Soil Resources of Saboba-Chereponi District: An Assessment for Agricultural Production

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Abstract

Evaluation of the soil of Saboba–Chereponi District for agricultural purposes was carried out in May 1999. Field visits across most parts of the District were made to examine and sample the soil at selected locations. The soil environmental conditions and physical properties were examined and samples analyzed to determine their fertility status. The soils have severe physical limitations, which render them marginal for any heavy investment in agricultural production. Most of the soils are concretionary and underlain at shallow depths by iron pan or rock. Agricultural activities in the District seem to be enhancing the exposure of these iron pans and, hence, accelerating the degradation of the soil. A close examination of the problem shows that unless effective managerial practices are put in place, this irreversible degradation of the soil will render large tracts of land uncultivable with serious implication on the livelihood of the farming community. Based on the study, recommendations were made on discouraging the use of tractors to prevent widespread exposure of iron pan and rather encourage the use of bullocks for ploughing. Crop residue, manure and fertilizer should be judiciously used to improve soil productivity, and the possibility of creating water reservoirs along the Oti river to irrigate the vast plains for rice and vegetable cultivation should be exploited.

Introduction

This study was a request by the District Director of Agriculture to assess the suitability of the soil resources of the Sabobo -Chereponi District for sustained and profitable crop production. The District is located in the Upper Oti basin in the Guinea savanna zone of Ghana. Low and erratic rainfall, long dry period of 5-6 months accompanied by intense heat and sparse vegetation subjected to annual bush fires are known constraints to savanna land use. Under these conditions, the soils are susceptible to severe degradation if not properly managed. In spite of these constraints, agriculture is the major economic activity for the people of the District. The soils are extensively used for the cultivation of various crops to satisfy the needs of the inhabitants. The major arable crops are sorghum, millet, groundnut, maize, yam and cowpea, which are grown for both income and home consumption. The commonly grown income-generating, non-arable crop is cotton.

The common farming systems are mixed cropping and crop rotation. Mixed cropping mainly involves sorghum and millet. The major rotation crops are maize-sorghum-cowpea and maize-yam-cotton. The hoe, bullock and tractor ploughing are the main methods of land preparation. There is only one farming season, which coincides with the rains from May/June to October.

Recently, farmers have observed a decline in their crop yields. This, they associated with observed changes in the physical appearance of the soil, mainly the presence of ironstone gravels and ironpan, which have been increasing over the years.

In addition, ponding of water after a moderate rainfall is now common. These concerns and the observations of farmers were reported to the Soil Research Institute by the District Director of Agriculture for investigations and possible solutions.

The study examined the existing information on Saboba-Chereponi District at the Institute (SRI, 1983), carried out field observations and analyzed soil samples for the diagnosis of the problems. From the results, recommendations were made on the sustainable management of the soil resources of the District.

Materials and methods

Basic information was derived from reports and maps of detailed reconnaissance soil survey conducted by Soil Research Institute of the Upper Oti and Nasia Basins at a scale of 1:250,000 (SRI, 1983, Adu, 1995).

Location of the Study area

Saboba-Chereponi District is located in the Northern Region of Ghana and is one of the newly created districts. The district lies within latitudes 9° 20' N and 10° 18' N and longitudes 0° 00' and 0° 30' E.

Climate

The District is within the Guinea Savanna ecological zone. The climate is characterized by alternate wet and dry seasons of equal lengths of 6 months. Annual rainfall is about 1000 mm or less, falling between May and October. A long dry period follows the end of the rains from November to April. Temperature, which is generally high throughout the year, ranges between 21 and 41°C. The Guinea Savanna vegetation is degraded in several locations; these areas include areas of high agricultural intensity and severely degraded lands that have become uncultivable as a result of iron pan, or where the soils are shallow due to rockiness. Trees sparsely populate such areas.

Geology and soils

The Voltaian shale underlies the District. In the interior savanna and the transition zones, most of the soils developed over shale contain abundant iron concretions and iron pan in their subsoil (Adu, 1969). These soils constitute the groundwater laterites and occupy 50% of the interior savanna. The groundwater laterites, due to impervious iron pan or clay pan in the subsoil, are characterized by waterlogging at the peak of the rains. About 80% or more of the soils fall under the *Kpelesawgu* soil association. In this association, low summits of the uplands are occupied by *Sambu series (Leptolsol*[1]*).* This soil series is shallow and consists of shale brash in a matrix of reddish brown silty clay loam to a depth of more than 30 cm with iron pan boulders often encountered. The middle and lower slope soils are occupied by *Kpelesawgu series (Endopetric Plinthosol)*. The profile consists of silty or fine sandy loam of about 30 cm thickness in the top horizons which are underlain by abundant iron concretions with iron pan encountered at depth of about 50 cm or more from the surface. This is the dominant soil in the association.

Down slope of *Kpelesawgu series* and adjoining the valley edges is *Changnalili series (Stagnic Plinthosol-Endopetric)*. This soil consists of silty or fine sandy top of 15-30 cm thick overlying a subsoil consisting of abundant iron concretions and gravel underlain by iron pan. The valley bottoms are usually flat and consist of poorly to

[1]FAO system. Applicable throughout the text.

imperfectly drained, deep, pinkish grey silty and sandy loams *Lima series (Plinthic Planosol*) and/or grey clays *Volta series (Eutric Gleysol).*

Field activities

The key agricultural centres (Fig. 1) were listed and visited. At every site, the soils were examined by digging inspection holes of about 40 cm diameter and to the depth of 60 cm or less where impenetrable layer is earlier encountered. The soil examination involved the identification of soil type and the description of the major properties comprising depth, texture and content of concretions and gravel. Soil samples were taken on the basis of the cropping system prevailing in the District. Thus, a total of 15 samples were taken to cover fields grown to rice, maize, sorghum/millet, groundnut, cotton and yam. The soil samples were brought to the Institute for analysis and interpretation. Farmers were also interviewed to derive information on farming practices and problems.

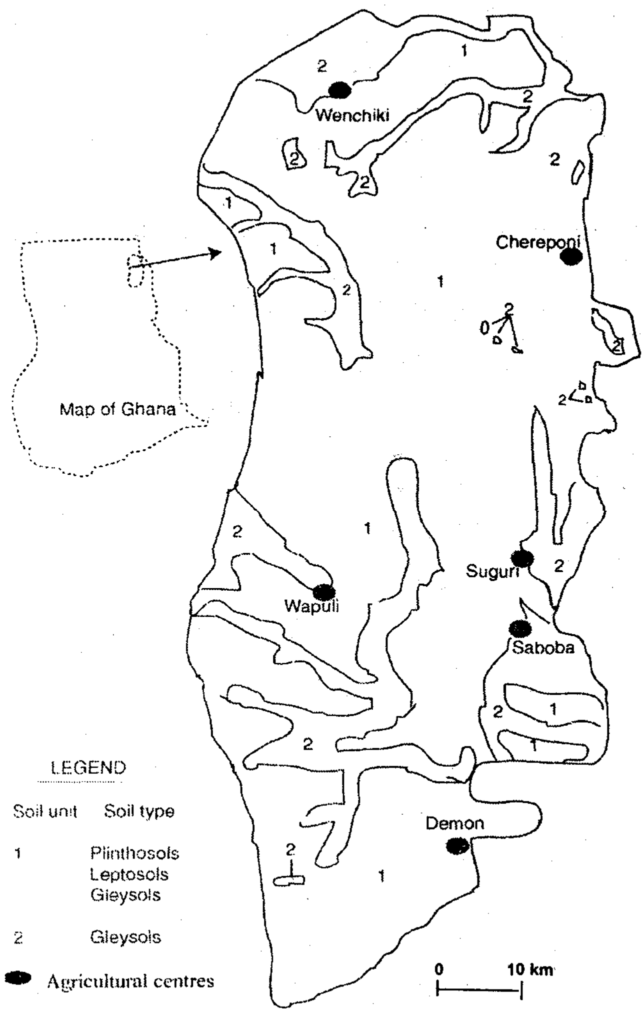

Fig.1. Map of Saboba-Chereponi District showing major soil units and some agricultural centres

Laboratory analysis

Soil samples were air-dried, ground and passed through 2-mm sieve. Soil *p*H (1:2.5 water) was measured with a *p*H meter with a glass electrode according to the method described by Maclean (1982). Total carbon and organic matter were determined by wet combustion (Walkley & Black, 1934). Flame photometer was used to determine exchangeable potassium while atomic absorption spectrophotometry was used to determine calcium and magnesium as described by Thomas (1982) after extraction with 1.0 *M* ammonium acetate. Available phosphorus was by the method of Bray & Kurtz (1945). Mechanical analysis was by the pippet method as described by Gee & Bauder (1986).

TABLE 1

Observations at some of the sites visited

Site	*Observations*
Kiteake (floodplain of River Oti)	▪ Vast flat land ▪ Soil is *Lima series* -silty loam texture ▪ Spill over from River Oti resulted in floods that washed away rice crop in recent times. Water dries quickly at the end of the dry season (information from farmers)
Garimata (floodplain of River Oti)	▪ The same as Kiteake ▪ Very serious erosion
Demon/Namongbani (upland and valley)	▪ Soils generally found to be moderately deep ▪ Valley contains *Lima series* -quite extensive ▪ Only few iron pan exposure found
Sanguli	▪ Exposure of iron pan common ▪ Valley examined had iron pan encountered at 15, 32 and 50 cm in observation holes ▪ Tractor ploughing in the valley ▪ Maize farm examined on the upland has concretionary shallow soils with iron pans encountered at 28 and 30 cm
Tombu	▪ Soils observed are moderately deep sandy loam with common iron concretions and gravel ▪ Farmers mentioned the presence of iron pans in few places ▪ Use of hoe and bullock plough in land preparation
Chereponi	▪ Shallow soils with rock outcrops ▪ Tractor pan boulders and outcrops found
Wenchiki	▪ Shallow soil with rock outcrops ▪ Iron pan boulders and outcrops found

Results and discussion

Soil type and their characteristics

Table 1 shows soil types and their major properties (depth, texture, concretions and gravel). On the uplands, most of the soils observed consist of iron concretions at the top and underlain by iron pan at various depths. Where the underlying iron pan occurs at a depth of 30 cm or less, the soil is *Wenchi series (Epipetric Plinthosol*). Where the underlying iron pan occurs at or more than 30 cm then the soil is *Kpelesawgu series.* Normally, *Kpelesawgu series* have the iron pan at depths of about 50 cm. These soils are supposed to be the dominant soils but observations show that they have been degraded to the extent that the iron pan is exposed on the surface as outcrops and boulders in several locations, and these areas are rendered uncultivable as a result. In several other locations, the iron pan occurs between 30 and 50 cm. In these places, the soils are used for cultivation of maize, sorghum, millet and groundnut.

The process of iron pan development and the manner they are getting closer to the surface and limiting root development is a serious threat to the soil resources of the

District. The process is hastened by erosion and tractor ploughing which bring up the subsoil to the surface.

Lima series are commonly found in the valleys and extend to the lower slopes of the upland in some locations. They are normally deep, imperfectly drained pinkish grey loamy sands. These soils were found to be cultivated to yam on the lower slopes where drainage was better. This was found in all the valleys visited. In two locations visited in Kuteake and Garimata, they were observed to be very extensive but are seriously affected by severe flooding from spill-over of the Oti river. The floods had washed away rice crops in recent times and, as a result, farmers have abandoned cultivation in these valleys. Severe erosion was observed in these floodplains (Kuteake and Garimata). However, the soils found at these locations are deep, silty or sandy loam. Due to their light textures, water quickly dries out from the top layers. These soils can be used for rice and dry season vegetable production under irrigation.

Some valleys which are occupied by *Lima* series are not influenced by the Oti flood. However, they are water-logged at the peak of the rains. These valleys were inspected at Namongbani and Sanguli, and rice is commonly grown in them. The absence of water control measures in these valleys lead to severe sheet erosion and rapid loss of water during short breaks in the rains and at the end of the rainy season. It was also observed that the *Lima* soils are prone to iron pan development. At Sanguli, iron pan exposures were commonly found and in the observed profiles, they were encountered at depths between 15 and 50 cm.

The Demon-Namongbani area was found to have good soils consisting of moderately deep, well-drained sandy loam topsoil overlying sandy clay loams in the subsoil. The soils contain only few to common iron concretions. However, any intention for high investment in agriculture will require a more detailed study to evaluate the extent and productivity of the soils for the planned use. From Chereponi area to Wenchiki and beyond, the soils were found to be largely shallow to rock. Rock outcrops were common all over this area and soil depth was generally found to be less than 50 cm.

Soil fertility

Soil fertility parameters (0-20 cm) of some of the selected sites are presented in Table 2. Soil *p*H ranged between 5.4 and 7.2 and generally good for the crops grown in this area. Low soil *p*H of 5.4 is within the *p*H range required for rice cultivation and may even rise with flooding. Exchangeable bases show a relatively serious problem especially magnesium and potassium. Except at Chereponi-Omati and Gbenja, values for exchangeable magnesium were all below 1.0 cmol (+) kg^{-1}. Moderate values [>2.0 cmol (+)kg^{-1}] of exchangeable potassium were observed at only three sites. About 60% of the sites gave moderate values of exchangeable calcium [>5.0 cmol (+) kg^{-1}] while over 25% show serious problem with exchangeable calcium [<2.0 cmol (+)/kg^{-1}]. Exchangeable acidity is of little problem for most of the sites. However, at Sanguli-Labaldo, very low exchangeable bases [Ca+Mg+K=2.0 cmol (+) kg^{-1}] coupled with the highest exchangeable acidity value [0.65 cmol (+) kg^{-1}] may create a problem. Given the environmental setting of the area, organic matter status is moderately good (> 80% of the sites showed

Saboba	6.4	1.6	0.48	0.07	0.10	3.2	5.6	9.7	740	210	50
Saboba	6.1	1.7	0.45	0.06	0.20	0.7	5.3	9.2	670	280	50
Chereponi-Omati	6.2	5.8	3.20	0.22	0.10	1.1	6.0	10.3	555	340	100
Chereponi-Omati	6.3	7.5	0.16	0.19	0.15	1.5	7.1	12.1	610	290	100
Chereponi-Banjani	6.3	7.5	1.28	0.25	0.15	2.2	11.6	19.9	680	250	70
Chereponi-Banjani	5.6	4.2	0.64	0.15	0.15	0.7	9.9	17.1	470	450	80
Chereponi-Banjani	6.2	5.3	0.96	0.19	0.15	1.1	14.7	25.3	590	330	80
Wenchiki	6.2	4.8	0.80	0.17	0.10	1.8	8.6	14.9	460	440	100
Wapuli	6.2	7.0	0.48	0.18	0.10	3.2	10.9	18.9	560	350	90
Wapuli	6.8	6.2	0.80	0.17	0.10	2.9	8.8	15.2	590	320	90
Gbenja	7.2	9.1	1.28	0.22	0.25	4.0	11.6	19.9	560	380	60
Demon-Namongbani	7.1	5.0	0.64	0.17	0.20	6.8	9.1	15.6	690	250	60
Demon-Namongbani	6.1	1.8	0.64	0.10	0.35	0.7	9.0	15.6	640	300	60
Sanguli	6.6	5.0	0.64	0.17	0.10	4.7	7.4	12.7	640	270	90
Sanguli-Labaldo	5.4	1.4	0.48	0.08	0.65	1.1	4.6	7.9	360	550	90

10 g/kg or more organic matter). The fallow site at Chereponi-Banjani gave the highest value of 25.3 g/kg organic matter.

Available phosphorus is the most limiting nutrient, being very low to low throughout the District. The soil *p*H values suggest that P fixation may not be a problem although available phosphorus is low in these soils. According to Wild (1988) and more recently Abekoe & Tiessin (1998), ironstone concretions are sinks for P and, therefore, contain appreciable amount of phosphorus, which is not easily available to crops. The presence of few to abundant iron concretions in most of these soils may partly explain why available phosphorus was very low.

Most of the soils are sandy loam in nature. This has serious implications regarding water and nutrient retention. The limitation in soil physical properties can be improved through addition of organic matter. The importance of organic matter in improving the cation exchange capacity (CEC) of tropical soil has been reported by some authors. Kadebe & Benjaminsen (1976) reported that 56-83 % of the variations in the CEC of tropical soils were due to organic matter. In Nigeria, Oyediran (1990) also observed a positive correlation between organic matter and CEC. Judicious use of crop residue, manure and improved fallow will result in improvement of the organic matter status of these soils and, hence, their general fertility status.

Farming system

The major crops grown include sorghum, millet, groundnut, maize, yam, cotton and cowpea. The extent of cultivation of each crop vary yearly depending largely on the price of that crop the previous year. Cotton has been recently introduced and incentives given to farmers by the Ghana Cotton Company explains why large areas are being put into cotton cultivation.

Cropping systems practiced are mixed cropping, crop rotation and continuous cultivation of one and the same crop. Mostly, sorghum and millet are mixed crop and sometimes groundnut is intercropped with sorghum or millet. These practices were observed throughout the District. Crop rotation comes in various forms. These include maize-sorghum-cowpea, which may be repeated or followed by groundnut; another rotation is maize-yam-cotton. In most cases it seems farmers do not consider the implication on soil fertility when planning their rotation. Continuous cultivation, mainly involving maize, was observed at Wenchiki.

Soil fertility is maintained by the application of household refuse, animal manure and fertilizer. The manure sources are from cattle, sheep and goats, which are normally inadequate. Fertilizer is usually applied to only maize, rice and cotton. Rates of fertilizer application depend on its availability and the ability of the farmer to obtain it. Usually, the amount applied ranges from zero through top dressing with only two bags of sulphate of ammonia to two bags 15-15-15 and two bags of sulphate of ammonia per hectare. Point application is usually the preferred method of application. At Tombu, farmers sometimes mix chemical fertilizers with cow dung before application.

Tractor operation and their effect

The use of tractor for ploughing is common and widely spread throughout the District. Concern over the use of tractor is due to the degradation effect it has on the fragile soils. Such areas have extensive distribution of surface ironstone concretions and iron pan exposures. At Tombu, where bullock ploughing is the major method of land preparation, the presence of iron pan is not common.

The following effects were observed in areas commonly ploughed by tractor; 1. Exposure of concretionary subsoil to the surface which hastens their hardening into iron pan. Iron pan boulders and outcrops commonly found throughout the District are a manifestation of this problem; 2. Soil erosion resulting from improper ploughing was also common. Most soils may have had iron pan deep in their subsoil, but widespread erosion of the topsoil has brought these pans close to the surface. In most of the inspection holes dug, iron pan was encountered at depths between 15 and 50 cm. Erosion of the topsoil will also result in loss of soil fertility; 3. Soil compaction arising from the heavy tractors was also common. Such compaction inhibits root penetration and aeration. It also causes higher run off.

Nearly the whole of the District is underlain by shale, which constitutes the parent material of the soils. Soils developed over shale are commonly found to develop iron concretions and iron pan than any other parent material. These may develop in their subsoil but improper use of the soil may either bring it closer to the surface in which case root depth is limited or exposed on the surface by which the land is rendered uncultivable.

Recommendations

Based on field visits, interaction with farmers and soil analysis, the following recommendations are proposed.

Soil conservation

1. Hand cultivation and the use of bullock plough (with small ploughs and ploughing across the slope) should be the preferred methods of land preparation. If tractors will continue to be used, then operators should be trained and insisted upon to do the right thing. Slope-wise and deep ploughing should be avoided; 2. Good and relatively extensive *Lima soils* should be managed as follows: (i) sites along the Oti river (e.g. Kuteake and Garimata) can be put to profitable crop production if flooding from the river is controlled and the water used for irrigation; (ii) other valley bottoms require water control through bunding for rice production. This will also check soil erosion; (iii) the use of heavy tractors should be avoided as much as possible since it enhances the development and exposure of iron pans, soil compaction and surface sealing. However, smaller and lighter tractors with appropriate implements can be used for land preparation and management.

Soil fertility

For improved and sustainable production, both the physical and chemical properties of the soils must be improved. It is important to conserve the soil by minimizing erosion and the development of iron pans as stated above. In addition, the fertility of the soil must be raised for increased production. The need to improve the fertility of these soils is further buttressed by the following:

1. Crop residues should be worked into the soil (hoe, bullock or tractor, if necessary). This is to ensure organic matter build up for soil improvement, both physically and chemically. Organic acids also inhibits iron pan formation; 2. Fallows should be vegetated with soil fertility enhancing plants. These may include, mucuna, cowpea, or any leguminous crop suited to the area.

Seeds of these crops should be broadcast at the start of the rainy season; 3. Cow dung and any animal droppings should be used judiciously; 4. Where chemical fertilizer is available, compound fertilizers should be applied at planting or at most 2 weeks after planting followed by top-dressing 6 weeks (or at tasseling or booting stage) after planting. With straight fertilizers, 1/3 of the nitrogen should be applied together with all K and P fertilizers. The remaining nitrogen should be applied as stated above. Recommended rates are maize 60-60-30; millet/ sorghum 60-30-30 and groundnut 20-55-25 ha^{-1} (Sarfo, 1998).

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