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CHARACTERISTICS, CLASSIFICATION AND MANAGEMENT OF INLAND VALLEY BOTTOM SOILS FOR CROP PRODUCTION IN SUB-HUMID SOUTHWESTERN NIGERIA.

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ABSTRACT

Inland valley bottoms (IVBs) on basement complex in sub-humid southwestern Nigeria were studied for water-table (WT) dynamics, and physical and chemical characteristics for their classification and management needs for crop production. The IVBs are generally small in size. About 64% of the IVBs averaged 0.78 ha while 36% averaged 1.69 ha. The dry season WT was 0 – 40 cm deep in 22%, 40 – 70 cm in 27% and 70 – 120 cm in 50% of the IVBs. These, corresponding to fluxial, high WT and very poorly drained IVBs (WT class 1), phreatic, medium and poorly drained IVBs (WT class II), and pluvial, low WT and imperfectly drained IVBs (WT class III), respectively. Clay and silt fractions are irregularly distributed in the soils but generally higher in the topsoil. Soil texture is highly variable both within and among the WT regimes, but while WTI and WTIII IVBs have loam or clay loam over sandy clay loam, WT II IVBs has silt loam over clay loam or sandy clay loam. Hydraulic conductivity (Ks) averaged 2.43 cmh^{-1} in the top 60 cm and 0.59 cmh^{-1} at lower depth in WT1 IVBs. The corresponding average values in WTII are 4.43 cmh^{-1} and 1.16 cmh^{-1}, and 4.14 cmh^{-1} and 0.77 cmh^{-1} in WT III. Organic C and effective CEC are moderately high, and the basic cations comprised more than 90% of the adsorption complex. The soils were classified as Aquic Endoaquepts, (WTI), Typic Endoaquepts and Aeric Typic Endoaquepts (WT III). Low input technologies for intensive uses of the IVBs consist in adapting farming to the wet condition by adopting the rice culture, or adopting a system of shallow drain-ditches with mound-tillage to simultaneously lower the WT and increase the rooting depth during the dry season. Equally, mound-tillage can be used to grow a toposequence of crops with decreasing tolerance for excessive wetness from the base to the apex. Occasional fertilizer supplementation and mulching will be needed to conserve the soils and sustain high crop yields when the IVBs are transformed into intensive agro ecosystem.

Keywords: Inland valley soils, Drainage, Tillage, Soil management and conservation, Crop production, Nigeria

INTRODUCTION

The soils of the IVBs are hydromorphic or waterlogged at least some of the time. These are soils with impeded drainage either because of flooding or because of a high groundwater table including ponding, to the extent that it influences their development and properties, and land use potentials. Okusami (1985) and National Research Council (1995) defined hydromorphic soils as those wetland soils that will not support crops (or plants) with aerobic edaphic requirement during the peak of groundwater recharge. Soil Survey Staff (1999) described hydromorphic soils and their classification and modified them with the element "aquic" either at the sub-order or sub-group level at control depths of 50 cm and 75 cm, respectively. Equivalent terms in the FAO-UNESCO Soil Map Legend (FAO-UNESCO, 1988) are Gleysol units and Gleyic sub-units.

Changes in the depth of the groundwater table are determined by climatological factors (precipitation and evapotranspiration and their distributions), hydrological characteristics (drainage in and out-flowing seepage), and soil conditions (hydraulic conductivity, storage capacity). Quantitative data on the height, fluctuation and duration of the ground-water table are scarce for tropical West Africa. Established morphological features such as mottles and presence of cutans have been used in the field identification of soils with acquic moisture regimes (Pomerening and Knox, 1962; Schwertman and Fanning, 1976; Veneman et al., 1976; Vepraskas and Bouma, 1976). Colour diagnosis of chroma 2 or less has also been used in soils with a fluctuating watertable or perennially high watertable (Veneman et al., 1976; Guthrie and Hajek, 1979; Franzmeier et al., 1983).

Dudal (1992) reported that mottling and grayish colour used in evaluating soil morphology neither indicate the duration of wetness nor reflect constraints. Reharge (1985) found saturation and morphological properties were not closely correlated for some claypan soils. Bouma (1973), Smith (1973) and Dudal (1992) reported that sometimes current pedogenic processes cannot be distinguished from relict pedogenic events, because the wetness conditions which produced them no longer prevail. Veldkamp (1979) reported that the prediction of groundwater regimes from soil characteristics can be inaccurate because great variations may occur during a year and between years, and because oxidation from incoming groundwater may obscure soil morphological features indicative of long term saturation. He therefore recommended the measurement of actual groundwater table depth to determine suitability for crops.

Ipinmidun (1973) and Wakatsuki (1989) have described IVBs surface and groundwater hydrology. Wakatsuki (1989) devised an ingenious way to depict changing groundwater depth over time for a single transect. Veldkamp (1979) proposed the classification of IVB land according to annual maximum and minimum depth of groundwater or depth of flood, so that technology development would be targeted to different classes of IV land.

Hydromorphic soils are distributed throughout the agroecological zones of West Africa. They occur in various categories of wetlands, namely, inland valleys (IVs), inland basins, river floodplains, and coastal plains (Andriesse, 1986). The relatively shallow and narrow IVs are estimated to cover between 8.9% and 20% or about 10 million ha while other categories constitute about 12% of the West African equatorial and savannah zones (Hekstra and Andriesse, 1993). In southwestern Nigeria, the IVs cover about 100,000 ha in the humid and another 100,000 ha in the Savannah area (Land Resources Div., 1973).

The IVs occur in the upper reaches of major and minor watersheds throughout the West African landscape (IITA, 1989/90). Inland valleys comprise the watersheds of drainage axes in which seepage and runoff from adjacent uplands converge. The WT is near or even above the soil surface at least during the wet season. Inland valleys are thus characterized by three hydrological processes, seepage, runoff, and vertical fluctuation in the water-table.

Inland valleys are significant ecosystems because the valleys have the potential to be used for agriculture in a sustainable way, are diverse and have a high physical potential for increasing food production compared with the adjacent uplands where the degradation of the resource base of agriculture is occurring (Juo and Hossner, 1992; IITA, 1990, 1994; Coraf Action, 1997). However, the potentials of IVs have remained relatively untapped and under-utilized besides that IV agro-ecosystems are highly complex and heterogeneous (IITA, 1990).

The soils are still generally little studied, are fallow during the rainy season, and are farmed in a diverse way, and generally at subsistence scale during the dry season when they may be the only places with enough water to support crops. The typical IVB cultivator is a small-scale farmer who cultivates three to six times as much upland area. International Institute of Tropical Agriculture (IITA, 1990) even reported that despite their agricultural potentials, IVBs traditionally have been neglected by agricultural researchers and policy makers as well as by farmers in favour of the more readily exploitable uplands. Knowledge of the IVBs is important for optimum use of the soils for crop production. This paper reports the characteristics and classification and discuses the management of the IVBs for crop production in southwestern Nigeria.

MATERIALS AND METHODS

Study Area:

The study was conducted in two watersheds, A and B, whose areas were estimated graphically at 1,400 and 4,425 km^2, respectively, in the Ayepe area of southwestern Nigeria. Ayepe lies approximately between latitudes 7^{o}15^1 and 7^{o}20^1 and longitudes 4^{o}15^1 and 4^{o}16^1 E in central southwestern Nigeria (Figure 1). The climate is sub-humid tropical, characterized by a long rainy season from April to October, and a short dry season from November to March (Table 1). The rainy season is interrupted annually by a short period of moisture deficit from late July to early August, traditionally known as "*August Break,*" which varies in duration from year to year. Equally, there is a short period of relative coldness and hazy weather from late December to January known as the *Harmattan.*

The area consists of gently rolling to undulating north-south hill ridges mixed with short and long slopes, and broad saucer and trough-shaped valleys. Morphologically, the valleys change from V-section at stream-head or upper reaches of the watershed to concave, gently rolling, flat portion of the valley, where the gradient is between 0 to 2%.

The soils are derived from Pre-Cambrian metamorphic rocks of the Basement Complex.

These exhibit great variation in grain size and mineral composition, ranging from very coarse pegmatite to fine grain schists and from acid quartzite to basic rock consisting largely of amphibolites (Hekstra and Andriesse, 1983). The natural vegetation is lowland tropical deciduous rainforest, but the forest is now secondary regrowth following decades of slash-and-burn farming.

Field Methods

Estimating area of valley bottom and catchment: The area of each valley bottom and catchment was demarcated according to Hilton (1981). Conventional methods, e.g. topographical maps and aerial photographs could not be used because according to Andriesse (1986), the IVs cannot easily be identified even from the FAO (1977) soil map at the present level of inventory. However, IITA (1994) researchers combined high resolution satellite images from the American Land Observation Satellite with a Thematic Mapper sensor (Landsat TM) and the French satellite *Le systems de la terre pour l' observation* with a High-Resolution visible sensor (SPOT-HRV) to provide data that hold great promise for mapping the small, diverse and heterogeneous IVBs. The area was estimated from the point where the valley begins to widen to where it joins another valley, and the width, which was the average of three transects from one foot slope to another on opposite sides of the valley.

Watertable monitoring: Twenty-two (22) IVBs comprising six (6) IVBs in watershed A, namely, AY15E, AY16E, AY17E, AY18E, AY21K and AY22K, and sixteen (16) in B, namely, AY1P, AY2P, AY3P, AY4P, AY5B, AY6B, AY7N, AY8N, AY9M, AY10M, AY11L, AY12L, AY13D, AY14D, AY19J and AY20J (Figure 1), were selected for the measurement of water table (WT) depth at intervals of one week from June 24, 1989 to March 17, 1990, about one hydrological year, to cover the times the WT was at its highest (rainy season) and lowest (dry season). The selection was based on the assumption that conditions in these sites were representative of the entire southwestern Nigeria.

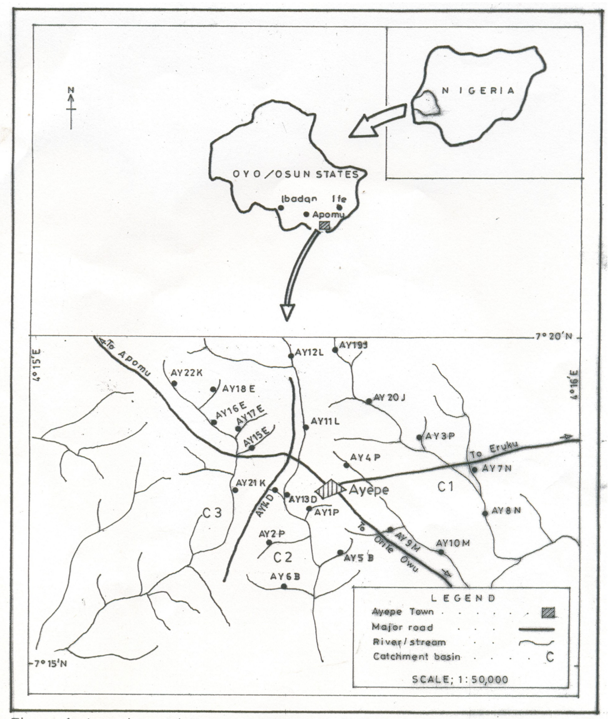

Figure 1: Location of inland valley bottom in Southwestern Nigeria

Table 1. Summary of climate data for 1989 at Ile -Ife in South -western Nigeria

Month	Monthly rainfall (mm)	Total evaporation (mm)	Mean wind speed (kmh^{-1})	Solar radiation ($gcalcm^{-2}day^{-1}$	Temperature (mean, ^{O}C)	Relative humidity (mean, %)
January	-	148	3.4	421	278	49
February	54	148	3.4	428	27.7	49
March	40	138	5.1	436	29.9	79
April	44	127	4.7	423	27.5	83
May	212	67	3.8	421	27.1	82
June	213	61	4.0	413	26.4	83
July	210	45	3.8	354	24.7	87
August	170	49	3.7	311	24.3	87
September	164	36	3.4	328	25.4	85
October	182	65	3.2	381	26.4	86
November	1	130	3.0	421	28.0	79
December	-	115	2.6	372	27.2	79

Source: Obafemi Awolowo University Farm Weather Station, Ile –Ife, Southwestern, Nigeria

In each site, a rectangular block 20 m x 10 m was taken across the valley with the stream or rivulet either running through the middle or bounding one side. The WT depth was measured in three unlined auger-holes in two parallel transects in a 10 m grid pattern in the stream direction. Each hole was 120 cm deep and 8 cm internal diameter. A 10 cm length of PVC pipe was inserted in the top of each hole, leaving a projection of 5 cm above the surface, and covered with plastic cup to prevent evaporation, direct rain-drop and extraneous materials. Thereafter, the WT was allowed one week to equilibrate before measurement commenced. The holes were dredged regularly with a bucket auger to ensure that the true depth of the WT was measure. Depth of the WT was measured by dropping the tip of a steel tape into the hole with the top of the pipe as reference. Water-table elevation was obtained by difference between depth of hole and length of pipe above the soil surface. Water-table records from each set of 6 holes per site were averaged weekly to obtain time-series of WT fluctuation data. The IVBs were classified into WT categories or drainage classes by adapting the scheme developed by Veldkamp (1979) and Smaling et al. (1985), based on the maximum and minimum depth of the WT. The classification is important in recommending appropriate soil and water management technologies for the soils.

Measuring hydraulic conductivity: Hydraulic conductivity below the WT was determined with the piezometer method, at three points 10 m apart along a central transect. Successive measurements were made in auger holes 120 cm deep at a depth increment of 30 cm. Hydraulic conductivity was calculated from the equation.

$$Ks = \frac{\Pi r^2 \, ln(h_o/h_n)}{C\Delta t}$$

where

Ks = saturated hydraulic conductivity, cmh^{-1}

r = radius of the cavity 15 cm deep below the PVC pipe, 6.8 cm internal diameter.

h_o = WT head (cm) at time t_o

h_n = WT head (cm) at time t_n

Δt = change in time $t_o - t_n$, h

C = a shape factor (cm) determined from tables (Youngs, 1968).

Identification of the soils: A profile pit was located in each site based on the results of auger borings. A total of 18 pits were dug to the dry season depth of the WT. The profile pits were demarcated, described and sampled according to FAO (1977). Undisturbed core samples were collected from the genetic horizons for the determination of bulk density.

Laboratory Methods: Particle-size distribution was determined by the Bouyoucos hydrometer method (Klute, 1986) and Soil Taxonomy (Soil Survey Staff, 1998) was used to designate the textual classes. Bulk density was also determined as described in Klute (1986). Chemical analysis followed Page et al. (1982).

RESULTS AND DISCUSSION

Area of Valley Bottom and Catchment: The IVBs are generally shallow and narrow, varying in sizes considerably both within and across the watersheds, A and B. Inland valley bottoms in A averaged 0.94 ha with CV = 79%, while those in B averaged 0.83 ha with CV = 78%. 64% of the IVBs averaged 0.48 ha with a CV = 37%, while 36% averaged 1.69 ha with CV = 32%. Their corresponding catchments also varied widely. The small size of the IVBs not only reflect the physiographic situation in the south-west agro-ecological zone, but also across the West African sub-region, and agree with reports by Hekstra and Andriesse (1983) and Andriesse (1986).

The small size of the IVBs is attributed to deeper incision of the landscape and convex nature of the valleys. It is also explained by the fact that the nature of the basement complex defies easy smoothening by past erosion cycles (Hekstra and Andriesse, 1983). The large number of streamflow valleys, indicating the drainage density and texture, closely relate to the lithological characteristics of the area. The morphological characteristics directly, greatly affect the hydrological processes, that is, the recharge/discharge relationships within the IVBs and their agronomic suitability for crop production in wetland, dryland, or wetland/dryland agricultural systems. The amount of water flowing into the valley depends not only on rainfall amount but also on catchment size. Killian and Teissier (1973) have reported that water capture would be too small for a catchment size less than 400 ha. This indicates that much of rainwater runs off the surface resulting in flooding of shallow depth and short duration. It also indicates that little of the rainwater contributes to upland depletion flow or seepage flow. However, despite the topographic condition and the high drainage density and texture, the rainwater does infiltrate and readily recharges the groundwater, causing a sharp rise in the regional groundwater table and seepage flows, resulting in the seasonal or perennial wetness condition which prevails in the IVBs.

Water-table depth and classification of IVBs: Time series data for 1989 rainy and 1990 dry season, on the seasonal fluctuation in the depth of the WT show fairly uniform variation among the IVBs in watershed A and wide variation in B. Across the watersheds, about 23% of the IVBs (AY5B, AY8N, AY10M, AY11L and AY14D) have WTs that vary between 0 and 40 cm (Figure 2). The WTs vary between 40 and 70 cm in about 27% (AY1P, AY2P, AY6B, AY7N, AY9M, and AY13D) and between 70 and 120 cm in about 50% (AY3P, AY4P, AY12L, AY15E, AY16E, AY17E, AY18E, AY19J, AY20J, AY21R and AY22R). These indicate that most IVBs become relatively dry during the dry season; they may, however, still have adequate water to support crops. The data also show that the IVBs (AY17E, AY18E, AY21R, and AY22R) in watershed A have dry season WTs in the category 70 to 120 cm, compared with those in watershed B having WTs mostly in the shallow range of 7 0 to 40 cm and 0 to 70 cm.

The results point to some possible management strategies for the IVBs. Figure 2 shows that the WT is at or near the soil surface for more than 6 months in IVBs with WT depth ranging from 0 to 40 cm and 40 to 70 cm, and about 5 months in those that range from 70 to 120 cm. Generally, the duration of the high WT average about 6 months during the hydrological year (June 1989 to March 1990). This is attributed to the high rainfall amount (>160 mm/month in 1989) which readily recharged the groundwater and sustained copious seepage flow, and the hydrogeology of the agro-ecological area.

Table 2. Estimated Area of Inland Valley Bottom and Catchment Basin in South-western Nigeria

Water table class	Valley bottom area (km^2)	Catchment area (km^2)
WTI, Very poorly drained		
AY5B	5.2 x 10-^{2}	1.56 x 10^{-2}
AY8N	6.0 x 10^{-2}	2.50 x 10^{-2}
AY10M	7.0 x 10^{-2}	2.50 x 10^{-2}
AYIIL	14.0x 10^{-2}	0.94 x 10^{-2}
AY14D	6.0 x 10^{-2}	0.63 x 10^{-2}
X	7.6 (0.36,47.3%)*	16.3(3.87,53.2%)*
WTII, Poorly drained		
AY1P	2.4 x 10^{-2}	0.94 x 10^{-2}
AY2P	4.5 x 10^{-2}	0.94 x 10^{-2}
AY6B	4.2 x 10^{-2}	2.81 x 10^{-2}
AY7N	3.8 x 10^{-2}	2.50 x 10^{-2}
AY9M	3.2 x 10^{-2}	1.25 x 10^{-2}
AY13D	15.0 x 10^{-2}	0.94 x 10^{-2}
X	5.5 (0.47.85.3%)*	15.6(3.51,55.0%)*
WT III, Imperfectly drained		
AY3P	6.8 x 10^{-2}	0.94 x 10^{-2}
AY4P	10.0 x 10^{-2}	0.94 x 10^{-2}
AY12L	25.0 x 10^{-2}	0.94 x 10^{-2}
AY15E	3.0 x 10^{-2}	0.78 x 10^{-2}
AY16E	13.5 x 10^{-2}	1.25 x 10^{-2}
AY17	6.8 x 10^{-2}	0.63 x 10^{-2}
AY18E	3.6 x 10^{-2}	0.63 x 10^{-2}
AY19J	2.5 x 10^{-2}	0.94 x 10^{-2}
AY20J	18.0 x 10^{-2}	1.56 x 10^{-2}
AY21K	7.0 x 10^{-2}	1.25 x 10^{-2}
AY22K	22.5 x 10^{-2}	1.25 x 10^{-2}
X	1.08 (0.79,73.3%) *	10.1 (0.87,29%)*

* Figures in parentheses are standard error of individual observation and coefficient of variation within WT class.

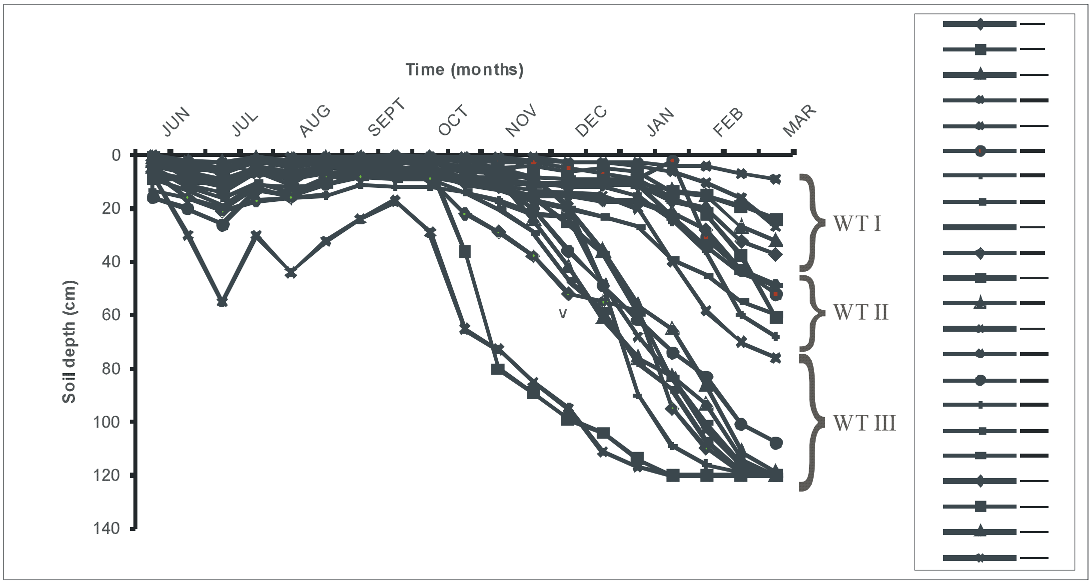

Figure 2. Variation in WT depth for 14-day period in WT I, WT II, and WT III IVBs in Ayepe, Southwestern Nigeria.

The high WTs are also attributed to poor surface and subterranean drainage outlets. The sharp decreases with depth in hydraulic conductivity supported the prevalence of poor acquifer characteristics. Consequently, all soils are waterlogged for a considerable length of time with implications for wetland farming. Hekstra and Andriesse (1993) and Andriesse (1986) have reported that IVBs in the West African sub-region have excellent conditions for more than one crop growing season (150 days or more) especially wetland crops, e.g. rice. International Institute of Tropical Agriculture (IITA, 1994) reported that the IVBs hold a rich potential for food production because more water is available and the soils more fertile than in the uplands bordering them.

The onset and recession of the WT, which commenced with the onset of the dry season also vary among the IVBs, but depending on the rainy season height of the WT, the amount and duration of seepage or upland depletion flow, and the underlying hydrogeology. Figure 2 indicates that these factors decreased in intensity from WTs ranging from 0 to 40 cm to 70 to 120 cm. By March 1990 (Figure 2), the WT had attained its mean lowest depth in the IVBs, allowing the cultivation of dryland crops, e.g. maize, cassava, sweet potato, yam and vegetable crops. The drying process is facilitated by the high solar radiation and temperature (Table 1) and a gradient of water deficit toward the atmosphere during the period, and the slow but steady flow down-stream and soil profile. The evaporation and internal drainage processes reduce the pore water pressure and improve aeration for crops with aerobic edaphic requirement.

Thus, a rise in the level of the WT decreases the zone of unsaturation, increases the pore water pressure, reduces the hydraulic gradient and increases the drainage load, and creates waterlogging conditions that inhibit cultivation and crop growth. On the other hand, the receding water-table reduces waterlogging conditions, or create unsaturated conditions or re-establishes the agricultural zone (Ap) of the soils. These alternating conditions explain the alternate fallow and farming in the IVBs.

Consequently, the dry season WT depth is a critical predictive criterion because it defines the effective rooting depth (ignoring the extent of the capillary fringe), the soil water storage depth and drainage requirements, and a distinguishing characteristic for classifying the IVBs into soil and water management regimes. Three hydrological regimes have thus been defined, namely, WTI or WT class 1 varying from 0 to 40 cm, WTII or WT class II, varying from 40 to 70 cm, and WTIII or WT class III, varying from 70 to 120 cm (Figure 2), similar to the classification developed by Veldkamp (1979) and Smalling et al. (1985). The distinguishing parameters are summarized as follows:

Water-table Class I Inland Valleys:

(i) dry season depth of the WT <40 cm (40 cm was chosen because it is assumed to represent a sufficient depth of unsaturated conditions for "dry foot" crops).
(ii) sustained seepage flow
(iii) WT generally range from 0 to 40 cm
(iv) duration of high WT is about 10 months (May – February)
(v) suitable for year round wetland crop production, preferably, rice.

Water-table Class II Inland Valleys:

(i) dry season depth of the WT <70 cm.
(ii) seepage flow diminishes as dry weather progresses.
(iii) WT generally range from 40 cm to 70 cm.
(iv) duration of high WT is 8 – 9 months (May – January).
(v) suitable for wetland (rainy season) and dryland (dry season) crop production without soil and water conservation in the dry season because the WT and capillary fringe are at shallow depths.

Water-table Class III Inland Valleys:

(i) dry season depth of the WT< 120 cm.
(ii) seepage flow ceases at onset of the dry season.
(iii) depth of the WT generally range from 70 cm to 120 cm.
(iv) duration of high WT is 6 – 7 months (May – November).
(v) suitable for wetland (rainy season) and dryland (dry season) crop production but with soil and water conservation using residue mulch together with early planting for roots to follow the receding WT.

Hydraulic conductivity Ks: Hydraulic conductivity, Ks, of the saturated soil averaged 2.43 cm/h (CV = 70%) in the top 60 cm soil depth and 0.59 cm/h (CV = 75%) at lower depth in WTI IVBs. The respective average values in WTII and WTIII IVBs are 4.43 (CV = 55%) and 1.16 cm/h (CV = 112%), and 4.14 (CV = 65%) and 0.77 cm/h (CV = 111%) (Figure 3). Saturated hydraulic conductivity, Ks is generally moderate in the top soil, decreasing sharply to slow rates with depth. Saturated hydraulic conductivity, Ks varied greatly at both the top soil and lower depth, and within and between the WT or hydrological regimes. This is, however, generally greater at lower depth than top soil layers of the IVBs. The spatial variability in Ks is attributed to differences in soil texture among the IVBs. The depth variability is attributed to finer texture and increasing bulk density with depth.

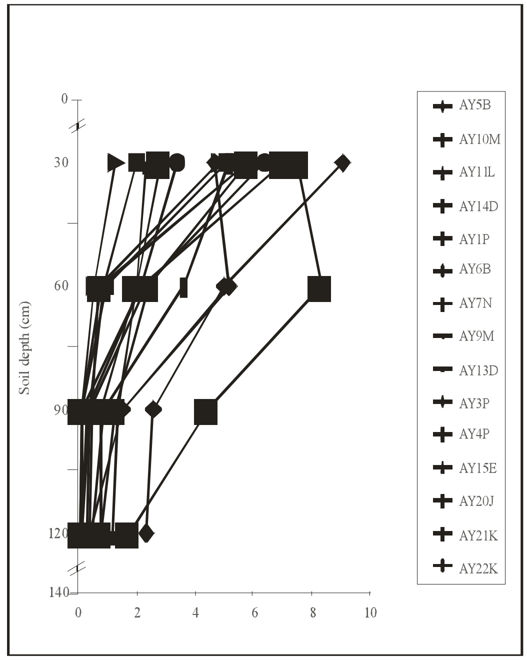

Fig. 3 Hydraulic conductivity (cm/h) of soils of IVBs in Ayepe Southwestern Nigeria

The effect is that water movement is restricted to lateral flow within a shallow topsoil depth. This depth could readily become saturated causing waterlogging or impeded drainage and ponding; hydraulic conductivity being a soil characterizer for drainage. The severe waterlogging condition in WTI IVBs may be explained by the low average Ks in both the top and subsoil layers. The effect of waterlogging is that low hydraulic gradients prevail in the IVBs creating agro-ecosystems whose hydrological regime is fluxial during the rainy season, and fluxial, phreatic and pluvial during the dry season (Moormann and Veldkamp, 1978), corresponding respectively to the WTI, WTII and WTIII.

In other words, the IVBs have very high WTs and very poorly drained during the rainy season, but that they differ in drainage category or requirement during the dry season. Similarly, the corresponding drainage classes to reflect the dry season hydrological regimes are very poorly drained (WTI fluxial IVBs), poorly drained (WTII, phreatic IVBs) and imperfectly drained (WTIII, pluvial IVBs). The overall implication of the hydrological classification is the separation of the IVBs into fairly homogeneous categories to which (soil and) water management technologies can be targeted for intensive uses of the land types.

Consequently, the fluxial agro-ecosystems are suitable for wetland crops notably rice, even though the rice culture is relatively unknown in the study area. However, to transform the IVBs to intensive agro-ecosystems would require adapting cultivation to the natural condition of the IVBs, but with the additional requirement that bunding or small earth-dams are used to pond and increase the depth of flooding (Ogban and Babalola, 2003). Alternatively, a system of rectangular open, shallow drain-ditches and mound-tillage is used to regulate the depth of the WT, and extend the rooting depth, and substantially increase the yield of upland, water-intolerant crops in the IVBs (Ogban and Babalola, 2002). Ogban and Babalola (2002) also found that mound-tillage without drain ditches could be used to grow a toposequence of crops with increasing demand for water, from the apex to the waterlogged base. (Moormann and Juo, 1986). These technologies are in consonance with the preferences and practices of the traditional farmers. Back of this is the fact that ecologically sustainable agriculture depends on successful water control (IITA, 1989/90).

Soil Morphology: The morphological features show that a hue of 7.5 YR typifies the soils (Table 3). The soils are gleyed and with a low chroma in the matrix and high value mottles. This indicates that hydromorphism is a common trait of the IVBs. Structurally, the soils are either weak or medium angular blocky. In terms of consistence, they are either friable or firm and slightly sticky or plastic. Generally, the soils are similar in morphological characteristics. In particular, there is no correlation between colour (matrix or mottle) differences and WT regimes. The similarity in colour and lack of correlation are attributed to either relict pedogenic events which obscured contemporaneous pedological developments or oxygen-rich groundwater. Morphological features thus serve to indicate the pattern and dominant soil forming factor in the IVBs. Consequently, the seasonal depth of the WT, rather than colour diagnosis, is the main distinguishing parameter for classifying the IVBs for soil management and conservation. Morphological features on the other hand, serve to indicate the pattern of pedological development in the soils.

Physical Properties: The sand and clay fractions were irregularly distributed in the soil profiles (Table 3). There was also a general pattern of higher silt and clay fractions in the top 20 to 30 cm depth. Soil texture is therefore highly variable among the IVBs (Andriesse, 1986). Another common characteristic of the soils is that they are generally loams. Generally most of the profiles consists of either fine or medium over fine or coarse-texture. There is a slight correlation between soil texture and WT regimes. Whereas WTI and WTIII IVBs have loam or clay loam overlying sandy clay loam, WTII IVBs have silt loam overlying clay loam or loam. However, all profiles have a finer texture at lower depth, and explains the slow rates of Ks observed. Lithologically, the texture differences indicate that WTI and WTIII soils are derived from granitic materials while WTII soils are derived from metamorphosed materials both of the basement complex (Hekstra and Andriesse, 1993). In addition, the high silt and clay fractions in the soils indicate the abundance of weatherable minerals which are derived from erosion in the adjacent uplands and alluvium both of the pre-cambrian basement complex. They also indicate the low erosion status of the IVBs at present level of cultivation. However, accelerated erosion may alter the ecological fragility and resilience of the IVBs when transformed into intensive, more productive agro-ecosystems. Ogban and Babalola (2003) have discussed the techniques necessary to avoid their rapid degradation, and to enhance their conservation for the sustainability of intensive agricultural production systems.

Bulk density of the top soil layers was generally low, but increasing to high values with depth (Table 3). The low bulk density or high macroporosity of the top soil depth indicate a soil zone favourable to root activity (water and nutrient uptake). The higher bulk density with depth indicates soil compaction and a preponderance of capillary pores (Table 3) both of which inhibit water movement. This may explain the observed slow rate of Ks and tendency for high WTs. However, the capillary fringe may be high with adequate soil water availability, underlying the prolonged growing conditions in the IVBs.

Chemical Properties: Ca and Mg are the predominant exchangeable bases and the cation distribution is Ca>Mg>Na>K in all soils (Table 4). Effective cation exchange capacity (ECEC) varied widely, and its abundance is in the order WTI>WTII>WTIII indicating a relationship between base status and relative dryness. The moderately high ECEC may be attributed to frequent supply of basic cations in runoff waters over the chemically rich basement complex rocks and or *in-situ* mineralization of the moderately high organic matter in the top soil. The high organic matter content in the surface layers is attributed to concentration of plant litter and that decomposition processes are usually slow in hydromorphic soils

Table 3. Physical and Morphological Properties of Soils of Inland Valley Bottoms in South-western Nigeria

Location	Horizon design	Depth (cm)	Sand %	Silt %	Clay %	Texture	Bulk density g/cm^3	Macro-porosity cm^3/cm^3	Colour (moist) matrix	Colour (moist) mottle	Structure	Consistence	Boundary
WTI, Very poorly drained inland valley bottoms													
AY5B	Apg	0-21	36	45	19	1	0.78	0378	7.5YR4/4	7.5R4/6	1,f,ab	fm,slst	cw
	ABg	21-40	86	8	6	s	1.63	0.233	10YR4/0	7.5R4/8	1,f,cr	fri,nst	
AY10M	Ag	0-20	41	37	22	1	0.56	0.623	7.5YR3/0	2.5YR4/8	1,f, ab	fm,slst	db
	ABg	20-32	36	34	30	cl	1.41	0.138	7.5YR5/0	7.5R4/8	3,m,ab	fm,mstp1	
AYIIL	Apg	0-11	35	35	30	1	1.19	0.231	7.5YR5/0	7.5R4/6	3,m,ab	fm,vstp1	db
	ABg	11-18	49	34	17	1	1.40	0.132	7.5YR5/0	7.5R4/8	2,m,ab	fm,s1st	db
	BAg	18-51	49	28	23	sc1	1.63	0.068	7.5YR4/0	7.5R4/8	2,m,ab	fri,mstp1	
AY14D	Apg	0-13	40	32	28	cl	0.69	0.478	7.5YR4/1	7.5YR3/4	1,f,gr	fri,s1stp1	cw
	ABg	13-23	88	2	10	s	1.64	0.129	7.5YR6/0	-	1,f,cr	fri,nst	
WTII, Poorly drained inland valley bottoms													
AY1P	Apg	0-9	15	54	31	sicl	0.86	0.309	2.5YR4/2	2.5YR4/8	I,m,ab	fm,slstpl	cw
	ABg	9-19	4	56	32	sicl	0.77	0.324	7.5YR5/0	2.5YR4/8	3,m,ab	fm,mstp1	gi
	BAg	19-41	74	15	11	s1	1.49	0.206	7.5YR4/0	-	1f,cr	fm,slstp1	
AY6B	Apg	0.11	48	36	16	1	1.36	0.152	7.5YR2/0	7.5YR3/2	2,m,ab	fri,s1st	ab
	ABg	11-64	54	26	20	1	1.67	0.108	7.5YR5/0	10R4/3	2,f,ab	fri,nst	
AY7N	Apg	0-14	31	44	25	sil	0.92	0.353	7.5YR4/2	5YR4/6	I,f,ab	fm,s1st	as
	ABg	14-18	53	25	22	1	1.22	0.378	7.5YR5/0	10R5/8	2,m,ab	fri,mst	db
	BAg	18-56	73	14	13	s1	1.76	0.138	7.5YR6/0	5R5/8	I,f,ab	fri,mst	
AY9M	Apg	0-17	22	47	31	si1	0.89	0.321	7.5YR5/2	-	1,f,cr	1,s1st	db
	ABg	17-33	46	33	22	1	0.75	0.470	7.5YR5/2	7.5R4/6	2,m,ab	fri,s1st	db
	BAg	33-56	84	5	11	s1	1.43	0.173	7.5YR5/0	5R4/6	2,m,ab	fri,mst	db
	BAg	56-64	64	17	19	sc1	1.43	0.109	7.5YR5/0	-	1,m,ab	fm,mstpl	
AY13D	Apg	0-18	18	42	40	sic	1.01	0.268	10YR3/1	7.5YR 3/6	3,m,ab	fm,slstpl	as
	ABg	18-34	49	20	31	scl	1.50	0.156	7.5YR5/0	7.5YR4/6	3,m,ab	fm.mstpl	gl
	BAg	34-54	64	34	12	sl	1.73	0.074	7.5YR4/0	7.5YR4/6	3,m,ab	fm,mstpl	gl
	Bg	54-61	60	19	21	scl	1.65	0.143	7.5YR4/0	7.5YR4/6	2,m,ab	fm,mstpl	
WTIII, Imperfectly drained inland valley bottoms													
AY3P	Apg	0-16	24	46	30	cl	1.14	0.221	10R3/2	7.5YR4/8	3,m,ab	fm,s1spl	db
	ABg	16-34	33	31	36	cl	1.22	0.221	7.5YR3/2	75YR5/8	3,m,ab	fm,mstpl	db
	Bg	34-78	87	4	9	s	1.67	0.140	7.5YR5/0	10R4/6	1,f,cr	fri,mst	
AY4P	Ag	0-9	66	24	10	sl	1.12	0.194	7.5YR3/2	-	1,f,cr	fri,s1st	
	ABg	9-35	44	28	28	scl	1.61	0.079	10R5/1	10R4/8	1,f,cr	fm,mst	
	BAg	35-54	79	7	14	s1	1.60	0.105	7.5YR4/2	2.5YR4/6	1,f,cr	fm,s1st	
	Bg	54-77	55	19	26	1	1.74	0.079	7.5YR6/0	7.5YR4/6	I,f,ab	fri,slst	
AY15E	Apg	0-5	37	21	42	c	1.10	0.69	10YR4/1	-	2,m,ab	fm,mstpl	cw
	ABg	5-78	66	16	18	cl	1.63	0.053	7.5YR6/0	7.5YR5/6	1,m,ab	fm,mst	db
	BAg	78-120	62	17	21	scl	nd	nd	7.5YR6/0	10YR7/8	3,m,ab	fm,mstpl	
AY17E	Apg	0-15	48	20	32	cl	0.92	0.360	10YR2/1	-	1,m,cr	fri,mstpl	as
	ABg	15-28	89	1	10	1s	1.21	0.097	10YR4/1	7.5YR4/6	1,m,cr	fri,mstpl	cw
	BAg	28-50	40	21	39	scl	1.55	0.058	10YR5/1	7.5YR4/6	1,m,cr	fri,mstpl	ab
	Bg	78-120	62	17	21	scl	1.67	0.036	7.5YR5/0	7.5YR4/6	1,m,ab	fri,mstpl	
AY18E	Ag	0-8	44	25	31	cl	0.85	0.301	7.5YR5/0	7.5YR4/6	I,f,cr	fm,stpl	cw
	ABg	8-43	44	22	34	cl	1.40	0.157	7.5YR5/0	7.5YR4/6	1,m,ab	fm,mstpl	as
	BAg	43-93	51	21	28	scl	1.48	0.120	7.5YR5/0	7.5YR4/4	2,m,ab	fm,stpl	
AY19J	Apg	0-9	47	25	28	scl	1.10	0.237	7.5YR4/2	7.5YR4/6	1,f,gr	fri,stpl	cw
	ABg	9-50	71	18	11	sl	1.62	0.145	5YR6/1	7.5YR4/6	I,f,ab	fri,stpl	db
	BAg	50-76	82	1	17	sl	1.74	0.141	5YR6/1	5YR4/6	1,f,cr	I,nstpl	
AY20J	Apg	0-9	16	22	62	c	0.75	0.241	7.5YR3/0	7.5YR4/6	I,m,gr	fri,vstpl	cw
	ABg	9-55	34	39	27	cl	1.62	0.022	10YR5/2	7.5YR4/4	2,m,ab	fm,stpl	db
	Bg	55-69	26	36	28	cl	nd	nd	10YR5/2	7.5YR4/4	2,m,ab	fm,stpl	
AY21K	Apg	0-11	37	32	31	cl	1.13	0.280	7.5YR2/0	-	I,f,ab	1,s1stpl	as
	BAg	11-66	89	1	10	is	1.54	0.005	7.5YR2/0	7.5YR4/8	I,f,cr	I,nst	
AY22K	Apg	0-14	53	14	33	scl	1.15	0.302	7.5YR6/2	10YR4/8	I,f,cr	1,stp1	as
	ABg	14-60	80	1	19	s1	1.62	0.193	10YR6/1	7.5YR5/4	I,f,cr	fm,slst	as
	Bg	60-120	67	13	20	scl	1.70	0.092	10YR5/1	7.5YR5/4	I,f,cr	fm,stp1	

Legend

1. Texture: s = sand; s1 = sandy loam; 1s = loamy sand; sil = sandy loam; sicl = silty clay loam; c1 = clay loam, c = clay;sic = silty clay.
2. Structure: 1 = weak, 2 = medium; 3 = strong; f = fine; m = medium; cr = crumbly; gr = gramular; ab = angular blocky
3. Consistence: fri = frable; fm = firm; 1 = loose; nst = non sticky; npl = non-plastic; s1st = slightly sticky; mst = moderately sticky; p1 = plastic; vst = very sticky; vpl = very plastic
4. Boundary: cw = clear wavy; gi = gradual irregular; db = diffuse broken; as = abrupt smooth.

Table 4. Chemical Properties of Soils of Inland Valley Bottoms in South-western Nigeria

Location	Horizon design	Depth (cm)	pH KCl	pH H_20	Org C (%)	Total N (%)	Avail P ($mgkg^{-1}$)	Ca	Mg	Na	K	Exc Ac	ECEC	Base satn (%)	Mn	Fe	Cu	Zn
								←		Exch bases cmol/kg			→		←	$mgkg^{-1}$		→
WT1, Very poorly drained inland valley bottoms																		
AY5B	Apg	0-21	6.1	6.5	3.15	0.27	8.36	8.50	3.41	0.78	1.02	0.40	14.11	97.2	260.0	698.0	3.7	16.4
	ABg	21.40	5.9	6.2	1.83	0.16	12.12	2.90	1.38	0.48	0.36	0.20	5.32	96.2	40.8	306.2	3.2	7.9
AY10M	Ag	0-20	6.0	7.4	5.08	0.44	8.84	10.00	4.24	0.70	0.18	0.20	15.32	98.7	137.0	34.4	4.0	14.9
	ABg	20-32	6.1	6.7	1.25	0.11	6.69	9.00	3.94	0.61	0.17	0.20	13.92	98.6	41.1	182.0	3.6	15.4
AYIIL	Apg	0-11	6.1	7.7	2.33	0.20	12.60	8.00	2.66	0.56	0.18	0.20	11.56	98.3	44.1	205.0	3.2	15.0
	ABg	11-18	5.8	6.8	1.07	0.09	9.10	15.00	4.36	0.70	0.19	0.20	20.45	99.0	99.7	326.0	4.9	18.6
	BAg	18-45	5.8	6.5	0.50	0.04	16.08	8.00	3.36	0.57	0.16	0.20	12.29	98.4	29.6	214.0	3.4	7.0
AY14D	Apg	0-13	6.0	7.4	3.79	0.33	13.18	4.75	3.27	0.36	0.54	0.40	9.32	95.7	25.4	433.00	2.1	15.7
	ABg	13-23	5.8	7.7	1.43	0.12	0.64	2.10	2.98	0.6	0.08	0.20	5.97	96.7	4.0	51.30	2.7	11.4
WT 11, Poorly drained inland valley bottoms																		
AYIP	Apg	0-9	6.5	6.7	4.76	0.41	17.36	12.0	4.34	0.74	0.51	0.20	17.79	98.9	340.0	471.0	7.0	75.0
	ABg	9-19	6.4	6.7	2.47	0.21	16.98	9.5	4.08	0.61	0.46	0.20	14.85	98.7	71.3	296.0	8.2	54.0
	BAg	19-41	6.6	6.9	1.79	0.17	20.26	3.7	1.98	0.48	0.46	0.20	6.85	97.1	39.1	149.0	2.4	13.4
AY6B	Apg	0-11	6.8	7.4	3.01	0.26	14.89	14.0	3.15	0.70	0.72	0.20	18.77	98.9	146.0	124.0	2.8	9.3
	ABg	11-64	6.5	7.5	2.51	0.22	5.02	7.0	4.34	0.57	0.19	0.20	12.30	98.4	21.0	132.0	2.4	8.0
AY7N	Apg	0-14	5.7	6.2	4.08	0.35	11.39	6.5	3.61	0.61	0.61	0.40	11.73	96.6	16.8	117.0	4.9	14.6
	ABg	14-18	5.8	6.2	2.15	0.19	7.65	5.5	3.34	0.52	0.17	0.20	9.73		9.9	206.0	4.0	11.9
	BAg	18-56	5.9	6.4	1.79	0.15	18.33	4.1	3.13	0.36	0.14	0.20	7.93	97.5	7.6	60.9	3.4	10.4
AY9M	Apg	0-17	6.0	6.1	3.65	0.32	17.14	8.00	4.20	0.50	0.21	0.20	13.31	98.5	176.0	672.0	3.2	11.9
	ABg	17-33	6.3	6.9	1.93	0.17	T	8.00	3.24	0.57	0.14	0.20	12.15	98.4	46.4	227.0	3.7	10.7
	BAg	33-56	6.6	7.2	1.68	0.15	1.32	3.80	3.27	0.34	0.20	0.20	7.76	97.4	12.5	67.9	3.2	7.4
AY13D	Apg	0-18	6.1	6.4	4.01	0.35	12.92	6.00	2.77	0.52	0.15	0.20	9.64	97.9	27.8	164.0	2.5	12.4
	ABg	18-34	6.3	6.1	1.54	0.13	8.04	7.00	3.33	0.52	0.15	0.20	11.20	98.2	26.0	17.0	2.3	11.9
	BAg	24-54	6.5	7.1	1.54	0.13	13.02	6.00	3.71	0.70	0.19	0.30	10.18	98.2	45.4	338.0	3.2	22.5
	Bg	54-61	6.4	7.3	0.82	0.07	5.14	1.65	1.63	0.30	0.06	0.40	4.06	90.2	7.7	127.0	1.8	10.7
WT 111, Imperfectly well-drained																		
AY3P	Apg	0-16	6.1	6.2	4.14	0.35	18.74	6.00	2.01	0.48	0.21	0.20	9.20	97.8	206.0	529.0	6.1	8.9
	ABg	16-34	5.7	5.9	3.11	0.27	8.13	4.10	1.52	0.48	0.23	0.60	7.13	91.6	20.0	622.0	7.0	7.8
	Bg	34-78	6.1	6.3	1.40	0.21	14.63	1.3	0.63	0.03	0.026	0.20	2.54	92.1	28.6	121.2	1.0	14.1
AY4P	Ag	0-9	6.5	6.7	5.08	0.44	5.31	13.00	2.14	0.70	0.21	0.20	16.45	98.8	84.2	211.0	8.1	16.3
	ABg	9-35	6.3	6.9	1.79	0.15	2.06	5.50	2.08	0.52	0.31	0.20	8.63	97.7	25.6	151.0	1.5	9.2
	BAg	35-54	6.2	6.9	1.04	0.05	3.31	6.50	2.89	0.57	0.33	2.20	10.49	98.1	12.9	150.0	1.6	6.8
	BCg	54-57	6.0	6.9	0.97	0.08	1.30	6.50	3.33	0.52	0.26	0.20	11.01	98.2	9.6	108.0	2.4	9.2
AY17E	Apg	0-15	6.2	6.9	2.47	0.21	10.71	7.00	3.61	0.61	0.16	0.20	11.55	98.3	19.9	227.6	0.7	12.5
	ABg	15-28	6.5	6.9	2.47	0.21	3.54	8.00	4.03	0.57	0.13	0.20	12.93	98.5	24.6	151.0	1.5	9.2
	BAg	28-50	6.4	7.4	0.52	0.05	10.06	10.00	2.00	0.78	0.24	0.20	13.52	98.5	62.3	264.0	1.2	9.2
	BCg	50-86	6.4	7.4	0.30	0.3	T	8.00	4.03	0.74	0.20	0.20	13.17	98.5	32.5	134.0	1.4	4.9
AY18E	Ag	0-8	6.1	6.6	3.03	0.26	11.25	9.00	4.18	0.91	0.22	0.20	14.54	98.6	82.9	2.32.0	1.4	5.6
	ABg	8-43	6.1	7.0	1.29	0.11	T	7.00	3.83	0.70	0.16	0.20	11.89	98.3	74.0	234.0	1.6	4.6
	BAg	43-64	6.0	7.0	1.18	0.10	18.00	2.35	1.59	0.52	0.31	0.60	5.37	88.8	39.1	517.0	2.3	13.2
	BCg	64-98	6.0	7.0	0.89	0.08	0.16	1.80	1.52	0.48	0.06	1.00	4.86	79.4	15.7	119.0	2.8	6.4
AY19J	ABg	9.50	5.3	6.3	1.18	0.10	10.35	12.00	2.47	0.87	0.19	0.20	15.93	97.5	21.3	68.1	1.6	3.0
	BAg	50-76	5.4	6.3	0.63	0.05	10.48	2.60	0.84	0.74	0.19	1.20	4.57	95.6	84.8	277.0	0.7	8.4
AY20J	Apg	0-9	5.8	6.2	2.47	0.21	48.23	13.00	3.29	1.09	0.31	1.20	18.89	93.7	13.0	107.0	2.0	3.7
	ABg	9-55	5.2	6.1	1.44	0.12	4.18	4.10	2.52	0.52	0.33	0.40	7.87	94.9	13.9	217.0	2.5	8.9
	Bg	55-69	5.2	5.9	1.44	0.10	3.54	0.30	0.47	0.28	0.08	0.20	1.33	85.0	3.6	58.6	1.1	5.4
AY21K	Apg	0.11	5.5	5.7	2.51	0.22	15.66	7.00	2.01	0.43	0.13	0.20	9.77	98.0	45.4	41.0	0.4	8.6
	ABg	11-66	5.8	6.2	0.48	0.04	3.70	3.70	2.10	0.37	0.10	0.20	6.49	96.9	6.4	29.1	0.9	8.7
AY22K	Apg	0-14	5.9	6.3	0.41	0.04	9.30	7.00	3.78	0.70	0.16	0.20	11.84	98.3	9.9	40.4	0.5	5.6
	ABg	14-60	6.3	7.1	0.33	0.03	0.64	7.00	3.43	0.57	0.16	0.20	11.36	97.2	8.1	39.2	0.7	4.8
	BCg	60-120	6.3	7.2	0.18	0.02	T	6.00	2.69	0.52	0.15	0.20	9.56	97.9	7.1	29.7	1.0	4.0

Total extractable Fe is irregularly distributed in the soils, varying widely both within and among the WT regimes (Table 4), and in the order WTI>WTII>WTIII. The pattern of variability of easily reducible manganese (ERMn) was similar to Fe. Average values decreased from WTI to WTIII correlating closely to sustained seepage flows in the bottomlands. The observed horizons with appreciably high content of Fe may not necessarily indicate zones of fluctuating redox potentials. The high total extractable Fe and ERMn suggested toxic levels in the soils, but the slightly acid to neutral pH indicated that toxicity is unlikely. These may rather indicate localized movement and deposition of Fe during the rainy season. At present level of utilization, the fragile ecosystems of the IVBs are preserved by a net balance of conservation processes. The physical and chemical fertility status as well as the resilience of the soils will decline when the IVBs are transformed into intensive ecosystems, and with soil-degrading practices, such as slash-and-burn and bare-cultivation common in the adjacent uplands. To conserve the soils and sustain productivity, fertilizer supplementation will be needed (Ogban and Babalola, 2002).

Moreover, the application of mulch from either plant or crop residue will need be a routine during the dry season. The tillage system must be either zero or reduced (soil inversion, mounding or ridging) tillage which is already common in the adjacent uplands. The role of mulch and its derivative organic matter in tropical agriculture has been reported (Agboola, 1990; Parr et al., 2003). Combined with the recommended tillage techniques as conservation tillage, the practice will improve and conserve both the physical and chemical fertility of the soils, and sustain crop production in the dry and rainy season in the IVBs.

Classification of the Soils: In the local system of classification (Smyth and Montgomery, 1962), the soils of the IVBs are classified into “geographical units”, with less emphasis on “taxonomic units”. A geographical unit”, also called “soil association”, is a grouping of soil series that are found to be repeatedly associated on the earths surface. The soils studied fall into Jago Association, occurring as the lowest member of every toposequence of almost every valley in southwestern Nigeria on basement complex. Consequently, they are affected by seasonal fluctuations in the regional WT. The soils are derived largely from alluvial, occasionally colluvial materials. They are differentiated artificially on the basis of texture in horizons between depths of 25 cm and 50 cm, and depth of WT above 25 cm for swampy soils (Oshun and Ikire series), and between 25 cm and 120 cm for poorly drained soils (Adio, Jago, Matako and Shasha series) with fluctuations from rainy to dry season. Based on the WT classification, WTI soils correspond to Oshun and Ikire series, while WTII and WTIII soils correspond to Adio and related series. However, the range of WTs in the latter series was modified into WTs less than 50 cm for WTII, and between 50 cm and 120 cm for WTIII soils. This classification demonstrates the influences of the WT as a dominant criterion for classifying the soils.

The soils are gleyed, and characterized by irregular clay distribution and regular decrease in organic carbon with depth and with levels higher than 0.2% at 120 cm depth. The soils are classified as Inceptisols (Soil Survey Staff, 1998). In the FAO/UNESCO legend (1988), the soils are classified as Gleysols, and Eutric Gleysols on account that they appeared well supplied with nutrients indicated by the ECEC.

The temperature regime is isohyperthemic, because they have a mean rainy season (summer) (June, July and August) and dry season (winter). December, January and February) temperatures differing by less than 5^{o}C (Soil

Survey Staff, 1999). It has been shown that the soils are under the influence of the ground WT, which although different in duration and intensity, indicates the presence of an aquic soil moisture regime. However, Soil Survey Staff (1998) describes the soils as those with a peraquic moisture regime. The aquic soil moisture regime places the soils in the Aquepts Sub order. At the Great Group level, the soils are classified as Endoaquents, because they can be saturated for more than 90 consecutive days. The aquic soil moisture regime is fully expressed in WTI at the sub-group level as at the Great Group level and classify the soils as Aquic Endoaquepts. The common soils in the area are those that are moderately dry (WTII) and dry (WTIII) and therefore classify as Typic Endoaquepts and Aeric Typic Endoaquepts, respectively. That is, WTII and WTIII soils usually have an aquic soil moisture regime in the rainy season, and become poorly to imperfectly well drained in the dry season. Consequently, the prefix “aeric” can be used to describe these soils. Fagbami and Ajayi (1990) used the prefix `ustic’ to describe similar soils, mostly WTIII soils in southwestern Nigeria. Although the long priod of drought (dry season) which follows that of high WT (rainy season) may inhibit the development of aquic characteristics in WTIII (Moormann and van der Wetering, 1985), high soil water potential due probably to high capillary fringe does not support an `ustic’ sub-groups, which is used for hydromorphic soils that have a matrix chroma of 2 or more, yet periodically subject to saturated conditions. Okusami et al. (1981) have used the prefix `aeric’ to classify some hydromorphhic soils of western Nigeria at the sub-group level. Eshiett et al. (1991) used the modifier to classify wetland soils of southeastern Nigeria. Consequently, WTII soils classify as Typic Endoaquepts, while WTIII soils classify as Aeric Typic Endoaquepts (Table 5). The classification can be extended to the family and series level, the basic units of soil management. However, since the WT is the dominant criterion for classifying the soils, the WT categories are also the basic units/groupings for soil management in the wetlands.

Table 5: Classification and Correlation of Soils of Inland Valley Bottoms (IVBs) in South- western Nigeria

Profile No.	Soil Taxonomy (1999)	FAQ/UNESCO (1988)	Smyth and Montgonery (1962)
WTt, very poorly drained IVB	Aquic endoaquepts	Eutric Gleysols	Ikireseries, sandy loam
AY5B	Aquic endoaquepts	Eutric Gleysols	Oshun series, clay loam
AY10M	Aquic endoaquepts	Eutric Gleysols	Ikire series. Loam
AY11L	Aquic endoaquepts	Eutric Gleysols	Oshun series, sandy clay loam
AY14D			
WT11, Poorly drained IVB			
AY1P	Topic Endoaquepts	Eutric Gleysols	Adio series, clay loan
AY6B	Topic Endoaquepts	Eutric Gleysols	Matako series, loam
AY7N	Topic Endoaquepts	Eutric Gleysols	Jago series, sandy clay loam
AY9M	Topic Endoaquepts	Eutric Gleysols	Jago series sandy, clay loam
AY13D	Topic Endoaquepts	Eutric Gleysols	Jago series sandy clay loam
WT111, Imperfectly drained IVB			
AY3P	Aeric Typic Endoaquepts	Eutric Gleysols	Jago series, sandy clay loam
AY4P	Aeric Typic Endoaquepts	Eutric Gleysols	Matako series, sandy clay loam
AY15E	Aeric Typic Endoaquepts	Eutric Gleysols	Jago series, sandy clay loam
AY17E	Aeric Typic Endoaquepts	Eutric Gleysols	Matako series, sandy clay loam
AY18E	Aeric Typic Endoaquepts	Eutric Gleysols	Jago series, sandy clay loam
AY19J	Aeric Typic Endoaquepts	Eutric Gleysols	Matako series, sandy clay loam
AY20J	Aeric Typic Endoaquepts	Eutric Gleysols	Adio series, clay
AY21K	Aeric Typic Endoaquepts	Eutric Gleysols	Matako series, sandy clay loam
AY22K	Aeric Typic Endoaquepts	Eutric Gleysols	Jago series, snady clay loam

CONCLUSION

Potentially productive inland valley bottoms (IVBs) on basement complex rocks are widespread in Southwestern Nigeria. This study demonstrates that the land types are generally small in area, and suitable for smallholder production systems. The soils are influenced by a cyclical groundwater table, whose depth distinguished the IVBs into hydrological classes, and therefore soil and water management regimes, namely, WTI or high WT IVBs, WTII or medium WT IVBs, and WTIII or low WT IVBs. The soils are also moderately low in physical and chemical fertility, and may require fertilizer supplementation for sustainable agricultural production when the wet land types are transformed into intensively managed agro-ecosystems. Their low topographic nature and prevailing hydromorphic conditions provide excellent conditions for swamp rice production. Planned exploitation of the wetlands will boost food production and the productivity of the farmers.

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