COSCA
Collaborative Study of Cassava in Africa
Working Paper No. 23

23

Cassava Production and Processing in Côte d'Ivoire

Felix I. Nweke, K. Ngoram, A.G.O. Dixon, B.O. Ugwu, O. Ajobo

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Contents

List of Tables

List of Figures

Executive Summary

Cassava was planted widely for sale; although tree crop production was the main source of cash income in the cassava-producing area, among food crops, cassava production was a source of cash income for the largest number of households. Cassava was the most important crop in the area studied, both in land area and farmers' ranking of the crops. Rice was second to cassava; maize, plantain, and yam were also important. Cassava land area expansion was reported in most villages in response to an increasing population of immigrants who worked in cocoa and coffee plantations. The villages which did not report the increasing trend were mainly around market centers where people had access to imported food and in areas where *attieke*, a convenient cassava food product, was made by manual methods which were very labor-intensive.

The food crop production practices were heavily influenced by tree crop growing. About 80% of the representative villages intercropped food crops with cocoa or coffee in one or more of their rotation systems; all food crops were involved in this practice. While tree/food crop systems were entirely continuous cultivation of food crops, food crop systems were 20% continuous cultivation with crop rotation and 80% fallow rotation. Fallow rotation was dominant because population densities were low and climate was mostly humid.

There was turnover in cassava cultivars grown by farmers, who continually introduced new cassava cultivars with desired attributes into their cropping systems. Such cultivars were not necessarily improved varieties but were often local and varied with villages and regions. As they introduced new cultivars, farmers often abandoned existing cultivars that might not possess desired attributes. The farmers were selecting the cultivars for high root yield, low cyanogen level, large canopy for weed control, and good processing qualities.

Although population pressure on land was low in the country in comparison with the other countries in the COSCA study, cassava root yield was below average. The cassava stand density which influenced the root yield positively and significantly was also below the average for other countries. Intensified land-use practices which also influenced the root yield positively and significantly were not adopted because population pressure on land was low. Purchased inputs including high yielding varieties were not adopted even though access to market conditions was better than average because the availability of imported rice around the market centers discouraged private investment in the use of the purchased inputs. In addition, most of the survey sites were in the humid zone where the root yield was low relative to the subhumid zone in other countries; and most of the cassava fields were planted with sweet cassava cultivars which were harvested early with low yields. The local cultivars were susceptible to the major cassava plant pests/diseases. The majority of cassava producers relied mainly on crop rotation, fallow management, and cultivar selection from among the available landraces to control the problems.

Cassava was commonly processed although more than 90% of the production was of the sweet cassava types. Processing labor-saving technology was available, but was not widely adopted. Similarly, the technique for making a convenient cassava food product was known but the product (*attieke*) was not widely produced, especially around market centers. Imported rice had an adverse influence on the demand for this product. The consequence was that the availability of the improved processing technologies did not produce the same result as in neighboring West African countries, Nigeria and Ghana, namely, an increasing trend in cassava land area.

PART ONE

INTRODUCTION AND METHODOLOGY

I. Introduction

In 1988, the Rockefeller Foundation made funds available to the International Institute of Tropical Agriculture (IITA) to collect authoritative information on cassava production systems, processing methods, market prospects, and consumption patterns in Africa. This information is needed to improve the relevance of research on cassava by national and international agricultural research centers, in order to realize the potential of cassava for increasing food supply and incomes of the people of Africa.

Côte d'Ivoire, Ghana, Nigeria, Tanzania, Uganda, and Zaire (Democratic Republic of Congo) were selected, as the leading cassava-producing countries of Africa, for the purpose of collecting the data. These countries also provide wide variability in climatic, demographic, and market pressures that have been hypothesized (Carter and Jones 1989; Stoorvogel and Fresco 1991) as determinants of cassava production. Burundi, Kenya, Malawi, and Zambia later began to collaborate with alternative funding.

Cassava contributed 10% of the average daily dietary energy intake per person in Côte d'Ivoire, the fourth largest contributor after rice (20%), yam (17%), and maize (15%) (FAO 1970).

Three continents produce cassava in large amounts; they are Africa, Asia, and Latin America. African production accounts for more than 50% of world production; Asia and Latin America share less than 50% with the rest of the world. African production is virtually entirely used as food for humans within the domestic sector; Asian and Latin American production is mainly used as raw material for industries, as feed for livestock, or for export (Quin et al. 1995). But while food supplies per person are increasing in Asia and Latin America, they are declining in Africa (fig. I-1). Why does this situation exist? Cassava is easy to produce in comparison with grains or legumes because, relative to those other commodities, it tolerates poor soil and pests/diseases and the carbohydrate yield is high per unit of input. If research on cassava is made more effective, perhaps cassava can be used to close the African food gap.

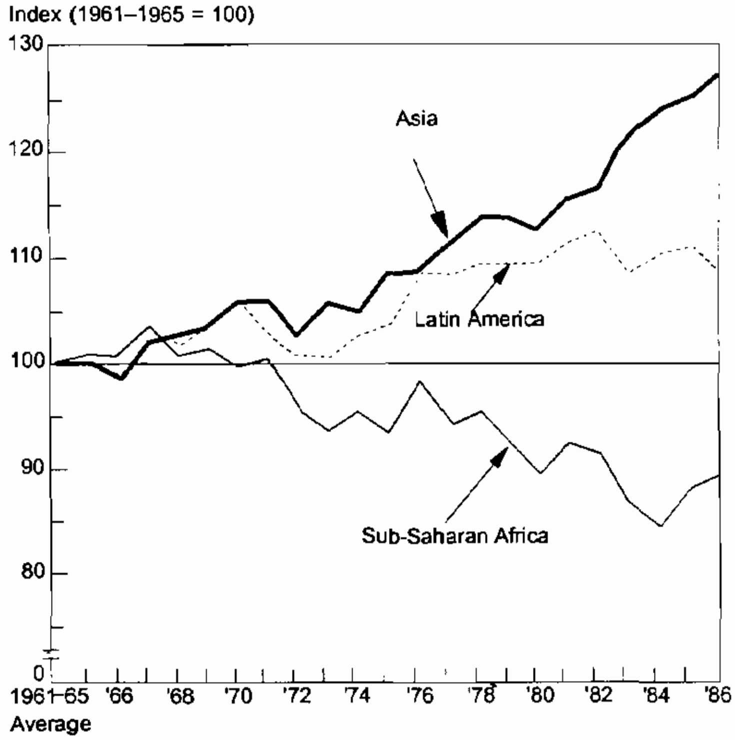

Fig. I-1. Trends in per capita food production in Asia, Latin America, and sub-Saharan Africa, 1961–65 average and 1965–1986

Source: Asuming-Brempong and Flinn (1990)

Method of the Study

The cassava information collection effort which eventually became known as the Collaborative Study of Cassava in Africa (COSCA) is executed by a multinational, multi-institutional, and multidisciplinary team. Each collaborating country has a multidisciplinary team of four senior-level scientists from different national agencies within the country, consisting of a breeder, an agronomist, a plant protectionist, an economist, and/or a statistician, where available. The collaborating international agencies are the International Institute of Tropical Agriculture (IITA), Centro Internacional de Agricultura Tropical (CIAT), Natural Resources Institute (NRI), Uppsala University, and the Rockefeller Foundation.

COSCA is being executed in three phases as follows:

Phase I involves a broad characterization of the following:
1. Environment (physical, social, economic)
2. Production
3. Processing
4. Marketing
5. Consumption

Phase II deals with cassava production details such as:
1. Yield
2. Land area
3. Utilization (sale/home use, processed/fresh use)
4. Input/output
5. Production practices

Phase III involves detailed studies on postharvest issues:
1. Processing
   Characterization of techniques
   Product quality assessment (nutritional, toxicity, and quality assessment)
2. Marketing
3. Consumption/demand

Phase IV covers urban utilization of cassava:
1. Marketing
2. Consumption/demand

Phases I, II, and III data collection surveys have been completed in Côte d'Ivoire, Ghana, Nigeria, Tanzania, and Uganda; Phases I and II have been carried out in Congo (DR), while only Phase I has been conducted in Burundi, Kenya, Malawi, and Zambia. This is a report of Phases I and II surveys.

1. Site and sample selection

Climate, human population density, and market infrastructure formed the bases for sampling. Following Carter and Jones (1989), four basic climatic zones were defined from temperature and duration of dry periods within the growing season (table I-1). Information available on all-weather roads, railways, and navigable rivers derived from Michelin travel maps was used to divide a market-access infrastructure map of Africa into good and poor zones according to the density of the roads, railways, or navigable waterways. Human population data from the United States Census Bureau were used to divide a population map of Africa into high demographic-pressure zones with 50 or more persons per km^2, and low, if less.

Table I-1. Definition of climatic zones

Climatic zone	Temperature (°C)		Duration of dry season (months)
	Daily mean	Range	
Lowland humid	< 22	< 10	< 4
Highland humid	< 22	< 10	< 4
Subhumid	> 22	> 10	4–6
Nonhumid	> 22	> 10	7–9

The three maps of climate, human population density, and market access infrastructure were overlaid to create zones with homogeneous conditions of climate, demographic pressure, and market access. Each climate/population density/market access zone with less than 10 000 ha of cassava in each country was excluded. The remaining areas were divided into grids of cells 12′ latitude by 12′ longitude to form the sample frame for site selection. A certain number of the grid cells distributed among the climate/population density/market access zones in proportion to the zone size was selected in each country, depending on the size of the country, by a random method. The total for the ten countries is 460 including 40 for Côte d'Ivoire (table I-2). One village was selected, by a random method, within each of the grid cells; the location of the villages in Côte d'Ivoire is shown by their identification numbers in fig. I-2 and listed by survey number, identification number, name, and coordinates in table I-3. In each selected village a list of farm households was compiled and grouped into large, medium, and small farm-holder units with the assistance of key village informants. Farm units which cultivated 10 ha or more of all crops were excluded. One farm unit was selected from each stratum.

Table I-2. Number of survey units by country

Country	No. of villages	No. of households		No. of fields
	Phase I	Phase II	Phase III	Phase II
Burundi	39	–	–	–
Congo (DR)	71	108	–	264
Côte d'Ivoire	40	120	222	267
Ghana	30	90	180	297
Kenya	34	–	–	–
Malawi	67	–	–	–
Nigeria	65	195	359	975
Tanzania	39	131	252	543
Uganda	37	120	240	359
Zambia	38	–	–	–
Total	460	764	1253	2704

2. Data collection

Leaders in cassava research in the national agricultural research systems in each country administered survey questionnaires to local farmers and took various measurements. They were knowledgeable in the cassava production systems of their respective countries and hence well qualified to collect the information.

A rapid rural appraisal technique was employed to collect village-level information in the Phase I survey. Farmer groups consisting of men and women with a wide range in age were constituted and interviewed in each village. Structured questionnaires were used to collect qualitative information. Phase II survey was carried out at field level. Phase III survey was at the levels of households, processing units, and marketing units. Relevant male and female members of the households, processing units, and marketing units were interviewed with structured questionnaires.

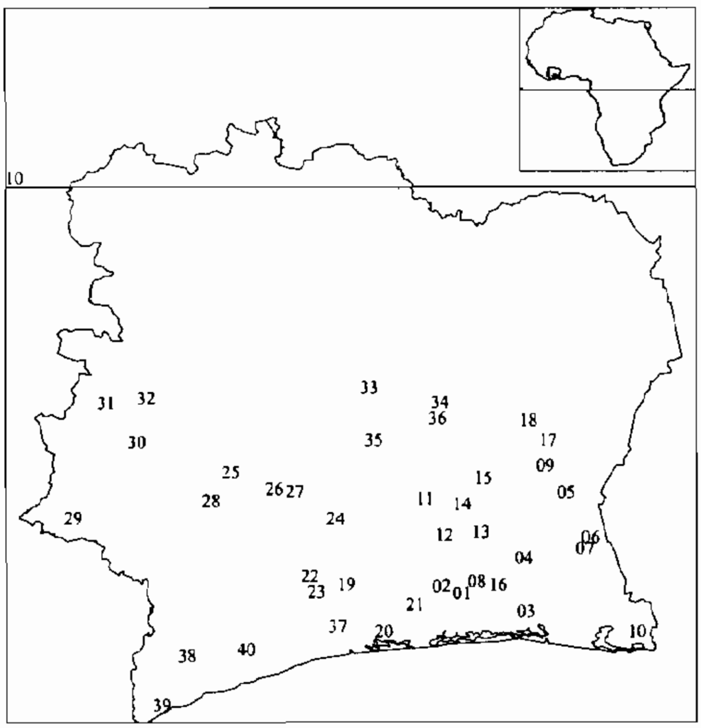

Fig. I-2. Survey sites by village identification numbers

Table I-3. Survey sites by coordinates

Survey no.	Village identification no.	Village name	Latitude	Longitude
101	1	Sahuye	5.7167	–4.5167
102	2	Boussoue	5.7833	–4.7000
103	3	Brofodoume	5.5167	–3.9167
104	4	N'koupe	6.0833	–3.9333
105	5	Akouakro	6.7667	–3.5500
106	6	Aprompron	6.3000	–3.3333
107	7	Akacomoekro	6.2000	–3.3667
108	8	Ano	5.8333	–4.3833
109	9	Ofolidie	7.0667	–3.7500
110	10	Allakro	5.3000	–2.9000
111	11	Angouakoukro	6.7167	–4.8500

Table I-3. continued

Survey number	Village identification no.	Village name	Latitude	Longitude
112	12	Sandiebounga	6.3167	–4.6833
113	13	Tchekou-Carrefour	6.3500	–4.3500
114	14	Komambo	6.6500	–4.5167
115	15	Koudieblekro	6.9333	–4.3167
116	16	N'gattakro	5.8000	–4.2000
117	17	Lalasso	7.3167	–3.7167
118	18	Adikankro	7.5333	–3.9000
119	19	Zozo Oliziriboue	5.8000	–5.6000
120	20	Ekradon	5.3167	–5.2333
121	21	Godesso	5.5833	–4.9500
122	22	Gahougnagbolilie	5.8833	–5.9167
123	23	Kripoko	5.7167	–5.8667
124	24	Digbouho	6.5000	–5.6833
125	25	Zahibo	6.9833	–6.6667
126	26	Bebouo-Sibouo	6.8167	–6.2500
127	27	Kangreta	6.7833	–6.0500
128	28	Detroya	6.6833	–6.8333
129	29	Medibli	6.5000	–8.1000
130	30	Blole	7.3000	–7.5167
131	31	Yepleu	7.7167	–7.8167
132	32	Douole	7.7667	–7.4333
133	33	Takra-Adiekro	7.8833	–5.3833
134	34	Sougban	7.7167	–4.7167
135	35	Kpato	7.3333	–5.3333
136	36	Saoua	7.5500	–4.7333
137	37	Okromodou	5.3500	–5.6667
138	38	Dogbo	5.0667	–7.0667
139	39	Meneke	4.5167	–7.3000
140	40	Gnity	5.1000	–6.5167

3. Data analyses

The data are at different levels of aggregation, the village community, the household unit, and the individual fields. The village data are at the highest level of aggregation while the data on the individual fields are at the lowest level of disaggregation. The lower order variables, when used to explain a high order variable, are aggregated upwards; the aggregate value used, the mean, mode, or the maximum value, varied depending on what is the most appropriate for the variable being explained. But when a high order variable is used to explain a lower order variable, because of the absence of appropriate disaggregation methods, the same value of the explanatory variable is matched with each value of the lower order dependent variable under it. This may introduce bias in the estimated parameter although the nature of the bias is not clear.

II. Specific Methodological Issues

Assessment of root yield

Yield estimation was made for fields which were 9 months old or more, except when the farmer harvested at less than that age. The estimation was based on a representative sample plot of 40 m^2, except when the field was too small, in which case a 20 m^2 plot was used. There were one or two plots per field depending on the size and heterogeneity of the field in terms of soil quality and toposequence. Cassava stands within the sample plot were separated by genotype, counted, and then harvested. Both the roots and the tops were weighed separately and the roots counted, again by genotype.

1. Root yield measurement problems of cassava

Cassava root yield depends on a wide range of factors, some of which are peculiar to cassava because of its flexibility with respect to planting and harvesting dates. Some of the factors are flexible planting date, flexible age at harvest, intercropping, varying root sizes from the same plant, and piecemeal harvesting. These occur in addition to environmental, cassava varietal, demographic pressure, and market demand factors. Any yield comparisons through field surveys which do not consider such factors run the risk of being subjective and therefore misleading (Fresco 1986). These factors are discussed below.

Environmental factors. To explain cassava root yield, detailed weather information up to field level is useful. However, the only weather information available is the broad classification of climatic zones which was used in the sampling design. Likewise, detailed information on soil including pedology will be needed at the field level to adequately explain yield. The FAO-UNESCO (UNESCO 1974) and the USDA (1978) soil classifications are both too broad to explain variations in cassava yield.

Varietal characters of cassava. Certain morphological characters may be determinants of yield. Jones indicated that bitter[1] varieties of cassava were much more common than sweet almost everywhere in the Congo region, although sweet varieties had been introduced and their propagation had been encouraged by the French and the Belgians. Whether the bitter cassava predominates because of its high yield remains uncertain (Jones 1959). Hahn indicates that nonbranching cassava types are prone to lodging, exposing the roots to damage and thereby reducing yield (S.K. Hahn, personal communication 1993).

A cassava plant produces a number of roots which vary in size and shape depending on genotype and environment (Fresco 1986). Size and shape of the root could affect processing cost; peeling is generally a labor-intensive operation, therefore tiny or irregularly shaped roots which are expensive to peel and which may also result in considerable waste, may be discarded by the farmers. However, alternative processing techniques, such as soaking the tiny, irregularly shaped roots in water before peeling makes the removal of the skin easier and quicker. This might be a more practical approach for processing such unusually shaped roots. In any case, whether or not farmers utilize tiny or irregularly shaped roots would depend on the time available to them, on their food needs, and on the numerous alternative uses of cassava, such as feed for animals or food for

[1]Cassava genotypes which farmers eat as a vegetable, boiled, or roasted in open fire without prior transformation are called sweet types. Cassava genotypes which if eaten raw or even boiled or roasted without prior processing are harmful to humans or animals are called bitter types.

the household. These factors are not easy to determine or compare. Consequently, it is rather difficult to determine the size or shape of cassava roots which farmers across sub-Saharan Africa will discard. Therefore, all storage roots which could be picked, irrespective of size or shape, were included in the yield measurement.

Agronomic practices. Cassava is generally grown under intercrop conditions, which could lead to great variations in plant density and also to shading, both of which affect yield. This situation is not limited to cassava, as almost all arable crops cultivated in the country are intercropped, although to varying degrees.

Cassava planting dates range over several months from the beginning to the end of the rainy season, because it is drought tolerant relative to virtually all other arable crops. A field of cassava is rarely harvested at one time; harvesting is generally spread over a period of one month or more. In this respect, the farmers may not harvest a field systematically from one corner to the other. Rather, they may target harvesting to particular stands, depending on variety, size, and location in different parts of a field.

Farmers also frequently milk their cassava plants; that is, they harvest some but not all the roots of a plant and come back later, sometimes after several weeks or even months, to harvest the remaining roots. This is more common where farmers grow sweet types which they use without processing. Such farmers store their subsistence/daily needs in the field and take as many roots as are needed, which could be less than one plant at a time. Fields where harvesting was targeted to specific plants in different parts of the field, as well as others where cassava plants were milked, were avoided at the yield measurement stage.

Market and demographic conditions. As cassava allows for great flexibility in harvesting time, harvesting is often deferred to when the need arises or to a convenient time. Although in Tanzania the mature cassava fields in which yields were measured ranged from 6 to 18 months in age after planting, in some of the other countries studied there were fields which had been planted 40 months before. Within this period, the bulking of the roots continues up to a point after which deterioration takes over (Jones 1959). Hence, yield varies with age, increasing up to a point, after which it declines. In a situation where there are food shortages, such as may be caused by drought, or war, cassava may be harvested early, before it attains maximum bulking. The farmers' decision to delay harvesting may be based on poor market conditions, or high costs of labor for harvesting and processing. Conversely, a farmer may harvest a field early if market conditions are attractive and labor for harvesting and processing is available. In other words, cassava yield is often a function of the general food supply situation, farm labor supply situation, and overall market conditions.

2. Root yield measurement advantages of cassava

Cassava yield measurement is not seriously influenced by yield variability from one year to another which is caused by short-term climatic changes. Measurement in any single year would, to a large extent, correctly reflect the yield of the crop. As a crop of more than one-year growth cycle, cassava fields planted in different years are simultaneously available at any time.

Cassava does not have a fixed harvest season, or harvest period. Yield measurements can be conveniently taken over a wide area, spreading the activity over time. This can be very important in sub-Saharan Africa where extremely difficult travel conditions exist.

Although some perennial crops such as *Musa* spp. yield all year round, they have peak periods, particularly in areas which have marked rainy and dry seasons, such as is the case in most parts of sub-Saharan Africa. For such crops, representative yield determination for a location would require measurements at different times of the year. Representative yields for cassava can be obtained with one measurement in any month of the year. In this respect, yield measurement for cassava is more convenient than for most other crops.

Assessment of trends in cassava land area

Trends in cassava land area are discussed in relative terms; the concept is based on qualitative information that was derived from farmer group responses to the questions: What have been the trends (increasing, no change, or decreasing) in cassava production in the last 20 years? Why? What is being replaced by cassava or what is replacing cassava? The last question assumes that the increase in cassava production, if any, is due to increasing land area under cassava.

Cassava land area can be expanded through land-use extensification, when land that was not previously included in the rotation is brought into cultivation (Fresco 1993). Cassava land area can also be expanded through land-use intensification, if fields already in the rotation are cultivated more frequently by either an increase in the number of consecutive cropping years while maintaining present fallow periods, or by including cassava in intercrops previously not so intercropped.

Assessment of fallow systems

The farmer groups interviewed in each village were asked to describe the three most common systems of arable crop production including crops grown, number of crop cycles before fallow, if any, duration of each crop cycle, duration of the fallow, etc. These are systems of intercropping, crop rotation, fallow rotation, and other aspects of crop management practices, planting and harvesting dates, growing period, for the various crops. A crop cycle was the cultivation of the same set of crops for a crop season or more without a change in the crop combination.

Greenland (1974) classified fallow systems into three: shifting cultivation (long fallow), recurrent cultivation (short fallow), and continuous cultivation (no fallow). For COSCA purposes, long fallow is considered to be less than 10 years of continuous cultivation followed by 10 or more years of fallow; only few cases of this were observed. For short fallow, the limits are less than 10 years of continuous cultivation combined with less than 10 years of fallow between crops. Continuous cultivation involves at least 10 years of continuous cropping with less than one year of fallow between crops. Okigbo (1984) stated that in areas of low population density where long periods of fallow were adopted, there was no guarantee that the farmer returned to the original farmed area in a definite period of time. Where population pressure was high, fallow periods were drastically reduced and farmers returned to the same piece of land after less than 10 years of fallow, leading to what was sometimes designated as land rotation. Most of the farmer groups interviewed considered that most fields would recover their fertility in less than 10 years of fallow.

Field area measurement and methodological issues in cassava field area determination

Field area was determined by measurement with tape, compass, and ranging poles. As explained earlier, in comparison with most of the other staple crops, cassava is flexible with respect to planting and harvesting dates and very suitable for intercropping. The practice of intercropping creates an error of bias in the analysis of importance, in terms of land area, of a crop such as cassava which is frequently intercropped. The value of a unit field area of such crop will vary according to whether it is the major or the minor crop. This follows from the practices usually adopted by farmers to reduce stand density which have implications for crop yields.

Stand density is substantially higher for cassava when it is grown sole than when it is grown as an intercrop. Cassava fresh root yield is directly related to cassava plant density being higher when cassava is grown as a sole crop than when it is grown as an intercrop (Nweke et al. 1994). The magnitude of the error of bias would vary with crops depending on the frequency of intercropping. The higher the frequency of intercropping, the greater the degree of bias is likely to be.

Cassava's ability to tolerate drought which allows flexibility with respect to planting date will create another error of bias in the estimation of the land area of cassava in comparison with other crops especially if care is not taken at the data collection stage of the survey. Depending on the convenience of the farmer with respect to labor availability and especially intercropping needs, cassava can be planted most of the months of the year in most of the climatic zones. The value of cassava relative to alternative crops will be underestimated if cassava fields planted outside the major planting months are not counted.

The existence of numerous early and late bulking cultivars and the ability of the crop to stay in the field for extended periods after bulking has been completed which allow great flexibility in harvesting strategy can, potentially, lead to a further error of bias in cassava field area measurement for purposes of comparison with other crops. As mentioned earlier, depending on variety, family food need, demographic or market pressure, and on labor availability, cassava can be harvested as from 6 to as much as 48 months after planting. The value of cassava relative to alternative crops will be overestimated if cassava fields not harvested after 12 months are counted. It will be underestimated if cassava harvested before 12 months are not counted. To avoid these errors of bias, fields are counted by calendar months rather than calendar year. All fields planted within 12 months prior to the day of the information taking, irrespective of whether such fields have been harvested or not, were counted.

Assessment of relative importance of crops in a village

Criteria for defining the importance of a crop should include area planted, its role in subsistence farming, its importance in income generation, whether or not it is a major staple, its role in periods of food scarcity among others (Carter and Jones 1989). Hence, the importance of a crop will vary with individual producers depending on production objectives. The relative importance of the crops can be based on two concepts; field area and farmers' ordinal ranks for the crops. Field area is a proxy for the level of investment the farmer makes on cassava production; ordinal ranking represents the importance of the crop to the farmer in terms of a wide range of values such as cash income, food security, employment, etc. Where crops are intercropped, the relative importance based on field area will be influenced by the position of a crop, main or minor, in the intercrop. Following Nweke (1994c), the relative importance of a crop is estimated on the different bases as follows.

1. Relative importance based on main fields only

The relative importance of a crop based on its main field area only is estimated as follows:

$$LAMIN_i = 100 * \sum_{n=0}^{N} (FLDAREA_n * CROPM_{in}) \sum_{n=0}^{N} FLDAREA_n)^{-1} \text{...........(eq. 1)}$$

where:

- n = a field belonging to representative farmers
- N = total number of fields of all crops owned by representative farmers
- $FLDAREA_n$ = area in ha of field n
- $CROPM_{in}$ = 1 if crop i is in field n as the main crop, 0 otherwise

The model of equation 1 does not assign any value to a crop when it is not the main crop, i.e., sole crop or the major crop in an intercrop. The model, therefore, underestimates the relative importance of a crop which is frequently grown as a minor crop in intercrops.

2. Relative importance based on main plus minor fields

The relative importance of a crop i based on its main plus minor field area is estimated as follows:

$$LAMINO_i = 100 \bullet \left(\frac{\sum_{n=0}^{N} FLDAREA_n \bullet CROPN_{in}}{\sum_{n=0}^{N} FLDAREA_n}\right)\left(\sum_{i=1}^{I}\left(\frac{\sum_{n=0}^{N} FLDAREA_n \bullet CROPN_{in}}{\sum_{n=0}^{N} FLDAREA_n}\right)\right)_i^{-1} \text{....(eq 2)}$$

where:

n = a field belonging to representative farmers
N = total number of fields of all crops owned by representative farmers
$FLDAREA_n$ = area in ha of field n
$CROPN_{in}$ = 1 if crop is in field n either as the main or as a minor crop, 0 otherwise

The model of equation 2 assigns equal weights to crops in a field irrespective of whether they are major or minor. The model, therefore, tends to overestimate the relative importance of crops which are intercropped at high frequencies. A summation of field area across crops will entail double counting when both the main and minor crops are counted. In relative terms, this sums to more than 100%. The model of equation 2 standardizes the relative importance so that it sums to 100% across crops considered.

3. Shortcomings of relative importance estimates based on field area

Both models of equations 1 and 2 assign the same values to a crop per unit field area without regard to the soil fertility level or to the location of the field. However, crops are cultivated on fields of different levels of soil fertility depending on the importance, to the farmer, of the crops. A high value crop such as yam is planted in high soil fertility fields in yam-growing areas. Similarly, high value crops such as *Musa* spp. are often cultivated in fields closer to residential compounds where soil fertility is enhanced with compound manure and where security against pilfering is relatively high.

Only arable fields cultivated in the current year are considered in the above models. However, some of the crops, particularly the *Musa* spp., are grown in arable fields under fallow, outside the arable fields such as in home gardens, in tree crop fields as nurse plants, etc. The models of equations 1 and 2 will underestimate the relative importance of the staple crops such as the *Musa* spp. which are widely grown outside arable fields.

4. Relative importance estimation on farmers' ordinal crop rank basis

The farmer groups interviewed in the village level survey phase of the COSCA study were asked to rank the first three most important intercrops and within each intercrop to rank the five most important crops in descending order of importance. They were also asked the reason for the most important crop in the most important crop mixture. The group members were free to hold council among themselves before responding to the question. To concretize the ranking process, specimens, such as roots, tubers, seeds, leaves, or even whole plants, were used to represent crops cultivated in the village. The group first organized the specimens by intercrop by putting the specimens of crops grown in one mixture in a separate bag. The group then ranked the bags of specimens in descending order of importance of the intercrop they represent. Beginning with the bag which represents the most important intercrop, the group ranked the specimens in each bag in descending order of importance, in the intercrop, of the crops the specimens represent. After ranking the specimens in the first bag, the group was asked why the crop represented by the specimen ranked first was the most important crop in the village. The group then proceeded to rank the specimens in the bag ranked number two, etc.

Following Nweke (1994b), the farmers' subjectively assigned ranks were used to compute, quantitatively, the relative importance of each crop as follows:

$$FRANK_r = 100 * (\sum_{t=1}^{M} (m_t * c_{rt})_t^{-1}) \quad (\sum_{r=1}^{R} \sum_{t=1}^{M} (m_t * c_t)_{tr}^{-1})^{-1} \text{ .... (eq. 3)}$$

for:

$1 \leq m_t \leq M$
$1 \leq c_{rt} \leq R_t$

where:

t elements are intercrops
r elements are crops
m_t = rank of intercrop t
M = number of intercrops in the village
c_{rt} = rank of crop r in intercrop t
R_t = number of crops in intercrop t

The narrower the range of crops cultivated in a village, the higher the relative importance the model of equation 3 assigns to individual crops and vice versa. Crops in an intercrop would usually not exceed five; but even if they do, the relative importance of crops ranked below five would not be high. The model assigns different values to a crop, depending not only on whether it is the main or minor crop in an intercrop but also on the relative importance of the intercrop in which the crop appears.

Assessment of incidence of famine

The farmer groups interviewed in each village were asked if the people of the village had suffered famine in the past, and what was responsible for it. Famine was defined as the situation in which people died from starvation or had to move away from the village because of lack of food. Forty-five percent of the representative villages reported that they had suffered famine in the past. The main causes were ascribed to drought in about 30% and to plant pests/diseases in 15% of the representative villages which had suffered famine in the past. The rest (55%) of the villages that reported they had suffered famine did not identify the causes. Fifty-five percent of all the representative villages reported that they did not suffer famine in the past.

Assessment of pests/disease problems

To the farmers, cassava mealybug (CMB) and cassava green mite (CGM) are diseases along with African cassava mosaic disease (ACMD) and cassava bacterial blight (CBB); while grass-hoppers, birds, rodents, monkeys, and other animals are reckoned as pests; therefore, it was not possible to separate diseases from pests while eliciting information from farmers.

During the Phase I survey, at the end of the group interview meeting in each village, the investigators visited a statistically representative sample of cassava fields between 6 and 12 months after planting. The investigators scored a representative sample of cassava plants of each available landrace for symptom severities of CMB, CGM, ACMD, and CBB on a scale ranging from zero, for no symptoms, to four for the most severe symptoms. Different landraces were often grown in the same field. Each landrace was assessed in all the representative fields in which it was observed. Nine landraces were assessed in a village except where fewer than nine were available. The number of plants scored per landrace varied depending on the judgement of the experienced national scientist investigators involved. The modal score for each problem was then assigned for each landrace. Although attacks of each pest/disease are mostly seasonal, symptom severity can be scored objectively in a single visit since the symptoms usually persist after an attack. Incidence data for each landrace are calculated as the number of affected plants expressed as a percentage of the total number of plants sampled. The symptom severity score is the mean for all affected plants, i.e., those with a symptom severity of at least one.

Classification of cassava cultivars

While in the cassava field, eight morphological characters of available cassava landraces which were identified by local names at the farmer group interview meeting were assessed (cultivars or genotypes). The characters were bitter/sweet, branching, pubescence status, leaf shape, color of young shoots, petiole color, inner skin color of roots, and color of root flesh.

The conventional concept of sweet cultivars is adopted as those which farmers eat without processing, and of bitter, as those which farmers regard as dangerous to humans and animals if eaten without processing. This classification has nothing to do with taste or sugar content, nor with the cyanogen content. The classification of the cultivars as bitter or sweet was made by the farmers and not by the investigators.

The branching habit refers to the height from the ground base to the forking point at which the first branch occurs. The height of the cassava plant varies not only genetically but also with environmental conditions such as altitude, temperature, insolation, soil fertility, lodging, socioeconomic conditions such as whether leaves are harvested or not. Therefore branching height is standardized in relative terms. A cassava plant is considered low branching if the first branch occurs at a point below a third of the total height and medium branching if the point of first branching is between the first third to two-thirds of the plant height, and high branching if the point of first branching is above two-thirds of the total height of the plant. Branching height was determined on mature plants only; branching height was not determined on plants from which leaves were harvested.

Leaf shape is either broad or narrow. Pubescence refers to the presence of hairiness in the growing tip of the plant; its presence was determined with the aid of a magnifying lens. All color characters were assessed with the aid of a color chart; the young shoot is either green or purple, the petiole is red or green, the inner skin of the root is white, cream, or red, and the root flesh is white, cream, or yellow. The petiole connects the leaf to the stem; the color is considered red if it has any red spot.

Classifying genotypes using one morphological character at a time is not very useful for varietal identification purposes since a variety cannot be distinguished by just one trait. However, classifying genotypes using more than one character simultaneously immediately creates problems because cassava is open-pollinated, and when seeds drop and germinate farmers often retain the resulting plants and collect planting materials from them (Fresco 1986). Genotype by environment (G x E) interaction is a major problem in cassava variety identification, as there is often a wide range of indeterminate varieties in the field. Morphological characters such as branching height, leaf size or shape, color traits, and cyanogen level in the same variety vary with climate, soil, and altitude.

To say that the number of morphologically distinct varieties of cassava in Africa is very high (Fresco 1986) or that African farmers cultivate cassava from a large variety of unknown different clones (Jones 1959) is, perhaps, an understatement. The situation is similar to the distinction between bitter and sweet varieties which rests upon the content of prussic acid. The different varieties show such a continuum of gradation in prussic acid content from nonpoisonous to very poisonous as to make a botanical classification impossible (Jones 1959). The cassava plant shows a similar continuum of gradation in morphological characters.

Principal component analysis was carried out following the method originated by Pearson (1901) and later developed by Hotelling (1933) to group the cultivars identified in the representative villages into clusters with uniform characteristics of bitter/sweet, branching habit, pubescence, leaf shape, color of young shoots, petiole color, inner skin color, and color of root flesh. Any cultivar for which any of the eight morphological characteristics was absent or indeterminate was excluded from the analysis.

Assessment of market access conditions

Farmers' access to market is defined to include ease of access to market centers and to the services of cassava marketing middlemen which would link the farmers to sources of demand for farm products and supply of farm inputs (Nweke 1996b).

The market access information as based on road maps was collected at different times and varied widely in veracity. It was therefore considered essential to collect information during the survey that would permit a more objective assessment of market access infrastructure. Accordingly, the farmers interviewed in Phase I were asked to indicate the main market used to sell their cassava products, the proximity of the market in kilometers, and the means of access. This was by motor vehicle, foot, or other means including use of bicycles, animals, or boats. Proximity to market is grouped into categories above or below 10 km based on a subjective estimate of the distance a farmer can walk in a day with a head load of cassava products.

Farmers in 59% of the villages attended markets on foot over distances no more than 10 km. Since the 10 km cut-off point is more or less arbitrary, it is uncertain how many of these villages have good or poor market access infrastructure. Three percent of the villages fall into the "others" category and it is not easy to determine whether or not this group of villages has good or poor market access infrastructure. Respondents in 28% of the villages stated that they went to market by motor vehicle, indicating good access. In 10% of the villages it was reported that they went to markets on foot over distances exceeding 10 km indicating poor access. Vehicle means indicates easy access because the farmers can reach buyers in distant markets more easily by vehicle than on foot.

Farmers in 52% of the villages reported that they sold cassava mostly through middlemen, traders or processors; in 48% they sold directly to consumers. Sale through middlemen indicates relatively easy access to market because farmers can reach consumers in distant markets through the middlemen.

PART TWO

PRODUCTION SYSTEMS

III. Fallow and Rotation Systems

The household resource base, namely household labor and farmland resource bases, and other economic activities of the households is first characterized in order to provide a context for the discussion of the systems.

Household resource base

There was an average of 9.2 persons/household with a range of one to 45. The mean was composed of 4.8 persons of 15 years or under, 1.8 males and 2.3 females 16–65 years old, and 0.4 person older than 65 (table III-1). The household heads were aged between 22 and 85 years with a mean of about 50 years. The distribution shows that 10% were 70 years old or above. The mean number of years of formal education of the household heads was about 2 and the range was 0 to 14. About 70% had zero education and about 5% had more than 10 years of formal education.

The households were headed approximately 90% by men and 10% by women. In most places, a woman is the head if there is no male in the household; hence males who were too old for the practical purpose of heading households were often designated heads.

Table III-1. Household size by age/gender composition

Age/gender	Mean	Minimum	Maximum	Standard deviation	No. of households
15 years or below	4.76	0	26	3.95	217
16–65 years, male	1.77	0	8	1.37	217
16–65 years, female	2.31	0	12	1.93	217
66 years and above	0.36	0	2	0.59	217
All members	9.21	1	45	6.21	217

Farmland

Among most African peoples, farmland is not owned but is held in trust by the present generation on behalf of their descendants in future. Farmland is held not only by individuals, but also by units such as extended families or entire village communities. When farmland is held by the community, its use for farming or any other purpose is controlled by a central authority which may be an individual community head or a community council (Chubb 1961). More than one farmland holding system within the same village is possible. Outright sale was not common but rental for a period could be accommodated in the system. Farmland holding by individuals was the most common in 55% of the representative villages, holding by the extended family was the most common in 30%, and holding by the village community was the most common in 15% of the representative villages.

The average farm size was 1.28 ha/household; the range was 0.07 ha to 7.23 ha. The distribution of the mean by major crops is presented in table III-2. The household farm was fragmented into an average of 2.2 fields/household; the range was 1 to 6 fields. Distribution by main crops is presented in table III-3.

Table III-2. Field area (ha) per household by crop

Crop*	Mean	Minimum	Maximum	Standard deviation	No. of households
Cassava	0.49	0	6.21	0.83	117
Yam	0.07	0	0.89	0.19	117
Plantain	0.10	0	2.81	0.36	117
Maize	0.12	0	2.55	0.34	117
Rice	0.39	0	4.71	0.81	117
Others	0.10	0	3.00	0.35	117
All	1.28	0.07	7.23	1.17	117

Note
*fields in which a crop was minor in an intercrop were counted

Table III-3. Number of fields per household by crop

Crop	Mean	Minimum	Maximum	Standard deviation	No. of households
Cassava	1.58	1	3	0.68	29
Yam	2.20	1	4	0.79	10
Plantain	1.67	1	2	0.49	12
Maize	2.64	1	5	1.08	14
Rice	3.15	1	6	1.63	13
Others	2.29	1	5	0.99	35
All	2.19	1	6	1.08	120

Note
*fields in which a crop was minor in an intercrop were not counted

Economic activities

Cocoa was grown in 80% of the representative villages by 30% of the farmers, coffee was grown in 95% of the villages by 45% of the farmers, and oilpalm was grown in 55% of the villages by 35% of the farmers. Similarly, cattle were kept in 30% of the villages by 50% of the households, and sheep and goats were kept in 95% of the villages by 80% of the households.

Several of the households had members engaged in different types of nonfarm economic activities. For example, about 5% of the households had members engaged in the sale of unskilled labor for wage in certain nonfarm activities, in off-farm farm product processing, in the extraction of forest products, and in traditional medical practices. About 10% of the households had members engaged in various crafts and in nonfarm wage employment and members in about 15% of the households were in different forms of small businesses in the surveyed villages.

Rotation systems

The fallow/rotation systems were continuous cultivation without crop rotation, continuous cultivation with crop rotation, short fallow without crop rotation, short fallow with crop rotation, long fallow without crop rotation, and long fallow with crop rotation. The combined data for the COSCA countries show that the fallow/rotation systems varied widely both within and across village sites depending on population, market, and pest/disease pressures, climatic zone, main crop, whether cattle were kept and how they were kept, soil physical characteristics and nutrient status, and on whether tree crops were also grown in the village. In Côte d'Ivoire, the population density was generally low, the climatic zone was mostly humid, and the range of food crops grown was narrow, consisting of rice, yam, cassava, maize, and plantain.

Most important crop in the village

The most important crop in the village was the main (lead) crop in the most important fallow/ rotation system as ranked by the farmers. Tree crops, cocoa and coffee, were the most important crops in about 60% of the representative villages (table III-4). These villages were in the humid and subhumid zones. Yam and rice were each the most important crop in 15% of the representative villages. Yam was grown as the most important crop in all the few villages studied in the nonhumid zone. Rice was not ranked the most important crop in any village outside the humid zone. The locations of the representative villages by the most important crop are shown in fig. III-1.

Table III-4. Percentage distribution of representative villages by most important crop by climatic zone

Crop	Percentage			
	Lowland humid (N = 28)	Subhumid (N = 8)	Nonhumid (N = 3)	Average (N = 39)
Tree crops	64	75	0	62
Cassava	7	13	0	8
Yam	7	12	100	15
Rice	22	0	0	15
Total	100	100	100	100

Note
N = number of villages

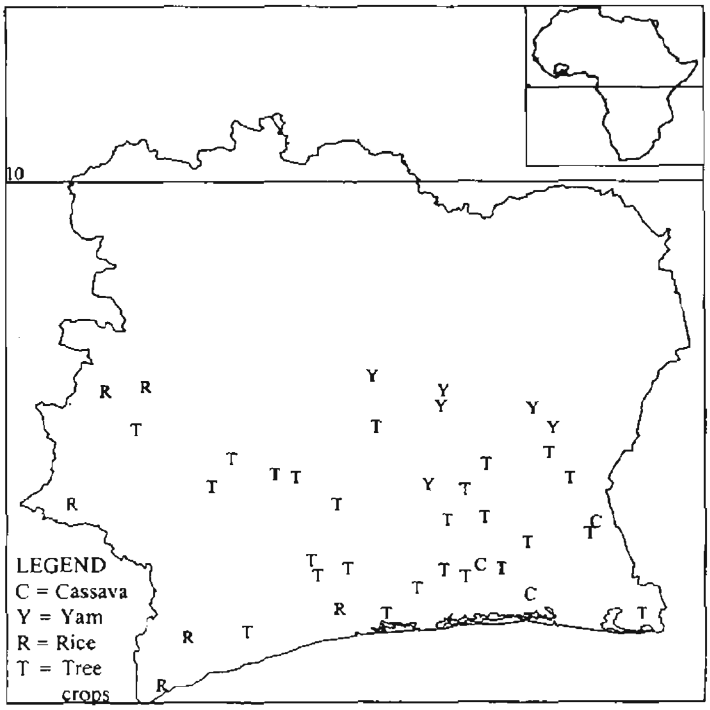

Fig. III-1. Distribution of representative villages by most important crop

Tree/food crop systems

The fallow rotation practices were heavily influenced by the growing of tree crops. About 80% of the representative villages intercropped food crops with cocoa or coffee in one or more of the maximum of three fallow/rotation systems described at the village level; all food crops were involved in this practice. The exceptional cases of villages which did not intercrop tree and food crops in any of their systems are illustrated in appendix charts 101, 103, 117, 133, and 134. All, 100%, of the tree/food crop systems were in continuous cultivation as food crops. Although crop rotation was not commonly practiced, relay cropping was commonly practiced; some of the examples are described in appendix charts 110 sys 1, III sys 1, 114 sys 1, 116 sys 1, 128 sys 1, 132 sys 1, 138 sys 2, etc. Plantain was widely intercropped in the tree/food crop systems.

Food crop systems

While tree/food crop systems were entirely in continuous cultivation of the food crops, food crop systems were 20% continuous cultivation with crop rotation and 80% fallow rotation, about 75% short fallow and about 5% long fallow (table III-5). Fallow rotation was so widespread because population densities were low and the climate was mostly humid. Continuous cultivation was most common with rice systems; it was also practiced with yam and maize. In other countries of the COSCA study, yam was not frequently grown under continuous cultivation but mostly under short fallow. In Côte d'Ivoire, yam was also frequently grown under long fallow. The types of yam that were frequently grown under continuous cultivation or under long fallow rotation systems in Côte d'Ivoire were not ascertained. Both crop rotation and relay cropping were commonly practiced. Plantain was also widely intercropped in the food crop system.

Table III-5. Percentage distribution of village fallow/rotation systems by major crop

Rotation system	Cassava	Yam	Maize	Rice	Average
Number of systems	25	14	5	20	64
			%		
Continuous cultivation:					
with crop rotation	0	21	20	40	18
Short fallow:					
without crop rotation	72	14	40	45	48
with crop rotation	28	36	40	15	28
Long fallow:					
with crop rotation	0	29	0	0	6
Total	100	100	100	100	100

Food crop systems were dominated by short fallow because the climate was mostly humid and cattle were free grazed in some places (table III-6). However, continuous cultivation was driven by intercropping food crops with tree crops and by rice cultivation around market centers (table III-7).

Table III-6. Percentage distribution of village fallow/rotation systems by zones of cattle-keeping methods

System	Cattle not kept	Cattle restricted	Cattle free grazed
Number of systems	68	9	12
	....	%	....
Continuous cultivation:			
with crop rotation	15	22	8
Short fallow:			
without crop rotation	51	78	59
with crop rotation	27	0	33
Long fallow:			
with crop rotation	7	0	0
Total	100	100	100

Table III-7. Percentage distribution of village fallow/rotation systems by market access zones

System	Foot, 10 km or less	Motor vehicle, any distance	Foot, above 10 km
Number of systems	38	18	5
	....	%	....
Continuous cultivation:			
with crop rotation	26	6	0
Short fallow:			
without crop rotation	50	39	0
with crop rotation	16	44	100
Long fallow:			
with crop rotation	8	11	0
Total	100	100	100

Plant pests/diseases problems and fallow/rotation systems

It is not possible to determine, based on Côte d'Ivoire data, the impact of the fallow systems on the control of cassava plant pests and diseases because of limited degrees of freedom. The combined data for the COSCA countries show that the incidence of CMB, ACMD, and CBB was highest and the incidence of CGM was lowest under the short fallow system (table III-8). The symptom severity scores for CMB ranged from 1.67 to 1.90 and did not differ statistically among the various fallow systems. The severity of CGM was higher in the short fallow than in the other fallow systems. The difference in symptom severity scores was not, however, significant between short and long fallow systems. The severities of ACMD and CBB decreased significantly from long fallow through short fallow to continuous cultivation systems. The reasons for these correlations are not clear. One possibility is that farmers may be able to cultivate continuously where pest and disease pressures are low but need to alternate cropping and fallow periods to break the pest/disease cycles where the pressures are high.

Table III-8. Incidence and symptom severity scores (1–4 scale) of four major cassava plant pests/diseases assessed by fallow systems (10 COSCA study countries)

Pest/disease/[a] fallow system	No. of landraces affected	Landraces affected (%)	Mean severity score	Probability level of significance of difference		
				CC and SF	CC and LF	SF and LF
CMB:						
continuous cultivation (CC)	148	8	1.67	*	–	–
short fallow (SF)	70	10	1.90	*	–	–
long fallow (LF)	14	8	1.85	–	–	–
CGM:						
continuous cultivation (CC)	554	29	1.62	***	*	–
short fallow (SF)	173	24	1.94	***	–	–
long fallow (LF)	45	27	1.82	–	*	–
ACMD:						
continuous cultivation (CC)	474	25	1.86	**	***	–
short fallow (SF)	294	41	2.02	**	–	***
long fallow (LF)	54	32	2.41	–	***	***
CBB:						
continuous cultivation (CC)	145	8	1.45	–	***	–
short fallow (SF)	174	24	1.48	–	–	***
long fallow (LF)	21	13	2.00	–	***	***

Notes

***$P \leq 0.01$; **$P \geq P > 0.01$; and *P $0.10 \geq P > 0.05$

[a]CMB = Cassava mealybug; CGM = Cassava green mite

ACMD = African cassava mosaic disease; CBB = Cassava bacterial blight

There was no significant difference in either the incidence or in the symptom severity score of ACMD between areas where cassava was grown in rotation and where it was not grown in rotation with other crops based on data from Côte d'Ivoire. However, combined data for the COSCA countries show that the incidence of CBB, CMB, and ACMD were lower when cassava was grown in rotation than when it was not; the symptom severity scores of ACMD and CGM were significantly lower when cassava was grown in rotation with other crops compared with continuous cultivation of cassava. Kesiwani (1987) states that crop rotation is one of the classical methods of plant disease management and perhaps the most cost-effective. The symptom severity scores of CMB and CBB were also lower under rotation systems, although the differences were not statistically significant.

The rotation system practiced was influenced by the severity of the cassava diseases. The relative frequency of cassava cultivation under continuous cultivation declined as the symptom severity scores of ACMD and CBB increased (tables III-9 and III-10). As the severities of the problems increased, cassava cultivation under short fallow rotation with multiple sets of crops declined while cultivation in rotation with only fallow increased. As the pressure of diseases increased, farmers replaced sets of crops with fallow in the rotation in cassava short fallow systems. There were no clear trends between rotation systems and the symptom severity scores of the two pests assessed. The situation in the case of CMB could be due to low incidence; the problem was being brought under control by the time the COSCA information was collected.

Table III-9. Percentage distribution of village fallow/rotation systems by severity score (0–4) for ACMD (6 countries*)

Fallow/rotation system	Score = 0	Score = 1	Score = 2	Score > 2	Overall
Number of systems	31	42	70	79	222
	....		%	....	
Continuous cultivation:	38	31	12	9	18
without crop rotation	3	7	2	0	2
with crop rotation	35	24	11	9	16
Short fallow:	62	69	82	86	78
without crop rotation	20	36	29	15	24
with crop rotation	42	33	53	71	54
Long fallow	0	0	6	5	4
Total	100	100	100	100	100

Note
*Côte d'Ivoire, Ghana, Nigeria, Tanzania, Uganda, and DR Congo

Table III-10. Percentage distribution of village fallow/rotation systems by severity score (0–4) for CBB (6 countries*)

Fallow/rotation system	Score = 0	Score = 1	Score = 2	Score > 2	Overall
Number of systems	103	72	26	21	222
	....		%	....	
Continuous cultivation:	24	14	15	10	18
without crop rotation	3	3	0	0	2
with crop rotation	21	11	15	10	16
Short fallow:	73	82	77	90	78
without crop rotation	20	35	23	9	24
with crop rotation	53	47	54	81	54
Long fallow	3	4	8	0	4
Total	100	100	100	100	100

Note
*Côte d'Ivoire, Ghana, Nigeria, Tanzania, Uganda, and DR Congo

Since COSCA information was collected following the methods of social sciences, the observed correlations between the rotation systems and the symptom severity scores of the diseases should not be considered cause-or-effect relationships but hypotheses which are subject to test using more appropriate scientific methods.

Crop sequence in relation to fallow

The position of a crop in relation to fallow, before or after, in a rotation cycle can provide an insight into the crops' tolerance of the problems which drive farmers to leave a field to fallow. The issue is not relevant to continuous cultivation systems because there is no fallow in the rotation cycle. The issue is not also relevant to fallow rotations with a single set of crops since in such cases the same set of crops come before and after fallow. The issue is, therefore, relevant only to systems of two sets of crops rotated one after the other followed by fallow in a three course rotation and three sets of crops rotated one after another followed by fallow in a four course rotation. These systems were not common practices in the country; the few cases of cassava or cocoyam grown under those systems were all before fallow (table III-11). These are described in appendix charts 102 sys 2, 135 sys 3, 136 sys 1, and 139 sys 1. The few cases of yam were all after fallow; maize was grown mostly before fallow while rice was grown mostly after fallow.

Table III-11. Percentage distribution of systems of short fallow rotation with multiple sets of crops by crop-fallow sequence by crop

Crop	No. of systems	Percentage		
		Before fallow	After fallow	Total
Cassava	8	100	0	100
Yam	6	0	100	100
Cocoyam	2	100	0	100
Maize	3	67	33	100
Rice	4	25	75	100

Combined data for the COSCA study countries show that, on an average basis, casssava and maize were each grown approximately 50% of the times before and after fallow. As cassava is relatively more tolerant of poor soil and pest disease problems, and as most existing landraces do not attain maximum root yield before 24 months after planting, farmers would use the crop to close a rotation cycle, i.e., plant it just before fallow. However, cassava performs better under favorable soil, pest, and disease conditions; sometimes farmers find it necessary to use the crop to open a rotation cycle. The crop was grown significantly more frequently after than before fallow under severe conditions of the arthropod pests CMB and CGM and major diseases ACMD and CBB (III-12 to III-15). The general trend was that the relative frequency of cassava cultivation before fallow declined, while cultivation after fallow increased as the severity of each of those problems increased. In good market access areas, where farmers harvest cassava earlier than necessary for maximum root yield in response to market demand, cassava was used to open rather than to close a rotation cycle (III-16). Cassava was not used to close the cycle where cattle were kept as often as where the animals were not kept. Under free grazing conditions farmers would not be able to keep cassava in fallow fields.

Table III-12. Percentage distribution of systems of short fallow rotation with multiple sets of crops by crop-fallow sequence by symptom severity score (0–4 scale) for CMB (all 10 countries)

Symptom severity score (0–4 scale)	No. of systems	Percentage		
		Before fallow	After fallow	Total
0	71	54	46	100
1	8	50	50	100
2	7	57	43	100
3 or 4	3	33	67	100

Table III-13. Percentage distribution of systems of short fallow rotation with multiple sets of crops by crop-fallow sequence by symptom severity score (0–4 scale) for CGM (all 10 countries)

Symptom severity score (0–4 scale)	No. of systems	Percentage		
		Before fallow	After fallow	Total
0	40	58	42	100
1	17	59	41	100
2	21	52	48	100
3 or 4	11	22	78	100

Table III-14. Percentage distribution of systems of short fallow rotation with multiple sets of crops by crop-fallow sequence by symptom severity score (0–4 scale) for ACMD (all 10 countries)

Symptom severity score (0–4 scale)	No. of systems	Percentage		
		Before fallow	After fallow	Total
0	11	55	45	100
1	21	52	48	100
2	40	60	40	100
3 or 4	17	35	65	100

Table III-15. Percentage distribution of systems of short fallow rotation with multiple sets of crops by crop-fallow sequence by symptom severity score (0–4 scale) for CBB (all 10 countries)

Symptom severity score (0–4 scale)	No. of systems	Percentage		
		Before fallow	After fallow	Total
0	40	58	42	100
1	35	51	49	100
2	13	46	54	100
3 or 4	1	0	100	100

Table III-16. Percentage distribution of systems of short fallow rotation with multiple sets of crops (including cassava) by crop-fallow sequence by distance to market and cattle keeping (all 10 countries)

Distance to market/ cattle keeping	No. of systems	Percentage		
		Before fallow	After fallow	Total
Distance to market centers:				
10 km or less	47	49	51	100
above 10 km	13	64	36	100
Cattle:				
kept	36	44	56	100
not kept	53	58	42	100

IV. Intercropping, Plant Density, and Harvest Age

Intercropping

Multiple crops were produced in multiple fields by each farm household. Cassava, yam, cocoyam, plantain, maize, and rice were among staple crops frequently observed.

1. Frequency of intercropping

The crops were sometimes grown as sole crops and sometimes as intercrops in mixed culture; when crops were grown in mixed culture, farmers distinguished, based on their production objectives such as food security, income generation, etc., which was the major and which was the minor crop in the mixture. On average for all the crops, about 30% of the fields were sole cropped and 70% were intercropped. Cassava was grown sole or as the major in an intercrop more frequently than the average for other crops (table IV-1). Cocoyam was not grown as a sole crop. Maize and plantain were grown more frequently as the minor crops than as sole crops or as the major crops in intercrops. The most common intercrops with cassava were maize, rice, plantain, and yam in descending order of frequency. These situations are evident in the appendix charts. A field was designated for a crop if that crop was grown sole or as the major in an intercrop.

Table IV-1. Percentage distribution of crop fields by cropping pattern

Crop	No. of fields*	Percentage			
		Sole	Major	Minor	Total
Cassava	110	55	25	20	100
Yam	26	19	65	16	100
Cocoyam	21	0	67	33	100
Plantain	52	17	27	56	100
Maize	71	15	13	72	100
Rice	42	31	67	2	100
All	306	32	**	**	100

Note
*there is multiple counting of intercropped fields
**intercropped 68%

2. Intercropping and cassava plant pests/disease control

Combined data for the COSCA study countries show that the incidences of the four major cassava plant pests/diseases were higher for intercrops than for sole crops (table IV-2). The symptom severity scores for CMB and ACMD were both higher under intercrop than under sole crop (table IV-3). There was, however, no significant difference between sole cropping and intercropping patterns in the symptom severity score of any of the four problems; a fact which may be associated with differences in rates of growth and leaf production. Toko (1992) did not observe statistical differences in the population densities of CGM between cassava/maize intercrop and a cassava sole crop. He concluded that maize harvested 3–4 months before the increase of CGM in the dry season had no residual effect on subsequent CGM densities in a comparison of formerly intercropped and monocropped plots. Maize was the most common intercrop for cassava in the survey. Some of the other common intercrops grown with cassava were of short duration.

Table IV-2. Incidences of four major cassava plant pests/diseases by farming practices

Farming practices		Landraces assessed	Landraces affected (%)			
			CMB	CGM	ACMD	CBB
Cropping pattern:[1]						
	intercropped	1870	10	31	34	15
	sole cropped	726	5	18	19	8
Crop rotation:[1]						
	practiced	1287	8	29	25	11
	not practiced	1041	9	29	38	15
Bush burning:[2]						
	practiced	1195	7	18	38	14
	not practiced	294	9	16	21	19

Notes
[1]All 10 COSCA countries in Phase I
[2]Congo (DR), Côte d'Ivoire, Ghana, Nigeria, Tanzania, and Uganda

Table IV-3. Symptom severity scores of four major cassava plant pests/diseases by farming practices

Farming practices		CMB			CGM		
		N	Mean	T-test	N	Mean	T-test
Cropping pattern:[1]							
	intercropped	187	1.80	−1.846	584	1.73	−3.838
	sole cropped	39	1.51	($P = 0.066$)	133	1.45	($P < 0.001$)
Crop rotation:[1]							
	practiced	100	1.70	0.9102	379	1.58	4.2044
	not practiced	98	1.82	($P = 0.363$)	295	1.82	($P < 0.001$)
Bush burning:[2]							
	practiced	80	1.75	3.2760	217	1.63	−4.4623
	not practiced	25	1.24	($P = 0.002$)	135	1.32	($P < 0.001$)

Table IV-3. continued

Farming practices		CMB			CGM		
		N	Mean	T-test	N	Mean	T-test
Cropping pattern:[1]							
	intercropped	635	2.01	−2.2245	272	1.50	0.3856
	sole cropped	139	1.81	($P = 0.026$)	59	1.51	($P = 0.700$)
Crop rotation:[1]							
	practiced	319	1.88	3.0869	134	1.49	1.0995
	not practiced	393	2.10	($P = 0.002$)	166	1.59	($P = 0.282$)
Bush burning:[2]							
	practiced	439	2.01	−4.7676	170	1.47	3.0969
	not practiced	62	1.42	($P < 0.001$)	57	1.40	($P = 0.002$)

Notes
N = number of landraces affected
[1]All 10 COSCA countries in Phase I
[2]Congo (DR), Côte d'Ivoire, Ghana, Nigeria, Tanzania, and Uganda

3. Reasons for intercropping

There are reasons for intercropping cassava other than the attempts to alleviate the problems of the four main cassava pests/diseases. Nearly 50% of 124 smallholder farm households studied by Norman (1974) gave the need for high aggregate output as their reason for intercropping, whereas 26% cited shortage of land, 14% security, and 3% shortage of labor. Intercropping practices are complex and generalizations cannot be made on their effects on pests, diseases, or weeds. Crop combinations should be selected mainly for their productivity, reliability, and overall suitability to the farmer's needs. Any beneficial effect on pest or disease control can be regarded as a bonus (Natarajan 1987). More research is needed on the effects of intercropping on pests and diseases to establish the possible benefits of intercropping (Kesiwani 1987). Gold (1994) provides an insight on the biology of intercropping. Lagemann (1977) observed that as pressure on farmland increased, farmers compensated for land scarcity by intensifying intercropping and devoting more energy to household gardens. The latter is characterized by dense planting of a great variety of crops. However, the combined data show that the frequency of intercropping cassava was lower in high population density zones than in low density zones; the frequency was also lower in good market access zones than in poor market access zones. It will be shown below that in the zone of high population density and good market access, the high cassava plant density compensated for the low frequency of intercropping.

Cassava plant density

The mean cassava plant density was 6700 stands/ha and the range was 750 to 16 750 stands/ha. The mean was below the average of about 8000 stands/ha for the COSCA study countries combined (fig. IV-1). It has been reported that climate, altitude, soil fertility status, and morphological characters of the cassava plant as well as intercropping influence the cassava plant density (Onwueme 1978; Fresco 1986; Ambe et al. 1992).

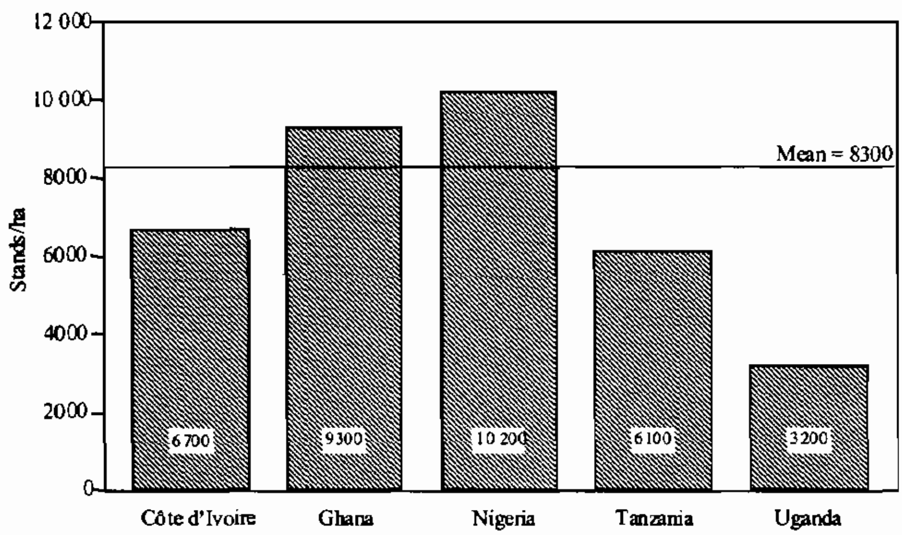

Fig. IV-1. Mean cassava plant density by country

The combined data for the COSCA study countries show that the plant density is lower both where the seedbed type is mound and where it is flat than where the seedbed is ridge. M. Akoroda (personal communication, 1993) reports that in the highland areas of Adamaoua Province in Cameroon, not affected by flooding, cassava plant density was observed to be higher by a factor of 3:2 in fields where cassava was planted on long continuous ridges than on the flat. R. Kapinga (personal communication, 1993) reports similar observations in the Kgera region of Tanzania. Farmers who rarely set distances between plants with caliberated instruments such as tapes have a better sense of spacing on continuous ridges than on the flat. In intercropped fields, the position of each component crop is predetermined for the top or the shoulder of the ridges; on the flat where the positions are not so predetermined, the temptation is to allow more space for secondary crops. Relative to planting on the flat, planting on ridges involves extra capital investment not only in labor but also in soil fertility management practices. In Adamaoua, the ridges are constructed by assembling and covering vegetative materials with top soil. Farmers would try to maximize returns from the extra investments by planting at higher densities.

The type of seedbed is frequently a reflection of the physical characters of the soil in the area. If the soil is shallow or has a high level of clay content or if the water table is high, farmers often plant on large heaps (mounds) to enhance drainage and soil aeration. If on the other hand, the soil is deep, sandy, and the water table is low enough, farmers plant on the flat.

Cassava plant density was higher where nonbranching cassava genotypes are cultivated than where branching genotypes are planted. Plant density is also higher when narrow-leaved cassava genotypes are cultivated rather than broad-leaved genotypes. Village market access had a significant relationship with cassava plant density; the cassava plant density was higher in areas where farmers had motor vehicle access to market than where they had only foot access to markets (table IV-4).

Table IV-4. Mean cassava plant density by market access zone

Zone	Mean	Minimum	Maximum	Standard deviation	No. of fields
Market access:					
vehicle, any distance	8293	1000	16 750	3276	34
foot, 10 km or less	5337	1500	12 000	3003	42
foot, above 10 km	6295	2000	11 500	3173	11

Cassava plant age at harvest

Cassava, unlike most other arable crops, does not have a precise maturity age. Some early bulking varieties form edible roots at 6 months after planting and they may be harvested then; if not harvested, the edible roots continue to bulk, in some cases for up to 24 months after planting beyond which period deterioration may set in, depending on variety, environmental condition, etc. (Jones 1959).

Cassava was harvested at an average of about 11 months after planting and the range was 6–39 months after planting; more than 90% of the representative villages reported that the normal age at which their cassava was harvested was 12 months after planting or earlier; this is evident in the appendix charts. The mean age was low in Côte d'Ivoire in comparison with other COSCA study countries (fig. IV-2).

It has been pointed out that in a situation of food shortages such as may be caused by drought or war, cassava may be harvested early, before it attains maximum bulking. On the other hand, the farmers' decision to delay harvesting may be based on poor market conditions, or the high cost of labor for harvesting and processing. Conversely, a farmer may harvest a field early if market conditions are attractive and labor for harvesting and processing is available. Among villages which had motor vehicle access to market, virtually all cassava fields (95%) were harvested at 12 months after planting or earlier; in contrast, among villages with foot access to market centers, less than 50% of the cassava fields were harvested at 12 months after planting or earlier.

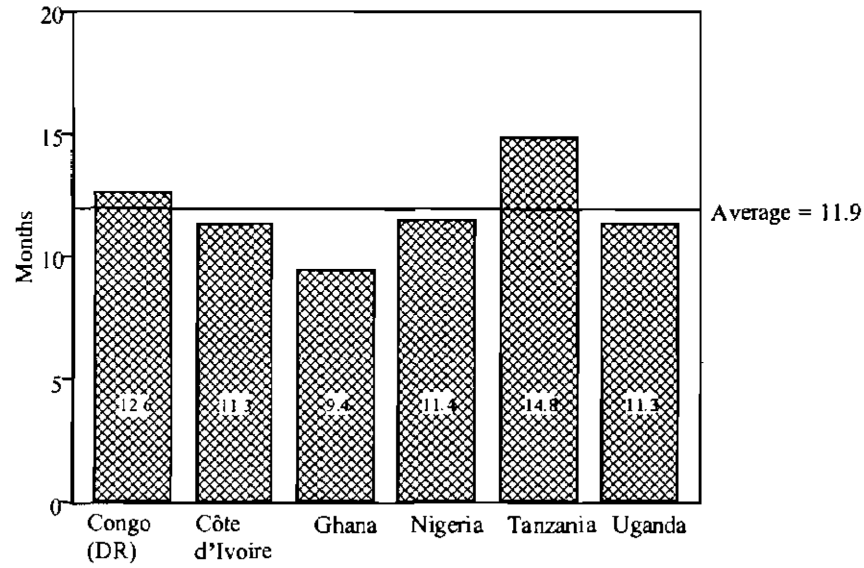

Fig. IV-2. Mean age of cassava fields at harvest in months after planting by country

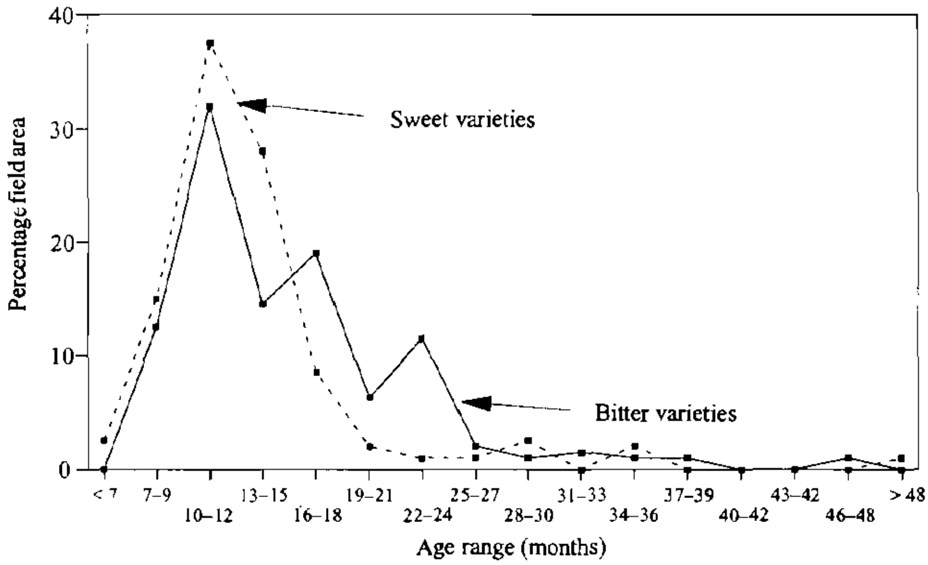

Fig.IV-3. Percentage distribution of mature cassava field area by age of the cassava by bitter/sweet genotypes (all 6 COSCA study countries)

In addition, the type of cassava, bitter or sweet, influences the age at which it is harvested. The percentage distribution of areas of unharvested mature sweet and bitter genotypes, based on combined data for the COSCA study countries, showed that on an average basis, farmers harvested sweet cassava genotypes earlier than bitter genotypes (fig. IV-3). The view of most farmers in the COSCA study countries who planted both the bitter and the sweet cassava types was that the bitter types stored longer in the field than the sweet types. Most of such farmers, however, also opined that sweet types bulked faster than the bitter types. As much as 65% of the yield sample fields which were taken randomly in Côte d'Ivoire were planted with only the sweet cassava types, another 30% were planted with both bitter and sweet cassava, and only 5% were planted with only bitter cassava types. Farmers who use cassava roots in the fresh form harvest earlier than others who use the cassava roots in a processed form because, as Jones (1959) observed, although many genotypes would continue to grow for up to 48 months, as the roots grow older they become fibrous and therefore harder to prepare for consumption. It will be shown later that nearly 40% of the representative villages in Côte d'Ivoire reported that they used cassava roots mostly in the fresh form, i.e., without preprocessing.

V. Relative Importance of Cassava in Producing Areas

The relative importance estimates for the different crops did not differ significantly with method of estimation except in the case of cassava for which the estimate based on main and minor crops was highest while the estimate based on farmers' ranking was lowest (table V-1). In the area studied, cassava was the most important of all the arable crops, irrespective of the method of estimation of relative importance; rice came second after cassava. Maize and plantain were also relatively important. The farmers ranked cassava lower in importance than suggested by the land area allocated; however, they ranked yam and plantain higher than suggested by the land area allocated.

Table V-1. Means of village level estimates of relative importance of crops

Staple	Relative importance estimates						Probability levels of significance of differences		
	Main fields only (a)		Main and minor crops (b)		Farmers' crop ranks (c)				
	N[1]	%[2]	N[1]	%[2]	N[1]	%[2]	a and b	a and c	b and c
Cassava	31	37	34	34	32	24	–	**	–
Yam	14	6	16	6	29	18	–	–	**
Cocoyam	7	8	10	6	22	6	***	***	**
Plantain	15	8	27	11	31	19	–	–	–
Maize	16	9	31	22	26	12	**		***
Rice	17	31	18	19	21	19	***	***	–
Beans/peas	1	1	6	2	5	2	–	–	–
Total	–	100	–	100	–	100	–	–	–

Note
[1]Number of villages on which the means are based
[2]Weighted by number of villages
***Significant at 1% probability level
**Significant at 5% probability level
–Not significant at 5% probability level

The distribution of the survey villages by the crop with the largest land area is shown in fig. V-1. The relative importance estimates are not representative of the whole country, since the sample design was focused on cassava-growing areas. For the whole country, the relative importance of cassava is probably overestimated. The relative importance of other crops which do not share the same ecologies with cassava are likely to be underestimated. For a crop grown more frequently as the main crop (sole or major in intercrop) such as cassava, yam, or rice, the relative importance estimate is higher if it is based on the main field area than if based on the main plus minor field area. The relative importance of such a crop is overestimated as main field area only and underestimated as main plus minor field area. On the other hand, for a crop grown more frequently as the minor in an intercrop than as a main crop, the relative importance estimate is higher if based on the main field area only. The relative importance of such a crop is overestimated as main plus minor field area and underestimated as main field area only.

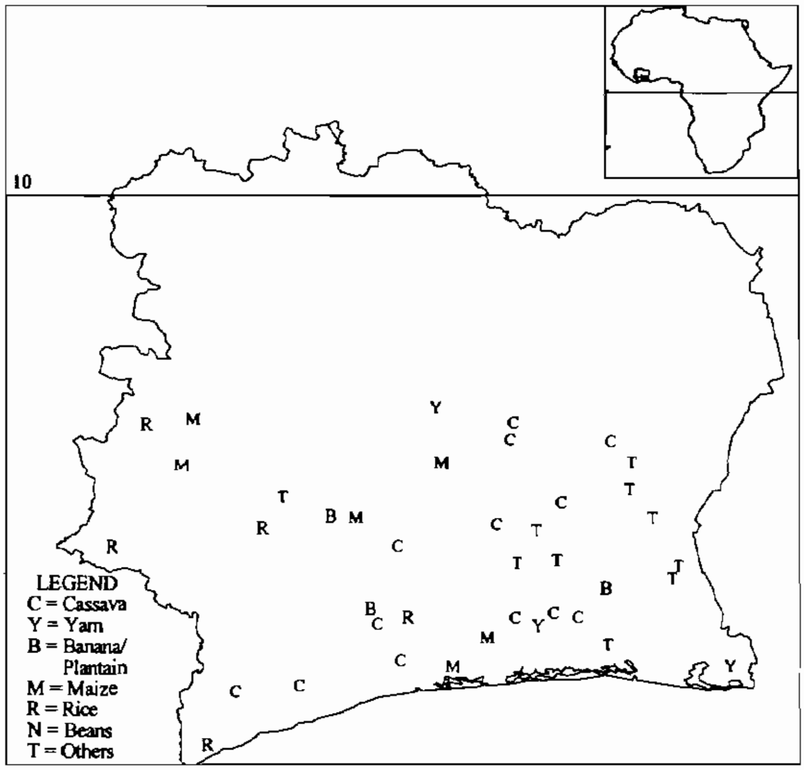

Fig. V-1. Distribution of representative villages by crop with largest field area

Climatic zone

Although the combined data for the COSCA countries show that the relative importance of cassava declined from the humid through the subhumid to the nonhumid zone, the situation was reversed in Côte d'Ivoire; the relative importance of cassava increased from the humid zone through the subhumid zone to the nonhumid zone (table V-2). This was due to the importance of tree crops and rice in the humid zone in Côte d'Ivoire.

Table V-2. Relative importance (field area) of staple crops by climatic zone

Crop	Main crop only			Main and minor crop			Farmers' ranking		
	Humid	SH	NH	Humid	SH	NH	Humid	SH	NH
Sample size (ha)	88.9	20.3	8.6	147.6	31.8	17.6	22	7	3
					%				
Cassava	24	44	65	19	37	40	25	27	23
Yam	5	1	27	4	1	13	12	26	54
Cocoyam	9	9	0	8	10	1	7	6	4
Plantain	9	12	6	15	16	7	17	17	7
Maize	13	5	2	30	15	27	12	15	12
Rice	40	29	0	24	18	0	26	7	0
Beans/peas	0	0	0	0	3	12	1	2	0
Total	100	100	100	100	100	100	100	100	100

Note
SH = subhumid, NH = nonhumid

Fallow systems and market factors

The combined data further show that cassava was more important where short fallow was practiced, although the relative importance did not differ significantly between villages which practiced continuous cultivation and others which practiced long fallow. Farmers were not able to respond to declining soil fertility by replacing other crops with cassava as fallow periods declined because of cassava's long growth cycle. In Côte d'Ivoire, cassava cultivation was much more common under short fallow than under continuous cultivation (table V-3) though for a different reason. In the country, cassava was of less importance around market centers than in areas remote from market centers (table V-4) even though there was evidence that cassava production was responsive to market availability. For example, cassava production was more common where traders provided market services than where the farmers sold directly to consumers (table V-5). Cassava was not as important in areas of continuous cultivation and around market centers as in remote areas in contrast to other countries because of the availability of imported rice. In 1992 the price of imported rice was higher by a margin of 50% in the remote areas (175 FCFA/kg) than in areas around market centers (116 FCFA/kg). This was an indication that imported rice was more easily accessible around market centers than in remote areas. In that year, US$ 1.00 exchanged for 260 FCFA on an average monthly basis.

Table V-3. Relative importance (field area) of staple crops by fallow system

Crop	Main crop only		Main and minor crop		Farmers' ranking	
	Continuous cultivation	Short fallow	Continuous cultivation	Short fallow	Continuous cultivation	Short fallow
Sample size (ha)	32.4	70.0	51.4	115.0	8	24
	%					
Cassava	9	37	15	27	6	32
Yam	3	6	2	5	10	15
Cocoyam	0	11	0	10	5	6
Plantain	8	12	14	16	46	12
Maize	19	7	31	23	7	13
Rice	61	27	38	16	26	20
Beans/peas	0	0	0	3	0	2
Total	100	100	100	100	100	100

Cassava processing technology

There was also evidence that farmer access to improved cassava processing technologies correlated positively with the relative importance of cassava. Cassava was more commonly grown where granules were the most common processed product than where chips/flour was the most common processed product or where cassava was used in the fresh, nonprocessed form (table V-6). Granules are a cassava food product superior to chips/flour in terms of food convenience; the product is more attractive to working-class urban consumers and competes effectively with grains in the market and therefore has wider market opportunities than chips/flour.

Farmers access to labor-saving cassava processing technologies also correlated positively with the relative importance of cassava (table V-7). It is shown elsewhere (Nweke 1994b) that the high labor requirement for processing is a major constraint to cassava cultivation. Some cassava farmers in Nigeria who were cultivating high-yielding varieties bred at IITA sometimes cut back on new plantings because they were unable to process what they had already cultivated.

Table V-4. Relative importance (field area) of staple crops by market access zone

Crop	Main crop only			Main and minor crop			Farmers' ranking		
	Vehicle, any distance	Foot, 10 km or less	Foot, above 10 km	Vehicle, any distance	Foot, 10 km or less	Foot, above 10 km	Vehicle, any distance	Foot, 10 km or less	Foot, above 10 km
Sample size	20.0	57.2	10.2	34.5	92.6	21.2	7	14	3
					%				
Cassava	62	14	29	42	12	17	25	16	16
Yam	9	4	19	6	4	9	30	13	38
Cocoyam	8	3	0	8	6	0	5	7	4
Plantain	4	11	8	12	11	7	17	16	28
Maize	4	14	5	23	34	36	11	10	7
Rice	12	54	39	7	33	22	8	37	7
Beans/peas	1	1	0	2	0	10	4	1	0
Total	100	100	100	100	100	100	100	100	100

Table V-5. Relative importance (field area) of staple crops by main buyer of cassava roots

Crop	Main crop only		Main and minor crop		Farmers' ranking	
	Trader	Consumer	Trader	Consumer	Trader	Consumer
Sample size (ha)	13.6	46.5	22.6	92.0	8	12
	%					
Cassava	66	29	43	24	26	27
Yam	17	7	11	3	29	17
Cocoyam	4	17	6	12	7	7
Plantain	5	6	8	16	12	20
Maize	1	7	15	27	14	9
Rice	7	34	7	17	11	19
Beans/peas	0	0	10	1	1	1
Total	100	100	100	100	100	100

Table V-6. Relative importance (field area) of staple crops by main cassava product in the village

Crop	Main crop only			Main and minor crop			Farmers' ranking		
	Fresh roots	Chips/ flour	Granules	Fresh roots	Chips/ flour	Granules	Fresh roots	Chips/ flour	Granules
Sample size (ha)	36.6	11.1	62.2	65.4	22.9	96.3	12	3	16
	%								
Cassava	26	9	35	20	8	28	32	19	24
Yam	3	10	7	2	5	6	14	17	21
Cocoyam	22	0	3	15	0	5	7	0	6
Plantain	2	0	15	13	3	16	13	12	19
Maize	12	0	10	30	41	22	9	12	13
Rice	34	81	30	19	42	20	22	38	16
Beans/peas	1	0	0	1	0	3	3	2	1
Total	100	100	100	100	100	100	100	100	100

Table V-7. Relative importance (field area) of staple crops by type of processing machine available in the village

Crop	Main crop only			Main and minor crop			Farmers' ranking		
	None	Pressing	Grating	None	Pressing	Grating	None	Pressing	Grating
Sample size (ha)	25.1	92.0	9.5	49.6	145.7	13.3	9	25	3
	%								
Cassava	30	30	53	20	25	40	23	25	28
Yam	2	8	0	1	5	12	20	19	31
Cocoyam	15	6	0	13	5	10	6	6	5
Plantain	3	9	17	9	15	12	7	20	13
Maize	4	13	4	33	26	6	14	11	17
Rice	46	33	26	24	21	18	29	18	6
Beans/peas	0	1	0	0	3	2	1	1	0
Total	100	100	100	100	100	100	100	100	100

Prospects for increased production

About 90% of the representative villages reported an increasing trend in cassava land area in the previous 20 years, 5% reported no change, and another 5% reported a declining trend. FAO data also indicated an increasing trend in cassava land area during the same period. On an annual average basis, cassava land area was more than 120% higher in 1985–89 than in 1965–69. Population growth mainly via immigration, market demand, high food yield, famine and hunger, drought, usability in a wide range of forms, declining soil fertility, poor access to market, land shortage, and pest and disease problems of other crops were variously cited as the reasons for the increasing trend. Cassava was reported to be replacing fallow, cocoyam, yam, sweetpotato, rice, tree crops, and plantain. Among the few representative villages which reported a declining trend, the reason cited was cassava plant pests/disease; tree crops were reported to be taking the place of cassava in the cropping system. However, all but one of the villages which did not report the increasing trend in the cassava land area were in a yam-based cropping system area; the lone exception was, however, in a tree crop-based system area. The increasing trend in the cassava land area was reported in virtually all the villages in the tree crop-based system areas (table V-8). There were numerous immigrants from several West African countries who work as laborers in cocoa and coffee plantations in Côte d'Ivoire.

Table V-8. Percentage distribution of representative villages by most important crop by cassava land area trend

Most important crop	No. of villages	Percentage			
		Increasing	No ehange	Decreasing	Total
Cassava	2	100	0	0	100
Yam	7	72	14	14	100
Rice	6	100	0	0	100
Tree	24	96	0	4	100

The few villages which did not report an increasing cassava land area were all in the humid zone (table V-9). It will be shown later that the problem of ACMD was highest in the humid zone. There was a negative relationship between the problem and the frequency of the villages which reported an increasing trend in the cassava land area.

Table V-9. Percentage distribution of representative villages by climatic zone and incidence of ACMD by cassava land area trend

Climatic zone/incidence of ACMD	No. of villages	Percentage			
		Increasing	No change	Decreasing	Total
Climatic zone:					
humid	27	89	4	7	100
subhumid	8	100	0	0	100
nonhumid	3	100	0	0	100
Incidence of ACMD:					
observed	37	89	8	3	100
not observed	2	100	0	0	100

Ease of access to market influenced the cassava land area expansion positively in other COSCA study countries. This was due to an increase in the market demand associated with improved market access; a market link road expanded market demand because farmers could reach more consumers. The few villages which did not report an increase in the cassava land area in Côte d'Ivoire were, however, all located around market centers (table V-10); market demand for cassava was restricted in such areas because of the ease of consumer access to imported food.

Table V-10. Percentage distribution of representative villages by cassava land area trend by market access, main cassava buyers, and main cassava product zones

Zone		No. of villages	Percentage			
			Increasing	No change	Decreasing	Total
Market:						
	motor vehicle	8	100	0	0	100
	10 km or less	17	88	6	6	100
	nonmotor vehicle	1	100	0	0	100
	foot, above 10 km	3	100	0	0	100
Buyers:						
	middlemen	16	100	0	0	100
	consumers	15	80	20	0	100
Product:						
	fresh roots	15	93	7	0	100
	steamed granules	16	81	13	6	100
	others	8	88	0	12	100

The combined data further show that almost all the villages which had access to mechanized cassava grating technology or which processed cassava into convenient cassava food products reported an expanding cassava land area. Farmers could expand cassava land area under conditions of difficult access to market centers provided improved processing technologies were available. The improved processing technologies improved product quality, reduced bulk, and extended shelf life, and made it possible for quality cassava products to be transported at reduced costs over poor roads to distant urban market centers. In addition, the improved processing technologies were labor-saving; processing cassava into certain products was very labor-intensive. The relative number of villages which reported the increasing trend in cassava land area was lowest among villages which made *attieke*. *Attieke* is a convenient cassava food product because it is available in a ready-to-serve form; it is attractive to urban consumers and hence it has a wide market potential. It is, however, labor-intensive to make; although mechanical pressers were widely available for expressing effluent, grating and other steps in making the product were manually carried out in nearly all the villages surveyed.

PART THREE

GENETIC MATERIALS

VI. Landraces Cultivated

Classification of cultivars by local names

Farmers distinguish cassava cultivars (landraces or genotypes) by local names; such names are descriptive of physical characteristics of the plant, such as color of certain parts, height, canopy size, etc., yield potentials, bulking period, early or late, etc. Such names may also describe the original source of the cultivar, such as the place or institution from where it was introduced for the first time or the individual who brought it originally. The local names may also be an indication of an event which coincided with the introduction of the cultivars in the village (Jones 1959). One hundred and seven local names were recorded for the 40 representative villages; such names will not, however, be useful as a starting point for botanical classification. Since the factors which form the bases for the assignment of such names at the village level were not unique but variable, it follows that names would not be the same but would vary from one village to another for the same cultivar.

Classification of cultivars by morphological characters

It is possible to classify the cultivars by morphological characters, using one character at a time. This is done for the 107 cultivars and discussed as follows:

Bitter/Sweet.[1] As many as 90% of cultivars were described by the farmers during the Phase I COSCA survey as sweet types and 10% as bitter. About 10% of cassava fields surveyed in Phase II were planted with bitter cassava, less than 2% were planted with bitter and sweet, and 88% were planted with only sweet cassava types.

Branching. About 30% of the cultivars were low branching, 10% medium branching, 50% high branching, and 10% were nonbranching types. Medium branching and nonbranching types were not common in the nonhumid zone.

Pubescence. About 5% of the cultivars were pubescent; the pubescent type predominated in the nonhumid zone.

Leaf shape. Most of the cultivars (about 85%) were broad-leaved. Variations across climatic zone was minimal except in the subhumid zone where the relative number of broad-leaved cultivars was as high as 95%.

Petiole color. About 20% of all the cultivars across the representative villages had green petioles and 80% had red petioles. Variation across the climatic zones was slight.

Color of young shoots. About 35% of all the cultivars were classified as purple shoot types and 65% as green shoot types. The relative number of cultivars with purple shoots was higher in the subhumid than in the humid or nonhumid zones.

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[1]Farmers distinguish two sets of cassava varieties, first those which they eat either raw as vegetables, or boiled, or roasted in an open fire without prior transformation. Such roots are normally sweet or bland in taste. The varieties in this set are conveniently referred to as sweet varieties. The second set of cassava varieties are those which, if eaten raw, or even boiled or roasted without prior processing, are presumed to be harmful to humans and animals. Roots of such varieties are often bitter tasting and waxy upon cooking. These varieties are conveniently referred to as bitter varieties. This convention is adopted in referring to these two sets of cassava in this report.

Inner root skin color. Reddish inner skin cultivars made up close to 70% of all cultivars, white inner skin more than 15%, and cream inner skin made up about 15%. Cream inner skin types were more common and reddish types least common in the nonhumid zone than anywhere else.

Color of root flesh. Only a few (about 5%) of the cultivars were classified as yellow root flesh type, most (over 80%) were classified as white root flesh type. Yellow root flesh type was not observed in the nonhumid zone.

Clusters of genotypes by uniform morphological characters

Principal component analysis, carried out on 73 out of the 107 cultivars for which adequate morphological information was available, shows that 33 clusters emerged from these 73 cultivars (table VI-1). All the cultivars that fell into each cluster had the same traits with respect to sweetness/bitterness, branching, pubescence, leaf shape, color of young shoots, petiole color, color of the inner root skin, and color of the root flesh (table VI-2). Each of those clusters may not, however, represent a unique variety. One reason is that while some of the causes of indeterminate morphological character could have been due to error in the assessment, some result from new varieties created as crosses from open pollination in farmers' fields. The next reason is that there are some important morphological characters which were not included in the analysis. These include stem color and color of the outer skin of the root as well as the length of the root neck. The magnitude of the number of clusters suggests the existence of considerable diversity in existing varieties. The wide range of locations where the cultivars in each cluster are cultivated confirms inter-village transfers of materials; many of the clusters have cultivars grown in different villages. The wide diversity of the varieties also reflects the existence of cultivars created as crosses resulting from open pollination, especially since the farmers protect the resulting plants and derive planting materials from them.

Table VI-1. Numbers of clusters of cassava cultivars with similar morphological characteristics per representative village by bitter/sweet type and climatic zones

Zone/group		No. of clusters	No. of villages*	No. of clusters/village
All cases		33	35	0.94
Bitter/sweet:				
	bitter	7	7	1.00
	sweet	26	35	0.74
	Total	33	42	–
Climatic zones:				
	lowland humid	26	26	–
	subhumid	8	5	–
	nonhumid	8	3	–
	Total	42	34	–

Note
*The total number of villages for all the climatic zones is less than the overall number of villages because the type is not specified for some of the villages

Separate cluster analyses for bitter and sweet cultivars confirm that genetic diversity is higher among sweet cultivars than among bitter cultivars. Out of the 33 clusters, 26 were classified as sweet and 7 as bitter. The total number of villages for both groupings is higher than the overall total number of villages, because in certain cases both types were grown in the same villages.

Table VI-2. Cassava cultivars currently grown by uniform morphological characters by village

SNO.	bitswt	shaplv	colpt	braht	colsh	pubes	colirt	colfrt	locname	villname	climate	altitude	gfirst	ebulk	hyield	from
1	Bitter	Narrow	Red	No-bra	Green	None	White	White	Bingerville	Boussoue	Humid	Low	NA	Y	Y	Ftown
2	Bitter	Narrow	Red	Branch	Green	None	Reddish	White	Bingerville	Sahuye	Humid	Low	1936	Y	N	Ftown
									Bonuva Rouge	Sahuye	Humid	Low	NA	Y	N	NA
									Seiin	Douole	Humid	Low	NA	N	Y	NA
3	Bitter	Narrow	Red	Branch	Green	None	Reddish	Yellow	Manioc Blanc	Boussoue	Humid	Low	NA	N	Y	Ftown
4	Sweet	Narrow	Green	Branch	Green	None	Reddish	White	Attiekbou	Kangreta	Humid	Low	NA	Y	N	NA
5	Sweet	Broad	Green	Branch	Green	None	White	White	Ghome Badi	Aprompron	Humid	Low	NA	N	NA	NA
									Bomunyo	Allakro	Humid	Low	NA	N	NA	NA
									Agba Houphoue	Takra-adiekro	NA	Low	NA	N	NA	NA
6	Sweet	Broad	Green	Branch	Green	None	Reddish	White	Mamawa	N'koupe	Humid	Low	1977	Y	Y	NA
									Akomun	N'koupe	Humid	Low	1980	Y	Y	NA
									Akpekpedjenoua	Ano	Subhumid	Low	NA	N	NA	NA
									Akpekpe Nondy	Ofolidie	Humid	Low	NA	Y	N	NA
									Zoylo	Angouakoukro	Subhumid	Low	NA	Y	Y	NA
									Thomnzoglo	Sougban	Nonhumid	Low	NA	N	N	Fvill
									Klede	Dogbo	Humid	Low	NA	N	NA	NA
									X1	Dogbo	Humid	Low	NA	N	NA	NA
7	Bitter	Narrow	Red	Branch	Purple	None	Reddish	White	Bonova	Boussoue	Humid	Low	NA	Y	Y	Ftown
8	Sweet	Broad	Red	Branch	Green	None	White	White	Konyomontan	Aprompron	Humid	Low	NA	N	NA	NA
									Tomlin	Dogbo	Humid	Low	NA	N	NA	NA
									Nonwlonkokozoci	Meneke	Humid	Low	NA	Y	N	Ocount
9	Sweet	Broad	Green	No-bra	Green	None	Reddish	White	Bonovablome	Sandicbounga	Subhumid	Low	NA	Y	Y	NA
10	Sweet	Broad	Red	Branch	Green	None	White	Yellow	Ghani	Allakro	Humid	Low	1986	Y	N	Ocount
11	Sweet	Broad	Red	No-bra	Green	None	White	White	Agbass	Akacomoekro	Humid	Low	NA	Y	N	NA
12	Sweet	Broad	Red	Branch	Green	None	Reddish	White	Bedegbegbe	N'koupe	Humid	Low	NA	Y	N	NA
									Kogomuke	Allakro	Humid	Low	NA	Y	N	NA
									X3	Allakro	Humid	Low	NA	N	NA	NA
									Zoylo1	Angouakoukro	Subhumid	Low	NA	Y	N	Ftown
									Soclo	N'gattakro	Humid	Low	NA	N	Y	NA
									Cocosovl	Lalasso	Humid	Low	1945	Y	Y	Ftown
									Kraba Kokore	Adikankro	Humid	Low	NA	Y	Y	NA
									Koko	Zozo Oliziribuue	Subhumid	Low	1912	Y	Y	Fvill
									Agricultu	Ekradon	Humid	Low	1980	Y	Y	NA
									Bonova	Godesso	Humid	Low	1978	Y	Y	Fvill
									Gobero Rouge	Digbouho	Humid	Low	NA	Y	Y	NA
									Maniocbefel	Bcbouo-sibouo	Humid	Low	NA	Y	N	Fvill
									Gbaloba	Medibli	Humid	Low	1920	Y	Y	Ocount
									Gbe	Blole	Humid	Low	1937	Y	Y	Ftown
									Tahou	Yepleu	Humid	Low	1939	Y	Y	Fvill
									Tabounouveau	Douole	Humid	Low	1952	Y	Y	Fvill
									Zoglo	Takra-adiekro	NA	Low	NA	Y	N	NA

Notes on page 47

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Table VI-2 continued

SNO.	bitswt	shaplv	colpt	braht	colsh	pubes	colirt	colfrt	locname	villname	climate	altitude	gfirst	ebulk	hyield	from
13	Sweet	Broad	Red	Branch	Green	None	Reddish	Yellow	Beol'e Bouna	Aprompron	Humid	Low	NA	N	NA	NA
									Bedebomom	Akacomoekro	Humid	Low	NA	Y	N	NA
14	Sweet	Broad	Green	Branch	Purple	None	Reddish	White	X1	Allakro	Humid	Low	NA	N	NA	NA
									Ngraangba	Lalasso	Humid	Low	1939	N	N	Ocount
15	Sweet	Broad	Red	Branch	Purple	None	White	White	Abodjo	N'koupe	Humid	Low	1984	Y	Y	NA
									Tubre	Aprompron	Humid	Low	NA	N	NA	NA
									Tetosokro	Zozo Olizirtboue	Subhumid	Low	1984	Y	Y	Fvill
16	Sweet	Broad	Green	Branch	Green	None	Reddish	Cream	Bonoua	Detroya	Humid	Low	1968	Y	Y	Ftown
17	Bitter	Narrow	Red	No-bra	Purple	None	Cream	White	Thcolothe	Ekradon	Humid	Low	1981	Y	Y	Ocount
18	Sweet	Broad	Red	No-bra	Purple	None	White	White	Atamaov	Akacomoekro	Humid	Low	NA	Y	N	NA
19	Sweet	Broad	Red	Branch	Purple	None	Reddish	White	Tambou	N'koupe	Humid	Low	NA	Y	Y	NA
									Nizebo	Aprompron	Humid	Low	NA	N	NA	NA
									Bedeteou	Ano	Subhumid	Low	NA	Y	N	Ftown
									Kadiouhonoua	Ano	Subhumid	Low	NA	Y	Y	NA
									Bedete	Ofolidie	Humid	Low	NA	Y	N	NA
									Kaole	Ofolidie	Humid	Low	NA	Y	Y	Ftown
									Bounoua	Allakro	Humid	Low	1974	Y	Y	Ftown
									Bonova	Angouakoukro	Subhumid	Low	NA	N	Y	Ftown
									Bonova Rouge	Sandiebounga	Subhumid	Low	1986	Y	N	Ftown
									Bononua Rouge	Adikankro	Humid	Low	1977	Y	N	Ftown
									Zoglo	Sougban	Nonhumid	Low	NA	N	Y	NA
									Kokosoclo	Okromodou	Humid	Low	1960	Y	N	NA
									Bonoval	Meneke	Humid	Low	NA	Y	N	NA
									Bononua	Gnity	Humid	Low	NA	Y	Y	NA
20	Sweet	Narrow	Red	Branch	Purple	None	Cream	White	Kueko	Gahougnagbolilie	Humid	Low	1988	Y	Y	Ftown
21	Sweet	Broad	Red	Branch	Green	None	Reddish	Cream	Koko	Ekradon	Humid	Low	1980	Y	Y	NA
									Bonoua	Kripoko	Subhumid	Low	1971	Y	Y	NA
									Bononua Rouge	Behouo-sibouo	Humid	Low	NA	N	NA	NA
22	Sweet	Narrow	Red	No-bra	Purple	None	White	Cream	Manioc Jaune	Boussoue	Humid	Low	NA	N	NA	NA
23	Bitter	Broad	Red	Branch	Purple	None	White	Cream	Yace	Brofodoume	Humid	Low	1970	Y	Y	Nvill
24	Bitter	Broad	Red	Branch	Purple	None	Cream	White	Boofie	Brofodoume	Humid	Low	1970	Y	N	Nvill
									Tinana	Okromodou	Humid	Low	1960	Y	Y	NA
									Wodo	Okromodou	Humid	Low	1980	Y	Y	NA
25	Bitter	Broad	Red	Branch	Green	None	Cream	Cream	Gebi	Kripoko	Subhumid	Low	NA	Y	Y	NA
26	Sweet	Broad	Green	Branch	Green	None	Cream	Cream	Ghanab	Gahougnagbolilie	Humid	Low	1984	Y	Y	Ftown
27	Bitter	Narrow	Red	Branch	Purple	None	Cream	Cream	Tielekro	Kpato	Nonhumid	Low	NA	N	NA	NA
28	Sweet	Broad	Red	Branch	Purple	None	White	Cream	Koudouka	Kripoko	Subhumid	Low	1979	Y	Y	NA
29	Sweet	Broad	Green	Branch	Green	Positive	White	White	Agbahon	Saoua	Nonhumid	Low	NA	Y	N	NA
30	Sweet	Broad	Green	No-bra	Green	None	Cream	Cream	Akana	Brofodoume	Humid	Low	1970	Y	N	Nvill
									Akomu	Brofodoume	Humid	Low	1970	Y	N	Nvill
31	Sweet	Broad	Red	Branch	Purple	None	Cream	White	Bonouo	Brofodoume	Humid	Low	1970	Y	N	Nvill
32	Sweet	Broad	Red	Branch	Green	None	Cream	Cream	Attote	Gahougnagbolilie	Humid	Low	1984	Y	Y	Ftown

Notes on page 47

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Table VII-2 continued

SNO.	bitswt	shaplv	colpt	braht	colsh	pubes	colirt	colfrt	locname	villname	climate	altitude	gfirst	ebulk	hyield	from
33	Sweet	Broad	Red	No-bra	Green	None	Cream	Cream	Bouanga	Brofodoume	Humid	Low	1970	Y	N	Nvill
34	Sweet	Broad	Red	Branch	Green	Positive	Reddish	White	Zoylo	Sandiebounga	Subhumid	Low	NA	Y	N	NA
									Nambobou	Detroya	Humid	Low	1940	Y	N	NA
									Gogoba	Medibli	Humid	Low	NA	Y	Y	NA
35	Sweet	Broad	Green	Branch	Green	Positive	Cream	White	Thomon	Sougban	Nonhumid	Low	1975	N	Y	Ocount
36	Sweet	Broad	Red	Branch	Green	Positive	Cream	White	Agbule	Sougban	Nonhumid	Low	NA	N	Y	NA
37	Sweet	Broad	Red	Branch	Purple	Positive	Reddish	White	Kouadio-ba	Sougban	Nonhumid	Low	NA	N	N	NA

Notes

bitswt	bitter or sweet cassva type
shaplv	shape of cassava leaf
colpt	color of petiole of cassava plant
braht	branching habit of cassava plant (Branch = branching cassava; No-bra = nonbranching)
colsh	color of the young shoot (growing point) of the cassava plant
pubes	pubescent or not pubescent, i.e., whether the growing tip is hairy or not; (positive = cassava plant is pubescent; none = cassava plant is not pubescent
colirt	color of inner skin of cassava root
colfrt	color of flesh of cassava root
locname	local name of cassava genotype where it was identified
villname	name of the village where the genotype was observed
gfirst	year the genotype was first grown in the village where it was observed
ebulk	early bulking genotypes (yes = early bulking; no = not early bulking)
hyield	high yielding genotypes (yes = high yielding; no = not high yielding)
from	where cassava genotype first came from
Fvill	village far away
Nvill	neighboring village
Ftown	city far away
Ocount	other country
NA	data not available

Although the number of clusters per village was higher for the bitter cultivars than for the sweet, the sweet cultivars were more widespread as they were cultivated in many more villages. While about 70% of the representative villages cultivated only the sweet cultivars, about 30% cultivated both the bitter and the sweet cultivars; none cultivated only the bitter cultivars. ~~Cultivars~~ Cultivars which were not classified into clusters because of incomplete morphological information are listed in table VI-3.

Rate and method of cultivar selection by farmers

There was a turnover in the cassava cultivars grown by farmers who continually introduced new cassava cultivars with desired attributes into their cropping system. Such cultivars were not necessarily improved varieties but were often local and varied with villages and regions. Hence, such genotypes may not be unique across villages. As they introduced new cultivars, farmers often abandoned the existing cultivars that may not possess desired attributes. The farmers therefore seemed keen to replace existing cassava cultivars with new ones which possessed more advantageous attributes. Farmers sourced their cassava planting materials mainly from other villages and towns. Some cultivars were also reported to have been introduced from other countries. Cultivars were brought in by traders, migrant farmers, or development agencies, and church organizations.

Farmers in group meetings during the Phase I survey were able to recall 37 different cultivars abandoned (table VI-4) in the representative villages and to trace the years when 28 of them were abandoned. Similarly the farmers were able to trace the years of introduction of 49 of the 107 currently grown cultivars (fig. VI-1). This information may not be exact because the numbers of the cultivars introduced or abandoned cluster around decade ends. This would suggest that there must be some memory lapses, as the information was based on memory and not on written records. The recall period, however, spans different generations of people, since the composition of the village groups from which the information was elicited involved people of different age groups. The overall trend appears consistent with historical experience. The mean numbers introduced or abandoned per period of time were relatively low until the 1931–1940 decade from which time they began to increase rapidly.

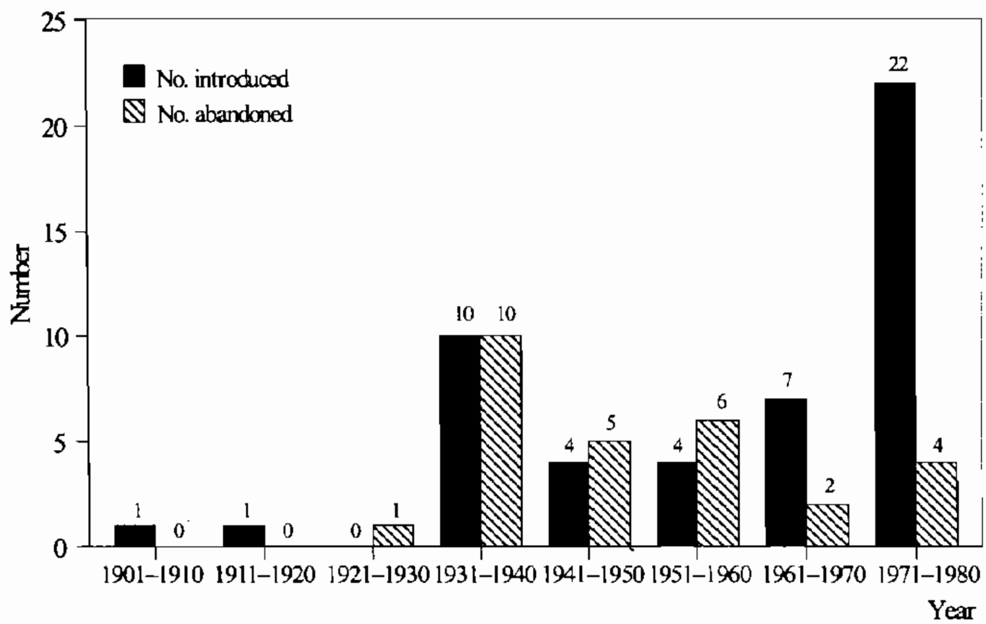

Fig. VI-1. Number of cassava genotypes introduced and abandoned in the representative villages in 10-year intervals, 1901 to 1980

Table VI-3. Cassava cultivars currently grown with incomplete morphological character information by village

SNO.	bitswt	shaplv	colpt	braht	colsh	pubes	colirt	colfrt	locname	villname	climate	altitude	gfirst	cbulk	hyield	from
1	Bitter	Narrow	–	Branch	Green	None	Reddish	White	Bonova	Sahuye	Humid	Low	1984	Y	Y	Ftown
2	Sweet	Narrow	–	Branch	Green	None	Reddish	White	Bahouizoclo	Meneke	Humid	Low	1800	Y	Y	NA
3	Sweet	–	–	Branch	Green	None	White	White	Akako	Akacomoekro	Humid	Low	NA	Y	N	NA
4	Bitter	Broad	–	Branch	Green	None	Reddish	White	Bonouab	N'gattakro	Humid	Low	1983	Y	N	Ftown
5	–	–	Green	Branch	Green	None	–	–	NA	Akacomoekro	Humid	Low	NA	Y	Y	Ocount
6	Sweet	Broad	–	Branch	Green	None	White	White	Manioc bslanc	Dogbo	Humid	Low	NA	Y	N	NA
7	–	Broad	Red	Branch	Green	None	Reddish	White	Cocoseclo	Komambo	Subhumid	Low	NA	N	Y	NA
8	Bitter	Broad	Red	Branch	–	None	White	White	Tchena	Zozo Oliziriboue	Subhumid	Low	1949	Y	N	Fvill
									Agbahouph	Kpato	Nonhumid	Low	1979	Y	N	NA
9	Sweet	Broad	–	Branch	Green	None	Reddish	White	Bonova 2	Meneke	Humid	Low	1980	Y	N	Ftown
10	Sweet	Broad	–	Branch	Green	None	Reddish	Yellow	Gedekuku	Ano	Subhumid	Low	NA	Y	N	NA
11		Broad	Red	–	Green	None	–	White	Bov	Zahibo	Humid	Low	NA	Y	N	NA
12	Sweet	Broad	Green	Branch	Green	None	–	White	Bonova	Zozo Oliziriboue	Subhumid	Low	1977	Y	Y	Fvill
									Kosuassipouka	Takra-adiekro	NA	Low	NA	Y	Y	NA
13	Bitter	Broad	–	–	Purple	None	White	White	Diabo	N'gattakro	Humid	Low	1983	Y	N	Ftown
14	Sweet	Narrow	–	Branch	Purple	None	Reddish	White	Aknagbu	Sandiebounga	Subhumid	Low	1975	Y	N	Ntown
15	–	–	–	–	–	None	–	–	N'kuku	Ofolidie	Humid	Low	NA	Y	N	NA
									Bonova rouge	Tchekou-carrefour	Subhumid	Low	NA	Y	N	NA
									Bonova blanc	Tchekou-carrefour	Subhumid	Low	NA	Y	Y	NA
									Zoylo	Tchekou-carrefour	Subhumid	Low	NA	Y	N	NA
									Soclo	Koudieblekro	Subhumid	Low	NA	Y	Y	NA
									Bononua blanc	Koudieblekro	Subhumid	Low	NA	N	N	NA
									Bonoua	Koudieblekro	Subhumid	Low	1967	N	N	Fvill
									Ngaragba	N'gattakro	Humid	Low	NA	N	N	NA
									Ghana	Ekradon	Humid	Low	1980	Y	Y	NA
									Akagba	Gahougnagbolilie	Humid	Low	1940	Y	Y	Ftown
									Chena	Gahougnagbolilie	Humid	Low	1956	Y	Y	Ftown
									Blafour	Kangreta	Humid	Low	NA	Y	N	NA
									Bouova	Sougban	Nonhumid	Low	NA	N	N	Fvill
									Agbakangha	Sougban	Nonhumid	Low	NA	N	N	Fvill
									Djagbe	Dogbo	Humid	Low	NA	Y	N	NA
									Bonova	Dogbo	Humid	Low	NA	N	NA	NA
16	–			Branch	–	None	–		Kpokochi	N'koupe	Humid	Low	1984	Y	Y	NA
									Kokozokao	Akouakro	Humid	Low	NA	N	N	NA
									Bonova	Akouakro	Humid	Low	NA	N	Y	Ftown
									Atambai	Akouakro	Humid	Low	NA	N	Y	NA
									Ehoiman foua	Akouakro	Humid	Low	1983	N	N	NA
									Bedeakako	Akouakro	Humid	Low	1984	N	N	NA

Notes on page 47

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Table VI-3 continued

SNO.	bitswt	shaplv	colpt.	braht	colsh	pubes	colirt	colfrt	locname	villname	climate	altitude	gfirst	ebulk	hyield	from
17	Sweet	Broad	–	Branch	–	None	Reddish	White	Gobebro blanc	Digbouho	Humid	Low	NA	N	NA	NA
18	Sweet	–	–	–	–	None	–	–	Batekofi	Aprompron	Humid	Low	NA	N	NA	NA
19	Sweet	Broad	Red	Branch	–	None	Reddish	White	Assovamble	Ekradon	Humid	Low	NA	Y	Y	Nvill
									Bonova	Digbouho	Humid	Low	NA	Y	Y	Ftown
									Bononua	Bebouo-sibouo	Humid	Low	1980	Y	Y	Fvill
									Manioe blanc	Kangreta	Humid	Low	NA	Y	N	NA
									Bonoua	Kangreta	Humid	Low	1940	Y	Y	Fvill
20	–	Broad	–	Branch	Green	None	Reddish	Cream	Bonoua blanc	Komambo	Subhumid	Low	1984	N	Y	Fvill
21	Sweet	Broad	–	Branch	Purple	None	Reddish	White	NA	Angouakoukro	Subhumid	Low	NA	N	N	NA
22	Bitter	Broad	Red	–	–	None	Cream	White	Manioc	Godesso	Humid	Low	NA	N	N	Nvill
23	–	Broad	Red	Branch	Purple	None	–	White	Bonova	Zahibo	Humid	Low	1972	Y	Y	Ftown
24	Bitter	Broad	Red	Branch	–	None	Cream	White	Adjo	Ekradon	Humid	Low	NA	N	Y	NA
25	Bitter	Broad	Red	Branch	–	None	Reddish	Cream	Kolaka	Gahougnagbolilie	Humid	Low	1984	Y	Y	Ftown
26	Sweet	Broad	Red	Branch	Purple	None	–	White	Bonoua	Brofodoume	Humid	Low	1945	Y	N	Fvill
27	Sweet	Broad	Red	Branch	–	None	White	Cream	Bonoua rouge	Blole	Humid	Low	1983	Y	N	Fvill
28	Sweet	Broad	Red	–	Green	None	–	Cream	Bovanga	Brofodoume	Humid	Low	NA	Y	N	NA
29	–	Broad	Red	Branch	Purple	None	Cream	White	Dabuu	Kripoko	Subhumid	Low	1979	Y	Y	NA
30	Sweet	Broad	Red	Branch	–	None	Reddish	Cream	NA	Allakro	Humid	Low	NA	N	NA	NA
31	–	Broad	Red	Branch	Purple	None	Reddish	Cream	Bonoua	Komambo	Subhumid	Low	1984	N	Y	Fvill
32	Sweet	Narrow	–	Branch	–	Positive	Reddish	White	Yolabou	Kangreta	Humid	Low	NA	Y	N	NA

Notes
as in table VII-2

Table VI-4. List of cultivars which were no longer grown (abandoned) by village

Survno1	Villno	Villname	Vary1	Bitswt1	Year1	Reas1	Vary2	Bitswt2	Year2	Reas2
101	1	Sahuye	Ayekamatsour	Sweet	1930	Weed	NA	NA	NA	NA
102	2	Boussoue	Kamgba	Sweet	NA	Process	NA	NA	NA	NA
103	3	Brofodoume	Tebou	Bitter	1940	Yield	Aba	Sweet	40	Weed
104	4	N'koupe	Aba	A	1950	Weed	NA	NA	NA	NA
105	5	Akouakro	Nominconne	Bitter	NA	Weed	NA	NA	NA	NA
106	6	Aprompron	NA	NA	NA	NA	NA	NA	NA	NA
107	7	Akacomockro	NA	NA	NA	NA	NA	NA	NA	NA
108	8	Ano	Bingerville	Sweet	1969	Cyanogen	NA	NA	NA	NA
109	9	Ofolidie	NA	NA	NA	NA	NA	NA	NA	NA
110	10	Allakro	NA	NA	NA	NA	NA	NA	NA	NA
111	11	Angouakoukro	Tchicaya	Bitter	NA	Cyanogen	NA	NA	NA	NA
112	12	Sandiebounga	Zoglo	Bitter	NA	Cyanogen	Gucbi	Bitter	NA	NA
113	13	Tchekou-carrefour	Assidjebi	Bitter	NA	Weed	NA	NA	NA	NA
114	14	Komambo	Djebi	Bitter	1949	Cyanogen	Kadjoyao	Sweet	1979	Yield
115	15	Koudieblekro	Agbakamgba	Sweet	1954	Yield	NA	NA	NA	NA
116	16	N'gattakro	Baoule Agba	Sweet	1971	NA	NA	NA	NA	NA
117	17	Lalasso	Agbafoufoue	Bitter	1950	NA	NA	NA	NA	NA
118	18	Adikankro	Agbadika	Bitter	1955	Process	Krabafoufoue	Bitter	1963	Process
119	19	Zozo	Oliziriboue	NA	NA	NA	NA	NA	NA	NA
120	20	Ekradon	Agbcdre	Bitter	1981	Branching	Ganusi	Bitter	1981	Branching
121	21	Godesso	NA	NA	NA	NA	NA	NA	NA	NA
122	22	Gahougnagbolilie	Gabi	Bitter	1940	NA	NA	NA	NA	NA
123	23	Kripoko	Chena	Sweet	1940	NA	Oulikisororo	Sweet	1940	NA
124	24	Digbouho	NA	NA	NA	NA	NA	NA	NA	NA
125	25	Zahibo	NA	NA	NA	NA	NA	NA	NA	NA
126	26	Bebouo-sibouo	NA	NA	NA	NA	NA	NA	NA	NA
127	27	Kangreta	Blafuun	Bitter	1989	NA	NA	NA	NA	NA
128	28	Dctroya	Ourabou	Bitter	1940	Cyanogen	NA	NA	NA	NA
129	29	Medibli	NA	NA	NA	NA	NA	NA	NA	NA
130	30	Blole	Simba	Bitter	1937	Cyanogen	NA	NA	NA	NA
131	31	Yepleu	Blam	Bitter	1939	Cyanogen	Bonn	Bitter	1939	Cyanogen
132	32	Douole	Geti	Sweet	1944	Yield	NA	NA	NA	NA
133	33	Takra-adiekro	Agbagnasisi	Sweet	1949	Yield	NA	NA	NA	NA
134	34	Sougban	NA	NA	NA	NA	NA	NA	NA	NA
135	35	Kpato	Kpouka	Sweet	1960	Yield	Ninmlin	Sweet	1960	Yield

Notes on page 52

cont'd

Table VI-4 continued

Survn01	Villno	Villname	Vary1	Bitswt1	Year1	Reas1	Vary2	Bitswt2	Year2	Reas2
136	36	Saoua	Agbahouphoue	Sweet	1989	Yield	NA	NA	NA	NA
137	37	Okromodou	Akangba	Sweet	1958	NA	Kina	Sweet	1958	NA
138	38	Dogbo	NA	NA	NA	NA	NA	NA	NA	NA
139	39	Meneke	Djogble	Bitter	1979	NA	NA	NA	NA	NA
140	40	Gnity	NA	NA	NA	NA	NA	NA	NA	NA

Notes

Survno1 = survey number of village
Villno = village identification number
Villname = village name
Vary1 = first landrace abandoned
Bitswt1 = whether Vary1 is bitter or sweet cassava
Year1 = year Vary1 abandoned
Reas1 = reason Vary1 abandoned
Vary2 = second landrace abandoned
Year2 = year Vary2 abandoned
Reas2 = reason Vary2 abandoned
Bitswt2 = whether Vary2 is bitter or sweet cassava
yield = low root yield
process = poor processing qualities
weed = weed susceptible
eyanogen = high cyanogen content
branching = unsuitable branching habit
NA = not available

Historical accounts indicate that rapid spread of cassava production occurred about the same period. Jones (1959) reported that Auguste Chevalier observed that cassava was almost unknown when he first visited Senegal in 1898. But when he revisited French West Africa in 1929 he found cassava cultivated throughout much of Senegal. Cassava spread steadily over the savanna areas of French West Africa during the 1930s (Jones 1959). According to Martin (1988), the decade 1920–1930 marked the beginning of the spread of cassava in southeastern Nigeria. From 1930 to 1950, cassava was displacing yam as a sole crop in areas where bush fallow declined below a 7-year period.

Further accounts from the same sources indicate that two broad sets of factors were responsible for the rapid spread of cassava production during that period. One was a series of natural disasters and the other was the increased rate of communication. Agricultural stations established by the colonial governments in some colonies had attempted to develop improved cassava varieties through selection and breeding. The programs were largely inspired by the appearance and rapid spread in the 1930s of mosaic all along the southern coast of West Africa; since that time it has spread over most of the area in Africa (Jones 1959).

As the European powers established political control over the West African states there was a great expansion of trade and a heavy seasonal migration of workers down from the Sudan into the southern areas. It is estimated that in the 1940s between 300 000 and 400 000 workers annually came down from the French Sudan, Niger, Upper Volta (Burkina Faso), northern Dahomey (Bénin), and northern Ivory Coast (Côte d'Ivoire). Both the movement of people between the coast and the interior and the increase in total population in the coastal zones served to stimulate the production of cassava. Once cassava was established in the coastal zones it was carried inland by migratory workers going home and by emigrants from the densely populated areas (Jones 1959).

VII. Farmer-desired Attributes of Cassava Cultivars

The relative frequencies of reasons for abandoning cultivation of the 37 cassava cultivars in the representative villages are presented in fig. VII-1 in decreasing order of the frequencies. The figure shows, for example, that the cultivation of 27% of the cultivars was abandoned because of low root yield. The implication is that in the villages where the cultivation of these cultivars was abandoned, the farmers were selecting for high root yield; similarly they were selecting for low HCN potential, weed suppression, good processing qualities, certain branching characteristics, and so on in areas where the cultivation of cultivars were abandoned because of related reasons.

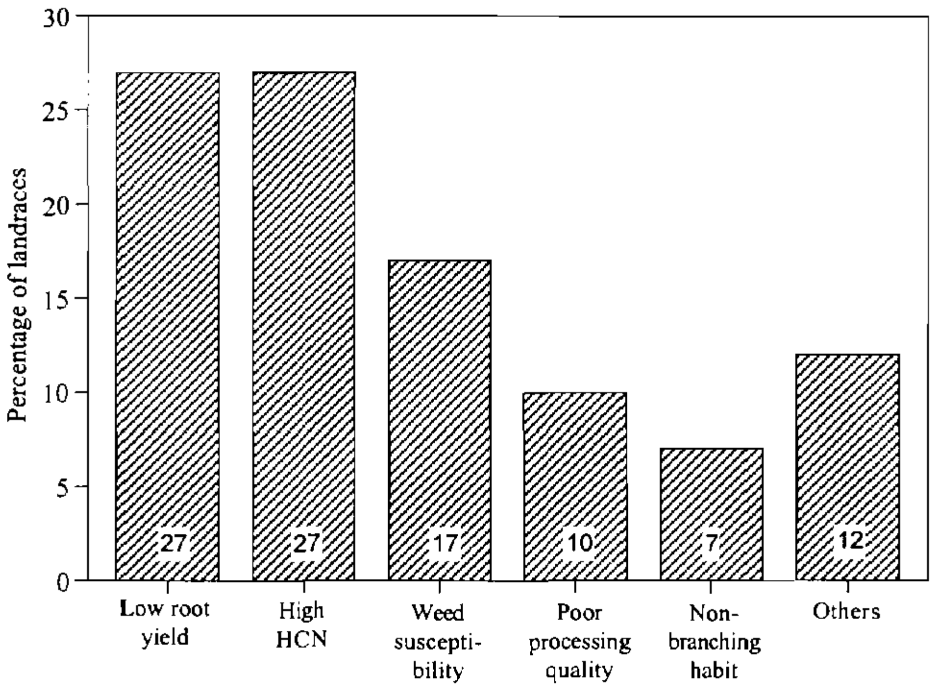

Fig. VII-1. Percentage distribution of abandoned cassava cultivars by the reasons why thcy were abandoned

Root yield

Level of root yield was an important consideration in the selection of cassava genotypes because it determined the production cost per unit of output. It was a less important consideration to farmers who were close to market centers (table VII-1) because, compared with farmers further away from the market centers, they were more concerned with rice than with cassava production for sale. Level of root yield was, however, an important consideration to farmers who made *attieke*, a granulated processed cassava product which had a high market value. Level of root yield was also a more important consideration outside the humid zone than within the humid zone (table VII-2) suggesting that perhaps root yield may be environmentally determined. Only sweet cassava genotypes were abandoned because of low root yield; farmers classified relatively more bitter genotypes than sweet genotypes as high yielding. Root yield will be discussed in greater detail in a later chapter.

Table VII-1. Percentage distribution of abandoned cassava cultivars by reasons they were abandoned by main cassava product used in the village and by market distance

Reasons	Cassava product			Market distance	
	Fresh (N = 7)	*Attieke* (N = 16)	Chips/flour (N = 4)	≤ 10 km (N = 21)	> 10 km (N = 9)
Low root yield	0	38	50	19	44
High HCN	29	19	50	29	22
Weed susceptibility	29	19	0	24	0
Poor processing quality	0	6	0	14	0
Undesirable branching habit	29	0	0	0	22
Others	13	18	0	13	12
Total	100	100	100	100	100

Note
N = cultivars abandoned

Table VII-2. Percentage distribution of abandoned cassava cultivars by reasons they were abandoned by climatic zone and by type of cassava abandoned

Reasons	Climatic zone		Type of cassava	
	Humid (N = 18)	Outside humid (N = 11)	Bitter (N = 18)	Sweet (N = 12)
Low root yield	0	38	19	44
High HCN	29	19	29	22
Weed susceptibility	29	19	24	0
Poor processing quality	0	6	14	0
Undesirable branching habit	29	0	0	22
Others	13	18	13	12
Total	100	100	100	100

Note
N = cultivars abandoned

Cyanogen content

The issue of the level of toxicity of the breakdown products of the cyanogens in cassava has been very controversial. In Nigeria, several cases of food poisoning, some of which have led to death, have been attributed to cassava consumption linking it to HCN in the cassava although these conclusions were not based on scientific observation. Cassava does not contain HCN at all but cyanogenic glucosides which upon an enzymatic breakdown catalyzed by linamarase release HCN (Maduagwu and Adewale 1981; Bokanga 1992). What is relevant is not the content of HCN but the potential to release HCN which is a reflection of the amount of cyanogenic glucosides. The HCN or the linamarin is eliminated when cassava is properly processed (Maduagwu and Adewale 1981; Hahn 1982). The most important processing procedure which gives rise to the efficient reduction of cyanide is that which involves crushing, fermentation, and cooking or toasting. Half of the genotypes abandoned in villages which produced chips/flour were dropped because of high cyanogen content. In a later chapter it will be shown that chips/flour is made by several methods including the most simple method of cassava processing which involves just peeling and drying and is not efficient in the reduction of the cyanogen level.

Most of the genotypes abandoned because of the high level of cynogens were in villages close to market centers. Villages further away from market centers processed more than villages around market centers because processed cassava is less bulky and has a longer shelf life and is, therefore, cheaper to transport and market than fresh cassava roots (Nweke 1994b). Although relatively more bitter cassava types were abandoned because of high cyanogen content than sweet cassava types, some sweet types were also abandoned because of the same reason. Again, most of the cultivars abandoned for high cyanogen content were outside the humid zone.

Weed suppression and branching habit

Weed suppression and branching habit are related attributes which are determined by canopy type. Weed susceptibility refers to the inability of the cassava plant to establish an early canopy which suppresses weeds. The branching height (low branching, high branching, or nonbranching) which is desired depends on the circumstances: low branching is desired for weed control, but not for the intercropping of cassava with other crops, while high or nonbranching is desired for intercropping but is not suitable for weed control and lodges early.

All the genotypes which were abandoned because of undesirable branching habit were abandoned because they were nonbranching. This meant that the farmers were selecting for a large canopy which suppressed weeds. Onwueme and Sinha (1991) stated that in appropriately spaced cassava, weeding is necessary for only the first 3 months after planting, after which the canopy closes and no further weeding is necessary. However, in a cropping systems survey of cassava production in the humid areas of Nigeria, Nweke et al. reported that 95% of the farmers surveyed identified weeding as their most labor-intensive farm operation (Nweke et al. 1988a). Data from various secondary sources reviewed by Knipscheer (1980), indicated that in proportional terms weeding labor as a percentage of total production labor (land preparation, planting, weeding, and harvesting) is about the same for cassava (25%) as for maize (28%), yam (22%) and rice (23%). The selection of cassava for weed suppression was determined by environmental factors; the relative frequency of this reason for abandoning the cultivation of cassava cultivars was higher in the humid zone than outside the zone.

Processing quality

The cultivation of some landraces of bitter cassava was abandoned because of certain issues relating to the ease of cassava processing. Those issues have been aggregated under processing qualities. They are important to farmers because most cassava is used in processed forms and because of the high cost of cassava processing by traditional methods. It will be shown later that most of the major processing steps such as peeling, grinding/grating/crushing/milling, and roasting are labor-intensive under traditional manual methods. The high processing costs also result from the loss of product in the transformation process because the traditional methods are inefficient in carrying out some of the processing steps. For example, hand peeling is expensive, not only because it is labor-intensive, but also because it results in large amounts of waste.

The need for those attributes was determined by type of cassava grown, type of processed cassava product made, and proximity to market centers. Significantly more bitter than sweet cassava cultivars were abandoned because of lack of processing quality attributes as the bitter types require elaborate processing before use. More cultivars were also abandoned because of the lack of these attributes by farmers who make *attieke*, a granulated cassava product which has high market value. Processing is essential for marketing; farmers processing for sale are more particular about quality than farmers processing for home use.

Postharvest scientists at IITA maintain that the development of mechanized technology to reduce the labor required and wastage is constrained by the physical characteristics of the cassava roots, which vary in shape depending on variety, growing environment, and age. The roots also lack uniformity in size; from the same plant there could be roots of different sizes. A high yield is not only in terms of the number of roots per plant but also in terms of root size, the larger the better. However, efficient mechanization of peeling and grinding or grating may depend on developing an optimum root size.

The postharvest scientists also maintain that the physical characteristics of the skins of the roots could influence the peeling labor as well as the amount of the product lost at the peeling stage. For example, skin which can be rolled or rubbed off will reduce product waste and require less labor than skin which has to be slashed off. A rubber knife has been designed whch can be used to scrape the skin off cassava roots depending on their thickness and adherence to the root flesh. However, the skin of the majority of existing cassava genotypes can only be peeled by slashing it off the flesh of the root with a sharp knife.

The postharvest scientists at IITA also maintain that the processing costs of certain cassava products, namely, flours, dried chips, etc., could be significantly reduced if genotypes could be developed which contain less moisture. The higher the moisture content, the higher the drying cost and the lower the quality of the end product. The problem of high moisture content at the processing stage may not, however, be relevant to cassava products such as granules, pastes, and even some chips which are made using techniques which involve water expressing.

These hypotheses of the postharvest scientists indicate that there could be breeding opportunities in postharvest issues in cassava. Breeding can contribute to reducing processing costs which arise from high labor needs and from postharvest handling losses, and towards the improvement of product quality at the processing stage.

VIII. Pest and Disease Problems

Introduction

Smallholders do not usually attempt to control the pest/disease problems of cassava with pesticides because of limited access to such chemicals and because cassava has low value per unit weight. Yet, as has been pointed out, the area of cassava grown continues to increase in most villages which suggests that certain production practices make at least some contribution to cassava plant protection. This section aims to assess the incidence and severities of key pests and diseases in relation to farm level conditions, practices, and market circumstances. The emphasis is on two pests, CMB and CGM, and two diseases, ACMD and CBB, because of their economic significance.

The premise is that farmers manipulate cultural practices rather than use pesticides to achieve at least a partial control of pests and diseases. No attempt is made to test this hypothesis in a biologically scientific sense. The information was obtained using mostly social science survey methodologies and not controlled experiments or repeated field visits. Consequently, it is not appropriate to consider the correlations established between the farmers' practices or their socioeconomic circumstances and any of the pest/disease problems as cause-and-effect relationships. The results presented should, therefore, serve as hypotheses to guide further research which will lead eventually to scientific explanations.

There are interactions among the various pests/diseases of cassava and the biological environment (Fabres et al. 1994) and hence the need for an holistic approach to the complex. This is consistent with the views of Kesiwani (1987), who states that multiple infections by different pathogens and interactions between them are very common with tropical crops and complicate diagnosis, estimation of crop losses due to disease, and control procedures.

Spread, incidence and severity of the problems

ACMD was the most widespread and had the highest incidence of all four problems (table VIII-1). CBB was next to ACMD in spread and in incidence; its symptoms were observed in 85% of the representative villages. CMB was the least widespread. It was observed in 5% of the representative villages; it also had the lowest incidence. ACMD has been known since 1894 and it has been studied since the 1930s (Hahn and Keyser 1985; Thresh et al. 1994). Hahn et al. (1981) reported that ACMD was the most widespread disease of cassava in tropical Africa and India and it was regarded as the most important vector-borne disease of any African food crop in a recent economic assessment (Geddes 1990). However, CGM as well as CMB and CBB have a very different history as they are recent introductions and were first reported in Africa only about 20 years ago (Nyiira 1975; Hahn et al. 1981; Yaninek 1994). CMB symptoms were observed in only 5% of the villages. The representative villages by symptom severity scores of the problems are shown in figs. VIII-1 to VIII-4.

Table VIII-1. Spread and incidence of four major cassava pests/diseases by climatic zone

Climatic zone	No. assessed		Villages (landraces) affected (%)			
	Villages	Landraces	CMB	CGM	ACMD	CBB
Humid	28	187	4(1)	7(2)	96(41)	21(4)
Subhumid	8	55	12(7)	12(7)	88(40)	12(2)
Nonhumid	3	22	0(0)	0(0)	100(50)	33(14)
All zones	39	271	5(2)	8(3)	95(42)	21(5)

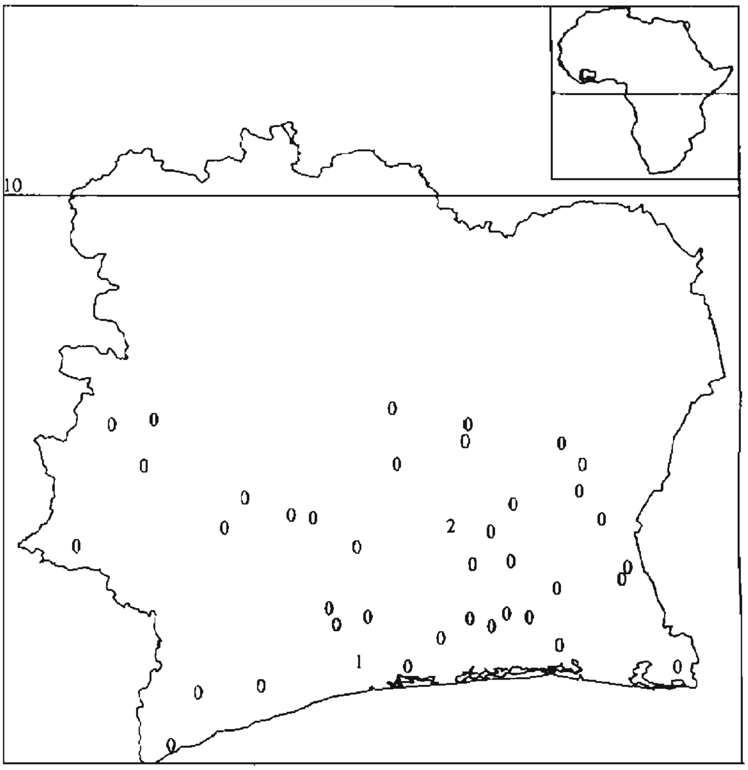

Fig. VIII-1. Representative villages by maximum symptom severity score (0–4 scale) of cassava mealybug (CMB)

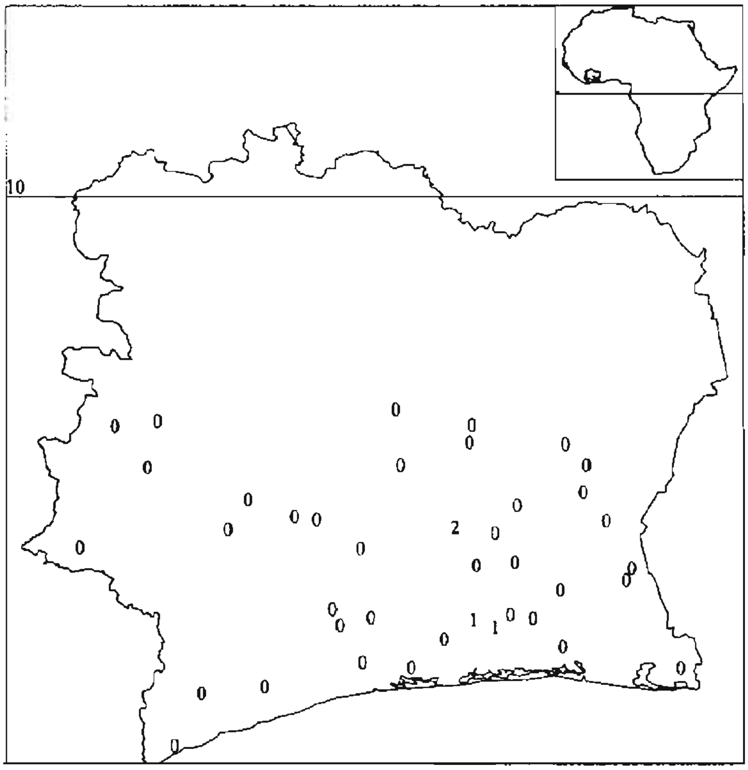

Fig. VIII-2. Representative villages by maximum symptom severity score (0–4 scale) of cassava green mite (CGM)

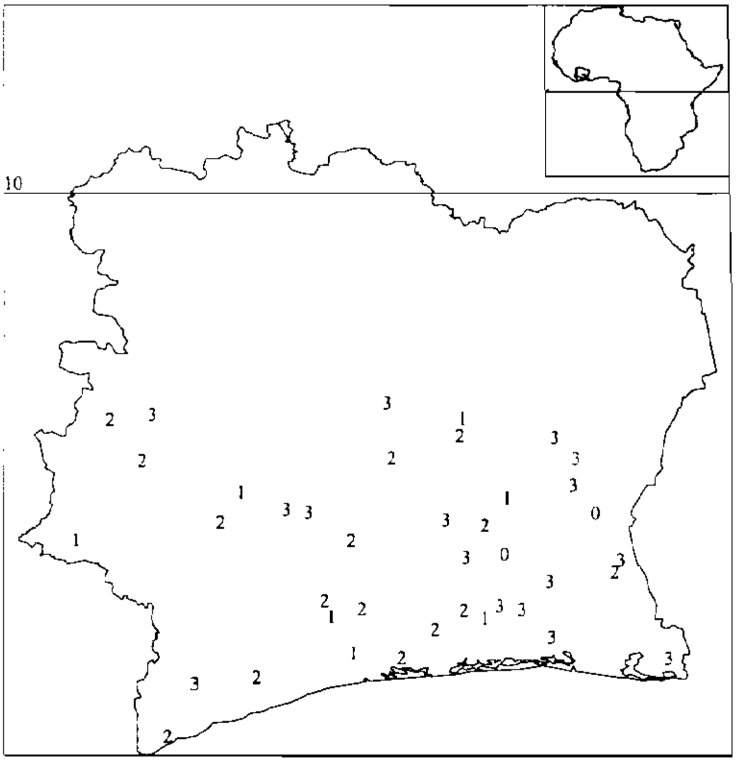

Fig. VIII-3. Representative villages by maximum symptom severity score (0–4 scale) of African cassava mosaic disease (ACMD)

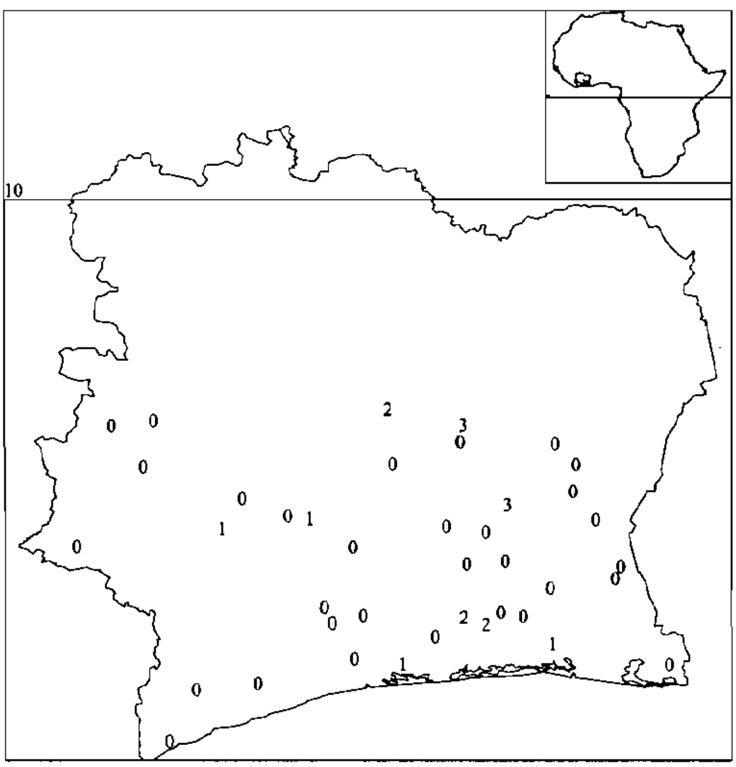

Fig. VIII-4. Representative villages by maximum symptom severity score (0–4 scale) of cassava bacterial blight (CBB)

1. Climatic zones

The incidences of CMB and CGM were higher in the subhumid zone than elsewhere but the symptom severity scores were similar in the three zones (table VIII-2). The incidence of ACMD was higher and symptom severity score lower in the nonhumid zone than elsewhere; the incidence and the symptom severity score were, however, both similar in the humid and nonhumid zones. The incidence of CBB was higher in the nonhumid zone than elsewhere but did not differ between the humid and subhumid zones. The symptom severity score was lowest in the humid zone but did not differ between the subhumid and nonhumid zones.

Table VIII-2. Symptom severity scores (1–4 scale) for four major cassava plant pests/diseases by climatic zones

Pest/disease/ climatic zone	No. of landraces affected	Mean	Probability level of significance of difference		
			H by S	H by N	S by N
CMB:					
humid (H)	1	1.00	NS	NA	
subhumid (S)	4	1.25	NS		NA
nonhumid (N)	0	–		NA	NA
CGM:					
humid (H)	3	1.00	NS	NA	
subhumid (S)	4	1.25	NS		NA
nonhumid (N)	0	–	–	NA	NA
ACMD:					
humid (H)	77	2.12	NS	***	
subhumid (S)	22	1.95	NS		***
nonhumid (N)	11	1.00	–	***	***
CBB:					
humid (H)	8	1.25	NS	***	
subhumid (S)	1	3.00	NS		NS
nonhumid (N)	3	2.67		***	NS
All zones	12	1.71	–	–	–

Note
***$P \leq 0.01$, **$0.05 \geq P > 0.01$, *$0.01 \geq P > 0.05$, NS = not significant at $P = 0.10$,
NA = test not applicable

The combined data for the COSCA study countries show that the symptom severity scores of ACMD and CBB were highest in the humid zone, while that of CGM was highest in the nonhumid zone (Nweke 1994a) but not statistically higher than in the humid zone. Therefore, the problems of CGM, ACMD, and CBB were not higher in any climatic zone other than in the humid zone. The symptom severity score for CGM was lowest in the subhumid zone, whereas the score for CBB was similar in the subhumid and nonhumid zones. Hence, these problems were not less severe in any other climatic zone than in the subhumid zone.

CBB is more widespread and severe in the savanna and forest transition ecological zones of Africa than in the rainforest. Severe incidences of the disease have, however, been reported from the rainforest zones of Nigeria (Terry 1981). In the forest zone, CBB and CMB are not generally a major problem. In the savanna zone where rainfall is less than 1200 mm and the dry season sometimes lasts more than 5 months, CMB is a major problem but not CBB. CBB is widespread in savanna areas where rainfall exceeds 1500 mm (Mabanza 1981).

2. Farmer access to market

The combined data for the COSCA study countries show that the incidences of all four major pests/diseases were lower in the villages with easy access to market than in other villages (table VIII-3). The symptom severity scores of the pests/diseases were also lower in the villages with easy access to markets than for others, although the differences were not statistically significant (table VIII-4). The frequencies of use of purchased inputs were higher in the villages with easy access to market than elsewhere (Nweke 1996b).

Table VIII-3. Incidences of four major cassava pests/diseases by farming conditions

Farming conditions	No. of landraces assessed	Landraces affected (%)			
		CMB	CGM	ACMD	CBB
Market access:[1]					
good	473	12	26	33	13
poor	307	13	33	39	18
Cassava marketing channel:[1]					
middlemen	857	9	19	31	14
consumers	1944	8	31	29	11
Farmland holding unit:[1]					
nuclear family	1493	7	28	29	14
whole community	735	14	27	26	9
Inorganic fertilizers:[2]					
used	307	14	21	35	19
not used	1182	5	24	33	14
Hired labor:[2]					
used	1046	9	28	35	19
not used	443	4	13	31	7

Notes

[1]All 10 COSCA study countries

[2]Congo (DR), Côte d'Ivoire, Ghana, Nigeria, Tanzania, and Uganda

The incidences of CBB, ACMD, and CMB were significantly higher among villages which sold cassava through middlemen than among those which sold direct. However, only the symptom severity scores for CBB and to some extent for CGM were significantly lower among the villages which marketed their cassava through the middlemen than in others which sold direct to consumers.

Tollens (1992) reported that in Zaire (Democratic Republic of Congo) the cassava marketing system was dominated by small-scale informal traders called *par-colis* (wrestlers). They are usually former cassava producers or city dwellers who are unemployed and without their own means of transport. They roam village markets or hustle from door to door in search of cassava. When they have collected a sufficient load, they rent space on a passing truck or river boat and take the cassava to Kinshasa. After sale they return to the interior with their empty sacks and cash reserves needed to buy further cassava. Hence, while the middlemen facilitate the marketing of cassava products, their activities would not, in many cases, facilitate farmers' access to purchased inputs.

Table VIII-4. Symptom severity scores (1–4 scale) for four major cassava pests/diseases by farming conditions

Farming practices	CMB			CGM			ACMD			CBB		
	N	Mean	T-test	N	Mean	T-test	N	Mean	T-test	N	Mean	T-test
Market access:[1]												
good	56	1.71	−2.27	122	1.63	−1.37	158	1.80	−1.57	60	1.53	0.24
poor	40	2.15	($P=0.025$)	101	1.76	($P=0.172$)	121	1.96	($P=0.117$)	56	1.50	($P=0.810$)
Cassava marketing channel:[1]												
middlemen	79	1.68	0.78	162	1.59	1.98	268	2.01	−1.21	121	1.30	4.02
consumers	154	1.78	($P=0.439$)	610	1.73	($P=0.048$)	555	1.92	($P=0.225$)	220	1.61	($P<0.001$)
Farmland holding unit:[1]												
nuclear family	106	1.60	−2.05	417	1.51	−6.08	428	1.77	−5.37	208	1.34	−4.37
whole community	103	1.84	($P=0.041$)	199	1.89	($P<0.001$)	190	2.19	($P<0.001$)	63	1.87	($P<0.001$)
Inorganic fertilizers:[2]												
used	42	1.76	−1.30	65	1.25	4.47	106	1.43	8.19	58	1.24	3.09
not used	63	1.54	($P=0.194$)	287	1.57	($P<0.001$)	395	2.07	($P<0.001$)	169	1.53	($P=0.002$)
Hired labor:[2]												
used	88	1.63	0.10	296	1.47	2.35	363	1.89	1.88	197	1.36	4.27
not used	17	1.65	($P=0.923$)	56	1.71	($P=0.002$)	138	2.07	($P=0.006$)	30	2.07	($P<0.001$)
Improved variety:[3]												
improved	10	1.20	3.15	2	1.00	3.68	36	1.47	2.45	25	1.34	4.20
local	48	1.96	($P=0.003$)	24	1.54	($P=0.001$)	58	1.86	($P=0.002$)	59	1.90	($P=0.001$)

Notes
N = number of landraces affected
[1]All 10 Phase I COSCA countries
[2]6 Phase II COSCA countries

3. Land tenure systems

Between the two main land-holding units, the incidences of the problems except for CGM were higher in villages where the nuclear family was the land-holding unit and not the village community. The symptom severities of the two pests did not differ between villages of the two land-holding units but the symptom severities of both diseases were significantly lower where the nuclear family was the land-holding unit and not the village community. However, the combined data for the COSCA study countries show that the symptom severity scores of all four cassava plant pests/diseases were lower among the villages where the nuclear family was the most common land-holding unit and not the whole community. For CGM, ACMD, and CBB, the differences were statistically significant. Land holding by individual nuclear families was more common in areas where the use of purchased inputs such as chemical fertilizers or hired labor was common (Nweke 1996b). Hence, the observed relationship between land tenure and cassava plant pests/diseases may be associated with commercial production.

Farm practices relevant to control

1. Fallow management, cropping pattern, and crop rotation

The incidences and severities of the cassava plant pests and diseases under farmers' various cultural practices of fallow management, cropping patterns, and crop rotation have been discussed. It was concluded that farmers seemed able to cultivate continuously where pest and disease pressures were low but needed to alternate cropping and fallow periods to break the pest/disease cycles where the pressures were high. There are reasons for intercropping cassava other than attempts to alleviate the problems of the four main cassava pests/diseases. Crop rotation appeared to be one of the classical methods of plant disease management and perhaps the most cost-effective.

2. Production with purchased inputs

It will be shown in a later chapter that among purchased inputs used in food crop production were hired labor and inorganic fertilizers. Pesticides were seldom used in the production of staple food crops. The following discussions refer to the overall incidences and symptom severity scores of the various pests/diseases in villages where purchased inputs were used in food crop production generally. Thus, the discussions do not necessarily refer to the effects of the inputs used in particular fields on pest/disease incidence.

Combined data for the COSCA study countries show that the symptom severity scores of ACMD, CGM, and CBB were statistically lower in villages where chemical fertilizers were used than elsewhere. Ambe-Tumanteh (1980) reported that soil nutrients, particularly N, P, and Na, were significantly associated with the severity of ACMD. By contrast, in the COSCA study, there was no statistical difference in the symptom severity score of CMB among villages where chemical fertilizers were used or not used.

Neuenschwander et al. (1990) observed that cultivation on sandy soils in the forest region predisposed cassava to increased CMB attack. In areas with similar rainfall distribution patterns, soils in the savanna, where leaching was less pronounced, yielded satisfactory cassava with low CMB-induced tip damage. Nitrogen availability to cassava which is lower on unmulched sandy soil could affect CMB. On plants stressed by lack of nitrogen, the pest could be favored in two ways: remobilization of amino acids from wilting leaves increases the nutritional value of the phloem sap on which CMB feeds, and reduced nitrogen supply might disrupt the production of chemicals such as cyanide and latex by the cassava plant.

The combined data further show that the incidences of all the pest/disease problems were lower in villages which used hired labor than in those which did not. The statistical relationships between the use of hired labor and the symptom severities of the various pests/diseases were similar to the relationships between the use of chemical fertilizers and symptom severity. Severity scores of ACMD, CGM, and CBB were statistically lower in the villages where hired labor was used than elsewhere. The main difference was that the probability levels of significance were lower for the relationships of the pests/diseases with the use of hired labor than with the use of chemical fertilizers.

3. Selection of planting material

Cassava is propagated vegetatively and the use of planting material derived from pest-infested or pathogen-infected plants is a common way of spreading many of the pests/pathogens of the crop (Rossel et al. 1994). Hence, the selection and use of planting materials derived solely from healthy plants can reduce their incidence and severity. The farmers' sources of planting materials were mainly their own production fields or neighbors and sometimes cassava marketing middlemen. The farmers selected cuttings for cleanliness to only a limited degree. When they had alternative sources they would derive cuttings from plants not older than 12 months and they would use freshly cut materials. They would not use stems which carried lesions or cankers but did not always discard stems affected by pests/diseases.

4. Selection of cultivars

However, farmers did select cultivars for resistance against pests/diseases and would abandon cultivars that were very susceptible to any of these. It has been explained above that there was a turnover in cassava landraces; farmers were continually introducing new landraces with desired attributes into their cropping systems. Such landraces were not necessarily improved varieties, but were often local and varied with villages, regions, and countries. As new landraces were introduced, the farmers often abandoned existing ones that may not possess the desired attributes. The main sources of new cassava planting materials for a village were neighboring villages and towns. Some material was also reported to have been introduced from other countries. Such material was brought by traders, migrant farmers, development agencies, and churches or other nongovernmental organizations.

The relatively low ranking of pests/diseases as a reason for abandoning the cultivation of cassava landraces could be due to cassava's relative tolerance (Fresco 1993) and the lack of serious pests/diseases other than ACMD as problems until recent decades. Moreover, the data on the turnover in cassava genotypes were collected after IITA's large-scale biological control project had been mounted against CMB. The ordinal ranking of the reasons is not entirely objective because most of the undesirable attributes of cassava are interrelated and not independent. For example, the susceptibility of cassava to pests/diseases is closely linked to low yield (Akinlosotu 1985).

There could be some relationship between the turnover in cassava landraces and the history of cassava pest/disease outbreaks in Africa. As noted earlier, the mean number of landraces introduced or abandoned per period of time was relatively low until the 1930s and 1940s, when the numbers begans to increase rapidly. It was mentioned above that Jones (1959) reported that agricultural stations in several of the colonial countries including Ghana, Nigeria, Madagascar, and Tanzania attempted to develop improved cassava varieties by selection and breeding. The programmes were largely in response to the occurrence and rapid spread of ACMD in the 1930s, when it was reported from a number of localities extending along the coast of West Africa and eventually over most of the cassava area.

5. Conclusion

The foregoing account does not represent final conclusions in the sense of cause-and-effect relationships and should be considered as providing hypotheses to guide further research which may eventually lead to scientific explanations. In view of the socioeconomic emphasis and lack of full biological explanations of the correlations established between the various farmer practices and the incidences and symptom severity scores of the pests/diseases problems and given that there were interactions among the pests/diseases and the biological environments, drawing any cause-and-effect type of conclusions on the basis of information presented above could be misleading. The problems appear to be less in the relatively few places where purchased inputs are used in agricultural production. However, the majority of the cassava producers seem to have relied mainly on crop rotation, fallow management, and cultivar selection from among the available landraces for the control of CMB, CGM, ACMD, and CBB.

IX. Root Yield

The mean fresh root yield was 10.8 t/ha, the range was 1.8–20.8 t/ha (table IX-1). The distribution was skewed to the lower level with a modal class of 6–9 t/ha (fig. IX-1). Sites of different yield levels are shown in fig. IX-2.

Table IX-1. Overall average root yield components for cassava

Yield component	Mean	Minimum	Maximum	Standard deviation	No. of households
Root (t/ha)	10.8	1.8	20.8	5.2	41
Plant density (std/ha)	6641	750	16750	3468	124*
No. roots/plant	5	1	2	9	41
Average root wt. (kg/root)	0.5	0.2	1.1	0.2	41
Harvest index	0.39	0.2	0.6	0.1	40

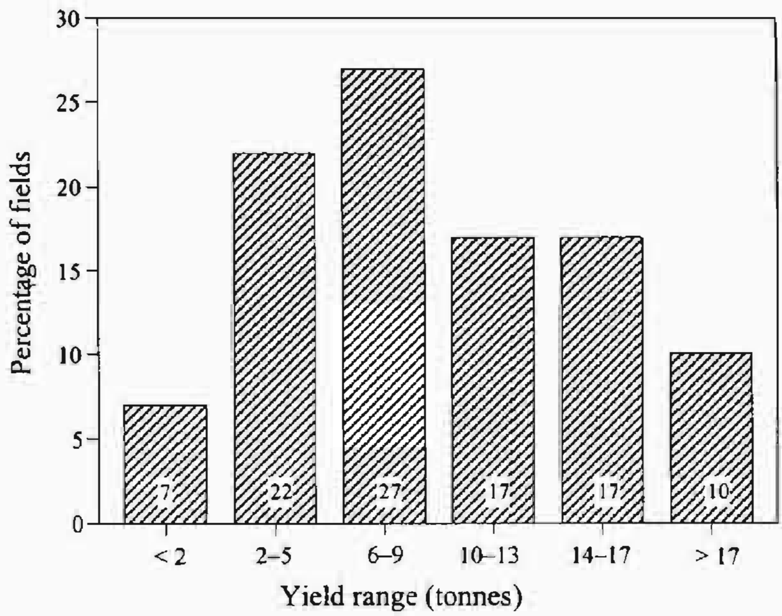

Fig. IX-1. Percentage distribution of fields by cassava yield range

FAO data show the average yield to be 9.8 t/ha in 1991 (FAO 1994) when the COSCA data were collected. The spatial coverage of the FAO data is probably the entire country. COSCA information is, however, based on a representative sample of the cassava-producing areas defined as any of the climatic/access/population zones with a minimum of 10 000 ha of cassava land area (Carter and Jones 1989). This amounts to more than 90% of the cassava-growing areas of the country. The mean yield was low in the country in comparison with other major producing countries (fig. IX-3).

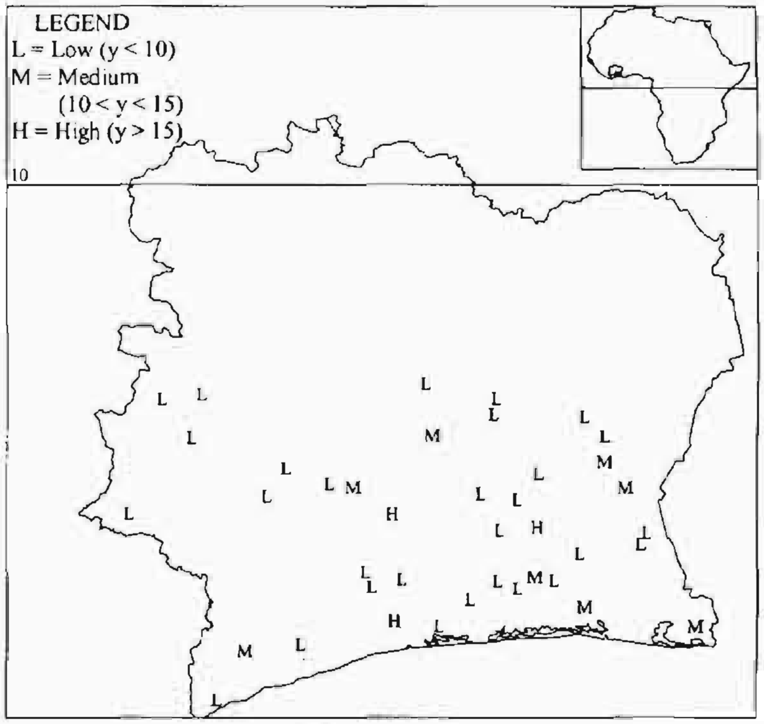

Fig. IX-2. Survey sites by relative cssava root yield range (t/ha)

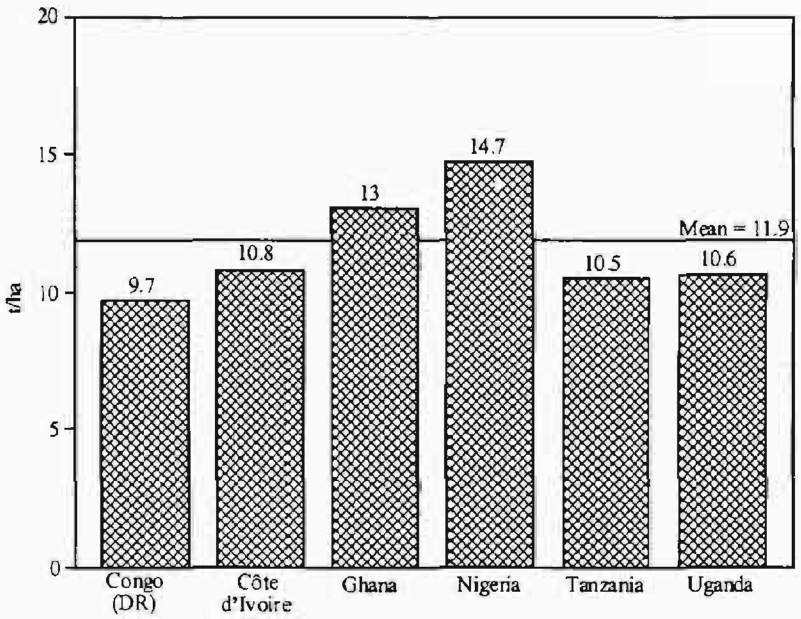

Fig. IX-3. Cassava fresh root yield (t/ha) by major producing countries

Agronomic management practices and type of cassava

Combined data for the COSCA study countries show that the cassava root yield was positively and significantly correlated with the cassava plant age as well as with the cassava stand density although there was an optimum stand density level, depending on canopy type, climatic condition, soil fertility level, etc., beyond which the yield declined (Nweke et al. 1994). It was shown above that the mean cassava plant age in Côte d'Ivoire was about average for the COSCA study countries, but the cassava stand density in the country was well below that average.

The mean root yield differed with cropping pattern; it was highest for cassava grown as a sole crop and lowest for cassava grown as a minor crop in an intercrop (table IX-2). This was due to similar differences in plant density among the cropping patterns.

Table IX-2. Cassava root yield components by cropping pattern and type of cassava

Cropping pattern Type of cassava	Root yield (t/ha)	Stand density (stand/ha)	Age (months)	No. of fields
Cropping pattern:				
sole	11.6	7490	10.3	20
major in intercrop	10.8	5019	10.9	6
minor in intercrop	9.4			13
Type of cassava:				
bitter only	14.4	10500	12.6	5
bitter and sweet	10.7	7694	9.9	6
sweet only	9.8	5907	10.8	28

Population pressure on land and intensified land-use practices

Lagemann (1977) concluded, based on his study in southeast Nigeria, that cassava yield was lower where population pressure on land was high. However, all the representative villages in the country were in the low population density class (table IX-3). Intensified land-use practices such as organic manuring and livestock grazing which the combined data for the COSCA countries showed as positively influencing yield were not adopted in Côte d'Ivoire because population pressure on land was low in comparison with other countries.

Table IX-3. Percentage distribution of representative villages by population density, market access, and climatic zones by country

Zones	Congo (DR)	Côte d'Ivoire	Ghana	Nigeria	Tanzania	Uganda
No. of villages	67	39	27	65	38	33
			%			
Population density:						
high	27	100	33	14	66	18
low	73	0	67	86	34	82
total	100	100	100	100	100	100
Market access:						
motor vehicle, any distance	5	28	43	38	28	3
foot, 10 km or less	47	59	39	54	52	68
nonmotor vehicle, any distance	7	3	4	5	8	29
foot, above 10 km	41	10	14	3	12	0
total	100	100	100	100	100	100
Climate:						
highland humid	13	0	0	0	0	36
lowland humid	55	72	63	26	12	64
subhumid	18	20	37	63	51	0
nonhumid	13	8	0	11	37	0
total	100	100	100	100	100	100

Market access conditions and use of purchased inputs

Purchased inputs such as hired labor and chemical fertilizers were shown by the combined data to positively influence the yield. Such inputs were more commonly used in areas with easy access to market centers. They were rarely used in Côte d'Ivoire even though market access conditions were better than average for the COSCA countries. Ease of access to imported food, especially rice around the market centers, discouraged private investment in the use of the purchased inputs in cassava production.

Similarly, growing of the improved cassava varieties was not reported in any village studied. The improved varieties were widely grown in Nigeria and they were high yielding because they were tolerant to the major cassava plant pests/diseases, CMB, CGM, ACMD, and CBB.

Other factors

The root yield was lower for sweet cassava than for bitter cassava; this was also the case in other countries as the combined data showed. The sweet types were harvested earlier than the bitter types because, according to farmers who planted both in the various countries, the sweet types had lower inground keeping quality than the bitter types. As already pointed out, most of the cassava fields in Côte d'Ivoire were planted with the sweet types. The combined data also showed that the root yield was lower in the lowland humid zone than in the subhumid zone; most of the sites studied in the country were in the lowland humid zone.

Summary and conclusion

Although population pressure on land was low in the country in comparison with other COSCA study countries, cassava root yield was below average. The cassava stand density which influenced the root yield positively and significantly was about average for other countries. Intensified land-use practices which also influenced the root yield positively and significantly were not adopted because population pressure on land was low. Purchased inputs including high-yielding varieties were not adopted, even though access to market conditions were better than average, because availability of imported rice around the market centers discouraged private investment in the use of the purchased inputs in cassava production. In addition, most of the survey sites were in the humid zone where the root yield was low relative to the subhumid zone in other countries; and most of the cassava fields were planted with sweet cassava cultivars. They were harvested earlier with lower yields in Côte d'Ivoire and in the other countries.

PART FOUR

MARKET ORIENTATION

X. Processing Technology

Processing is important for the marketing of cassava. In their fresh form, cassava roots are bulky and perishable; processing reduces the bulk and extends shelf-life and therefore reduces transportation cost. Fresh cassava roots have a low value per unit weight; processing adds value and extends the market, especially to urban consumers. In addition, fresh roots of some cassava cultivars contain cyanogens which are reduced or eliminated through processing.

Processing steps

Cassava processing involves a combination of activities which are performed in stages. Such activities are peeling; chipping, milling, slicing, or grating; dehydration by pressing, decanting, drying in the sun or over a hearth, or frying; fermenting by soaking in water or by heaping; sedimentation; sieving; and cooking, boiling, or steaming. The number of steps required and the sequence vary with the products being made. The sequence of activities also generates a wide range of intermediate products which can either be sold or stored until the need arises. Hence, it is not always easy to distinguish between intermediate and end products of processed cassava. In addition, some of the processed products are ready to eat without further cooking, while others require some extra preparation. The following analysis is based on end products, those which enter the marketing system. This will include some intermediate products, such as cassava chips. Following Nweke (1994b) the major products and the steps involved in producing them are shown in fig. X-1 and discussed on page 74.

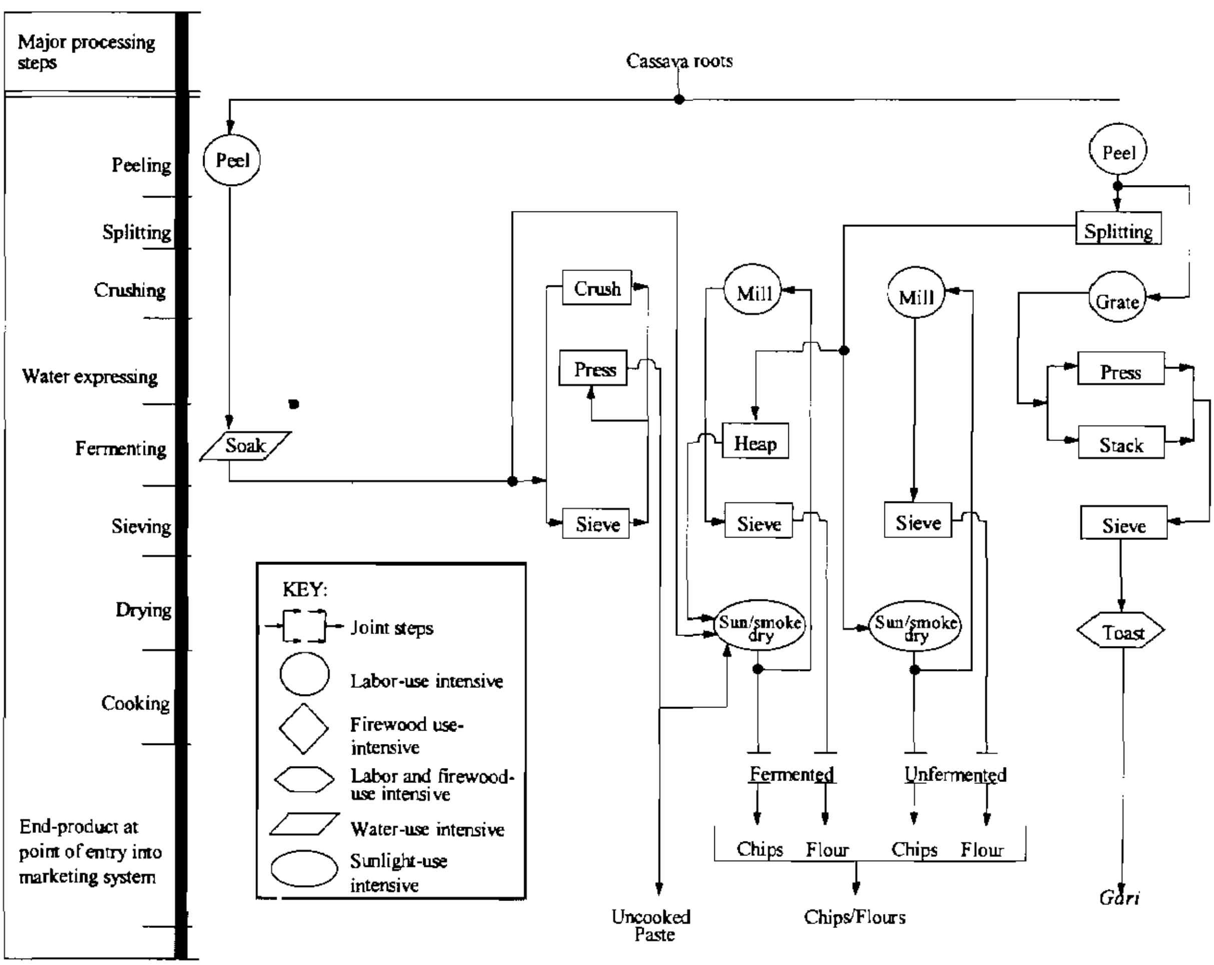

Fig. X-1. Processing steps for major processed products

Processed products

Cassava pastes. To make cassava pastes, whole roots are immersed in water (streams, puddles, or in a container) for 3 to 5 days, while they soften and ferment. They are taken out of the water and peeled. Fibers are removed from the pulp by sieving in water using a basket, fiber bag, or perforated metal bowl. The mash is squeezed in a fiber bag to reduce water content. Sometimes peeling is done before soaking, which improves the attractiveness of the end product but makes it more expensive because fresh roots are harder to peel. The fermentation step is intensive in its use of water, but fuel is not required although it will be needed at meal preparation stage.

Chips and flour. Flour is often made at home from cassava chips. Chips and flour are made by a wide range of traditional methods. Soaked roots can be converted into chips by sun- or smoke-drying either directly after peeling or after crushing, sieving, pressing, and rolling into balls. Alternatively, chips are made directly from fresh roots by sun- or smoke-drying.

Granules. Granules may be steamed or toasted; steamed granules are called *attieke* while toasted granules are widely known as *gari*. Fresh roots are peeled and grated, the grated pulp is put in sacks, and the sacks are placed under heavy objects for 1 to 4 days to drain excess liquid from the pulp while it is fermenting. The dewatered and fermented lumps of pulp are sieved, and the resulting fine pulp is steamed to make *attieke* or toasted in a pan to make *gari*. Palm oil is often added during toasting to stop the pulp from burning.

Quality of processed cassava products

The processing methods show that cassava processing has many traditional technological pathways which are adapted to take advantage of locally available processing resources or market opportunities in the area. Where scarcity of fuelwood is a constraint to toasting or steaming, solar energy is adopted for drying, and so on. The wide range of technological pathways, however, leads to an equally wide range of products which vary in taste, appearance, texture, convenience of preparation into food, nutritive value, and in other quality characteristics.

1. Farmers' perception

Frequency distribution of the quality characteristics of the various products desired by the processors shows that texture or consistency was the most important quality characteristic for 43% of the villages, taste for 23%, bright color or appearance for 20%, and water content for 14%. Color or appearance was the most important in so many villages because of commercial production; the product has to be visually attractive to the buyer. Texture of a processed food product is an important consideration because food eaten with the fingers has to stay together and not fall apart. Flavor or taste was also an important attribute, especially for consumers who eat fermented cassava products and who look for a sour taste which is characteristic of proper fermentation.

Chips/flour is made following different technological pathways depending on whether it is fermented or unfermented and, when fermented, depending also on the method of fermentation, i.e., soaking or heaping. What is common to all chips/flour irrespective of the technological pathway is the drying process. The color and the taste of flour depend on the method and duration of fermentation (if fermented), on the method of drying, the efficiency of the drying energy, and on the cleanliness of the drying environment. In the case of chips/flour, taste is imparted in two steps, at the fermentation and at the drying steps. For fermented chips/flour made following the pathway of fermentation in heaps, the effect of the fermentation on color and taste depends on the duration of the heaping.

The taste and the color imparted at the fermentation step are modified at the drying stage. The roots are dried in the form of crumbs of soaked-crushed root mash or soaked-peeled whole roots if soaking is the technique; or in the form of split pieces if the technical footpath is either heaped fermentation or no fermentation at all. Sun-drying can be done on virtually any surface in the open air including the flat surface of a big rock in the field, on the shoulders of a paved road, on the roof top, on a mat, in flat baskets, or even on bare ground. Although chips being dried on a mat or in flat baskets may be moved to protect them from bad weather, those dried on rocks in the field, on the roadside, on the roof top, etc., are often not moved. If it rains, the chips get soaked and drying starts all over again. The wide range of drying surface possibilities and practices is such that the products can gather significant amounts of molds, dust, and other dirt which influence the taste and the color of the end product. In the humid moist zones where it drizzles or rains frequently, sun-drying is not efficient, the color or the end product is not bright white, and the taste is strong. In the dry climates, however, sun-drying is efficient, the color of the end product can be bright white, and the taste may not be so strong.

Chips/flour can also be made by smoke-drying instead of sun-drying. The roots are smoke-dried in the form of balls of soaked crushed mash if the technique followed is that of unsteamed paste, but if the pathway is any other, the roots are smoke-dried in the same form as when sun-drying. Smoke-drying is done in sacks over kitchen fire; consequently this technique could impart a dull color and smoky taste to the end product. To reduce these, the dark coating due to smoke is scraped off before the chips are milled into flour (Hahn 1989).

The level of fineness desired is attained at the milling step. The traditional method of converting cassava chips into flour is by pounding them with pestle and mortar and sieving in a fine basket or perforated metal tray. These steps are labor-intensive because flours are in fine particles.

2. Nutritional value

From a nutritional point of view, cassava's chief advantage is as a source of cheap carbohydrate. The roots contain a negligible amount of protein (Berry 1993) although substantial amounts are derived from cassava leaves in areas where that product is a popular vegetable. Until recently, enhancement of cassava's nutritive value has not been given serious consideration either in breeding or in processing research. This is because cassava products are rarely eaten alone but commonly in combination with relatively protein-rich items. However, certain processing techniques may result in reduction or in enhancement of the protein, vitamin, or mineral contents of the cassava roots. Nutrients such as vitamin C are lost in processing and cooking (Berry 1993). An advantage of heaping or stacking over soaking methods of fermentation is that most nutrients in the roots are retained; yet another nutritional advantage of fermentation by heaping (not in Côte d'Ivoire) is that the mold growth associated with it increases the protein content of the end product (Hahn 1989).

3. Food convenience

The various cassava processed food products can be grouped into two with respect to convenience of preparation into a meal. The first group consists of products which enter the marketing system in ready (or near ready) to serve forms; *attieke* or *gari* are examples of the products in this group. *Attieke* is made by advanced methods of processing; it is attractive to working-class urban consumers because it is eaten directly without further preparation. It can compete effectively with grains in the market. The second group consists of products which need further processing or elaborate cooking at home. Chips/flour is an example of the products in this group; it is made by a wide range of methods. Some are quite rudimentary involving only peeling and drying the fresh roots. The product is not as attractive to working-class urban consumers and therefore does not have as many market opportunities as products in the first group.

4. Summary

Bright color, texture, and taste do not necessarily depend on product type but can vary even for the same product depending on the quality, efficiency, or cleanliness of the processing resources or environment. The nutritional value can also vary for a product depending on processing methods. Color, texture, taste, or nutritional value cannot therefore be useful for comparing different products in terms of quality. Some products are, however, consistently superior to others in terms of convenience of preparation into food even though there are some in-between cases. *Attieke* is superior to other cassava products because it is eaten directly without further preparation. Pastes and chips/flour both need further preparation, sometimes elaborate, before they can be eaten.

Fermentation trend

In cassava processing, fermentation imparts a sour taste which is cherished by some people. There is a breakdown of cyanogens during fermentation although fermentation is not the only way of eliminating cyanogens in cassava. Fermentation also results in the extension of the shelf-life of some cassava products.

About 10% of those villages where the major products are made with techniques which involve fermentation reported that the fermentation period had declined in the previous few years. All the villages which reported the declining fermentation trend had access to mechanized pressing machines (to be discussed later) and they made pastes or *attieke*. Combined data for the COSCA study countries show that the declining trend seemed to be related to the mechanization of cassava processing. The relative frequency of report of the declining fermentation trend was high among villages where mechanized processing method was adopted, compared with others where it was not adopted (table X-1). The frequency was also higher among villages which had easy access to markets than among others which were remote from markets. It was also higher among villages in high population density areas than where this was low. The implication is that processing techniques could change in favor of less fermentation with increasing commercialization and population density.

Table X-1. Percentage distribution of representative villages which produce fermented cassava products by product type, availability of cassava grating machine, access means to market, and by population density (6 countries*)

Variable	No. of villages	Percentage			
		Decreasing	No change	Increasing	Total
Product type:					
toasted granules (*gari*)	40	43	50	7	100
wet paste (*agbalima*)	14	36	64	0	100
chips/flour (*kokonte*)	127	9	86	5	100
Cassava grating machine:					
available	45	44	49	7	100
not available	171	11	85	4	100
Access to market:					
vehicle, any distance	63	25	72	3	100
foot, 10 km or less	97	13	81	6	100
foot, above 10 km	29	17	83	0	100
Population density:					
high	98	27	66	7	100
low	109	10	89	1	100

Note
*Côte d'Ivoire, Ghana, Nigeria, Tanzania, Uganda, and DR Congo

The implication of the declining fermentation period for the health of people who grow bitter cassava is not clear. Cyanogenic glucosides which release HCN are present in cassava. The cyanogens can be eliminated by two main mechanisms, by leaching in boiling water and by hydrolysis to less stable compounds. Micro-organisms present during fermentation create conditions favorable to leaching and hydrolysis by inducing retting (Bokanga 1992). As gas, the cyanogens evaporate when cassava roots are peeled, sliced, and crushed such as in milling and grating operations. Usually evaporation can reduce the HCN potential to below fatal level. The frequency of the reported declining fermentation trend was highest among villages whose major cassava product was *gari*. The crushing and the water expressing steps are more efficently performed when mechanized and thus make the loss of linamarase more efficient than under traditional methods. This makes it easy to reduce the fermentation period without increasing the risk of cyanide poisoning.

Mechanization of processing techniques, population, and market pressures which are reducing fermentation periods will also be changing the taste of cassava products. This situation will have implications for the acceptance of new cassava products particularly in noncommercial areas where cassava serves food security needs.

Distribution of cassava products

Attieke which was reported as the most important cassava product in 45% of the representative villages was the most widely used form of cassava roots; this is followed by fresh roots (35%), paste (10%), chips/flour (5%), and starch (5%).

Fresh roots were more widely reported as the most important cassava product in the humid zone than outside the humid zone. The range of cassava products which was wide in the humid zone was narrow outside that zone (fig. X-2). The production of *attieke* as the most important cassava product in the village was widely distributed in the country (fig. X-3). The first three cassava products used in a village are listed in descending order of importance, within the village, in table X-2.

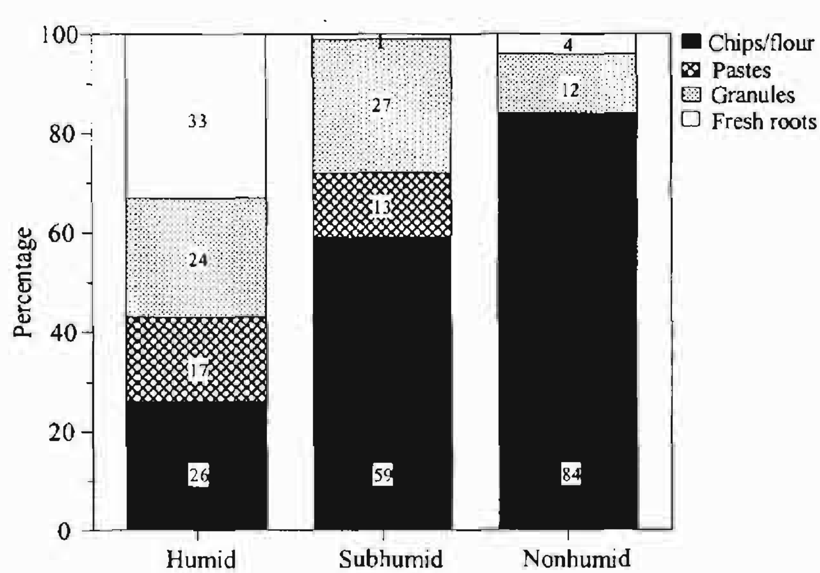

Fig. X-2. Percentage distribution of representative villages by most important cassava product by climatic zone (6 countries*)

Note

*Congo (DR), Côte d'Ivoire, Ghana, Nigeria, Tanzania, and Uganda

Combined data for the COSCA countries show that the relative frequency distribution of the representative villages by the most important processed cassava products had definite climatic trends; processors concentrate on making products which reflect the resource endowments of the zone. For example, the relative frequency of pastes as major cassava products made with water use-intensive techniques, declined from more than 15% in the humid zone, to zero in the dry zone where rainfall was limited (fig. X-2). The relative frequency of chips and flour, which require ample sunshine for drying, decreases from over 75% in the dry climatic zone where sunshine is most abundant, to only about 25% in the humid zone where sunshine is the most limiting factor. Processing cassava into granules did not depend on the availability of relevant resources locally. It was made in commercial areas where market demand existed even if critical resources such as fuelwood had to be bought. In Côte d'Ivoire, however, *attieke* was not more commonly made around market centers. Although *attieke* is a convenient food product which can potentially compete with food grains in the market, it was not able to express that potential because of the availability of low cost rice especially around market centers.

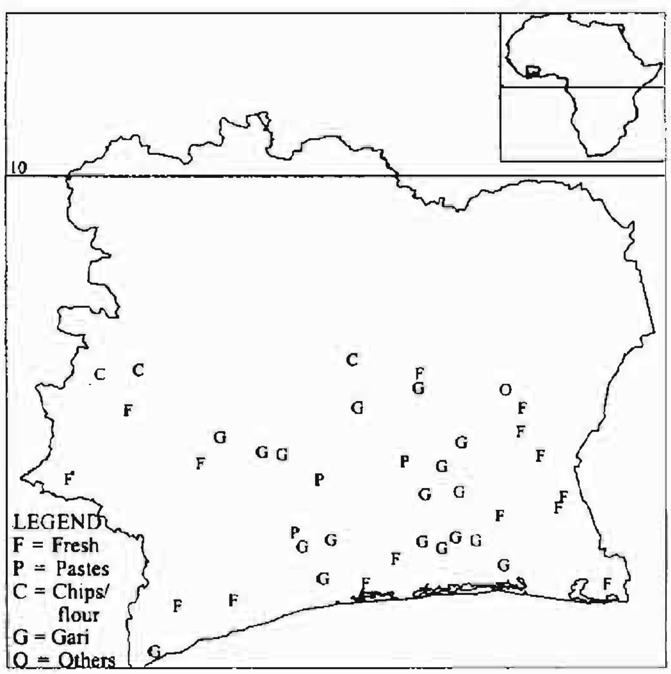

Fig. X-3. **Representative villages by main cassava product**

Table X-2. Cassava products by village

Survn01	Villno	Villname	Locname	Category	Ferm	Vary	Gen
101	1	Sahuye	*Attieke*	Granules	Y	S	NA
			Fede	NA	Y	S	F
			Akpusi	NA	N	S	F
102	2	Boussoue	*Attieke*	Granules	Y	A	NA
			Foutou	Fresh roots	N	D	F
			Placali	Pastes	Y	NA	F
103	3	Brofodoume	*Attieke*	Granules	Y	B	NA
			Foutou	Fresh roots	N	S	F
			Placali	Pastes	Y	S	F
104	4	N'koupe	*Foutou*	Fresh roots	N	S	NA
			Placali	Pastes	Y	NA	F
			Attieke	Granules	Y	S	F

Notes on page 81

Table X-2 continued

Survn01	Villno	Villname	Locname	Category	Ferm	Vary	Gen
105	5	Akouakro	*Foutou*	Fresh roots	N	D	NA
			Attieke	Granules	Y	S	F
			Placali	Pastes	Y	NA	F
106	6	Aprompron	*Foutou*	Fresh roots	N	NA	NA
			Attieke	Granules	Y	D	F
			Kokonte	Chips/flour	Y	NA	F
107	7	Akacomoekro	*Foutou*	Fresh roots	N	D	NA
			Attieke	Granules	Y	NA	F
			Kokonte	Chips/flour	Y	NA	F
108	8	Ano	*Attieke*	Granules	N	S	NA
			Placali	Pastes	Y	S	F
			Gari	Granules	N	S	F
109	9	Ofolidie	*Foutou*	Fresh roots	N	D	NA
			Attieke	Granules	Y	NA	F
			Placali	Pastes	Y	NA	F
110	10	Allakro	*Foutou*	Fresh roots	N	D	NA
			Attieke	Granules	Y	D	F
			Gari	Granules	Y	S	F
111	11	Angouakoukro	*Placali*	Pastes	N	D	NA
			Foutou	Fresh roots	N	S	F
			Ragout	NA	N	S	F
112	12	Sandiebounga	*Attieke*	Granules	Y	S	NA
			Placali	Pastes	Y	NA	F
			Foutou	Fresh roots	N	S	F
113	13	Tchekou-carrefour	*Attieke*	Granules	Y	S	NA
			Gari	Granules	Y	S	F
			Foutou	Fresh roots	N	S	F
114	14	Komambo	*Attieke*	Granules	Y	S	NA
			Kokonte	Chips/flour	Y	S	F
			Gari	Granules	N	S	F
115	15	Koudieblekro	*Attieke*	Granules	N	B	NA
			Kokonte	Chips/flour	Y	S	F
			Gari	Granules	Y	S	F
116	16	N'gattakro	*Attieke*	Granules	Y	B	NA
			Placali	Pastes	N	B	F
			Kokonte	Chips/flour	Y	S	F
117	17	Lalasso	*Foutou*	Fresh roots	N	S	NA
			Kokonte	Chips/flour	Y	S	F
			Attieke	Granules	Y	S	F
118	18	Adikankro	*Starch*	Starch	N	S	NA
			Kokonte	Chips/flour	Y	S	F
			Attieke	Granules	Y	S	F
119	19	Zozo Oliziriboue	*Attieke*	Granules	Y	B	NA
			Placali	Pastes	Y	S	F
			Starch	Starch	N	S	F
120	20	Ekradon	*Foutou*	Fresh roots	N	S	NA
			Attieke	Granules	Y	A	F
			Agbelikklo	Starch	Y	B	F
121	21	Godesso	*Foutou*	Fresh roots	N	S	NA
			Attieke	Granules	Y	B	F
			Kokonte	Chips/flour	Y	NA	F

Notes on page 81

Table X-2 continued

Survn01	Villno	Villname	Locname	Category	Ferm	Vary	Gen
122	22	Gahougnagbolilie	*Placali*	Pastes	Y	S	NA
			Foutou	Fresh roots	N	S	F
			Attieke	Granules	Y	S	F
123	23	Kripoko	*Attieke*	Granules	N	B	NA
			Foutou	Fresh roots	N	S	F
			Placali	Pastes	N	B	F
124	24	Digbouho	*Placali*	Pastes	N	S	NA
			Attieke	Granules	N	NA	F
			Foutou	Fresh roots	N	NA	F
125	25	Zahibo	*Attieke*	Granules	Y	S	NA
			Placali	Pastes	Y	S	F
			Kokonte	Chips/flour	Y	NA	F
126	26	Bebouo-sibouo	*Attieke*	Granules	N	S	NA
			Placali	Pastes	N	S	F
			Foutou	Fresh roots	N	S	F
127	27	Kangreta	*Attieke*	Granules	Y	S	NA
			Placali	Pastes	Y	S	F
			Kokonte	Chips/flour	Y	S	F
128	28	Detroya	*Foutou*	Fresh roots	N	S	NA
			Kokonte	Chips/flour	Y	S	F
			Placali	Pastes	Y	S	F
129	29	Medibli	*Foutou*	Fresh roots	N	S	NA
			Kokonte	Chips/flour	Y	S	F
			Attieke	Granules	Y	S	F
130	30	Blole	*Foutou*	Fresh roots	N	S	NA
			Attieke	Granules	Y	S	F
			Kokonte	Chips/flour	Y	S	F
131	31	Yepleu	*Kokonte*	Chips/flour	Y	S	NA
			Foutou	Fresh roots	N	S	F
			Ragout	NA	N	S	F
132	32	Douole	*Kokonte*	Chips/flour	Y	S	NA
			Foutou	Fresh roots	N	S	F
			Ragout	NA	N	S	F
133	33	Takra-adiekro	*Kokonte*	Chips/flour	Y	S	NA
			Placali	Pastes	Y	S	F
			Foutou	Fresh roots	N	S	F
134	34	Sougban	*Foutou*	Fresh roots	N	S	NA
			Kokonte	Chips/flour	Y	S	F
			Attieke	Granules	Y	S	F
135	35	Kpato	*Attieke*	Granules	Y	S	NA
			Foutou	Fresh roots	N	S	F
			Placali	Pastes	Y	B	F
136	36	Saoua	*Attieke*	Granules	Y	S	NA
			Kokonte	Chips/flour	Y	S	F
			Placali	Pastes	Y	S	F
137	37	Okromodou	*Attieke*	Granules	Y	B	NA
			Foutou	Fresh roots	N	S	F
			Placali	Pastes	Y	S	F
138	38	Dogbo	*Foutou*	Fresh roots	N	S	NA
			Attieke	Granules	Y	S	F
			Gari	Granules	Y	S	F

Notes on page 81

Table X-2 continued

Survn01	Villno	Villname	Locname	Category	Ferm	Vary	Gen
139	39	Meneke	*Gari*	Granules	Y	S	NA
			Gari	Granules	N	S	F
			Foutou	Fresh roots	N	S	F
140	40	Gnity	*Placali*	Pastes	N	S	NA
			Placali	Pastes	Y	S	F
			Attieke	Granules	Y	B	F

Notes
The products are listed within village in decreasing order of importance in terms of quantity produced
Survn01 = survey number
Villno = village identification number
Villname = village name
Locname = local name
Category = general name
Ferm = whether processing method involved fermentation
Y = yes, N = no
Vary = type of cassava most suitable for making the product
B = bitter, S = sweet
Gen = gender that performs most of the processing tasks
Na = information not available, F = female, M = male

Level of cassava processing

An average of about 45% of the total cassava produced in the representative villages was transformed into the various processed products while the remainder, about 55%, was used in the fresh form. This was the case even though, as already pointed out, 88% of the cassava fields were planted with only sweet cassava, 2% with sweet and bitter types, and 10% of the fields were planted with only bitter cassava types. The level of processing was high even though production was mostly of the sweet type because the consumption of cassava in its unprocessed form is limited by the extreme perishability of the roots which begin to deteriorate within 24 hours after harvesting. With the present facilities for storage and transport, it is difficult to market fresh cassava at any distance from the place where it is grown. Processed cassava, on the other hand, is less bulky to transport and by far less perishable than fresh roots. Perhaps for this reason, cassava is usually eaten in processed forms (Berry 1993). Most (55%) of farmers who cultivate both the bitter and the sweet genotypes in the COSCA study countries reported that the bitter genotypes were preferred for processing.

The combined data further showed that there was a negative correlation between the proportion processed and the various market factors. For example, the proportion processed was lower among villages located around market centers than in others located further away from market centers. Farmers in remote areas market most of their cassava in processed forms. The proportion processed was significantly higher in fields planted for sale than in fields planted for home use. Fresh roots which are bulky and which have a short shelf-life are expensive to market. In Côte d'Ivoire, market access conditions did not influence the proportion of cassava processed (table X-3), an indication that there was little market incentive for cassava processing because of easy access to imported food, especially rice around market centers.

Berry argues that to assess cassava's potential for increasing food production and food security in semiarid areas, it is important to know how far the advantages of cassava's tolerance of drought, poor soil, and irregular labor inputs may be outweighed by the fact that processing is dependent on the availability of water; that the importance of water for processing is potentially a serious constraint for increased reliance on cassava both as a source of local food security in times of drought, and as a source of steady real income for rural households. In areas where water is available for only a few months out of the year, the possibility of relying on piecemeal harvesting and processing of cassava to even out a seasonal variation in income and food supply may be significantly reduced. Hence, apart from ecological constraints on increasing production, developing cassava as a source of food security in semiarid and/or drought-prone areas may depend in part on people's willingness to grow and consume fresh roots of cassava varieties which are low in cyanogens (Berry 1993).

Table X-3. Percentage of cassava processed by climatic zones, number of people buying fuelwood, and distance to market

Zone	Mean	Minimum	Maximum	Standard deviation	No. of households
Climatic zone:					
humid	41	0	100	25	31
subhumid and nonhumid	53	30	80	28	7
No. of people buying fuelwood:					
none or few	41	0	80	23	28
many or most	49	10	100	30	10
Distance to market:					
10 km or less	43	0	80	25	15
all others	41	20	70	22	9

However, while water availability may determine the type of cassava product made, it did not affect the quantity of cassava processed; therefore, it is not likely that the importance of water for processing is a serious constraint for increased reliance on cassava as a source of steady real income for rural households even in areas of low rainfall or in periods of drought without having to grow cassava varieties which are low in cyanogens. But it is likely that the importance of water for processing could be a serious constraint for increased reliance on cassava as a source of local food security in times of drought especially in the drought-prone dry climates which produce bitter cassava. It is possible that shortage of water could compel processors in such areas to make chips and flour, their major product, from bitter cassava, with the technique of sun-drying with insufficient soaking or without soaking at all. This technique which is usually adopted for processing sweet cassava if adopted for processing bitter cassava would result in products which contain considerable amounts of cyanogens (Hahn 1989).

The method of direct sun-drying of cassava roots after peeling without adequate soaking has a little significance in reducing the cyanogens. This is because the root tissue is not effectively disintegrated, giving no chance for the enzyme linamarase to act on the cyanogenic glucoside to liberate hydrogen cyanide (Bokanga 1992). The roots which are split into smaller pieces before sun-drying have an increased surface area which exposes more tissue of the roots thus enhancing the action of linamarase enzymes.

The proportion processed was higher where many or most people bought fuelwood and hence where fuelwood was scarce than where none purchased fuelwood and hence fuelwood was not scarce. Hence, the level of cassava processing did not also depend on fuelwood availability. Availability or scarcity of water or fuelwood, which in some places determines the type of cassava product made, did not determine how much cassava was processed. This is because cassava processing is flexible; it is easily adapted to take advantage of locally available resources.

These analyses show that water or fuelwood scarcity is not a constraint to the level of cassava processing; level of processing and type of product made were both adversely affected by the lack of market incentive resulting from easy access to imported rice around market centers.

Processing cost

High labor requirement was the only resource constraint in cassava processing which none of the traditional techniques was able to circumvent. Cassava processing was essentially the responsibility of the female gender; in about 80% of the representative villages, cassava processing was carried out mostly by the women and mostly by the men in only 20% of the representative villages (table X-4). This, however, varied with processing task; men's contribution was highest for crushing and lowest for cooking/toasting.

Table X-4. Percentage distribution of representative villages by gender which carried out the processing operations

Operation	Females	Males	Total
Peeling	82	18	100
Spliting	91	9	100
Crushing	62	38	100
Pressing/fermenting	83	17	100
Sieving	79	21	100
Cooking/toasting	92	8	100
Others	68	32	100
Average	80	20	100

Evidence from eastern Nigeria shows that high root yields attained through the adoption of improved cassava varieties would not have a substantial cost-saving advantage under manual processing technology (Nweke et al. 1991). Field production costs, i.e., the cost of planting material and field operations' labor per unit weight of output declined as yield increased because most of such costs were constant per unit area irrespective of the yield. Therefore, the percentage contribution of field production to total costs per unit weight of output declined as yield increased. Processing costs per unit weight of output were, however, constant as yield increased, because the processing technique employed was manual, with a low level of capital investment. Consequently, the percentage contribution of processing to total costs per unit weight of output increased as yield increased. The cost-saving advantage of yield-increasing technology may not fully translate into expanded production if there is no matching cost-saving technology at the processing stage. This is because the cost constraint is merely shifted to the processing stage. It was pointed out above that some Nigerian farmers employing IITA's high-yielding TMS 30572 variety to produce *gari* have been observed at certain seasons to cut back drastically on planting because they were unable to process the previous season's plantings (Nweke et al. 1988a). Improvement in the processing technology would have as much effect on cassava production expansion as improvement in yield.

Mechanized cassava grating machines (graters), cassava water expressing machines (pressers), and food crop milling machines (millers) were observed in the villages surveyed. While the mechanized millers were used for converting any food crop, including cassava chips, into flour, the use of mechanized graters or pressers was restricted to cassava processing. Graters were used to convert fresh roots into pulp (mash) for making *attieke* and the pressers were used to press water from cassava mash, mostly grated pulp, in the process of making *attieke* and in some places soaked roots in the process of making cassava paste. While the pressing machine was a manually operated screw presser, the food crop milling and the cassava grating machines were motorized and driven with petroleum or electric energy. The machines were available, at the village level, to individual farmers; farmers could take their food crops to the village square to be milled or grated for a fee. Some machines were mounted on wheels and pushed to the individual farmers' homes on request. Some machines were owned by men and some by women.

The mechanized pressers were the most common among the three, probably because they were used in the making of *attieke*, the most common cassava product processed in the country. The pressers were observed in 40% of the representative villages. They were reported to have been introduced for the first time in a surveyed village in 1940, but it was in the 1960s that widespread adoption commenced (fig. X-4). Pressers were also used in palm oil processing. The millers were present in about 20% of the representative villages; they were reported to have been first introduced in a surveyed village in 1968. The graters were observed in just about 5% of the villages surveyed; although they were reported to have been introduced for the first time among the surveyed villages in 1940 and although they were used in making *attieke* which had high market value, widespread adoption did not take place.

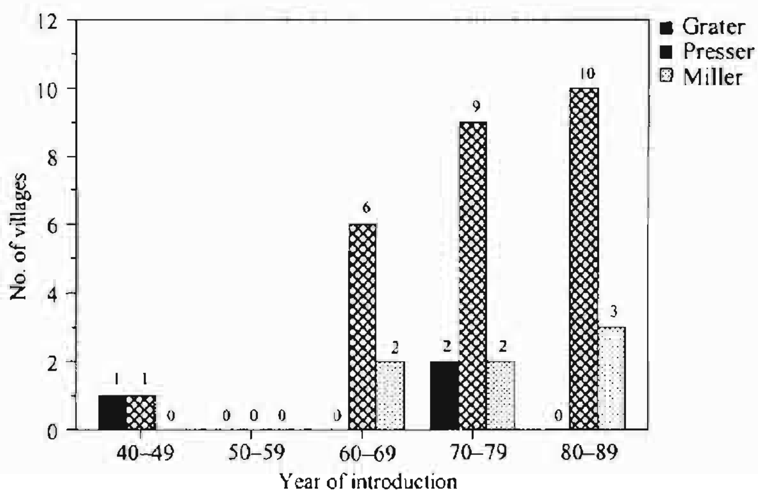

Fig. X-4. Number of villages with mechanized processing facilities by year of introduction

Note

Graters were observed in four villages, but the year of introduction was not known in one village

Combined data for the COSCA study countries in West Africa show that the type of cassava product made in a village, the amount of cassava processing carried out, population density, level of cassava production, and distance to city influenced the frequency of adoption of the grater or the presser (Inaizumi et al. 1997). These are market-related explanatory variables; certain cassava products, particularly convenient food products, are made more commonly around market centers than other products. Gender factors had an important influence on the mechanization of cassava processing. The frequency of adoption of the mechanized techniques declined with the increase in the level of cassava production by women. Women produce more cassava in remote areas than in market centers; they produce less for market sales than men (Nweke and Enete 1999). The processing tasks that have been mechanized are those to which males contribute most; perhaps, an effort was made to mechanize those tasks because of the involvement of men. It was, however, more likely that men were more involved because those tasks have been mechanized since the machines were operated by men. The frequency of adoption of the machines decreased with number of wives per household and increased with number of women per household who engaged in secondary occupations in addition to farming, suggesting a negative relationship with the availablity of female labor. As most processing labor was provided by women, mechanization of the activity was not cost-effective where such labor was cheaply available.

In Côte d'Ivoire, however, widespread adoption of the grater did not take place although it was introduced more than 50 years ago and even though its use was applicable to the making of *attieke* which has high market potentials. Whereas the grater was a motorized machine which was dependent on an imported engine and also on imported petroleum, the presser, a manually operated machine, was made with local materials without an import component except when it was made with scrap such as motor vehicle jacks. Therefore, the grater was a more expensive machine; since there was a low market demand for *attieke* around market centers, as a consequence of the availability of imported rice, there was no market incentive for private investment in the adoption of the grater. The result was that grating cassava for making *attieke*, a laborious task, continued to be manual, making the product even more expensive and less competitive with imported rice in the market.

In 1992, the price of *attieke* was just 20% higher around market centers (34 FCFA/kg) than in areas remote from the market centers (28 FCFA/kg). In contrast, in Nigeria, in the same year, the price of *gari* was 35% higher around market centers (3.0 Naira/kg) than in areas remote from the market centers (2.2 Naira/kg). In Ghana, the price of *gari* was as much as 45% higher around market centers (133 Cedis/kg) than in areas remote from the market centers (92 Cedis/kg). In the same year, one US dollar was exchanged for 266 CFA, 430 Cedis, or 17 Naira on a average monthly basis. These comparisons of the relative price levels suggest that market demand for *attieke* around market centers in Côte d'Ivoire was not as high as the market demand for its equivalent, *gari*, around the market centers in Nigeria and Ghana.

Improved cassava processing technology and production growth

Improved technology which would reduce processing labor would lead not only to an increased level of processing but also to increased production since labor released could be channelled into production activities. The second effect of improved cassava processing technology would be improved product quality. Improved quality would make the product attractive to urban consumers and thereby expand the market for the product; this would provide an incentive for expanded production.

Almost all the villages which had access to mechanized pressers reported an increasing trend in cassava land area (fig. X-5). But the relative number of the villages which reported the increasing trend among the few with access to mechanized graters was substantially lower than the relative number which reported the increasing trend among other villages without access to any mechanized cassava processing machine. This suggests that the presence of the mechanized graters did not stimulate expansion in cassava land area in the few villages where they were adopted. This could help to explain why widespread adoption did not take place. The machines were probably being operated at less than full capacity because of the low demand for the product. This was confirmed by the fact that the relative number of villages which reported the increasing trend among those which produced *attieke* was lower than the relative number which reported the increasing trend among other villages which used cassava mostly in the fresh form (table X-5). These were contrasts to the situations in other West African countries, Nigeria and Ghana, where *gari*, an equivalent of *attieke*, was in high market demand around market centers.

Table X-5. Percentage distribution of representative villages by main cassava product by cassava land area trend

Main product	No. of villages	Percentage			
		Increasing	No change	Decreasing	Total
Fresh roots	15	93	7	0	100
Attieke	14	82	12	6	100
Other products	7	86	0	14	100

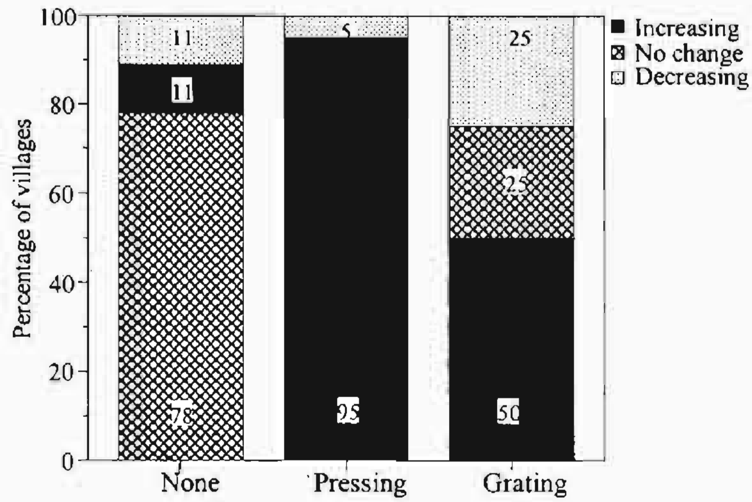

Fig. X-5. Percentage distribution of representative villages by processing task mechanized by trend in cassava land area

Conclusion

Cassava was commonly processed, although about 90% of the production was with the sweet cassava types. Processing labor-saving technology was available, but not widely adopted. Similarly, convenient techniques for making cassava food products were known but the products were not widely produced around market centers. Imported rice which was readily available around the market centers had an adverse influence on the demand for the convenient cassava product. The consequence of all these was that availability of the improved processing technologies did not produce the same results as in neighboring West African countries, Nigeria and Ghana, an increasing trend in cassava land area.

XI. Cassava Planting for Sale and Producer Household Cash Income

Level of cassava planting for sale

An average of 50% of cassava fields were planted purposely for sale; these ranged from 0% to 100%. No proportion was planted for sale in just about 5% of the fields while the entire output of cassava from 10% of the fields was planted for sale. Berry (1993) reported that in Nigeria, Zaire (Democratic Republic of Congo), and elsewhere, there were both large- and small-scale farms on which cassava was grown entirely for sale, by both full-time and part-time farmers.

Information was not collected on the proportions of other crops planted purposely for market by the farmers. However, Berry (1993) reported that both large- and small-scale farmers often sold a higher proportion of their cassava than of other crops. Tollens (1992) reported that in the Bas-Zaire region of Zaire (Democratic Republic of Congo), the proportion of total production marketed for cassava (55%) was similar to that for plantain (54%) but higher than for maize (45%), beans (45%), groundnut (35%), and rice (20%). Spiro (1980) estimated that the proportion marketed in southwest Nigeria for cassava (72%) was higher than that for maize (67%). These observations suggest that proportions of other crops marketed by the farmers in the cassava-growing areas would be lower than that of cassava.

Determinants of level of planting for sale

Combined data for the COSCA study countries show that the proportion of cassava fields planted for sale varied depending on the ease of farmer access to market and to improved postharvest technology, among others.

Farmers who used cassava mainly in any processed form planted more for sale than others who used cassava mainly in the fresh form (table XI-1). In the fresh form, cassava roots are bulky and perishable and therefore expensive to transport and market. Farmers, especially in areas remote from market centers, market most of their cassava in processed forms.

Table XI-1. Mean proportion (%) of cassava fields planted for sale by market and cassava product factors

	Mean	Minimum	Maximum	Standard deviation	No. of fields
Market access:					
10 km or less	44	10	70	19	15
other zones	56	30	70	15	9
Buyer:					
middlemen	53	10	80	18	15
consumers	41	10	70	24	14
Main product:					
fresh roots	31	10	50	12	8
attieke	51	20	100	27	15
other products	63	0	100	71	4
Overall	51	10	80	21	38

The proportion planted for sale was lower around market centers than in areas further away form the market centers where farmers had to go to market by vehicle. This was because of a low level of diversification in crop production among remote villages (Nweke 1996b). The more concentrated the cassava production, the higher the proportion of total production marketed.

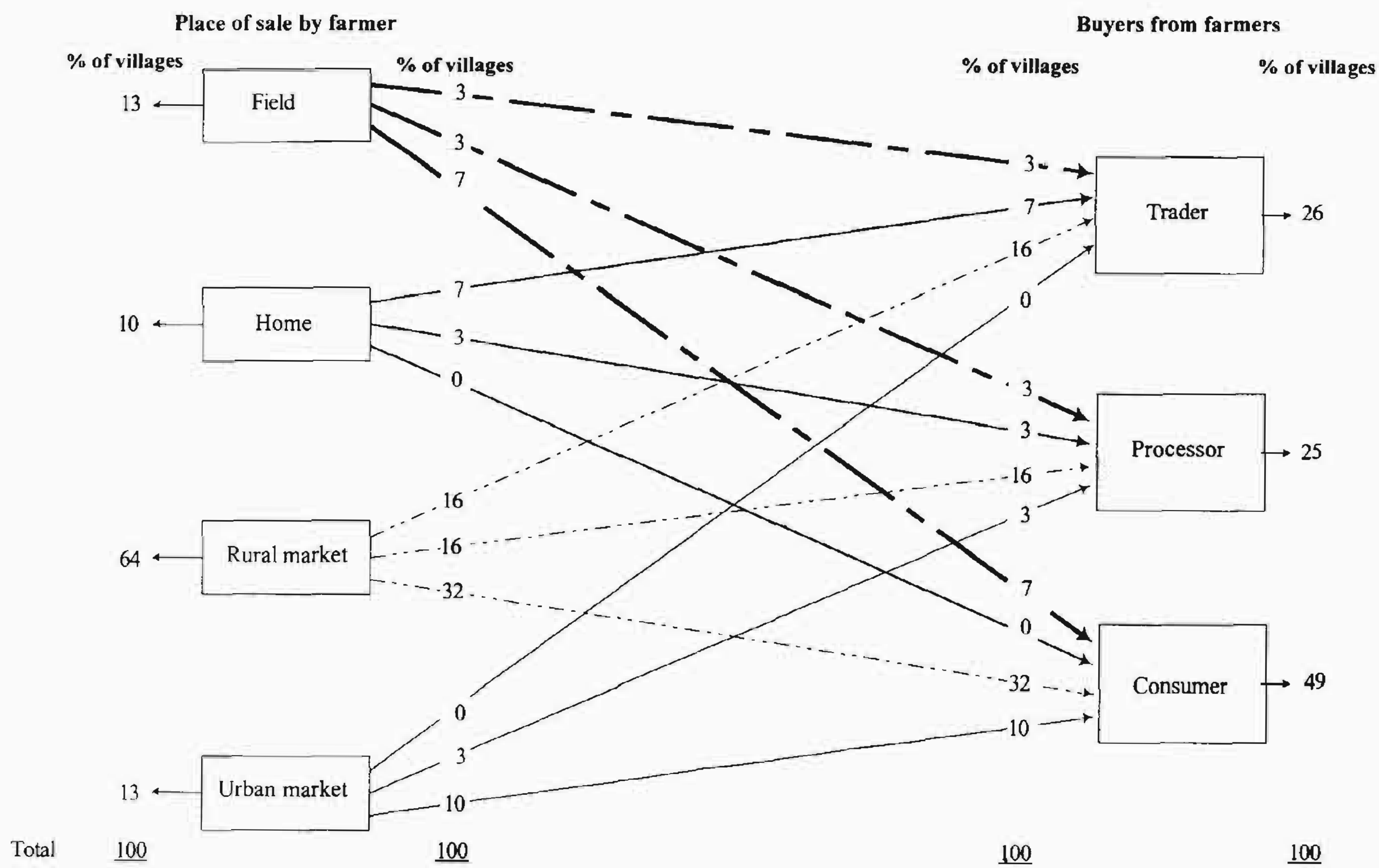

Fig. XI-1. Percentage distribution of villages by market channel for fresh roots

The proportion of cassava fields planted for sale was higher among villages which sold mainly to the middlemen than among others which sold directly to consumers. In other words, the proportion marketed increased as the participation of middlemen in the marketing process increased. The participation of middlemen discouraged diversification away from cassava production as the market access infrastructure got better.

Marketing channel

The farmers sold cassava in the field before harvest; they sold cassava roots after harvest in the rural markets, in the urban markets, and also at their homes. About 15% of the representative villages sold cassava in the field before harvest and 85% sold cassava roots after harvest, 10% at home, 65% in the rural market, and 10% in the urban market as their most frequent points of sale (fig. XI-1). Sale of cassava in the field before harvest saved the farmer not only the harvesting labor but also a range of marketing functions such as transportation, processing, storage, retailing, and a host of market risks and uncertainties.

Sale of cassava in the field before harvest was higher among villages that used cassava mainly in the form of fresh roots than in any of the processed forms. Since cassava roots have a short shelf-life, those who use fresh roots and wish to buy more than they require for a day or two must buy in the field before harvest where it can be stored.

The farmers made the sales to the middlemen, traders, and processors, and directly to consumers at each of these points of sale. About 25% of the representative villages sold to traders, 25% to processors, and 50% sold directly to consumers as their most frequent buyers. Berry (1993) observes that commercial cassava production in Nigeria entailed changes in contractual arrangements and market structures. People who plant cassava as a commercial investment often sell the crop in the ground after a few months, to buyers who assume the risks and costs of managing the farm until harvest time as well as of harvesting and marketing the tubers. The middlemen were widespread, being available in more than 50% of the villages surveyed.

Level of farm households' cash income

In 1992, mean cash income at current prices per household was about 288 000 FCFA. At an average monthly exchange rate of 266 FCFA to a dollar in the same year, and the average of 9 persons per household, the mean cash income per person was equivalent to US $114 which amounted to 25% of agricultural GDP per capita in the same year. It was shown above that about 50% of cassava fields were planted for sale and that the proportions of other crops planted for sale were likely to be lower. Therefore, farm cash income per person was likely to be substantially lower than the agricultural GDP per person. The cash income of the representative farmers in Côte d'Ivoire was dominated by earnings from tree crops which constituted 76% of the mean cash income per household surveyed. The tree crops were mainly cocoa, coffee, oil palm, kola nut, rubber, and coconut. Food crops contributed only 15% of the household cash income. Nonfarm activities included craftsmanship, trading, wage employment, unskilled nonfarm labor, farm product processing, off-farm forest products extraction such as palm wine tapping, hunting and lumbering, and traditional medical practices. These activities did not constitute major sources of cash income (just 1%) among the representative households. Livestock, including chicken, sheep, pigs, goats, and to a small degree cattle, contributed just 3% of the households' cash income. Therefore, in the cassava-producing areas, tree crop production was the major source of cash income for the smallholder households.

Food crops as sources of household cash income

The relative importance of a food crop as a cash income generator is the proportion of the household food crops cash income generated from the crop. Comparison of this value across crops may be biased since sampling was biased towards cassava. The objective of this study is, however, to establish the extent to which cassava-producing households depend on cassava for cash income.

Cassava. Among the cassava-producing households, cassava contributed 37% of cash income from all food crops. All other food crops produced by the same households together accounted for the remaining 63%. None of the other food crops rivalled cassava as a source of cash income. Of the 199 cassava-producing households, 57% also produced yam, 4% produced sweetpotato, 70% produced plantain, 64% produced maize, and 42% produced rice. The mean cash income from each of these other major food crops was calculated over the number of cassava-producing households. It was shown subsequently that cassava, with the exception of rice and maize, still contributed relatively more cash income even when the number of households producing the other crops was respectively higher than the number growing cassava. Therefore, among cassava-producing households, cassava was the most important food crop generating cash income.

Yam. Among yam-producing households, yam accounted for 10% of cash income from all food crops; the other food crops together accounted for 90%. Virtually all the yam-producing households also produced cassava, plantain, and maize. The yam-producing households earned proportionately more cash from cassava than from yam. Therefore, among the yam-producing households, cassava and maize, but not yam, were the most important food crops generating cash income. A similar observation was made by Okorji (1983) among Abakaliki yam farmers of southeastern Nigeria.

Sweetpotato. Among sweetpotato-producing households, sweetpotato accounted for only 4% of cash income from food crops. The sweetpotato-producing housesholds earned more cash income from cassava and from rice than from sweetpotato.

Plantain. Among plantain-producing households, plantain contributed 17% of the cash income from all food crops. The plantain-producing households also earned more cash income from cassava and from rice than from plantain.

Maize. Among maize-producing households, maize accounted for about 15% of food crops cash income; other food crops accounted for about 85%. The maize-producing households earned proportionately more cash income from cassava than from maize production. Hence, cassava and not maize was the major food crop generating a substantial cash income for several of the maize-producing households.

Rice. Among rice-producing households, rice accounted for 37% of the food crops cash income. Cassava contributed a sizeable proportion of the rice-producing households' cash income.

Summary. Among all the major food crops, cassava and rice each accounted for the largest proportion of the cash incomes generated by food crops in the producing households. There were more cassava-producing households than households producing any of the other crops. Consequently, in the cassava-growing areas, cassava was one of the most important food crops generating cash income although food crop production was not the main source of the household cash income in the area. Therefore, in comparison with other food crops, cassava was not a subsistence crop or just a food security crop; its production was a source of cash income for the producing households. Outside cassava-producing areas, another crop may well be the major source of cash income.

Distribution of cash income from food crop production

More than 35% of the cassava-producing households earned cash income from cassava (fig. XI-2). This was higher than the percentage of any other crop-producing households which earned cash income from that crop. The only exception was rice; also more than 35% of rice-producing households earned cash income from rice. However, the cash income from cassava production accrued to more households (about 40% of all households surveyed) than any other crop, and more than rice in particular. Only about 15% of the surveyed households earned cash income from rice production (fig. XI-3).

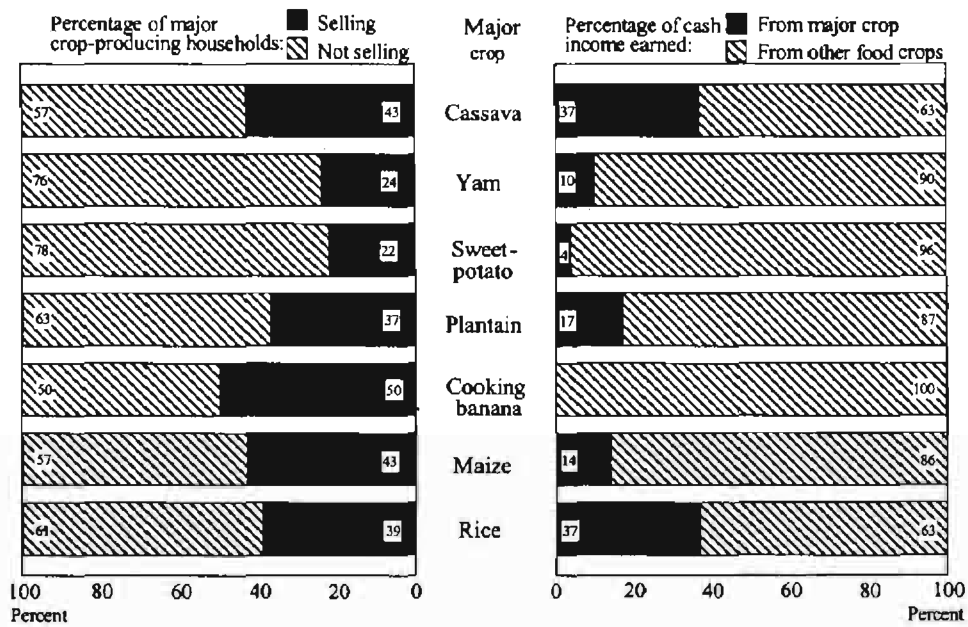

Fig. XI-2. Proportions of households selling and of cash income earned from various major crops

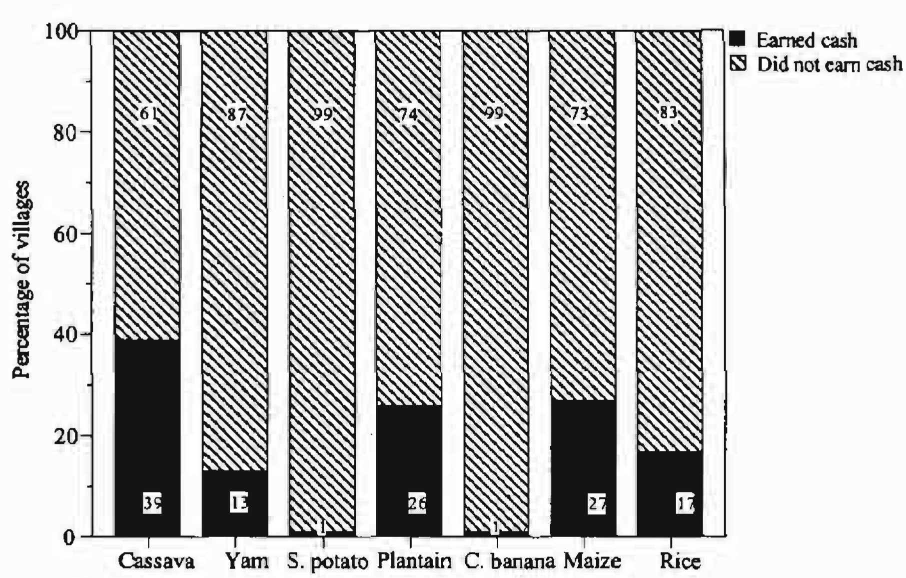

Fig. XI-3. Percentage of representative households which earned cash income from each major crop

These observations confirm Berry's (1993) hypothesis that the production of cassava is more egalitarian than the production of most of the other major food crops in cassava-producing areas. Cassava production is able to perform this role because the crop, relative to most of the other food crops, has a wide ecological adaptation; it is less expensive to produce as it tolerates poor soil, adverse weather, and pests/disease. Carbohydrate yield from the cassava per unit of resource is higher than that of most of the other major food crops. In addition, cassava is widely accepted as food for humans in various forms in many parts of the country even outside its major producing areas, hence it has a wide market.

APPENDIX

Appendix

Fallow Systems Charts

Notes

Village level information which may drive the systems is presented as descriptive data at the village level. This includes pests/disease symptom severity scores which were determined at the village level:

CMB = Cassava mealybug
CGM = Cassava green mite
ACMD = African cassava mosaic virus disease
CBB = Cassava bacterial blight

The score is on a scale of zero for no symptom to 4 for the most severe symptoms.

Systems data are plotted; months and years, are presented along the horizontal axis beginning with January (J for January) of Year 1 as J/1 to December (not indicated) up to December of Year 20; the last J/O refers to January of Year 20.

The systems are standardized at a 20–year period to accommodate the longest rotation cycle described in any representative village; short rotation cycles are repeated several times within the 20–year period.

Crops are listed in boxes; a set of crops consists of boxes which touch one another vertically. The boxes are positioned in a decreasing order of the importance of the crops in the set, as ranked by the farmers.

Each box covers the growth cycle, beginning with peak planting month for the crop and ending with peak harvesting month.

Relevant-system information which could not be plotted is listed for each system as descriptive data. Crop calendar, although plotted in the charts, is also presented as descriptive data to facilitate the reading of the charts.

However, the calendar information could only be listed for the first set of crops in each system because of space limitation.

Other abreviations
MZ = Maize
SP = Sweetpotato
BP = Beans/peas
SM = Sorghum/millet
COTT = Cotton
SES = Sesame
CASS = Cassava
S.FL = Sunflower
CALA = Calabash

Chart 101. Crop production systems in SAHUYE village

Descriptive data

——————— VILLAGE ——————————————————— 101

Name = SAHUYE Identification number = 1 Altitude = 120 meters
Lon. = 4.5200 degrees Lat. = 5.7167 degrees

Total annual rainfall = 1897 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26 deg. cent.; temp. range = 7.1 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 25 kilometers
Main market: distance = 0 kilometers; access means = foot/head
Main cassava buyer = N/A

CMB symptom severity score = 0 ; CGM symptom severity score = 1
ACMD symptom severity score = 1 ; CBB symptom severity score = 2

Cattle kept in village? Yes; Method = free range
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.44 hectares.
Mean household size = 7.17, number of households = 13

Mean soil properties (No. of samples = 6)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = NA	Ca^{++} = NA	Avail P = 2.74	Ca^{++} = 1.5667
K^{+} = NA	Mn^{++} = NA	K^{+} = 0.1	Mn^{++} = 0.15
Mg^{++} = NA	Total N = NA	Mg^{++} = 0.6833	Total N = 0.072
K:S ratio = NA	Mg:K ratio = NA	K:S ratio = 6.8333	Mg:K ratio = 6.8333
Mn:P ratio = NA	N:P ratio = NA	Mn:P ratio = 0.0472	N:P ratio = 0.0354
N:S ratio = NA	Org. C = NA	N:S ratio = 12.2177	Org. C = 0.7
Org. matt = NA	pH = NA	Org. matt = 1.2068	pH = 6
Sand = NA	Silt = NA	Sand = 69.3333	Silt = 20.3333
S:P ratio = NA	TEB = NA	S:P ratio = 0.0015	TEB = 2.55
Total S = NA	BS = NA	Total S = 0.0216	BS = 74.8519
Ca:Mg ratio = NA	Ca:S ratio = NA	Ca:Mg ratio = 2.4944	Ca:S ratio = 183.9002
Clay = NA	C:N ratio = NA	Clay = 10.5	C:N ratio = 9.6333
Na^{+} = NA	ECEC = NA	Na^{+} = 0.2	ECEC = 3.3667
EPP = NA	ESP = NA	EPP = 3.3225	ESP = 6.6065
TEA = NA		TEA = 0.8167	

——————— SYSTEM 3 ———————

Land form = middle slope; land location = mixture of near and far fields
Fallow period < 1 year; vegetation at the end of fallow = N/A
Seedbed type = heaps
1st crop = cassava ; peak planting month = February ; age at harvest = 12 months
2nd crop = maize ; peak planting month = February ; age at harvest = 3 months

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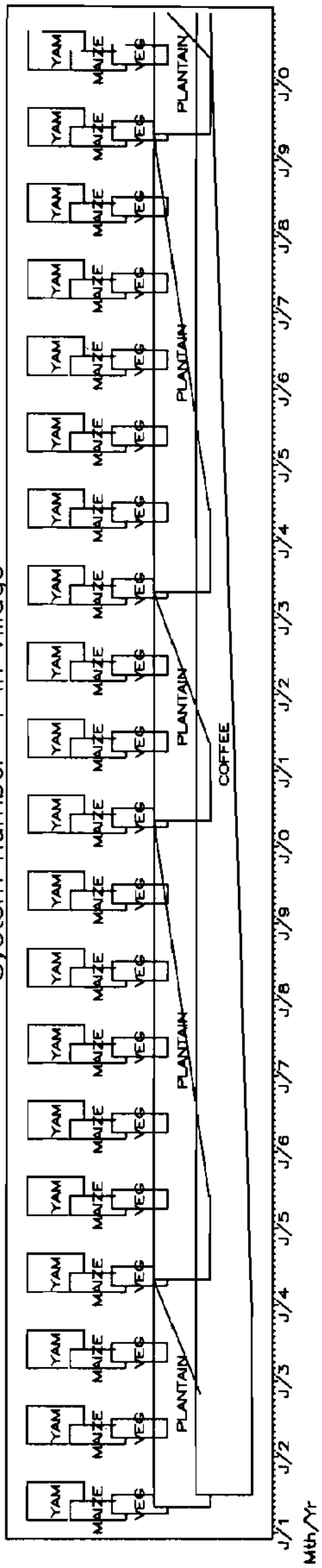
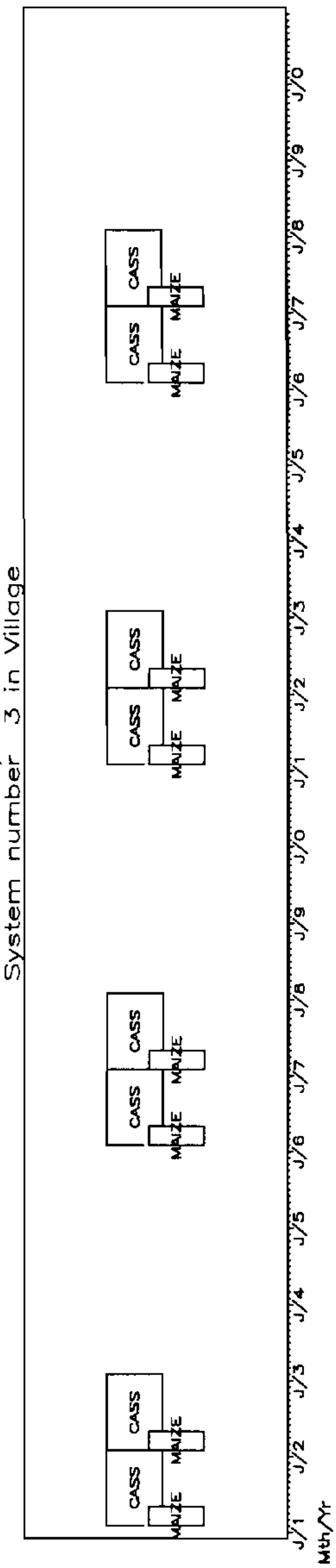
Coffee-based systems are not indicated

System number 1 in Village



System number 3 in Village



0101

Chart 2. Crop production systems in BOUSSOUE village

Descriptive data

——— VILLAGE ——— 102

Name = BOUSSOUE Identification number = 2 Altitude = 120 meters
Lon. = 4.7000 degrees Lat. = 5.7833 degrees

Total annual rainfall = 1735 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26.6 deg. cent.; temp. range = 7.3 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 25 kilometers
Main market: distance = 0 kilometers; access means = bicycle
Main cassava buyer = N/A

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 1 ; CBB symptom severity score = 2

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 5.75 tons per hectare, number of fields = 2;
Mean field area (all crops)/household = 0.74 hectares;
Mean household size = 6.08, number of households = 11

Mean soil properties (No. of samples = 9)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 7.7667	Ca^{++} = 7.6333	Avail P = NA	Ca^{++} = NA
K^+ = 0.3556	Mn^{++} = 0.6667	K^+ = NA	Mn^{++} = NA
Mg^{++} = 2.2778	Total N = 0.1944	Mg^{++} = NA	Total N = NA
K:S ratio = 33.3333	Mg:K ratio = 6.8241	K:S ratio = NA	Mg:K ratio = NA
Mn:P ratio = 0.0971	N:P ratio = 0.0328	Mn:P ratio = NA	N:P ratio = NA
N:S ratio = 15.1667	Org. C = 1.59	N:S ratio = NA	Org. C = NA
Org. matt = 2.7412	pH = 6.5778	Org. matt = NA	pH = NA
Sand = 73	Silt = 18.8889	Sand = NA	Silt = NA
S:P ratio = 0.0012	TEB = 10.6889	S:P ratio = NA	TEB = NA
Total S = 0.012	BS = 99.8004	Total S = NA	BS = NA
Ca:Mg ratio = 3.3036	Ca:S ratio = 575	Ca:Mg ratio = NA	Ca:S ratio = NA
Clay = 8.1111	C:N ratio = 7.8889	Clay = NA	C:N ratio = NA
Na^+ = 0.4222	ECEC = 10.7222	Na^+ = NA	ECEC = NA
EPP = 3.3872	ESP = 4.2175	EPP = NA	ESP = NA
TEA = 0.0333		TEA = NA	

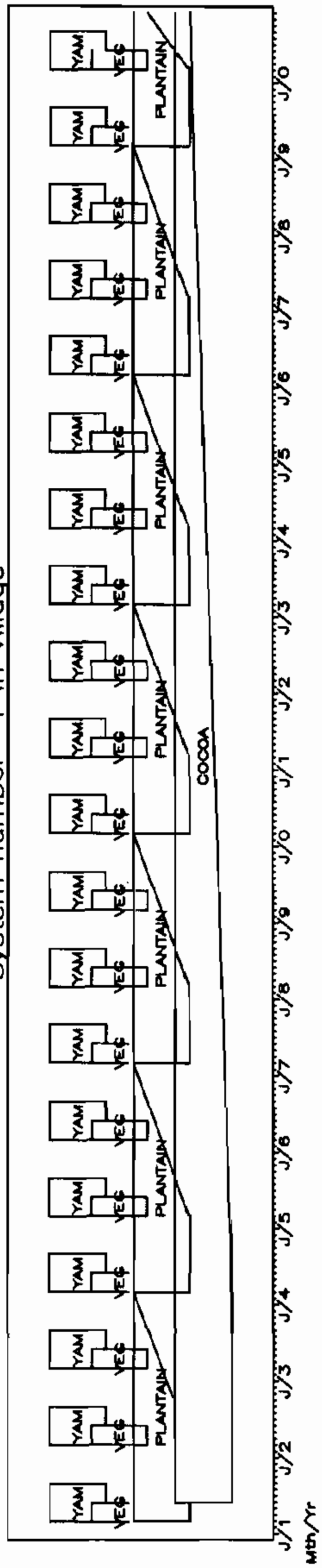
——— SYSTEM 1 ———

Land form = dry plain; land location = nonresidential area
Fallow period < 1 year; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = June ; age at harvest = 36 months
2nd crop = plan. ; peak planting month = March ; age at harvest = 12 months
3rd crop = yams ; peak planting month = March ; age at harvest = 6 months

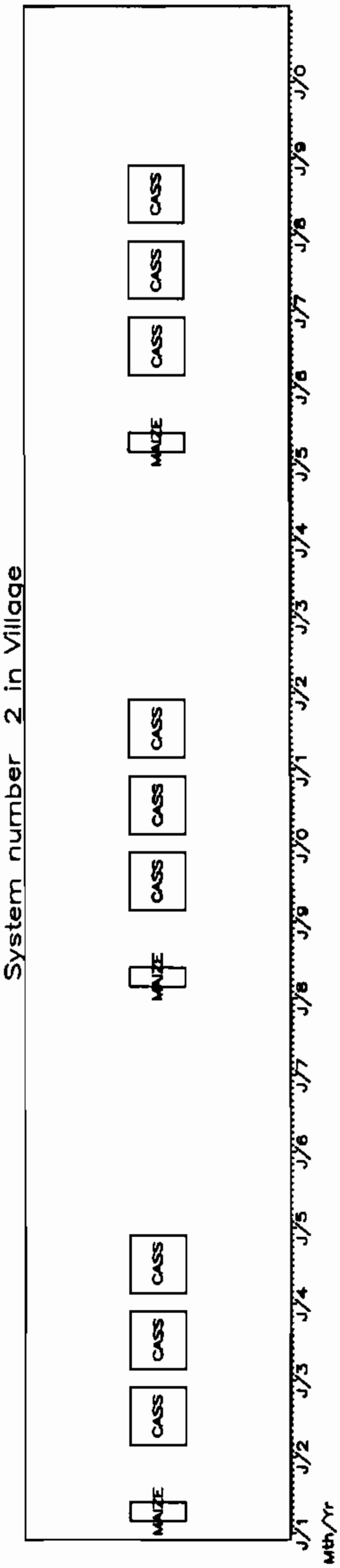
——— SYSTEM 2 ———

Land form = dry plain; land location = nonresidential area
Fallow period = 3 years; vegetation at the end of fallow = grass
Seedbed type = flat (no tillage)
1st crop = maize ; peak planting month = March ; age at harvest = 3 months

System number 1 in Village



System number 2 in Village



0102

Chart 3. Crop production systems in BROFODOUME village

Descriptive data

VILLAGE 103

Name = BROFODOUME Identification number = 3 Altitude = 140 meters
Lon. = 3.9200 degrees Lat. = 5.5167 degrees

Total annual rainfall = 2096 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 25.8 deg. cent.; temp. range = 6.8 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 14.1 kilometers
Main market: distance = 0 kilometers; access means = N/A
Main cassava buyer = N/A

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 1

Cattle kept in village? No
Sheep/goats kept in village? No
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 13.42 tons per hectare, number of fields = 6;
Mean field area (all crops)/household = 1.11 hectares;
Mean household size = 6.92 , number of households = 13

Mean soil properties (No. of samples = 13)

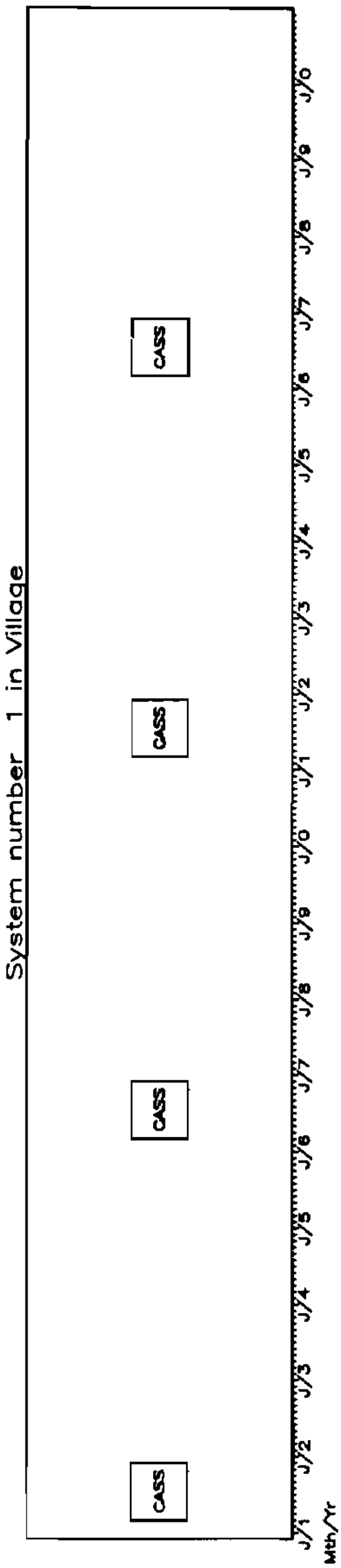
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 6.9875	Ca^{++} = 1.9625	Avail P = 5.02	Ca^{++} = 0.28
K^{+} = 0.0725	Mn^{++} = 0.1463	K^{+} = 0.1	Mn^{++} = 0.028
Mg^{++} = 0.85	Total N = 0.0984	Mg^{++} = 0.24	Total N = 0.0648
K:S ratio = 30.4984	Mg:K ratio = 18.0417	K:S ratio = 2.4	Mg:K ratio = 2.4
Mn:P ratio = 0.0565	N:P ratio = 0.0321	Mn:P ratio = 0.0062	N:P ratio = 0.016
N:S ratio = 53.7576	Org. C = 1.06	N:S ratio = 8.2051	Org. C = 0.476
Org. matt = 1.8274	pH = 5.3625	Org. matt = 0.8206	pH = 5.12
Sand = 76	Silt = 11.75	Sand = 83.2	Silt = 5.6
S:P ratio = 0.0045	TEB = 3.0613	S:P ratio = 0.0013	TEB = 0.84
Total S = 0.0249	BS = 74.3066	Total S = 0.0078	BS = 33.0978
Ca:Mg ratio = 1.9454	Ca:S ratio = 1040.6288	Ca:Mg ratio = 1.1	Ca:S ratio = 25.641
Clay = 12.25	C:N ratio = 11.0125	Clay = 11.4	C:N ratio = 7.34
Na^{+} = 0.1763	ECEC = 3.6613	Na^{+} = 0.22	ECEC = 2.48
EPP = 1.7954	ESP = 6.1055	EPP = 4.1033	ESP = 8.8315
TEA = 0.8		TEA = 1.64	

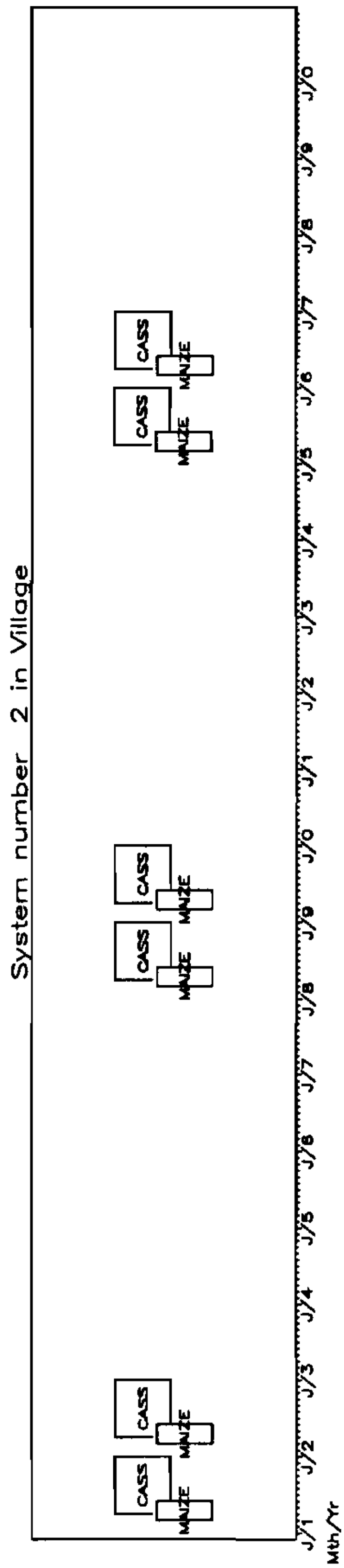
SYSTEM 1

Land form = swamp land; land location = residential area
Fallow period = 4 years; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = March ; age at harvest = 9 months

SYSTEM 2

Land form = upper slope/upland ; land location = residential area
Fallow period 4 years; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = April ; age at harvest = 9 months
2nd crop = maize ; peak planting month = March ; age at harvest = 3 months


System number 1 in Village
CASS
Mth/Yr


System number 2 in Village
CASS
Mth/Yr

0103

Chart 4. Crop production systems in N'KOUPE village

Descriptive data

——— VILLAGE ——— 104

Name = N'KOUPE Identification number = 4 Altitude = 180 meters
Lon. = 3.9300 degrees Lat. = 6.0833 degrees

Total annual rainfall = 1838 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 25.4 deg. cent.; temp. range = 7 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 9 kilometers
Main market: distance = 9 kilometers; access means = motor vehicle
Main cassava buyer = trader

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 0 tons per hectare, number of fields = 2;
Mean field area (all crops)/household = 0.39 hectares;
Mean household size = 4.5, number of households = 8

Mean soil properties (No. of samples = 8)

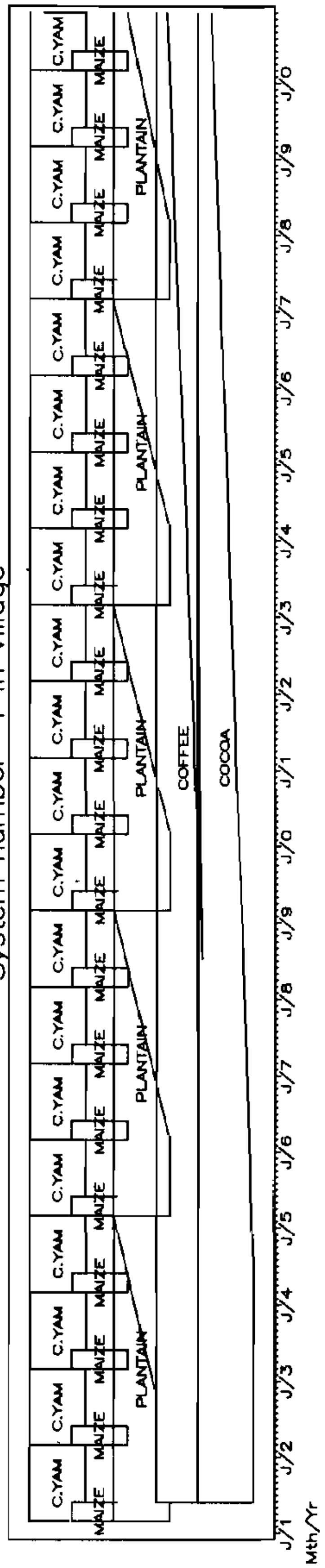
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 12.2429	Ca^{++} = 2.3857	Avail P = 0.5	Ca^{++} = 1.3
K^{+} = 0.0971	Mn^{++} = 0.1314	K^{+} = 0.03	Mn^{++} = 0.03
Mg^{++} = 0.8429	Total N = 0.1141	Mg^{++} = 1	Total N = 0.092
K:S ratio = 2.3744	Mg:K ratio = 15.5556	K:S ratio = 33.3333	Mg:K ratio = 33.3333
Mn:P ratio = 0.025	N:P ratio = 0.016	Mn:P ratio = 0.06	N:P ratio = 0.184
N:S ratio = 2.6379	Org. C = 1.1943	N:S ratio = NA	Org. C = 1.85
Org. matt = 2.0589	pH = 5.2286	Org. matt = 3.1894	pH = 5.4
Sand = 81.7143	Silt = 6.8571	Sand = 55	Silt = 18
S:P ratio = 0.0008	TEB = 3.64	S:P ratio = NA	TEB = 2.63
Total S = 0.041	BS = 62.9524	Total S = NA	BS = 62.1749
Ca:Mg ratio = 2.2576	Ca:S ratio = 50.3877	Ca:Mg ratio = 1.3	Ca:S ratio = NA
Clay = 11.4286	C:N ratio = 10.6571	Clay = 27	C:N ratio = 20
Na^{+} = 0.3143	ECEC = 4.7543	Na^{+} = 0.3	ECEC = 4.23
EPP = 1.6106	ESP = 7.6892	EPP = 0.7092	ESP = 7.0922
TEA = 1.56		TEA = 1.6	

——— SYSTEM 3 ———

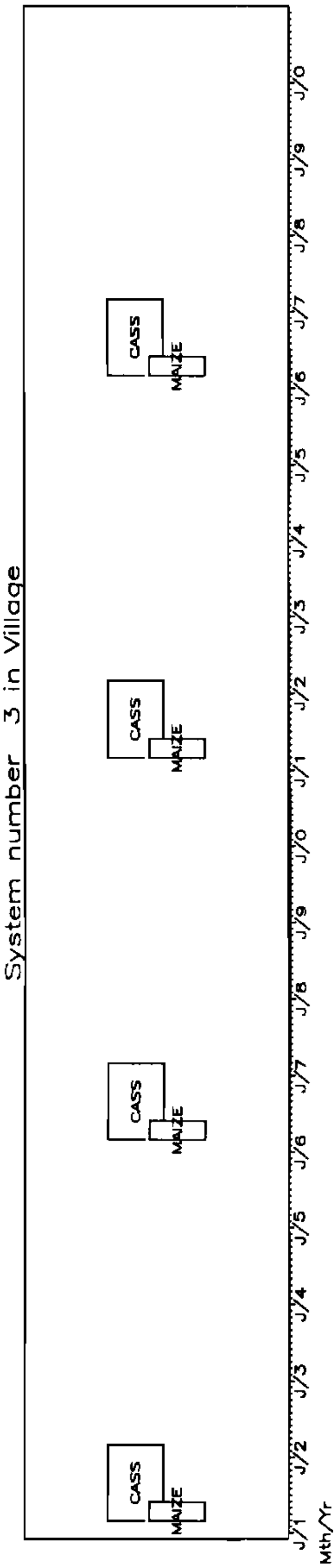
Land form = dry plain ; land location = residential area
Fallow period = 3 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = March ; age at harvest = 12 months
2nd crop = maize ; peak planting month = March ; age at harvest = 3 months

Coffee-based systems are not indicated

System number 1 in Village



System number 3 in Village



0104

Chart 5. Crop production systems in AKOUAKRO village

Descriptive data

——— VILLAGE ——— 105

Name = AKOUAKRO Identification number = 5 Altitude = 210 meters
Lon. = 3.5500 degrees Lat. = 6.7667 degrees

Total annual rainfall = 1538 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 25.6 deg. cent.; temp. range = 8 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 5 kilometers
Main market: distance = 5 kilometers; access means = motor vehicle
Main cassava buyer = processor

CMB symptom severity score = 0 ; CGM symptom severity score = 0
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 0 tons per hectare, number of fields = 2;
Mean field area (all crops)/household = 0.25 hectares;
Mean household size = 3.83, number of households = 7

Mean soil properties (No. of samples = 10nbhb)

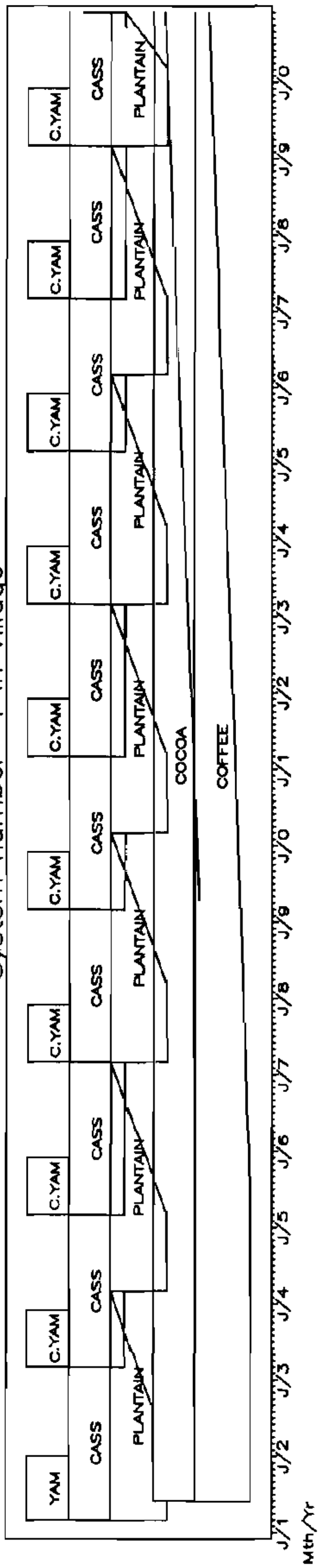
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 5.9571	Ca^{++} = 5.4571	Avail P = 1.5333	Ca^{++} = 4
K^{+} = 0.3	Mn^{++} = 0.1429	K^{+} = 0.3667	Mn^{++} = 0.2667
Mg^{++} = 1.4429	Total N = 0.2331	Mg^{++} = 1.3	Total N = 0.1433
K:S ratio = 3.5441	Mg:K ratio = 4.5857	K:S ratio = 4.4	Mg:K ratio = 4.4
Mn:P ratio = 0.0257	N:P ratio = 0.0392	Mn:P ratio = 0.3529	N:P ratio = 0.1925
N:S ratio = 2.987	Org. C = 2.61	N:S ratio = NA	Org. C = 0.8933
Org. matt = 4.4996	pH = 5.7	Org. matt = 1.5401	pH = 6.4
Sand = 54.2857	Silt = 20.2857	Sand = 44.6667	Silt = 18
S:P ratio = 0.0139	TEB = 7.4857	S:P ratio = NA	TEB = 6.0333
Total S = 0.0858	BS = 89.42	Total S = NA	BS = 99.2754
Ca:Mg ratio = 4.0908	Ca:S ratio = 59.5382	Ca:Mg ratio = 3.1092	Ca:S ratio = NA
Clay = 25.4286	C:N ratio = 11.3857	Clay = 38	C:N ratio = 6.2667
Na^{+} = 0.2857	ECEC = 8.1	Na^{+} = 0.3667	ECEC = 6.0667
EPP = 3.6655	ESP = 3.5413	EPP = 6.4939	ESP = 6.4939
TEA = 0.6143		TEA = 0.0333	

——— SYSTEM 2 ———

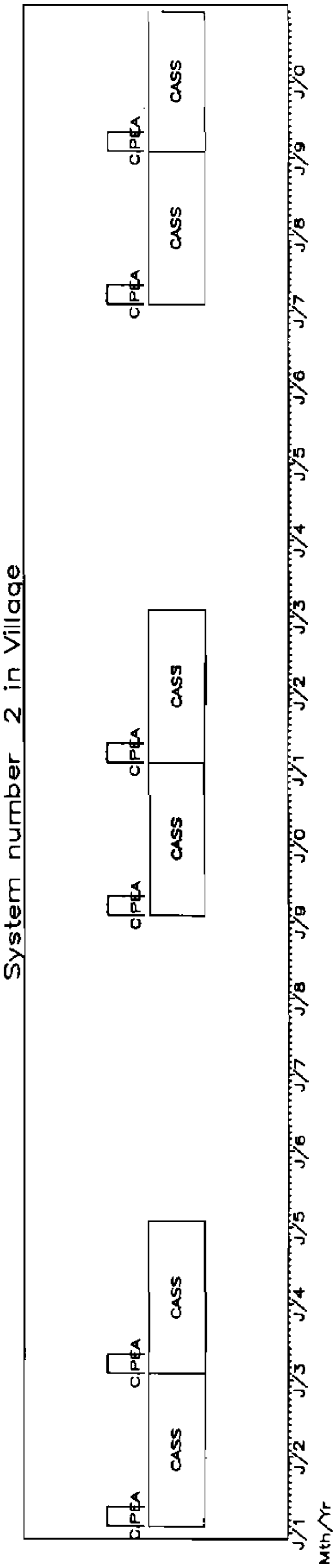
Land form = dry plain ; land location = residential area
Fallow period = 3 years; vegetation at the end of fallow = trees/shrubs
Seedbed type = flat (no tillage)
1st crop = beans ; peak planting month = February ; age at harvest = 3 months
2nd crop = cassava ; peak planting month = February ; age at harvest = 24 months

Coffee-based systems are not indicated

System number 1 in Village



System number 2 in Village



0105

Chart 6. Crop production systems in APROMPRON village

Descriptive data

VILLAGE ——— 106

Name = APROMPRON Identification number = 6 Altitude = 220 meters
Lon. = 3.3300 degrees Lat. = 6.3500 degrees

Total annual rainfall = 1632 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 24.9 deg. cent.; temp. range = 7.9 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 30 kilometers
Main market: distance = 0 kilometers; access means = NA
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? Yes; Method = herded
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 6.5 tons per hectare, number of fields = 1;
Mean field area (all crops)/household = 1.28 hectares;
Mean household size = 13.42, number of households = 26

Mean soil properties (No. of samples = 5)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 5.2	Ca^{++} = 1.4	Avail P = 4.1	Ca^{++} = 2.45
K^{+} = 0.1	Mn^{++} = 0.02	K^{+} = 0.1175	Mn^{++} = 0.1775
Mg^{++} = 1.2	Total N = 0.07	Mg^{++} = 1.425	Total N = 0.1148
K:S ratio = NA	Mg:K ratio = 12	K:S ratio = 19.0833	Mg:K ratio = 19.0833
Mn:P ratio = 0.0038	N:P ratio = 0.0135	Mn:P ratio = 0.0495	N:P ratio = 0.0448
N:S ratio = NA	Org. C = 1.13	N:S ratio = 3.1627	Org. C = 1.2025
Org. matt = 1.9481	pH = 4.6	Org. matt = 2.0731	pH = 5.075
Sand = 44	Silt = 38	Sand = 53	Silt = 28
S:P ratio = NA	TEB = 3.1	S:P ratio = 0.0089	TEB = 4.2675
Total S = NA	BS = 59.6154	Total S = 0.0456	BS = 84.972
Ca:Mg ratio = 1.1667	Ca:S ratio = NA	Ca:Mg ratio = 1.6079	Ca:S ratio = 60.7767
Clay = 18	C:N ratio = 16	Clay = 19	C:N ratio = 9.275
Na^{+} = 0.4	ECEC = 5.2	Na^{+} = 0.275	ECEC = 4.8675
EPP = 1.9231	ESP = 7.6923	EPP = 2.2318	ESP = 7.9489
TEA = 2.1		TEA = 0.6	

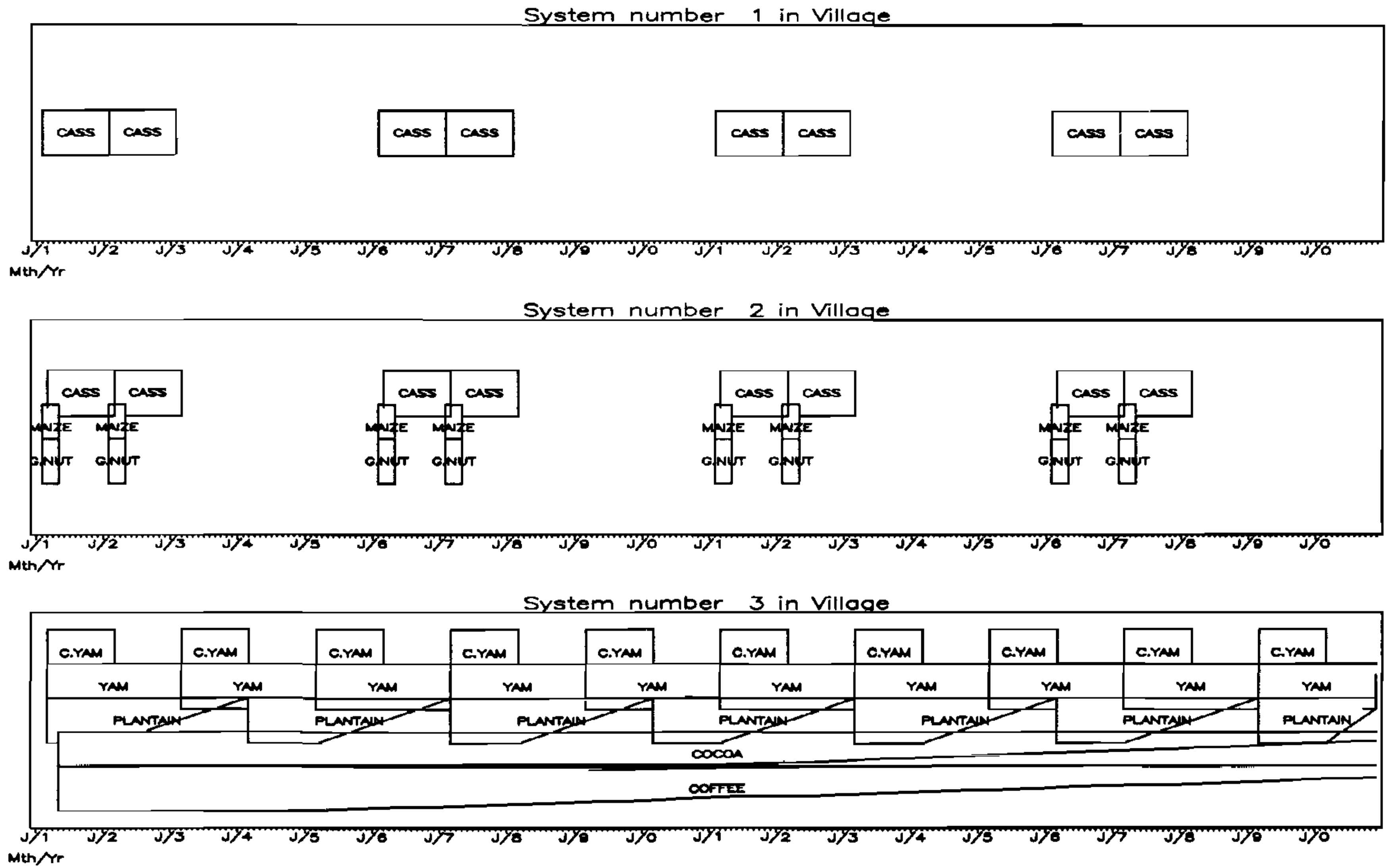
SYSTEM 1

Land form = dry plain ; land location = residential area
Fallow period = 2 years ; vegetation at the end of fallow = grass
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = February ; age at harvest = 12 months

SYSTEM 2

Land form = dry plain ; land location = residential area
Fallow period = 2 years ; vegetation at the end of fallow = grass
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = March ; age at harvest = 12 months
2nd crop = maize ; peak planting month = February ; age at harvest = 3 months
3rd crop = beans ; peak planting month = February ; age at harvest = 3 months

Coffee-crop based systems are not indicated


System number 1 in Village
CASS
Mth/Yr
System number 2 in Village
CASS
MAIZE
G.NUT
Mth/Yr
System number 3 in Village
C.YAM
YAM
PLANTAIN
COCOA
COFFEE
Mth/Yr

0106

Chart 7. Crop production systems in AKACOMOEKRO village

Descriptive data

——————— VILLAGE ——————————————— 107

Name = AKACOMOEKRO   Identification number = 7   Altitude = 190 meters
Lon. = 3.3700 degrees   Lat. = 6.1833 degrees

Total annual rainfall = 1744 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 25.5 deg. cent.; temp. range = 7.3 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 15 kilometers
Main market: distance = 0 kilometers; access means = NA
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 0 tons per hectare, number of fields = 1;
Mean field area (all crops)/household = 0.56 hectares;
Mean household size = 7.75, number of households = 15

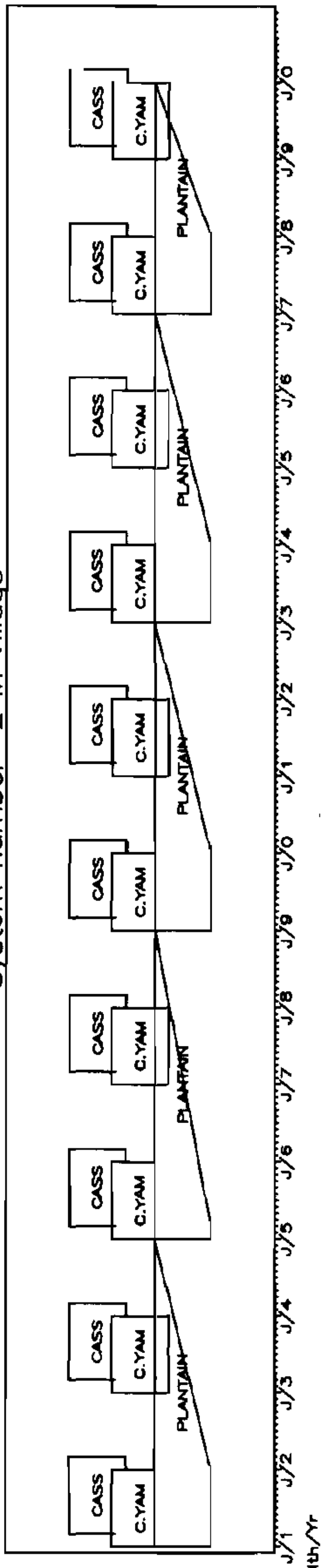
Mean soil properties (No. of samples = 5)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 5.875	Ca^{++} = 3.375	Avail P = 0.9	Ca^{++} = 1.1
K^+ = 0.305	Mn^{++} = 0.1525	K^+ = 0.1	Mn^{++} = 0.03
Mg^{++} = 1.725	Total N = 0.165	Mg^{++} = 0.7	Total N = 0.098
K:S ratio = 4.4643	Mg:K ratio = 15	K:S ratio = 7	Mg:K ratio = 7
Mn:P ratio = 0.0234	N:P ratio = 0.0262	Mn:P ratio = 0.0333	N:P ratio = 0.1089
N:S ratio = 2.2991	Org. C = 2.04	N:S ratio = NA	Org. C = 1.81
Org. matt = 3.517	pH = 5.175	Org. matt = 3.1204	pH = 5.4
Sand = 60	Silt = 18.5	Sand = 54	Silt = 20
S:P ratio = 0.0136	TEB = 5.755	S:P ratio = NA	TEB = 2.3
Total S = 0.0896	BS = 96.875	Total S = NA	BS = 76.6667
Ca:Mg ratio = 1.8708	Ca:S ratio = 45.7589	Ca:Mg ratio = 1.5714	Ca:S ratio = NA
Clay = 21.5	C:N ratio = 13	Clay = 26	C:N ratio = 19
Na^+ = 0.35	ECEC = 5.98	Na^+ = 0.4	ECEC = 3
EPP = 4.3822	ESP = 6.3218	EPP = 3.3333	ESP = 13.3333
TEA = 0.225		TEA = 0.7	

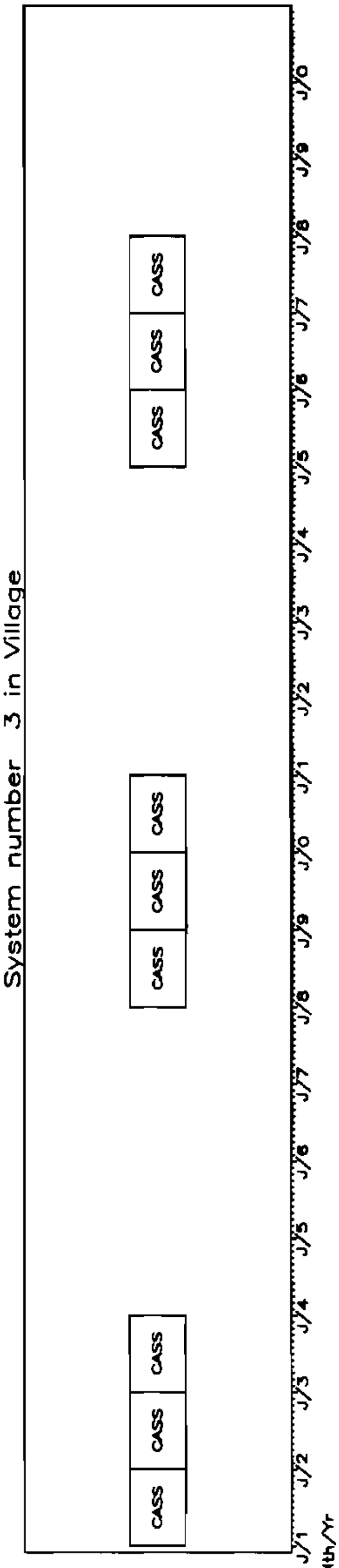
——————— SYSTEM 2 ———————
Land form = dry plain ; land location = residential area
Fallow period = 3 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = March ; age at harvest = 12 months
2nd crop = cocoyams ; peak planting month = January ; age at harvest = 12 months
3rd crop = plan. ; peak planting month = January ; age at harvest = 12 months

——————— SYSTEM 3 ———————
Land form = dry plain ; land location = residential area
Fallow period = 3 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = January ; age at harvest = 12 months

System number 2 in Village



System number 3 in Village



0107

Chart 8. Crop production systems in ANO village

Descriptive data

VILLAGE — 108

Name = ANO   Identification number = 8   Altitude = 100 meters
Lon. = 4.3800 degrees   Lat. = 5.8333 degrees

Total annual rainfall = 1897 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26 deg. cent.; temp. range = 7.1 deg. cent.
Climatic zone = Subhumid

Population density = 24 persons/sq km.
Distance to nearest city = 25 kilometers
Main market: distance = 0 kilometers; access means = N/A
Main cassava buyer = trader

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 14.63 tons per hectare, number of fields = 1;
Mean field area (all crops)/household = 0.16 hectares;
Mean household size = 5.58, number of households = 10

Mean soil properties (No. of samples = 8)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 56.22	Ca^{++} = 3.72	Avail P = 3.8	Ca^{++} = 4.7667
K^{+} = 0.132	Mn^{++} = 0.18	K^{+} = 0.2333	Mn^{++} = 0.4333
Mg^{++} = 0.72	Total N = 0.119	Mg^{++} = 1.8667	Total N = 0.175
K:S ratio = 3.9806	Mg:K ratio = 5.2	K:S ratio = 7.6111	Mg:K ratio = 7.6111
Mn:P ratio =-0.0338	N:P ratio = 0.0178	Mn:P ratio = 0.1149	N:P ratio = 0.0517
N:S ratio = 3.5741	Org. C = 1.226	N:S ratio = 3.4219	Org. C = 1.82
Org. matt = 2.1136	pH = 6.44	Org. matt = 3.1377	pH = 6.2333
Sand = 75	Silt = 13.6	Sand = 61.3333	Silt = 24
S:P ratio = 0.0026	TEB = 4.732	S:P ratio = 0.0106	TEB = 7.2
Total S = 0.0317	BS = 70.3297	Total S = 0.0602	BS = 100
Ca:Mg ratio = 6.2162	Ca:S ratio = 95.4835	Ca:Mg ratio = 2.9136	Ca:S ratio = 98.0066
Clay = 11.4	C:N ratio = 11.08	Clay = 14.6667	C:N ratio = 10.1667
Na^{+} = 0.16	ECEC = 5.272	Na^{+} = 0.3333	ECEC = 7.2
EPP = 1.8408	ESP = 4.3142	EPP = 3.272	ESP = 4.7362
TEA = 0.54		TEA = 0	

SYSTEM 1

Land form = upper slope/upland ; land location = nonresidential area
Fallow period = 2 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = April ; age at harvest = 12 months
2nd crop = maize ; peak planting month = March ; age at harvest = 3 months

SYSTEM 2

Land form = mixture of upland and lowland ; land location = nonresidential area
Fallow period = 2 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = April ; age at harvest = 12 months

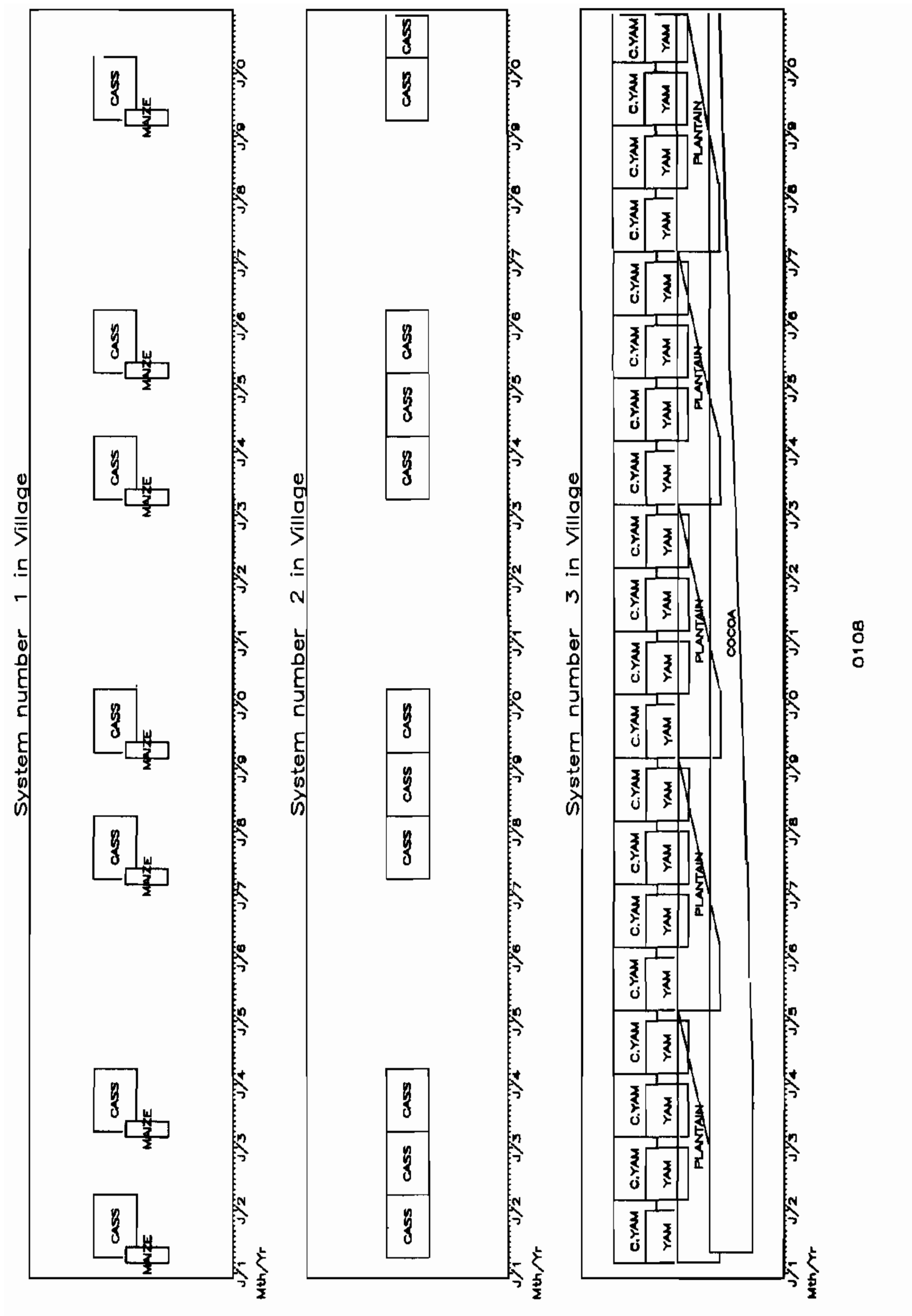

System number 1 in Village
CASS
MAIZE
System number 2 in Village
CASS
System number 3 in Village
C.YAM
YAM
PLANTAIN
COCOA
J/1
J/2
J/3
J/4
J/5
J/6
J/7
J/8
J/9
J/0
Mth/Yr
0108

Chart 9. Crop production systems in ALLAKRO village

Descriptive data

—————— VILLAGE —————————————— 110

Name = ALLAKRO Identification number = 10 Altitude = 70 meters
Lon. = 2.9000 degrees Lat. = 5.3000 degrees

Total annual rainfall = 2044 millimeters
Growing season : beginning = February ; length = 11 months
mean temp = 25.7 deg. cent.; temp. range = 5.5 deg. cent.
Climatic zone = Humid

Population density = 48 persons/sq km.
Distance to nearest city = 44 kilometers
Main market: distance = 1 kilometers; access means = N/A
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 0 tons per hectare, number of fields = 1
Mean field area (all crops)/household = 0.44 hectares;
Mean household size = 8.58, number of households = 16

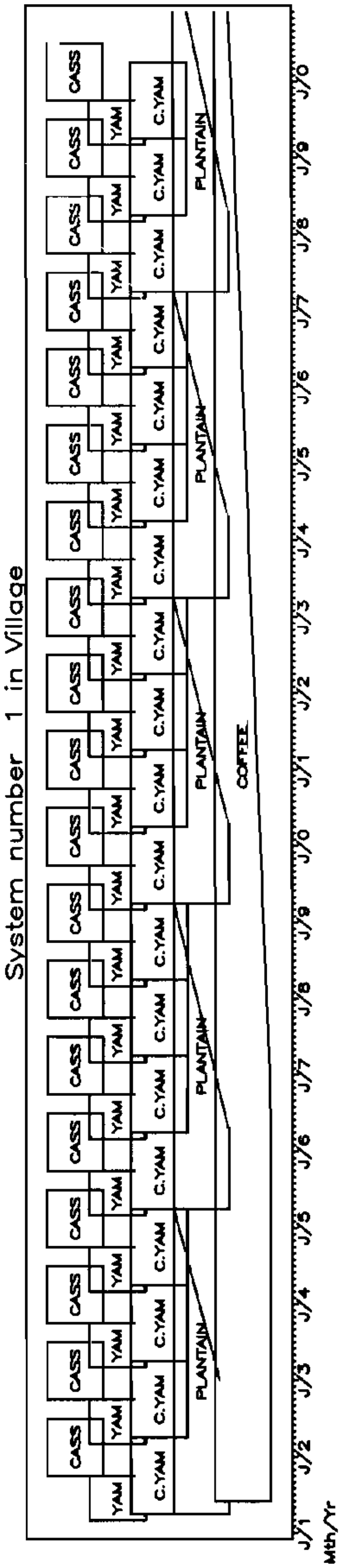
Mean soil properties (No. of samples = 6)

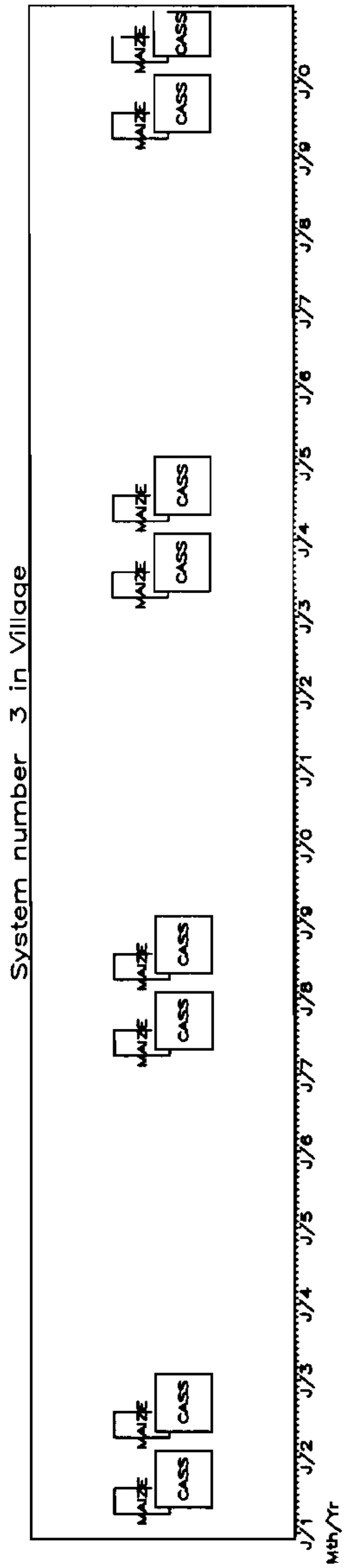
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 5.65	Ca^{++} = 1.5	Avail P = 4.375	Ca^{++} = 1.45
K^{+} = 0.05	Mn^{++} = 0.16	K^{+} = 0.05	Mn^{++} = 0.05
Mg^{++} = 1.15	Total N = 0.0725	Mg^{++} = 0.5	Total N = 0.1223
K:S ratio = 2.5	Mg:K ratio = 17	K:S ratio = 8.5	Mg:K ratio = 8.5
Mn:P ratio = 0.0481	N:P ratio = 0.0175	Mn:P ratio = 0.0105	N:P ratio = 0.0284
N:S ratio = 2.25	Org. C = 0.83	N:S ratio = 4.427	Org. C = 1.63
Org. matt = 1.4309	pH = 5.85	Org. matt = 2.8101	pH = 4.225
Sand = 79	Silt = 10	Sand = 67.5	Silt = 10.5
S:P ratio = 0.0125	TEB = 2.85	S:P ratio = 0.0094	TEB = 2.15
Total S = 0.04	BS = 95.2381	Total S = 0.05	BS = 54.8443
Ca:Mg ratio = 1.5294	Ca:S ratio = 45	Ca:Mg ratio = 2.5417	Ca:S ratio = 54.3073
Clay = 11.5	C:N ratio = 12	Clay = 22.25	C:N ratio = 14.175
Na^{+} = 0.15	ECEC = 3.05	Na^{+} = 0.15	ECEC = 3.4
EPP = 1.1905	ESP = 5.0125	EPP = 0.9347	ESP = 5.3549
TEA = 0.2		TEA = 1.25	

—————— SYSTEM 3 ——————————————

Land form = N/A ; land location = N/A
Fallow period = 3 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = flat (no tillage)
1st crop = maize ; peak planting month = April ; age at harvest = 4 months
2nd crop = cassava ; peak planting month = May ; age at harvest = 9 months

Coffee-based systems are not indicated


System number 1 in Village
CASS
YAM
C.YAM
PLANTAIN
COFFEE
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr


System number 3 in Village
MAIZE
CASS
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr

0110

Chart 10. Crop production systems in ANGOUAKOUKRO village

Descriptive data

——— VILLAGE ——— 111

Name = ANGOUAKOUKRO   Identification number = 11   Altitude = 180 meters
Lon. = 4.8500 degrees   Lat. = 6.7167 degrees

Total annual rainfall = 1215 millimeters
Growing season : beginning = March ; length = 9 months
mean temp = 27.2 deg. cent.; temp. range = 8.8 deg. cent.
Climatic zone = Subhumid

Population density = 12 persons/sq km.
Distance to nearest city = 22 kilometers
Main market: distance = 22 kilometers; access means = motor vehicle
Main cassava buyer = trader

CMB symptom severity score = 2 ; CGM symptom severity score = 3
ACMD symptom severity score = 2 ; CBB symptom severity score = 0

Cattle kept in village? Yes; Method = herded and penned
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? No
Oil palm grown in village? No

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.26 hectares;
Mean household size = 3.5, number of households = 6

Mean soil properties (No. of samples = 16)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 7.6111	Ca^{++} = 1.8889	Avail P = 2.8286	Ca^{++} = 1.0857
K^{+} = 0.1111	Mn^{++} = 0.2078	K^{+} = 0.1286	Mn^{++} = 0.31
Mg^{++} = 0.9667	Total N = 0.0847	Mg^{++} = 0.6571	Total N = 0.0841
K:S ratio = 14.721	Mg:K ratio = 8.5556	K:S ratio = 6.1905	Mg:K ratio = 6.1905
Mn:P ratio = 0.0557	N:P ratio = 0.0228	Mn:P ratio = 0.1888	N:P ratio = 0.0485
N:S ratio = 9.4302	Org. C = 0.6678	N:S ratio = 2.3873	Org. C = 0.8771
Org. matt = 1.1512	pH = 6.0444	Org. matt = 1.5122	pH = 5.6143
Sand = 78.4444	Silt = 10.8889	Sand = 59.8571	Silt = 15.1429
S:P ratio = 0.0013	TEB = 3.1889	S:P ratio = 0.0471	TEB = 2.4
Total S = 0.0085	BS = 97.9424	Total S = 0.0479	BS = 66.9425
Ca:Mg ratio = 1.9748	Ca:S ratio = 342.4128	Ca:Mg ratio = 1.6893	Ca:S ratio = 27.209
Clay = 10.6667	C:N ratio = 8.9444	Clay = 25	C:N ratio = 10.2286
Na^{+} = 0.2222	ECEC = 3.2444	Na^{+} = 0.5286	ECEC = 3.5286
EPP = 4.2884	ESP = 7.6872	EPP = 3.7249	ESP = 13.6222
TEA = 0.0625		TEA = 1.1286	

——— SYSTEM 2 ———

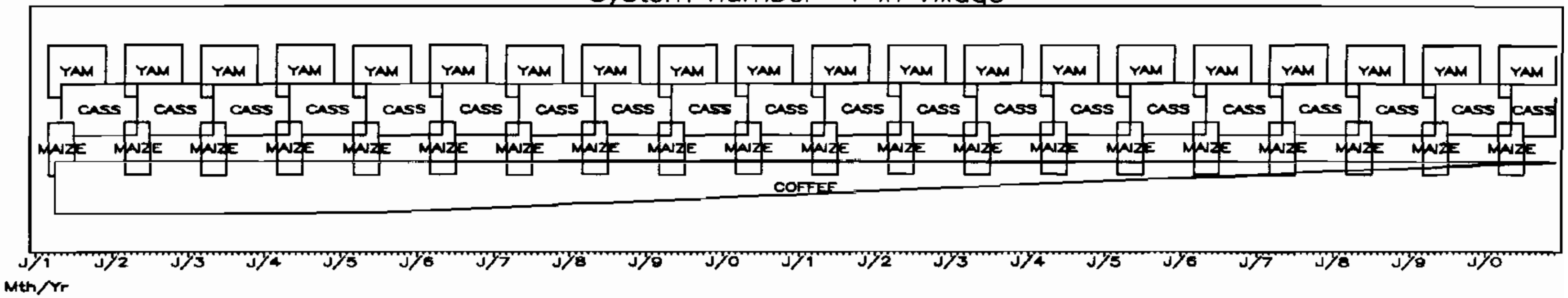
Land form = dry plain ; land location = nonresidential area
Fallow period = 8 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = heaps
1st crop = yams ; peak planting month = March ; age at harvest = 9 months
2nd crop = cassava ; peak planting month = April ; age at harvest = 12 months
3rd crop = beans ; peak planting month = December ; age at harvest = 3 months

——— SYSTEM 3 ———

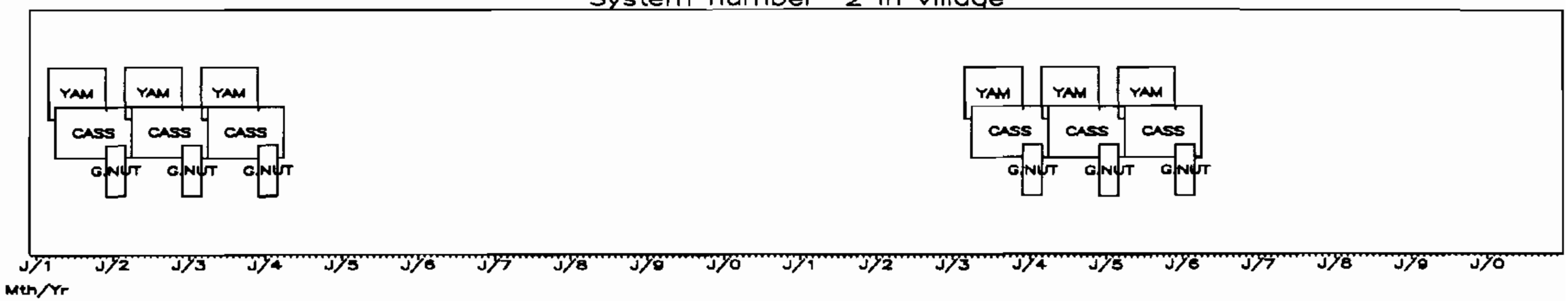
Land form = dry plain ; land location = nonresidential area
Fallow period = 8 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = March ; age at harvest = 12 months

Coffee-based systems are not indicated

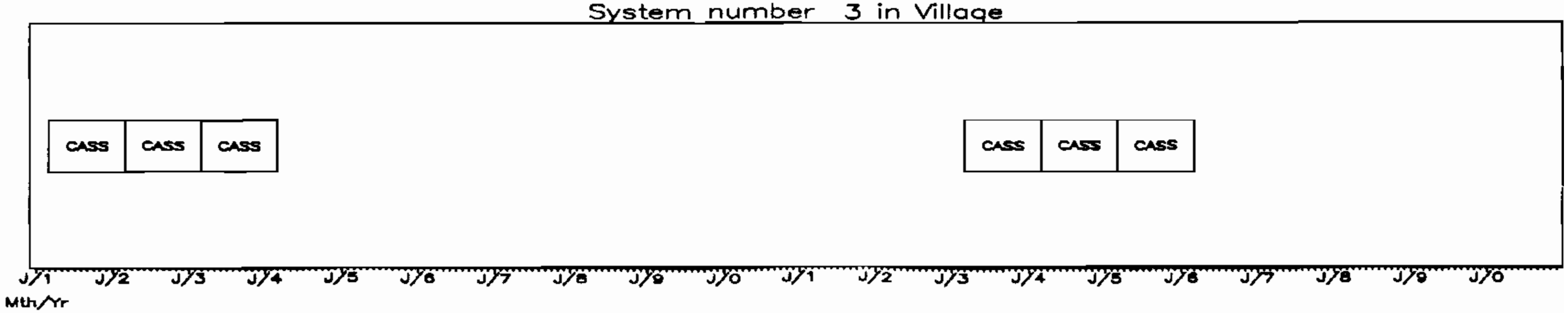
System number 1 in Village



System number 2 in Village



System number 3 in Village



0111

Chart 11. Crop production systems in SANDIEBOUNGA village

Descriptive data

VILLAGE 112

Name = SANDIEBOUNGA Identification number = 12 Altitude = 130 meters
Lon. = 4.6800 degrees Lat. = 6.3167 degrees

Total annual rainfall = 1380 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 27.2 deg. cent.; temp. range = 7.8 deg. cent.
Climatic zone = Subhumid

Population density = 12 persons/sq km.
Distance to nearest city = 60 kilometers
Main market: distance = 0 kilometers; access means = N/A
Main cassava buyer = processor

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.29 hectares;
Mean household size = 5.7, number of households = 10

Mean soil properties (No. of samples = 10)

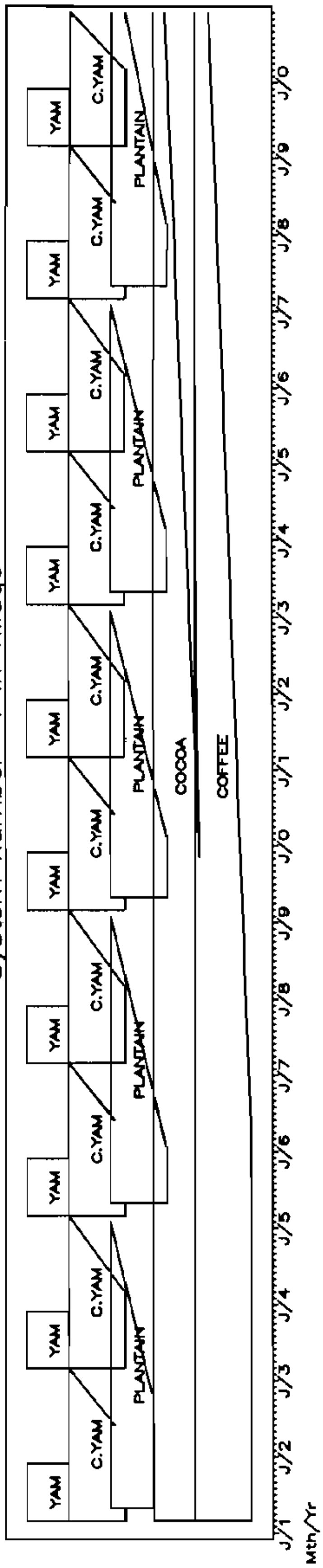
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 3.28	Ca^{++} = 3.68	Avail P = 11.66	Ca^{++} = 2.42
K^{+} = 0.12	Mn^{++} = 0.5	K^{+} = 0.1	Mn^{++} = 0.42
Mg^{++} = 1.5	Total N = 0.106	Mg^{++} = 1.2	Total N = 0.0982
K:S ratio = 12.8289	Mg:K ratio = 12.8	K:S ratio = 12	Mg:K ratio = 12
Mn:P ratio = 0.1875	N:P ratio = 0.0409	Mn:P ratio = 0.0717	N:P ratio = 0.0146
N:S ratio = 9.3684	Org. C = 0.962	N:S ratio = 2.8297	Org. C = 1.326
Org. matt = 1.6585	pH = 6.4	Org. matt = 2.286	pH = 5.14
Sand = 69	Silt = 18.4	Sand = 74	Silt = 12
S:P ratio = 0.0021	TEB = 5.54	S:P ratio = 0.0084	TEB = 3.92
Total S = 0.0078	BS = 99.6491	Total S = 0.0554	BS = 89.6
Ca:Mg ratio = 2.4657	Ca:S ratio = 360.8553	Ca:Mg ratio = 1.8936	Ca:S ratio = 42.7564
Clay = 12.8	C:N ratio = 9.3	Clay = 14	C:N ratio = 12.8
Na^{+} = 0.24	ECEC = 5.56	Na^{+} = 0.2	ECEC = 4.18
EPP = 2.3277	ESP = 4.6187	EPP = 2.5882	ESP = 5.1765
TEA = 0.0333		TEA = 0.26	

SYSTEM 3

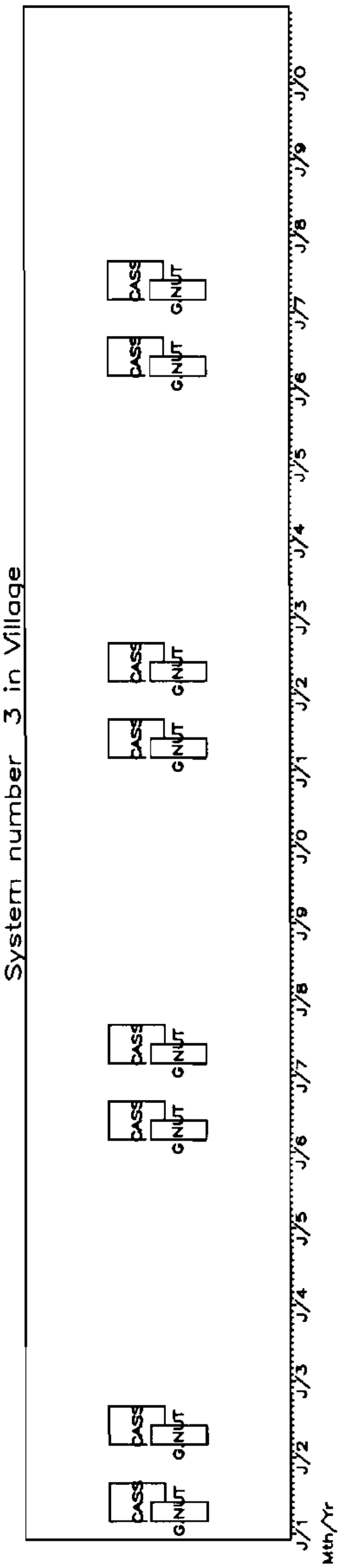
Land form = dry plain ; land location = residential area
Fallow period = 3 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = March ; age at harvest = 6 months
2nd crop = beans ; peak planting month = March ; age at harvest = 3 months

Coffee-based systems are not indicated

System number 1 in Village



System number 3 in Village



0112

Chart 12. Crop production systems in TCHEKOU-CARREFOUR village

Descriptive data

———————— VILLAGE ———————————————— 113

Name = TCHEKOU-CARREFOUR   Identification number = 13   Altitude = 165 meters
Lon. = 4.3500 degrees   Lat. = 6.3500 degrees

Total annual rainfall = 1425 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26.9 deg. cent.; temp. range = 8 deg. cent.
Climatic zone = Subhumid

Population density = 12 persons/sq km.
Distance to nearest city = 17 kilometers
Main market: distance = 0 kilometers; access means = NA
Main cassava buyer = trader

CMB symptom severity score = 0 ; CGM symptom severity score = 0
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = 0 tons per hectare, number of fields = 1;
Mean field area (all crops)/household = 0.46 hectares;
Mean household size = 4.75, number of households = 9

Mean soil properties (No. of samples = 10)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 6.9143	Ca^{++} = 4.4857	Avail P = 5.3	Ca^{++} = 3.6667
K^{+} = 0.19	Mn^{++} = 0.2429	K^{+} = 0.12	Mn^{++} = 0.11
Mg^{++} = 1	Total N = 0.1161	Mg^{++} = 0.7667	Total N = 0.0623
K:S ratio = 11.5298	Mg:K ratio = 15.6357	K:S ratio = 14.5556	Mg:K ratio = 14.5556
Mn:P ratio = 0.0788	N:P ratio = 0.0315	Mn:P ratio = 0.0474	N:P ratio = 0.0244
N:S ratio = 25.9013	Org. C = 1.1757	N:S ratio = 7.7228	Org. C = 0.7633
Org. matt = 2.0269	pH = 6	Org. matt = 1.316	pH = 8.2333
Sand = 72.1429	Silt = 16.2857	Sand = 83	Silt = 7.3333
S:P ratio = 0.0013	TEB = 5.9329	S:P ratio = 0.0013	TEB = 4.7533
Total S = 0.0154	BS = 76.764	Total S = 0.0101	BS = 100
Ca:Mg ratio = 3.7694	Ca:S ratio = 379.7932	Ca:Mg ratio = 4.2424	Ca:S ratio = 168.3168
Clay = 11.5714	C:N ratio = 10.4857	Clay = 9.6667	C:N ratio = 30.4
Na^{+} = 0.2571	ECEC = 6.8471	Na^{+} = 0.2	ECEC = 4.7533
EPP = 2.414	ESP = 5.2838	EPP = 1.8767	ESP = 4.9126
TEA = 0.9143		TEA = 0	

———————— SYSTEM 3 ————————————

Land form = NA ; land location = NA
Fallow period = 3 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = March ; age at harvest = 9 months

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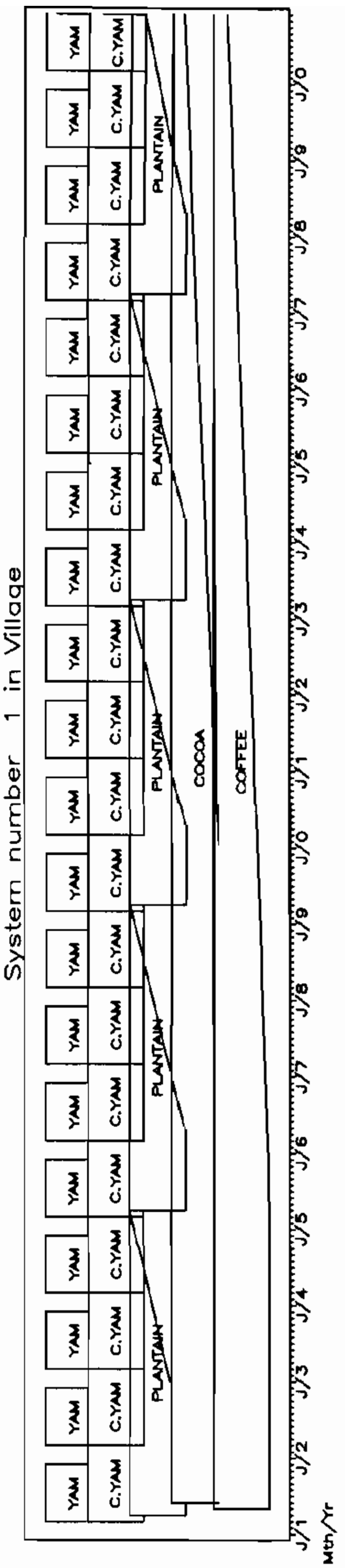
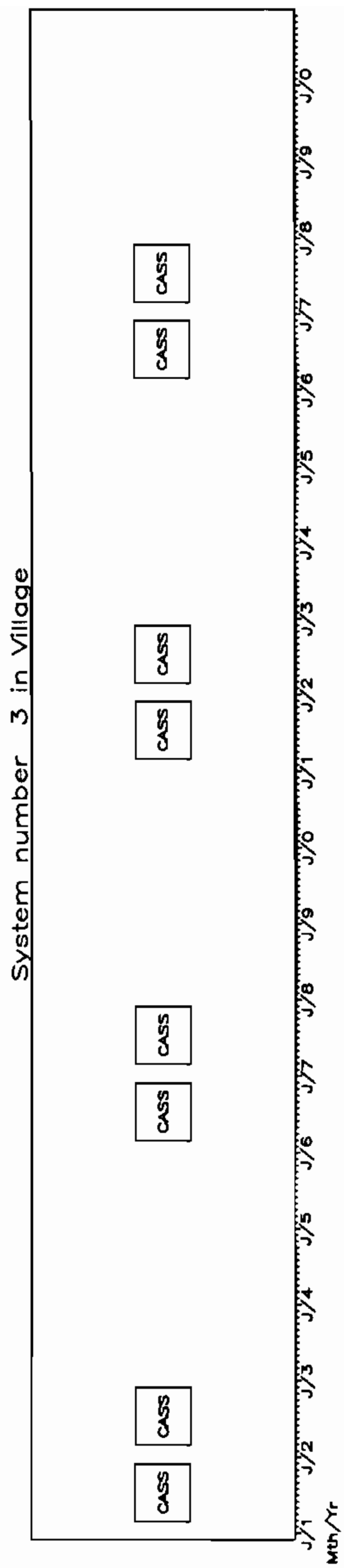
Coffee-based systems are not indicated


System number 1 in Village
YAM
C.YAM
PLANTAIN
COCOA
COFFEE
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr


System number 3 in Village
CASS
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr

0113

Chart 13. Crop production systems in KOMAMBO village

Descriptive data

—————— VILLAGE —————— 114

Name = KOMAMBO Identification number = 14 Altitude = 170 meters
Lon. = 4.5200 degrees Lat. = 6.6500 degrees

Total annual rainfall = 1357 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26.4 deg. cent.; temp. range = 8.3 deg. cent.
Climatic zone = Subhumid

Population density = 12 persons/sq km.
Distance to nearest city = 25 kilometers
Main market: distance = 25 kilometers; access means = motor vehicle
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.57 hectares;
Mean household size = 3.25, number of households = 6

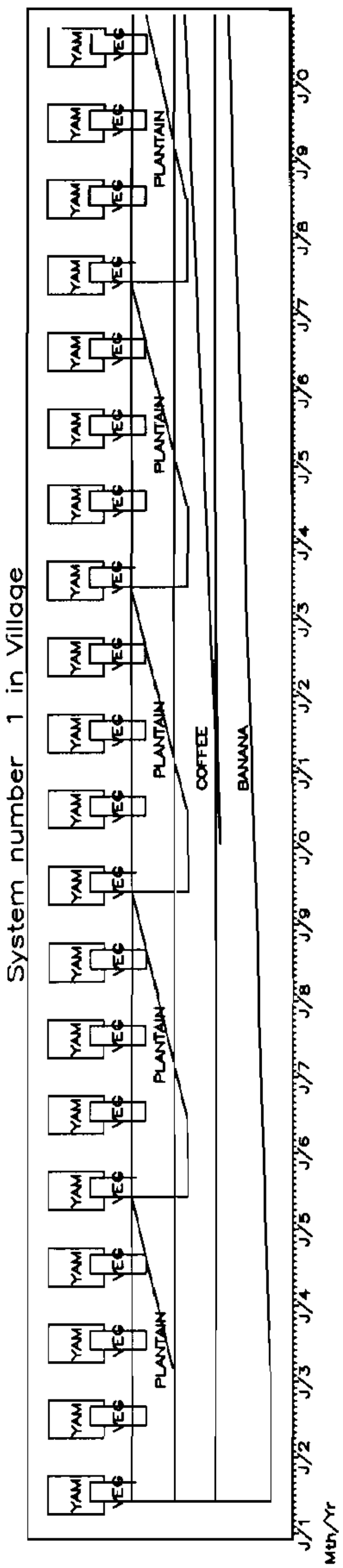
Mean soil properties (No. of samples = 6)

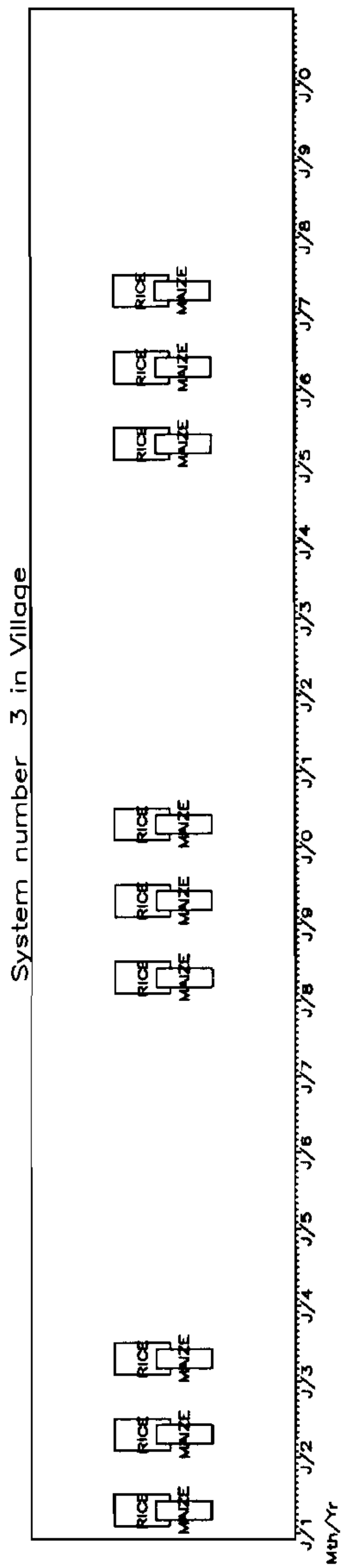
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 13.6	Ca^{++} = 3.72	Avail P = 3	Ca^{++} = 0.7
K^{+} = 0.272	Mn^{++} = 0.22	K^{+} = 0.3	Mn^{++} = 0.3
Mg^{++} = 1.12	Total N = 0.124	Mg^{++} = 1.1	Total N = 0.151
K:S ratio = 4.8782	Mg:K ratio = 8.46	K:S ratio = 3.6667	Mg:K ratio = 3.6667
Mn:P ratio = 0.0764	N:P ratio = 0.0288	Mn:P ratio = 0.1	N:P ratio = 0.0503
N:S ratio = 3.288	Org. C = 1.394	N:S ratio = NA	Org. C = 0.89
Org. matt = 2.4033	pH = 5.84	Org. matt = 1.5344	pH = 4.8
Sand = 73.4	Silt = 10	Sand = 49	Silt = 36
S:P ratio = 0.0036	TEB = 5.532	S:P ratio = NA	TEB = 2.4
Total S = 0.0438	BS = 88.7324	Total S = NA	BS = 82.7586
Ca:Mg ratio = 3.075	Ca:S ratio = 64.6939	Ca:Mg ratio = 0.6364	Ca:S ratio = NA
Clay = 16.6	C:N ratio = 11.48	Clay = 15	C:N ratio = 5.9
Na^{+} = 0.42	ECEC = 5.772	Na^{+} = 0.3	ECEC = 2.9
EPP = 3.9164	ESP = 11.1012	EPP = 10.3448	ESP = 10.3448
TEA = 0.24		TEA = 0.5	

—————— SYSTEM 3 ——————

Land form = swamp land ; land location = nonresidential area
Fallow period = 4 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = February ; age at harvest = 5 months
2nd crop = maize ; peak planting month = March ; age at harvest = 3 months

Coffee-based systems are not indicated


System number 1 in Village
YAM
VEG
PLANTAIN
COFFEE
BANANA
J/1
J/2
J/3
J/4
J/5
J/6
J/7
J/8
J/9
J/0
Mth/Yr


System number 3 in Village
RICE
MAIZE
J/1
J/2
J/3
J/4
J/5
J/6
J/7
J/8
J/9
J/0
Mth/Yr

0114

Chart 14. Crop production systems in KOUDIEBLEKRO village

Descriptive data

——— VILLAGE ——— 115

Name = KOUDIEBLEKRO Identification number = 15 Altitude = 180 meters
Lon. = 4.3200 degrees Lat. = 6.9333 degrees

Total annual rainfall = 1369 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26 deg. cent.; temp. range = 8.9 deg. cent.
Climatic zone = Subhumid

Population density = 12 persons/sq km.
Distance to nearest city = 32 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 1
ACMD symptom severity score = 0 ; CBB symptom severity score = 3

Cattle kept in village? Yes; Method = free range
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? No
Oil palm grown in village? No

Mean cassava root yield in village = 0 tons per hectare, number of fields = 1;
Mean field area (all crops)/household = 0.23 hectares;
Mean household size = 5.5, number of households = 10·

Mean soil properties (No. of samples = 7)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = NA	Ca^{++} = NA	Avail P = 1.4	Ca^{++} = 4.2
K^{+} = NA	Mn^{++} = NA	K^{+} = 0.3	Mn^{++} = 0.5
Mg^{++} = NA	Total N = NA	Mg^{++} = 1.8	Total N = 0.1
K:S ratio = NA	Mg:K ratio = NA	K:S ratio = 6	Mg:K ratio = 6
Mn:P ratio = NA	N:P ratio = NA	Mn:P ratio = 0.3571	N:P ratio = 0.0714
N:S ratio = NA	Org. C = NA	N:S ratio = NA	Org. C = 0.2
Org. matt = NA	pH = NA	Org. matt = 0.3448	pH = 9.6
Sand = NA	Silt = NA	Sand = 49	Silt = 28
S:P ratio = NA	TEB = NA	S:P ratio = NA	TEB = 6.6
Total S = NA	BS = NA	Total S = NA	BS = 100
Ca:Mg ratio = NA	Ca:S ratio = NA	Ca:Mg ratio = 2.3333	Ca:S ratio = NA
Clay = NA	C:N ratio = NA	Clay = 23	C:N ratio = 2
Na^{+} = NA	ECEC = NA	Na^{+} = 0.3	ECEC = 6.6
EPP = NA	ESP = NA	EPP = 4.5455	ESP = 4.5455
TEA = NA		TEA = 0	

——— SYSTEM 2 ———

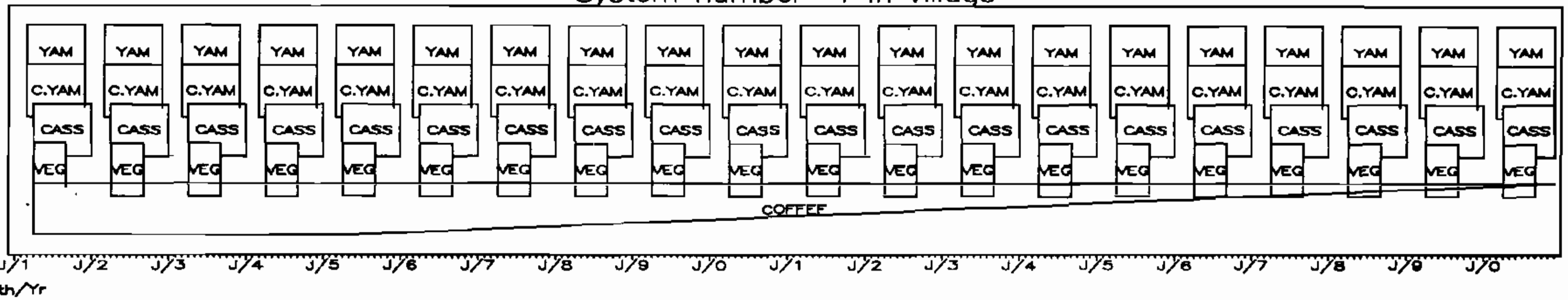
Land form = upper slope/upland ; land location = residential area
Fallow period = 3 years ; vegetation at the end of fallow = grass
Seedbed type = tied ridge
1st crop = cotton ; peak planting month = June ; age at harvest = 6 months

——— SYSTEM 3 ———

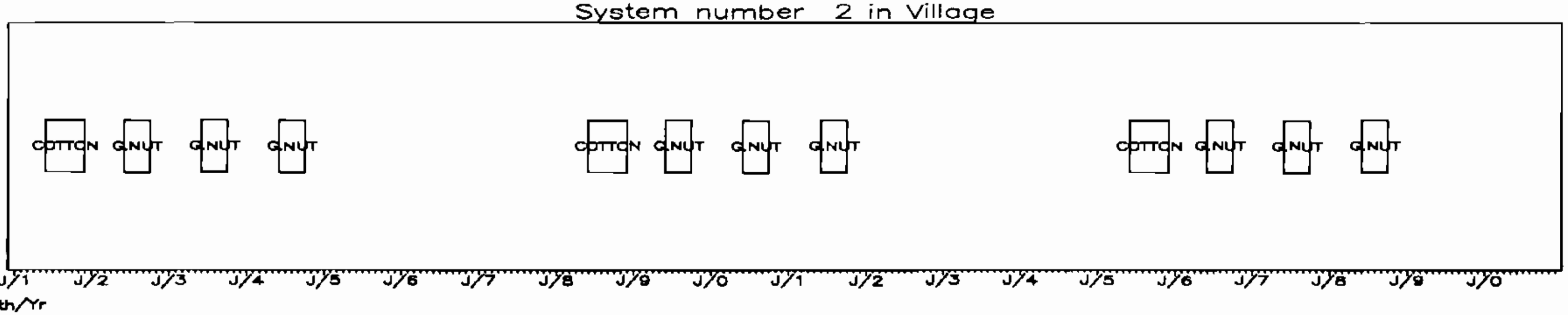
Land form = upper slope/upland ; land location = residential area
Fallow period = 8 years ; vegetation at the end of fallow = grass
Seedbed type = heaps
1st crop = cassava ; peak planting month = March ; age at harvest = 12 months

Coffee-based systems are not indicated

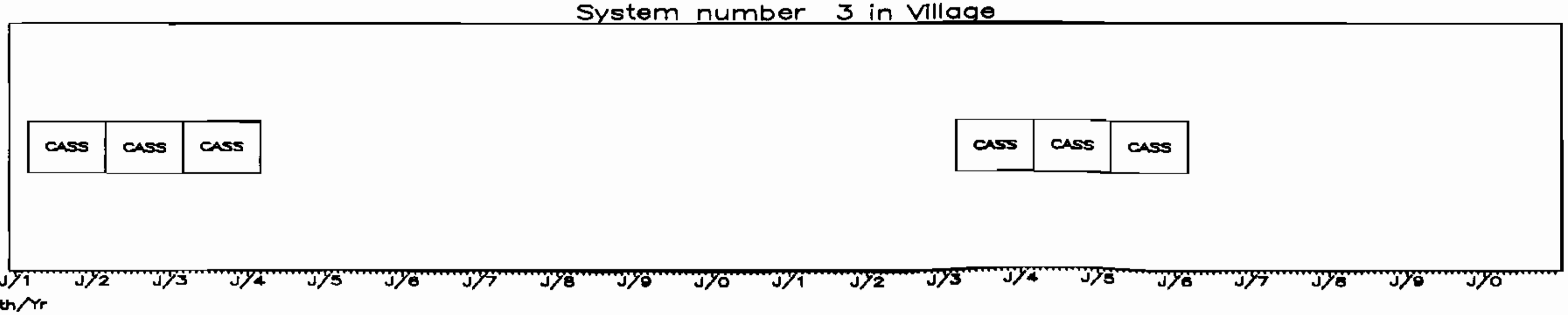
System number 1 in Village



System number 2 in Village



System number 3 in Village



0115

Chart 15. Crop production systems in KOMAMBO village

Descriptive data

——— VILLAGE ——— 116

Name = N'GATTAKRO Identification number = 16 Altitude = 190 meters
Lon. = 4.2000 degrees Lat. = 5.8000 degrees

Total annual rainfall = 2008 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 25.7 deg. cent.; temp. range = 6.8 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 21 kilometers
Main market: distance = 21 kilometers; access means = motor vehicle
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? Yes; Method = free range
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 15.25 tons per hectare, number of fields = 1;
Mean field area (all crops)/household = 0.82 hectares;
Mean household size = 7.5, number of households = 14

Mean soil properties (No. of samples = 4)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 0	Ca^{++} = 5.5	Avail P = 2.7333	Ca^{++} = 2.2333
K^{+} = 0.3	Mn^{++} = 0.6	K^{-} = 0.08	Mn^{++} = 0.5
Mg^{++} = 2.3	Total N = 0.134	Mg^{++} = 0.9333	Total N = 0.0677
K:S ratio = NA	Mg:K ratio = 7.6667	K:S ratio = 10.3333	Mg:K ratio = 10.3333
Mn:P ratio = NA	N:P ratio = NA	Mn:P ratio = 0.1662	N:P ratio = 0.0265
N:S ratio = NA	Org. C = 2.81	N:S ratio = 25.8175	Org. C = 0.6833
Org. matt = 4.8444	pH = 6.4	Org. matt = 1.1781	pH = 6.9
Sand = 52	Silt = 20	Sand = 68	Silt = 23.3333
S:P ratio = NA	TEB = 8.4	S:P ratio = 0.0013	TEB = 3.4467
Total S = NA	BS = 100	Total S = 0.0044	BS = 89.0187
Ca:Mg ratio = 2.3913	Ca:S ratio = NA	Ca:Mg ratio = 3.6417	Ca:S ratio = 815.0794
Clay = 28	C:N ratio = 21	Clay = 8.6667	C:N ratio = 9.8
Na^{+} = 0.3	ECEC = 8.4	Na^{+} = 0.2	ECEC = 3.7467
EPP = 3.5714	ESP = 3.5714	EPP = 2.0687	ESP = 5.7767
TEA = 0		TEA = 0.3	

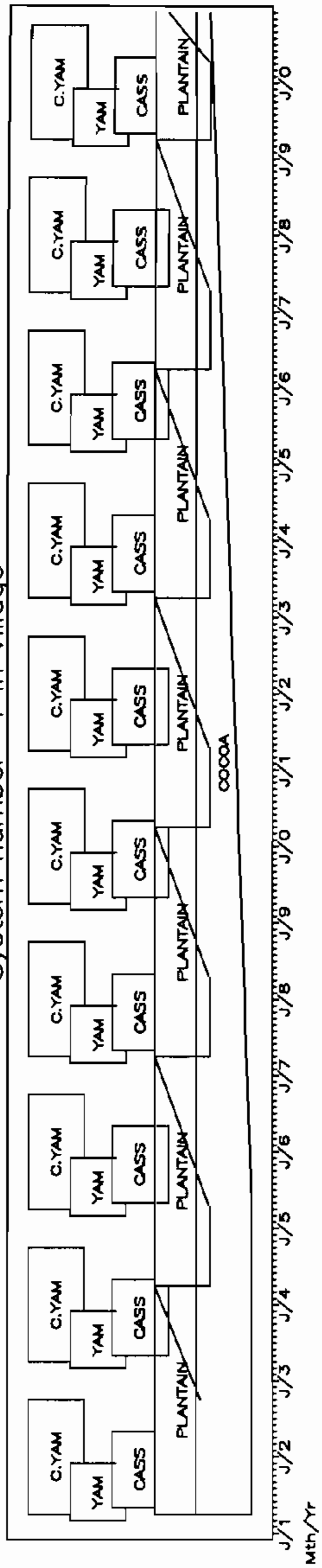
——— SYSTEM 1 ———

Land form = upper slope/upland ; land location = nonresidential area
Fallow period = 1 year ; vegetation at the end of fallow = NA
Seedbed type = flat (no tillage)
1st crop = yam ; peak planting month = March ; age at harvest = 9 months
2nd crop = cocoa ; peak planting month = April ; age at harvest = 48 months
3rd crop = cocoyam ; peak planting month = April ; age at harvest = 18 months
4th crop = plan. ; peak planting month = April ; age at harvest = 12 months
5th crop = cassava ; peak planting month = May ; age at harvest = 12 months

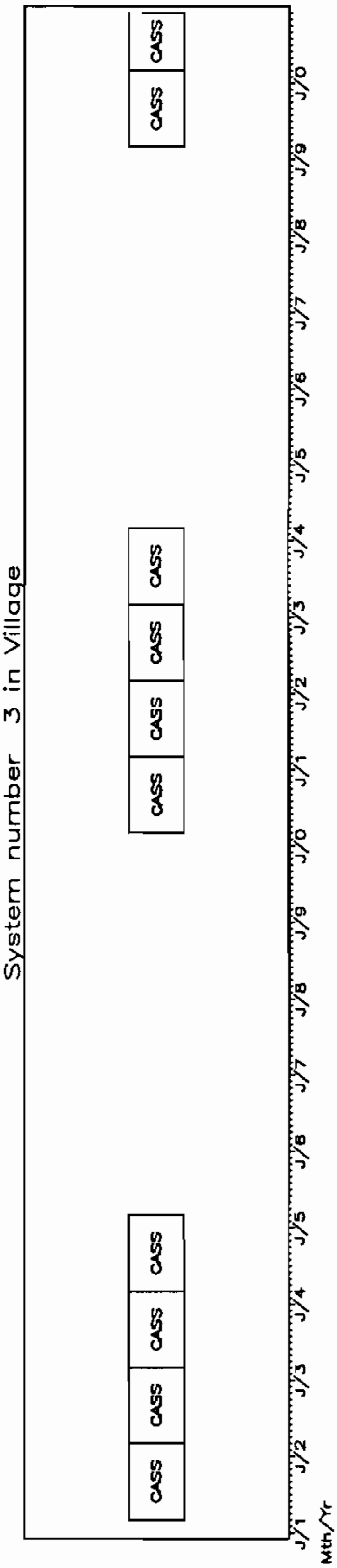
——— SYSTEM 3 ———

Land form = upper slope/upland; land location = residential area
Fallow period = 5 years; vegetation at the end of fallow = grass
Seedbed type = heaps
1st crop = cassava ; peak planting month = March ; age at harvest = 12 months

System number 1 in Village



System number 3 in Village



0116

Chart 16. Crop production systems in LALASSO village

Descriptive data

——— VILLAGE ——— 117

Name = LALASSO Identification number = 17 Altitude = 240 meters
Lon. = 3.7200 degrees Lat. = 7.3167 degrees

Total annual rainfall = 1256 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26.7 deg. cent.; temp. range = 9.1 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 47 kilometers
Main market: distance = 2 kilometers; access means = foot/head
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = NA
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = NA, number of fields = NA;
Mean field area (all crops)/household = 1.26 hectares;
Mean household size = 6.75, number of households = 13

Mean soil properties (No. of samples = 2)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = NA	Ca^{++} = NA	Avail P = 2.95	Ca^{++} = 2.4
K^+ = NA	Mn^{++} = NA	K^+ = 0.065	Mn^{++} = 0.065
Mg^{++} = NA	Total N = NA	Mg^{++} = 1.35	Total N = 0.066
K:S ratio = NA	Mg:K ratio = NA	K:S ratio = 15.8333	Mg:K ratio = 15.8333
Mn:P ratio = NA	N:P ratio = NA	Mn:P ratio = 0.033	N:P ratio = 0.0315
N:S ratio = NA	Org. C = NA	N:S ratio = 10	Org. C = 0.45
Org. matt = NA	pH = NA	Org. matt = 0.7758	pH = 5.7
Sand = NA	Silt = NA	Sand = 65	Silt = 22
S:P ratio = NA	TEB = NA	S:P ratio = 0.001	TEB = 4.015
Total S = NA	BS = NA	Total S = 0.0042	BS = 87.6847
Ca:Mg ratio = NA	Ca:S ratio = NA	Ca:Mg ratio = 3.72	Ca:S ratio = 285.7143
Clay = NA	C:N ratio = NA	Clay = 13	C:N ratio = 7.3
Na^+ = NA	ECEC = NA	Na^+ = 0.2	ECEC = 4.265
EPP = NA	ESP = NA	EPP = 1.5081	ESP = 4.7707
TEA = NA		TEA = 0.25	

——— SYSTEM 1 ———

Land form = NA; land location = nonresidential area
Fallow period = 10 years; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = heaps
1st crop = yams ; peak planting month = April ; age at harvest = 8 months
2nd crop = cocoyams ; peak planting month = April ; age at harvest = 24 months
3rd crop = cassava ; peak planting month = June ; age at harvest = 12 months

——— SYSTEM 2 ———

Land form = dry plain; land location = residential area
Fallow period = 3 years; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = April ; age at harvest = 4 months
2nd crop = maize ; peak planting month = April ; age at harvest = 4 months

——— SYSTEM 3 ———

Land form = dry plain; land location = nonresidential area
Fallow period < 1 year; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = April ; age at harvest = 60 months
2nd crop = yams ; peak planting month = April ; age at harvest = 8 months
3rd crop = cocoyams ; peak planting month = April ; age at harvest = 24 months
4th crop = plan. ; peak planting month = April ; age at harvest = 12 months

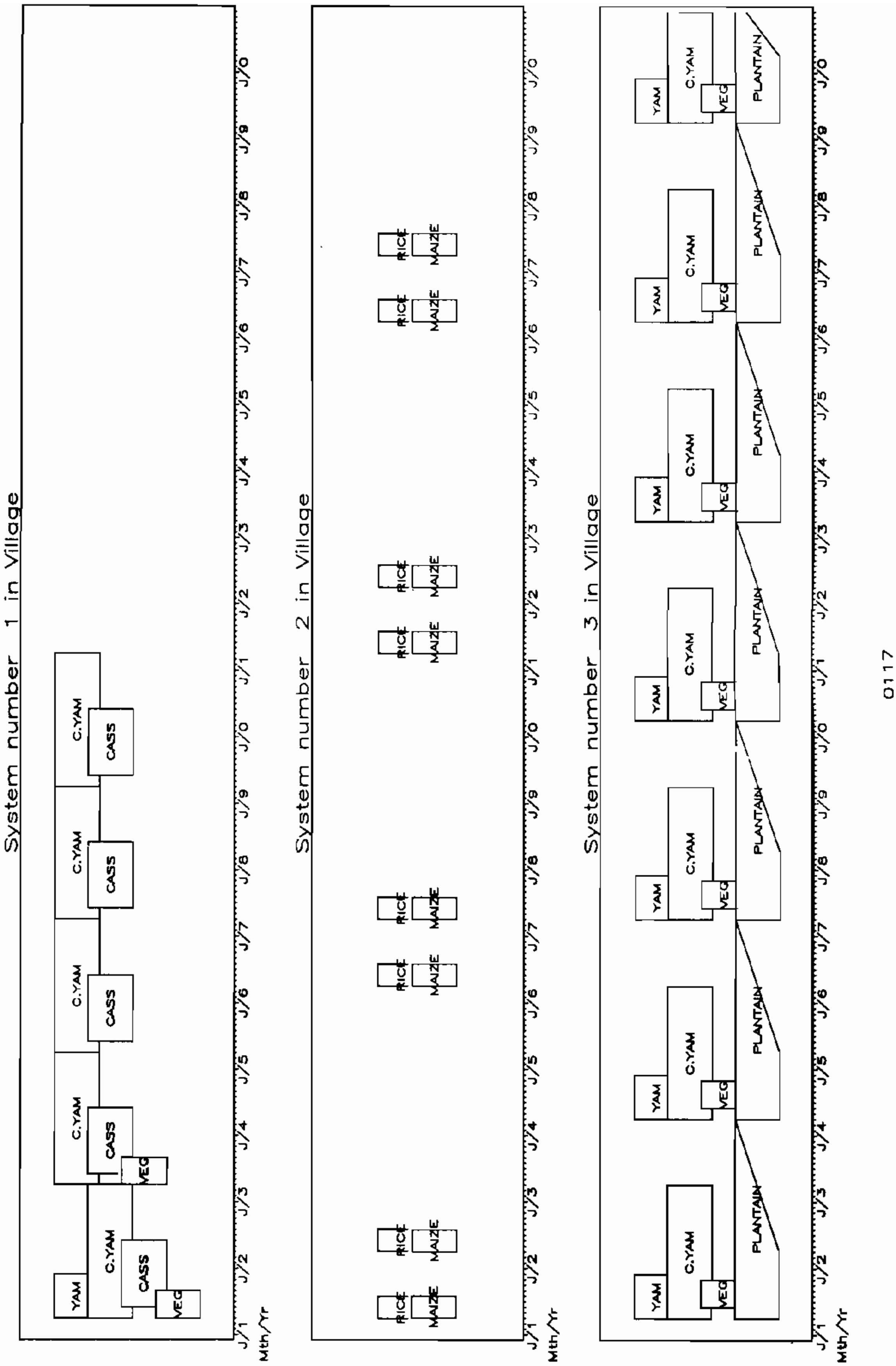

System number 1 in Village
YAM
C.YAM
CASS
VEG
Mth/Yr
J/1
J/2
J/3
J/4
J/5
J/6
J/7
J/8
J/9
J/0
System number 2 in Village
RICE
MAIZE
System number 3 in Village
PLANTAIN
0117

Chart 17. Crop production systems in ADIKANKRO village

Descriptive data

——— VILLAGE ——— 118

Name = ADIKANKRO Identification number = 18 Altitude = 290 meters
Lon. = 3.9000 degrees Lat. = 7.5333 degrees

Total annual rainfall = 1249 millimeters
Growing season : beginning = March ; length = 9 months
mean temp = 27.1 deg. cent.; temp. range = 9.5 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 19 kilometers
Main market: distance = N/A ; access means = N/A
Main cassava buyer = N/A

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? Yes; Method = NA
Sheep/goats kept in village? Yes; Method = NA
Coffee grown in village? No
Cocoa grown in village? No
Oil palm grown in village? Yes

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.62 hectares;
Mean household size = 3.42, number of households = 6

Mean soil properties (No. of samples = 2)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = NA	Ca^{++} = NA	Avail P = 4.1	Ca^{++} = 0.7
K^{+} = NA	Mn^{++} = NA	K^{+} = 0.15	Mn^{++} = 0.06
Mg^{++} = NA	Total N = NA	Mg^{++} = 0.5	Total N = 0.109
K:S ratio = NA	Mg:K ratio = NA	K:S ratio = 4	Mg:K ratio = 4
Mn:P ratio = NA	N:P ratio = NA	Mn:P ratio = 0.0122	N:P ratio = 0.02
N:S ratio = NA	Org. C = NA	N:S ratio = 2.0423	Org. C = 1.215
Org. matt = NA	pH = NA	Org. matt = 2.0947	pH = 4.8
Sand = NA	Silt = NA	Sand = 63	Silt = 11
S:P ratio = NA	TEB = NA	S:P ratio = 0.0098	TEB = 1.7
Total S = NA	BS = NA	Total S = 0.0803	BS = 43.8365
Ca:Mg ratio = NA	Ca:S ratio = NA	Ca:Mg ratio = 1.4167	Ca:S ratio = 7.472
Clay = NA	C:N ratio = NA	Clay = 26	C:N ratio = 12
Na^{+} = NA	ECEC = NA	Na^{+} = 0.35	ECEC = 3.9
EPP = NA	ESP = NA	EPP = 3.7904	ESP = 8.9321
TEA = NA		TEA = 2.2	

——— SYSTEM 1 ———

Land form = upper slope/upland; land location = nonresidential area
Fallow period = 'shift'; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = heaps
1st crop = yams ; peak planting month = April ; age at harvest = 8 months
2nd crop = cocoyams ; peak planting month = April ; age at harvest = 4 months
3rd crop = maize ; peak planting month = April ; age at harvest = 12 months
4th crop = cassava ; peak planting month = April ; age at harvest = 3 months

——— SYSTEM 2 ———

Land form = bottom land/dry lowland ; land location = nonresidential area
Fallow period = 5 years; vegetation at the end of fallow = grass
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = March ; age at harvest = 5 months
2nd crop = maize ; peak planting month =March ; age at harvest = 3 months

——— SYSTEM 3 ———

Land form = middle slope; land location = residential area
Fallow period = 4 years; vegetation at the end of fallow = grass
Seedbed type = tied ridge
1st crop = cotton ; peak planting month = July ; age at harvest = 5 months
2nd crop = maize ; peak planting month = April ; age at harvest = 3 months

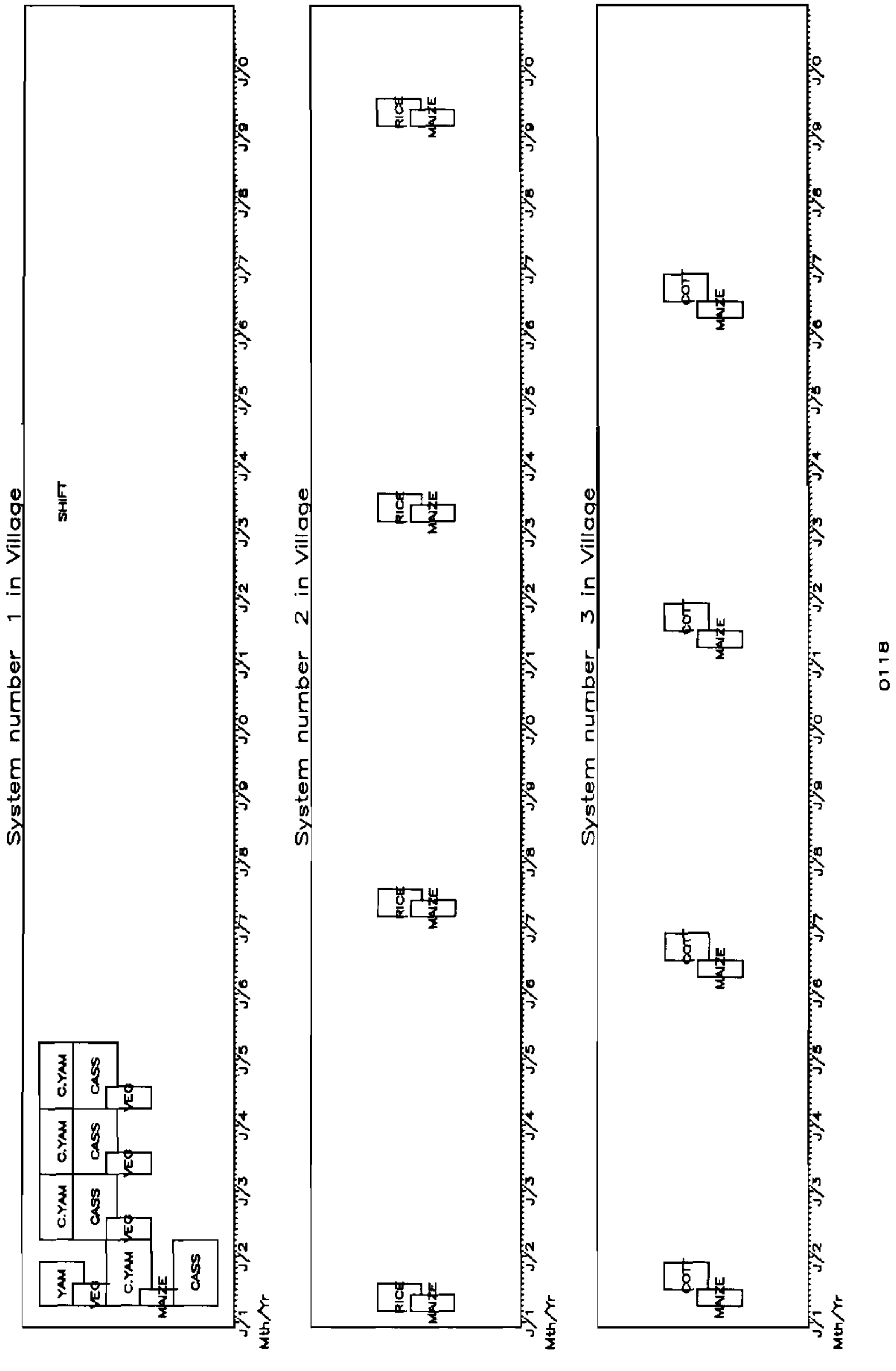

System number 1 in Village
SHIFT
YAM
VEG
C.YAM
CASS
MAIZE
System number 2 in Village
RICE
MAIZE
System number 3 in Village
COT
MAIZE
Mth/Yr
J/1
J/2
J/3
J/4
J/5
J/6
J/7
J/8
J/9
J/0
0118

Chart 18. Crop production systems in ZOZO OLIZIRIBOUE village

Descriptive data

——— VILLAGE ——— 119

Name = ZOZO OLIZIRIBOUE Identification number = 19 Altitude = 210 meters
Lon. = 5.6000 degrees Lat. = 5.8000 degrees

Total annual rainfall = 1531 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26.2 deg. cent.; temp. range = 7.8 deg. cent.
Climatic zone = Subhumid

Population density = 12 persons/sq km.
Distance to nearest city = 16 kilometers
Main market: distance = 16 kilometers; access means = motor vehicle
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? Yes; Method = free range
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.64 hectares;
Mean household size = 2.9, number of households = 5

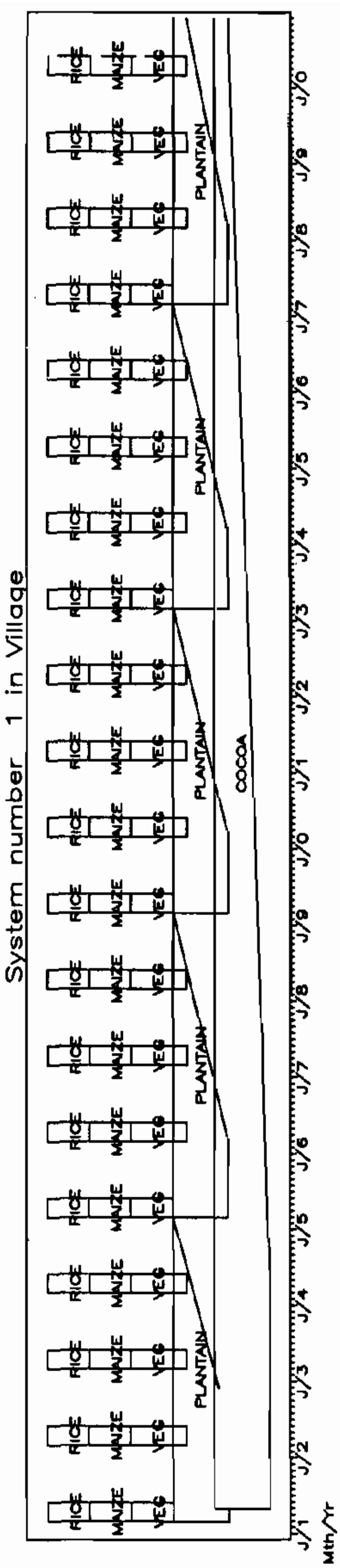
Mean soil properties (No. of samples = 4)

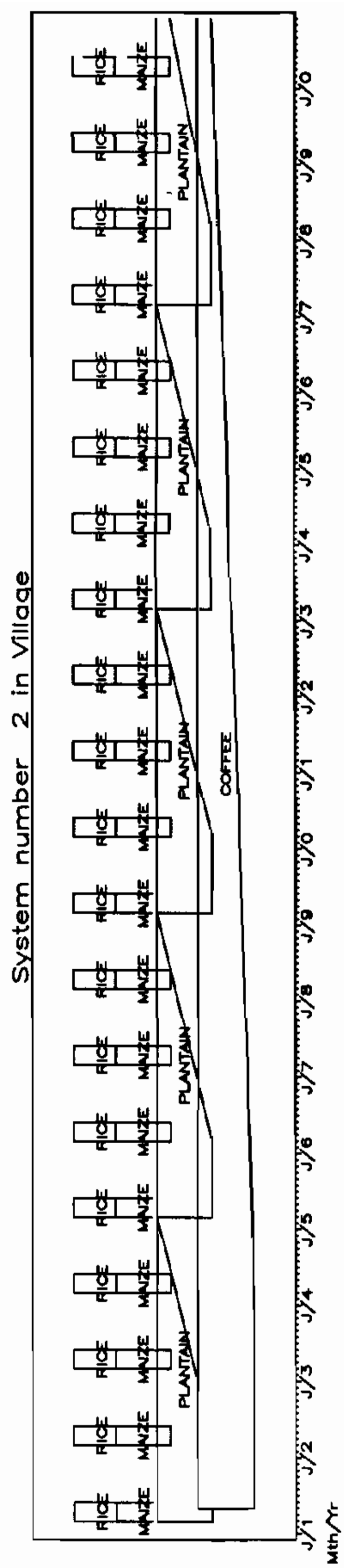
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 6.9	Ca^{++} = 1	Avail P = 4.2	Ca^{++} = 4.9333
K^{+} = 0.03	Mn^{++} = 0.01	K^{+} = 0.1467	Mn^{++} = 0.11
Mg^{++} = 0.4	Total N = 0.08	Mg^{++} = 1.1333	Total N = 0.1357
K:S ratio = NA	Mg:K ratio = 13.3333	K:S ratio = 12.3333	Mg:K ratio = 12.3333
Mn:P ratio = 0.0014	N:P ratio = 0.0116	Mn:P ratio = 0.0237	N:P ratio = 0.0372
N:S ratio = NA	Org. C = 0.66	N:S ratio = 7.4139	Org. C = 1.37
Org. matt = 1.1378	pH = 4.1	Org. matt = 2.3619	pH = 6.0333
Sand = 58	Silt = 26	Sand = 70	Silt = 12.6667
S:P ratio = NA	TEB = 1.63	S:P ratio = 0.0056	TEB = 6.4467
Total S = NA	BS = 64.4269	Total S = 0.0354	BS = 95.6989
Ca:Mg ratio = 2.5	Ca:S ratio = NA	Ca:Mg ratio = 3.8	Ca:S ratio = 284.9475
Clay = 16	C:N ratio = 8.3	Clay = 17.3333	C:N ratio = 9.5333
Na^{+} = 0.2	ECEC = 2.53	Na^{+} = 0.2333	ECEC = 6.58
EPP = 1.1858	ESP = 7.9051	EPP = 2.9934	ESP = 5.2181
TEA = 0.9		TEA = 0.1333	

——— SYSTEM 1 ———

Land form = bottom land/dry lowland; land location = mixture of near and far fields
Fallow period < 1 year; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = May ; age at harvest = 36 months
2nd crop = plan. ; peak planting month = March ; age at harvest = 12 months
3rd crop = rice ; peak planting month = March ; age at harvest = 3 months
4th crop = maize ; peak planting month = March ; age at harvest = 3 months

Coffee-based systems are not indicated


System number 1 in Village
RICE
MAIZE
VEG
PLANTAIN
COCOA
J/1
J/2
J/3
J/4
J/5
J/6
J/7
J/8
J/9
J/0
Mth/Yr


System number 2 in Village
RICE
MAIZE
PLANTAIN
COFFEE
J/1
J/2
J/3
J/4
J/5
J/6
J/7
J/8
J/9
J/0
Mth/Yr

0119

Chart 19. Crop production systems in KOMAMBO village

Descriptive data

——————— VILLAGE ——————————————— 121

Name = GODESSO   Identification number = 21   Altitude = 40 meters
Lon. = 4.9500 degrees   Lat. = 5.5833 degrees

Total annual rainfall = 1902 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 25.9 deg. cent.; temp. range = 7.1 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 50 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = processor

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.94 hectares;
Mean household size = 3.5, number of households = 6

Mean soil properties (No. of samples =11)

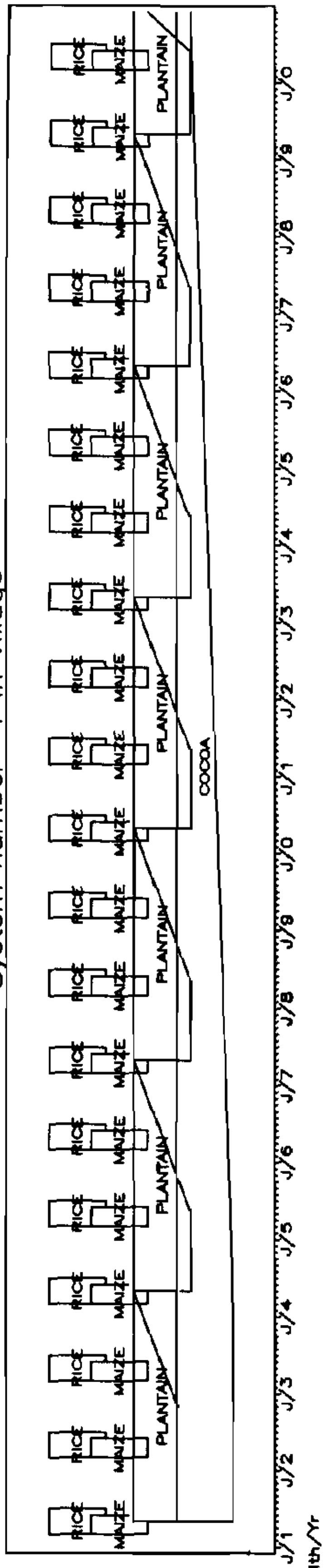
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 5.025	Ca^{++} = 3.025	Avail P = 6.4143	Ca^{++} = 1.7571
K^{+} = 0.5575	Mn^{++} = 0.1675	K^{+} = 0.2814	Mn^{++} = 0.0829
Mg^{++} = 1.025	Total N = 0.0868	Mg^{++} = 0.5286	Total N = 0.0561
K:S ratio = 13.4966	Mg:K ratio = 10.8268	K:S ratio = 8.0286	Mg:K ratio = 8.0286
Mn:P ratio = 0.0342	N:P ratio = 0.0184	Mn:P ratio = 0.0279	N:P ratio = 0.0166
N:S ratio = 7.5162	Org. C = 0.9275	N:S ratio = 10.4633	Org. C = 0.5171
Org. matt = 1.599	pH = 5.9667	Org. matt = 0.8916	pH = 6.0429
Sand = 69	Silt = 19.5	Sand = 78.4286	Silt = 12.2857
S:P ratio = 0.0026	TEB = 5.0325	S:P ratio = 0.0032	TEB = 2.8814
Total S = 0.0118	BS = 95.1675	Total S = 0.0126	BS = 85.2692
Ca:Mg ratio = 3.0299	Ca:S ratio = 271.6976	Ca:Mg ratio = 3.2917	Ca:S ratio = 408.2427
Clay = 11.75	C:N ratio = 10.5	Clay = 9.2857	C:N ratio = 9.1571
Na^{+} = 0.425	ECEC = 5.2325	Na^{+} = 0.3143	ECEC = 3.2671
EPP = 7.8101	ESP = 6.7848	EPP = 8.0562	ESP = 12.4416
TEA = 0.2667		TEA = 0.3857	

——————— SYSTEM 1 ———————

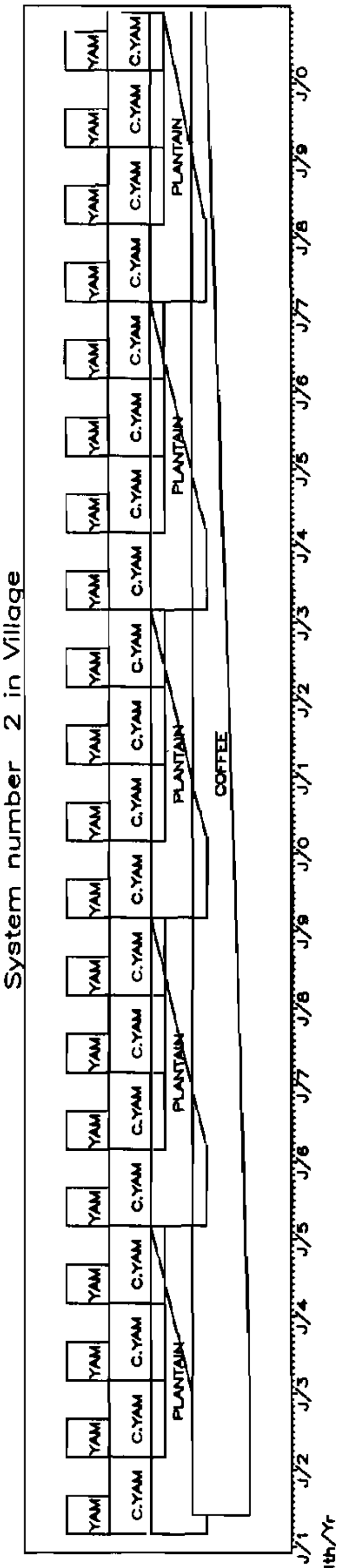
Land form = mixture of upland and lowland ; land location = residential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = May ; age at harvest = 36 months
2nd crop = plan. ; peak planting month =May ; age at harvest = 12 months
3rd crop = rice ; peak planting month = March ; age at harvest = 4 months
4th crop = maize ; peak planting month = March ; age at harvest = 3 months

Coffee-based systems are not indicated

System number 1 in Village



System number 2 in Village



0121

Chart 20. Crop production systems in GAHOUGNAGBOLILIE village

Descriptive data

——— VILLAGE ——— 122

Name = GAHOUGNAGBOLILIE Identification number = 22 Altitude = 220 meters
Lon. = 5.9200 degrees Lat. = 5.8833 degrees

Total annual rainfall = 1444 millimeters
Growing season : beginning = February ; length = 11 months
mean temp = 26 deg. cent.; temp. range = 8.3 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 26 kilometers
Main market: distance = N/A ; access means = N/A
Main cassava buyer = N/A

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.48 hectares;
Mean household size = 3, number of households = 5

Mean soil properties (No. of samples =9)

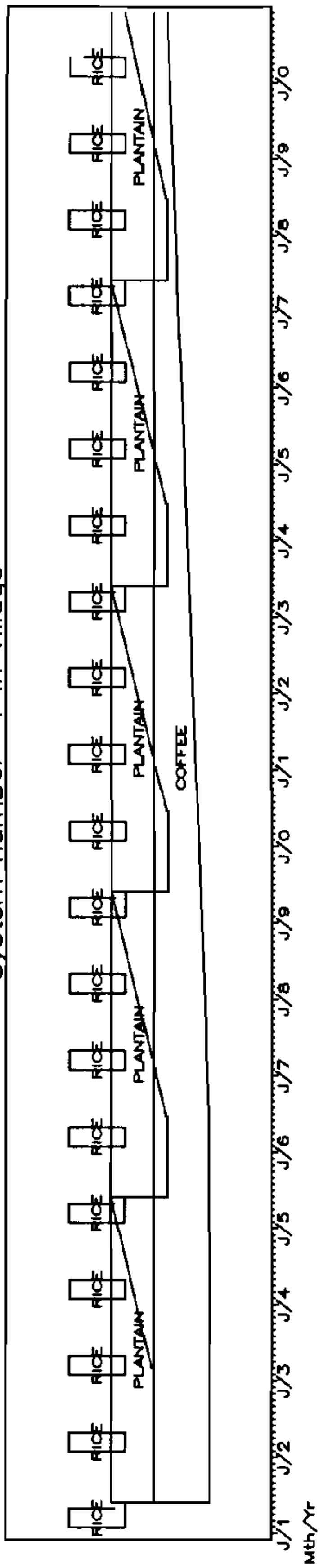
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 8.06	Ca^{++} = 1.8333	Avail P = 3.1	Ca^{++} = 1.8
K^{+} = 0.12	Mn^{++} = 0.0933	K^{+} = 0.1033	Mn^{++} = 0.07
Mg^{++} = 0.65	Total N = 0.0762	Mg^{++} = 0.4667	Total N = 0.0713
K:S ratio = 8.0572	Mg:K ratio = 13.5	K:S ratio = 6.1667	Mg:K ratio = 6.16667
Mn:P ratio = 0.0105	N:P ratio = 0.0116	Mn:P ratio = 0.0188	N:P ratio = 0.0239
N:S ratio = 4.739	Org. C = 0.7017	N:S ratio = 7.9452	Org. C = 0.56
Org. matt = 1.2097	pH = 5.8833	Org. matt = 0.9654	pH = 4.5667
Sand = 79.6667	Silt = 8	Sand = 80	Silt = 7.3333
S:P ratio = 0.0036	TEB = 2.8867	S:P ratio = 0.0038	TEB = 2.57
Total S = 0.021	BS = 81.3429	Total S = 0.0073	BS = 79.5322
Ca:Mg ratio = 3.0818	Ca:S ratio = 110.4559	Ca:Mg ratio = 2.9907	Ca:S ratio = 205.4795
Clay = 12.3333	C:N ratio = 9.15	Clay = 12.6667	C:N ratio = 8.3
Na^{+} = 0.2833	ECEC = 3.5867	Na^{+} = 0.2	ECEC = 3.7367
EPP = 4.1546	ESP = 8.8438	EPP = 2.705	ESP = 18.7369
TEA = 0.7		TEA = 1.1667	

——— SYSTEM 2 ———

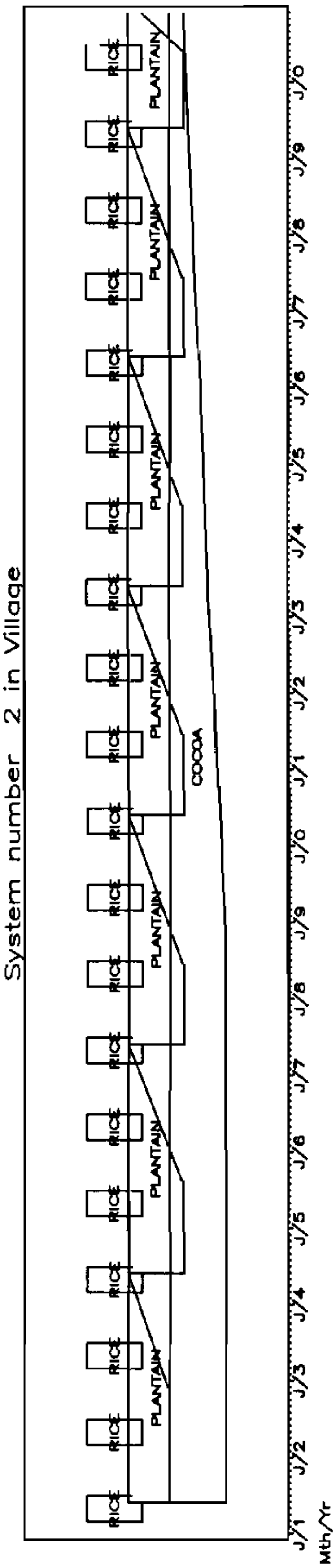
Land form = mixture of upland and lowland ; land location = mixture of near and far fields
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = June ; age at harvest = 84 months
2nd crop = plan. ; peak planting month =June ; age at harvest = 12 months
3rd crop = rice ; peak planting month = March ; age at harvest = 4 months

Coffee-based systems are not indicated

System number 1 in Village



System number 2 in Village



0122

Chart 21. Crop production systems in DIGBOUHO village

Descriptive data

——— VILLAGE ——— 124

Name = DIGBOUHO Identification number = 24 Altitude = 250 meters
Lon. = 5.6800 degrees Lat. = 6.5000 degrees

Total annual rainfall = 1400 millimeters
Growing season : beginning = March : length = 10 months
mean temp = 26.3 deg. cent.; temp. range = 8.4 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 35 kilometers
Main market: distance = 1 kilometers; access means = foot/head
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? Yes; Method = herded
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = 20.75 tons per hectare, number of fields = 1;
Mean field area (all crops)/household = 0.39 hectares;
Mean household size = 5.67, number of households = 10

Mean soil properties (No. of samples = 15)

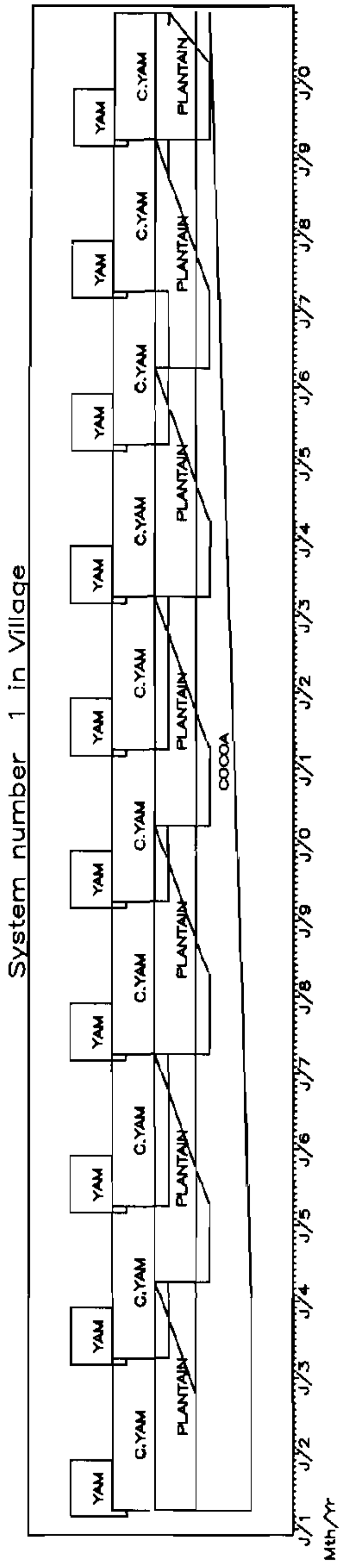
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 3.1167	Ca^{++} = 4.625	Avail P = 2.1333	Ca^{++} = 1.4
K^{+} = 0.1083	Mn^{++} = 0.15	K^{+} = 0.0433	Mn^{++} = 0.0667
Mg^{++} = 0.7	Total N = 0.0769	Mg^{++} = 0.6	Total N = 0.0377
K:S ratio = 10.6383	Mg:K ratio = 6.375	K:S ratio = 22.6667	Mg:K ratio = 22.6667
Mn:P ratio = 0.0637	N:P ratio = 0.0274	Mn:P ratio = 0.0414	N:P ratio = 0.0192
N:S ratio = 7.766	Org. C = 0.475	N:S ratio = 10.4167	Org. C = 0.28
Org. matt = 0.8189	pH = 8.3083	Org. matt = 0.4827	pH = 7.3667
Sand = 80.3333	Silt = 12.1667	Sand = 79.6667	Silt = 9.3333
S:P ratio = 0.0028	TEB = 5.7333	S:P ratio = 0.0017	TEB = 2.1867
Total S = 0.0094	BS = 84.2995	Total S = 0.0024	BS = 86.755
Ca:Mg ratio = 7.0722	Ca:S ratio = 489.3617	Ca:Mg ratio = 2.375	Ca:S ratio = 208.3333
Clay = 7.5833	C:N ratio = 6.1583	Clay = 11	C:N ratio = 8.3333
Na^{+} = 0.3	ECEC = 6.8167	Na^{+} = 0.1433	ECEC = 2.3867
EPP = 1.5872	ESP = 4.336	EPP = 1.4719	ESP = 6.7547
TEA = 1.0833		TEA = 0.2	

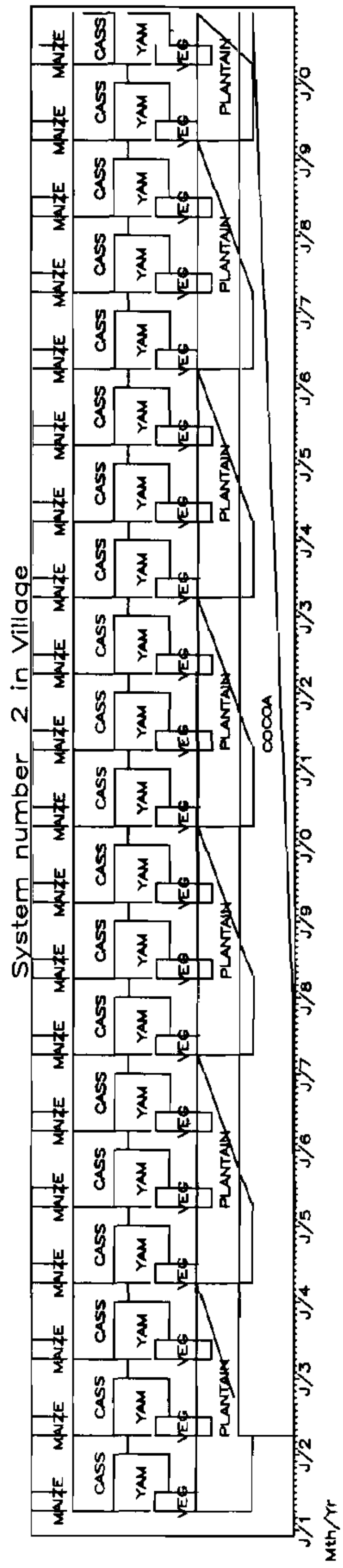
——— SYSTEM 1 ———

Land form = N/A ; land location = mixture of near and far fields
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = April ; age at harvest = 36 months
2nd crop = plan. ; peak planting month =April ; age at harvest = 12 months
3rd crop = yams ; peak planting month = March ; age at harvest = 9 months
4th crop = cocoyams ; peak planting month = April ; age at harvest = 24 months

——— SYSTEM 2 ———

Land form = N/A ; land location = N/A
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = plan. ; peak planting month = April ; age at harvest = 12 months
2nd crop = maize ; peak planting month =April ; age at harvest = 3 months
3rd crop = cassava ; peak planting month = April ; age at harvest = 12 months
4th crop = yams ; peak planting month = April ; age at harvest = 9 months


System number 1 in Village
YAM
C.YAM
PLANTAIN
COCOA
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr


System number 2 in Village
MAIZE
CASS
YAM
VEG
PLANTAIN
COCOA
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr

0124

Chart 22. Crop production systems in ZAHIBO village

Descriptive data

VILLAGE 125

Name = ZAHIBO Identification number = 25 Altitude = 219 meters
Lon. = 6.6700 degrees Lat. = 6.9833 degrees

Total annual rainfall = 1693 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26.3 deg. cent.; temp. range = 10.2 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 30 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = processor

CMB symptom severity score = 0 ; CGM symptom severity score = 1
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? Yes; Method = free range
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = 9 tons per hectare, number of fields = 2;
Mean field area (all crops)/household = 0.74 hectares;
Mean household size = 3.67, number of households = 6

Mean soil properties (No. of samples = 13)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 8.175	Ca^{++} = 7.625	Avail P = 19.0333	Ca^{++} = 1.8
K^{+} = 0.325	Mn^{++} = 0.325	K^{+} = 0.1889	Mn^{++} = 0.1633
Mg^{++} = 1.775	Total N = 0.1813	Mg^{++} = 0.6333	Total N = 0.078
K:S ratio = 4.2553	Mg:K ratio = 9.3393	K:S ratio = 4.2103	Mg:K ratio = 4.2103
Mn:P ratio = 0.0824	N:P ratio = 0.0401	Mn:P ratio = 0.0725	N:P ratio = 0.0292
N:S ratio = 4.7234	Org. C = 1.735	N:S ratio = 50.7936	Org. C = 0.75
Org. matt = 2.9911	pH = 6.1667	Org. matt = 1.293	pH = 6.1667
Sand = 70.5	Silt = 18.5	Sand = 73.8889	Silt = 9.1111
S:P ratio = 0.005	TEB = 10.075	S:P ratio = 0.0023	TEB = 2.8889
Total S = 0.0235	BS = 100	Total S = 0.0275	BS = 75.2267
Ca:Mg ratio = 4.7454	Ca:S ratio = 161.7021	Ca:Mg ratio = 3.0356	Ca:S ratio = 2020.4939
Clay = 11.25	C:N ratio = 10.175	Clay = 17.1111	C:N ratio = 9.8111
Na^{+} = 0.35	ECEC = 10.075	Na^{+} = 0.2667	ECEC = 3.4889
EPP = 3.2326	ESP = 3.6819	EPP = 4.6912	ESP = 8.8509
TEA = 0		TEA = 0.675	

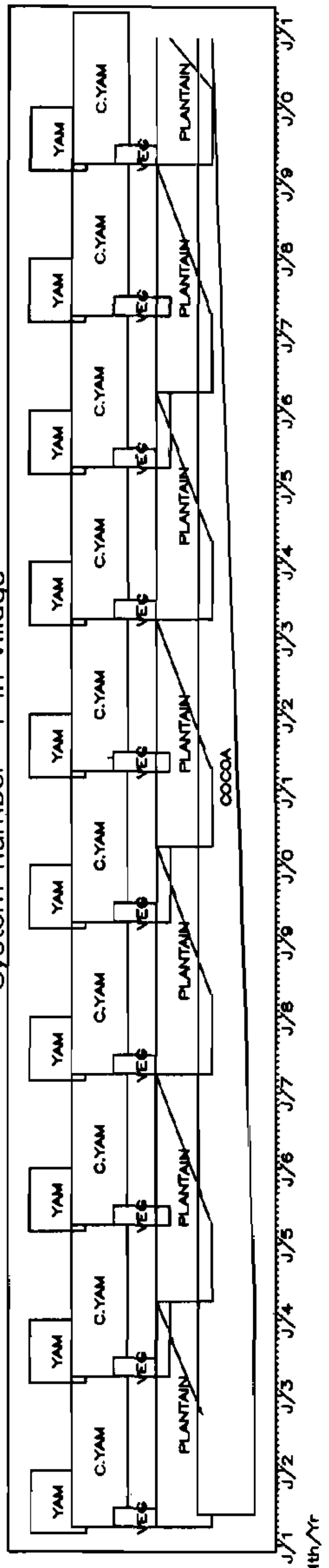
SYSTEM 1

Land form = upland, lowland and plains ; land location = mixture of near and far fields
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = June ; age at harvest = 36 months
2nd crop = plan. ; peak planting month =April ; age at harvest = 12 months
3rd crop = yams ; peak planting month = March ; age at harvest = 10 months
4th crop = cocoyams ; peak planting month = April ; age at harvest = 24 months

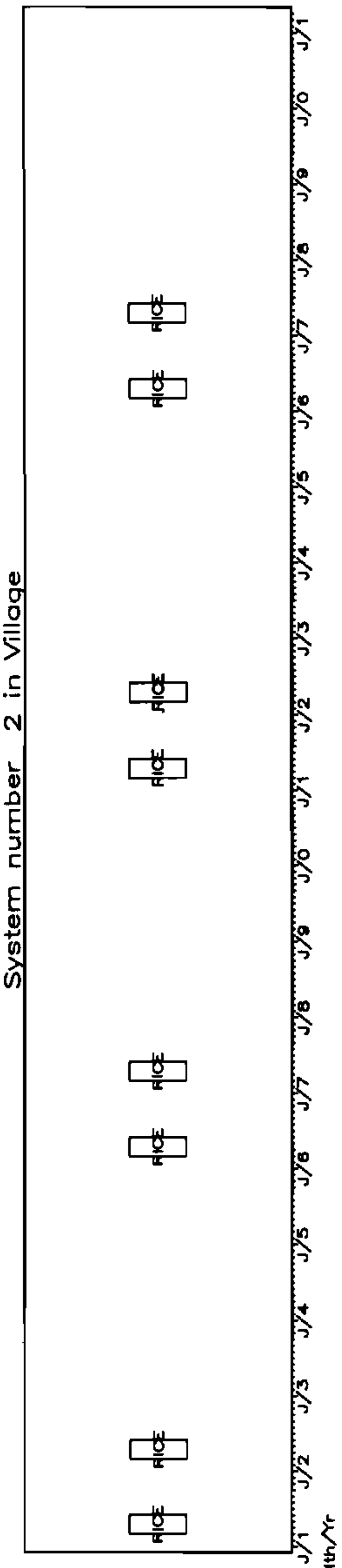
SYSTEM 2

Land form = bottom land/dry lowland ; land location = N/A
Fallow period = 3 years ; vegetation at the end of fallow = grass
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = March ; age at harvest = 3 months

System number 1 in Village



System number 2 in Village



0125

Chart 23. Crop production systems in BEBOUO-SIBOUO village

Descriptive data

——— VILLAGE ——— 126

Name = BEBOUO-SIBOUO   Identification number = 26   Altitude = 280 meters
Lon. = 6.2500 degrees   Lat. = 6.8167 degrees

Total annual rainfall = 1409 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 25.8 deg. cent.; temp. range = 8.7 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 32 kilometers
Main market: distance = 3 kilometers; access means = foot/head
Main cassava buyer = processor

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = NA, number of fields = NA;
Mean field area (all crops)/household = 1.05 hectares;
Mean household size = 4.58, number of households = 8

Mean soil properties
NA

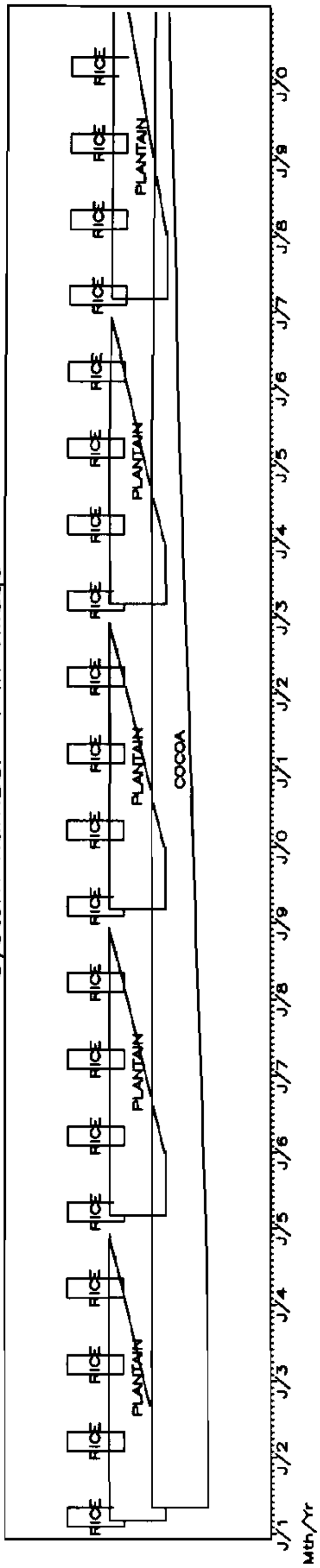
——— SYSTEM 1 ———

Land form = upland, lowland and plains ; land location = mixture of near and far fields
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = May ; age at harvest = 36 months
2nd crop = plan. ; peak planting month =March ; age at harvest = 9 months
3rd crop = rice ; peak planting month = February ; age at harvest = 3 months

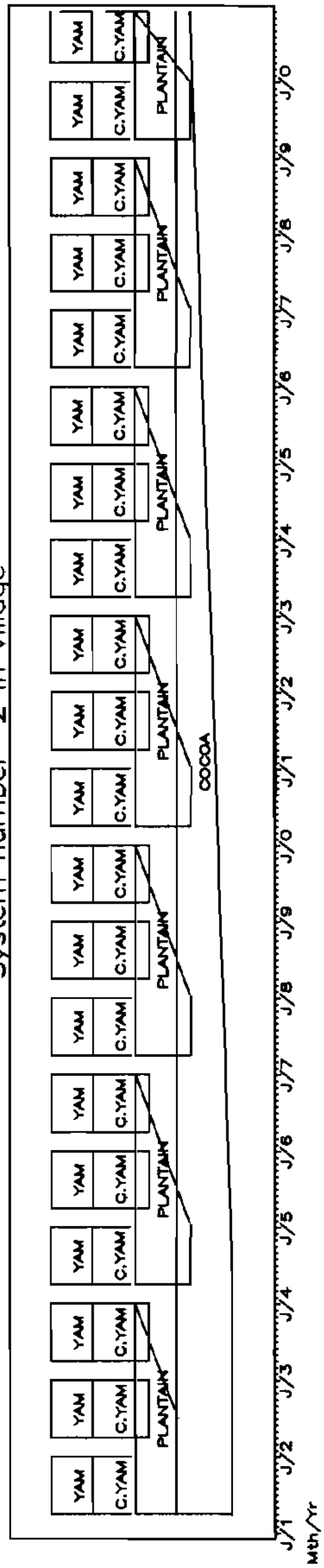
——— SYSTEM 2 ———

Land form = upland, lowland and plains ; land location = nonresidential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = April ; age at harvest = 36 months
2nd crop = plan. ; peak planting month =April ; age at harvest = 9 months
3rd crop = yams ; peak planting month = April ; age at harvest = 9 months
4th crop = cocoyams ; peak planting month = April ; age at harvest = 24 months

System number 1 in Village



System number 2 in Village



0126

Chart 24. Crop production systems in KANGRETA village

Descriptive data

—————— VILLAGE —————— 127

Name = KANGRETA Identification number = 27 Altitude = 276 meters
Lon. = 6.0500 degrees Lat. = 6.7833 degrees

———

Total annual rainfall = 1409 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 25.8 deg. cent.; temp. range = 8.7 deg. cent.
Climatic zone = Humid

———

Population density = 12 persons/sq km.
Distance to nearest city = 50 kilometers
Main market: distance = 1 kilometers; access means = foot/head
Main cassava buyer = processor

———

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 1

———

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

———

Mean cassava root yield in village = 11.75 tons per hectare, number of fields = 2;
Mean field area (all crops)/household = 0.56 hectares;
Mean household size = 4.58, number of households = 8

———

Mean soil properties (No. of samples =12)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 3.9	Ca^{++} = 4.4	Avail P = 6.9091	Ca^{++} = 0.8091
K^{+} = 0.3	Mn^{++} = 0.1	K^{+} = 0.0164	Mn^{++} = 0.0436
Mg^{++} = 1.1	Total N = 0.12	Mg^{++} = 0.2818	Total N = 0.0554
K:S ratio = NA	Mg:K ratio = 3.6667	K:S ratio = 14.7727	Mg:K ratio = 14.7727
Mn:P ratio = 0.0256	N:P ratio = 0.0308	Mn:P ratio = 0.0296	N:P ratio = 0.0143
N:S ratio = NA	Org. C = 1.04	N:S ratio = 1.4319	Org. C = 0.6136
Org. matt = 1.793	pH = 5.9	Org. matt = 1.0579	pH = 5.7182
Sand = 76	Silt = 16	Sand = 73.1818	Silt = 7.8182
S:P ratio = NA	TEB = 6.1	S:P ratio = 0.0047	TEB = 1.3164
Total S = NA	BS = 100	Total S = 0.0426	BS = 56.1126
Ca:Mg ratio = 4	Ca:S ratio = NA	Ca:Mg ratio = 3.5918	Ca:S ratio = 9.3897
Clay = 8	C:N ratio = 8.7	Clay = 19.0909	C:N ratio = 11.5091
Na^{+} = 0.3	ECEC = 6.1	Na^{+} = 0.2091	ECEC = 2.0982
EPP = 4.918	ESP = 4.918	EPP = 0.7487	ESP = 10.755
TEA = 0		TEA = 0.7818	

—————— SYSTEM 1 ——————

Land form = upland, lowland and plains ; land location = mixture of near and far fields
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = June ; age at harvest = 36 months
2nd crop = rice ; peak planting month =February ; age at harvest = 3 months
3rd crop = maize ; peak planting month = February ; age at harvest = 3 months

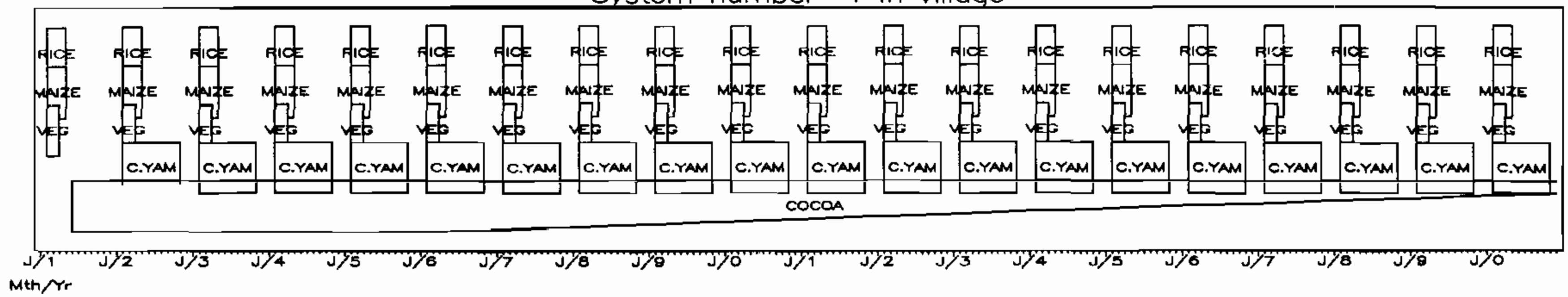
—————— SYSTEM 2 ——————

Land form = upland, lowland and plains ; land location = mixture of near and far fields
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = February ; age at harvest = 3 months
2nd crop = plan. ; peak planting month =June ; age at harvest = 12 months
3rd crop = cocoyams ; peak planting month = February ; age at harvest = 12 months

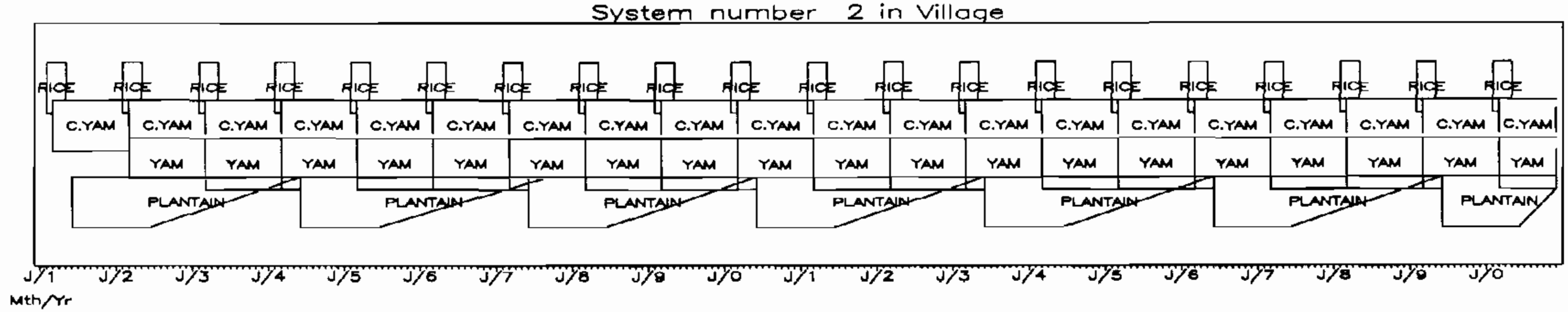
—————— SYSTEM 3 ——————

Land form = dry plain ; land location = mixture of near and far fields
Fallow period = 1 year ; vegetation at the end of fallow = none
Seedbed type = heaps
1st crop = yams ; peak planting month = March ; age at harvest = 7 months
2nd crop = cassava ; peak planting month =March ; age at harvest = 12 months
3rd crop = plan. ; peak planting month = March ; age at harvest = 12 months

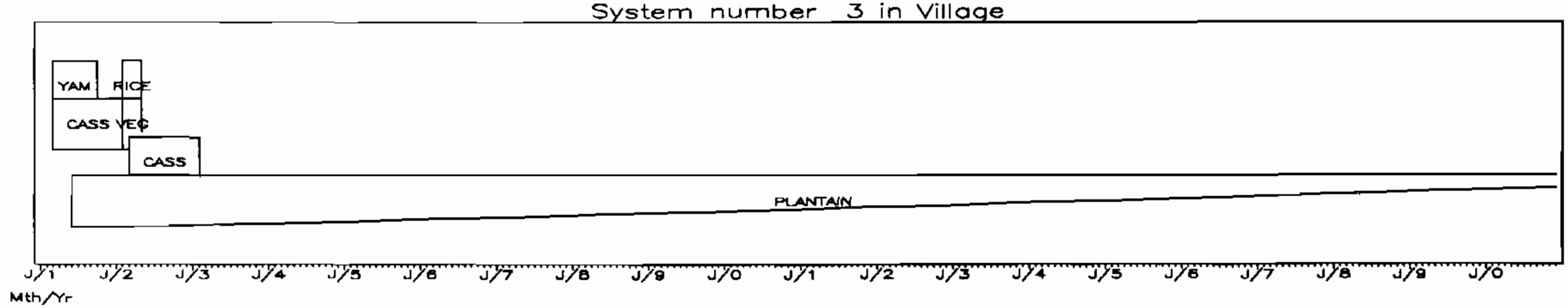
System number 1 in Village



System number 2 in Village



System number 3 in Village



0127

Chart 25. Crop production systems in DETROYA village

Descriptive data

——— VILLAGE ——— 128

Name = DETROYA   Identification number = 28   Altitude = 258 meters
Lon. = 6.8300 degrees   Lat. = 6.6833 degrees

Total annual rainfall = 1618 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26.2 deg. cent.; temp. range = 10 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 10 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = N/A

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 1

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = NA, number of fields = NA;
Mean field area (all crops)/household = 0.54 hectares;
Mean household size = 2.67, number of households = 4

Mean soil properties (No. of samples =4)

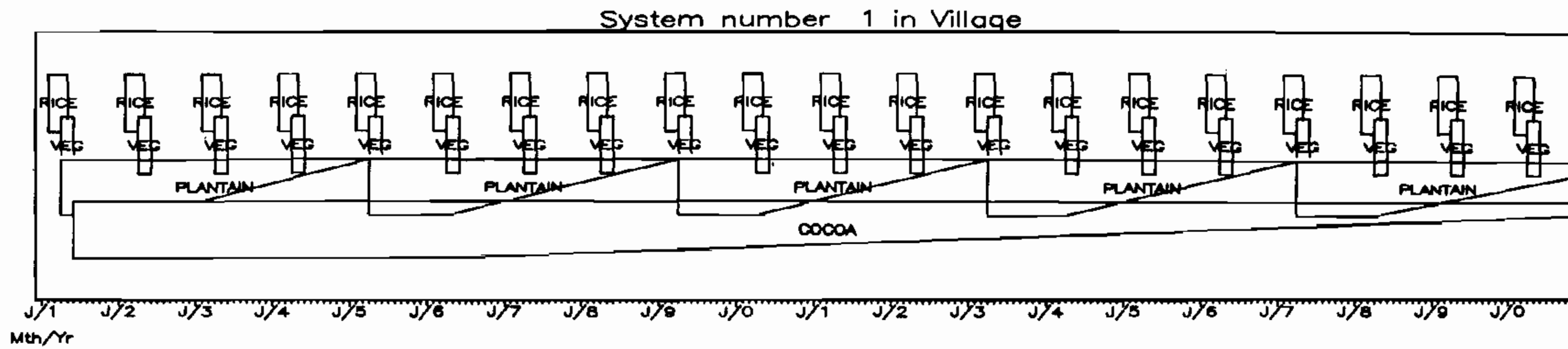
Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 3.85	Ca^{++} = 3.75	Avail P = 5.6	Ca^{++} = 2.7
K^{+} = 0.4	Mn^{++} = 0.4	K^{+} = 0.35	Mn^{++} = 0.85
Mg^{++} = 1.15	Total N = 0.168	Mg^{++} = 1.1	Total N = 0.1015
K:S ratio = NA	Mg:K ratio = 2.875	K:S ratio = 3.5	Mg:K ratio = 3.5
Mn:P ratio = 0.1071	N:P ratio = 0.0442	Mn:P ratio = 0.1594	N:P ratio = 0.0182
N:S ratio = NA	Org. C = 1.72	N:S ratio = 21.3	Org. C = 0.93
Org. matt = 2.9653	pH = 5.3	Org. matt = 1.6033	pH = 5.9
Sand = 67.5	Silt = 7	Sand = 57	Silt = 19
S:P ratio = NA	TEB = 5.7	S:P ratio = 0.0016	TEB = 4.5
Total S = NA	BS = 94.4444	Total S = 0.009	BS = 74.3058
Ca:Mg ratio = 3.2008	Ca:S ratio = NA	Ca:Mg ratio = 2.1806	Ca:S ratio = 806.6667
Clay = 25.5	C:N ratio = 10	Clay = 24	C:N ratio = 8.9
Na^{+} = 0.4	ECEC = 5.95	Na^{+} = 0.35	ECEC = 5.5
EPP = 7.1471	ESP = 7.5826	EPP = 7.4602	ESP = 7.4602
TEA = 0.25		TEA = 1	

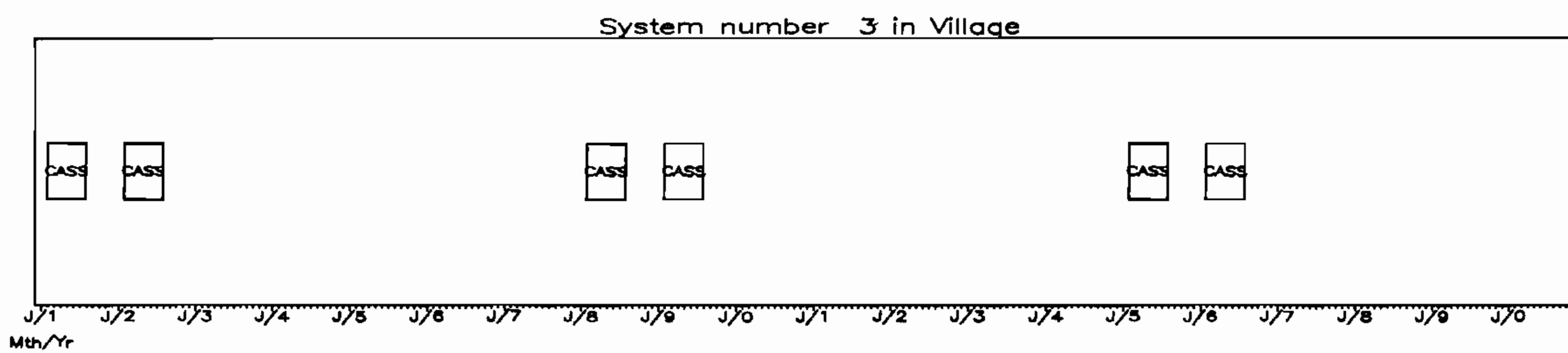
——— SYSTEM 1 ———

Land form = upland, lowland and plains ; land location = nonresidential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = June ; age at harvest = 36 months
2nd crop = rice ; peak planting month =February ; age at harvest = 3 months
3rd crop = plan. ; peak planting month = April ; age at harvest = 12 months

——— SYSTEM 3 ———

Land form = dry plain ; land location = nonresidential area
Fallow period = 5 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = February ; age at harvest = 6 months


System number 1 in Village
RICE
VEG
PLANTAIN
COCOA
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr


System number 3 in Village
CASS
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr

0128

Chart 26. Crop production systems in MEDIBLI village

Descriptive data

——— VILLAGE ——— 129

Name = MEDIBLI Identification number = 29 Altitude = 295 meters
Lon. = 8.1000 degrees Lat. = 6.5000 degrees

Total annual rainfall = 2007 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26.1 deg. cent.; temp. range = 12.8 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 10 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = N/A

CMB symptom severity score = 0 ; CGM symptom severity score = 1
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? Yes; Method = free range
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = 0 tons per hectare, number of fields = 2;
Mean field area (all crops)/household = 0.61 hectares;
Mean household size = 4.13, number of households = 7

Mean soil properties (No. of samples =6)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = NA	Ca^{++} = NA	Avail P = 0.7	Ca^{++} = 2
K^{+} = NA	Mn^{++} = NA	K^{+} = 0.1	Mn^{++} = 0.1
Mg^{++} = NA	Total N = NA	Mg^{++} = 0.9	Total N = 0
K:S ratio = NA	Mg:K ratio = NA	K:S ratio = 9	Mg:K ratio = 9
Mn:P ratio = NA	N:P ratio = NA	Mn:P ratio = 0.1429	N:P ratio = 0
N:S ratio = NA	Org. C = NA	N:S ratio = NA	Org. C = 0.82
Org. matt = NA	pH = NA	Org. matt = 1.4137	pH = 4.5
Sand = NA	Silt = NA	Sand = 52	Silt = 8
S:P ratio = NA	TEB = NA	S:P ratio = NA	TEB = 3.3
Total S = NA	BS = NA	Total S = NA	BS = 76.7442
Ca:Mg ratio = NA	Ca:S ratio = NA	Ca:Mg ratio = 2.2222	Ca:S ratio = NA
Clay = NA	C:N ratio = NA	Clay = 40	C:N ratio = NA
Na^{+} = NA	ECEC = NA	Na^{+} = 0.3	ECEC = 4.3
EPP = NA	ESP = NA	EPP = 2.3256	ESP = 6.9767
TEA = NA		TEA = 1	

——— SYSTEM 2 ———

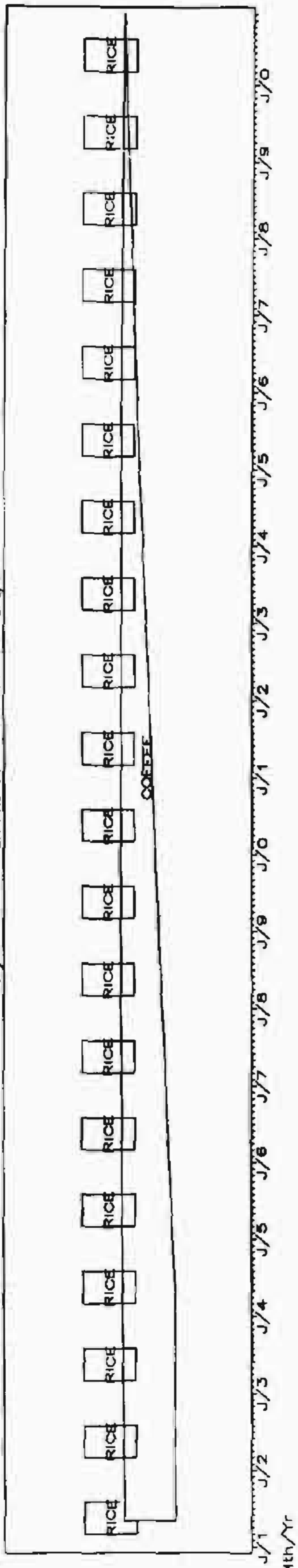
Land form = N/A ; land location = nonresidential area
Fallow period = 7 years ; vegetation at the end of fallow = plain land
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = March ; age at harvest = 5 months

——— SYSTEM 3 ———

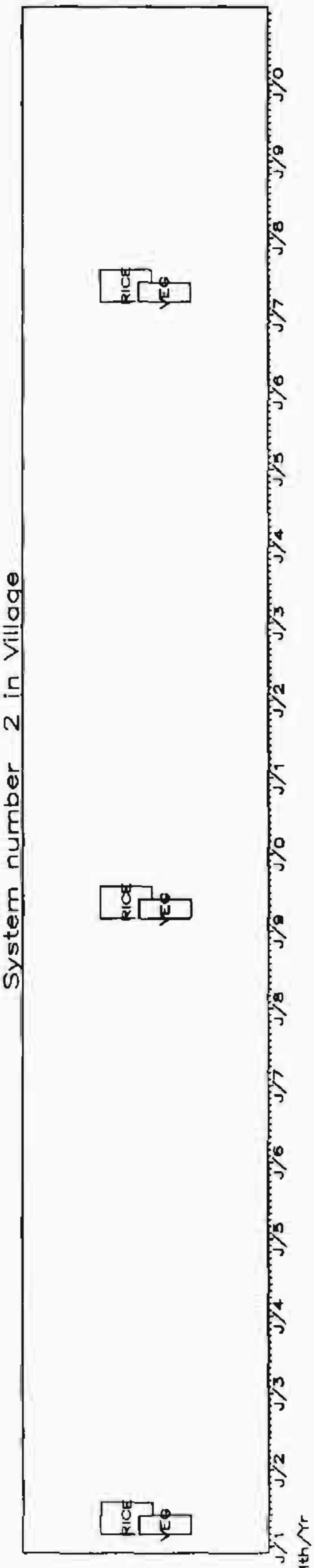
Land form = dry plain ; land location = nonresidential area
Fallow period = 1 year ; vegetation at the end of fallow = trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = April ; age at harvest = 12 months
2nd crop = rice ; peak planting month =March ; age at harvest = 5 months

Coffee-based systems are not indicated

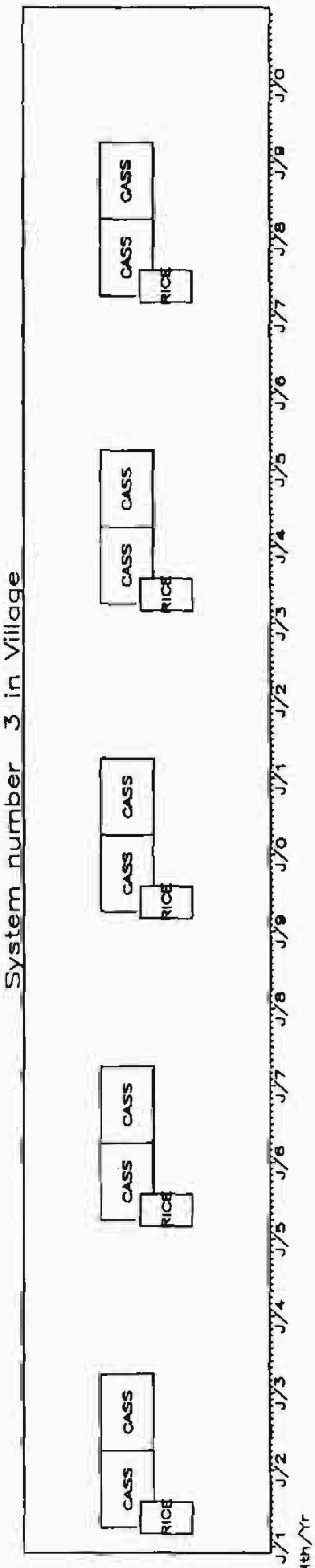
System number 1 in Village



System number 2 in Village



System number 3 in Village



0129

Chart 27. Crop production systems in BLOLE village

Descriptive data

——— VILLAGE ——— 130

Name = BLOLE Identification number = 30 Altitude = 340 meters
Lon. = 7.5200 degrees Lat. = 7.3000 degrees

Total annual rainfall = 1817 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 24.4 deg. cent.; temp. range = 10.3 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 10 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? No
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = 7.75 tons per hectare, number of fields = 1
Mean field area (all crops)/household = 0.43 hectares;
Mean household size = 4.64, number of households = 12

Mean soil properties (No. of samples =8)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 8.5	Ca^{++} = 1.6	Avail P = 1.5	Ca^{++} = 0.7
K^{+} = 0.2	Mn^{++} = 0.04	K^{+} = 0.1	Mn^{++} = 0.01
Mg^{++} = 0.6	Total N = 0.077	Mg^{++} = 0.5	Total N = 0.086
K:S ratio = NA	Mg:K ratio = 3	K:S ratio = 5	Mg:K ratio = 5
Mn:P ratio = 0.0047	N:P ratio = 0.0091	Mn:P ratio = 0.0067	N:P ratio = 0.0573
N:S ratio = NA	Org. C = 1.2	N:S ratio = NA	Org. C = 0.59
Org. matt = 2.0688	pH = 4.6	Org. matt = 1.0172	pH = 4.7
Sand = 74	Silt = 12	Sand = 63	Silt = 6
S:P ratio = NA	TEB = 2.8	S:P ratio = NA	TEB = 1.6
Total S = NA	BS = 70	Total S = NA	BS = 36.3636
Ca:Mg ratio = 2.6667	Ca:S ratio = NA	Ca:Mg ratio = 1.4	Ca:S ratio = NA
Clay = 14	C:N ratio = 16	Clay = 31	C:N ratio = 6.9
Na^{+} = 0.4	ECEC = 4	Na^{+} = 0.3	ECEC = 4.4
EPP = 5	ESP = 10	EPP = 2.2727	ESP = 6.8182
TEA = 1.2		TEA = 2.8	

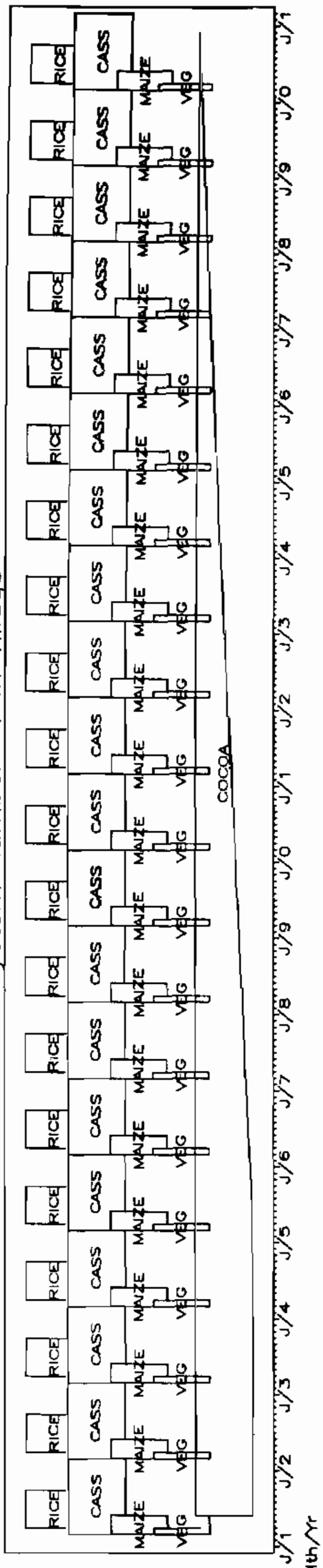
——— SYSTEM 1 ———

Land form = upland, lowland and plains ; land location = mixture of near and far fields
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = June ; age at harvest = 48 months
2nd crop = rice ; peak planting month =April ; age at harvest = 6 months
3rd crop = cassava ; peak planting month = March ; age at harvest = 12 months
4th crop = maize ; peak planting month = March ; age at harvest = 3 months

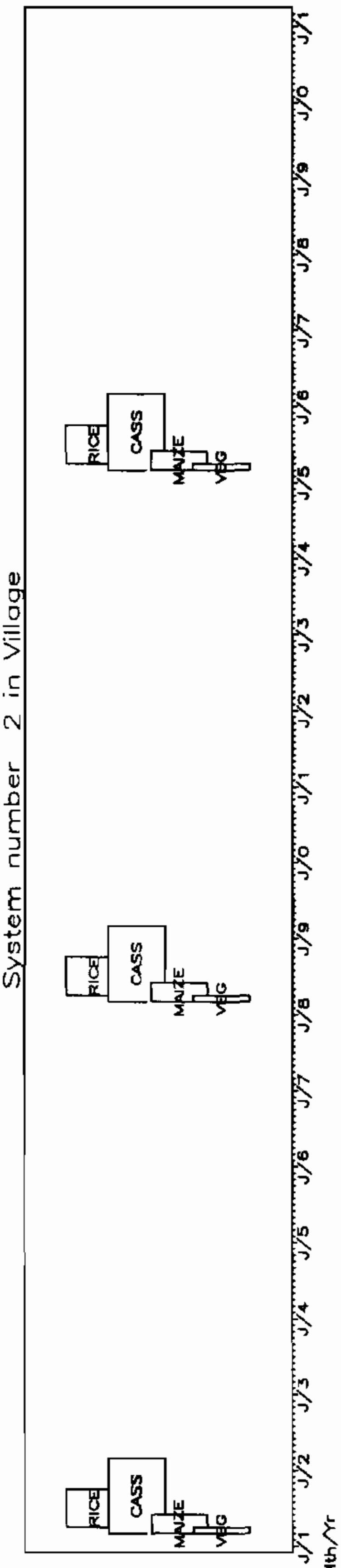
——— SYSTEM 2 ———

Land form = upland, lowland and plains ; land location = mixture of near and far fields
Fallow period = 5 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = flat ploughed
1st crop = rice ; peak planting month = April ; age at harvest = 6 months
2nd crop = cassava ; peak planting month =March ; age at harvest = 12 months
3rd crop = maize ; peak planting month = March ; age at harvest = 3 months

System number 1 in Village



System number 2 in Village



0130

Chart 28. Crop production systems in YEPLEU village

Descriptive data

——— VILLAGE ——— 131

Name = YEPLEU Identification number = 31 Altitude = 480 meters
Lon. = 7.8200 degrees Lat. = 7.7167 degrees

Total annual rainfall = 1875 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 22.8 deg. cent.; temp. range = 10.8 deg. cent.
Climatic zone = Humid

Population density = 24 persons/sq km.
Distance to nearest city = 30 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? Yes; Method = herded
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? No
Oil palm grown in village? No

Mean cassava root yield in village = 0 tons per hectare, number of fields = 2;
Mean field area (all crops)/household = 1 hectares;
Mean household size = 4.83, number of households = 9

Mean soil properties (No. of samples =11)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 3.6857	Ca^{++} = 2	Avail P = 9.2	Ca^{++} = 1.45
K^{+} = 0.1286	Mn^{++} = 0.5286	K^{+} = 0.0775	Mn^{++} = 0.0575
Mg^{++} = 0.8	Total N = 0.1111	Mg^{++} = 0.525	Total N = 0.085
K:S ratio = 6.4103	Mg:K ratio = 6.6667	K:S ratio = 7.5	Mg:K ratio = 7.5
Mn:P ratio = 0.1516	N:P ratio = 0.0316	Mn:P ratio = 0.0166	N:P ratio = 0.0125
N:S ratio = 6.859	Org. C = 0.9357	N:S ratio = 1.3383	Org. C = 0.8675
Org. matt = 1.6132	pH = 4.8571	Org. matt = 1.4956	pH = 5.775
Sand = 60.5714	Silt = 22.8571	Sand = 76.25	Silt = 5
S:P ratio = 0.004	TEB = 3.1571	S:P ratio = 0.0049	TEB = 2.2275
Total S = 0.0156	BS = 68.2261	Total S = 0.0673	BS = 59.0375
Ca:Mg ratio = 2.5306	Ca:S ratio = 115.3846	Ca:Mg ratio = 2.525	Ca:S ratio = 9.4555
Clay = 16.5714	C:N ratio = 8.2286	Clay = 18.75	C:N ratio = 9.85
Na^{+} = 0.2286	ECEC = 4.5571	Na^{+} = 0.175	ECEC = 3.3025
EPP = 2.6959	ESP = 4.9235	EPP = 2.391	ESP = 5.6491
TEA = 1.4		TEA = 1.075	

——— SYSTEM 2 ———

Land form = N/A ; land location = N/A
Fallow period = 6 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat ploughed
1st crop = rice ; peak planting month = April ; age at harvest = 6 months
2nd crop = cassava ; peak planting month =March ; age at harvest = 12 months
3rd crop = maize ; peak planting month = March ; age at harvest = 3 months
4th crop = plan. ; peak planting month = March ; age at harvest = 12 months

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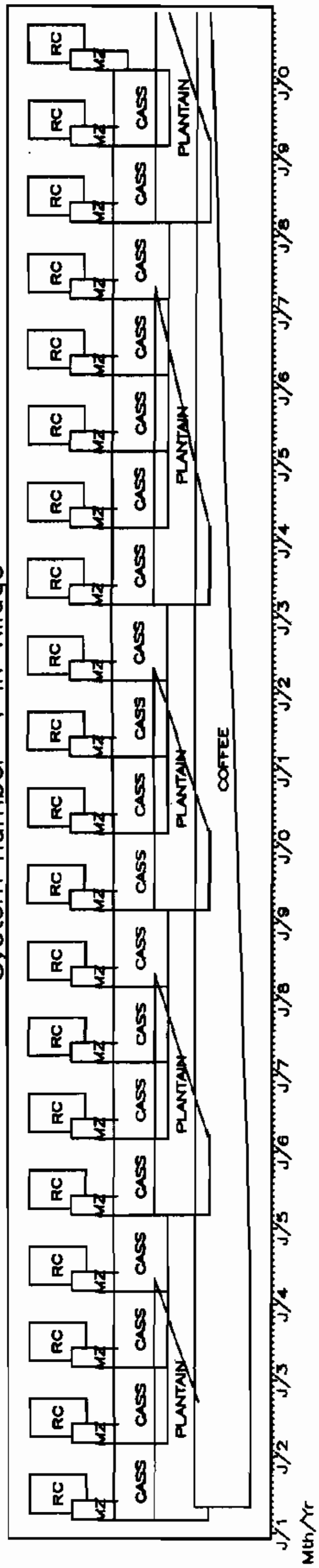
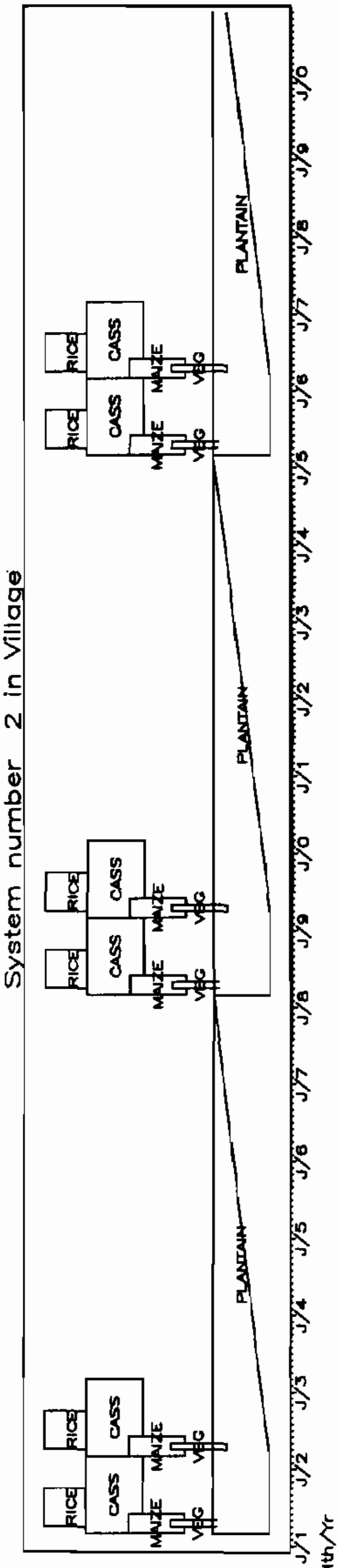
Coffee-based systems are not indicated

System number 1 in Village



System number 2 in Village



0131

Chart 29. Crop production systems in DOUOLE village

Descriptive data

——— VILLAGE ——— 132

Name = DOUOLE Identification number = 32 Altitude = 710 meters
Lon. = 7.4300 degrees Lat. = 7.7667 degrees

Total annual rainfall = 1851 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 23.3 deg. cent.; temp. range = 10.7 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 30 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = N/A

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = NA, number of fields = NA;
Mean field area (all crops)/household = 1.2 hectares;
Mean household size = 4, number of households = 7

Mean soil properties
NA

——— SYSTEM 2 ———

Land form = upland, lowland and plains ; land location = nonresidential area
Fallow period = 3 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = flat ploughed
1st crop = rice ; peak planting month = May ; age at harvest = 4 months
2nd crop = maize ; peak planting month =March ; age at harvest = 3 months
3rd crop = cassava ; peak planting month = May ; age at harvest = 1 months

——— SYSTEM 3 ———

Land form = dry plain ; land location = nonresidential area
Fallow period = 3 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = heaps
1st crop = cassava ; peak planting month = May ; age at harvest = 12 months
2nd crop = beans ; peak planting month =March ; age at harvest = 2 months

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Coffee-based systems are not indicated

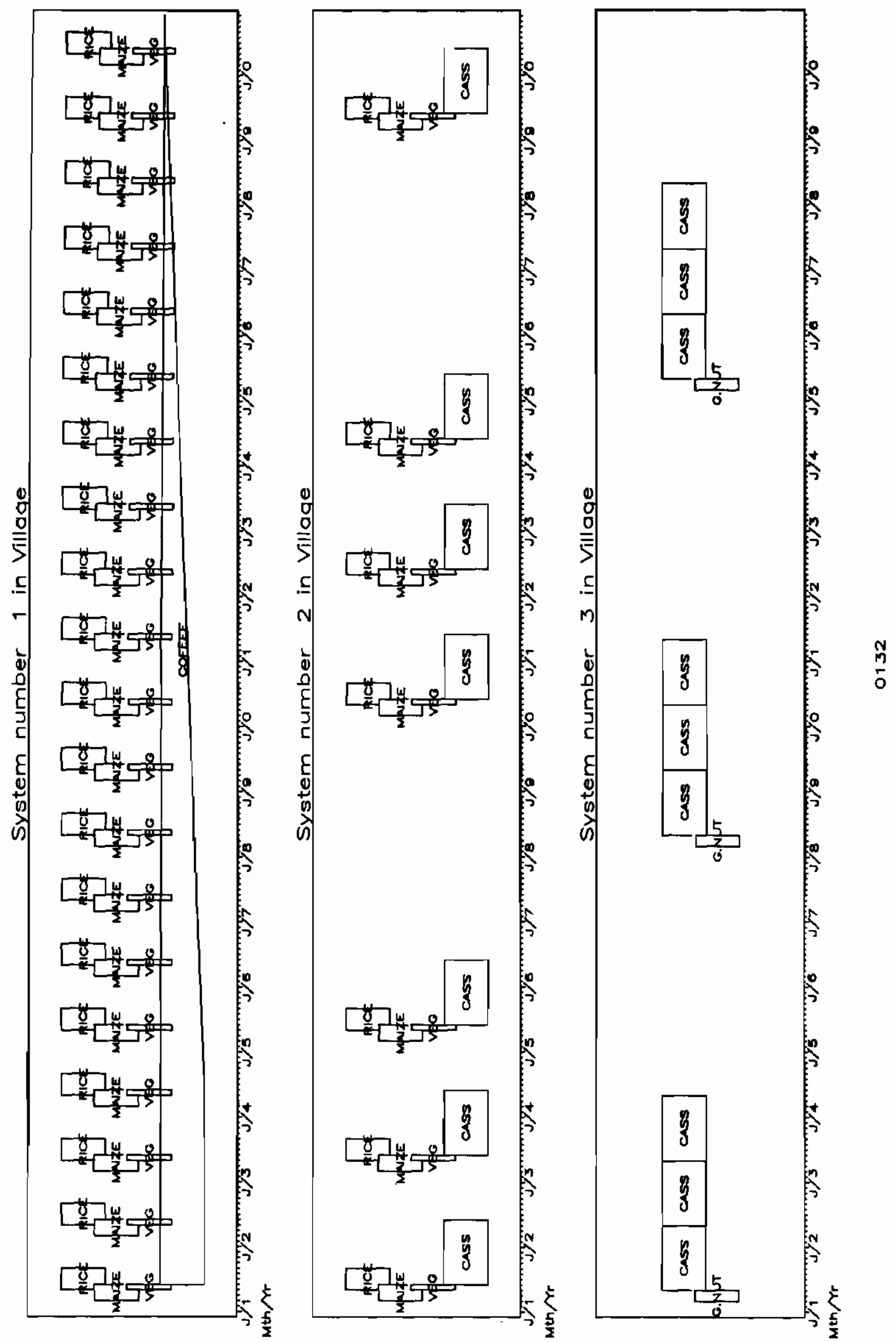

System number 1 in Village
RICE
MAIZE
VEG
COFFEE
System number 2 in Village
CASS
System number 3 in Village
G.NUT
J/1
J/2
J/3
J/4
J/5
J/6
J/7
J/8
J/9
J/0
Mth/Yr
0132

Chart 30. Crop production systems in TAKRA-ADIEKRO village

Descriptive data

——————— VILLAGE ——————————————— 133

Name = TAKRA-ADIEKRO   Identification number = 33   Altitude = 255 meters
Lon. = 5.3800 degrees   Lat. = 7.8833 degrees

Total annual rainfall = 1224 millimeters
Growing season : beginning = April ; length = 8 months
mean temp = 27 deg. eent.; temp. range = 10.6 deg. cent.
Climatic zone = NA

Population density = 12 persons/sq km.
Distance to nearest city = 12 kilometers
Main market: distance = 12 kilometers; access means = foot/head
Main cassava buyer = trader

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 2

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? No
Oil palm grown in village? Yes

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.48 hectares;
Mean household size = 2.5, number of households = 4

Mean soil properties
NA

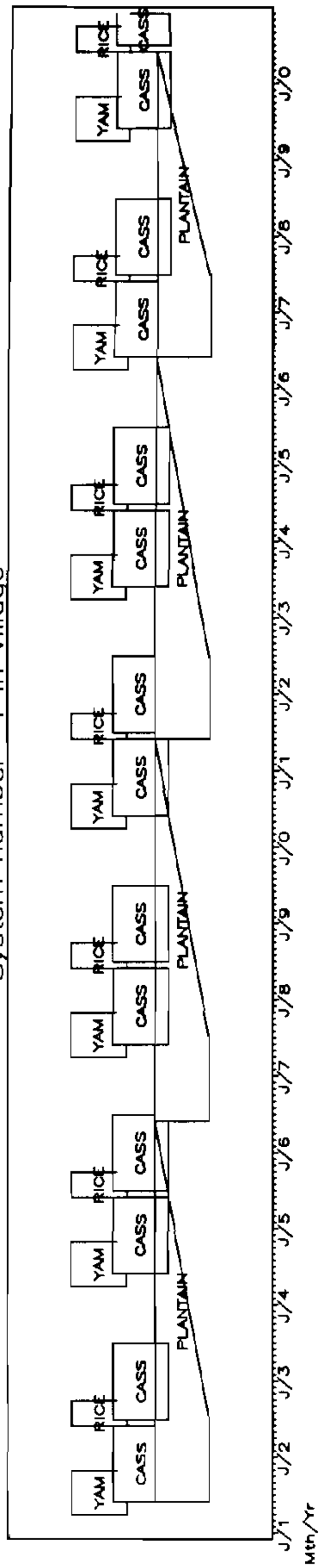
——————— SYSTEM 1 ———————

Land form = dry plain ; land location = nonresidential area
Fallow period = 3 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = heaps
1st crop = yams ; peak planting month = April ; age at harvest = 7 months
2nd crop = plan. ; peak planting month =April ; age at harvest = 12 months
3rd crop = cassava ; peak planting month = June ; age at harvest = 12 months

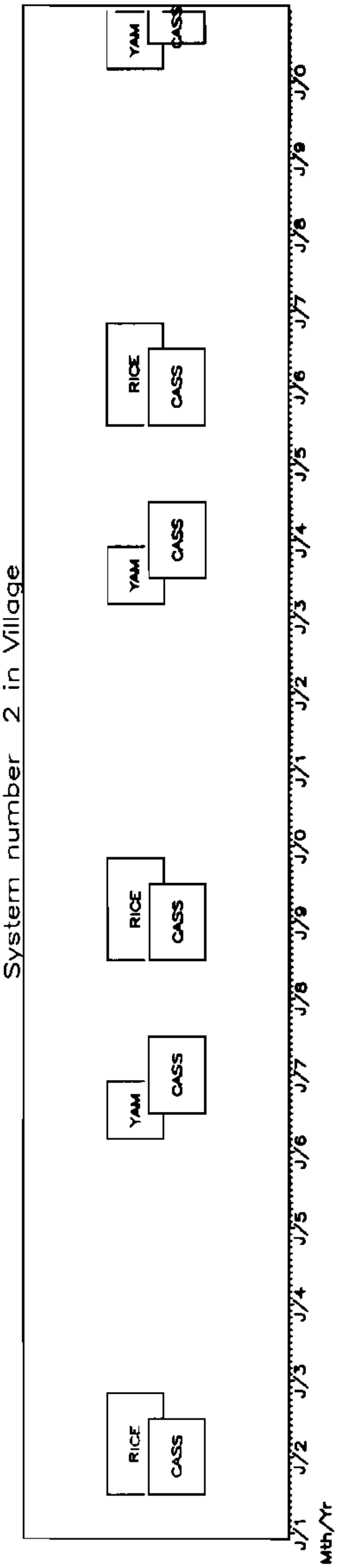
——————— SYSTEM 2 ———————

Land form = dry plain ; land location = nonresidential area
Fallow period = 3 years ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = July ; age at harvest = 4 months
2nd crop = cassava ; peak planting month =July ; age at harvest = 12 months
3rd crop = plan. ; peak planting month = July ; age at harvest = 12 months

System number 1 in Village



System number 2 in Village



0133

Chart 31. Crop production systems in SOUGBAN village

Descriptive data

VILLAGE 134

Name = SOUGBAN Identification number = 34 Altitude = 200 meters
Lon. = 4.7200 degrees Lat. = 7.8167 degrees

Total annual rainfall = 1214 millimeters
Growing season : beginning = April ; length = 5 months
mean temp = 27 deg. cent ; temp. range = 10.3 deg. cent.
Climatic zone = Non Humid

Population density = 12 persons/sq km.
Distance to nearest city = 12 kilometers
Main market: distance = 14 kilometers; access means = motor vehicle
Main cassava buyer = N/A

CMB symptom severity score = 0 ; CGM symptom severity score = 1
ACMD symptom severity score = 0 ; CBB symptom severity score = 3

Cattle kept in village? No
Sheep/goats kept in village? Yes: Method = free range
Coffee grown in village? Yes
Cocoa grown in village? No
Oil palm grown in village? No

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.35 hectares;
Mean household size = 4.5, number of households = 8

Mean soil properties (No. of samples =7)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 3.2	Ca^{++} = 7.9	Avail P = 4.9	Ca^{++} = 1
K^{+} = 0.3	Mn^{++} = 0.7	K^{+} = 0.1	Mn^{++} = 0.3
Mg^{++} = 3.4	Total N = 0.225	Mg^{++} = 1	Total N = 0.103
K:S ratio = 16.2162	Mg:K ratio = 11.3333	K:S ratio = 10	Mg:K ratio = 10
Mn:P ratio = 0.2188	N:P ratio = 0.0703	Mn:P ratio = 0.0612	N:P ratio = 0.021
N:S ratio = 12.1622	Org. C = 2.84	N:S ratio = 93.6364	Org. C = 0.92
Org. matt = 4.8962	pH = 6.8	Org. matt = 1.5861	pH = 5.3
Sand = 60	Silt = 26	Sand = 62	Silt = 26
S:P ratio = 0.0058	TEB = 11.9	S:P ratio = 0.0002	TEB = 2.3
Total S = 0.0185	BS = 100	Total S = 0.0011	BS = 82.1429
Ca:Mg ratio = 2.3235	Ca:S ratio = 427.027	Ca:Mg ratio = 1	Ca:S ratio = 909.0909
Clay = 14	C:N ratio = 13	Clay = 12	C:N ratio = 8.9
Na^{+} = 0.3	ECEC = 11.9	Na^{+} = 0.2	ECEC = 2.8
EPP = 2.521	ESP = 2.521	EPP = 3.5714	ESP = 7.1429
TEA = NA		TEA = 0.5	

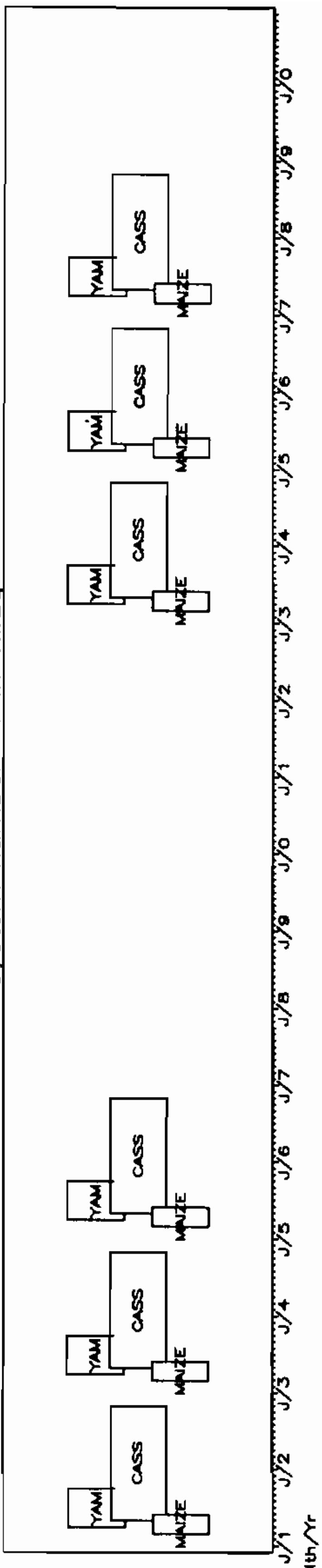
SYSTEM 1

Land form = dry plain ; land location = nonresidential area
Fallow period = 7 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = heaps
1st crop = yams ; peak planting month = April ; age at harvest = 6 months
2nd crop = cassava ; peak planting month =May ; age at harvest = 18 months
3rd crop = maize ; peak planting month = March ; age at harvest = 3 months

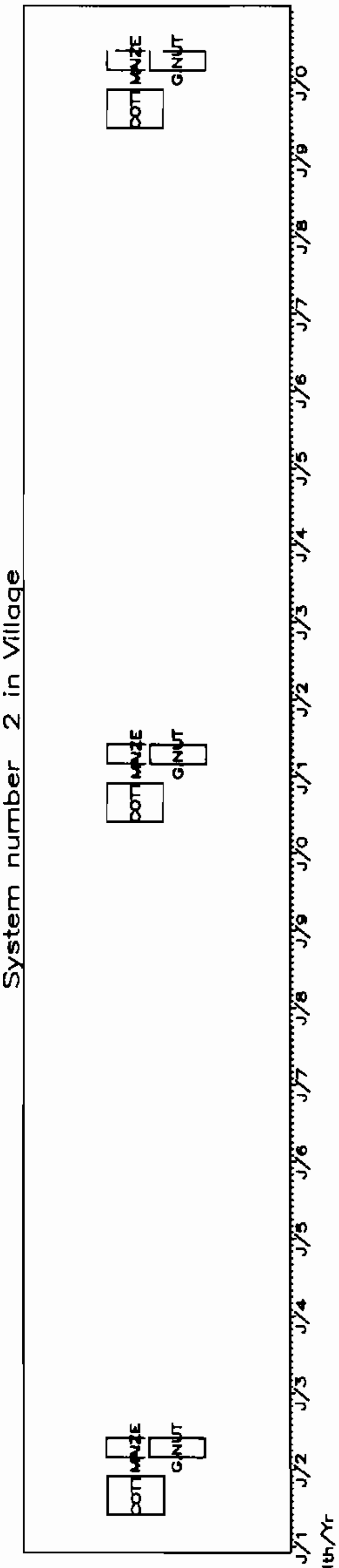
SYSTEM 2

Land form = dry plain ; land location = nonresidential area
Fallow period = 7 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = open ridges
1st crop = cotton ; peak planting month = June ; age at harvest = 6 months

System number 1 in Village



System number 2 in Village



0134

Chart 32. Crop production systems in KPATO village

Descriptive data

——— VILLAGE ——— 135

Name = KPATO   Identification number = 35   Altitude = 230 meters
Lon. = 5.3300 degrees   Lat. = 7.3333 degrees

Total annual rainfall = 1248 millimeters
Growing season : beginning = April ; length = 8 months
mean temp = 27 deg. cent.; temp. range = 10.2 deg. cent.
Climatic zone = Nonhumid

Population density = 12 persons/sq km.
Distance to nearest city = 15 kilometers
Main market: distance = 15 kilometers; access means = foot/head
Main cassava buyer = trader

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 10 tons per hectare, number of fields = 1;
Mean field area (all crops)/household = 0.41 hectares;
Mean household size = 5.17, number of households = 9

Mean soil properties (No. of samples =13)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 14.3714	Ca^{++} = 4.4857	Avail P = 15.5667	Ca^{++} = 2.2167
K^{+} = 0.2143	Mn^{++} = 0.5057	K^{+} = 0.095	Mn^{++} = 0.59
Mg^{++} = 1.5857	Total N = 0.1194	Mg^{++} = 1.1333	Total N = 0.0977
K:S ratio = 3.6318	Mg:K ratio = 12.0476	K:S ratio = 11.2778	Mg:K ratio = 11.2778
Mn:P ratio = 0.2127	N:P ratio = 0.0385	Mn:P ratio = 0.1538	N:P ratio = 0.0206
N:S ratio = 2.7324	Org. C = 1.1886	N:S ratio = 7.1822	Org. C = 1.2183
Org. matt = 2.0491	pH = 5.6	Org. matt = 2.1004	pH = 5.4
Sand = 59.7143	Silt = 18.5714	Sand = 65.3333	Silt = 22.3333
S:P ratio = 0.0159	TEB = 6.6	S:P ratio = 0.006	TEB = 3.695
Total S = 0.0403	BS = 85.7296	Total S = 0.0439	BS = 72.9992
Ca:Mg ratio = 2.6391	Ca:S ratio = 79.6349	Ca:Mg ratio = 1.6806	Ca:S ratio = 217.2048
Clay = 21.7143	C:N ratio = 10.3286	Clay = 12.5	C:N ratio = 11.95
Na^{+} = 0.3143	ECEC = 7.0429	Na^{+} = 0.25	ECEC = 4.395
EPP = 2.7029	ESP = 5.781	EPP = 2.0467	ESP = 6.8877
TEA = 0.62		TEA = 0.84	

——— SYSTEM 1 ———

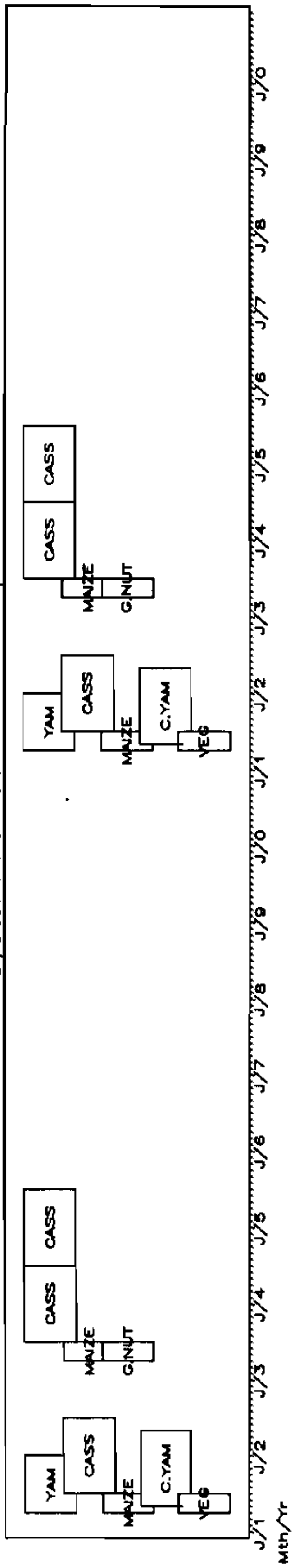
Land form = dry plain ; land location = nonresidential area
Fallow period = 5 years ; vegetation at the end of fallow = trees/shrubs
Seedbed type = heaps
1st crop = yams ; peak planting month = April ; age at harvest = 9 months
2nd crop = cassava ; peak planting month =July ; age at harvest = 12 months
3rd crop = maize ; peak planting month = April ; age at harvest = 3 months
4th crop = cocoyams ; peak planting month = May ; age at harvest = 12 months

——— SYSTEM 3 ———

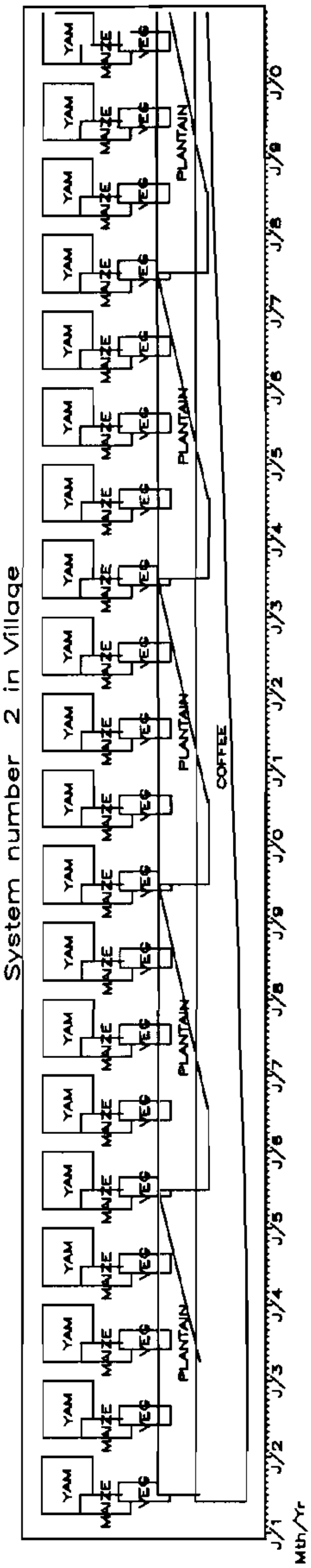
Land form = dry plain ; land location = nonresidential area
Fallow period = 5 years ; vegetation at the end of fallow = forest
Seedbed type = heaps
1st crop = yams ; peak planting month = April ; age at harvest = 9 months
2nd crop = cassava ; peak planting month =July ; age at harvest = 12 months
3rd crop = maize ; peak planting month = April ; age at harvest = 3 months
4th crop = cocoyams ; peak planting month = July ; age at harvest = 12 months

Coffee-based systems are not indicated

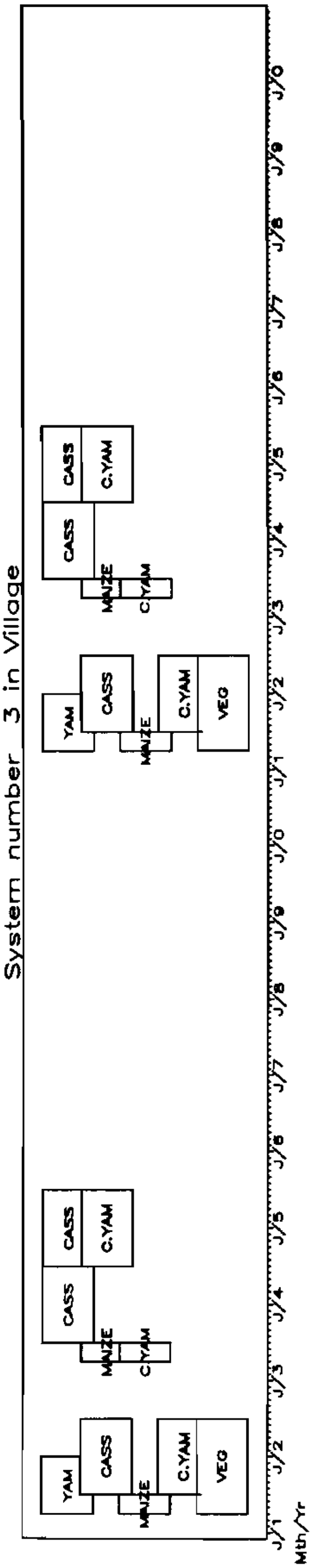
System number 1 in Village



System number 2 in Village



System number 3 in Village



0135

Chart 33. Crop production systems in KOMAMBO village

Descriptive data

——— VILLAGE ——— 136

Name = SAOUA Identification number = 36 Altitude = 210 meters
Lon. = 4.7300 degrees Lat. = 7.5500 degrees

Total annual rainfall = 1219 millimeters
Growing season : beginning April ; length = 8 months
mean temp = 27.4 deg. cent.; temp. range = 10.4 deg. cent.
Climatic zone = Nonhumid

Population density = 24 persons/sq km.
Distance to nearest city = 50 kilometers
Main market: distance = N/A ; access means = motor vehicle
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? No
Oil palm grown in village? Yes

Mean cassava root yield in village = 4.5 tons per hectare, number of fields = 1;
Mean field area (all crops)/household = 0.51 hectares;
Mean household size = NA, number of households = NA

Mean soil properties (No. of samples = 12)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 3.9167	Ca^{++} = 5.05	Avail P = 13.4333	Ca^{++} = 1.6667
K^{+} = 0.2333	Mn^{++} = 0.6167	K^{+} = 0.0917	Mn^{++} = 0.44
Mg^{++} = 1.55	Total N = 0.1307	Mg^{++} = 0.7833	Total N = 0.0835
K:S ratio = 65.0126	Mg:K ratio = 8.3611	K:S ratio = 11.4444	Mg:K ratio = 11.4444
Mn:P ratio = 0.1898	N:P ratio = 0.0405	Mn:P ratio = 0.541	N:P ratio = 0.0412
N:S ratio = 62.8235	Org. C = 1.3717	N:S ratio = 36.365	Org. C = 0.7367
Org. matt = 2.3648	pH = 6.25	Org. matt = 1.27	pH = 5.4333
Sand = 58.1667	Silt = 24.6667	Sand = 64.6667	Silt = 19.3333
S:P ratio = 0.0017	TEB = 7.1333	S:P ratio = 0.0029	TEB = 2.825
Total S = 0.0104	BS = 91.6667	Total S = 0.0262	BS = 74.7393
Ca:Mg ratio = 3.1084	Ca:S ratio = 603.0151	Ca:Mg ratio = 1.9393	Ca:S ratio = 1486.6657
Clay = 17.1667	C:N ratio = 10.2333	Clay = 16.1667	C:N ratio = 8.6333
Na^{+} = 0.3	ECEC = 7.4333	Na^{+} = 0.2833	ECEC = 3.725
EPP = 3.1962	ESP = 5.0075	EPP = 2.8312	ESP = 8.8268
TEA = 0.3		TEA = 0.9	

——— SYSTEM 1 ———

Land form = dry plain ; land location = nonresidential area
Fallow period = 10 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = heaps
1st crop = yams ; peak planting month = April ; age at harvest = 8 months
2nd crop = cassava ; peak planting month = April ; age at harvest = 3 months
3rd crop = plan. ; peak planting month = April ; age at harvest = 12 months

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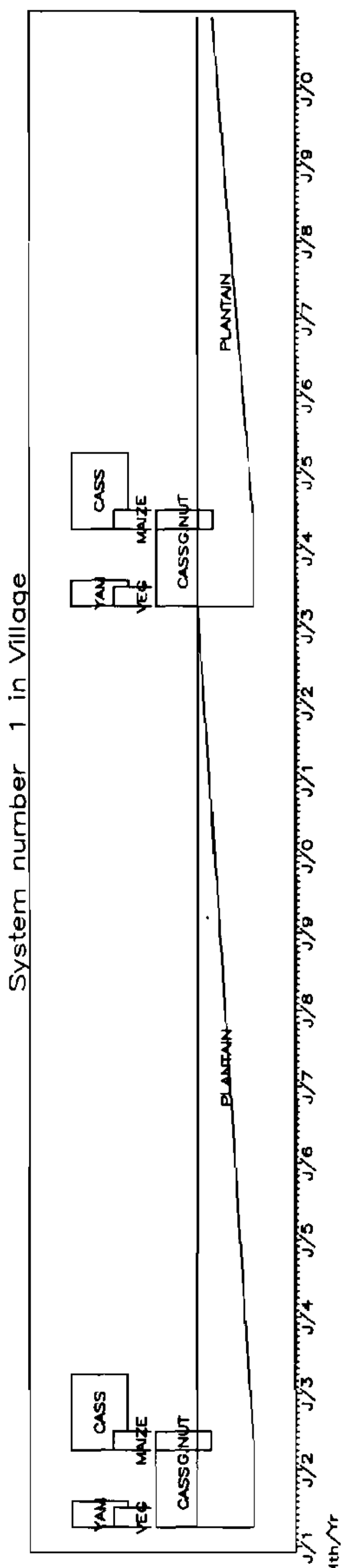
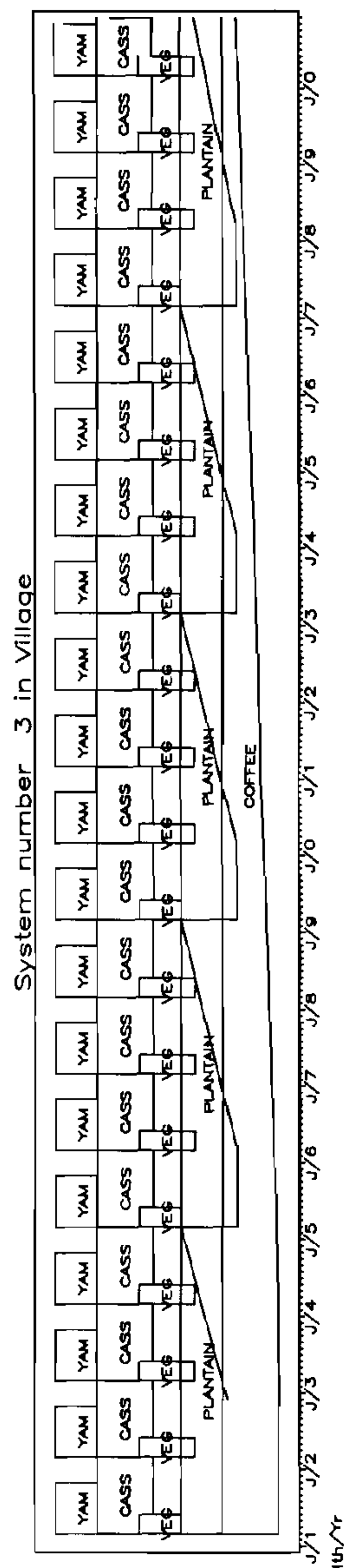
Coffee-based systems are not indicated


System number 1 in Village
YAM
VEG
CASS
MAIZE
CASSGNUT
PLANTAIN
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr


System number 3 in Village
YAM
CASS
VEG
PLANTAIN
COFFEE
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr

0136

Chart 34. Crop production systems in OKROMODOU village

Descriptive data

VILLAGE 137

Name = OKROMODOU Identification number = 37 Altitude = 120 meters
Lon. = 5.6700 degrees Lat. = 5.3500 degrees

Total annual rainfall = 1555 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 26.2 deg. cent.; temp. range = 7.2 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 55 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = trader

CMB symptom severity score = 1 ; CGM symptom severity score = 1
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? No
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = 20 tons per hectare, number of fields = 2;
Mean field area (all crops)/household = 0.28 hectares;
Mean household size = 2.5, number of households = 4

Mean soil properties (No. of samples =6)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 2.9167	Ca^{++} = 1.9667	Avail P = NA	Ca^{++} = NA
K^{+} = 0.025	Mn^{++} = 0.9333	K^{+} = NA	Mn^{++} = NA
Mg^{++} = 1.0833	Total N = 0.0545	Mg^{++} = NA	Total N = NA
K:S ratio = 0.3597	Mg:K ratio = 85.8333	K:S ratio = NA	Mg:K ratio = NA
Mn:P ratio = 0.3321	N:P ratio = 0.0186	Mn:P ratio = NA	N:P ratio = NA
N:S ratio = 1.8345	Org. C = 0.4267	N:S ratio = NA	Org. C = NA
Org matt = 0.7356	pH = 5.85	Org. matt = NA	pH = NA
Sand = 74.8333	Silt = 13.6667	Sand = NA	Silt = NA
S:P ratio = 0.0099	TEB = 3.2917	S:P ratio = NA	TEB = NA
Total S = 0.0278	BS = 87.4119	Total S = NA	BS = NA
Ca:Mg ratio = 1.7556	Ca:S ratio = 57.554	Ca:Mg ratio = NA	Ca:S ratio = NA
Clay = 11.5	C:N ratio = 7.5833	Clay = NA	C:N ratio = NA
Na^{+} = 0.2167	ECEC = 3.7083	Na^{+} = NA	ECEC = NA
EPP = 0.5442	ESP = 5.9124	EPP = NA	ESP = NA
TEA = 0.4167		TEA = NA	

SYSTEM 1

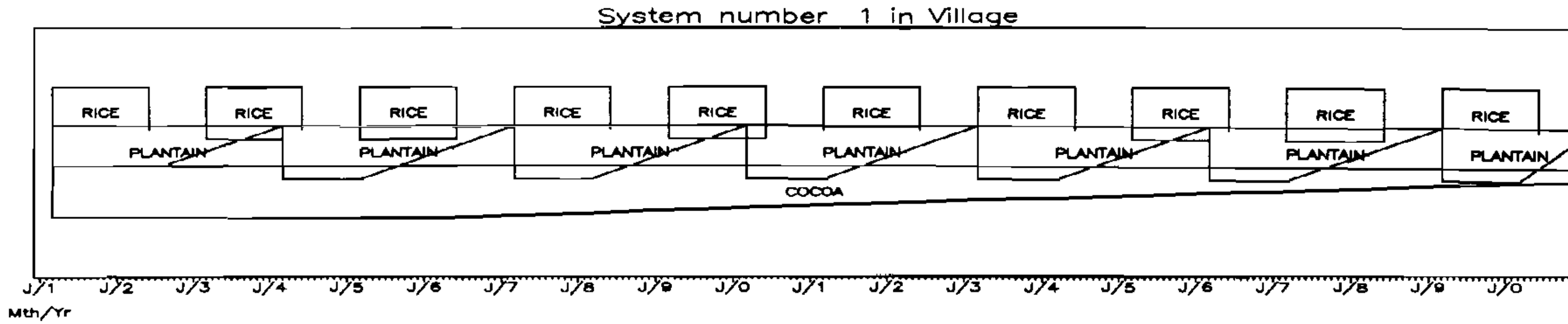
Land form = middle slope ; land location = nonresidential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = March ; age at harvest = 3 months
2nd crop = plan. ; peak planting month =March ; age at harvest = 12 months

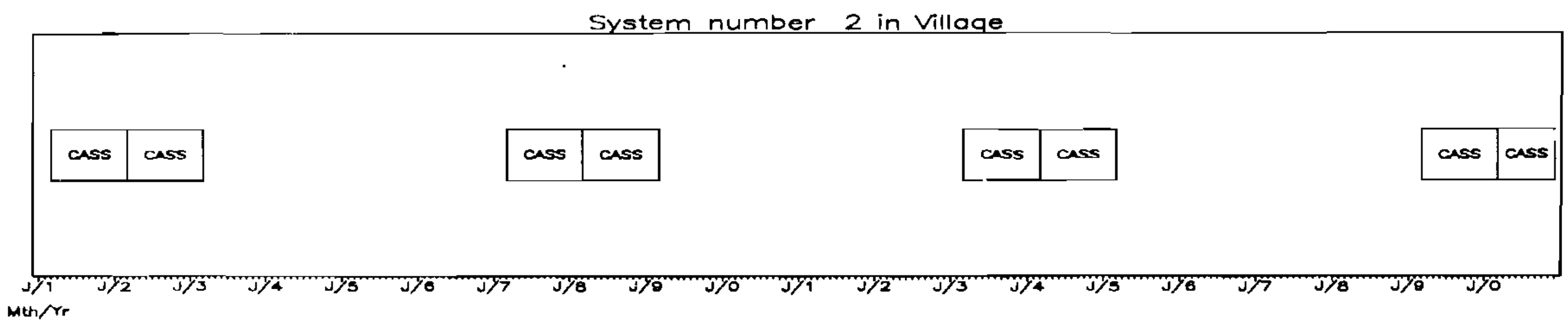
SYSTEM 2

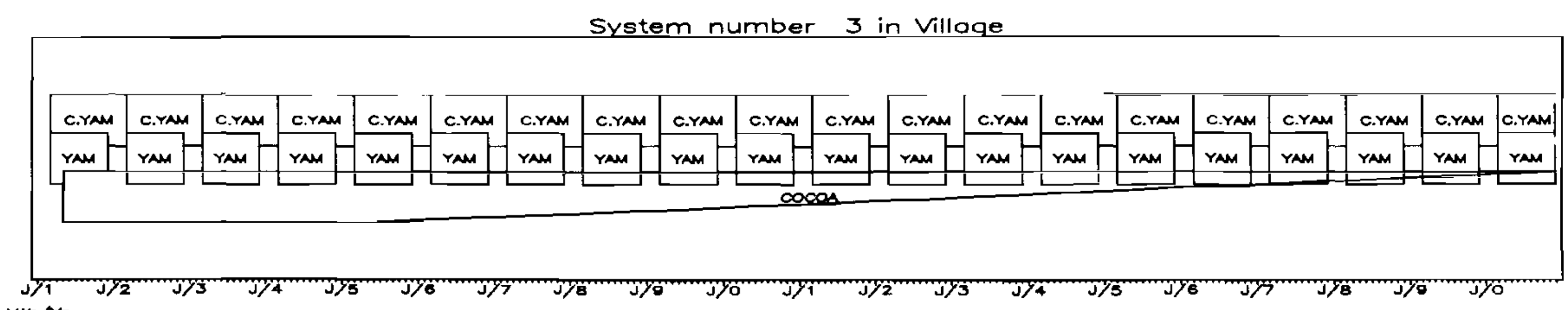
Land form = mixture of upland and lowland ; land location = residential area
Fallow period = 3 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = cassava ; peak planting month = March ; age at harvest = 12 months

SYSTEM 3

Land form = dry plain ; land location = nonresidential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = May ; age at harvest = 48 months
2nd crop = yams ; peak planting month =March ; age at harvest = 9 months
3rd crop = cocoyams ; peak planting month = March ; age at harvest = 12 months


System number 1 in Village
RICE
PLANTAIN
COCOA
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr


System number 2 in Village
CASS
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr


System number 3 in Village
C.YAM
YAM
COCOA
J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0 J/1 J/2 J/3 J/4 J/5 J/6 J/7 J/8 J/9 J/0
Mth/Yr

0137

Chart 35. Crop production systems in DOGBO village

Descriptive data

VILLAGE 138

Name = DOGBO Identification number = 38 Altitude = 160 meters
Lon. = 7.0700 degrees Lat. = 5.0667 degrees

Total annual rainfall = 2190 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 23.8 deg. cent.; temp. range = 6.5 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 49 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = consumer

CMB symptom severity score = 0 ; CGM symptom severity score = 3
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? Yes

Mean cassava root yield in village = 11.83 tons per hectare, number of fields = 3;
Mean field area (all crops)/household = 0.64 hectares;
Mean household size = 5.67, number of households = 10

Mean soil properties
NA

SYSTEM 2

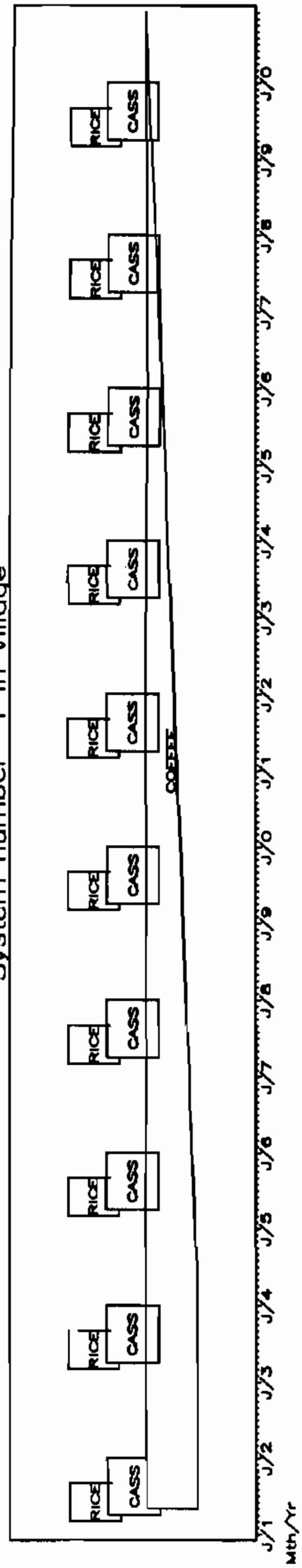
Land form = upper slope/upland ; land location = nonresidential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = March ; age at harvest = 6 months
2nd crop = cocoa ; peak planting month =April ; age at harvest = 36 months
3rd crop = plan. ; peak planting month = April ; age at harvest = 12 months
4th crop = cocoyams ; peak planting month = May ; age at harvest = 12 months
5th crop = cassava ; peak planting month = August ; age at harvest = 12 months

SYSTEM 3

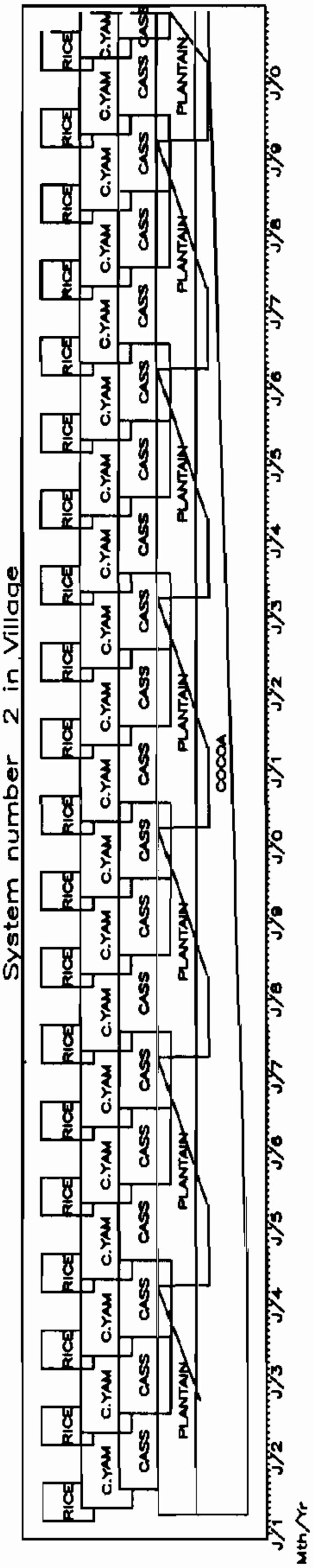
Land form = dry plain ; land location = nonresidential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = heaps
1st crop = yams ; peak planting month = March ; age at harvest = 9 months
2nd crop = cocoa ; peak planting month =April ; age at harvest = 36 months
3rd crop = cocoyams ; peak planting month = April ; age at harvest = 12 months
4th crop = plan. ; peak planting month = April ; age at harvest = 12 months
5th crop = cassava ; peak planting month = May ; age at harvest = 6 months

Coffee-based systems are not indicated

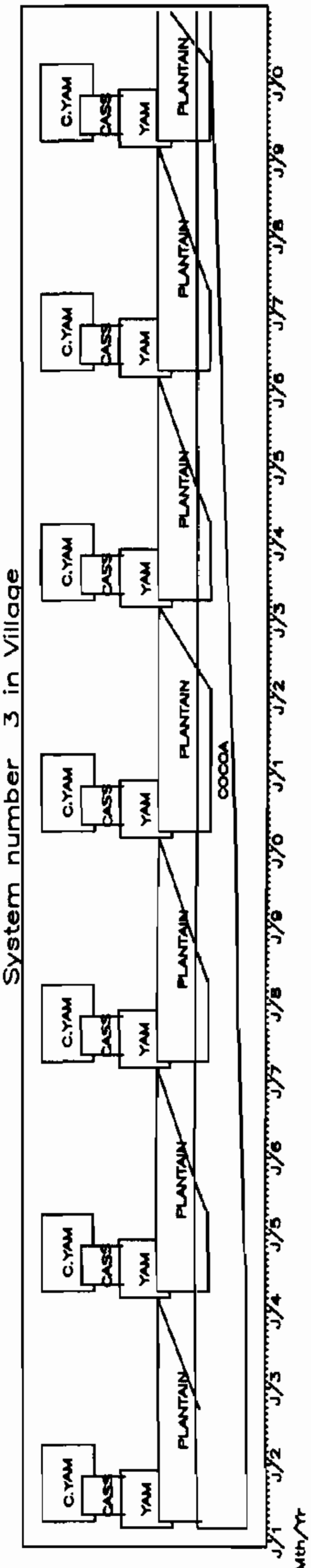
System number 1 in Village



System number 2 in Village



System number 3 in Village



0138

Chart 36. Crop production systems in MENEKE village

Descriptive data

——— VILLAGE ——— 139

Name = MENEKE Identification number = 39 Altitude = 40 meters
Lon. = 7.4300 degrees Lat. = 4.5167 degrees

Total annual rainfall = 2380 millimeters
Growing season : beginning = March ; length = 10 months
mean temp = 25.1 deg. cent.; temp. range = 5.4 deg. cent.
Climatic zone = Humid

Population density = 48 persons/sq km.
Distance to nearest city = 12 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = processor

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = 9 tons per hectare, number of fields = 2;
Mean field area (all crops)/household = 1 hectares;
Mean household size = 4.06, number of households = 7

Mean soil properties (No. of samples = 14)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 4.8571	Ca^{++} = 0.8714	Avail P = 1.6714	Ca^{++} = 0.5714
K^{+} = 0.0671	Mn^{++} = 0.0514	K^{+} = 0.0786	Mn^{++} = 0.03
Mg^{++} = 0.5143	Total N = 0.0913	Mg^{++} = 0.3	Total N = 0.1134
K:S ratio = 4.2901	Mg:K ratio = 10.5714	K:S ratio = 5.7778	Mg:K ratio = 5.7778
Mn:P ratio = 0.0137	N:P ratio = 0.0232	Mn:P ratio = 0.0197	N:P ratio = 0.0859
N:S ratio = 4.0934	Org. C = 0.9429	N:S ratio = 5.265	Org. C = 1.2
Org. matt = 1.6255	pH = 5.4143	Org. matt = 2.0688	pH = 4.5714
Sand = 72.5714	Silt = 12.2857	Sand = 59.1429	Silt = 12
S:P ratio = 0.0078	TEB = 1.7529	S:P ratio = 0.0216	TEB = 1.1357
Total S = 0.0252	BS = 67.539	Total S = 0.0248	BS = 40.671
Ca:Mg ratio = 1.6293	Ca:S ratio = 63.1139	Ca:Mg ratio = 1.7381	Ca:S ratio = 33.9473
Clay = 15.2857	C:N ratio = 10.2571	Clay = 29	C:N ratio = 10.3
Na^{+} = 0.3	ECEC = 2.61	Na^{+} = 0.1857	ECEC = 2.95
EPP = 2.6016	ESP = 11.6779	EPP = 2.4353	ESP = 7.2869
TEA = 0.8571		TEA = 1.8143	

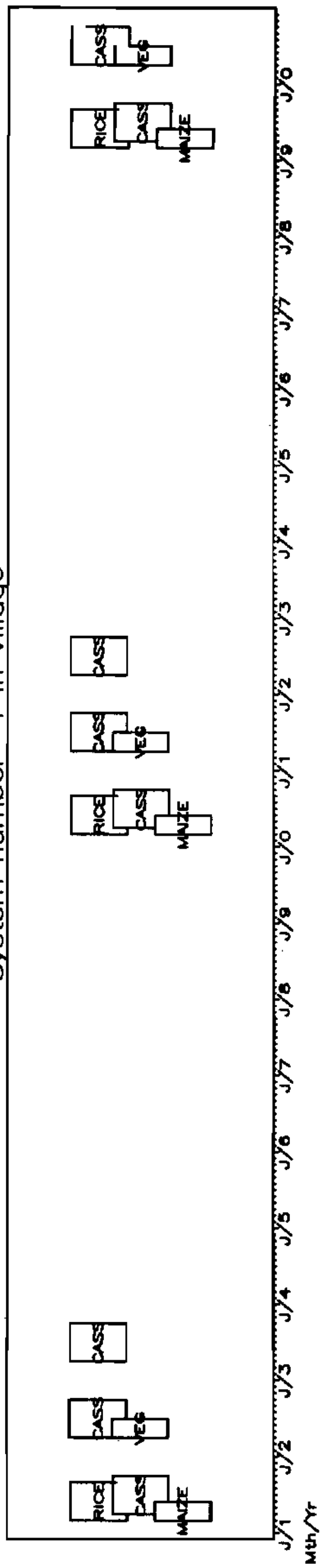
——— SYSTEM 1 ———

Land form = dry plain ; land location = nonresidential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = rice ; peak planting month = March ; age at harvest = 6 months
2nd crop = cocoa ; peak planting month =June ; age at harvest = 36 months
3rd crop = plan. ; peak planting month = June ; age at harvest = 10 months
4th crop = maize ; peak planting month = March ; age at harvest = 3 months

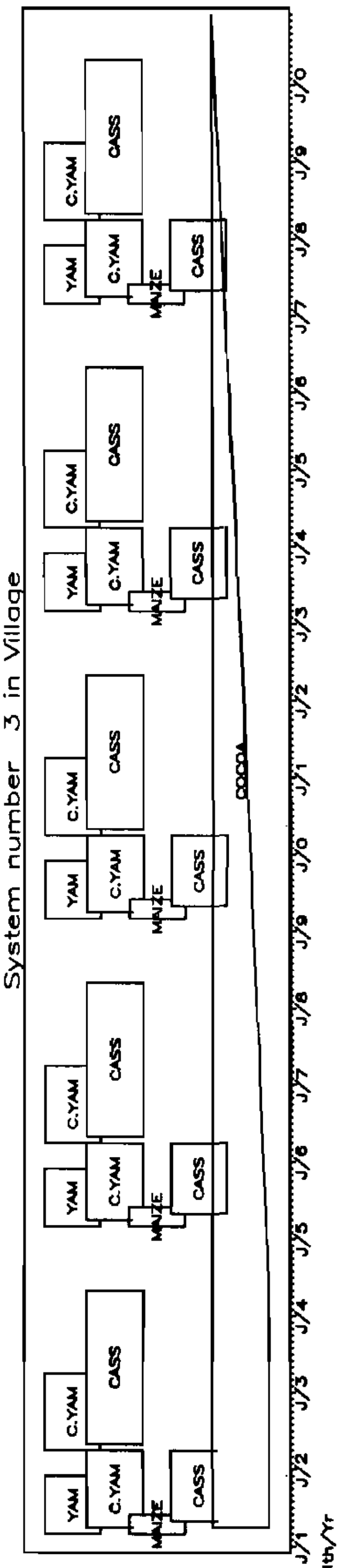
——— SYSTEM 3 ———

Land form = middle slope ; land location = nonresidential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = heaps
1st crop = yams ; peak planting month = March ; age at harvest = 9 months
2nd crop = cocoa ; peak planting month =April ; age at harvest = 36 months
3rd crop = cocoyams ; peak planting month = April ; age at harvest = 12 months
4th crop = maize ; peak planting month = March ; age at harvest = 3 months
5th crop = cassava ; peak planting month = May ; age at harvest = 12 months

System number 1 in Village



System number 3 in Village



0139

Chart 37. Crop production systems in GNITY village

Descriptive data

——— VILLAGE ——— 140

Name = GNITY Identification number = 40 Altitude = 50 meters
Lon. = 6.5200 degrees Lat. = 5.1000 degrees

Total annual rainfall = 1640 millimeters
Growing season : beginning = April ; length = 9 months
mean temp = 24.6 deg. cent.; temp. range = 6.7 deg. cent.
Climatic zone = Humid

Population density = 12 persons/sq km.
Distance to nearest city = 50 kilometers
Main market: distance = N/A ; access means = foot/head
Main cassava buyer = trader

CMB symptom severity score = 0 ; CGM symptom severity score = 2
ACMD symptom severity score = 0 ; CBB symptom severity score = 0

Cattle kept in village? No
Sheep/goats kept in village? Yes; Method = free range
Coffee grown in village? Yes
Cocoa grown in village? Yes
Oil palm grown in village? No

Mean cassava root yield in village = NA, number of fields = 0;
Mean field area (all crops)/household = 0.47 hectares;
Mean household size = 5.58, number of households = 10

Mean soil properties (No. of samples =9)

Depth = 0–20 cm		Depth = 20–40 cm	
Avail P = 5.825	Ca^{++} = 1.9	Avail P = 5.5	Ca^{++} = 1.18
K^{+} = 0.135	Mn^{++} = 0.1	K^{+} = 0.166	Mn^{++} = 0.188
Mg^{++} = 1.025	Total N = 0.099	Mg^{++} = 0.72	Total N = 0.0706
K:S ratio = 7.9428	Mg:K ratio = 13.25	K:S ratio = 4.8	Mg:K ratio = 4.8
Mn:P ratio = 0.0218	N:P ratio = 0.0199	Mn:P ratio = 0.0547	N:P ratio = 0.0193
N:S ratio = 8.9704	Org. C = 1.175	N:S ratio = 4.3104	Org. C = 0.51
Org. matt = 2.0257	pH = 5.75	Org. matt = 0.8792	pH = 5.54
Sand = 77	Silt = 10	Sand = 76.8	Silt = 8
S:P ratio = 0.0023	TEB = 3.285	S:P ratio = 0.0039	TEB = 2.426
Total S = 0.0108	BS = 82.7303	Total S = 0.0242	BS = 72.0175
Ca:Mg ratio = 1.9591	Ca:S ratio = 171.3721	Ca:Mg ratio = 2.06	Ca:S ratio = 116.5937
Clay = 13.25	C:N ratio = 12.85	Clay = 15.4	C:N ratio = 6.66
Na^{+} = 0.225	ECEC = 3.885	Na^{+} = 0.36	ECEC = 3.226
EPP = 3.4749	ESP = 5.7569	EPP = 5.1096	ESP = 11.3167
TEA = 0.6		TEA = 0.8	

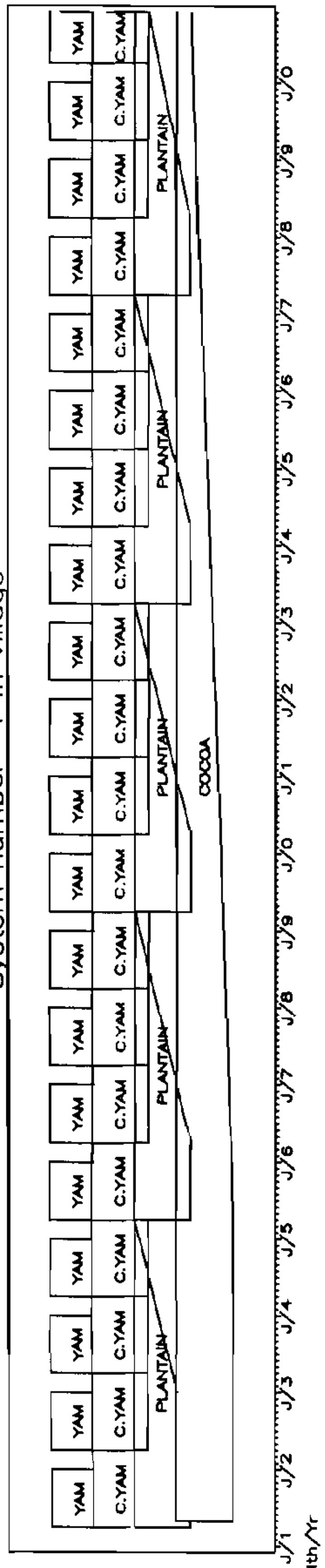
——— SYSTEM 1 ———

Land form = upper slope/upland ; land location = nonresidential area
Fallow period < 1 year ; vegetation at the end of fallow = N/A
Seedbed type = flat (no tillage)
1st crop = cocoa ; peak planting month = May ; age at harvest = 48 months
2nd crop = yams ; peak planting month =April ; age at harvest = 9 months
3rd crop = cocoyams ; peak planting month = April ; age at harvest = 12 months
4th crop = plan. ; peak planting month = April ; age at harvest = 12 months

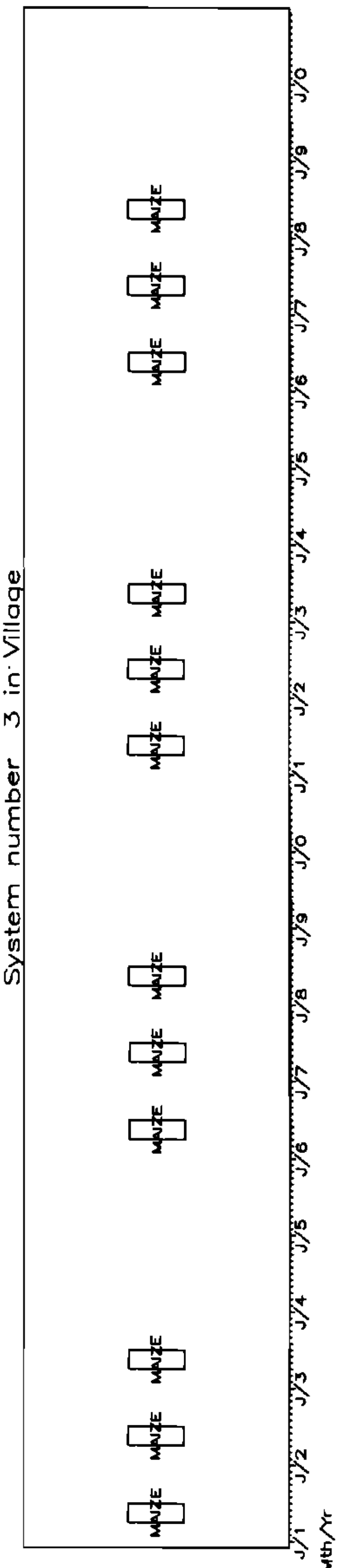
——— SYSTEM 3 ———

Land form = middle slope ; land location = nonresidential area
Fallow period = 2 years ; vegetation at the end of fallow = grass/trees/shrubs
Seedbed type = flat (no tillage)
1st crop = maize ; peak planting month = April ; age at harvest = 3 months

System number 1 in Village



System number 3 in Village



0140

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Although tree crop production was the main source of household cash income, cassava was the most important food crop, generating cash income for more households than any other food crop in the cassava-producing area. Cassava was the most important crop in terms of land area as well as in farmers' ranking of the crops; rice was next to cassava. Cassava land area was expanding in most places in response to an increasing population of immigrant tree crop workers.It was not, however, increasing around market centers where imported rice was easily available. Farmers were selecting local cassava cultivars for high root yield, low cyanogen level, large canopy for weed control, and for good processing qualities. Root yield was low in comparison with other countries because the cultivars were susceptible to major cassava plant pests/diseases. Intensified land-use practices such as purchased inputs were not adopted because of a low demand for cassava products arising from competition from imported rice. Cassava was commonly processed even though production was mostly with sweet cultivar types. Available improved processing technologies were not widely adopted because of the limited demand for cassava products.