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Impact of Bush Burning on Chemical Properties of Some Soil in Igboora, Oyo State, Nigeria

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Abstract

Soil is used in agriculture as an anchor and primary nutrient base for plants, and the types of soil and available moisture determine the species of plants that can be cultivated. Bush burning, whether as result of a wildfire or a controlled burning, affects not only the appearance of the landscape, but the quality of the soil. Bush burning method of land clearing is a traditional farming system used as a means of land clearing for crop production. This method of land clearing has both beneficial and detrimental effects on soil physical and chemical properties. Therefore, this study investigated the effects of bush burning on soil chemical properties at different soil depth of 0-30 cm and 30-60 cm respectively base on the rooting depth of crop planted. The experiment was carried out in six selected farms in Igboora, Ibarapa central Local Governmental, Oyo State.

The soil sampled were collected from burnt and unburnt experimental soil and analyzed using USDA standard methods for soil analysis for the selected chemical characteristics (pH, Ca^{2+}, Mg^{2+} Na^{+}. TN and P). Two samples were taken from each burnt and un-burnt locations at depth of 0-30 and 30-60 cm. Paired t-test was used to compare means value of soil chemical properties determined from burnt and un-burnt soil. ANOVA was used for significance difference between soil from burnt and un-burnt soil. pH increased from moderately acidic to slightly acidic, phosphorus content of the soil increased greatly from un-burnt soil to burnt soil at 0-30 cm and 30-60 cm depths from 6.64 to 22.21 ppm and 3.53 to 24.95 ppm, respectively. Similarly, potassium increased from 0.27 to 0.40ppm at 0-30cm depth but decreased from 0.23 to 0.17 ppm at 30-60 cm depth. Nitrogen reduced at both depths from 0.80 to 0.76% and 0.72 to 0.68% respectively. Magnesium also increased from 1.3 cmol/kg to 2.00 cmol/kg and 1.65 to 1.75 cmol/kg at both 0-30 cm and 30-60 cm depth respectively. Whereas calcium showed a reduction from 3.17 to 2.85 cmol/kg and 1.65 to 1.45 cmol/kg at both depths. The variations observed between burnt and un-burnt soil for Ca, Mg, exchangeable acidity, pH, Nitrogen, potassium was significant at $p<0.05$ probability level. This indicates that bush burning has an impact on soil physical and chemical properties which may affect the suitability of the soil for crop production. Based on this, there is need for environmental education for farmers in the area in order to know the implications of bush burning on soil properties for soil sustainability which will boost food production.

Keywords: Bush - burning, unburnt, plot, soil fertility, soil chemical properties.

Introduction

Soil which has over the years been a basic resource for agricultural production and the most important possession and assets of farmers to grow plants, is made up of different features and characteristics that make it unique. Soil naturally forms from animal and plant decay while a soil nutrients loss is caused by a certain degree of bush burning (Fite *et al.*, 2007). Bush burning is the removal of the natural vegetation cover from the surface of the soil through the use of fire thereby exposing the land to direct effect of weather such as wind, water erosion and ultraviolet radiation. Bush burning can be a major cause of ecosystem degradation and may result in loss of soil nutrient, human life, economic devastation, soil disruption and environmental deterioration (Elise *et al.*, 2019). Burning of vegetation has a catastrophic effect on the ecosystem and physiochemical properties of the soil (Ketterings and Biham, 2000). The effects of the heating processes caused by bush fire on soil are a result of burning severity which is determined by the peak temperatures and duration of fire (Certini, 2005). Medium fire severity result in darkening of the top soil while high severity fire (> 600^{o}C) causes pronounced reddening of the top soil (Ketterings and Bigham, 2000). In his review of the effect of bush burning on soil Certini, (2005) concluded that moderate severity fires result in a renovation often dominate vegetation by the elimination of undesired species and transient increase in soil pH and available nutrients in the soil, while severe burning generally led to a great significant loss of organic matter, deterioration of both structure and porosity, leaching and erosion, among others.

Soil fertility maintenance is a major concern in agricultural production, particularly with the rapid population increase, which has occurred in the past few decades. In traditional farming systems, farmers use bush fallow, plant residues, household refuse, animal manures and other organic nutrient sources to maintain soil fertility. Farmers clears their land by burning in preparation for planting season without considering its effects on soil chemical properties, this method of clearing is common among the farmers in the study area. De Rouw, 1994, Giardina *et al.*,2000, Tabi *et al*., 2013and Ubuoh *et al.*,2017 in their research find out that slash-and burn increased in soil nutrient availability after burning. Therefore, this research is set out to investigate the effect of bush burning on soil chemical properties of selected farm in Igboora Oyo state Nigeria.

Materials and Methods

The study area, Igboora, is the headquarters of Ibarapa Central Local Government Area of Oyo State, Southwest Nigeria. Igboora is located on longitude 7^{o} 26$^{'}$ 1.79$^{''}$N, latitude 3^{o}17$^{'}$ 16.37$^{''}$E. Igboora is approximately 66 km North-northwest of Ibadan, the Oyo State capital and about 32 km North of Abeokuta, the capital of Ogun State. Igboora share boundary with Ogun State to the South and West, Ibarapa North Local Government Area to the North-West, Iseyin Local Government Area to the North-East and Ibarapa East Local Government to the East.

The soil samples were collected from experimental plot using a soil auger. Soil samples were first collected when the farmlands were not subjected to burning and after burning of debris by farmers base on their traditional farmland preparation. Soil samples were randomly taken from burnt and un-burnt plot of six locations; Salami (sample A), Bandele (sample B), Oyebode (sample C), Sokunbi (sample D), Olurin (sample E) and Ere (sample E). Two samples were collected from each location at depth of 0-30 cm and 30-6 0cm, twenty-four total sample were collected. Each soil sample was stored in a well - labeled polythene bag and transported to the soil science laboratory at Lower Niger River Basin Development Authority Ilorin for analysis.

Laboratory analysis of soil physical and chemical parameters

Chemical properties of the soil samples collected were determined using (USDA, 2014) laboratory soil standards. The methods used in determining the Chemical properties include: pH which was determined with pH meter E520 using 1: 25 (soil to water ratio) as described by Clothier (2002). Atomic Absorption Spectrophotometer (AAS) was used in determining calcium (Ca) and magnesium (Mg). Total nitrogen of the soil was determined using the macro Kjeldal method. Available phosphorous in the soil was determined using Bray P1 method (exchangeable cations ($Ca^{2+,}$ $Mg^{2+,}$ K^{+} and Na^{+}) were determined using 1M NH_4OAC (Ammonium acetate) buffered at pH 7.0 (USDA, 2014)

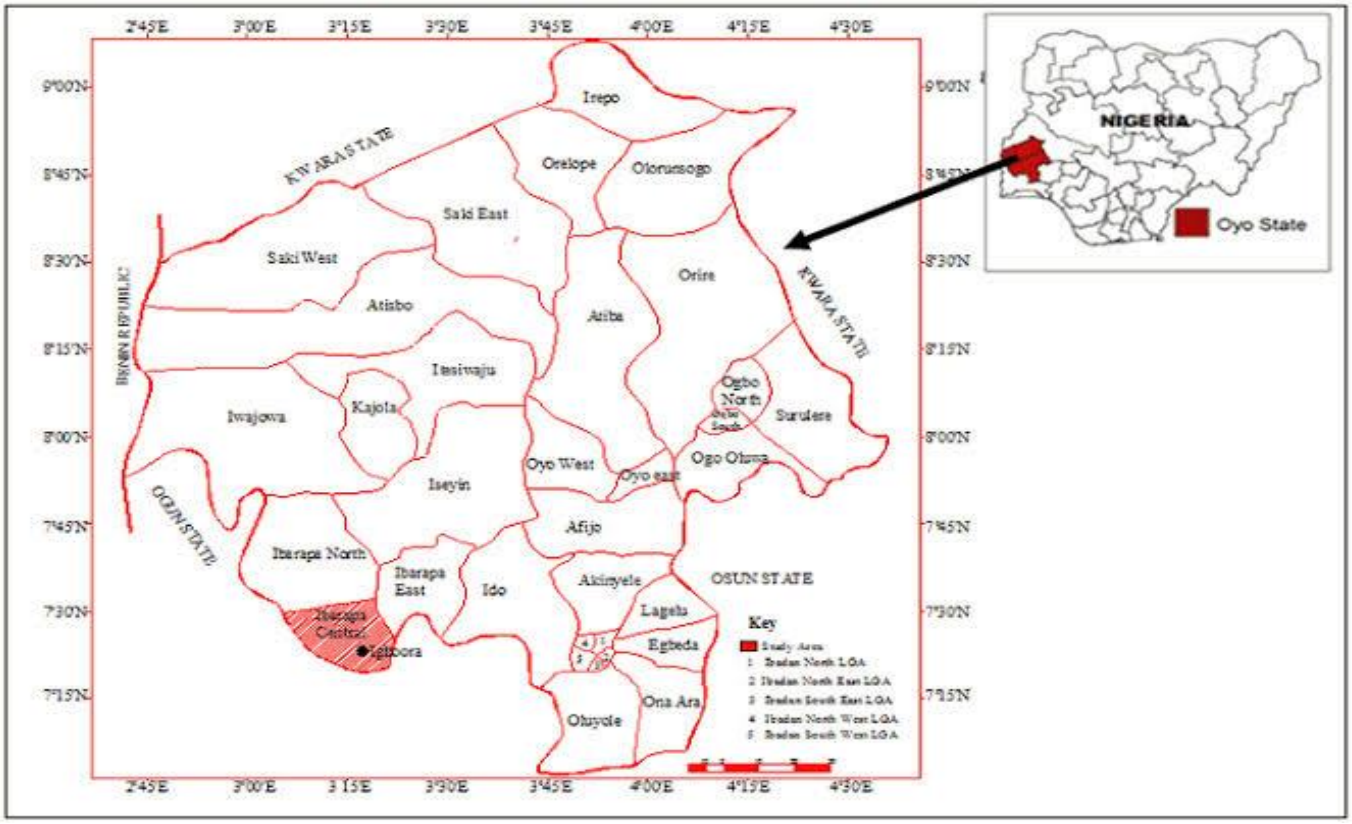

Figure 1: Map of Oyo state showing Ibarapa central local Government

Statistical Analysis*:* Data were statistically analyzed for variance (ANOVA), and significant means were compared using Duncan multiple range test. Paired test was used to compare means of the unburnt and burnt soil. For all tests, a threshold of $P \leq 0.05$ was used to define statistical significance.

Results and Discussion

Results of mean values of soil chemical properties of burnt and unburnt soil are presented in Table 2 and 3, ANOVA for statistical variance are presented in Table 2.1 and 3.1. Soil pH from the result in Figure 2 at depth of 0-30cm, the mean pH value in the unburnt soil increased from 6.08 to 7.43 after burning (slightly acidic to moderately alkaline) which indicate that the soil at this depth has become alkaline due to burning which make it unsuitable for crop production at this depth. At 30 – 60 cm depth the mean pH of unburnt soil increased from 5.94 to 6.5 that is from moderate acidic to slightly acidic this indicate that soil at this depth is tending towards neutral, soil at this depth is satisfactory, ash residue after burning serves as liming and fertilizing material while reducing soil acidity (Adeyolanu *et al.* 2013). Tabi *et al.*, 2013 also reported significant increase in pH of burnt and unburnt soil this was essentially due to the production of K and Na oxides, hydroxides and carbonates immediately after burning (Arocene and Opio, 2003), also increased soil pH would increase the affinity of Ca^{+} for P and the potential for precipitation of Ca phosphate minerals during the fraction procedure (Giardian, *et al.*, 2000). From the ANOVA result (Table1) mean value of pH of burnt and unburnt soil are different and not significant at all depth.

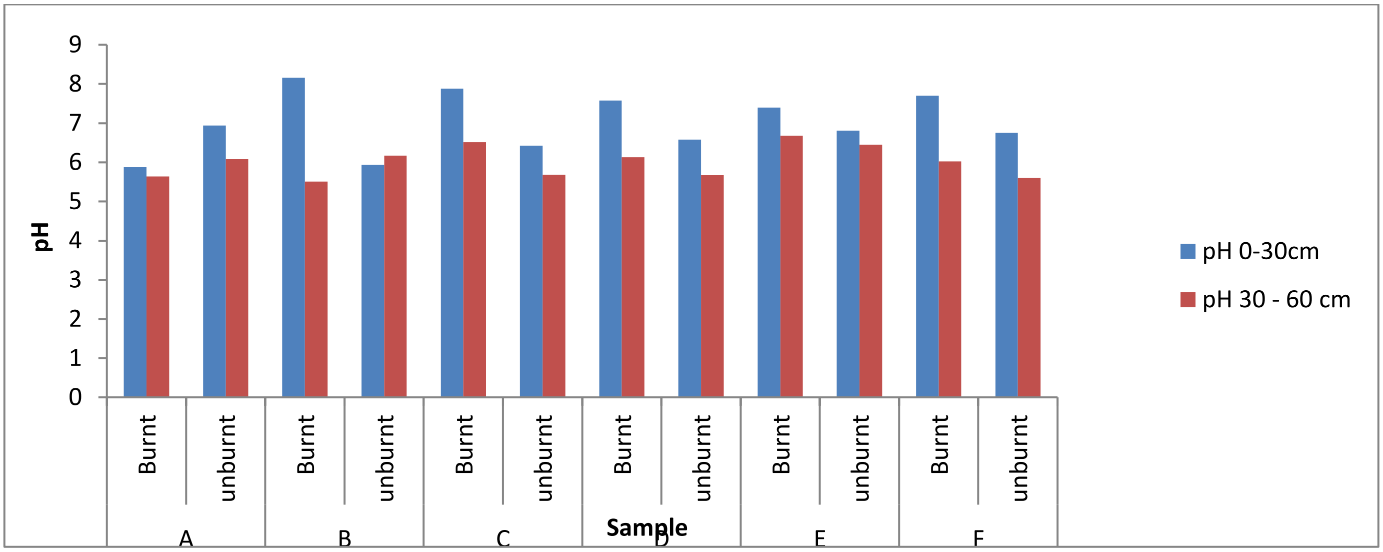

Figure 2: pH values of the soil sample soil

Table 1: ANOVA for Soil pH

Source of variation	SS	Df	MS	F	P-value	F crit
Sample	0.46133	1	0.464133	0.857561	0.381509	5.317655
Columns	2.632033	1	2.632033	4.863104	0.058513	5.317655
Interaction	0.700833	1	0.700833	1.294902	0.288076	5.317655
Within	4.3298	8	0.541225			
Total	**8.1268**	**11**				

Phosphorus, Nitrogen and Potassium

It was observed in the Table 2 that mean values of phosphorus content of the soil increased greatly from 6.64 Pmg kg^{-1} to 22.21 Pmg kg^{-1} when the soil was burnt at 0-30 cm depth, similar increase was noticed at 30-60 cm depth when the phosphorus increased from 3.53 to 24.95 Pmg kg^{-1}. The result conformed with (Ubuoh *et al.*,2017) who observed higher increase in P on the burnt soil. These would have effect on the type of plant that can be planted on this soil as not all plants need phosphorus in very large quantity. The level of phosphorous content of the soil is high and may be due to moderate organic matter content (Adejumobi *et al.*, 2019). Total Nitrogen and Potassium on the other hand experienced a slight reduction in quantity. Nitrogen at 0- 30 cm depth reduces from 0.80 to 0.76 Pmg kg^{-1} when the soil was burnt and from 0.72 to 0.68 Pmg kg^{-1} at 30 – 60cm depth, while Potassium increases from 0.2 to 0.40 ppm at 0.30cm depth while it reduces from 0.23 to 0.17 Pmg kg^{-1} at 30 -60 cm depth as shown in Table.2, these differences are negligible thus might not affect plant growth. The mean value of phosphorus of burnt and unburnt soil sample is different and not significant at all depth.

Total nitrogen (TN): the mean values (Table 2) of nitrogen varied between 0.76-0.80 kg^{-1}at depth of 0-30 cm and 0.68-0.72 kg^{-1}at depth 30-60 cm, with burnt plot at different depths having the lowest mean values respectively. Giardina *et al.*, (2000) reported that soil nitrogen is very sensitive to biological transformations and to losses due to leaching, volatilization, oxidation and gentrification. This conforms to findings of (Ubuoh *et al.*, 2017) which observed decreased in TN of soil after burning. FAO (1997) stated that 0.45kg^{-1} of total nitrogen in soil is good for agricultural food production. Therefore, the burnt soil is still rich in nitrogen for agricultural crop production since the result falls within the recommended value. It can be concluded that burning have reduced soil Total nitrogen contents at both depths.

Result from Table 2, the mean value of phosphorus varied between 6.64-22.21Pmg kg^{-1}at depth of 0-30cm and 3.53-24.95Pmg kg^{-1} at depth of 30-60cm with burnt plot at different depth, having the highest mean values respectively than unburnt soil. This result conforms to the finding of (Tabi *et al.*, 2013) who observed increase in available phosphorus immediately after burning FAO (1997), stated that 16.1Pmgkg^{-1} of phosphorus is essential for agricultural crop production. Therefore, the burnt soil is still good for agricultural crop production, increased in available phosphorus increases the fertility of the soil in term of phosphorus required for plant yield. The mean values of nitrogen of burnt and unburnt sample are different and not significant at soil depth.

Potassium (K): From Table 2, potassium ranged between 0.27-0.40 (cmolkg^{-1}) at depth of 0.30 cm and 0.17-0.23 (cmolkg^{-1}) at depth of 30-60 cm with burnt plot having the higher value than unburnt soil at depth of 0-30 cm and unburnt soil having the highest value than burnt plot at depth of 30-60 cm. The increased in the burnt plot could have been due to rainfall and wind which play major role in the sustainability of potassium as reported by (Ulery 1993). The actual potassium present in the burnt plot farmland is adequate for agricultural food production because FAO recognized exactly 0.40 (cmolkg^{-1}) of potassium for agricultural crop production.

The mean values of potassium of burnt and unburnt soil are different and not significant.

Table 2: Chemical properties of burnt and unburnt soil (Nitrogen, phosphorous and potassium)

	T Nitrogen (%)				**Phosphorus (ppm)**				**Potassium (ppm)**			
	0-30		*30-60*		*0-30*		*30-60*		*0-30*		*30-60*	
	Burnt	Unburnt	Burnt	Unburnt	Burnt	Unburnt	Burnt	Unburnt	Burnt	Unburnt	Burnt	Unburnt
Mean	0.76	0.80	0.68	0.72	22.21	6.64	24.95	3.53	0.40	0.27	0.17	0.23
Std Dev.	0.10	0.11	0.03	0.09	31.23	2.71	29.84	0.06	0.17	0.15	0.04	0.10
Minimum	0.62	0.70	0.63	0.66	5.42	5.04	4.10	3.47	0.12	0.14	0.12	0.12
Maximum	0.90	0.92	0.70	0.82	85.53	9.77	84.96	3.59	0.64	0.44	0.20	0.31
Conf. Level (95.0%)	0.11	0.28	0.03	0.22	32.77	6.73	31.32	0.15	0.18	0.38	0.04	0.24

Table 2.1: ANOVA for Soil Nitrogen, Phosphorous and Potassium

Source of variation	**SS**	**Df**	**MS**	**F**	**P-value**	**F crit**
Nitrogen						
Sample	0.007008	1	0.007008	0.98186	0.351148	5.317655
Columns	0.023408	1	0.0238408	3.273893	0.107991	5.317655
Interaction	7.5E-05	1	7.5E-05	0.01049	0.920945	5.317655
Within	0.0572	8	0.00715			
Total	**0.087692**	11				
Phosphorous						
Sample	1024.162	1	1024.162	2.485713	0.153535	5.317655
Columns	541.3633	1	541.3633	1.313927	0.284812	5.317655
Interaction	821.0456	1	821.0456	1.992736	0.195745	5.317655
Within	3296.154	8	412.0193			
Total	**5682.725**	11				
Potassium						
Sample	0.002133	1	0.002133	0.080808	0.783424	5.317655
Columns	0.073633	1	0.073633	2.789141	0.133453	5.317655
Interaction	0.038533	1	0.038533	1.459596	0.261493	5.317655
Within	0.2112	8	0.0264			

Total	**0.3255**	**11**

Magnesium, Calcium and Exchangeable acidity

Magnesium (Mg): The mean values of magnesium (Table 3) ranged between 1.31-2.00 ($cmolkg^{-1}$) at depth of 0-30 cm and 1.65-1.75 ($cmolkg^{-1}$) at depth of 30-60 cm with burnt plot recording the highest value than unburnt soil at both depths respectively. Increased magnesium content in burnt soil may be due to increase in pH level due to the present of ash from burning. FAO (1997), stated that 0.66 ($cmolkg^{-1}$) of magnesium in the soil is required by plant for optimum yield. Therefore, magnesium contents in the burnt plot farmland increased greatly which make it to richer for agricultural crop production, therefore mean values of magnesium of burnt and unburnt sample are different and not significant

Table 3: Chemical properties of burnt and unburnt soil (Magnesium, Calcium and Exchangeable acidity)

	Magnesium (cmol/Kg)				Calcium (cmol/Kg)				Exchangeable acidity (mMol/100g)			
	0-30		*30-60*		*0-30*		*30-60*		*0-30*		*30-60*	
Mean	2.00	1.31	1.75	1.65	2.85	3.17	1.45	1.65	0.83	0.78	0.96	0.91
Standard Deviation	0.97	0.32	1.04	0.41	1.21	1.21	0.20	0.32	0.11	0.09	0.10	0.09
Minimum	0.80	0.96	0.88	1.20	1.52	2.32	1.12	1.28	0.64	0.72	0.88	0.80
Maximum	3.52	1.60	3.76	2.00	5.04	4.56	1.68	1.84	0.96	0.88	1.12	0.96
Confidence Level (95.0%)	1.02	0.80	1.10	1.02	1.27	3.01	0.21	0.80	0.11	0.23	0.11	0.23

Table 3.1: ANOVA for Soil Magnesium, Calcium and Exchangeable acidity (mMol/100g)

Source of variation	**SS**	**Df**	**MS**	**F**	**P-value**	**F crit**
Magnesium						
Sample	2.7075	1	2.7075	3.847885	0.085446	5.317655
Columns	0.0675	1	0.0675	0.0675	0.764683	5.317655
Interaction	0.116033	1	0.116033	0.164906	0.695325	5.317655
Within	5.629067	8	0.703633			
Total	**8.5201**	11				
Calcium						
Sample	0.8112	1	0.8112	1.416201	0.268145	5.317655
Columns	5.018133	1	5.018133	8.760708	0.01815	5.317655
Interaction	0.154133	1	0.154133	0.617984	0.617984	5.317655
Within	4.5824	8	0.5728			
Total	**10.56587**	11				
Exchangeable acidity (mMol/100g)						
Sample	0.008533	1	0.008533	0.571429	0.471369	5.317655
Columns	0.053333	1	0.053333	3.571429	0.095452	5.317655
Interaction	0.008533	1	0.08533	0.571429	0.471362	5.317655
Within	0.119467	8	0.014933			
Total	**0.189867**	**11**				

Calcium (Ca): From Table 3, at depth of 0-30 cm the mean values of calcium ranged between 2.85-3.17 cmol kg^{-1} with burnt soil recording the lowest value and unburnt soil having the highest value, while at the 30-60 cm depth, calcium ranged between 1.45-1.65 cmol kg^{-1} with burnt soil having the lowest value and unburnt soil having the highest value than burnt soil. This result conforms to (Ubuoh *et al.,* 2017) which reported that an increase of calcium at this depth of unburnt plot may not be due to leaching because calcium is present adequately in most soils and is a component of several primary and secondary minerals in the soil. The mean values of calcium of burnt and unburnt sample are different and not significant.

Exchangeable acidity: From the result exchangeable acidity range between 0.78-0.83 (cmolkg^{-1}) at depth of 0-30 cm and 0.91-0.96 (cmolkg^{-1}) at depth of 30-60 cm with burnt soil recording the highest value and unburnt soil recording the lowest value at both depths respectively. The exchangeable cations in the soil are Calcium (Ca^{++}), Magnesium (Mg^{++}), Potassium (K^{+}), Sodium (Na^{+}). (Ubuoh *et al.,*2016). Increase in soil nutrients of burnt soil may also due to the deposit of ash that increased the pH level of the soil as supported by the finding of (Kettering *et al.,*2000). Therefore, the soil is good for agricultural food production due to increase in calcium, magnesium and potassium deposited by ashes during the burning. The mean values of exchangeable acidity of burnt and unburnt sample are different and not significant at all depth.

Conclusions

Impact of bush burning on soil physical and chemical properties (case study of Igboora, Ibarapa central local government), Oyo state were investigated and analyzed after annual year of active farming operation. Based on the findings of the research work, the following conclusions are drawn:

The soils at both depths for the burned soil have become moderately acidic tending towards alkaline. There was increased in Potassium, phosphorus and Magnesium in the burnt soil, exchangeable acidity remains constant in burnt plot under study, it was also observed that there were reductions in Ca content.

Recommendation

Since farmers in this area adopted fire burning method as their cultural land preparation from time immemorial, therefore, local farmers in the area should be sanitized on both positive and negative impact of burning on soil available for agricultural food production. It therefore suggests for an effective environmental extension for better greater awareness

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