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Relationship of Landscape Positions with Soil Properties on Maize (*Zea Mays L.*) Yield in Ultisol

Edem, I.D[1,]*, Stephen O.Edem[1] and Kingsley O. Harold[2]

[1]Department of Soil Science University of Uyo, P.M. B.1017, Uyo, Akwa Ibom State, Nigeria.

[2]Department of Crop Science University of Uyo, P.M. B.1017, Uyo, Akwa Ibom State, Nigeria.

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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 after slashing the re-growth vegetation with cutlass. The trashes was left on the sites and allowed to dry for three weeks before burning. 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 (ASTM and IITA). 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.

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). According to Akobundu (1994), weed control practices have not changed significantly in the developing countries in the last 25 years despite that 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 problems, which have been reviewed by Fadayomi (1991). These include the cost of herbicides which too expensive for the resource-poor peasant farmers. 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).

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

Tele:
E-mail addresses: dennis.edem@gmail.com

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. Author 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

Study area

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 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. The maize seeds were sourced from National Root Crop Research Institute, Umudike. High breed maize seeds were planted in March, 2010 as soon as rain started and germination was almost uniform two weeks after planting.

Characteristics of hybrid maize used	
Maize seed Classification	
Variety	Oba 98
Moisture content	< 12 %
Germination Minimum	90 %
Purity Minimum	98 %

Source: Premier seeds Nigeria Limited (2010)

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.

Laboratory Analysis

Both the physical and chemical properties of the soil were analyzed using standard methods and procedure of Carter (1993). 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 cations (Na, Ca, Mg, K) exchangeable acidity and base saturation while Micro nutrient analysed were Cu, Fe, Zn and Mn.

Treatments and experimental design

The experimental units were arranged in a Randomized complete Block Design (RCBD) with three geomorphic surfaces of upper slope, middle slope and valley bottom forming the blocks with three replications. The plot size used was 40 x 3 m^2 with a distance of 30 cm between plots. The crop planted in double row with spacing of 75 cm between two double rows. The planting spacing was 75 x 30 cm in both burnt and unburnt plots. Both treatments were given NPK fertilizer as a starting dose at the rate of 40 kgha^{-1}. At harvesting the crop was harvested after 85days from date of planting and data was taken on maize yield (husk and dehusk). Weed control on the experimental plots was done manually (hoe weeding) three times before harvesting

Statistical analysis

GenStat Discovery Edition 3 statistical soft ware was used for the analysis of data. Maize yield and soil data obtained were descriptively analyzed for range, mean and standard deviation while analysis of variance was used to compare treatments means and means of significant parameters were separated using Duncan multiple range test of adjacent means. Pearson Product moment correlation analysis was employed to assess the relationship between soil properties and maize yield. Mean soil properties and maize yield from burnt and control were also determined and compared using LSD $_{0.05}$.

Results and discussion

Mechanical analysis and texture

Mechanical analysis showed soil particles changes in different landscape positions before and after vegetation burning in the surface and subsurface soils (Table 1). 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 content 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 US, while in the 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 BV mean bulk density was 1.53 mg/m^3 before burning and 1.57 mg/m^3 after vegetation burning. Bulk density of the soil increased after burning except on the US (Table 1), but there was no significant change among the landscape position. Variation in the values of the bulk density in difference landscape positions in the following order; US > BS > BV. Generally the bulk density was within favourable 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. 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 US, while in the MS, mean total porosity was 43.6 m^3/m^3 before vegetation burning and decreased to 37.7 m^3/m^3 after burning, whereas in the BV, mean total porosity were 42.0 m^3/m^3 and 40.0 m^3/m^3 before and after burning respectively.

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 US, while in the (MS) mean saturated hydraulic conductivity was 17.0cm/hr before vegetation burning and 13.5cm/hr after burning, whereas in the BV mean saturated hydraulic conductivity was 20.2cm/hr before vegetation burning and 19.1cm/hr after vegetation burning (Table 1). Comparing the differences in both treatments, high saturated hydraulic conductivity was observed after burning in the US and BV. This showed that more capillary pores were created on these geomorphic positions resulting from the heat imposed. This is in line with Obi (1984) observations that low conductivity is attributable to low proportion of micro pores in the soils.

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. The was no significant change in available water content among the landscape potions and between the two treatments.

Changes in soils chemical properties among the landscape position

Soil pH and Electrical Conductivity

Among the three landscape positions studied**,** there were not significant changes in pH after slash–and-burn. The soils are generally slightly acidic, this posed constraint in yield to low acid tolerant crops such as cowpea, rice and maize (National Agency for Food Security, 2005).

The values of electrical conductivity in the upper slope before burning was 0.02 dS/m and 0.03 dS/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. The conductivity of the soil is low and the soil is considered be non-saline and this is in line with the report of DHV consult (1994) that when electrical conductivity of any soil is less than 1dS/m, the soil is said to be non-saline.

Organic C and Total Nitrogen

Organic C content of the soil was higher after vegetation burning among the landscape positions except on the middle slope. The corresponding mean C content in unburnt soils were 17.6 g/kg, 31.6 g/kg and 25.4 g/kg and 30.0 g/kg, 23.8g/kg and 30.4 g/kg for burnt soils in US, MS and VB respectively suggested the contributive effect of slash-and burn on organic C content of Ultisol (Table 2). Under both treatments, organic C content was high in the surface (0-15cm) soil layer than the subsurface (15-30cm).

Mean Total N content of soils before burning were 0.04 g/kg, 0.07 g/kg and 0.06 g/kg and 0.07 g/kg 0.05 g/kg and 0.07 g/kg after burning in the respective geomorphic surface positions. But in subsurface soil layer, stable N content was noticed after burning on the upper position, middle and bottom positions averaged 0.07 g/kg (before burning) and reduced to 0.05 g/kg and 0.04 g/kg respectively after burning. This suggests a non significant contributive effect of N from slash-and-burn method of land clearing and supports the findings of National Special Programme for Food Security (2005) that Total N was generally low (0.06 -0.1 g/kg) in Ultisol This low N content may be as a result of leaching due to high solubility in water which rapidly drains down the slope and decreased with depth of soils. This work is in agreement with the earlier work of Tsui et al; (2004).

Available Phosphorus

The available P level in the unburnt plots on all the landscape ranged from 41.5 mg/kg on the subsurface of bottom to 69.30 mg/kg on the upper position (Table 2). Phosphorus content of burnt plots on the upper and bottom positions increased 52 %, while middle slope was by 51 %. A positive beneficial influence of slash-and-burn on P content in all the geomorphic positions.

The critical available P level for maize yield is about 15 mg/kg and most arable crops will not respond to P above this level (Ibia and Udo,1993).

***Basic cations* (Ca, Mg, K, Na)**

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 but decreases down the slope with high values noticed in the middle slope similar in magnesium content (Table 2). Leaching of calcium and magnesium is largely responsible for the development of acidity among the landscape positions in Ultisol.

The pH of the soil varies from slightly acidic to acidic. A low pH value indicates low level of Ca and Mg which may favour the solubility of Al and Mn thus reducing maize yield. The values of calcium varied from 3.04-5.12cmol/kg while magnesium varied from 2.40-5.12cmol/kg. Calcium deficiency 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 affect 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 (0.21cmol/kg) 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).

Maize yield among the landscape positions

Table 3 showed maize yield harvested from the six plots in the three respective landscape positions. For the control plots, means yield with husk were 0.09 kg/ha, 0.12 kg/ha, and0.14 kg/ha, while for the burnt plots, average yield were 0.11 kg/ha, 0.16 kg/ha and 0.16kg/ha.

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)	Control	Burnt	$LSD_{(0.05)}$	Control	Burnt	$LSD_{(0.05)}$	Control	Burnt	$LSD_{(0.05)}$
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

Table 2. Chemical properties of soils along the toposequence

		Upper Slope			Middle Slope			Bottom Valley		
Soil Property	Depth (cm)	Control	Burnt	$LSD_{(0.05)}$	Control	Burnt	$LSD_{(0.05)}$	Control	Burnt	$LSD_{(0.05)}$
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*

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

Plot	US			MS			BV	
	First season	Second		First season	Second		First season	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

Table 4: Correlation coefficients between soil properties and maize yield

	Upper Slope		Middle Slope		Bottom Valley	
Soil Properties						
	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%

In the burnt plots on the respective landscape positions, maize yield averaged 0.342kg/ha, 0.468kg/ha, and 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 was 1.002kg/ha with a mean weighted yield of 0.086kg/ha in the US, 0.12kg/ha in the MS and 0.128 kg/ha in the BV.

Among landscape position, the bottom valley had the highest mean husked yield (0.15 kg/ha) followed by middle slope (0.14kg/ha) while the upper slope had the least (0.10 kg/ha). The same trend pattern was true for de-husked yield; 0.12kg/ha, 0.11kg/ha and 0.07kg/ha respectively (Fig. 1). Generally, maize yield was higher in burnt soil than un-burnt soil and the husk contributed about 23% of the mean total in the burnt plots. Slash-and-burn increases the chemical reaction of the soil which resulted in an increase of soil nutrients thus improves crop yield (Edem *et al*., 2012). It also reduces incidence of pests in favour of the higher yield in burnt plots. Significant (($p < 0.05$) high maize yield was noticed in the BV and MS and this result is in variance with the result of Shubeck and Young (1970) who reported non significant different in yields of maize planted in different landscape positions.

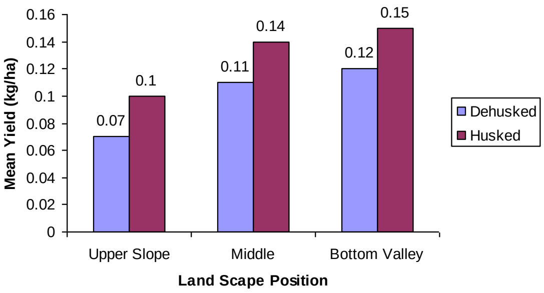

Fig. 1: Variation of Maize Yield (Husked and de-husked) With landscape position

Relationship between soil properties and maize yield

As shown in Table 4, the correlation coefficients between selected soil properties and maize yield in the respective geomorphic positions revealed that there were significant negative relationships between husked maize yield and soil pH (r =0.78**) and EC(r = -0.88*) in the upper slope, whereas husked maize yield related positive with; Bulk density (r =0.779*) ,Organic matter (r =-0.830*), Total N (r = 0.835*) and Na (r = 0.902*) in the middle slope. And also negatively related with Total porosity (r = -0.779*), pH (r = -0.905**), and Mg (r = 0.853*) within the same landscape position. In the VB, only exchangeable acidity related negatively with yield (r = -0.795*).

Considering the grain yield in the upper slope, there were significant relationships with pH (r = - 0.873*) and EC (r = -0.918**). In the middle slope, it correlated significantly with pH (r = -0.979**), Om (r = 0.844*), Total N (r = 0.845*), Mg (r = -0.944**) and Na (r = 0.837**) while in the bottom valley, significant relationship was with only exchangeable acidity (r = -0.795*). These results further showed that soil properties interacted more with maize yield at the upper and middle slope while its association was very weak at the bottom valley. Hence, maize planted at the upper or middle slopes need more attention in term of soil fertility management than those planted on the bottom valley especially, with these selected parameters.

Conclusion

Soil physical conditions in terms of available water content, available phosphorus, Ca and Mg were significantly affected by biomass burning in all the geomorphic positions studied, nevertheless Mg generally was more in the control plots and less after burning. The significant beneficial effect of slash-and burn was producing the highest maize yield in all the landscape positions with potential danger of water pollution by higher inexhaustible nutrient loads in the over land flow down the watershed in the absence of erosion control measure**.**

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