Indigenous System of Soil Fertility Management in a Typical Farm Settlement in Osun State, Southwestern Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author KFA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OOIO and BOA managed the analyses of the study. Author FYA managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Lives on earth depends on soil for survival and functioning as soil provides the basis for livelihood, however, this essential resource has been totally degraded and depleted due to human mismanagement and thus hampering its productivity potential. Therefore, this study focused on the knowledge of the peasant farmer's indigenous system of soil fertility management with a view to documenting and comparing the indigenous and scientific knowledge adopted by farmer in assessing soil nutrient availability status in Ago-Owu farm settlement. The physico-chemical analysis of the soil samples for soil characterization and land dynamics are in agreement with the indigenous knowledge in operation in the study area. The study concluded that it is essential to integrate the traditional knowledge base as a complimentary component to the modern methods for effective management of soil fertility as an essential resource.

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1. INTRODUCTION

Studies have shown that soil is an important resource, which requires proper management that provides fundamental ecosystem services of food production by ensuring the environment has the basic nutrients for plant growth, needed for the existence of life [11]. Ultimately, every life depends on soil for survival and proper functioning. However, this important component of life has been severely degraded year-in year-out with damning statistics of loss due to human mismanagement. According to Senjobi and Ogunkunle [2] accelerated land degradation processes and by extension fertility loss have been attributed not only to rapid human population growth, but also to unabated land uses to cater for the expanding demography. Such that in the last five decade, about 20% of the world's agricultural fertile lands was recorded to have been lost, thus, if the process of destruction continues at this rate, agriculture could lose 15 to 30% of its productivity (Food and Agricultural Organization [3]. Sanchez et al. [4] reported that the loss of fertile agriculture soil was known to be responsible for the decline of per-capital food production, hunger and malnutrition in Sub-Saharan Africa. In order to employ appropriate management techniques, Paradzayi and Ruther [5] opined that the extent of the soil current and future capacity to sustain plant growth must be assessed and understood. This was corroborated by a study carried out by Sanchez et al. [6,7] that soil fertility management is key to the sustainability of continuous, semi-permanent farming systems that allow cropping intensification.

It has been established that resource management is an area which requires intimate knowledge of local conditions and of ecosystems, as well as experience and expertise. This was supported by Egger and Majeres, [8] submission that resource management plan is a domain of holistic knowledge, putting together various technical fields, where traditional knowledge can be as relevant as modern specialized knowledge. It can be inferred that this acknowledges the importance of indigenous knowledge in resource management.

Therefore, the knowledge and experiences of the people working and living with soil for generations can be tapped as one of the bases for designing conservation measures. Cools et al. [9], referred to this as an indigenous knowledge which was developed by people in a given community or environment over time, that is, knowledge built by community of people from generations to generation by their living in close contact with nature. According to Orimoloye, et al. [10] this include a system of classification, a set of empirical observations about the local environment, and a set of homemade-management that govern resource-use. Agenda 21 of the United Nation Sustainable Development (UNSD) [11] stated that in order to design sustainable land management strategies, the analysis of the rational decision-making processes of the resource users that result in environmental degradation should be based not only on scientific results but also on people's assessment of the problem. Ajibade [12] opined that a more effective policy for soil and water conservation can be elaborated if land user's perception of the problem is taken into consideration. Intergovernmental Panel on Climate Change (IPCC) [13] gave a widely recognition of indigenous knowledge systems in soil characterization, fertility assessment and land use decision making and management practices have been widely recognized.

Despite the fact that the indigenous knowledge has been receiving greater attention for the past few decades, it should be noted that farmer's knowledge on soil and land degradation has not yet been synthesized as a component in addressing sustainable land management and environmental initiatives. Therefore, the pathway to environmental sustainability now is the detailed understanding of the various methods by which local farmers evaluate their land and possibility of documenting and integrating them into the body of existing knowledge base in order to increase the utilization of this knowledge and create a pathway for healthy environment. This is the thrust of this research effort.

2. MATERIALS AND METHODOLOGY

2.1 Study Area

The study was conducted in Ago-Owu farm settlement established in the early 1960's by the then Western government of Nigeria, now in Ayedaade Local Government Area of Osun State, Nigeria. The area is located between latitude 7°15'N and 7°30'N and between

longitude 4°07'E and 4°27'E. The location has been identified as one of the major food baskets of Osun State and cash crops production hubs for Nigerian national economy, covering an area of about 76 square Kilometers. The place is carved out of the forest reserve in the southern part of Osun State. It is the largest farm settlement in the state with over 10,000 settlers. The entire area is rural while an overwhelming 95% of the populations are farmers. The area represent rain fed agricultural system agro-ecological zone and is being inhabited by 'Yoruba' tribes. The area experiences a tropical climate with the mean annual rainfall of about 1300 mm reaching its peak between April and late September. The mean annual temperature is about 28°C, solar radiation averaged 382 gcm^{-2} and total evaporation averaged 92 mm [14]. The relative humidity coincides with months with low rainfall – December to March [15,16,17]. The area is subject to marked wet and dry season typical of Southwestern Nigeria. The wet season has double rainfall maxima. The primary rainfall maximum is usually in the month of July while the secondary maximum, occurs in September. The period of rainy season varies between seven and nine months. The vegetation type in this area is a secondary forest. The vegetation has been greatly impacted by increase in human population and activities. The study area was part of the ancient 'Orile-Owu' forest kingdom with varieties of plant species. The predominant plants that exist in this locality comprise of tree species such as oil palm (*Elaeis guineensis*), iroko (*Milicia excela*), mahogany (*Entadrophragma cylindricum*), arere (*Triplocyton scleroxylon*) and teak (*Tectona grandis*). The area is well drained by rivers and streams including the Obalufon, Omu, Ope, Oranran, Osun and Shasha rivers. The availability of these rivers and streams has some positive impact on local agriculture and other livelihood including palm oil production [17]. The soil is fertile thereby allowing the cultivation of various cash and subsistence crops. The availability of the essential natural resource at the site made it a suitable place for the ancient population to settle.

2.2 Data Collection and Analysis

Data collection involved field survey and personal interviews using some standardized questionnaires followed by focus group discussions which were conducted across the whole farm settlement. The study adopted Gosai, et al. [18] research methodological flow chart which combined indigenous knowledge with scientific knowledge for the same purpose in the humid tropics of Arunachal Pradesh. Ten percent (10%) of the total number of farmers in the farm settlement were sampled for questionnaire administration, using systematic random sampling approach (one out of 10). By which 100 long stayed farmers between 35-65 years of age were purposely selected for questionnaire administration, while 320 farmers were met during focus group discussion [14]. Questions focusing on indigenous knowledge about soil fertility, soil conservation, soil management as well as traditional ecological knowledge of the Ago-Owu farm settlement among others were asked. This was complimented with the conduct of interview where the respondents are unable to answer the questionnaire questions by themselves. From each of the sampled farmer's farm holdings, sampling plot of 10 m by 10 m size were marked out from the middle of each farm land. Soil samples (4 replicates) were obtained from 0-30cm soil depths with a soil auger. During the collection, local name of each of the soil type as given by the farmers and characteristics were noted based on the traditional ecological knowledge of the area. The soil samples were brought to the laboratory, sieved through 2 mm mesh screen, and used for the analysis of soil physico-chemical properties. Soil texture was analyzed by Bouyoucos soil hydrometer method [19], water holding capacity by keen's box method, and organic carbon content by rapid titration method [20]. Soil pH was determined in both distilled water and 10 m KCl (1:1 soil solution ratio) using glass electrode, pH meter (kent model 720) after equilibration for 30 minutes [21]. Soil moisture was determined gravimetrically [22] and Total Nitrogen by macro Kjeldah method digestion method [23,24].

3. RESULTS AND DISCUSSION

3.1 Indigenous Soil Classification Scheme

It is evident from physical observation and the interactive section held with the farmers in the study area, that they relied solely on indigenous knowledge of soil classification to name and classify the soil status, which was carried out by using both soil physical characteristics and their sense of perceptions developed over the year. The physical classification involved the identification of the most observable characteristics of the soil, such as the texture (degree of coarseness), soil colour, soil yield (fertility status as regard soil age and usage) as
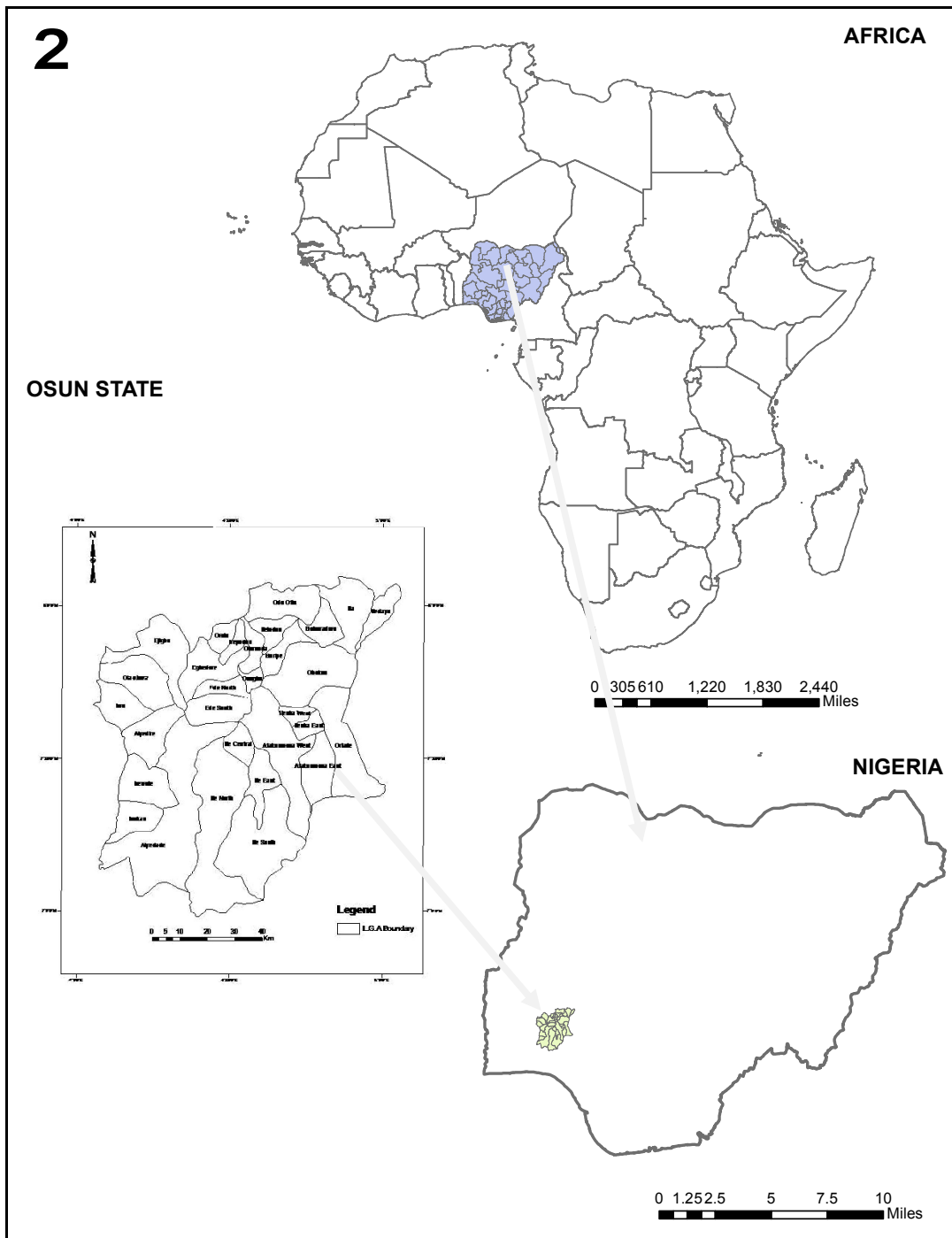
Fig. 1. Africa showing Nigeria showing Osun State and the study area

well as the soil topographic condition. The interactive section carried out by using the focus group discussion revealed that the farmers identified soil typed by rubbing a lump of soil between fingers to feel the proportion of sand, silt and clay in order to determine the soil texture.

Soil colour was determined by visual inspection and this depends on farmers' knowledge of different colours. Cutlass was used for soil depth determination, such that when it goes in easily and takes much part of the cutlass, they see such soil as being deep because they are

interested in top, that is, soil which ranged between 0-30 cm deep.

Farmers used visual inspection for water retention capacity and this is usually done and determined during the raining season. It was further submitted that when cultivating the land and the soil is composed of small pebbles contents that means the soil is stony. The farmer also revealed that Soil reaction or pH, is being determined when plants leaves turn yellow and this always have negative impacts on plant yield, which is an indicator of soil fertility (low fertility status). Above all, the farmers rest on observing the annual yield to confirm the soil fertility, which takes time. Further, farmers identified five parcels of land under different land uses according to their traditional knowledge of soil fertility. These are soil under virgin forest which was classified as fertile land, followed by soil under cocoa, palm, maize and cassava. In accordance with the observation, farmers selected these soils with reference to level of fertility and crops found on these soils which serve as pointer for soil samples collected and named. Principal Component Analysis (PCA) was used for validation of soil grouping by farmers, which help to discern the regularity order within the soil phenomena. The study gave credence to previous studies, where traditional soil classification and procedures have been studied and documented both in Nigeria and other parts of the world [12] Gray and Morant [25], Gosai et al. [18] and UNFCCC [27].

Based on the farmers understanding, the soil in the study area was classified into six main categories in accordance with the adopted perceptive characteristics of the soil used for the local nomenclature. This is evident in Table 1, thus, Y*anrin, Ile-Olora, Ilepa, Werekuta, Ile Akuro* and *Asale. Yanrin* (sandy soil). The soils are classified using soil attribute such as soil texture - degree of coarseness of the soil grains (*Yanrin* - sandy; *Ile amo* - Layey soil); based on colour (*Iledu*- black soil; *Ilepa* - Red Soil). Farmers also adopted features as stickiness for *Ile Amo* (Clayey soil); moisture contents for *Akuro* (Alluvial soil); fertility staus for *Asale* (Infertile soil) and undisturbed land for *Ile Tuntun* (Forest soil/Virgin land). *Yanrin* are permeable soils with low water holding capacity characterized by their sandy surface texture; can be dark, light brown or white in colour, contain small particles less than 2mm diameter). In terms of fertility indicator, it was described as low yield and poor growth.

In accordance with the study observation and interactive section, Iledu are less permeable soils having high water retentive capacity, composed of particles that is finer than those of *Yanrin*. They could be black or dark brown in colour, a characteristic which they acquire from the humus content is organic matter. In terms of fertility indicator, the farmers identified this soil to be less erodible; give forth more yield coupled with vigorous growth and dark in colour. It is easy to work. *Ile pupa* is otherwise called *Ilepa, Ileamo (clayey soil)*. They are usually light brown or red as the name implies. The proportion of clay is greatly higher in this type of soil. They have the highest capacity for retaining water. In terms of fertility indicator, the farmers identified this type of soil to be of low yield coupled with poor growth. It is difficult to work during the raining season or when wet and contains less stone. *Ile Akuro, Ile-Odo, and Ile Abata;* a land or soil in water logging environment. Farmers used location rather than physico-chemical properties. It intensively cultivated during the dry season some vegetables only in small pocket that the farmers used it for rice cultivation and sugar cane during the raining season. Another classification identified by farmers is called *Asale* which represents infertility status of the soil, that is, the nutrient as being totally depleted. *Asale* can be any of the soil types identified whose fertility has been exhausted due to over-use. In terms of fertility indicators, it becomes difficult to work, poor and stony. Another classification identify was *Ile titun* (virgin land), that is, a land that has not been disturbed. In terms of fertility indicator, erodibility rate is little or not in existence; it gives more yield and support vigorous growth. It is the best of all soil described by the farmers. It can be inferred that the local people have significant knowledge of their environment and soils, which has been acquired through age-long experiences over many generations as a result of living very close to the environment which is crucial for success or failure of any type of agriculturally-based development. This submission was corroborated by previous scholars such as Winkler Prins, [28] and Winkler Prins and Sandor [29]. Also the studies by Orimoloye, Akinbola, and Abubakar [10] and Abera and Belachew [26,30] gave credence to this submission that indigenous knowledge of; visual appraisal, plants indicator, vegetation vigour, cropping history, and soil type determined land suitability and perceived effects of soil on rubber yield in three farm settlements of Southern Nigeria. The main management techniques identified by farmers during the study include such system as shifting

cultivation, fallowing, crop rotation and intercropping. It is evident during the study that farmers embarked on shifting cultivation after a particular land has been cultivated for three to four years; and allowed it to regained the nutrient loss by abandoned it for at most five years before coming back to it for cultivation.

3.2 Soil Local Nomenclature, Characterization, Distribution and Crop Preference

From the survey mapping, it was discovered that farmers in the study area classified and name soil in their locality using different criteria which are observable to them, as it is evident in Table 1. The results of the interviewed revealed that soil colour (*Awo ile*), the degree of the soil stoniness (*okuta wewe ile*), soil water retention/ holding capacity (*dida omi duro ile*), soil fertility status (*ora iyepe*) soil sloppiness (*idagun ile*) and level of acidity (*bile tikansi*) are the main factors taking into consideration in soil classification in the study area. Majority of the respondents (87% - 98%) identified that colour, stoniness, water content and fertility status are the main indicators for soil characterization while the remaining respondents (18% and 20%) was of the opinion that acidity and slope, that is land configuration are very important for local soil classification and characterization in their locality.

The identifiable names of soils and the six criteria used are indicated in Fig. 2. It is evident from the Figure, that in using colour two main soil are identified (*iledu* – black soil *and ilepa* – red soil); in using components such as stone and size of stone (equivalent of texture), a soil is classified as *werekuta* (stony soil); in using water or moisture content and its retentive capacity, a soil is classified as *akuro or abata* (waterlogged or wetlands); in using fertility status, soil in the soil area was classified as *ile olora* or *ile titun* (fertile soil or virgin soil).

It is evident from the study that the farmers in Ago-Owu may not be absolute in their knowledge base as regard soil nutrients status and texture with regards to their perceptive ability; however they are near perfect in their soil classification when juxtaposed with the laboratory analysis presentation. This gave credence to the study carried out by Gosai et al. [18] in the humid tropics of Arunachal Pradesh. For instances, *Iledu / Ile Olora* had greater Organic Carbon and Nitrogen Contents, whereas *Yanrin* the soils registered low Organic Carbon and very poor water holding capacity (Table 1), thus being the major contributing factor to poor crop yield. The correlation between laboratory estimated outputs and indigenous knowledge as observed from the forgoing has been recorded by other scholars elsewhere [31,32,10]. The nexus between the indigenous knowledge and science will go a long way in impacting the local knowledge base positively thereby enhancing the understanding, assessment and utility among the wider society [33,34]. Base on the findings of this study the farmers used indigenous knowledge acquired over the ages to classify the soil found in their locality and characterized them into established nomenclature. The soils were further categorized on the areal coverage and extent viz-a-viz their crop preference and yield. The indigenous knowledge of soil location, colours, particle size, year of cultivation and yield were all combined to arrive at the name given to each of the soil in the study area. For instance, *Ile Olora* was classified based on its, fertility status by the outcome of its yield, the organic matter contents, the dark colour, clay and silt contents, indicating adequate water retention capacity. This was corroborated by a study carried out by Orimoloye et al. [10].

3.3 Physico-chemical Analysis of Soil Parameters by Location

The results of the laboratory analysis of the soil properties taken from the selected farmers farm in the study area were to a large extent correlated with the local soil fertility obtained using the indigenous knowledge system proposed by the farmers. The soil texture as derived from the textural triangle (Fig. 2) revealed that soil identified as black soil is loam, infertile soil is sand, alluvial soil is sandy clayey loam and forest soil is sandy loam. Table 2, also clearly indicates that the soil physico-chemical properties are significantly different among the various levels of fertility as identified by the farmers in the study area. It is obvious from the results that farmers' perception/indigenous method of land evaluating of soil fertility correspond significantly with modern method of land evaluation as most of the soil properties under black soil, valley, alluvial and infertile characterizations are significantly lower than those under forest. It can thus, be inferred that there should be a synergy between the scientific researcher for more holistic approach to agricultural research activities involving traditional ecological knowledge systems,

particularly on soil and nutrient management for sustainable yield. Corbeels, et al. [35] reported that for the development of appropriate research and programs aimed at improving integrated nutrient management practices, the researchers need to understand farmers' indigenous knowledge and perceptions of soil fertility status. Studies such as the one by Winkler Prins and Sandore [29] and Saito et al. [36] give credence to this by callings for the incorporation of the indigenous knowledge of farmers, acquired over the ages from generations of experience and experimentation, by adaption to their agricultural systems using limited resources under harsh and insecure conditions over the years into the scientific methods of soil fertility knowledge.

3.4 Indigenous Farmers Understanding of Soil Problems and Their Management

The indigenous soil management techniques identified in the study area are associated with farmers' activities on the farm and soil problems mitigations as indicated in Table 3. Soil erosion was identified to be caused by excessive rainfall and by human activities of over cultivation which weakens the soil structure. It resulted in washes away of the top soil especially during the rainy season and consequently leads to loss of topsoil and loss of fertility and crop yields. Farmers are able to identify a whole range of signs of soil erosion and land degradation in the study area and indicated what measures are put in place to actively arrest and mitigate this menace. The

problem of soil infertility was also identified as another serious problem that followed soil erosion. The farmers advocated that this was caused by longtime intensive use of land and has negatively impacted on crop yield. The third problem was that of pests and diseases which also caused reduction of crop yield. Farmers in the study area has responded to these problems through mixed cropping, shifting cultivation, fallowing, application of animal dung and poultry dropping coupled with green manures; application of inorganic fertilizers; and planting of cover crops as solutions to soil erosion and infertility while scare-crows are used to scare animals and pest when erected in strategic positions on their farmland. It is evident from the study that more than half (65%) of the farmers identified mixed cropping and fallowing as one of the frequently used indigenous methods of mitigating soil degradation and maintain soil fertility. According to the farmers in the study area, these methods create favourable condition for soil, soil moisture and nutrients, and provide excellent and healthy environmental sustainability.

In essence, Ago-Owu farmer's indigenous methods were observed to possess skills in the identification of soil nomenclature, soil colour and soil texture determination. Although, the farmer's indigenous evaluation methods have produced some similarities to scientific methods, this was not without its limitations as the farmers were imprecise, inconsistent and lacked confidence as they could not quantify their techniques. It is
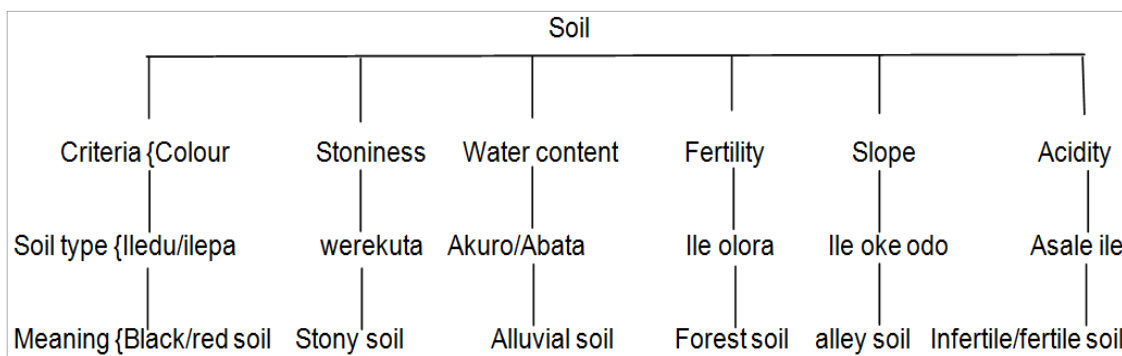

Fig. 2. Nomenclature and characterization adopted by the local farmers of Ago-Owu

Table 1. Indigenous criteria for soil classification by the local farmers of Ago-Owu

Criteria	Colour	Stoniness	Water content	Fertility	Slope	Acidic
Percentage	96	90	87	98	20	18

Table 2. Values of selected physico-chemical parameters from different soil types by location

Location	pH	OC	TN	AP	EA	Ca	K	Mg	Na	Mn	Fe	Cu	Zn
						Topsoil							
Black	6.9	26.7	2.5	6.5	0.2	11.2	0.2	1.0	0.5	163.8	106.9	1.0	1.0
Valley	6.8	19.8	2.0	15.6	0.7	7.5	0.5	0.4	2.5	172.8	62.6	2.6	1.2
Alluvial	6.4	18.9	1.8	20.9	0.4	11.0	0.2	0.3	0.6	157.4	98.5	4.9	1.0
Infertile	6.3	21.0	1.9	16.9	0.2	8.5	0.3	0.3	0.6	109.7	62.9	1.0	1.0
Forest	6.7	35.8	3.7	4.0	0.3	3.7	32.9	1.5	0.3	96.0	36.4	2.5	3.8
						Subsoil							
Black	6.5	20.1	1.6	3.4	0.2	4.3	0.1	0.7	0.6	103.0	73.5	0.8	1.0
Valley	6.8	8.5	7.4	12.4	0.4	9.4	1.2	3.1	53.6	141.7	55.4	3.1	1.3
Alluvial	9.6	2.6	1.1	14.4	0.2	4.8	0.5	0.3	0.7	154.1	103.0	6.9	1.1
Infertile	6.5	14.5	1.3	8.3	0.2	3.1	0.1	0.3	0.6	16.0	168.0	1.9	1.1
Forest	6.6	26.5	2.7	3.2	0.2	2.3	0.3	0.7	0.3	58.8	36.5	1.9	1.2

Table 3. Farmers understanding of soil problems and their management

S/N	Land problems	Causes	Effects	Indigenous Solutions
1	Soil erosion	Excess rainfall usually during August and September, bush burning, continuous cultivation for long term. Weakness of the soil.	It destroy crop roots and washes away top soil	Ridges are made across the farm to reduce water movement. Make ridges across slope contour ridging.
2	Infertility	Long-term usage of land, bush burning and erosion.	Lower crop yield	Fallowing, shifting cultivation, planting cover crops, mulching, use fertilizer animal dungs.
3	Pest and diseases	No idea	Destroy crop and lower yield	Caricaturized objects are erected on the farmlands to scare birds and rodents. Storage of crops for supplements in the fallowing season, up case of declining yield insecticide and herbicide.

thereby recommended that the indigenous method should be complemented with scientific facts. Even now that the use of in-organic fertilizers are declining due to their unavailability and costs which are beyond the means of most small-scale farmers in the tropics [37].

4. CONCLUSION

This study was carried out to understand the correlation between the indigenous knowledge and scientific knowledge of assessing soil fertility status in Ago-Owu farm settlement, Osun State, Southwestern Nigeria. It is evident from the study that the farmers use indigenous methods for soil classification and soil fertility maintenance in the study area. Some of the soil fertility management adopted in the study area include; shifting cultivation, mixed cropping, organic manure and inorganic fertilizer application, crop rotation and poultry litters application. The study revealed that the indigenous knowledge was not without limitations in the study area as farmers were

imprecise and could not quantify the importance of most of their techniques. Notwithstanding, the study therefore concluded that indigenous knowledge should be seen as complementary to the scientific knowledge for better management of soil resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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