ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 5 (3): 387-390, 2006
ISSN 1812-5379

Influence of Agricultural Land Use Types on Some Soil Properties in Midwestern Nigeria

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Abstract: Physical and chemical properties of four agricultural land use types (Arable, Gmelina, Oil palm and Citrus plots) on an acid sand Ultisol (Rhodic Paleudult) were assesed in terms of surface (0-15 cm soil depth) sand, silt, clay, soil pH, organic carbon, total nitrogen, available phosphorus, calcium, magnesium, potassium, sodium, organic matter, exchange acidity and effective cation exchange capacity. There were significant differences ($p<0.05$) between the land use types for all the properties except silt, organic carbon, total nitrogen, available phosphorus, potassium, sodium, organic matter and effective cation exchange capacity. All the land use types differ significantly from each other in at least three properties. Oil palm and citrus differed in at least seven properties, arable and citrus in at least six and Gmelina and citrus in at least six. In terms of properties with high variability (CV≥35%), the order was citrus (5)>Oil palm, arable (3)>Gmelina (1).

Key words: Land use, phosphorus, organic carbon, physical properties, chemical properties, ultisol

INTRODUCTION

The importance of land use among global issues is enhanced because of it's impact on world food security and quality of the environment. Land use in a particular location is based on the extent to which the land characteristics match the use the land will be utilized (Verheye, 1986). Soil properties are very important land characteristics particularly when they are to be put into agronomic uses. But in practice the use to which a land is put may not be related to the soil type because decisions on land use will rest on farmer's capability and not the evaluator. Under small scale peasant agricultural land use and soil type are rarely closely associated due to constraints like land tenure system, financial status of farmers, lack of relevant information or ignorance of farmers (Ogunkunle and Eghaghara, 1992). Different land use types often occur on similar soils or same land use type on dissimilar soils.

However the efficiency with which land use systems can be optimized will be based on the soil properties which match the land use requirements. For instance the effect of mechanization on soil structure will differ from that of hand hoe cultivation on the same soil. Also different crops may cause changes in soil properties because of the microenviroments created by different plants. Kowal and Tinker (1959) found no decrease of chemical soil fertilty during 16 years under oil palm (Elaeis guineensis) after secondary forest on a Nigerian Alfisol, except for losses of K and Mg which would have been replaced by fertilizer. In contrast Ollagnier *et al*. (1978) found decreases of total soil C to 60% and of total N to 75% of the levels under adjacent forest in oil palm plantation of up to 14 years age on an Ultisol in the Southern Cote d'Ivoire. Lal *et al*. (1975) measured differences in pH, organic matter, exchangeable Ca and K and P between vegetation types on the same soils. Ogunkunle and Eghaghara (1992) also found differences in pH, K, soil temperature and bulk density in different land use on the same soil type on an Alfisol (Typic Kandiudalf). If such soil contrasts are statistically significant, they may cause problem in land use planning in practical farming and in soil sampling and field layout in soil/crop research. Based on these this study was therefore carried out to asses the extent of different land use on topsoil properties in an Ultisol (Rhodic Paleudult).

MATERIALS AND METHODS

Study area: The study took place in Benin at the Experimental farm of Faculty of Agriculture, University of Benin between Longitude 5 and 6°E and Latitude 6 and 7°N. It is a segment of the coastal plain sand commonly referred to as acid sand of Nigeria. The natural climate is humid tropical. The natural vegetation is rain forest. The rainy season is bimodal with peak in July and September. Average rainfall is between 1500-2500 mm annually. Mean maximum and minimum temperature are 31 and 22°C. The soil has been mapped as Ultisol with Rhodic Paleudult as the modal profile.

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Four land use or crop types occur on the same soil type within a distance of 50-80 m.

Oil Palm (OP): A 15 year old oil palm plantation. It was opened from the original forest by slash and burn using hand cutlasses. The surface is covered with litter of dead palm leaves and bunches.

Gmelina (GM): A 15 year old plantation opened from the forest by hand cutlasses. The soil surface is covered with a thick layer of dead leaves.

Citrus orchard (OC): A 11 year old orchard opened from original forest by hand cutlasses. The soil surface is covered with grasses and leave litter.

Arable (SP): A five-year old cassava plot with some maize and cowpea. It was opened from the original forest by slash and burn using hand cutlasses. Weeding is by hand and dead weeds and stover from previous cassava and maize were left on the soil surface.

Soil sampling: An area of 50×50 m was selected in each land use and 25 plots (10×10 m) were demarcated for sampling surface (0-15 cm soil depth). Samples were taken at 10 randomly located points within each plot to form a composite sample for laboratory analysis. A total of 100 composite samples were collected (i.e., 25 per land use).

Laboratory analysis: Soil pH was determined by using the glass electrode method at soil : solution ratio of 1:1 and in 1N KCL solution at a ratio of 1:2. Particle size analysis was carried out by the Bouyoucus (1951) hydrometer procedure after the destruction of organic matter with concentrated hydrogen peroxide. Organic carbon was determined by wet oxidation procedure of Walkley and Black (1934). Total Nitrogen was extracted by the kjeldahl procedure as described in Black (1965), Available phosphorus was extracted by using Bray P-1 extractant and the available P was determined by the vanadomolybdate method of Murphy and Riley (1972). Exchangeable bases (Ca, Mg, K and N) were extracted with 1N neutral NH_4OAc. Na and K in the extract were determined by flame photometer while the Ca and Mg were determined by atomic absorption spectophotometer. Exchange acidity was extracted with 1N KCL solution and titrated with 0.1N NaOH solution (Jackson, 1958). Effective cation exchange capacity was obtained by summation of Ca, Mg, K and Na.

Statistical analysis: Data generated was analysed by the SAS package.

RESULTS AND DISCUSSION

From Table 1 the citrus (OC) plot is more fertile than any of the others. It contains more exchangeable bases and extractable P. There was more organic matter in the Gmelina (GM) than any other plots. This may have been due to the accumulation of organic matter over the years on top of the soil which corroborates with similar work done by Ogunkunle and Eghaghara (1992). But in their own case it was for secondary forest. Table 2 shows the result of LSD tests. The test are summarised in Table 3. The oil palm plot differs from the citrus plot in seven properties. The Gmelina plot differs from the citrus plot in six properties, from the arable plot in four properties and from the citrus plot in three properties. The least different pairs in at least three soil properties. Citrus is different from all the other plots in sand, pH, Ca, Mg and Exchange

Table 1: Mean values of soil properties under different land use types (±SEM)

		Land use types			
Soil properties	Unit	GM	OC	OP	SP
Sand	g kg^{-1}	817.5±0.8	775±0.88	810±0.85	812.5±0.82
Silt	g kg^{-1}	25±1.13	37.5±1.53	47.5±1.23	35.0±1.14
Clay	g kg^{-1}	1575±1.44	187.5±1.24	142.5±1.43	152.5±1.40
PH H_2O (1:1)		5.26±0.16	5.91±0.11	5.14±0.13	7.17±0.15
PH KCL (1:2)		4.36±0.17	5.18±0.15	4.21±0.17	5.98±0.13
Org. carbon	g kg^{-1}	13.1±0.18	11.4±0.16	10.1±0.19	8.5±0.13
Total N	g kg^{-1}	1.8±0.01	0.7±0.01	0.5±0.01	0.43±0.01
Avail. P	mg kg^{-1}	6.76±0.13	6.77±1.13	5.9±0.19	4.34±1.03
Ca	cmol kg^{-1}	2.35±0.19	2.78±0.15	2.18±0.20	2.13±0.18
Mg	cmol kg^{-1}	0.55±0.08	0.90±0.10	0.40±0.05	1.30±0.12
K	cmol kg^{-1}	0.11±0.04	0.20±0.02	0.12±0.06	0.11±0.03
Na	cmol kg^{-1}	0.06±0.01	0.07±0.01	0.06±0.01	0.06±0.01
OM	g kg^{-1}	22.6±0.31	19.7±0.43	17.3±0.31	14.5±0.51
Exch. acidity	cmol kg^{-1}	0.04±0.08	0.0.3±0.07	0.02±0.06	0.02±0.08
ECEC	cmol kg^{-1}	3.07±0.19	3.95±0.29	2.76±0.26	3.6±0.20

GM = Gmelina plot, OC = Citrus plot, OP = Oil palm plot, SP = Arable plot

Table 2: Significant differences ($p<0.05$) in soil properties between land use types

Soil properties	GM	SP	OP	OC
	Significant differences between land uses			
Sand	a	a	a	b
Silt	a	a	a	a
Clay	ba	ba	b	a
pH H_2O (1:1)	c	a	c	b
pH KCL (1:2)	c	a	c	b
Org. carbon	a	a	a	a
Total N	a	a	a	a
Avail. P	a	a	a	a
Ca	b	a	c	ba
Mg	c	a	c	b
K	a	a	a	a
Na	a	a	a	a
OM	a	a	a	a
Exch. acidity	a	c	a	b
ECEC	a	a	b	a

GM = Gmelina plot, OC = Citrus plot, OP = Oil palm plot, SP = Arable plot

Table 3: Summary of LSD tests: number and properties significantly different between land use pairs

Land use pairs	No of properties	Soil properties
GM-SP	4	pH, Ca, Mg, EA
GM-OP	3	Clay, Ca, ECEC
GM-OC	6	Sand, Clay, pH, Ca,Mg, EA
SP-OP	6	Clay,pH, Ca, Mg, EA, ECEC
SP-OC	6	Sand, Clay,pH, Ca, Mg, EA
OP-OC	7	Sand, Clay,pH, Ca, Mg, EA, ECEC

GM = Gmelina plot, OC = Citrus plot, OP = Oil palm plot, SP = Arable plot

Table 4: Variability of soil properties within land use types

	CV Group+ in land use type			
Soil properties	GM	OC	OP	SP
Sand	I	I	I	I
Silt	III(69.28%*)	III(59.12%*)	III(55.36%*)	III(68.01%*)
Clay	I	I	II	II
pH H_2O (1:1)	I	I	I	I
pH KCL (1:2)	I	I	I	I
Org.carbon	I	III	II	II
Total N	II	I	I	I
Avail. P	I	I	I	I
Ca	II	I	III	I
Mg	II	II	I	I
K	I	III	I	III
Na	II	III	III	III
OM	I	III	II	II
Exch. acidity	II	II	II	I
ECEC	I	II	I	I

GM = Gmelina plot, OC = Citrus plot, OP = Oil palm plot, SP = Arable plot, + I = CV<15%; II = CV 15-35%; III CV>35%, * Percentage indicates highest CV for the specific land use

Acidity (EA). However the changes in soil properties resulting from different land use or plant species are large, though it is difficult to explain some of these results. In there own work, Ogunkunle and Eghaghara (1992) concluded that for future use some of the land use types need to be merged. In doing this they can be grouped rationally according to the number of significantly different properties. From Table 3 the plots that after combining will give us least problem are Gmelina and oil palm. But at the other extreme it is oil palm and citrus which have seven properties significantly different. Merging this two pair of land use will not be advisable because of high degree of soil variability.

From the result, it is very clear that soils are variable in properties and any attempt to assume uniformity because of same soil type carrying different crop or crop combinations may not be wise. When the soil properties are grouped by coefficient of variation (CV%) as shown in Table 4, the Gmelina plot is more homogenous than the others which also corroborates with the findings of Ogunkunle and Eghaghara (1992). Only one soil property (silt) was very variable (group III) in the Gmelina plot but 3-5 properties were very variable in other plots. This suggests that the Gmelina plot improves soil fertility. This may be very useful for the practice of agroforestry thereby helping to combat land degradation problems, produce a good economic return from timber sales at the same time (Anonymous, 1993).

CONCLUSIONS

It is very clear for experiment that changes in relevant soil properties do result from different land uses. This will need to be put into consideration when two plots under different uses are to be combined for a new use in sampling for soil testing or in allocating plots for field experiments. From this study areas under some land use type (e.g., Gmelina and oil palm) can be merged more safely than others (e.g., oil palm and citrus). This also has implication for land use planning, crop production and experimental agriculture.

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