A COMPARATVE ANALYSIS OF CONVENTIONAL AND FARMERS' INDIGENOUS TECHNOLOGICAL KNOWLEDGE IN SOILS: THE CASE OF BANKANU VILLAGE, KWARE LOCAL GOVERNMENT AREA, SOKOTO STATE.

BY

Abdulrahim, Marufdeen Adekunle, (P.hd)
Department of Geography, Usmanu Danfodiyo University, Sokoto.

Abstract

There has been a long argument that conventional Knowledge is superior to Indigenous Technological Knowledge (ITK) on the premise of the former been able to measure precisely
and examine microscopically, while rural people with ITK are usually relatively weak on measurement and unable to observe except with the naked eye. Thus, this paper therefore, attempt to further verify the claim by comparing and contrasting the strengths and weaknesses
of conventional and indigenous Knowledge in taking parametric measurements of soils' physical and chemical properties for agricultural purpose. To achieve the broad objective, 63
soil samples were collected in the study area by systematic random sampling for laboratory analysis. The same samples were examined by the respondent farmers who offered their ITK of

soils to give the parametric values of the soils properties. These values were eventually compared. The results revealed that in the area of soil texture, ITK is superior in measurements
than Conventional while in the other areas which include soil colour and details of soil nutrients
Conventional is measurable and precise. It iis therefore recommended that it is important for outsiders to understand rural peoples' way of

thinking in order to avoid misunderstandings. Thus integration of the two types of knowledge for sustainable development of the Nigerian Environment becomes imperative.

Introduction

Outsiders' scientific technology are superior to Indigenous Technological Knowledge because it is being able to measure precisely and examine microscopically, while rural people are usually relatively weak on measurement and unable to observe except with the naked eye (Chambers, 1984). For instance, the outsider's knowledge can both measure trace elements and identify missing trace elements in soils. This cannot be done by the rural peoples' knowledge. Whereas the ability to know this could guide land management practices that would add or conserve the required trace elements in the soils. Thus, the rural people lacks precise quantitative gathering, experimental control and sophisticated biochemical analysis.

Unfortunately, these dazzling capabilities blind outsiders. For originators and bearers of modern scientific knowledge, it requires a major effort to recognize that rural people's knowledge exists at all, let alone see that it is often superior. The arrogance of ignorant educated outsiders is part of the problem. According to Chambers, "they do not know what rural people know and do not know that not knowing matters" (Chambers, 1984:p.98) By natural rule, nobody should arrogate knowledge to himself or herself because; it exists infinitely in accordance with the experience of different races in their different environment

in time. This fact, is already earlier proven where case of rural knowledge is superior to the outsiders in respect of mono cropping versus mixed cropping which gain upper hand in the context of rural technology (Yayock et al 1987). Moreover, it has been proven that even though

The outsiders have systematic way of experimenting and possess quantitative knowledge, the precision of people could probably have given much more accurate estimates of village level grain losses in storage than those figures which were so misleadingly believed for so long. Most of the relative strengths of rural people's knowledge lie in what can be observed locally and over a sustained period and in what touches directly their lives and livelihoods. Obviously, this applies to their knowledge of customs and practices (Chambers, 1983). There is however, little doubt that people at the "grassroots" have knowledge of their environment that transcends conventional social economic and biosocial indicators (Mwesigye, 1996).

The local people also have standards and units of measurements and may incorporate important criteria, which outsiders would otherwise miss. People could also be taught or helped to measure or quantify. Thus, the rural people are not totally ignorant of quantitative knowledge. Occasionally however, both outsiders' knowledge and knowledge of rural people can be wrong (Chamber, 1984).

In the light of the above arguments, this paper attempt to assess the physical and chemical characteristics conventionally as comparable to the Indigenous Technological Knowledge ITK practice of the farmers in Bankanu as a case study with a view to establish the place of ITK in quantitative measurements as obtained conventionally. Thus, this paper is divided into four parts, the introduction, the second part contains materials and methods, the discussion of the results and concluding remarks are in sections three and four respectively.

Materials and Methods

The study area is about 270Mtrs above sea level. The settlement is intersected by latitude 13^{o} $14^{/}$ $13.10^{//}$ N and longitude 5^{o} $15^{/}$ $14.30^{//}$ E, North of Sokoto town (Fig 1)

Fig 1: BANKANU VILLAGE.

There are 63 soil samples collected using systematic sampling technique on the landscape. The soil samples were conventionally analyzed for physical and chemical parameters and compared with farmers ITK of soils. The physical parameters examine were the soil texture and soil color. The chemical parameter tested were; pH in water and Calcium Chloride, Organic Carbon, Nitrogen, Cation Exchangeable Capacity, Sodium, Potassium, Calcium, Magnesium and Phosphorous. The Data acquired for the indigenous Technical Knowledge were obtained from primary and secondary sources. The secondary sources are documents and official reports such as Sokoto Survey Report, Journals, books from Libraries and History Bureau in Sokoto. Topographical map of the study area (FRN, 1974).The primary sources are personal observations. Interviews and questionnaires in form of structured and unstructured format were also utilized as the research instrument; participatory research in form of Focused Group Discussions (FGD), was also used to augment ITK information derived from individual.

Prefieldwork.

The study of existing data shows that; a topographical map of 1:100,000 scale Sheet No 10 was used in collaboration with panchromatic aerial photographs of 1:25,000 scale interpreted prior to the field visits in order to identify the soil sample points. The available Aerial photographs (Kentine Africa, 1978) interpreted with the use of mirror stereoscope are the photo products with clarity and high resolution. The interpretation of the photographs were based on tone, contrast of color, texture, figure ground, and all other basic elements in conjunction with the secondary and inferred elements. These interpretations were followed by the field reconnaissance survey in order to familiarize the researcher with the area. Thereafter, the appropriate intensive/management scale 1: 12,500 which only becomes superior in the range of intensive scale according to Young, (1976) was adopted for this field study. Thus, one sample per 12.5 ha tied to the 1.25,000 scale aerial photographs has been used.

Landscape Sampling and Procedure

The need for sampling landscape is because it is continuous but variable in nature. Thus, to discover landscape properties, observations must be restricted to small part only, that is, to a sample (Mitchell, 1991). Consequently, Bankanu village has been purposively chosen because it has been identified with rural characteristics where indigenous knowledge of land management is still strongly practiced. Having purposively chosen Bankanu, Systematic Random sampling technique was used for the landscape sampling in respect of the Land Management/Detailed Survey following Young, (1976); Dent and Young, (1981); Landon, (1991); and Mitchell, (1991).

To abide by the systematic method being the same as grid survey required of any management survey (Young, 1976, Landon 1991 and Mitchell 1991); a series of parallel traverse lines intersecting at fixed intervals of 353.554m were super imposed on a pair of aerial photograph NGH19087 and NGH19088 because they sufficiently covered the study area at a scale of 1:25,000 snapped in 1978 along with the 1 100,000 scale topographic sheet No. 10 captioned "Sokoto" prepared in 1974 and transferred on to the landscape. What followed the grids was the random sampling of the composite soil samples (0-30cm depth) around each soil sample points with the use of random number table. Composite soil samples are the mixture of soil samples collected at the sample point and its immediate surroundings (60cm). This systematic randomness was however carried out by tracing the grid referencing Eastings and Northings coordinates of the graticles from the bottom left of the table upward. Eventually a total of 63 soil samples were collected from a total area of 778.13 ha.

Respondents Sampling Size

Within Bankanu village, 63 respondents (farmers) were sampled out of 636 farmers' list (FRN, 1991) that forms the sample frame. Thus, 10% samples were taken. These respondents were served with questionnaires. In other words, the owners of the sample plots were interviewed. The nature and characteristics of the respondents required of indigenous knowledge studies have been widely accepted to be matured men and women who have knowledge of historical profiles and time trend in the acquisition of the indigenous knowledge and experiences in their locality with minimum age of 30 years (Kinyunyu and Swantz, 1995). In the light of this view, respondent's farmers have the aforesaid qualities and thus, were interviewed. This is because of the nature of the research being on indigenous knowledge which relies heavily on person's long standing association with a community.

Fieldwork: The field observation reveals that the farmer's fields were visited in order to make on the spot assessment of their land management practices. Also, photographs of selected farmlands were taken.

Interview and Questionnaire Administration

The questionnaires administered, apart from the oral interviews been used to unveil other salient information; were divided into three sections. The first section is on indigenous and conventional land management practices in Bankanu. The second section was designed to enable researcher assess the extent of indigenous knowledge of land management through the respondents' farmlands side by side interviewing them on the nature of their farmlands. The third section is on a focused Group Interview.

Focused Group Discussion Approach

This approach is recent and akin to participatory method, which gives outsider/researcher a chance to learn how the local people live and sustain their everyday, lives by using open-ended questions (Kinyuyu and Swantz, 1995). The approach seeks a more systematic accommodation of indigenous knowledge in research on technological intervention (Shafer, 1989; and Sillitoe, 1998). The method therefore, integrates members of the community as research assistants because they are knowledgeable about their surrounding lands and communities.

It is in the light of this recognition that the focused Group Discussion (FGD) approach is hereby applied. The FGD often consist of farmers in the group that participated in the discussions related to their knowledge of indigenous land management practices in the study area.

The outcome of the group discussions brought out salient information to corroborate what has been gathered from individual farmlands. Information such as social - organization, land tenure in operation, indigenous land classifications and the bases and when the indigenous knowledge has been handed over were discussed. The responses were tape recorded and later transcribed. The gathering of the group took place on two consecutive Fridays from 4-7p.m. after the "Jumaat and Asri" prayers.

Soil Samples Collection

The collection of the samples took place because it provides a better estimate of mean values than the single sample from a specific point. The instruments used were buckets and screw augers on the basis of the USDA Soil Survey Manual (1954) and the soil description form used. Each sample was collected in a polythene bag and labeled accordingly.

Global Positioning System (GPS) was used to reference the soil sample points selected from farmlands where the farmers were interviewed on indigenous land management. The materials used for the profile pit observation on the field were diggers, shovels, buckets, matchets, augers, rope, moisture tester, hydrochloric acid to test for the carbonate content of the soil, magnifying lenses of 3xs , Munsel Soil Color Chart, traveling bag, soil bag, transport, 2Nos laborers. Other materials/instruments used are Prismatic Compass, Abney Level, Steel Tapes, Ranging Poles to measure the direction, slope angle, lengths.

Post field work: The laboratory analysis of the soil samples taken reveals that the collected soil samples analyzed in the laboratory for some physical and chemical characteristics. The soil samples were air dried and passed through a 2mm sieve. Particles larger than 2mm are weighed as the gravel content in the sample. The samples were analyzed for the various parameters by the methods described by Page, et al (1982). The particle size analysis was performed by the hydrometer method and the texture determined on the USDA triangle. As regards the soil reaction, the soil pH in both water (1:1 ratio) and 0.01m Calcium chloride (1:2 ratio) was measured on a pH meter.

The organic carbon was determined by Walkey blakey method. The total Nitrogen was determined by Macro-kjeldahl digestion - distillation method. The Cation Exchangeable Capacity (CEC) of the soils was determined by Ammonium saturation method, in respect of the Exchangeable bases in the soils, they were extracted with the neutral normal ammonium acetate solution. The extracts were analyzed for Calcium and Magnesium by EDTA titration Method and Sodium and Potassium by flame photometry. The available Phosphorus was determined by Bray 1 method.

The Soil color is due to two factors humus content and the chemical nature of the iron compounds present in the soil (Olaitan and Lombin, 1985). The procedure was derived by the use of the Munsell color charts. It possesses a series of standards representing soil color according to the Hue, Value and Chroma arranged in a form of matrix. Each soil sample was compared with the color it matches when dry and when wet and consequently recorded.

Results and Discussion

Soil Physical Properties

The physical parameters that are hereby measured on both conventional and indigenous techniques for comparison are soil texture and color in relation to the topography they are found. By and large, in respect of topography, both knowledge practices agreed with the concept of upland and lowland with their flooding "fadama" as the same, therefore they are not taken for further discussion.

Soil Texture:

The five indigenous land classes identified by the respondents in Bankanu *(Yashi, Fako, Baringo, Farin laka and Bakin laka)* have been regrouped into three (Sand, loamy Sand and Sandy loamy) textural classes based on the result of the laboratory analysis (Table I). *Yashi* whose equivalent meaning is sand falls as sand conventionally *while fako* soils that actually means derelict land with regoliths is also conventionally classified as Sand. *Baringo* soils having literal meaning of soils that is clayey is mostly classified as sand with barely three (27.27%) of the total *baringo* soil samples conventionally classified as loamy sand. *Farin laka* (white clay) and *Bakin laka* (black clay) soils whose meanings emphasis clayey soils are both grouped as sandy loam based on the conventional approach to textural analysis.

The observation as regards the comparison of the indigenous and conventional approach to soil textural analysis is that unlike indigenous textural classification that is specific and more detailed, the conventional textural classification is generalized as the case of *Yashi. Fako* and most *of Baringo* soil samples. By and large, *Baringo* soils being divisible as sand and loamy sand is a further proof that conventional method sometimes generalize. This sometimes brings about inconsistencies in the classification between the indigenous and conventional techniques. This observation is not unconnected with the claim of Kante and Deafoer, 1994, that; "unlike the local peoples' knowledge which is specific to local conditions, the conventional knowledge is a comprehensive system which tries to generalize and are not normally developed by users". Consequently, it can be safely put forward that the relative strength of indigenous soil textural classification over conventional method is it's near accuracy and site-specific characteristic. *Farin and Bakin laka* soils are also generally grouped as sandy loam. Besides the color contrast, a latent difference *between Farin* and *Fakin laka* is that *Bakin laka* has higher silt content than *Farin laka.*

On the overall, it is obvious that the textural class, which exists in conventional knowledge, also exist in indigenous knowledge. By and large, there are either significant exaggeration or under exaggeration on the part of conventional and indigenous knowledge of soil texture, particularly in the sand texture class by conventional method which grouped three classes of indigenous texture namely *"kasanfako ", "Yashi* and *"Baringo "* together. *"Kasanfako "is* even though sandy as conventionally analyzed, contains more of regoliths or otherwise called gravels far greater than 2mm diameter than *"Kasan yashi"* known to be the only sand in indigenous soil textural sense. The differentiation *of yashi* from *fako* by the respondents therefore, indicate that indigenous knowledge of soil texture is more detailed than conventional knowledge in that respect because the conventional textural class did not provide class for regoliths/pebbles or gravels such *that fako* soils would have been placed in those category.

Table I: Indigenous and Conventional Soil Textural Classes

Indigenous soil texture (*yanayin kasa)*	Conventional soil texture	Sample sizes
Yashi	Sand	36
Fako	Sand	07
Baringo	Sand	08
Baringo	Loamy sand	03
Farin laka	Sandy loam	06
Bakin laka	Sandy loam	03
Total		63

Source: Author's fieldwork (2005).

"Kasan Baringo" is known to contain some clay content by indigenous knowledge practice because it is slightly sticky when held, while the laboratory analysis shows it is sandy and to a little extent loamy sand when read on the soil textural class.

A closer examination however, indicated that the *"Baringo* soils" is overlapping the sand and loamy sand textural triangle. Furthermore, *"Farin Laka"* and *"Bakin laka "* in indigenous knowledge meaning white clay and black clay soils have not yet contained any sufficient clay content by conventional method of classification as it is sandy loam on its textural triangle. This is a show of disparity in indigenous and conventional textural classification. In this light, the indigenous knowledge practices in Bankanu of soil texture classification are more sensitive to differentials in soil textural compositions than the conventional knowledge in soil texture classification.

Soil Color:

The soil color of the respondents farmers field were examined under dry and moist conditions (see table II and appendix I) with the use of Munsell soil color charts. The outcome of the comparison of soil color between the indigenous and conventional method shows that the respondents color classification is simple not complex and lack detail unlike conventional knowledge of color differentiation. This is because where the indigenous knowledge in the study area only has three colors *(launi)* namely white *(fari),* red *(ja)* and black *(baki)* the conventional method has a lot of sub divisions of the major colors as already highlighted. For instance, sand *(yashi)* being referred to white color by the respondents is specifically differentiated with a munsell soil color chart into yellow when dry to strong brown when wet and reddish yellow to yellowish brown. Furthermore, the indigenous color is often approximated as what the respondents refer to as red (ja) in *Baringo* is conventionally known as strong brown, light red to weak red.

Table II: Indigenous and Conventional Soil Colour

Indigenous land classes/soil texture	***Conventional soil texture***	***Indigenous color***	***Conventional color when dry to when wet***	***Munsell Notation for color, when dry to when wet***
Yashi	Sand	*Fari* (White)	Yellow to strong brown, reddish yellow to yellowish brown.	10YR/7/6 to7.5YR/4/6, 7.5YR/7/6 to 1OYR/5/8
Fako	Sand	*Ja* (Red)	Yellow to strong brown, reddish yellow to yellowish brown.	10YR/7/6 to 7.5YR/4/4, 5YR/5/8 to 5YR/3/4 and 2.5YR/4/4 to 5YR/3/4 10YR/7/6 to

Baringo	Sand	*Ja* (Red)	Yellow to strong brown, light red to weak red.	7.5YR/4/6, 10R/6/8to 10R/5/4
Baringo	Loamy sand	*Ja* (Red)	Light red to reddish brown.	10R/6/8 to 5YR/5/4
Farin laka	Sandy loam	*Fari* (White)	Yellowish red to reddish brown, light red to dark reddish grey.	5YR/5/6 to 10YR/4/4, 10R/6/8 to 5R/4/1

Source: Author's fieldwork and Munsell Soil Color Chart (2005)

Similarly, the sandy loam (Farin laka) being called white clay and sandy loamy (Bakin laka) being called black clay are respectively of yellowish red to reddish brown, light red to dark reddish grey and dark grey to very dark grey in the munsell soil colour chart. In this case as well, the indigenous method is not as specific as the conventional method.

In summary, the considered two physical properties compared under indigenous knowledge and conventional method have indicated that; indigenous knowledge of soil texture is more specific, concise and thorough while the conventional method is more generalized and of broad classification. Color wise, the conventional method is however, more specific than the indigenous knowledge of color and classification as already examined.

Soils Chemical Properties

The conventional result that is specifically compared with the indigenous knowledge of the respondents' farmers is the soil reaction (pH) because it has corresponding terminology in Bankanu indigenous land management practices. All other parameters; Organic Carbon, Nitrogen, Cation Exchange Capacity (CEC), Sodium, Potassium, Calcium, Magnesium and Phosphorus as presented in the appendix (II) have no specifically corresponding terminologies. Consequently, the parameters are lumped together to conclude on the extent of nutrient fertility status of the soil/land type for comparison with the indigenous soil fertility status The succinct comparison with the pH conventional method of the Bankanu respondent farmers is predicated on the response of the farmers that they have a way of distinguishing acidity level of soil by taste. The other chemical variables in the conventional methods are not specifically made mentioned of by the indigenous farmers of Bankanu who generally called them nutrients. Therefore, the basis for comparison between the indigenous and conventional method is in respect of the nutrients fertility status.

Soil Reaction

The pH data on the entire soil samples fell between the ranges of 6.21 and 7.57 pH Scale. The conventionally classified sandy textures are mostly between 6.21- .67 pH Scale, the loamy sand samples are classified between 7.21 and 7.48 pH scale and sandy loam is within the range of pH 7.26-7.57.

On comparison with the indigenous knowledge of soil reaction by the respondents, they tasted the soil reaction with their tongue instead of laboratory as the case of conventional method. The Bankanu indigenous farmers therefore reported three types of tastes found in their soils. These are *"gishiri"* taste meaning *"salty", "babii "* meaning none and *"dalch"* meaning sour taste. The three sequences they present means pH Scale 7 to 14, 7and 1 to 7. The *"Yashi"* sandy soils mostly fall under slightly acidic *dachi* (less than pH7) The *"Fako"* soils all fall under alkaline group (greater than 7). Similarly, *"Baringo "* soils classified as loamy sandy soils by conventional method also have alkaline pH characteristics having recorded greater than pH 7 (for example serial number 18 in appendixes ii) and some are equal to 7 which is neutral. In effect the pH classification also exists in the Bankanu indigenous system of soil pH, which aids their land management practices. Although, their own grouping are three major classes similar to conventional but it lacks sub-classification for detailing as in the conventional method.

Nutrient Fertility Status

By conventional method, the averages of the laboratory results of the Chemical nutrients assessed by the conventional method have the same ratings with the indigenous fertility ranking (Table 3). The only difference is in respect of Fako that was rated last by the indigenous method whereas the conventional method rated it 4th. Also, the sand been rated 4th by the indigenous method has been rated fifth in accordance with the laboratory result Generally speaking, the two methods are highly positively related more because 60% of the two methods of fertility ranking have the same ranking.

Table 3. Indigenous Fertility Assessment Compared with the Conventional Nutrient *f* fertilit ters.

Indigenous Knowledge of .and Types/Soil	Indigenous knowledge of Major Crops Grown.	Indigenous knowledge Most Suitabl Crops Grown	Indigenous knowledge of Years of Continuous Cropping (YCC).	Indigenous Fertility Ranking.	Conventional Nutrient Parameters Ranking
*Yashi (San*dy)	Millet, Cowpea Sorghum.	Millet Cowpe	2	4th	5th
Baringo	Millet, Sorghum and Cowpea	Sorghu Cowpe	4	3rd	*3rd*
Fako (Sandy/Regolith)	None	Browse for grazing animals	0	5th (due to Deficiency in fertility, it cannot be used for	4th

Bakin laka (Sandy	Sugarcane, Cassava, Potatoes Vegetables and Rice	All the	Indefinitely.	1st	1st
Farin laka (Sandy loam)	Orchard, Vegetables and cassava	Orchard and Vegetables.	1st	2nd	2nd

Source; Author's Fieldwork and modified based on laboratory result (2005).

Conclusion

In the light of the results of the discussions, it is hereby suggested that there is need to harmonize the two-knowledge system in order to have comparative advantages in land management practices. To forge ahead in respect of integration, it is important for outsiders to understand rural peoples' way of thinking and to avoid misunderstandings before integration could arise of the two types of knowledge for sustainable development of the Nigerian Environment.

References

Abdulrahim, M. A (2004) An Appraisal of Indigenous System of Agricultural Land Classification and Management in Bankanu, sokoto Close Setttled Zone, Nigeria.

Chambers, R. 1983: Rural Development: Putting the Last First. London, Longman. Pp. 75-101.

Dent, D and Young A. 1981; Soil Survey and Land Evaluation, London, George Alien and University of London. Pp. 128-139,

Federal Republic of Nigeria, 1991; National Population Census Commission. Lagos: Government Press.

Federal Republic of Nigeria. 1974; 1:100.000 Scale Topographical Map of Sokoto. Sheet No 10. Lagos: Federal Surveys.

Hesse, P.R. 1971; A Textbook of Chemical Analysis. London: John Marray.

Kante. S and T. Defoer 1994; 'How farmers classify and manage their Land: Implications For research and development activities', London, Issues paper No. 51. Institute for Environment and Development.

Kenting Africa, 1978: Aerial Photograph ofBankanu. Sokoto Closed settled Zone, Lagos-Kano: Resource Service Limited.

Kinyungu L. and Swantz M.L 1996; 'Research methodologies for identifying and validating grassroots indicators', in Hambly, H and Angura, T.O; (ed)

Grassroots Indicators for desertification, ph://www. idrc .ca/books/focus/794/preface. Html Pp.1 -12.

Mitchell,C. W. 1991; Terrain Evaluation: An Introductory handbook to the history.principle and methods of practical Terrain Assessment, second edition. UK: Longman.

Mwesigye F. 1996; "Language and Grassroots Environment Indicators" In Hambly, H and Angura T.O; (ed). Grassroots Indicator for Desertification. Hp://www.ldrc.ca/books/focus/794/perface. html pp 1 -4.

Olaitan, S.O and G. Lombin 1988; Introduction to Tropical Soil Science. London: Macmillan Intermediate Agriculture Series.

Schafer, I. 1989; 'Utilizing indigenous agricultural knowledge in the planning of agricultural research projects designed to a small scale farmer'. In Warren, D. M, L.J. Slickerveer, and S.O. Titilola (eds) Indigenous knowledge systems: Implications for agricultural and international development. IOWA State University, IOWA.

Sillitoe, P. 1998 'The Development of Indigenous knowledge'. In Fox **R.G.** (eds) Journal of Current Anthropology. Volume 39, Number 2, April. USA: The University of Chicago Press,

Yayock, J.Y., Ajayi 0., Karikari, S. K and Owonubi, J.J (1987) Improvement in the Productivity of food grains in drought prone areas of Nigeria. In J. M Menyinga, T. Bezunah and A Yondeowei (ecis), Proc. International Drought Symposium on food Grains Production in Semi and Regions of Sub Saharan Africa, 19-23 Mary 1986, Kenyatta Conference Centre, Nairobi. SAFGRAD, Ouagadougou, Burkina Faso, 96-115.

Young, A 1976; Tropical Soils and Soil Survey. UK: Cambridge University Press.