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Evaluation of Productivity Potentials of Soils of the Gubi Soil Series

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Abstract: Six soils subgroups; two each from Alfisols, Inceptisols and Entisols in the Gubi soil series of Bauchi State were evaluated for their productivity potential using soil site characteristics and physicochemical properties. Ratings and grades for these soil characteristics were allotted and their means used for comparison. The result of the land evaluation grading was observed to ranged from A to E i.e., Extremely high productivity potential (Oxyaquic Ustifluvent, profile 02T2/02T3) to moderately low productivity potential (Typic Ustropept and Ustic Dystropept). The grading is highly correlated with the soil subgroups and is recommended for assessing productivity potential of soils under defined climate and management practice.

Key words: Productivity, potential, gubi soil series

INTRODUCTION

Land evaluation is the process of estimating the potentials of land for alternative kind of use. These, according to Dent and Young (1981) include productive uses, such as arable farming, livestock production and forestry, together with uses that provide services or other benefits, such as water catchment's areas, recreation, tourism and wildlife conservation. Gaikawad *et al.* (1995) also pointed out that evaluation of productivity is a multidisciplinary approach involving various methods, systems and factors. According to them, the yield or output per unit area of land is the best approach but it is time consuming and not really feasible to conduct an experiment at each site.

The fundamental purpose of land evaluation is to predict the consequence of change. The ever-increasing human population of the world, especially in the developing countries has called for attention to thee proper inventory and use of soils. This study evaluates the productivity potentials of soils based on selected soil-sites characteristics and physical and chemical characteristic of the different soil units of the Gubi soil series in Bauchi state, Nigeria.

MATERIALS AND METHODS

Experimental site: Gubi is located about 12 km north west of Bauchi town and bounded by 9°40'E and 10°00'E and 10°20'N and 10°30'N. The geology of the area is mainly undifferentiated basement complex. The area receives a mean annual rainfall of about 1094 mm and is markedly seasonal. The rains starts in April to September while the dry season last from October to March. Daily average maximum and minimum temperatures are between 28.4-34.9 and 19.6-22.8°C, respectively. The area lies within the northern ecological zones of Nigeria. It has a vegetation mosaic of savanna woodland and shrub savanna with cultivated parkland around some small settlements along the floodplains (FUTB, 1982). The original vegetation has in part been destroyed through farming activities, grazing and bush burning. The dominant tree species include *Combretum* sp., *Parkia clapertoniana*, *Anogeissus leocarpus* and *Butyrospermum parkii*. Most of the cultivated portions of the land have been under fallow for over 10 years. The main crops grown include sorghum, millet, maize, rice, groundnuts and grazing activities. A detailed soil survey of the area was conducted using standard procedures as described by Soil Survey Manual (Soil Survey Staff, 1999). Soil samples from genetic horizons of the profil pits were then taken to the laboratory and analysed. Soil classification was done using criteria of both the USDA Soil Taxanomy (Soil Survey Staff, 1994) and the FAO/UNESCO, (1990).

Laboratory analysis: Particle size distribution was determined using Bouyoucos hydrometer method as described by Day (1965). Soil chemical properties were analysed using the procedures outlined by Agbenin (1995). These properties include soil pH, exchangeable bases, organic carbon, total nitrogen, available phosphorus, cation exchange capacity, exchangeable acidity and cation exchange capacity-clay.

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Table 1: Soil site characteristic and assigned ratings

Ratings	Soil depth	Horizon development	Slope	Drainage	Land-use	Texture	Structure	Erosion hazard
5	V. deep	Well dev.	0-2	Well drained	Intensive cultivation	SL, L	Well dev.	Little or none
4	Deep	Developed	2-4	Mod. well drain ed	Extensive cultivation/Fallow	SCL, CL,SiL	Mod. well dev.	Sheet
3	Mod. deep	Mod. dev	4-6	Poorly drained	Rice crop	SiCL, LS, CL	Mod. dev.	Rill
2	Shallow	Poorly dev.	6-8	V. poorly drained	Grazing	SiC, SC	Weakly dev.	Flood plain
1	V. shallow	Not dev.	>8	Excessively drained	Hills	S, C	Structureless	Gully

Productivity evaluation: For the evaluation of productivity potential, the procedure described by Gaikawad *et al.* (1995) was used with modification. The procedure assumes climate, management and other inputs/yield contributing factors as not variable. Soil site characteristics are allotted ratings as presented in Table 1. The values for soil site characteristics, physicochemical and chemical characteristics were calculated using the following procedure:

Step 1: The rating for soil site characteristics are allotted on a numerical basis and their mean values calculated.

Step 2: For physicochemical and chemical characteristics, calculated values per cm of individual determinations in each horizon and the sum made of the values in all horizons in profile are used for further calculation.

The mean values per cm were the computed by dividing it by the number of horizons in a profile and were multiplied by the thickness of the profile. The procedure is used for all the determinations in the profile.

$$\text{Individual determination value per cm in individual horizon} = \frac{\text{Total values of individual determination in horizon}}{\text{Thickness of horizon (cm)}}$$

$$\text{Individual determination value per cm in profile} = \frac{\text{Sum of value of individual determination per cm in horizon in profile}}{\text{Number of horizons in a profile}}$$

$$\text{Total of individual determination's value per cm in a profile} = \text{Individual determination value per cm in a profile} \times \text{thickness of profile (cm)}$$

$$\text{Mean value of all the determinations in a profile} = \frac{\text{Sum of value of individual determinations in a profile}}{\text{Number of individual determinations used in the profile}}$$

RESULTS AND DISCUSSION

Soil classification. The soils were classified to the subgroup level as shown in Table 2.

Soil site characteristics: The allotted ratings for soil site characteristics and their means are presented in Table 3.

Physicochemical and chemical properties: The potential ratings of the soils for physicochemical and chemical properties are presented in Table 4. Table 5 shows the ratings for productivity potentials for commonly cultivable crops while Table 6 shows the grading of productivity potentials of the different soils. The predicted productivity potential and grade of the soils is in the descending order of Oxyaquic Ustifluvvent (02T2/02T3) > Typic Haplustalf (01T4) > Typic Haplustalf (01T3) > Oxyaquic Ustorthent (00T1) > Typic Ustropept (02T1/03T1) = Ustic Dystropept (00T2/01T2) under a defined set of climatic conditions and management.

From Table 6, it is clear that the Oxyaquic Ustifluvent had the highest productivity potential with A followed by profile 01T4 (Typic Haplustalf) with grade B. The Oxyaqui grade is not surprising because it is a flood plain, which as expected receives materials from other soils, which have been washed away by water. The Alfisols (Typic Haplustalf, profiles 01T4 and 01T3) followed very closely with grades B and C, respectively although their total rating values are similar. This again is expected since they are mature soils, they ought to be more productive than either the Inceptisols or the Entisols. The profile 00T1 which is an Oxyaquic Ustorthent had grade D. Although this soil is also an Entisol like profile 02T2/02T3, it is not on a flood plain, its genesis seen to be attributable to the presence of high sand content which is resistant to weathering or may be affected by erosion as described by Fanning and Fanning (1989). The Inceptisols i.e. Profiles 02T1/03T1, Typic Ustropept and 00T2/01T2, Ustic

Table 2: Summary of soil classification

Pedon	Classification
01T4	Typic Haplustalf
01T3	Typic Haplustalf
02T1/03T1	Typic Ustropept
00T2/01T2	Ustic Dystropept
00T1	Oxyaquic Ustorthent
02T2/02T3	Oxyaquic Ustifluvent

Table 3: Ratings allotted for soil site characteristics of the different soils

Pedon	Soil depth	Horizon development	Slope	Drainage	Land-use	Texture	Structure	Erosion hazard	Mean
01T4	4	4	5	5	4	4	1	4	3.88
01T3	4	4	4	4	4	4	1	4	3.13
01T1/03T1	4	3	5	5	4	5	2	5	4.13
00T2/01T2	3	3	5	5	4	5	2	4	3.88
00T1	4	2	5	4	4	5	1	4	3.63
02T2/02T3	4	2	4	3	3	4	1	2	2.88

Table 4: Physicochemical and chemical properties ratings of the soils

Pedon	Soil classification	Rating
01T4	Typic Haplustalf	82.56
01T3	Typic Haplustalf	76.62
02T1/03T1	Typic Ustropept	53.62
00T2/01T2	Ustic Dystropept	48.17
00T1	Oxyaquic Ustorthent	61.13
02T2/02T3	Oxyaquic Ustifluvent.	112.05

Table 5: Proposed ratings for productivity potentials for commonly cultivable crops

Rating	Grade	Rating value	Limitation for cultivable crops
Extremely high productivity potential	A	>90	No limitation
Very high productivity potential	B	80-90	Very few limitations
High productivity potential	C	70-80	Few limitations
Medium productivity potential	D	60-70	Moderate limitations
Moderately low productivity potential	E	50-60	High limitations
Low productivity potential	F	40-50	Very high limitations
Very low productivity potential	G	<40	Temporarily/permanently not suitable.

Table 6: Grading of productivity potentials of the different soils

Pedon	Soil Classification	Soil site characteristics	Physicochemical and chemical properties	Total value	Grade
01T4	Typic Haplustalf	3.88	82.56	86.44	B
01T3	Typic Haplustalf	3.13	76.62	79.75	C
02T1/03T1	Typic Ustropept	4.13	53.62	57.75	E
00T2/01T2	Ustic Dystropept	3.88	48.17	52.05	E
00T1	Oxyaquic Ustorthent	3.63	61.13	64.76	D
02T2/02T3	Oxyaquic Ustifluvent	2.88	112.05	114.93	A

Dystropept had the lowest grade, E. Again the result is not surprising and is logical given the fact that these are young soils which are still undergoing active pedogenesis. The higher grade, A of the Entisols is attributable to the amount of materials received as alluvium and the higher degree of base saturation of the Entisols.

The values obtained in this study are correlated with the soil subgroups and this agrees with the findings of Gaikawad *et al.* (1995). According to them, the ratings allotted for soil-site characteristics and physicochemical and chemical properties, although theoretical, hold true for evaluating the productivity potential of soils.

From this study it is concluded that under a defined set of climate and management, the productivity of the soils studied will be in the observed order.

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