inteGrity Research Journals

Journal of Agricultural Science and Practice
Volume 5(1), pages 46-54, February 2020
Article Number: 64AB19A66
ISSN: 2536-7072
https://doi.org/10.31248/JASP2020.184
https://integrityresjournals.org/journal/JASP

Full Length Research

Suitability assessment of soils derived from fine-grained biotite gneiss and schist in rainforest region of southwestern Nigeria for pepper (*Capsicum Sp.* L.) production

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Received 13th January, 2020; Accepted 22nd February, 2020

ABSTRACT: Soils derived from fine-grained biotite gneiss and schist are extensive in southwestern Nigeria and are reportedly suitable for both arable and tree crops. Pepper is an indispensable part of the daily diet of millions of Nigerians. However, its productivity in southwestern Nigeria is low compared with its' demand. This study assessed the suitability of soils formed in fine-grained biotite gneiss and schist in rainforest area of southwestern Nigeria for pepper production. The selected toposequence was delineated into four physiographic units and soil profile pits were established, described and sampled at each unit. The soil samples collected were analyzed for particle size distribution, pH, salinity and organic carbon. Land characteristics obtained were matched with the crop requirements for pepper to obtain the soils' suitability classes using parametric method. Results show that the soils were currently marginally suitable (S3) to not suitable (N) for pepper production. The major agronomic constraints of the soils in order of severity were climate (too high rainfall), fertility (high soil acidity) and topography (slope greater than 3%). It was therefore recommended that planting in areas with less amount of rainfall (750-900 mm) and effective agronomic practices will ensure sustainable pepper production.

Keywords: Biotite gneiss and schist, land suitability, parametric, pepper.

INTRODUCTION

Soils of southwestern Nigeria are dominantly formed in basement complex rocks areas and the landscape is characterized by undulating topography (Obi et al., 2009). Soils of Egbeda association, derived from fine-grained biotite gneiss and schist are very extensive in southwestern Nigeria (Smyth and Montgomery, 1962) and are extremely important on the account of their suitability for both arable and tree crops.

Poor knowledge and appraisal of suitability of parcels of land for agricultural production is a major problem of agricultural development in Nigeria. The result is poor farm management practices, low yield and unnecessarily high cost of production (Aderonke and Gbadegesin, 2013). Soil characterization and land evaluation for specific land uses is one of the strategies for achieving food security as well as sustainable environment (Esu, 2004). The suitability of a given piece of land is its natural ability to support a specified land use; such as rain-fed agriculture, livestock production, forestry, etc. Suitability, therefore, is the fitness of a given type of soil for a defined agricultural use (FAO, 2016).

Nigeria is the largest producer of pepper in Africa, accounting for about 50% of African production (Adamu et al., 1994). Nigeria produced 695,000 metric tons of pepper from total land area of 77,000 ha (FAO, 2008). Pepper is largely grown in many parts of Nigeria but the bulk of its production is found in the drier Savanna and derived Savanna areas of the Northern Nigeria (Erinle, 1989). The world's second most important vegetable crop after tomato is pepper (AVRDC, 1989). Consumption of pepper accounts for about 20% of the average vegetable consumption per person per day in Nigeria (Alegbejo, 2002); making it an indispensable part of daily diet of millions of Nigerians, owing to its increase in popularity and demand (Adesina et al., 2014). It is used extensively in food flavouring in the daily diet of over 1.2 million Nigerians; irrespective of their socio-economic status, used as spice in the preparation of soup and stew (Benson et al., 2014), as condiment and extensively in flavouring of processed meat and colouring in certain food preparations (Alabi, 2006).

In the past, the study area was used for cocoa and kola production but recently due to age, the tree crops were gone and regeneration had been very difficult. There is dearth of information on soils derived from fine-grained biotite gneiss and schist in the rainforest region of southwestern Nigeria and their suitability for pepper production. Thus, the objective of the study was to assess the suitability of soils derived from fine-grained biotite gneiss and schist in the rainforest area of southwestern Nigeria with a view for enhancing sustainable pepper (*Capsicum sp*. L.) production in the area.

MATERIALS AND METHODS

The study area

The study was carried out between 2016 and 2017, in an area located approximately between latitudes 7º32ᴵ N and 7º34ᴵ N and longitudes 4º32ᴵ E and 4º34ᴵ E (Figure 1) within the Teaching and Research Farm (T&R-F) of Obafemi Awolowo University (OAU), Kajola, Ile-Ife. The site is located within the schist belt of the rainforest in southwestern Nigeria (Rahaman,1988) as reported by Fawole et al. (2016). The study area has hot, humid tropical climate with distinct dry and bimodal rainy season. Mean annual rainfall is approximately 1527 mm and mean monthly air temperature is approximately 31ºC.

Vegetation and land use

Native vegetation in the study area was originally rainforest, characterized by very tall, big trees and thick shrubs. However, as a result of human interference, the vegetation now consists of a mixture of bush re-growth, arable crop farms and tree crop plantations. Specifically, the crest (summit) and shoulder are presently being used for cocoa cultivation (*Theobroma cacao*) and scattered cocoyam (*Colocasia esculenta*), and upper slope area was cultivated to cocoa (*Theobroma cacao*) but was left to over grow into secondary forest. The mid slope area was over grown with *Chromolaena odorata* and scatter oil palm (*Elaeis guinensis*) trees, while the lower slope area supported cocoa (*Theobroma cacao*) plantation inter-planted with cassava (*Manihot spp.*) and banana/plantain (*Musa spp*.). Plantain and banana (*Musa spp.*) and cocoa (*Theobroma cacao*) were grown in the valley bottom areas.

Field study

Guided by geological map of the study area produced at the Department of Geology, OAU, Ile-Ife, a toposequence underlain by biotite gneiss and schist was selected for the study. The toposequence is gently undulating with relatively flat top. The toposequence is approximately 500 m long from the valley bottom to the crest, with an elevation of 295.9 m above mean sea level (amsl) at the crest and 268.6 m amsl at the valley bottom. The other physiographic positions, upper slope and hill-wash areas were 293.6 m and 276.9 m amsl respectively.

Four (4) soil profile pits were established along the toposequence at different physiographic units. All the pedons were described following the FAO/UNESCO (2006) guidelines for soil profile description. Multiple sub sampling technique was employed to ensure representativeness of the samples collected from delineated diagnostic horizons, starting from the lowest to the uppermost profile depths, in order to prevent cross-contamination of soil samples. The soil samples collected were bagged, labeled and analyzed in laboratory for particle size distribution, pH, salinity and organic carbon. The location of individual soil profile pit was recorded using a hand held geographic positioning system (GPS) receiver.

Laboratory analyses

The soil samples were air dried, crushed gently in a ceramic mortar and passed through 2 mm sieve to separate gravel content and obtain the less than 2 mm fractions for laboratory analyses. Particle size distribution was evaluated by the modified Bouyoucos hydrometer method (Bouyoucos, 1965) as reported by Gee and Bauder (2002). Bulk density was determined by the core method (Blake and Hartge, 1986). Soil pH was determined both in distilled water and 1.0 M KCl (1:1 soil: solution ratio), using a combined glass electrode digital pH meter (Thomas, 1996). Electrical conductivity was evaluated by the saturated paste method (US Salinity Laboratory Staff, 1954) as reported by Gartley (2011) and determined using conductivity meter (JENWAY 4510 model). Soil organic carbon (SOC) was determined by the Walkley Black method (Walkley and Black, 1934) using the chromic acid digestion (Allison, 1965) as reported by Darrell et al. (1994).

Land suitability evaluation

The FAO framework for soil suitability classification was used for the study (Sys et al., 1993; FAO, 2007). Land characteristics recognizable on the field were combined with those determined in the laboratory for land qualities assessment. For the parametric method used, each characteristic was rated and the aggregate suitability (AS) for each pedon was calculated using square root method equation:

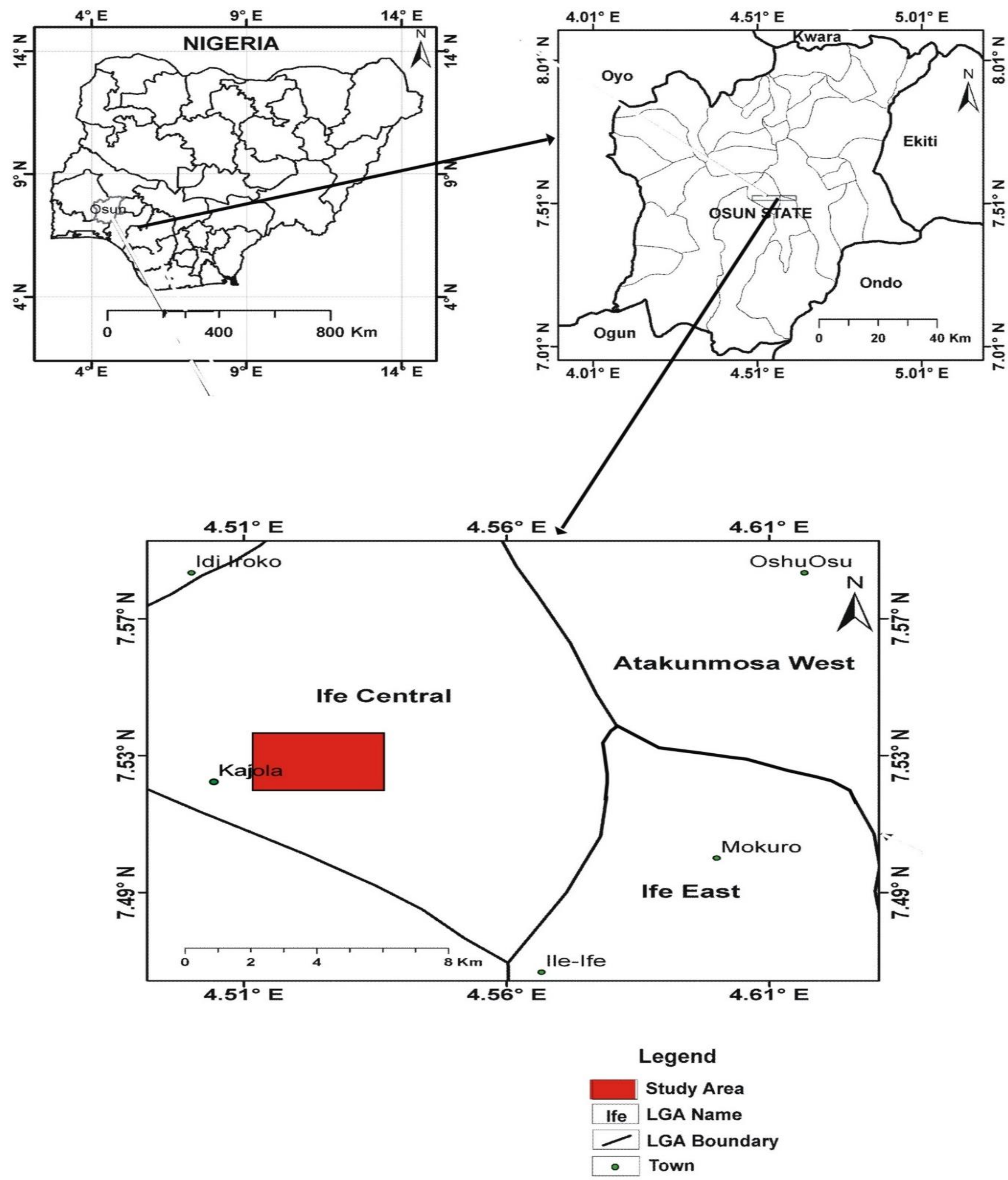

Figure 1. Map of study area.

$$AS = A \times \sqrt{\frac{B}{100} \times \frac{C}{100} \times \ldots \times \frac{F}{100}}$$

where: A is the overall lowest characteristic rating and B, C…F are the lowest characteristic ratings for each land quality group (Sys et al., 1993).

Six land quality groups: climate (c), topography (t), soil physical properties (s), wetness (w), fertility (f) and toxicity (n) were used. For actual (current) aggregate suitability, all the lowest characteristic ratings for each land quality group were substituted into the aggregate suitability equation above. However, in the case of potential aggregate suitability, it was assumed that the corrective fertility measures would no longer have fertility constraints. Therefore, other qualities except fertility (f) were used to calculate the potential aggregate suitability. Suitability classes S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable) and N (not suitable) are equivalent to AS values of 75 – 100, 50 – 74, 25 – 49 and 0 – 24, respectively.

RESULTS AND DISCUSSION

Selected soil characteristics

The soils are underlain by fine-grained biotite gneisses and schist and are extensive in southwestern Nigeria and occupy an area of approximately 4,470 square kilometers. Soils derived from the fine-grained biotite gneisses and schist parent rock was grouped as Egbeda Association (Smyth and Montgomery, 1962). Sequence of the association along a typical topography is Egbeda, Olorunda, Makun and Oba series, from the upper slope position to the lower slope, at the valley bottom is the Jago series. Physiography of the study site was gently undulating with 0 - 6% slope gradient.

Some selected properties of the soils along the toposequence under study are shown in Table 1. Particle size distribution data showed that texture of the surface soils was sandy clay loam, except pedon 4 which was sandy loam. The B and BC horizons were clayey in texture, except pedon 4. The subsurface horizons in all the pedons had more clay than the surface horizons since clay content increased with soil depth in all the pedons. Clay eluviation from the topsoil to the subsoil and differential sorting of materials are factors that could be implicated (Smyth and Montgomery, 1962). Sand content ranged from 320 to 750 g kg^{-1} and decreased with soil depth; except in the lower B and BC horizons. Silt content ranged from 80 to 250 g kg^{-1}. The values fluctuated with depth within the pedons examined. Generally, the silt content was low, a characteristic reported for many soils derived from basement complex in southwestern Nigeria (Ojanuga, 1978; Mbagwu and Scott, 1983; Okusami and Oyediran, 1985). Clay content ranged from 120 to 560 g kg^{-1} and increased with depth; except in the lower B and BC horizons. Sand particles appeared to be the most dominant size fraction while silt content was least in all the horizons. This might be responsible for the well-drained nature of the soils (Smyth and Montgomery, 1962; Amusan, 1991; Ogunkunle, 1993). Amusan (1991) attributed the higher content of sand in surface horizons to translocation of colloidal clay particles deep into the profile with percolating water and selective erosion and transport of fine particles to the lower slope positions during heavy downpour. The lower sand and higher clay contents in the subsoil, according to Ojanuga and Nye (1969) could be accounted for by differential sorting of clay from the surface horizon to subsoil depths. Bulk density values ranged from 0.86 gcm^{-3} in the Ap horizon to 1.65 gcm^{-3} in Bt horizons. Bulk density is a reflection of soil texture and structure. Commonly, soils with low bulk densities are associated with high total porosity, while root penetration and seed emergence become difficult when bulk density exceed 1.6 gcm^{-3} (Russell, 1976; Payne, 1988). Generally, the bulk density values increased with soil depth to a maximum 1.65 and then decreased at the BC horizon (Table 1). The values obtained are within acceptable range for most agronomic activities (Wild, 1993).

Generally, pH of the soils were low, ranging from 5.4 to 6.2 and 4.4 to 5.4 in water and 1 M KCl solution respectively. The pH of surface and subsurface horizons are within the strongly acid class of 4.0 to 5.5 (Adepetu et al., 2014). Acidic nature of the soils could be attributed to high rainfall in the area, which probably resulted in extensive leaching of bases from the soils' rooting zone; acid rain and crop removal of nutrients. However, pH of the soils was below the optimum soil pH range of 6.0 to 7.0 for pepper production (Rai and Yadav, 2005: Naidu et al., 2006). The differences in soil pH values (ΔpH = pH (KCl) – pH (H_2O)) were negative (Table 1). These suggest that silicates dominate mineralogy of the soils over oxides (Van Raij and Peech, 1972; Navarrete et al., 2007) or indicative of the presence of negatively charged colloidal particles (Soil Survey Staff, 2009). Electrical conductivity (EC) across the pedons ranged from 0.20 to 0.70 dSm^{-1}. The values were below the salinity threshold of 4 dS/m for normal arable crops (Adepetu et al., 2014). The EC of soils examined was low with no problem of salinity envisaged. Organic carbon (SOC) content of the soils varied from 0.40 to 14.40 g kg^{-1} was within the range of low to moderate class. Adepetu (1986) classified percentage SOC into low (0 – 8.70 g kg^{-1}), medium (8.70 – 14.50 g kg^{-1}) and high (>14.50 g kg^{-1}). The low SOC obtained may be partly due to the effect of high temperature and relative humidity which favours rapid mineralization of soil organic matter (SOM) (Fasina et al., 2005). The SOC content of the surface horizons was higher than the subsurface horizons in all the pedons except pedon 2. The higher content of SOC at the surface soil was as a result of accumulation of litters and subsequent decomposition to yield SOM (Olayinka, 2009). The lower content of SOC in the surface horizon of pedon 2 compared with the subsurface horizons could possibly be attributed to root decay leading to SOC accumulation below the soil surface.

Suitability evaluation of the soils for pepper production

Land evaluation was carried out using the parametric method (Sys et al., 1993; FAO, 2007). Table 2 shows the factor rating of land use requirements for pepper (*Capsicum sp.*) indicating S1 (highly suitable) rated 100%, S2 (moderately suitable) rated 74%, S3 (marginally suitable) rated 49% and N (not suitable) rated 24%. Land charac-

Table 1. Selected properties of the soils.

Horizon	Depth (cm)	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	Texture	Bulk density (g/cm^3)	pH		ΔpH	EC (dS/m)	SOC (g kg^{-1})
							H_2O	KCl			
Pedon 1: Egbeda series (Crest)											
Ap	0-30	620	120	260	sandy clay loam	1.17	6.1	5.2	-0.9	0.62	13.20
AB	30-44	520	110	380	sandy clay	1.48	6.2	5.1	-1.1	0.70	3.10
Bt21	44-94	360	80	560	clay	1.54	6.0	5.2	-0.8	0.23	3.50
Bt22	94-146	340	160	500	clay	1.61	6.0	5.4	-0.6	0.20	4.30
B23	146-178	400	250	360	clay loam	1.65	6.0	5.2	-0.8	0.27	5.50
BC	178-200	440	240	320	clay loam	1.50	5.8	5.1	-0.7	0.20	5.00
Pedon 2: Olorunda series (Upper slope)											
Ap	0-31	580	100	320	sandy clay loam	1.14	5.7	5.0	-0.7	0.26	7.00
AB	31-64	500	110	400	sandy clay	1.35	5.6	4.4	-1.2	0.57	9.30
Bt21	64-105	420	110	470	clay	1.50	6.1	5.4	-0.7	0.70	13.60
Bt22	105-130	320	160	520	clay	1.64	5.9	5.1	-0.8	0.59	14.40
BC	130-200	420	230	360	clay loam	1.30	6.1	5.4	-0.7	0.64	6.20
Pedon 3: Oba series (Lower slope)											
Ap	0-20	640	130	240	sandy clay loam	1.04	5.6	5.3	-0.3	0.59	11.30
AB	20-35	580	100	330	sandy clay loam	1.35	5.4	4.5	-0.9	0.23	8.50
Bt21	35-70	480	110	420	sandy clay	1.46	5.5	4.6	-0.9	0.25	8.90
Bt22	70-124	420	130	460	clay	1.57	5.4	4.7	-0.7	0.53	4.60
2B3	124-170	440	170	400	clay loam	1.42	5.5	5.2	-0.3	0.35	0.40
Pedon 4: Jago series (Valley bottom)											
Ap	0-20	750	140	120	sandy loam	0.86	5.8	4.8	-1.0	0.20	7.00
AB	20-50	740	130	140	sandy loam	1.28	5.5	4.7	-0.8	0.27	2.30

EC = electrical conductivity, SOC = soil organic carbon.

teristics of the four land units recognized on the field were combined with those determined in laboratory to make preferred land qualities (Table 3). The land qualities used for the suitability assessment were climate (annual rainfall and mean annual temperature), wetness (drainage), soil physical properties (soil texture and depth), fertility (soil pH and organic carbon), topography (slope) and toxicity (salinity measured by electrical conductivity). The factor rating of land use requirements for pepper (Table 2) were matched with properties of the soils (Table 3) to obtain actual (A) suitability class scores of each land unit for pepper (*Capsicum sp.*) (Table 4). Numerical rating of land characteristics in a normal scale from a maximum (100) to a minimum value was employed. If a land characteristic was optimal for pepper production, maximum rating of 100 was attributed and if unfavourable, a minimal rating was applied. The potential (B) suitability class scores were obtained after soil fertility had been corrected and attributed 100. Aggregate suitability class score for each land unit was calculated using the square root method equation and placed in the

Table 2. Soil site suitability criteria (crop requirements) for pepper (*Capsicum sp*. L.).

Land qualities	Land characteristics	Unit	S1 100%	S2 74%	S3 49%	N 24%
Climate (c)	Annual Rainfall	(mm)	750-900	900-1200	500-600 & >1200	<500
	Mean Annual Temperature	(°C)	25-32	33-35	36-38	>38
Wetness (w)	Soil drainage	(class)	Well drained	Moderately to imperfectly drained	Poorly drained	Very poorly drained
Soil physical properties (s)	Texture	(class)	L, Scl, Cl, Sil	Sl, Sc, Sic C(m/K)	C(ss), Ls, S	C(ss), Ls, S
	Effective soil depth	(cm)	>75	50-75	25-50	<25
Fertility (f)	Soil pH		6.0-7.0	7.1-8.0	8.1-9.0 & 5.0-5.9	>9.0 & <5.0
	Soil organic carbon	(g kg^{-1})	>7.50	5.00-7.50	<5.00	<5.00
Topography (t)	Slope	(%)	<3	3-5	6-10	>10
Soil toxicity (n)	Salinity (EC)	(dSm^{-1})	Non saline	1-2	3-4	>4

S1 = Highly suitable, S2 = Moderately Suitable, S3 = Marginally suitable, N = Not suitable, L = loam, Scl = sandy clay loam, Cl = clay loam, Sil = silt loam, Sl = sandy loam, Sc = sandy clay, Sic = silt clay, C(m/K) = clayey (mixed/kaolinitic), C(ss) = shrink swell clay, Ls = loamy sand, S = sand; EC = electrical conductivity.
Source: Modified from Naidu et al. (2006).

appropriate suitability classes as follow: S1 (highly suitable) = 75 – 100, S2 (moderately suitable) = 50 – 74, S3 (marginally suitable) = 25 – 49 and N (not suitable) = 0 – 24.

Climatic data of the study area indicated that the area experience great uniformity of temperature of 31°C, rainfall amount of approximately 1500 mm, relative humidity of 73.8%, sunshine of 6.6 hours and wind speed of 114.6 kmd^{-1} (Meteorological data bank, T&R-F, OAU, Ile-Ife, 2010). The soils were well-drained except Jago series which waspoorly drained. Texture ranged from sandy clay loam to sandy loam at the top soil and effective soil depth ranged between 50 cm and 200 cm. Soil pH ranged between 4.8 and 5.3, and soil organic carbon was between 7.0 and 13.2 g kg^{-1} in the top soil respectively. The slope ranged from 0 to 6% along the toposequence and there was no problem of salinity (Table 3). Generally, climatic data of all the soil series are the same. The annual rainfall of the area was within the marginally suitability class (S3) for pepper and rated 49 due to excessive rainfall which was above the optimal (750 to 900 mm) requirement for *Capsicum sp.* Meanwhile, mean annual temperature of the soils was within the S1 class, rated 100 and was therefore, highly suitable for pepper production.

The soil drainage (well-drained), texture (sandy clay loam), effective soil depth (> 75 cm) and salinity (< 1 dSm^{-1}) of Egbeda, Olorunda and Oba series were highly suitable for an optimal yield of pepper and rated 100. Soil pH of the series was within the range of 5.0 to 5.9, which is marginally suitable (S3) for *Capsicum sp.* production and was scored 49. The soil organic carbon for Egbeda and Oba series (13.20 and 11.30 g kg^{-1} respectively) was highly suitable for pepper and rated as 100, while SOC of 7.00 g kg^{-1} for Olorunda series was within the moderately suitable class (S2) and scored 74. More so, the percent slope of the soils of Egbeda and Oba series (5 and 4% respectively) was within the moderately suitable class (S2) for pepper and rated 74, while Olorunda series of 6% slope was marginally suitable (S3) for pepper and rated 49. The actual aggregate suitability class scores for Egbeda, Olorunda and Oba series, 30, 24 and 30 respectively revealed that the soils of Egbeda and Oba series are marginally suitable while Olorunda series are not suitable for pepper (*Capsicum sp*.) production.

Potentially, the aggregate suitability class scores of Egbeda, Olorunda and Oba series were 42, 34 and 42, respectively and are marginally suitable (S3) for pepper (*Capsicum sp*.) production. The

Table 3. Summary of land characteristics of the study area

Land characteristics	Unit	P1	P2	P3	P4
Annual Rainfall	(mm)	1500	1500	1500	1500
Mean Annual Temperature	(ºC)	31	31	31	31
Soil drainage	(class)	Well-drained	Well-drained	Well-drained	Poorly drained
Texture	(class)	Scl,	Scl,	Scl,	Sl
Effective soil depth	(cm)	> 200	> 200	> 170	50
Soil pH		5.2	5.0	5.3	4.8
Soil organic carbon	(g kg^{-1})	13.20	7.00	11.30	7.00
Slope	(%)	5	6	4	0
Salinity (EC)	(dSm^{-1})	0.62	0.26	0.59	0.20

P1 = Egbeda series (crest), P2 = Olorunda series (upper slope), P3 = Oba series (lower slope), P4 = Jago series (Valley bottom), Scl = sandy clay loam, Sl = sandy loam, EC = electrical conductivity.

Table 4. Suitability class scores of soil units in the study area for pepper (*Capsicum sp*. L.)

Land qualities	P1 (A)	P1(B)	P2(A)	P2(B)	P3(A)	P3(B)	P4(A)	P4(B)
Climate (C)								
Annual rainfall	49	49	49	49	49	49	49	49
Mean Annual temperature	100	100	100	100	100	100	100	100
Wetness (w)								
Soil drainage	100	100	100	100	100	100	49	49
Soil physical properties (s)								
Texture	100	100	100	100	100	100	74	74
Effective soil depth	100	100	100	100	100	100	49	49
Fertility (f)								
Soil pH	49	100	49	100	49	100	24	100
Soil organic carbon	100	100	74	100	100	100	74	100
Topography (t)								
Slope	74	74	49	49	74	74	100	100
Soil toxicity (n)								
Salinity (EC)	100	100	100	100	100	100	100	100
Aggregate suitability	30	42	24	34	30	42	8	24
Suitability symbol	S3	S3	N	S3	S3	S3	N	N

P1 = Egbeda series (crest), P2 = Olorunda series (upper slope), P3 = Oba series (lower slope), P4 = Jago series (Valley bottom), A = actual/current suitability class, B = potential suitability class (after soil fertility improvement/correction). Aggregate suitability scores: S1(highly suitable) = 75-100, S2(moderately suitable) = 50-74, S3(marginally suitable) = 25-49, N (not suitable) = 0-24.

major agronomic constraints of the soils' series for pepper production in order of severity were climate (too high rainfall), fertility (low soil pH or high soil acidity) and topography (slope greater than 3%). The low soil pH or acidic limitation of the soils could be attributed to an excessive leaching of basic cations under heavy rainfall, as found in the area; acid rain; fertilizer use; and the release of H^+ from SOM decomposition. The topographic limitation of the soils of Olorunda series could be attributed to its steepness at the upper slope position of the toposequence such that, a heavy rainfall on the bare land would cause an excessive movement of fine surface soils and leaching of essential nutrient elements from the soils down the toposequence. More so, according to Rai and Yadav (2005), hills that are too steep mostly suffer from heavy loss of surface soil.

The physiographic position of soils of Jago series is the valley bottom. They are poorly drained soils with texture, effective soil depth, pH, organic carbon, slope and salinity being sandy loam, 50 cm, 4.8, 7.00 g kg^{-1}, 0% and 0.20 dS/m respectively. The soils were classified as S3 and scored 49 under drainage and soil depth respectively, and this could be ascribed to the presence of ground water at 50 cm depth. The texture of this soil and organic carbon content were within the moderately suitable class (S2) requirement for pepper and rated as 74 while the pH was within the not suitable class (N) and scored 24. The percent slope and salinity of Jago series were within the highly suitable class (S1) requirement for pepper and rated as 100. Land characteristics suitable for optimal growth of pepper in this series were temperature, slope (flat land) and salinity. The actual and potential aggregate suitability class scores computed were 8 and 24 respectively; therefore, classified as not suitable (N) for *Capsicum sp.* production.

However, the major agronomic constraints of these soils in order of severity were fertility (low soil pH and organic carbon), climate (too high rainfall), drainage (poorly drained), depth (shallow, less than 50 cm) and texture (sandy loam). The soils of Jago series were severely limited for pepper production due to fluctuation in ground water table at a shallow depth and flooding on the land surface during wet season; thereby causing oxygen depletion needed in the soils for plant roots' respiration, root stress and subsequent death of crops. Further, land cultivation for pepper production becomes difficult due to the prevalence of excess moisture condition in the soils. Waterlogged soil condition (as in Jago series) is injurious to *Capsicum sp.* which could cause poor fruit setting, diseases and fruit rotting (Grubben and Denton, 2004). More so, the soil texture was sandy loam which is low in nutrient retention capacity, have poor aggregate stability and anchorage for plant roots.

Conclusion

Soils derived from fine-grained biotite gneiss and schist in rainforest region of southwestern Nigeria are currently marginally suitable to not suitable for pepper production. The soils are severely limited in climate due to a high annual rainfall (approximately 1500 mm) above the optimal requirement of 750 to 900 mm for pepper and low fertility due to the acidic nature of the soils. The other agronomic constraint of Egbeda, Olorunda and Oba series is topography (percent slope) ranged from 4 to 6% as against the optimal 3% for pepper production. The major agronomic constraints of soils of Jago series are poor drainage, shallow soil depth and high groundwater table. The climatic condition; most importantly the annual average rainfall in the area, may probably be difficult to control. Planting in areas with less amount of rainfall will ensure sustainable pepper production. Agronomic practices that can improve pH of these soils for a sustainable pepper production should be employed. Such practices are liming; avoiding the use of acidifying fertilizers; additions of organic materials; and breeding of crop (pepper) that is tolerant to acid soils. The use of contour strip cropping could be adopted to reduce the limitation of slope in the soils of Egbeda, Olorunda and Oba series. It is a practice which would help to interrupt the flow of water down the slope and enhance its retention within the soil.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

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