.87	23.67	0.74

*** Significant at $P < 0.05$;** ♯ = values are mean of three replicates

Before vegetation burning at 0-15cm of the upper slope, the distribution of sand fraction dropped from 835.97g/kg to 808.3g/kg after burning. Silt content was 37g/kg before burning but increased 51.30g/kg after burning, while clay fraction was 127g/kg and 140.3g/kg before and after burning respectively. In the middle slope, sand fraction was 816g/kg before vegetation burning and 829.3g/kg after burning. In sub-surface soil, sand particles in the upper slope before burning was 829.3g/kg and 796.8g/kg after burning of vegetation, silt particles raised from 23.6g/kg to 43.6g/kg after burning, whereas clay particle after burning dropped by 9 %. But in the middle slope, 11 % sand fraction was found after burning. The texture of the soils was generally loamy sand. This confirmed very high sand fraction in acid sand soils. Clay particles distribution among the landscape position was generally low as well as silt fraction, indicating low surface area, thus low sorption site for basic cations which results in low fertility of the soil. The indefinite trend in the distribution of particle size may be as a result of nature of parent material and the slope (Obi, 1984).

Bulk Density and porosity

The mean value of bulk density before vegetation burning was 1.55mg/m^3 and 1.55 mg/m^3 in the upper slope (US), while in the Middle slope (MS) mean bulk density was 1.49 mg/m^3 before vegetation burning and 1.63 mg/m^3 after vegetation burning, whereas in the Bottom valley (Bv) mean bulk density was 1.53 mg/m^3 before burning and 1.57 mg/m^3 after vegetation burning. The result showed high bulk density within the landscape positions in both treatments (Table 1). There was variation in the values of the bulk density in difference landscape positions following the magnitude; upper slope > bottom slope > middle slope, but there was no significant difference in these landscape position. The values decrease down the slope. Generally the bulk density was within favorable limit for maize growth. Edem and Effiong (1997), and Hilner (1981) stated that bulk density of more than 1.70 mg/m^3 can restrict water storage and root penetration. He also stated that excessive high bulk density can inhibit root penetration and proliferation which may impede drainage and hinders crop yield and production (FAO, 1976).

The mean total porosity before vegetation burning was 41.7m^3/m^3 and 41.6 m^3/m^3 after burning in the upper slope, while in the middle slope mean total porosity was 43.6 m^3/m^3 before vegetation burning and 37.7 m^3/m^3 after burning, whereas in the bottom valley mean total porosity works 42.0 m^3/m^3 and 40.0 m^3/m^3 before and after burning. Total porosity increases down slope in the following magnitude; middle slope > bottom slope > upper slope Compare the two treatments. Result showed high total porosity variation among the landscape positions. The type of soil has influence on the porosity of the soil, hence the productivity of the soil.

Saturated hydraulic conductivity along the slope

The mean value of saturated hydraulic conductivity was 19.0cm/hr before vegetation burning and 22.2cm/hr after vegetation burning in the upper slope, while in the middle slope (MS) mean saturated hydraulic conductivity was 17.0cm/hr before vegetation burning and 13.5cm/hr after burning, whereas in the bottom valley mean saturated hydraulic conductivity was 20.2cm/hr before vegetation burning and 19.1cm/hr after vegetation burning (Table 1).

Compare the differences in both treatments, the results showed high saturated hydraulic conductivity in the upper slope and bottom valley, with a decrease in middle slope. The values of Ks were high but varies among the landscape position in the magnitude as follows; upper slope > bottom slope > middle. This may be caused as a result of soil pores being sealed up by cementing agent due to heat generated during burning. However there was no significant different in the middle slope positions.

The results further showed decrease in the saturated hydraulic conductivity down the slope. Similarly, top soils have high conductivity in all landforms compared to sub-soils. This is in line with Obi (1984) observations that many sub-soils have low conductivity and it may be attributed to the low proportion of macro pores in the sub-soils.

Moisture Content

The moisture content of the soil in the upper slope before vegetation burning had a mean value of $5.9m^3/m^3$ and $6.5m^3/m^3$ after vegetation burning, while in the middle slope moisture content (MC) mean value was $7.3m^3/m^3$ before vegetation burning and $6.2m^3/m^3$ after burning, whereas in the bottom valley MC mean value was $6.1m^3/m^3$ before and after vegetation burning. Result showed high moisture content mean value noticed in the middle slope and lost value in the upper slope on the magnitude middle > bottom valley > upper slope. The high or low moisture content of the soil may be attributed to organic matter present in the field to improve soil quality for maize yield. The field capacity water (MC) has significant differences among the landscape position. This work is in line with the earlier study, Tryon (1948) that the soil water retention is improved by addition of soil organic matter loamy sand soil texture to improve the yield of maize crop.

Available Water Content

The mean available water content was $23.3m^3/m^3$ before vegetation burning and $22.4m^3/m^3$ after vegetation burning in the upper slope, while in the middle slope mean available water content was $22.1m^3/m^3$ before vegetation burning and 22.8 m^3/m^3 after vegetation burning, whereas in the bottom slope available water content 22.8 m^3/m^3 before vegetation burning and 23.7 m^3/m^3 after vegetation burning. On the whole, available water content decreases down the slope with the high value noticed in upper slope and bottom slope. Comparing the two treatments, Available Water content followed the order: bottom valley > upper slope > middle slope. This work follows the trend that low soil organic matter may be responsible for the low available water content and the weak structure of many agricultural soils (Bembridge, 1989); Mbagwu, 1989; Mc Rae and Mehyus, 1985; Piccolo et al., 1996; Rose, 1991).

Soil pH and Electrical Conductivity

In the upper slope, the mean soil pH in water was 6.3 before vegetation burning and increases to 6.5 after vegetation burning while in the middle slope mean value soil pH was 6.1 before vegetation burning and 6.5 after vegetation burning (table 2). In the valley bottom mean soil pH was 6.2 before burning and 6.4 after vegetation burning at 0-0.15m soil depth (surface soil). The mean pH difference was significantly different between the two geomorphic surfaces except in sub soil of the middle slope ($p<0.05$).

Comparing the distribution among Landscape positions, low in all the landscape positions resulting in acidic conditions. This posed a constraint to low acid tolerant crops such as cowpea, rice and maize. The low pH may have been resulted from high rainfall in the area. The result showed that pH ranged was slightly acid (6.1- 6.5) in all the geomorphic surfaces and it tends to favour maize growth (National Agency for Food Security , 2005).

The values of electrical conductivity in the upper slope before burning was 0.02dS/m and 0.03dS/m after vegetation burning, while in the middle slope EC was 0.03dS/m before burning and 0.06 after vegetation burning whereas in the bottom value EC was 0.03 before burning and same mean value after burning at 0-15cm soil depth. But in subsurface EC mean value was 0.03ds/m in the upper slope before burning, and 0.02ds/m after burning, while in the middle slope EC mean value 0.03dS/m and same value after vegetation burning whereas in the bottom valley EC value was 0.03 dS/m before burning and 0.04 dS/m after burning. This is in line with the report by DHV consult (1994) that when electrical conductivity of any soil is less than 1dS/m, the soil is said to be non-saline.

Organic Matter and Total Nitrogen

The mean OM value in the upper slope before vegetation burning was 17.6g/kg and 30g/kg after vegetation burning, while in the middle slope OM mean value was 31.6g/kg before burning and 23.8 after burning, whereas in the bottom slope OM mean value was 25.4 g/kg before burning and 30.4 g/kg after burning in the surface soil 0-15cm. But in the subsurface 0.15-0.30m the mean OM value was 22.1g/kg before burning and 20.6 g/kg after burning, while in the middle slope the mean OM value was 31.0 g/kg before burning 20.3 g/kg after vegetation burning, whereas in the bottom valley OM mean value was 31g/kg before burning and 19.4g/kg after burning (Table 2). In (table 2) Organic matter were increases down the slope in the manner; upper slope > bottom slope > middle slope with significant differences in their landscape positions. Compare both the burnt and un-burnt plots, results showed high organic matter in the surface (0-15cm) soil depth and decreases with (15-30cm) soil depth. This is similar to the observation by Edem (1997) in his study of the effect of clay, iron and organic matter on the stability of soil aggregate. High organic matter content in most soils may be beneficial for maize production in many soils of low pH predominantly soils of Akwa Ibom State. Organic matter produces high percentage of net negative charges of exchange site.

Total nitrogen in the upper slope before burning was 0.04g/kg and mean of 0.07g/kg in the surface (0-15cm) soil depth after burning vegetation while in the middle slope the mean TN was 0.07g/kg before burning and a mean of 0.05g/kg after burning, whereas in the bottom slope the mean TN was 0.06 g/kg before burning and 0.07 g/kg after burning. But in subsurface (15-30cm) soil depth in the upper slope mean TN was 0.05g/kg and same value after while in the middle slope (MS) TN was 0.07g/kg and a mean value of 0.05g/kg after burning, whereas in the bottom valley (BV) Total N 0.07g/kg before burning and a mean of with a mean of 0.04g/kg after vegetation burning (Table 2). Compare the mean difference of both treatments. Result indicated that TN values increases in this magnitude; middle slope > bottom valley > upper slope; with the significant difference in their landscape position. The result further indicated that TN value was generally low 0.06-0.1(low) National Special Programme for Food Security (2005). The low values may be as a result of leaching due to high solubility in water which rapidly drains down the slope and decreased with dept of soils. This work is in agreement with the earlier work of Tsui et al; (2004).

Available Phosphorus

The available P in the upper slope before burning was 30.8mg/kg and a mean of 63.8mg/kg after vegetation burning while in the middle slope AV.P was 28.9 mg/kg mean value before burning and 59.2mg/kg after burning, whereas in the bottom valley AV.P mean was 28.5mg/kg before burning and 60.5 mg/kg after burning in 0-15m soil depth. But in the 15-30cm soil depth AV.P in the upper slope was 43.6 mg/kg before burning and 69.3 mg/kg after burning, while in the middle slope AV.P was 29.2 mg/kg before burning and 45.2 mg/kg after burning, whereas in the bottom slope AV.P mean value was 39 mg/kg before burning 41.5 mg/kg after burning. Compare the mean difference of both the burnt and un-burnt plots.

High values of AV.P were noticed in the upper slope position and Bottom valley. Result showed that AV.P decreases down the slope. Result further showed variation in it distribution in the soil (Table2). The critical AV.P for maize yield is about 15ppm and most arable crops will not respond to P above this level. This result showed high P distribution with significant difference among the landscape position in this magnitude; upper slope > bottom slope > middle slope. The low available phosphorus some of the landscape positions may be as a result of high rainfall in the area which causes leaching of soil nutrient. This work is in agreement with the findings earlier reported by Ibia and Udo (1993) had available P ranged from as low as 2 mg/kg to as high as 112 mg/kg, bray P-1and 6 to 174 mg/kg. Bray P-2 procedures.

Table 2. Chemical properties of soils along the toposequence

		Upper Slope			Middle Slope			Bottom Valley		
Soil Property	Depth (cm)	First season	Second season	$LSD_{0.05}$	First season	Second season	$LSD_{0.05}$	First season	Second season	$LSD_{0.05}$
Soil pH	0-15	6.3	6.5	0.04*	6.1	6.5	0.10*	6.2	6.4	0.04*
	15-30	6.4	6.7	0.014*	6.2	6.6	0.93	6.4	6.5	0.08*
EC (ds/m)	0-15	0.02	0.03	0.01	0.03	0.06	0.07	0.03	0.03	0.01

	15-30	0.03	0.02	0.01	0.03	0.03	0.01	0.03	0.04	0.03
OM (g/kg)	0-15	17.6	31	1.50	31.6	23.8	3.66*	25.4	30.4	13.51
	15-30	22.1	20.6	11.82	31	20.3	2.36*	31	19.4	8.60
TN (g/kg)	0-15	0.04	0.07	0.001*	0.07	0.05	0.01*	0.06	0.07	0.03
	15-30	0.05	0.05	0.03*	0.07	0.05	0.01*	0.07	0.04	0.03
Av. P(Mg/kg)	0-15	30.8	63.8	14.29*	28.9	59.2	12.15*	28.5	60.5	12.43*
	15-30	43.6	69.3	27.11	29.2	45.2	10.56*	39	41.5	15.67
Ca(Cmol/kg)	0-15	3.52	3.04	0.58	5.12	2.56	0.22*	3.52	4.48	0.22*
	15-30	4.48	3.36	1.35	5.6	4	1.35*	3.2	4.48	0.97*
Mg(Cmol/kg)	0-15	3.52	2.4	0.001*	5.12	1.76	0.44*	3.52	4.48	0.44*
	15-30	4.48	2.24	0.39*	5.6	1.92	0.39*	3.2	4.48	0.96*
K (cmol/kg)	0-15	0.07	0.12	0.07	0.08	0.09	0.01	0.07	0.08	0.01
	15-30	0.05	0.13	3.50	0.07	0.15	3.79	0.09	0.12	3.41
Na (Cmol/kg)	0-15	0.03	0.04	0.001	0.03	0.04	0.001	0.04	0.04	0.001
	15-30	0.03	0.04	0.001	0.04	0.05	0.001	0.04	0.04	0.001
EA (Cmol/kg)	0-15	1.86	1.76	0.25	1.92	1.65	0.26*	1.49	1.8	0.26*
	15-30	1.8	1.92	0.19*	1.7	1.7	0.056	1.54	2.02	0.07*
BS (%)	0-15	73.5	76	0.96	79.4	72.9	2.71*	77.5	78.5	2.50
	15-30	77.5	75	4.64	81.5	77.5	4.55	77.7	76.3	0.26*
ECEC (cmol/kg)	0-15	7.25	7.36	1.17	9.4	6.11	10.81	6.73	8.35	0.90*
	15-30	8.29	7.69	1.08	9.49	7.83	1.08*	6.79	8.58	0.46*

Exchangeable Cations

The exchangeable cations values agree with the decreasing cation magnitude of Oputa and Udo (1980), that is $Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$. The calcium level in the soil increases with soil depth and decreases down the slope with high values noticed in the middle slope > upper slope > bottom valley is similar to magnesium (Table 2). The leaching of calcium and magnesium is largely responsible for the development of acid sands among the landscape positions. The pH of the soil varies from slightly acidic to acidic. A low pH may indicate low levels of Ca and Mg present which may favour the solubility of Al and Mn which are toxic to maize yield. The values of calcium varied from 3.04-5.12cmol/kg with the lest value of 2.56cmol/kg and high value of 5.12cmol/kg in subsurface magnesium varied from 2.40-5.12cmol/kg with the lest value of 1.76cmol/kg and high value of 5.12cmol/kg noticed in the middle slope position with significant differences among the respective landscape positions. This is agreed by Brubaker et al, (1993), that soil properties such as sand, silt and pH, calcium carbonate content and exchangeable Ca^{2+} and Mg^{2+} were noticed to be highly related to landscape position and found significant differences among the properties. Calcium deficiency per Se, has not been identified as a limitation to maize production, but magnesium deficiency is common. The indirect effect of calcium and magnesium is the rise in the level of exchangeable Al which may occur at low pH and do not enhanced maize yield. The level of potassium is described as generally as low ranging from 0.04 to 0.15cmol/kg Boyer (1972) reported absolute and relative minimum quantities of exchangeable K as 0.07 to 0.02 meg/100g and at least 2% of the sum of all exchangeable basis respectively to avoid deficiencies in humid tropical soils. Also, National Special Programme for Food Security (2005) described K value from low to moderate as 0.21-0.3cmol/kg to 0.31-0.6cmol/kg. Jones and Wild (1975) pointed out that the values (K) are only approximate and will vary with crops (0.21) for maize yield. This level is less than what FAO (1976) described as marginal suitable for crop production. Exchangeable sodium varies from 0.03cmol/kg to 0.05cmol/kg and 0.04-0.05cmol/kg among the landscape position (Table 2).

Exchange Acidity

In the upper slope in the upper slope EA ranged from 1.86 -1.76coml./kg and 1.8 -1.92 Cmol./kg before and after vegetation burning in the surface and subsurface soils, while in the middle slope the mean EA ranged from 1.92-1.65 Cmol./kg and 1.70Cmol./kg before and after vegetation burning in the surface and subsurface, whereas in the bottom slope EA range from 1.49-1.8Cmol./kg and 1.54 -2.02Cmol./kg before and after vegetation burning in the surface and subsurface soils (table 2).

Compare both treatments, result indicate that EA high values were noticed in the upper slope and in the bottom Slope position (Table 2). Generally, the low content of EA is as a result of acid in the soil, which brings about low exchangeable bases in the soil. It is in line with the observation of Brady and Weil (1996) that acidity have been neutralized and is associated with aluminum hydroxyl ions is residual acidity.

Base Saturation

In the upper slope BS distribution in the soil was virtually uniform in all the landscape positions before and after vegetation burning with BS mean values ranged from 73.5-76.0%, 77.5-75.0% in the surface and subsurface soils, while in the middle slope BS mean values were 79.4 -72.9%, 81.5% -77.5% before and after burning in the surface and subsurface soils, whereas in the bottom valley BS mean values ranged from 77.5- 78.5%, 77.1- 76.3% before and after vegetation burning in surface and subsurface soils (Table 2). Compare the two treatments. Result showed high BS values noticed in the middle slope and bottom valley of the landscape positions (Table 2). The percentage base saturation although it showed irregular distribution among the landscape positions, it was generally low and nutrient content posses inherently poor fertility. Liming and appreciable supply of major nutrients through fertility status of these of soils to support available crops (E.J. Udo et al; 1988).

Effective Cation Exchange Capacity

The ECEC mean value in the upper slope before and after vegetation burning were 7.25cmol/kg and 7.36 coml./kg, while in the middle slope the mean ECEC were 9.4 coml./kg before burning, whereas in the bottom valley ECEC was 6.73 coml./kg before burning and 8.35 coml./kg after burning in the surface soils (0-15cm) (Table 2). But in the subsurface (0.15-0.30m) ECEC was 8.29 coml./kg before burning in the burning and 7.69 coml./kg after burning and 7.83 coml./kg after burning, whereas in the bottom valley ECEC was 6.79 coml./kg before and 8.58 coml./kg after vegetation burning. Compare the mean difference in both treatments. Result showed high values of ECEC in the middle slope > upper slope > bottom valley (Table 2). The low values of ECEC are attributed to the type of clay minerals formed. According to FAO (1976), soil with effective cation exchange capacity greater than 20 coml./kg are indicative of high suitability for maize yield.

Maize Yield among Landscape Positions

Table 3. showed maize yield harvested from the six plots. Mean husked yield was 0.09 and 0.11kg/ha for before and after burning of the upper slope, 0.12 and 0.16kg/nha in the middle slope and 0.14 and 0.16kg/ha in the bottom valley. Among landscape position, the bottom valley had the highest mean husked yield (0.15kg/ha) followed by middle slope (0.14kg/ha) while the upper slope had the least (0.10kg/ha) (Figure 1).

The trend was similar in de-husked yield compared to the pattern in husked yield. The bottom valley recorded the highest mean de-husked yield (0.12kg/ha) followed by the middle (0.11kg/ha) while the upper slope had the least (0.07kg/ha) (fig. 1) and the difference was significant ($p < 0.05$). Variation of maize yield with landscape position followed similar pattern in both husked and de-husked yields: BV>MS>US. Altogether, the yield was higher in burnt soil than un-burnt soil. Burning might have increased the chemical reaction in the soil which resulted in increase in soil nutrients thereby improving

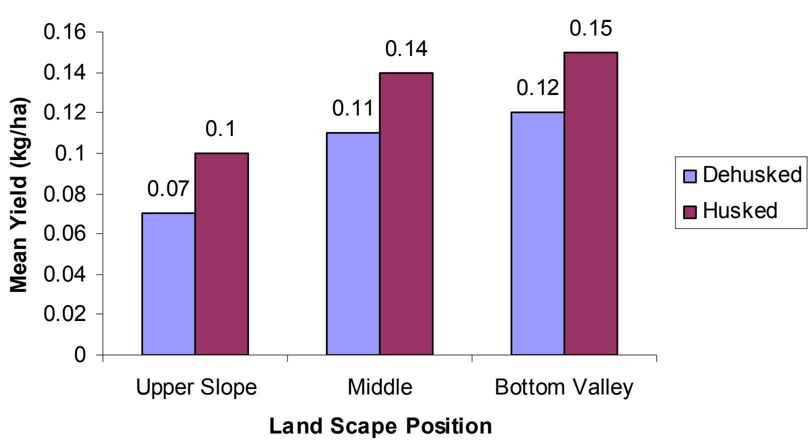

Figure 1: Variation of Maize Yield (Husked and de-husked) with landscape position

crop yield. It might also reduce the activity of pests in favour of the higher yield than in un-burnt soil.

Table 3: Maize yield (kg/ha) of respective Landscape Position

Plot	US		MS		BV	
	First	Second	First	Second	First	Second
I: Husk Weight	0.084	0.126	0.132	0.168	0.144	0.162
De-Husk Weight	0.048	0.090	0.096	0.126	0.114	0.132
II: Husk Weight	0.096	0.108	0.114	0.156	0.150	0.168
De-Husk Weight	0.060	0.084	0.084	0.120	0.120	0.132
III: Husk Weight	0.096	0.108	0.120	0.144	0.132	0.156
De-Husk Weight	0.078	0.084	0.096	0.114	0.090	0.120
Husked Mean	**0.090**	**0.110**	**0.120**	**0.160**	**0.140**	**0.160**
De-husked Mean	**0.060**	**0.090**	**0.090**	**0.120**	**0.110**	**0.130**

US: Upper Slope; MS: Middle Slope; BV: Bottom Valley

The high husked yield obtained in bottom valley may be attributed to the nutrient content of the bottom valley. Often time materials are washed from the upper slope down via the middle slope and got deposited at the bottom valley. In the burnt plots, maize yield was 0.342kg/ha in the upper slope, while in the middle slope, maize yield was 0.468kg/ha, whereas in the Bottom valley maize yield was 0.486kg/ha. On the whole the mean total maize yield in the burnt plots was 1.296 kg/ha, of these yield, grain yield alone (De-husk) was 1.002kg/ha with a mean weight yield of maize (grain yield) was 0.086kg/ha in the upper slope, 0.12kg/ha in the middle slope and 0.128 kg/ha in the Bottom valley.

Hence, maize husk contributed about 23% of the mean total in the burnt plots. But in the control (un-burnt) plots, maize yield was 0.276kg/ha in the upper slope, while in the middle slope maize yield was 0.366kg/ha, whereas in the Bottom valley maize yield was 0.426kg/ha. Also, the total maize in the control plots was 1.068kg/ha of these yield, grain yield alone (De-husk) was 0.788kg/ha with a mean yield weight of 0.062kg/ha in the upper slope, 0.092 kg/ha in the middle slope and 0.11 kg/ha in the Bottom valley, while maize husk contributed 26% yield in the control plots. Compare the yield differences in both treatments. High in maize yield was noticed in the middle slope and the Bottom valley with the magnitude as follows; bottom > middle > upper slope there was significant differences in grained yield in respective landscape position, this is variance with the result obtained by Shubeck and Young (1970) who confess non significant different in yields of maize planted in different landscape position.

Relationship between soil properties and maize yield

Table 4 shows the correlation coefficients between selected soil properties and yield of maize in upper, middle slope and bottom valley respectively.

Table 4: Correlation coefficients between soil properties and maize yield

Soil Properties	Upper Slope		Middle Slope		Bottom Valley	
	Husked	Dehusked	Husked	Dehusked	Husked	Dehusked
KS	0.232	0.197	-0.733	-0.599	0.147	0.099
BD	0.203	0.543	0.779*	0.688	-0.066	-0.29
TP	-0.26	-0.593	-0.779*	-0.688	0.128	0.349
MC	-0.155	-0.203	-0.215	-0.252	-0.3	-0.291
AWC	-0.078	0.196	0.548	0.408	0.023	-0.214
pH	-0.780*	-0.873*	-0.965**	-0.979**	-0.332	-0.268
EC	-0.88*	-0.918**	-0.1	-0.111	0.03	0.122
OM	-0.26	-0.24	0.830*	0.844*	0.324	0.342
TN	-0.261	-0.24	0.835*	0.848*	0.328	0.345
Avp	-0.741	-0.617	-0.389	-0.269	0.12	0.001
EA	0.068	-0.374	0.375	-0.299	-0.820*	-0.795*
BS	0.013	0.281	0.628	0.49	0.382*	0.282
K	-0.365	-0.032	-0.621	-0.498	-0.645	-0.715
Ca	-0.01	-0.275	-0.488	-0.652	0.049*	0.063
Mg	-0.515	-0.513	-0.853*	-0.944**	0.52	0.339
Na	0.589	0.673	0.902*	0.0837*	0.441	0.299
ECEC	-0.108	-0.046	0.787	0.779	-0.529	-0.418

*** Significant at 5%; ** significant at 1%**

There was significant negative relationship between husked maize yield and soil pH (r =0.78**) and EC(r = -0.88*) in the upper slope; a significant positive relationship with Bd (r =0.779* ,Om (r =-0.830*),TNC (r = 0.835*) and Na (r = 0.902*) in the middle slope. Still in the middle slope, husked yield showed significant negative relationship with TP (r = -0.779*), pH (r = -0.905**), and Mg (r = 0.853*) while other soil properties in the middle slope did not show significant relationship. The relationship between husked yield and soil properties was not very strong in the bottom valley. This is informed by the number of statistically significant variables (soil properties with maize yield). Only exchange acidity (EA) had significant (negative) relationship with husked maize yield at the bottom valley (r = -0.795*). Considering the de-husked yield in the upper slope, there were significant relationships with pH (r = - 0.873*) and EC (r = -0.918**). In the middle slope, dehusked maize yield correlated significantly with pH (r = -0.979**), Om (r = 0.844*), TN(r = 0.845*), Mg (r = -0.944**) and Na (r = 0.837**) while significant relationship was obtained with EA only (r = -0.795*) in the bottom valley. The results about the relationship further showed that soil property interacted much with maize yield at the upper and middle slope while the association was very weak at the bottom valley. These results are inline with prior expectation because there is translocation of soil materials including nutrients from the upper and middle slope down the bottom valley. Such effects might be due to erosion and implication of this therefore is that, it might lead to decline in soil nutrient along the upper and middle slope than the bottom valley. Hence, maize planted at the upper or middle slope need more attention in term of soil fertility management than those planted on the bottom valley. Also, soil pH was seen to interact much with yield both at upper and middle slope but very weak at the bottom valley. This is an indication that condition of the soil reaction has much impact on plant growth.

CONCLUSION

Studies on the relationship of landscape position and soil properties to maize (Zea mays L.) yield in Ultisol show that soils is slightly acidic on the loamy sand with low organic matter content, ECEC and moderate base saturation. The available P was high, Total N was low, K was low. Bulk density was high and total porosity as well as moisture content and available water were low. The exchangeable rate of cations follows the magnitude; $Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$ and the soil fertility was low because nutrient were not adequately supplied to the soil due to un-directional fertility gradient.

Among landscape position, the bottom valley had the highest mean husked yield (0.15kg/ha) followed by middle slope (0.14kg/ha) while the upper slope had the least (0.10kg/ha) with F-cal of 14. 255 highly significant at p<0.001. The values were different in de-husked yield compared to the pattern in husked yield. The middle slope recorded the highest mean de-husked yield (1.10kg/kg) followed by the bottom valley (o.12kg/ha) while the upper slope had the least and the difference was significant. Variation of maize yield with landscape position followed the in both husked and de-husked yields: BA>MS>US. Altogether, the yield was higher in burnt soil than un-burnt soil (Fig. 1). Burning might have increased the chemical reaction in the soil which resulted in increase in soil nutrients thereby improving crop yield. It might also reduced the activity of paste in favour of the higher yield than in un-burnt soils. Comparing the distribution of pH among Landscape position, the US had mean of 6.49 greater than 6.40 and 6.39 in middle and Bottom valley but difference was not statistically significant ($p<0.05$). Altogether, the distribution of the soil properties before and after burning was significantly different in pH, TN, Av.P. Mg and EA in upper slope , pH, OM, TN, Av.P, Ca, Mg, Na, EA and ECEC in middle slope and pH, Av.P, Ca, Mg, Ea and ECEC again in Bottom Valley (table 2). Among the Landscape position, Non of the chemical properties was significant ($P<0.05$). This may be due to the percent slope considered. Generally, the soil was not too sloppy as the slope angle was < 7%. There was significant negative relationship between husked maize yield and soil pH (r =0.78**) and EC(r = -0.88*) in the upper slope; a significant positive relationship with Bd (r =0.779*, Om (r =-0.830*), TNC (r = 0.835*) and Na (r = 0.902*) in the middle slope. Still in the middle slope, husked yield showed significant negative relationship with TP (r = -0.779*), pH (r = -0.905**), and Mg (r = 0.853*) while other soil properties in the middle slope did not show significant relationship. The relationship between husked yield and soil properties was not very strong in the bottom valley. This is informed by the number of statistically significant variables (soil properties with maize yield). Only exchange acidity (EA) had significant (negative) relationship with husked maize yield at the bottom valley (r = -0.795*). For dehusked maize yield, there were significant relationships with pH (r = - 0.873*) and EC (r = -0.918**). In the middle slope, dehusked maize yield correlated significantly with pH (r = -0.979**), Om (r = 0.844*), TN(r = 0.845*), Mg (r = -0.944**) and Na (r = 0.837**) while significant relationship was obtained with EA only (r = -0.795*) in the bottom valley. Variations in geomorphic had immediate and direct effect on soil physical and chemical properties of the soil as well as yield of crops but landscape position did not have significant effect on chemical and physical properties of the soils. Similarly, it can be inferred that the yield of maize varies with landscape position and with soil properties like soil acidity and fertility indices.

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