African Crop Science Journal,Vol. 2. No.4, pp. 563-582, 1994
ISSN 1021-9730/94 $ 4.00
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# FARM LEVEL PRACTICES RELEVANT TO CASSAVA PLANT PROTECTION

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## ABSTRACT

**This paper is based on information collected during the Collaborative Study of Cassava in ten countries of Africa and considers the incidence of cassava mealybug (CMB) and green mite (CGM) pests and African cassava mosaic virus (ACMD) and bacterial blight (CBB) diseases of cassava in relation to farm practices. African cassava mosaic disease was the most widespread of the four problems assessed and was observed in almost all the representative villages in West Africa. Cassava mealybug was the least widespread, although the incidence was relatively high in Nigeria, Malawi and Tanzania. Cassava greenmite was most widespread in the countries of eastern and southern Africa, whereas CBB was widespread in Nigeria and Uganda. The problems of CGM, ACMD and CBB were not higher in any other climate zone, than in the humid climate zone, while those problems were not less severe in any other climate zone than in the subhumid climate.While the incidences of the various pests and diseases varied between villages which used and others which did not use purchased inputs, symptom severity scores of most of the problems were lower in villages where the purchased inputs were used. In Nigeria where improved varieties were mostly used, the symptom severity scores of all four pest/disease problems were lower for the improved varieties that had been released in the 1970s than for the local land races. Similarly, based on information from the ten countries, the symptom severity scores of the four problems were lower among villages which had easy access to a market than in other villages. The symptom severity scores of the four problems were lower when cassava was grown in rotation with other crops than in other situations. The problems were also lower under continuous cultivation systems although the reason is not clear. There was a high rate of turnover in the land races grown and susceptibility to pests and diseases was one of the most frequently mentioned reasons for this.**

*Key Words:* **Africa, cassava bacterial blight, fallow, green mite, marketing, mealybug, mosaic virus disease, pests, rotation**

## RÉSUMÉ

**Cet article est basé sur une étude menée à large échelle par l'Etude Collaborative du Manioc en Afrique (COSCA) dans 10 pays d'Afrique. Il traite de l'incidence des infestations de la cochenille farineuse (CMB) et de l'acarien vert (CGM), ainsi que des degâts dus au virus de la mosaïque africaine du manioc (ACMD) était le plus répandu de quatre pestes et maladies rencontrées dans presque tous les villages représentatifs de l'Afrique de l'Ouest. La cochenille farineuse (CMB) était la peste la moins répandue, quoique son incidence était relativement élevé au Nigeria, au Malawi et en Tanzanie. L'acarien vert était plus répandu dans les pays de l'Afrique de l'Est, alors que la bactériose du manioc était répandue au Nigeria et en Uganda. Les dégâts dus a l'acarien vert, au virus de la mosaïque africaine du manioc et à la bactériose du manioc n'étaient plus élevés dans aucune autre zone climatique que dans la zone humide; tandis que ces dégâts n'étaient moins sévères dans aucume autre zone climatique que dans la zone subhumide. Alors que l'incidence de différentes pestes et maladies variaient entre les villages qui avaient et ceux qui n'avaient pas utilis´s les facteurs de production extérieurs, les scores de sévérité des symptômes de la plupart des**

**degâts étaient plus bas dans les villages où les facteurs de productio extérieurs étaient utilis´s. Au Nigeria où les varieétes améliorées étaient le plus utilisés, les scores de s´v´rité des symptômes de toutes les quatre pestes et maladies étaient plus bas pour les variétés améliorés lesquelles avaient été introduites dans les annés 1970 que pour les variétes locales. La même étude dans les dix pays a révelé que les scores de sévérite des symptômes de quatre pestes et maladies étaient plus bas dans les villages qui avaient un accès facile à un marché que dans d'autres villages. Les scores de sévérité des symptômes de quatre pestes et maladies étaient plus bas lorsque le manioc était cultivé en rotation avec d'autres cultures. Les dégâts étaient aussi moins sévères en système de culture continue quoique la raison ne soit pas claire. Le taux d'abandon de variétés locales cultivées était élevé et leur susceptibilité aux pestes et maladies était la raison la plus fréquemment citée.**

***Mots Clés:*** **Manioc, Afrique, pestes, maladies, cochenille farineuse, acarien vert, bacteriose du manioc, mosaïque, pratiques culturales, commercialisation, jachère, rotation**

## INTRODUCTION

It is probably true that cassava(*Manihot esculenta* Crantz) is more tolerant of adverse conditions than other food crops grown in Africa. Total failure of a cassava crop is rare and at least some yield is obtained even on marginal soil or under drought conditions. It was originally considered that cassava was not attacked by many pests or disease in Africa, but increasingly these are being recognised as problems of economic importance. The smallholders do not usually attempt to control the problems with pesticides because of limited access to such chemicals and because cassava has low value per unit weight. Yet, the area of cassava grown continues to increase (Nweke *et al.*, 1993), which suggests that certain production practices make at least some contribution to cassava plant protection. Moreover, varieties bred for resistance to several of the problems are being made available to farmers in many countries (Mahungu *et al.*, 1994).

The objective of this paper is to assess the incidences of key pests and diseases in Africa in relation to farm level conditions, practices and market circumstances. The emphasis is on two pests, cassava mealybug (CMB) and cassava green mite (CGM), and two diseases, African cassava mosaic virus disease (ACMVD) and cassava bacterial blight (CBB), because of their economic significance. The paper is based on information collected between 1989 and 1991 during the Collaborative Study of Cassava in Africa (COSCA), which was funded by the Rockefeller Foundation.

The paper is based on the premise that farmers manipulate cultural practices rather than use pesticides to achieve at least partial control of pests and diseases. The paper does not, however, attempt to test this hypothesis in a biologically scientific sense. The paper is based on information 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 farmers' practices or their socio-economic 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, as discussed by many other contributors to this volume including Fabres *et al.* (1994 ) who argue the need for an holistic approach to the whole complex of cassava pests and diseases. 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.

## METHOD OF THE COSCA STUDY

**Sampling .** Climate, demographic pressure and market infrastructure formed the bases for sampling (Carter and Jones, 1989). Four zones were distinguished:- (1) *lowland humid*: growing season daily mean temperature (GSDT) above 22°C, temperature range of less than 10°C and less than four months of dry season (a dry month is considered to be one with a total rainfall of up to 60 mm); (2) *highland humid*: GSDT below 22°C, a range of less than 10°C and less than four months of dry season; (3) *sub-humid*: GSDT above 22°C, a range of 10°C and four to six months of dry season; and (4) *non-humid*: GSDT above 22°C, a range exceeding 10°C and four to nine months of dry season.

All-weather roads, railways and navigable rivers were derived from the 1987 Michelin travel maps and used to create a market access infrastructure map of the areas to be surveyed. This map was divided into 'good' and 'poor' zones according to accessibility. Unpublished population data from the United States Census Bureau as projected forward to 1990, were used to calculate population densities and create a population map of Africa. This was divided into 'high' and 'low' demographic pressure zones, the former comprising areas with 50 or more persons per square kilometre.

The three maps of climate, population density and market access infrastructure were overlaid to create zones of homogeneous climatic, demographic and market conditions within the cassava producing areas. Each climate/population/market zone with less than 10,000 ha of cassava in each country was excluded from the survey as being unrepresentative. The remaining areas which formed the potential survey regions were divided into grids of cells 12' latitude by 12' longitude to form the sample frame for site selection. In each country, grid cells were selected at random from among the climate/population/market zones. The number selected was in proportion to the size of the country and ranged from 30 in Ghana to 71 in Zaire.

One village was selected, by a random method, within each of the grid cells and the number in each country is presented in Table 1. In each selected village, a list of farm households was compiled and grouped into large, medium, and small farm units, with the assistance of key informants. Atypically large farm units of 10 ha or more of all crops were excluded. One farm unit was selected randomly from each stratum. Information was taken from all the fields of such selected farmers.

**Data collection.** The COSCA survey was conducted in phases. For Phase I, a rapid rural appraisal technique was employed in ten countries:- Côte d'Ivoire, Ghana, Nigeria, Zaire, Burundi, Kenya, Malawi, Tanzania, Uganda and Zambia. Farmer groups consisting of men and women of diverse age were constituted and interviewed in each selected village, which was the unit of analysis. The groups in each village were interviewed to obtain qualitative information on the following aspects among many others: (1) The cassava land races grown currently and previously; if in the past why the land race is no longer grown and which year it was abandoned; if currently grown, when it was first grown and its advantages. (2) The cropping systems adopted in the village, in the sense of a system of intercropping, crop rotation and fallow management. (3) Market conditions including distance from and means of travelling to the markets. (4) The most common buyer of the cassava:- consumers or middlemen. (5) Land tenure systems.

After the interview meetings, the investigators visited a statistically representative sample of cassava fields once between six and twelve months after planting. The investigators scored a representative sample of cassava plants of each available land race for symptom severities of cassava mealybug (CMB), cassava green mite (CGM), African cassava mosaic disease (ACMD) and cassava bacterial blight (CBB) on a scale ranging from zero for no symptoms to four for the most severe symptoms. Different land races were often grown in the same field. Each land race was assessed in all the representative fields in which it was observed. Nine land races were assessed in a village except where fewer than nine were available. The number of plants scored per land race varied depending on the judgement of the experienced national scientist investigators involved. The modal score for each problem was then assigned for each land race. 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. The investigators who are leaders in cassava research in the National Agricultural Research System in each country and who administered the survey instruments, are very knowledgeable in the cassava production systems of their countries and so are well qualified to collect such information.

Phase II of the COSCA study was conducted in six of the original ten countries:- Côte d'Ivoire, Ghana, Nigeria, Zaire, Tanzania and Uganda. It aimed at a detailed characterisation of the cassava production methods. The information collected included, crops cultivated, purchased inputs used and cultural practices adopted.

**Data analysis.** Incidence data for each land race are based on 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. The analytical method consisted of estimation, in the framework of ANOVA for unbalanced data, of the probability level of significance of the differences in the means of the incidence or symptom severity of each problem under different farm practices and village market access circumstances.

## DISTRIBUTION OF EACH PEST AND DISEASE PROBLEM

**Overall.** Cassava mealybug was observed in 23% of the 463 villages surveyed and in 8% of the 2808 land races (Table 1). The mean severity score of the land races affected was 1.8 (Table 2) and the score was 2 or less for 77% of the land races.

Cassava green mite symptoms were observed in 53% of the villages and in 28% of the land races (Table 1). The mean symptom severity score was 1.7 for the land races affected (Table 2) and 2.0 or less for 84% of the land races.

African cassava mosaic disease symptoms were observed in 66% of the villages and in 29% of the land races (Table 1). The mean symptom severity score was 1.9 (Table 2) and the mean was 2.0 or less for 75% of the land races.

Cassava bacterial blight was observed in 32% of the 463 villages and in 12% of the land races (Table 1). Those which showed symptoms had a mean severity score of 1.5 (Table 2). The score was 2.0 or less in more than 87% of the land races.

African cassava mosaic disease was the most widespread of the four problems and symptom severity scores of 2.0 and above were observed on more land races than for any other problem. The disease has been known since 1894 and it has been studied since the 1930s (Hahn and Keyser, 1985; Thresh *et al.*, 1994a, 1994c). 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).

Cassava mealybug, CGM and CBB have a very

TABLE 1. Incidences of the four major cassava pests/diseases in the villages and land races assessed in each of the ten phase 1 COSCA countries 1989-91

| Country | No. assessed | | % villages (landraces) affected | | | |
|---|---|---|---|---|---|---|
| | Villages | Landraces | CMB | CGM | ACMD | CBB |
| Cote d'Ivoire | 40 | 271 | 5 (2) | 7 (3) | 95 (42) | 24 (5) |
| Ghana | 30 | 175 | 7 (3) | 7 (2) | 100 (43) | 10 (5) |
| Nigeria | 65 | 361 | 57 (16) | 31 (9) | 89 (33) | 86 (28) |
| Zaire | 71 | 385 | 24 (10) | 59 (38) | 68 (44) | 45 (27) |
| Tanzania | 39 | 308 | 33 (11) | 92 (51) | 72 (27) | 23 (7) |
| Uganda | 40 | 280 | 5 (2) | 100 (49) | 64 (30) | 72 (27) |
| Burundi | 39 | 179 | 5 (1) | 49 (31) | 8 (3) | 0 (0) |
| Malawi | 67 | 423 | 34 (18) | 49 (22) | 40 (11) | 6 (1) |
| Kenya | 34 | 184 | 6 (1) | 59 (24) | 65 (25) | 6 (1) |
| Zambia | 38 | 235 | 15 (4) | 57 (40) | 68 (32) | 13 (4) |
| All 10 countries | 463 | 2801 | 23 (8) | 53 (28) | 66 (29) | 32 (12) |

N = number of land races assessed; CMB = cassava mealybug; CGM = cassava green mite; ACMD =African cassava mosaic disease; and CBB = Cassava bacterial blight

TABLE 2. Mean symptom severity (1-4 scores) for four major cassava plant pests/diseases by country

| Country | CMB | | CGM | | ACMD | | CBB | |
|---|---|---|---|---|---|---|---|---|
| | N | Score | N | Score | N | Score | N | Score |
| Côte d'Ivoire | 5 | 1.2 | 7 | 1.1 | 114 | 2.0 | 14 | 1.7 |
| Ghana | 5 | 2.4 | 3 | 2.0 | 76 | 2.2 | 8 | 1.0 |
| Nigeria | 57 | 1.5 | 37 | 1.1 | 118 | 1.4 | 100 | 1.2 |
| Zaire | 38 | 2.3 | 148 | 2.1 | 170 | 2.4 | 104 | 1.8 |
| Tanzania | 35 | 1.8 | 157 | 1.3 | 88 | 1.3 | 22 | 1.1 |
| Uganda | 5 | 1.0 | 136 | 1.7 | 83 | 2.7 | 79 | 1.6 |
| Burundi | 2 | 1.0 | 56 | 1.2 | 5 | 2.2 | 0 | - |
| Kenya | 2 | 1.5 | 44 | 1.5 | 46 | 1.7 | 2 | 1.5 |
| Malawi | 74 | 1.8 | 94 | 1.8 | 47 | 1.7 | 3 | 1.3 |
| Zambia | 10 | 1.5 | 95 | 2.2 | 76 | 1.6 | 9 | 1.4 |
| All 10 countries | 233 | 1.8 | 772 | 1.7 | 823 | 1.9 | 341 | 1.5 |

N = number of land races affected
Score= mean for plants with symptoms (score of 1 or more)

different history as they are recent introductions and were first reported in Africa only about 20 years ago (Nyira, 1972; Hahn *et al.*, 1981; Yaninek, 1994). The COSCA results showed CMB to be the least widespread of the four problems and CMB symptom severity scores of 2.0 and above were observed in relatively few villages compared with CGM and CBB. This can be explained by the fact that before the survey, IITA in collaboration with other international research agencies and African national programmes had brought CMB under control by releasing, beginning in 1981, an insect parasitoid *Epidinocarsis lopezi* (Herren *et al.*, 1987; Neuenschwander *et al.*, 1994). Although CBB was more widespread than CMB, symptom severity scores above 2.0 were recorded in fewer villages than for CMB.

**Differences between countries.** The incidence of cassava mealybug was relatively high in Nigeria, Zaire, Malawi and Tanzania and low in Côte d'Ivoire, Uganda, Burundi, Kenya and Ghana (Table 1). Symptom severity scores were highest in Ghana and Zaire and lowest in Uganda and Burundi (Table 2).

Cassava green mite was more widespread in Zaire and the countries of eastern and southern Africa than in those of West Africa (Table 1). However, mean symptom severity scores for the land races that were infested exceeded 2.0 only in Zambia and Zaire (Table 2).

African cassava mosaic disease was observed in almost all the villages assessed in West Africa. The disease was less common in those of Central, East and southern Africa, with the exception of Uganda (Table 1). The incidence was particularly low in Burundi, although the mean symptom severity score for the land races infected exceeded 2.0 there and also in Uganda, Ghana and Zaire (Table 2).

Cassava bacterial blight was widespread in Nigeria, Zaire and Uganda, but it was found in relatively few or in no villages of Burundi, Malawi, Kenya, Ghana and Zambia (Table 1).

**Differences between climatic zones.** Cassava mealybug damage was not observed in any land race assessed in the highland humid zone and was higher in the sub-humid zone than elsewhere (Table 3). Symptom severity scores for CMB were similar in each of the three climatic zones where the disease was recorded (Table 3).

The incidence of CGM was higher in the highland humid zone than in each of the other climate zones (Table 3). The differences between the other climate zones were not significant. By contrast, the symptom severity score was significantly less in the sub-humid zone than elsewhere and was highest in the non-humid climate zone.

The incidence of ACMD was lowest in the highland humid zones. The symptom severity

TABLE 3. Symptom severity (1-4) scores by climate zone for the four major casava pests/diseases in ten Phase I COSCA countries

| Pest/disease Climate zone | No. of land races assessed | No. (%) of land races affected | | Mean symptom score | Probability levels of significance of difference | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 by 2 | 1 by 3 | 1 by 4 | 2 by 3 | 2 by 4 | 3 by 4 |
| **CMB** | | | | | | | | | | |
| 1. HL humid: | 205 | 0 | (0) | - | - | - | - | - | - | - |
| 2. LL humid: | 863 | 57 | (7) | 1.75 | - | - | - | - | - | - |
| 3. Subhumid: | 789 | 105 | (13) | 1.77 | - | - | - | - | - | - |
| 4. Nonhumid: | 812 | 66 | (8) | 1.74 | - | - | - | - | - | - |
| **CGM** | | | | | | | | | | |
| 1. HL humid: | 205 | 74 | (36) | 1.73 | - | ** | - | - | - | - |
| 2. LL humid: | 863 | 201 | (23) | 1.74 | - | - | - | *** | - | - |
| 3. Subhumid: | 789 | 207 | (26) | 1.52 | - | ** | - | *** | - | *** |
| 4. Nonhumid: | 812 | 234 | (29) | 1.81 | - | - | - | - | - | *** |
| **ACMD** | | | | | | | | | | |
| 1. HL humid: | 205 | 36 | (18) | 2.28 | - | *** | *** | - | - | - |
| 2. LL humid: | 863 | 331 | (38) | 2,23 | - | - | - | *** | *** | - |
| 3. Subhumid: | 789 | 206 | (26) | 1.68 | - | *** | - | *** | - | * |
| 4. Nonhumid: | 812 | 204 | (25) | 1.54 | - | - | *** | - | *** | * |
| **CBB** | | | | | | | | | | |
| 1. HL humid: | 205 | 36 | (18) | 1.78 | - | *** | ** | - | - | - |
| 2. LL humid: | 863 | 164 | (19) | 1.54 | - | - | - | *** | - | - |
| 3. Subhumid: | 789 | 90 | (11) | 1.30 | - | *** | - | *** | - | - |
| 4. Nonhumid: | 812 | 47 | (6) | 1.40 | - | - | ** | - | - | - |

*** Pr $\leq$ 0.01; ** 0.05 $\geq$ Pr > 0.01; * 0.10 $\geq$ Pr > 0.05

scores were significantly higher in the two humid zones than elsewhere (Table 3).

For CBB the incidence was lower outside the humid zone than within (Table 3). The symptom severity score was lowest in the sub-humid zone. The differences were highly significant between the humid and non-humid zones.

The symptom severity scores for CGM, ACMD and CBB were similar in both the highland and lowland humid zones (Table 3). The symptom severity scores of ACMD and CBB were highest in the humid zone, while that of the CGM was highest in the non-humid zone. However, the symptom severity score for CGM was not statistically higher in the non-humid than in the humid zones. Therefore, the problems of CGM, ACMD, and CBB were not higher in any other climate zone than in the humid one.

The symptom severity score for CGM was lowest in the sub-humid zone, whereas scores for CBB were similar in the sub-humid and non-humid zones. Hence, these problems were not less severe in any other climate zone than in the sub-humid one.

Cassava bacterial blight is more widespread and severe in the savannah 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 five months CBB is not a major problem, whereas CMB is. Cassava bacterial blight is widespread in savannah areas where rainfall exceeds 1500 mm (Mabanza, 1981).

The differences in the symptom severity scores of the common cassava pests/diseases were reflected in the levels of cassava root yield in the various climate zones. Yields were highest in the sub-humid zone and marginally higher in the lowland humid than in the non-humid zone (Table 4). However, the differences in the severities of the pest/disease problems were not reflected in the extent of cassava cultivation in the various zones. Cassava was more widely grown in the humid zones where it occupied 35% of the total

TABLE 4. Cassava root yield components by climate zone in the six COSCA Phase II countries

| Climate zone | | Fresh root ($t\ ha^{-1}$) | Plant density ($stds\ ha^{-1}$) | Average root wt (kg) | No. of roots $plant^{-1}$ |
|---|---|---|---|---|---|
| HIGHLAND HUMID | Minimum | 0.4 | 1000 | 0.08 | <0.1 |
| n = 33 | *Mean* | *10.6* | *3096* | *0.36* | *3.4* |
| | Maximum | 28.4 | 8750 | 0.72 | 9.0 |
| | Std Deviation | 7.0 | 2134 | 0.16 | 1.7 |
| LOWLAND HUMID | Minimum | 0.8 | 500 | 0.11 | <0.1 |
| n = 210-212 | *Mean* | *12.0* | *7489* | *0.44* | *2.5* |
| | Maximum | 52.5 | 33750 | 5.08 | 25.0 |
| | Std Deviation | 8.1 | 5303 | 0.40 | 3.0 |
| SUB-HUMID | Minimum | 1.3 | 750 | 0.05 | <0.1 |
| n = 176 | *Mean* | *13.9* | *9605* | *0.39* | *1.9* |
| | Maximum | 74.1 | 41250 | 1.39 | 9.0 |
| | Std Deviation | 8.8 | 5506 | 0.23 | 1.5 |
| NON-HUMID | Minimum | 1.2 | 1250 | 0.06 | <0.1 |
| n = 54 | *Mean* | *11.2* | *6146* | *0.32* | *2.4* |
| | Maximum | 57.2 | 14000 | 0.85 | 14.0 |
| | Std Deviation | 9.8 | 3664 | 0.22 | 2.6 |

n = number of fields assessed in Côte d'Ivoire, Ghana, Nigeria, Zaire, Tanzania and Uganda

staple crop field area than outside the humid areas; it occupied 25% of the staple food crop area in the sub-humid and 15% in the non-humid zones (Fig. 1). In the humid zone, cassava production was driven by population growth, while in the non-humid zones it was driven more by market demand (Nweke, 1994). Stoorvogel and Fresco (1991) postulated that the distribution of cassava is primarily a function of population density rather than of agro-ecological conditions.

## PURCHASED INPUTS

**Use of purchased inputs.** The purchased input most widely used in producing staple crops in the six countries of the Phase II COSCA survey was

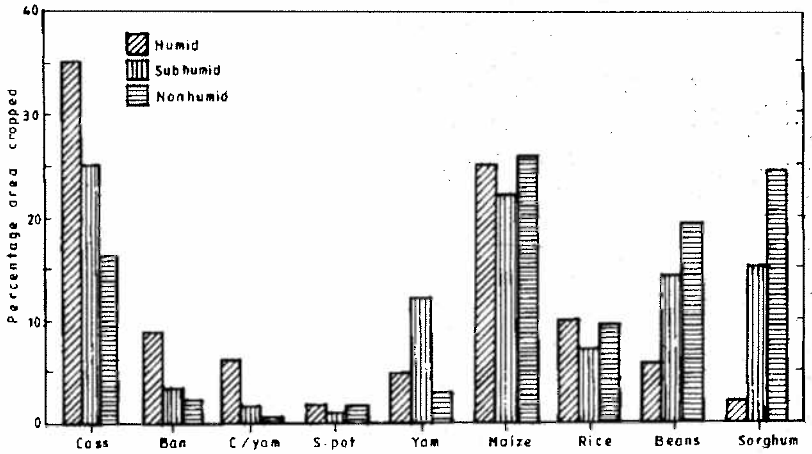


Figure 1. Relative importance (field area) of cassava by climate zone. Cass = Cassava; ban = bananas and plantains, C/yams = cocoyam, S.pot = sweet potato, Sorghum = sorghum and millet

hired labour which was used on 41% of the fields assessed. Chemical fertilizers were used on only 5% of farms. As mentioned earlier, pesticides are seldom used in the production of staple food crops in Africa. 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. The use of purchased inputs indicates the extent of commercial production in an area and not on specific farms. Thus the discussions do not necessarily refer to the effects of the inputs used in particular fields on pest/disease incidence.

**Chemical fertilizers.** The proportion of fields receiving fertilizer was below the overall average of 5% for all crops for cassava (3%), banana/plantains (2%) and sweet potato (0%); the proportion was relatively high for rice (11%), maize (15%) and especially yam (20%). Thus cassava and several other staple crops were low input and only one or two other crops can be considered high input ones using this criterion.

The incidences of CMB, ACMD and CBB were higher and the incidence of CGM was lower in villages where chemical fertilizers were used compared with other villages (Table 5). The symptom severity scores of ACMD, CGM and CBB were, however, statistically lower in villages where chemical fertilizers were used than elsewhere (Table 6). Ambe-Tumante (1980) reported that soil nutrients, particularly N, P and Na, were significantly associated with the severity of ACMD. By contrast, in the COSCA study

TABLE 5. Incidences of four major cassava plant pests/diseases by farming conditions and practices in the ten Phase 1 COSCA countries (unless otherwise stated)

| Farming conditions/practices as discussed in text | | No. of land races assessed | % land races affected | | | |
|---|---|---|---|---|---|---|
| | | | CMB | CGM | ACMD | CBB |
| Inorganic fertilizer²/: | Used | 307 | 14 | 21 | 35 | 19 |
| | Not used | 1182 | 5 | 24 | 33 | 14 |
| Hired labour²/: | Used | 1046 | 9 | 28 | 35 | 19 |
| | Not used | 443 | 4 | 13 | 31 | 7 |
| Improved variety³/: | Used | 49 | 20 | 4 | 73 | 71 |
| | Not used | 93 | 50 | 26 | 62 | 63 |
| Market access¹/: | Good | 473 | 12 | 26 | 33 | 13 |
| | Poor | 307 | 13 | 33 | 39 | 18 |
| Cassava marketing channel¹/: | Middlemen | 857 | 9 | 19 | 31 | 14 |
| | Consumer | 1944 | 8 | 31 | 29 | 11 |
| Farmland holding unit¹/: | Nuclear family | 1493 | 7 | 28 | 29 | 14 |
| | Whole community | 735 | 14 | 27 | 26 | 9 |
| Cropping pattern¹/: | Intercropped | 1870 | 10 | 31 | 34 | 15 |
| | Sole cropped | 726 | 5 | 18 | 19 | 8 |
| Crop rotation¹/: | Practised | 1287 | 8 | 29 | 25 | 11 |
| | Not practised | 1041 | 9 | 29 | 38 | 14 |
| Bush burning²/: | Practised | 1195 | 7 | 18 | 38 | 14 |
| | Not practised | 294 | 9 | 46 | 21 | 19 |

¹/: All 10 Phase I COSCA countries
²/ : 6 Phase II COSCA countries
³/: Nigeria only

there was no statistical difference in the symptom severity score of CMB between 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 containing clay retained enough water for adequate cassava growth. Conversely, sandy soils in the savannah, 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 favoured in two ways: (1) remobilisation of amino acids from wilting leaves increases the nutritional value of the phloem sap on which CMB feeds, and (2) reduced nitrogen supply might disrupt the production of chemicals such as

TABLE 6. Symptom severity scores (1-4 scale) for four major cassava pests/diseases by farming conditions and practices in the ten Phase 1 COSCA countries (unless otherwise stated)

| Farming conditions/ practices as discussed in text | CMB | | | CGM | | | ACMD | | | CBB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | t-test | N | Mean | t-test | N | Mean | t-test | N | Mean | t-test |
| Inorganic fertilizer: 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 labour: 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 | 46 | 1.96 | (p=0.003) | 24 | 1.54 | (p=0.001) | 58 | 1.86 | (p=0.002) | 59 | 1.90 | (p=0.001) |
| 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 mkting channel:¹ | | | | | | | | | | | | |
| Middlemen | 79 | 1.68 | 0.78 | 162 | 1.59 | 1.98 | 268 | 2.01 | -1.21 | 121 | 1.30 | 4.02 |
| Consumer | 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 | | | | | | | | | | | | |
| Ind. 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) |
| Cropping pattern: ¹/ | | | | | | | | | | | | |
| Intercropped | 187 | 1.80 | -1.8467 | 584 | 1.73 | -3.838 | 635 | 2.01 | -2.2245 | 272 | 1.50 | 0.3856 |
| Sole cropped | 39 | 1.51 | (p=0.066) | 133 | 1.45 | (p<0.001) | 139 | 1.81 | (p=0.026) | 59 | 1.51 | (p=0.700) |
| Crop rotation: ¹/ | | | | | | | | | | | | |
| Practised | 100 | 1.70 | 0.9102 | 379 | 1.58 | 4.2044 | 319 | 1.88 | 3.0869 | 134 | 1.49 | 1.0995 |
| Not practised | 98 | 1.82 | (p=0.363) | 295 | 1.82 | (p<0.001) | 393 | 2.10 | (p=0.002) | 166 | 1.59 | (p=0.282) |
| Bush burning: ²/ | | | | | | | | | | | | |
| Practised | 80 | 1.75 | -3.2760 | 217 | 1.63 | -4.4623 | 439 | 2.01 | -4.7676 | 170 | 1.47 | 3.0969 |
| Not practised | 25 | 1.24 | (p=0.002) | 135 | 1.32 | (p<0.001) | 62 | 1.42 | (p<0.001) | 57 | 1.40 | (p=0.002) |

N = number of land races affected
¹/ = all 10 Phase 1 COSCA countries
²/ = 6 Phase II COSCA countries
³/ = Nigeria only

cyanide and latex by the cassava plant (Neuenschwander *et al.*, 1990).

**Hired labour.** Hired labour was employed for one or more farm tasks in 41% of the fields of the major food crops including cassava. The proportion was highest for yam (67%) and lowest for sweet potato (19%) and close to the overall average for cassava (40%).

The incidences of all pest/disease problems were lower in villages which used hired labour than in those which did not (Table 5). The statistical relationships between the use of hired labour and the symptom severity of the various pests/diseases (Table 6) 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 labour was used than elsewhere. The main difference was that the probability levels of significance were lower for the relationships of the pests/diseases with use of hired labour than with use of chemical fertilizers.

These discussions do not necessarily imply cause and effect relationships because of the interactions among the various variables. For example, there was considerable overlap between uses of chemical fertilizers and hired labour. Hired labour was used in all villages where chemical fertilizers were used in food crop production, although the reverse was not necessarily true.

## IMPROVED CASSAVA VARIETIES

**Phase I Survey.** The farmer groups were asked to indicate the relative number (none, few, many or most) of the farmers in the village who were cultivating improved cassava varieties. It was established that in 1989 the improved cassava varieties were available in nearly 90% of the 65 villages sampled in Nigeria. Many or most of the farmers grew the improved varieties in *c.* 60% of the villages. Outside Nigeria relatively small proportions of farmers were growing improved varieties at the time (Nweke *et al.*, 1994).

In the 1960s, some improved cassava varieties were released by the Nigerian National Agricultural Research System (NARS) and more were released in the mid-1970s, some by the NARS, but mostly by the International Institute of Tropical Agriculture (IITA), Ibadan. The varieties released in the 1960s were no longer easily distinguished from a wide range of local land races. Hence, improved varieties are here defined as bred varieties which were released since the 1970s.

**Phase II Survey.** It was observed that in the humid climate zone of Nigeria, *c.* 60% of the cassava land area carried improved cassava varieties compared with *c.* 35% in the sub-humid and *c.* 40% in the non-humid areas sampled. These data are consistent with other studies. In an earlier 1984 survey of a humid forest area of southwestern Nigeria, 80% of the cassava land area was planted with improved varieties (Nweke *et al.*, 1988). In the sub-humid zone of southeast Nigeria, Ezedinma (1989) estimated that 29% of the cassava area was planted with such varieties. In 1985, a team of agricultural scientists assessed the impact of these varieties in Oyo State of southwest Nigeria which is mostly in the sub-humid climate zone. It was estimated that 54% of the farmers planted IITA improved cassava varieties which occupied 63% of the cassava land area (Akoroda *et al.*, 1989).

The incidence and symptom severity scores of the various pests/diseases discussed here are based exclusively on the Nigerian data for 93 local land races and 49 improved varieties assessed in 976 fields in the 61 villages assessed. Therefore, the comparisons are on a limited but more precise set of information than the assessment of the effects of the other inputs or practices.

The incidences of the two arthropod pests (CMB and CGM) were higher among the local land races than among the improved varieties, whereas the incidences of the two diseases (ACMD and CBB) were somewhat less (Table 5). However, the symptom severity scores for all four problems were significantly lower for the improved varieties than for the local land races (Table 6), indicating substantial differences in tolerance. Statistical analysis by climate zone was not appropriate because of the limited data available.

Hahn *et al.* (1981) stated that the development of resistant cultivars provides the most appropriate and realistic approach to control of cassava pests and diseases. They reported that ACMD-resistant breeding materials from IITA have been tested in many countries in West Africa, Central Africa, East Africa, and India and have consistently shown disease resistance. This absence of regional variation in resistance to ACMD and the polygenic nature of the resistance suggest it is durable and widely applicable, which is consistent with the allotetraploid and genetically heterozygous nature of cassava. The CBB-resistant materials from IITA showed resistance when tested in Kenya and Zaire, suggesting that this resistance is also generally effective. Resistance of cassava to CBB is polygenic, durable and effective in several localities. Some cultivars at IITA seem resistant to CGM and the progenies raised from several parents produced at IITA showed resistance to CGM in Tanzania (Hahn *et al.*, 1981). Mahungu *et al.* (1994) provide more details on breeding for resistance to CGM and other pests/diseases of cassava.

## MARKET ACCESS

The market access information as based on road maps was collected at different times and varies widely in veracity. It was therefore considered essential to collect information during the survey that would permit a more objective definition 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 kilometres, 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 more than 50% of the villages attended markets on foot over distances of up to 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. About 10% 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 only *c.* 25% of the villages stated that they went to markets by motor vehicle indicating good access. In 15% of the villages it was reported that they went to markets on foot over distances exceeding 10 km; indicating poor access.

The incidences of all four major pests/diseases were lower in the villages with easy access to markets than in other villages (Table 5). The symptom severity scores of the pests/disease were also lower for the villages with easy access than for others, although the differences were not statistically significant (Table 6). The frequencies of use of purchased inputs were higher in the villages with easy access to markets than elsewhere (Nweke *et al.*, 1994).

## MARKETING CHANNELS FOR CASSAVA PRODUCTS

About 55% of the representative villages sold fresh cassava roots through middlemen, namely traders and processors, and 45% sold directly to consumers as their most frequent buyers. Berry (1993) observed that commercial cassava production in Nigeria has entailed changes in contractual arrangements and market structures. People who plant cassava as a commercial investment often sell the crop in the ground and within a few months of planting to buyers who assume the risks and costs of managing the farm until harvest, as well as of harvesting and marketing the tuberous roots.

The incidences of CBB, ACMD and CMB were significantly higher among villages which sold cassava through middlemen than among those which sold direct (Table 5). However, in analyses of symptom severity scores only those for CBB and to some extent CGM were significantly lower among the villages which marketed their cassava through the middlemen than in others which sold direct (Table 6).

Tollens (1990) reported that in Zaire 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 empty except for their 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.

## FARM LAND HOLDING UNITS

Among most African peoples, farm land is not owned but held in trust by the present generation of people on behalf of their ancestors for future descendants. The farm land is held not by individuals but by units such as nuclear families, extended families, or entire village communities. When land is held communally, use for farming or any other purpose is controlled by a central authority which may be an individual community head or the community council (Chubb, 1961). More than one system is possible within the same village. Farm land holding by the nuclear family was the most common system in *c.* 55% of the representative villages compared with *c.* 30% by the community and *c.* 15% by the extended family.

Although the difference between villages of the two main land-holding types in the incidence of any of the four problems did not appear significant (Table 5), the symptom severity scores of all four cassava plant pests/diseases were lower among the villages where the nuclear family rather than whole community was the most common land holding unit (Table 6). For CGM, ACMD and CBB the differences were statistically highly significant. Land holding by individual nuclear families was more common in areas where the use of purchased inputs such as chemical fertilizers or hired labour was common. Hence, the observed relationship between land tenure and cassava plant pests/diseases may be associated with commercial production.

## CULTURAL PRACTICES

**Fallow management.** Fallow systems involve shifting, recurrent and continuous cultivation (Greenland, 1974). For COSCA purposes, *shifting cultivation* is considered to be less than 10 years of continuous cultivation followed by 10 or more years of fallow. For *recurrent cultivation*, 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. Most of the farmer groups interviewed considered that most fields would recover their fertility after 10 years of fallow. 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 land rotation.

Village level information suggests that on average up to 20% of the major food crop fields were under continuous cultivation, 75% under recurrent and only 5% under shifting systems. The proportions of cassava fields under the different systems were similar. In contrast, yam was seldom grown under continuous cultivation and it was grown more than any other crop under recurrent and shifting systems. Maize, rice and sweet potato were commonly grown under continuous cultivation and maize and sweet potato did not appear to be adaptable to shifting systems. The proportions of fields of beans/peas were more evenly distributed under different fallow systems than cassava fields, but the beans/peas comprised a wide range of different legume crops. Hence, as a single crop, cassava seems to be the most adaptable to different fallow management practices.

The incidences of CMB, ACMD and CBB were highest and the incidence of CGM was lowest under recurrent cultivation systems (Table 7). The symptom severity scores for CMB ranged from 1.67 to 1.90 and did not differ statistically between the various fallow systems (Table 7). The severity of CGM was higher in recurrent cultivation than in the other fallow systems. The difference in symptom severity score was not, however, significant between recurrent and shifting cultivation systems. African cassava mosaic disease and CBB decreased significantly from shifting through recurrent 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

TABLE 7. Incidence and symptom severity scores (1-4 scale) of four major cassava plant pests/diseases in the ten phase 1 COSCA countries assessed by fallow systems

| Pest/disease/* Fallow system | Number of of land races affected | % land races affected | Mean Severity score | Probability levels of significance of difference | | |
|---|---|---|---|---|---|---|
| | | | | C. and R. | C. and S. | R. and S. |
| **CMB** | | | | | | |
| Continuous (C) | 148 | 8 | 1.67 | * | - | - |
| Recurrent (R) | 70 | 10 | 1.90 | * | - | - |
| Shifting (S) | 14 | 8 | 1.85 | - | - | - |
| **CGM** | | | | | | |
| Continuous (C) | 554 | 29 | 1.62 | *** | * | - |
| Recurrent (R) | 173 | 24 | 1.94 | *** | - | - |
| Shifting (S) | 45 | 27 | 1.82 | - | * | - |
| **ACMD** | | | | | | |
| Continuous (C) | 474 | 25 | 1.86 | ** | *** | - |
| Recurrent (R) | 294 | 41 | 2.02 | ** | - | *** |
| Shifting (S) | 54 | 32 | 2.41 | - | *** | *** |
| **CBB** | | | | | | |
| Continuous (C) | 145 | 8 | 1.45 | - | *** | - |
| Recurrent (R) | 174 | 24 | 1.48 | - | - | *** |
| Shifting (S) | 21 | 13 | 2.00 | - | *** | *** |

*** $P \leq 0.01$; ** $P\ 0.05 \geq Pr > 0.01$; and * $P\ 0.10 \geq Pr > 0.05$
*CMB = Cassava mealybug; CGM = Cassava green mite;
ACMD = African cassava mosaic disease; and CBB = Cassava bacterial blight

and fallow periods to break the pest/disease cycles where the pressures are very high. For systems under recurrent cultivation, fallow and cropping periods would each, by definition, vary from one to nine years. Three years was the most common cropping period and accounted for 33% of all those reported. Cropping periods of one, two and four years were also common. Similarly, three years was the most common fallow period, although two, four and five years were also common. Fallow and cropping periods are combined at varying frequencies in fallow management practices. Three years of cropping combined with three years of fallow was the most common practice and accounted for 12% of all; other common combinations of cropping and fallow periods were three years of cropping with four years of fallow and two years of cropping with three years of fallow. Most common practices involve one to three years of fallow and similar periods of cropping and fallow, or the fallow period exceeding the cropping period.

**Cropping pattern.** Staple crops are sometimes grown alone and sometimes with intercrops. In mixed cultures, farmers distinguish the major and minor crops based on their production objectives, such as food security or income generation. On average *c.* 25% of the fields were in sole crops and *c.* 75% were mixed. Cassava at *c.* 40% was above average as a sole crop. More than 55% of the cassava fields also contained other crops. Cassava was the major crop in *c.* 30% of all fields and minor in *c.* 25%. Cassava/maize intercrops were by far the most common, comprising half of all intercropped cassava fields. Other cassava-based intercrops included cassava/banana or plantain, cassava/rice, cassava/millet or sorghum, cassava/yam and cassava/sweet potato. For this analysis a crop is considered to be minor unless it is the only one grown in a field, or it is the main one in an intercrop.

The incidence of all four cassava plant pests/diseases was higher for intercrops than for sole crops (Table 5). For CMB, CGM and ACMD the symptom severity scores were significantly greater for intercropped cassava than for sole crops (Table 6), 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 intercrops 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 effects on subsequent CGM densities in a comparison of formerly intercropped and monocropped plots. Maize was by far the most common intercrop for cassava in the survey. Most of the other common intercrops grown with cassava including most legumes and rice were of short duration.

There are reasons for intercropping cassava other than attempts to alleviate the problems of the four main cassava pests/diseases. Nearly 50% of the 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% tradition, 4% security and 3% shortage of labour. Intercropping practices are complex and generalisations 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 farmers' 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 possible benefits of intercropping (Kesiwani, 1987). Gold (1994) provides an insight on the biology of intercropping.

**Crop rotation.** As much as 75% of the fields under continuous cultivation involved crop rotation, with a maximum of four sets of crops being rotated on the same fields. For fields under recurrent cultivation, the proportion involving crop rotation was *c.* 45%, with a maximum of three sets of crops being rotated on the same fields. In recurrent cultivation fallow was used to replace one set of crops in the rotation. Thus, in terms of proportion of fields as well as number of sets of crops being rotated, crop rotation was more common under continuous than under recurrent or shifting cultivation. Under recurrent or shifting cultivation, fallow was used to replace one set of crops in the rotation system, while high rates of crop rotation were substituted for fallow under continuous cultivation.

Cassava was grown *c.* 60% of the times without rotation with any other crop. This figure was exceeded only by rice for which the proportion grown without rotation was *c.* 65%. The equivalent proportion was only 30% for sweet potato and 35% for yam, which was usually rotated with fallow.

The incidences of CBB, CMB and ACMD were lower when cassava was grown in rotation than when it was not (Table 5). The symptom severity scores of ACMD and CGM were significantly lower when cassava was grown in rotation with other crops compared with continuous cultivation (Table 6). 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. With CMB this may be because at the time of the survey in 1989, the pest had already been brought under control in many areas by the IITA biological control programme, as discussed previously. For detailed consideration of the programme see Neuenschwander (1993, 1994).

**Bush burning for land clearing.** Approximately 40% of the fields of the major food crops including cassava were cleared by fire. The proportion was highest for yam (72%) and rice (60%) and lowest for sweet potato (6%). The incidences of CGM, CBB and CMB were lower where bush burning was adopted to clear land compared with other systems (Table 5). The symptom severity scores of all four problems were, however, significantly higher under bush burning (Table 6).

Neuenschwander (1993) reports that from all countries where qualitative country-wide data on the impact of the parasitoid *E. lopezi* were available, it was clear that it reduced CMB to the status of a minor pest throughout its range. Reductions were less marked and CMB damage persisted in a few fields on repeatedly used, leached, sandy soils low in organic material. Mulching of these fields seemed to reduce CMB populations to acceptable levels. Okigbo (1984) reported that in undisturbed soils under adequate vegetation cover, microbial activities were vital in decomposition and mineral cycling processes leading to maintenance of favourable soil structure and textural characteristics and the attainment of a dynamic equilibrium in the eco-system.

According to Mouttapa (1974) clearing and burning associated with cultivation in traditional shifting cultivation and related fallow systems cause loss of most of the nitrogen, sulphur and carbon in gases during burning. Nevertheless, plant nutrients are rendered more available to the crop, although they are prone to loss through leaching and erosion. There is also destruction of humus with adverse soil physical and textural characteristics where intense burning is achieved in thick wood piles as used in the chitemene system of Central Africa, and there are adverse effects on soil macrofauna and microflora.

There are reasons for clearing and burning other than to control CMB, CGM, ACMD or CBB. The reasons include control of other pests such as rodents, termites and grasshoppers, or for control of poisonous animals including snakes and scorpions. Clearing and burning can also constitute a labour saving technique in the smallholder cropping system. Apart from a reduction in labour for land clearing, burning may also reduce the need for weeding since some weed seeds are destroyed (Melifonwu, 1994).

**Selection of planting material.** Casava 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 (Boher and Verdier, 1994; Rossel *et al.*, 1994; Thresh *et al.*, 1994c). Hence, the selection and use of planting material derived solely from healthy plants can reduce the incidence and severity of some of the important pests/diseases. From the survey results it was established that the farmers' sources of planting materials were mainly their own production fields or neighbours and sometimes cassava marketing middlemen (Otim-Nape *et al.*, 1994). 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 twelve months and they would use freshly cut material. They would not use stems which carried lesions or cankers but did not always discard stems affected by pests/diseases. However, they did select cultivars for resistance against pests/diseases and would abandon cultivars that were very susceptible to any of these. Otim-Nape *et al.* (1992) reported that the variety Bukalasa 11 that was released by the Uganda Department of Agriculture in the 1950s because of its resistance to ACMV and because its roots cooked well had largely been abandoned by farmers in most districts of the country, mainly because of its high susceptibility to CGM (Thresh *et al.*, 1994b, 1994c).

There is a high turnover in cassava land races as described by Otim-Nape *et al.* (1994) from experience in Uganda. African farmers are continually introducing new land races with desired attributes into their cropping systems. Such land races are not necessarily improved varieties, but are often local and vary with villages, regions and countries. As new land races are introduced, the farmers often abandon existing ones that may not possess the desired attributes. The main sources of cassava planting material for a village were neighbouring villages and towns. Some material was also reported to have been introduced from other countries. Such material was brought by traders, migrant farmers or development agencies and church or other non-governmental organisations. Less than 5% were reported to be from government sources.

It was reported during the COSCA survey that the cultivation of *c.* 400 land races has been abandoned by farmers since 1900. Approximate years of abandonment were traced by the farmers in the Phase I group meetings. Similarly, approximate years of introduction were also traced for 30% of the 2808 land races recorded. The information may be imprecise because the numbers of land races introduced or abandoned cluster around decade ends. This suggests that there must be some memory lapses, which is understandable as the information was not based on written records. The collective memory, however, spans different generations of people since the age composition of the village groups was very diverse.

The relative frequency of reasons given for abandoning land races shows that the farmers were selecting for early bulking, high root yield, weed suppression, good in-ground storability, disease and pest tolerance, good processing qualities, desirable branching habit, low HCN potential, good cooking qualities and good yield of planting material; in descending order of frequency. The relatively low ranking of pests/diseases as a reason for abandoning the cultivation of cassava land races could be due to cassava's relative tolerance of pests/diseases (Fresco, 1993) and the lack of serious pest/disease problems other than ACMD until recent decades. Moreover, the data on the turnover in cassava genotypes was collected after the 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 inter-related and not independent. For example, the susceptibility of cassava to pests/diseases is closely linked to low yield (Akinlosotu, 1985; Herren *et al.*, 1987; Odongo and Orone, 1992; Otim-Nape *et al.*, 1992).

There could be some relationship between the turnover in cassava land races and the history of cassava pest/disease outbreaks in Africa. The mean number of landraces introduced or abandoned per period of time was relatively low until the 1930s, when the numbers began to increase rapidly. 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 (Jones, 1959; Thresh *et al.*, 1994c).

Between 1901 and 1980, the annual compound rates of abandonment and introduction of land races were higher in East than in West Africa: 3.8% and 3.7% for East compared with only 1.8% and 1.5%, respectively, for West Africa. This situation could be the result of early efforts to combat two viral diseases of cassava in East Africa, i.e., ACMD and cassava brown streak. According to Nichols (1947), these diseases were two of the most important factors decreasing yields of cassava in East Africa. This necessitated the acquisition or development of immune, or at least, highly resistant or tolerant varieties. A solution to the problem was attempted in Tanzania and Madagascar by importing varieties from elsewhere in the hope that some would prove more resistant than the local ones. Over 100 varieties were introduced to Tanzania from Brazil, British West Indies, Belgian Congo, Federated Malay States, Java, Madagascar, Mauritius and West Africa. With few exceptions, these varieties proved highly susceptible to both viruses.

When the use of imported materials failed to provide suitably resistant varieties, it was decided in Tanzania and at much the same time in Madagascar to approach the problem through plant breeding, including controlled inter-crossing of the most resistant cassava varieties available and inter-specific hybridization of cassava and other *Manihot* species (Jennings, 1994). Before this, selection work on cassava had been carried out by agricultural departments in several East African territories but with only limited success. For example in Kenya, variety trials and selections were started as early as 1929. A number of field resistance trials were carried out at the Morogoro Experiment Station in Tanzania and around 1940, a considerable number of seedlings were raised from naturally pollinated seeds. Work on similar lines, using open-pollinated seed, was started by the ~~Agricultural~~ Department, Zanzibar, in 1941 (Nichols, 1947).

## CONCLUSION

The foregoing account does not present 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 socio-economic 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 pest/disease problems and given that there were interactions among the pests/diseases and the biological environments, drawing cause and effect type of conclusions on the basis of information presented above could be misleading. The use of improved varieties which are resistant to the main pests/diseases seems to hold promise for the future control of these problems. Currently, 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 in Africa seem to have relied mainly on crop rotation, fallow management and cultivar selection from among the available land races for the control of the CMB, CGM, ACMD and the CBB.

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