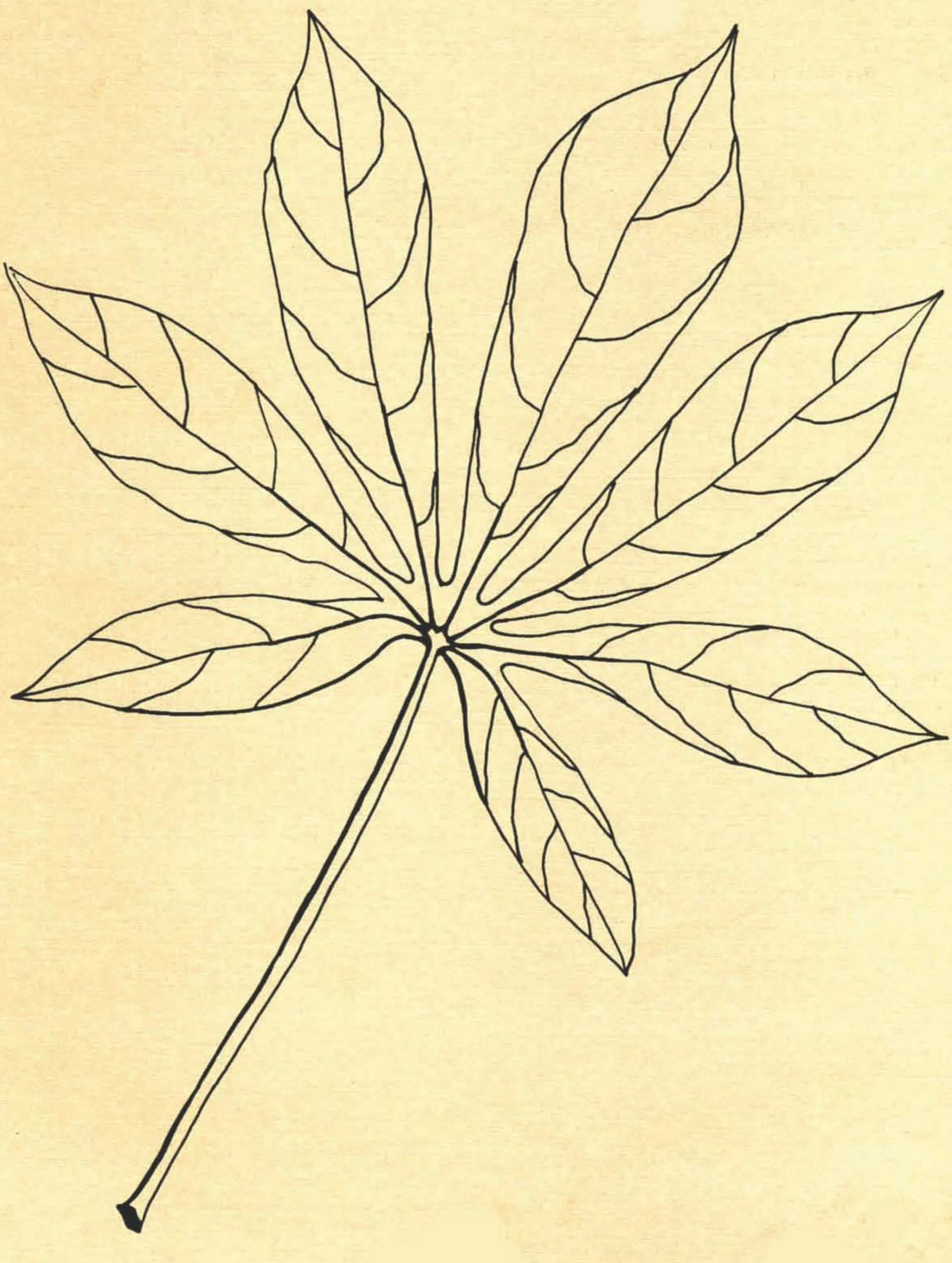
COSCA

Collaborative Study of Cassava in Africa
Working Paper No. 5

5

The Identification of Agro-ecological Zones for Cassava in Africa with particular emphasis on soils

J.J. Stoorvogel and L.O. Fresco



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Introduction

ALTHOUGH cassava's role as a major African staple and household food security crop is generally acknowledged (Jones 1959, Cock 1985), few details are known about the combination of factors which determine changes in cassava supply. Even basic questions, such as whether reliance on cassava is increasing or decreasing remain unanswered (De Bruijn and Fresco 1989). Major factors which influence cassava production and consumption are the ecology, human population density and the market infrastructure (Carter and Jones 1989).

This paper deals with ecological determinants of cassava supply: climate and more particularly soils. Cassava plant growth is optimal in warm humid climates with deep fertile soils, but the crop is known to tolerate considerably less favorable conditions (Cock 1985). In many areas, cassava can still be cultivated even after considerable land degradation has taken place. The objective of this paper is to show to what extent current cassava distribution coincides with suboptimal ecological conditions.

Materials and Methods

Africa is mapped into regions which may be regarded as homogeneous with respect to the ecological requirements of the cassava crop--so called agro-ecological zones, at a scale of 1 : 10,000,000. Previous attempts to do so, in particular in the FAO Agro-ecological Zones Project for Africa (FAO 1978), included only a few specific conditions for cassava and produced a classification of physical suitability, but not a description of agro-ecological zones.

The mapping is carried out in two steps: (a) zonation based on temperature and rainfall, and (b) zonation based on soils and topography. The resulting map is compared to actual cassava distribution as derived from (Carter and Jones 1989) for Nigeria and Ghana.

Climate. The climatic classification system for cassava elaborated by Carter (1987), needs modification to deal adequately with the level of detail required in the sub-Saharan region. Preference is, therefore, given to the Papadakis climatic map, which is also included in the soil map of the world (Papadakis 1970). The use of single value maps for rainfall and temperature will result in a fragmented division that does not correspond directly to large geographical units. Some degree of generalization is therefore necessary to maximize the level of detail as well as its readability and usefulness. Table 1 illustrates the structure of the Papadakis classifications as applied to cassava.

Cassava is well adapted to a wide range of climates. Optimal conditions are temperatures of 25°C to 29°C and at least 1000 mm of well distributed rainfall. Below 10°C the growth of cassava will stop, but the crop survives light frost. At temperatures above 29°C the yield will diminish. This paper uses an annual average temperature of 20°C as the lower critical limit. Cassava is occasionally found at high altitudes, but the crop is not widespread above 1500 m. For mapping purposes, and in order to avoid the fragmentation of zones, the limit of 1100 m is used. This limit encompasses the great majority of cassava-growing regions, with exception of the higher altitude zones in East Africa.

Table 1 Structure of the classification system for climatic regions for cassava

				CLASS	
Non-suitable	Mediterranean		M	6	
	Tropical highland		C	2	
	Desert		D	3	
Suitable	Semi-arid	tropical	A	1	st,mo
		sub-tropical	a	4	st,mo
	Savanna	tropical	S	1	MO,Mo
		sub-tropical	s	4	MO,Mo
	Humid	tropical	H	1	HU,Hu
		sub-tropical	h	4	HU,Hu

Source: Papadakik 1970.

Critical lower rainfall values for cassava vary widely, and the crop appears able to survive occasional annual rainfall conditions of less than 500 mm. For the purpose of this paper, the lower limit of 750 mm suggested by Cock (1985) has been converted to 900 mm in order to allow for adequate mapping.

Soils. The optimal soil for cassava can be described as well drained, light textured, deep and fertile. Cassava tolerates almost all textural classes, although very heavy soils reduce yield and apparently require more labor to harvest. Sandy soils are more likely to be less moisture retentive and less fertile. Cassava is tolerant of low fertility levels, low P content, high Al content and low pH. Poor drainage and salinity can cause serious problems.

The approximately 5000 units contained in detail (scale 1 : 5 million) in the FAO/UNESCO (1967) soil map of the world are used as a starting point. Units that are considered unsuitable with respect to climate and soil are excluded (e.g., desert areas or areas with saline soils).

Soils are classified into five groups in a declining order of suitability for growing cassava (table 2). Group 1 soils are the most favorable to cassava cultivation; group 2 soils exhibit certain textural restrictions (e.g., aerosols) and lower fertility (e.g., ferralsols); group 3 soils are similar to group 2, but the unfavorable soils are more concentrated. The restrictions in the soils of group 4 are so serious that these soils are unsuitable for cassava. Since these soils are unsuitable, no phases are added, to avoid further subdivision of the units. Group 5 contains all soils with salinity problems, which are for that reason totally unsuitable. As restrictions by phases occur in some cases, these are compensated by adding phases to the code representing a restriction: 't' represents textural restrictions, 'ℓ' for lithic or stoniness, 'p' for petric and/or petroferric phases. When phases are added the soil group does not correspond anymore with the suitability class. Grouping the original 5000 units of the FAO/UNESCO soils map results in a total of 475 units in the final map, which is presented on a scale of 1 : 10,000,000.

Table 2 Soil types grouped according to their suitability for cassava

GROUP 1 HIGHLY SUITABLE SOIL TYPES		
	Ao: Orthic Andosol	Lo: Orthic Luvisol
	Bc: Chromic Cambisol	Ne: Eutric Nitosol
	Be: Eutric Cambisol	Re: Eutric Regosol
	Hh: Haplic Phaeozem	Th: Humic Andosol
	Hl: Luvic Phaeozem	Tm: Mollic Andosol
	Lc: Chromic Luvisol	To: Ochric Andosol
GROUP 2 MODERATELY SUITABLE SOIL TYPES		
	Bd: Dystric Cambisol	Nh: Humic Nitosol
	Bh: Humic Cambisol	Ph: Humic Podsol
	Bk: Cambic Cambisol	Qa: Albic Arenosol
	Fh: Humic Ferralsol	Qc: Cambic Arenosol
	Fo: Orthic Ferralsol	Qf: Ferralic Arenosol
	Fr: Rhodic Ferralsol	Ql: Luvic Arenosol
	Fx: Xanthic Ferralsol	Rc: Calcaric Regosol
	La: Albic Luvisol	Rd: Dystric Regosol
	Lk: Calcic Luvisol	Tv: Vitric Andosol
	Nd: Dystric Nitosol	We: Eutric Planosol
GROUP 3 MARGINALLY SUITABLE SOIL TYPES		
	Af: Ferric Acrisol	Lf: Ferric Luvisol
	Ap: Plinthic Acrisol	Lp: Plinthic Luvisol
	Bf: Ferralic Cambisol	Lv: Vertic Luvisol
	Bv: Vertic Cambisol	Wd: Dystric Planosol
	Fp: Plinthic Ferralsol	
GROUP 4 NON SUITABLE SOIL TYPES		
	Ag: Gleyic Acrisol	U: Rankers
	Bg: Gleyic Cambisol	V: Vertisols
	G: All Gleysol	Ws: Solodic Planosol
	L: Lithosols	Xh: Haplic Xerosol
	Lg: Gleyic Luvisol	Xl: Luvic Xerosol
	O: Histosols	Y: All Yermosols
GROUP 5 ALL SALINE AND CALCIC SOILS, NON SUITABLE		
	All soils with phases - petrocalcic - petrogypsic - saline - sodic - solonchaks and solonetz	

3. Results

The map shows the combined climatic and soils mapping for cassava in Africa. Each of the mapping units defines an agro-ecological zone where similar climate and soil conditions occur. For example H2t in the map refers to humid tropical climate, moderately suitable land, textural restrictions phase (see legend to map).

Legend to Map

CLIMATIC SUBDIVISION

M	mediterranean climates
C	tropical highlands (1200 m)
D	desertic climates
A	semi-arid tropical climate
a	semi-arid subtropcial climate
S	savanna tropical climate
$	savanna subtropical climate
H	humid tropical climate
h	humid subtropical climate

LAND SUITABILITY

1. highly suitable
2. moderately suitable
3. marginally suitable
4. non suitable (no phases added)
5. saline and calcic soils (non suitable, no phases added)

PHASES

t	textural restrictions
s	topological restrictions
ℓ	lithic and/or stoniness phases
p	petric and/or petroferric phases

Notes: a. No land suitability and phases are added to M, C and D climatic subdivisions in the map. As they are already non suitable, a further subdivison is not relevant.
b. Land suitability is the soil suitability plus the number of phases, e.g. a soil suitability of 2 with one phase will give a land suitability of 3.

In most of western Africa, cassava cannot be grown north of the latitude 15° N as a result of the desert and mediterranean climate. Suitability increases marginally moving southward until the highly suitable Gulf of Guinea climate is reached. At the same latitude in the Horn of Africa, the climate is dominated by highland and desert conditions. East Africa is extremely varied in climate owing to the marked difference in altitude. The central Congo basin has a humid and hot equatorial climate and is, therefore, highly suitable for cassava. All of southern Africa, except for the coastal strip of Mozambique is dominated by a colder climate unsuitable for cassava. The coastal strip of Mozambique is warmer and better watered than its plains, and is therefore very suitable. Madagascar is very heterogeneous with very suitable areas at the west and east coasts. The southern part of Africa and the Kenyan highlands are dominated by climates not suitable for cassava.

With respect to soil zones the African continent is very heterogeneous, although some general patterns can be distinguished. As expected, the geographical distribution of the saline and alkaline soils is restricted to the dry areas of Africa. Just south of the Sahara, Arenosols are dominant (soil group 2). Further south to the Gulf of Guinea, groups 2, 3, and 4 are present. The tropical lowlands are dominated by Ferrasols (soil group 2) and Yermosols (soil group 4).

In Nigeria and Ghana, cassava is present in ecologically suboptimal zones. In Nigeria, cassava is present in all zones excpet in the humid coastal areas, where the soils have salinity problems. Main concentrations of cassava cultivation are found around Kano and Ibadan and other parts of southwestern Nigeria where there are areas of very high population density. In Ghana, cassava is concentrated in zone A1 (around Kumasi) and in zone S3 (around Accra). In northern Ghana (zone S3p), however, cassava is rarely grown in the humid southwest areas. This situation in Nigeria and Ghana is confirmed for the rest of Africa; a cursory look at a distribution map (Carter and Jones 1989) suggests that most cassava is found outside the most suitable climate-soil units.

Conclusions

This paper has briefly described the African soil zones with respect to cassava production. The optimal conditions for cassava production are very similar to those of other crops, and because cassava tolerates marginal conditions, cassava cultivation has no comparative advantage in the most suitable areas (De Bruijn and Fresco 1989). Comparison between cassava growing environments and actual cassava distribution in Nigeria and Ghana demonstrates that the distribution of cassava could be primarily a function of population density rather than of agro-ecological conditions. This suggests that cassava grows under suboptimal conditions where traditional soil fertility restoration through fallowing has deteriorated.

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Major soil zones for cassava in Africa are mapped and described using the FAO-UNESCO soil map of the world and taking account of rainfall and temperature limitations. A comparison of actual distribution of cassava with climate-soil zones in two countries suggests that the crop is mainly found in areas of high population density and under suboptimal ecological conditions. The agro-ecological zone determines the cassava cropping system, as well as cassava yields.

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