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DIRECT EFFECTS OF STUBBLE BURNING ON SOME EDAPHIC CHARACTERISTICS OF COASTAL PLAIN SANDS AT DIFFERENT HEATING INTENSITIES

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ABSTRACT

Stubble burning had been identified as a contributor to soil structural degradation and loss of plant nutrients. Contrary to this, some studies have suggested that burning activities might increase availability of plant nutrients and also reported that charcoal residues and charred biomass left on kiln sites improve the fertility of tropical soils by direct nutrient addition and retention. The effect is not sufficiently understood or quantify in areas with very high rainfall intensity that evidenced in high leaching and erosion associated with slope. We; (1) examined the effect of stubbles burning on soil conditions in acid sands, and (2) identified any changes in soil chemical and physical properties under burning at different level of intensity. The experimental fire was performed with measured dry biomass of 30, 90, 120 kg m-^{2}, in three replicates on the plots to provide three levels of burning and the unburned plots served as control. At each of the sampling points, random spots were core sampled and augered at 0-15 cm depth, with the aid of a Dutch auger and bulked together to give a composite sample. Laboratory methods of analyses were carried out on soil samples for particle size distribution, pH (soil reaction), organic matter contents, total nitrogen, available phosphorus and exchangeable cations (K, Ca, Mg and Na). The textural class of the soils within the study area was found to be sandy loam with sand fraction being the dominant particle size in all locations after burning and was found to have significant effect on the particle size distribution. Coarse sand fraction was higher in the burnt plot with the mean value of 16.00 gkg^{-1} in 30 and 120 kgm-^{2}, 13.33 gkg^{-1} in 90 kgm-^{2} and 12.66 gkg^{-1} in the unburnt plot. Also soil burnt with 30 and 90 kgm-^{2} of the dry biomass was found to increase bulk density by 4 and 9 % respectively, while 6 % reduction in bulk density occurred in soil burnt with 120 kgm-^{2} stubble materials. Total nitrogen content was found to be significantly reduced as a result of burning, while available phosphorus was higher in burnt plots than in the un-burned soil.

Keywords: Stubble, Agricultural burning, Nutrient loss, Ultisol, Degradation.

1. INTRODUCTION

Agricultural burning practice is generally used to reduce crop residue, stimulate yield, control diseases, reduce unwanted plant species or otherwise maintain the productivity of agricultural lands. It also helps to control pests and diseases and enables cultivators to clear land quickly and efficiently with minimal labour requirements [1]. Agricultural practices in the humid tropics generally involve the destruction of vegetation by clearing the land, followed by burning before cultivation Mackensen, et al. [2]. It is an economic and simple management tool that can be used to remove plant residues for site preparation, [2]. Stubble burning has affected a variety of soil properties including the loss or reduction of structure and soil organic matter and reduced porosity [3]. These changes also resulted in various indirect impacts including increased hydrophobicity (water repellency) which results in decreased infiltration and increased run-off which often results in increased erosion [4]. Although Alegre and Cassel [5] has suggested that the best possible system for removing stubble materials was still that of burning. According to Oyekanmi and Okeleye [6] and DeFries, et al. [7], biomass burning for land preparation is common in Africa. It accounts for 94.7% of total energy supply in the country [8]. Electric and

Corporation [9] also stated that the major indigenous sources of energy are woody biomass and crop residues.In regard to nutrient cycling, burning releases to the soil about half of the nitrogen and phosphorus of the burning biomass and practically all of the other nutrients in the form of ash, which also causes a liming effect. Higher soil temperature following burning also accelerates the decomposition of soil organic matter. These factors provide high nutrient availability for one or two years to grow food crops, depending on the inherent fertility status of the soil [10]. Farmers that aim at benefiting from the lush re-growth after burning tend to subject their grassland to fire every season, irrespective of the amount of moribund herbage at the end of the season, thus exposing the surface mat layer to destruction [11-13]. It is also believed to rid the grassland of parasitic insects and to prevent the encroachment of undesirable invasive plant species. The later is subjective since fire is also known to break seed dormancy in some of the common invasive species [14].

Agricultural burning had been also identified as a contributor to soil structural degradation [15] and loss of plant nutrients. Contrary to this, some studies have suggested that burning activities might increase availability of plant nutrients [16, 17]. Glaser, et al. [18] and Ogundele, et al. [19] also reported that charcoal residues and charred biomass left on kiln sites improve the fertility of tropical soils by direct nutrient addition and retention. Agricultural burning has a detrimental effect on the environment and health of mankind. All fires, regardless of whether they are natural or manmade, alter the re-cycling of nutrients, the biotic, physical, moisture, and temperature characteristics of soil [20]. It may alter several physical soil properties, such as soil structure, porosity, infiltration rate and water holding capacity. The extent of fire effects on soil physical properties vary considerably depending on fire intensity, fire severity, and fire frequency. Its intensity is the factor that determines the soil status with respect to its response to nutrient losses which affect crop production. Thus, as a means of land clearance and field preparation prior to planting is a common practice in the West Africa Savannah ecological zone and it is regarded as the easiest and most convenient method of removing plant residues from previous cropping and other debris from the farm [21]. Studies have shown that severe burning has drastic effects on soil texture, color, mineralogy, and other soil properties [22].

A significant decrease in clay fraction and a corresponding increase in sand fraction of severely burnt soils may eventually lead to poor water- holding capacity [23]. Low to medium fire severity resulted in darkening of the topsoil while high-severity burns (>600°C) caused pronounced reddening of the topsoil, accompanied by an increase in both munsell value and chroma [23, 24].Moreover, majority of farmers in Akwa Ibom State, Nigeria practiced stubble burned method of land preparation. This practice is impinging on the structural stability of soils. However, very few studies have been conducted regarding the impacts of agricultural burning especially in Ultisol. Therefore this work aims at: (1) examining the effect of stubbles burning on soil conditions, and (2) identifying any changes in soil chemical and physical properties under burning at different level of intensity.

2. MATERIALS AND METHODS

2.1. Experimental Study Area

The study was conducted at the University of Uyo Teaching and Research farm, Use Offot Uyo, Akwa Ibom State, South Eastern Nigeria. The area, is located between latitudes 40^0 30^1 and 5^0 3^1N and longitudes $7^0 27^1$ and $8^0 27^1$ E and attitude 65m from sea level. The area is divided into two distinct seasons, the wet or rainy and dry seasons. The wet or rainy season begins form April and lasts till October. It is characterized by heavy rainfall of about 2500 – 4000 mm per annum [25]. The rainfall intensity is very high and there is evidenced of high leaching and erosion associated with slope and other rainfall factors in the area. The dry season starts from November and lasts till March of which period is characterized by high temperature with a mean annual temperature of 28°C. The highest temperature is often experienced between January through March, the period described by Enwezor, et al. [26] as overhead passage of the sun.

The landscape is generally undulating to steep hills while the vegetation is mainly, the tropical rain forest. The soils are derived from sandy parent materials which are weathered with low activity clay. The predominant land use is continuous cropping.

2.2. Performance of Experimental Fire

The experimental fire was performed with measured dry biomass of 30, 90, 120 kg m^{-2}, in three replicates on the plots to provide three levels of burning and the unburned plots served as control. The fire weather conditions at the time of burning were mild, relative humility of 50-59 % and variable winds ranging from 0 to 7 km h^{-1} .This resulted in a slow creeping ground fire with mean flame heights under 2.5 m.

2.3. Soil Sampling and Processes

At each of the sampling points, random spots were core sampled and augered at 0-15 cm depth, with the aid of a Dutch auger and bulked together to give a composite sample. The soil samples from different sampling points were, on each occasion, collected in polythene sample bags and labeled accordingly. Another set of soil samples was taken to estimate the Ksat and bulk density, and all the samples were then transported to the laboratory for analysis.

Laboratory methods of analyses were carried out on soil samples for particle size distribution, pH (soil reaction), organic matter contents, total nitrogen, available phosphorus and exchangeable cations (K, Ca, Mg and Na).

Particle size analysis was determined using Day's hydrometer method as described by Udo, et al. [27]. After dispersing the soil particles with sodium hexametaphosphate solution and fractionation, the textural classes of the soil were determined using the textural triangle.

Bulk density was estimated by dividing the oven dry mass of the soil by volume of the soil as described by Grossman and Reinsch [28]. $BD\ (g\ cm^{-3}) = \frac{Ms}{Vs}$

Where: BD = Bulk Density (g cm^{-3})
Ms = mass of oven-dried soil samples (g)
Vs = total volume of soil (cm^3), (solid + pores)

The total volume of the soil was calculated from the internal diameter of the core cylinder. Total porosity was calculated from bulk density assuming particle density of 2.65g cm^{-3} as described by Gee and Or [29].

Saturated hydraulic conductivity was determined using constant head parameter method according to Day's procedures [30]. The saturated core samples were placed in funnel, resting on a tripod stand after the constant head cylinder was placed on top of it and fastened together using marking tape: A constant head of water was maintained throughout the period of the experiment. The flux of water passing through the soil column was collected in a measuring cylinder and readings were attended in each of the samples and expressed as follows:

$$U = -K\frac{dh}{dz} \quad ,$$

Where, U is Darcy's velocity (or the average velocity of the soil fluid through a geometric cross-sectional area within the soil), h is the hydraulic head, and z is the vertical distance in the soil. The coefficient of proportionality, K is the hydraulic conductivity (Ksat)

Water stable aggregates (WSA) were determined using modified Hubbert, et al. [31] wet sieving methods described by Nimmo and Perkins [32]. 100g of moist soil sample at 0- 15cm and 15-30cm depths were placed on a nest of sieves (2, 1, 0.5 and 0.25mm). The nests of sieves were cycled through a column of water for 10 minutes (10cycels per mm). The percentage of water stable aggregate (WSA) and means weight diameter (MWD)fraction of the total sample were calculated, a statistical index of aggregation was calculated from aggregate size distribution data after correction had been made for sand fractions by dispersion with sodium hexametaphosphate using this formula:

$$MWD = \sum_{i=1}^{n} X_i W_i$$

Where, MWD = mean weight diameter of each size fraction (mm) and w_1 is the proportion of total samples in the corresponding size fraction after deducting the mass of stones (upon dispersing and passing through the 210 µm sieve)

The soil pH was determined in water (1: 2.5 soil to water ratio), with the aid of a Glass-electrode pH meter. Twenty grammes of air-dry soil (passed 2 mm sieve) was weighed into a 50 ml beaker and 20 ml of distilled water added to it. This was allowed to stand for 30 minutes and stirred occasionally with a glass rod. Following this, the electrodes of the pH meter was inserted into the partly settled suspension and the pH measured. The pH meter was calibrated with pH 7.0 and pH 4.0 buffer standards before use.

The soil electrical conductivity was determined with the aid of a conductivity meter. The suspension used for the soil pH determination was filtered and the electrical conductivity was determined on the filtrate. Calibration was first carried out using standard potassium chloride solution.Organic Carbon in soil was determined by the Walkley-Black method [33]. A representative soil sample was ground to pass through 0.5 mm sieve and 1.0 g weighed out in duplicate into 250 ml Erlenmeyer flask. Ten milliliters of 1N $K_2Cr_2O_7$ solution was pipetted into each flask and swirled gently to disperse the soil. Twenty milliliters of concentrated H_2SO_4 was then added to the suspension and then vigorously for one minute for effective oxidation. One hundred milliliters of distilled water was then added to the contents of the flask after allowing it to stand for 30 minutes. Three drops of ferroin indicator was added to the solution and titrated with 0.5N ferrous sulphate solution. The end-point was indicated by a sharp colour change from blue to red in reflected light against a white background. Total nitrogen in soil was determined by the macro Kjeldahl method as described by Nelson [34]. A representative soil sample was ground to pass through 0.5 mm sieve and 5.0 g weighed out into a dry 500 ml macro-Kjeldahl flask. Twenty millilitres of distilled water was added and then swirled for a few minutes before being allowed to stand for 30 minutes. To this was added one tablet of mercury catalyst and 10 g of K_2SO_4 , followed by 30 ml of concentrated H_2SO_4 . The 4flask was heated at low heat on the digestion stand until water was removed and frothing ceased. The heat was then increased until digest cleared after which the mixture was boiled for 5 hours.

One hundred millilitres of distilled water was added to the digest after it had been allowed to cool and then transferred into a bigger (750 ml) macro-Kjeldah flask with the sand particles retained in the original digestion flask. The sand residue was then washed with 50 ml of distilled water four times and the aliquot transferred to the 750 ml flask on each occasion.

Fifty millilitres of H_3BO_3 indicator solution was measured into a 500 ml Erlenmeyer flask and placed under the condenser of the distillation apparatus. The 750 ml Kjeldahl flask was then attached to the distillation apparatus and 150 ml of 10 N NaOH poured through the distillation flask by opening the funnel stopcock. Distillation was then commenced and 150 ml of distillate collected. The ammonium nitrogen in the distillate was determined by titrating with 0.01N standard HC1 with the end-point being indicated by a colour change from green to pink. The percent nitrogen content of the sample was obtained by calculation.

Available phosphorous in soil was determined by the Bray No.1 as described by method Klute [30]. One gram of air dried soil, which has been passed through a 2 mm sieve was weighed into a 15 ml centrifuge tube and 7 ml of the extracting solution of NH_4F and HC1 added. This was first shaken on a mechanical shaker for one minute before being centrifuged at 2000 revolution per minute for 15 minutes. Two millilitres of the clear supernatant was pipetted into a 20 ml test tube and 5 ml distilled water added followed by 2 ml of ammonium molybdate $\{(NH_4)_6 MO_7O_{24})\}$ solution. The content was mixed and one millilitre of stannous Chloride $\{SnC1_2.2H_2O\}$ dilute solution was added and mixed again. After 10 minutes, the percent transmittance of the solution was measured on a spectronic-20 spectrophotometer at 660 nm wavelength. The available phosphorous concentration in soil was then calculated with reference to a standard curve of optical density of standard solutions against available phosphorous concentrations.

Exchangeable cations Ca, Mg, K and Na in soil samples were determined as described by Klute [30]. Five grammes of air-dried soil, which has been passed through a 2 mm sieve was transferred into a centrifuge tube. To this was added 30 ml of 1N NH_4OAC and shaken on a mechanical shaker for 2 hours, then centrifuged at 2,000 revolution per minute for 5 minutes. The clear supernatant was decanted into a 100 ml volumetric flask and another 30ml of NH_4OAC solution was added to the residue, shaken for 30 minutes and centrifuged. The supernatant was transferred into the same volumetric flask and the step repeated again before the flask was made up to mark with the NH_4OAC solution. Potassium (K^+), Sodium (Na^+) and Calcium (Ca^{++}) were determined from the supernatant with the aid of a flame photometer, while magnesium (Mg^{++})

was determined by atomic absorption spectrophotometry. Consideration was taken of the dilution factor in concentration calculations.

2.4. Data Analysis

Data obtained from the treatments were diagonalized and subjected to statistical analysis of multivariate technique using SPSS for windows (version 17 Inc. Chicago) and significance was based on an alpha of 0.05.

3. RESULTS AND DISCUSSION

The physical properties of the study area as shown in Table 1 were grouped based on different levels of treatment; 30, 90, 120 kgm^{-2}. This soil is characterized by relatively low quantity of silt and clay contents. The low content of silt and clay reflects subjection of the soils to some degree of leaching, water erosion [35] after burning. The textural class of the soils within the study area was found to be sandy loam with sand fraction being the dominant particle size in all locations after burning and was found to have significant effect on the particle size distribution.

Coarse sand fraction was higher in the burnt plot with the mean value of 16.00 gkg^{-1} respectively in 30 and 120 kgm^{-2}, 13.33 gkg^{-1} in 90 kgm^{-2} and 12.66 gkg^{-1} in the unburnt plot. The process of burning not only helps to increase coarse sand distribution but also enhanced permeability and causes leaching of plant nutrients which is detrimental to arable crops production in this area of high rainfall. This results agrees with the findings of Chandler, et al. [36] who started that intense fire (>600^{0}C) permanently alter soil texture by aggregating clay particles into stable sand size particle thereby making the soil texture more coarse and erodible.

Intense burning resulted in a significantly high bulk density with a mean value of 1.50 gcm^{-3} which is statistically similar to the effect produced as a result of light burning but different ($p<0.05$) from the bulk density of un-burnt areas which gave a mean value of 1.44 gcm^{-3} within the study. Also soil burning with 30 and 90 kgm^{-2} of the dry biomass was found to increase bulk density by 4 and 9 %, while 6 % reduction in bulk density occurred in soil burnt with 120 kgm^{-2} stubble materials. The result is in agreement with the finding that the increase in bulk density of the soil is as a result of the loss of organic matter and destroyed soil structure in heated soils [37].

Aggregate sizes of wet sieving method were with a set of sieve of 4, 2, 1, 0.5 and 0.25 mm in diameter. The stable aggregates were higher in the unburnt soils with aggregate values of 8.75, 1.01, 3.69, 2.28 and 3.45 mm for 4, 2, 1, 0.5 and 0.25 mm respectively. In the burnt soils the incremental average trend of, 4mm > 1mm, > 0.5mm >0.25mm> 2mm applied to all levels of burning. Plots receiving 30 kgm^{-2} treatment had aggregate size of 14.35, 1.01, 3.36, 2.98 and 2.72 mm for the respective sieve diameter, while plots receiving 90 kgm^{-2} of dry biomass retained respective aggregates of 14.74, 0.68, 3.55, 2.59 and 8.40 mm, whereas plots where 120 kgm^{-2} treatment was applied, stable aggregates obtained were 11.86 (4 mm), 1.01 (2 mm), 3.33 (1mm), 2.67 (0.5 mm) and 3.06 (0.25mm). Generally, stubble burning in the farmland alters soil aggregation and increases the rate of erosion due to distortion of pore geometry, hence affects the soil water movement [17]. Caravaca and Albaladejo [38] reported that decline in soil structure in phase of MWD is increasingly seen as form a of degradation. With respect to Mean weight diameter, data in the unburnt plot have a mean value of 0.60 mm, but with 30 kgm^{-2} stubble burning, MWD reduced to 0.40 mm. Further increase in the quantity of stubble in the burning process to 90 kgm^{-2}, MWD increased to 0.91mm and only 3 % increment of MWD was recorded with 120 kgm^{-2} of dry biomass burning. Therefore direct effects of stubble burning on MWD and stability of aggregates are vague and inconsistence.

Soil water characteristics as shown by volumetric moisture in Table 1, showed the observed differences in moisture retention before and after burning the field. The amount of moisture content from one landscape position to the other varied considerably with differences in particles distribution. Only a small decrease in moisture content was observed in un-burnt plot. Volumetric moisture content decreased considerably after stubble burning. The results of permanent wilting coefficient revealed that significant ($p<0.05$) quantity of water (> 50 %) is tenaciously held in the soil after burning. Obtained data on available water content pointed out that burnt plots tends to store relative more atmospheric moisture for plants use than in unburnt condition. This is consequence upon the fact that aggregates have been shown to increase water holding capacity, infiltration and porosity, and reduce compatibility [39] after burning.

3.1. Effects of Stubble Burning on Saturated Hydraulic Conductivity (Ksat)

Ksat in the unburned plot range from 0.66 - 5.04 cm hr^{-1} with the mean value of 3.36 cm hr^{-1}. Plots burnt with 30 kg m^{-2} of stubbles had Ksat range between 7.56 -10.74 cm hr^{-1} with the mean value of 1.76 $cmhr^{-1}$, plots receiving 90 kgm^{-2} of stubbles recorded Ksat range from 0.72 - 22.68 $cmhr^{-1}$ with the mean conductivity of 8.08 $cmhr^{-1}$, but the plot burnt with 120 kgm^{-2} of stubbles conducted water between 5.64 -16.38 $cmhr^{-1}$ with the mean value of 9.86 $cmhr^{-1}$ on the soil surface. Significant ($p<0.05$) high saturated hydraulic conductivity was noticed in plots receiving 120 kgm^{-2} treatment level. According to Lal and Stewart [40] decrease in hydraulic conductivity enhances accumulation of water on soil surface and thereby encourages surface runoff while high value of saturated hydraulic conductivity is an indication of high rate of water movement in the soil which is due to the presence of organic matter content and pore space in the soil [41]. From this research finding, it could be concluded that light stubble burning (30 kgm^{-2}) is detrimental to soil.

Table-1. Physical parameters of soil at different levels of stubble burning per square meter of experimental plot

		Burned plots			
Soil parameters	**Unburned plot**	**30 kg m^{-2}**	**90kg m^{-2}**	**120 kg m^{-2}**	**SEM**
BD (gcm^{-2})	1.44	1.51	1.57	1.35	0.96
Ksat (cm hr^{-1})	3.36	1.76	8.08	9.86	4.29
4.00mm	8.75	14.35	14.7	11.8	2.53
2.00mm	1.01	1.01	0.6	1.01	0.44
1.00mm	3.69	3.36	3.55	3.33	1.12
0.5mm	2.28	2.98	2.59	2.67	0.64
0.25mm	3.54	2.72	8.4	3.06	2.26
MWD	0.6	0.4	0.91	0.62	0.11
GMWD	0.9	0.86	1.00	33.57	16.35
T P (cm3cm-3)	0.46	0.45	0.41	0.49	0.03
CS (g/kg-1)	12.66	16.00	13.33	16.00	0.74
FS (g/kg-1)	69.66	63.00	67.00	64.33	1.37
Silt (g/kg-1)	1.66	1.00	1.00	1.66	0.47
Clay (g/kg-1)	16.66	20	18.66	18.00	0.94
Texture	SL	SL	SL	SL	SL
GMC(m3m3)	0.09	0.06	0.01	0.06	0.04
VMC(m3m3)	0.13	0.04	0.02	0.08	0.05
FC(m2m3)	0.38	0.12	0.09	0.11	0.15
PWP(m2m3)	0.03	0.06	0.04	0.06	0.01
AWC(m3m3)	0.03	0.05	0.05	0.05	0.15

MWD = Mean Wet Diameter, GMC =Gravimetric Moisture Content, GMWD =Geometry mean wet diameter; Ksat = Saturated Hydraulic Conductivity, VMC = Volumetric Moisture Content; AWC= Available Water Content ; SL = Sandy loam

3.2. Effects of Burning on Soil Nutrients

As shown in Table 2, soil pH value in the unburnt and burnt soils ranged from 5.5 - 5.7 (control), for soil receiving 30, 90, and 120 kgm^{-2} of stubbles there was increase in soil pH value and this increase may be as a result of ash, acieration due to burning and also due to buffering capacity of the soil. Also similar observation as reported by other researchers [3, 36, 42] [13] has resulted from ash deposit from the consumed plant biomass. The resulting ash material is also known to be a rich source of cations.

The value of EC_{25} of all the burned plots decreased significantly and showed reverse trend compared to pH. Unburned plot had a mean electrical conductivity value of 0.63 dSm^{1}; burned plots with 30, 90, and 120 kgm-^{2} of stubbles had a mean value of 0.03 dSm^1, 0.10 dSm^1 and 0.06 dSm^{1}respectively.

The content of organic C was slightly higher in the burnt plots. Results of burning stubbles with 30, and 90, 120 kgm-^{2} increased organic C content from 0.96 to 1.15 gkg^{-1}, and 1.16 gkg^{-1}, respectively and 9 % organic C loss at 120 kgm-^{2} (0.88 gkg^{-1}).This is in contrast to a previous report from the trial of Materechera, et al. [43]. The observed discrepancy in soil organic carbon response could be explained by the dynamics of soil organic carbon in response to surface fire. Often, there is an initial loss of soil organic carbon after fire treatments due to the combustion of the organic matter fraction in the surface mat layer. Thereafter, soil organic carbon recuperation follows with the decomposition of roots of dead or burnt-off plants, which overtime attains a balance with the unburnt plot.

Table-2. Chemical parameters of soil at different level of stubble burning per square meter experimental plots

Soil parameters	Unburned	30 kg m^{-2}	90kg m^{-2}	120 kg m^{-2}	SEM
pH	5.52	5.66	5.55	5.58	0.06
EC(dSm^{-1})	0.06	0.03	0.1	0.06	0.01
Organic Carbon (g kg^{-1})	0.96	1.15	1.16	0.88	0.27
Total Nitrogen (g kg^{-1})	0.04	0.04	0.05	0.04	0.01
AVP (mg kg^{-1})	23.79	17.52	21.48	22.87	1.74
Calcium (cmol kg^{-1})	4.1	3.36	3.36	2.61	0.52
Magnesium (cmol kg^{-1})	1.49	1.49	1.86	1.12	0.45
Sodium (cmol kg^{-1})	0.05	0.04	0.04	0.05	0.00
Potassium (cmol kg^{-1})	0.1	0.09	0.11	0.12	0.00
EA (cmol kg^{-1})	2.18	0.26	0.81	1.7	0.28
ECEC (cmol kg^{-1})	7.94	5.26	6.19	5.16	1.35
B.S (%)	72.8	94.72	85.35	69.34	15.81

EC =Electrical Conductivity, ECEC = Effective Cation Exchange Capacity
AVP =Available Phosphorus; B.S = Base Saturation; EA= Exchange Acidity

Total nitrogen content was found to be significantly reduced as a result of burning. This is the confirmation that he decrease in total nitrogen with increasing burning may be related to the decrease in organic nitrogen contained in organic matter [44] and direct volatilization as reported by Wan, et al. [45]. For available P, andExchangeable bases (Ca, Mg, K and Na),available phosphorus was higher in burnt plots than in the un-burned soil, meanwhile, the values obtained in similar trend was observed with plot receiving 30, 90, and 120 kgm-^{2} level of treatment in which value ranged from 16.33-19.18 mgkg^{-1} with a mean value of 17.52 mgkg^{-1} , 20.66 -22.33 mgkg^1 with a mean value of 21.48 mgkg^{-1} and 20.66-26.49 mgkg^{-1} with a mean value of 22.87 respectively.This observation was ascribed to the supply of phosphorus through frequent ash from the burnt plants. It has been reported that virtually all the phosphorus content of the standing phytomass are added to the soil as ash, since phosphorus is a less mobile soil nutrient [42, 46].

The amounts of exchangeable bases (Ca, Mg, K and Na) in the soil under study varied differently as a result of burning within the level of treatment sizes. Ca content of the soil was seen to have reduced from 4.10 cmolkg^{-1} (un-burnt) to 3.36 cmolkg^{-1} for 30, 90 kgm-^{2} level of stubble burningand 2.61cmolkg^{-1} for120 kgm-^{2} level of stubble burning

There was also a similar trend in the amount of soil Mg content, though plots receiving 90 kgm-^{2} level of stubble burning showed significant (about 24 %) increase. The trend of K, and Na was similar to that of Ca (Table 2). This remarkable loss in exchangeable bases after burning is in agreement with Neff, et al. [47]. But other researchers [37], found the amount of soil Ca and Mg to either be increased or remain unaffected as a result of burning. there was a significant reduction in exchangeable acidity and remarkable increase in ECEC after burning.

This results agreed with the finding of Ketterings and Bigham [48] who reported that heating of soil increases bulk soil specific surface area which increases soil ECEC after burning.

4. CONCLUSION

This huge loss of nutrients associated with burning of topsoils has not only deteriorated soil fertility but also reduced the crop production and led to pollution of the environment and atmosphere. Therefore, the losses of the topsoil by stubble burning have serious disturbance to the society and habitat, and would be detrimental to the functioning of relevant ecosystem, environment and atmosphere. The present investigation insight an increasing awareness about the status of soil degradation and environmental pollution induced by the burning of topsoils through this method of land preparation.

The result revealed that experimental burning had no impact on soil textural class, even though there were changes in particle size distribution after burning. Increase in post burnt soil properties was observed in soil pH, exchangeable bases, exchange acidity, ECEC, porosity, coarse sand fraction, volumetric moisture content and available water capacity. Clay content was also affected by burning. There was reduction in saturated hydraulic conductivity.

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