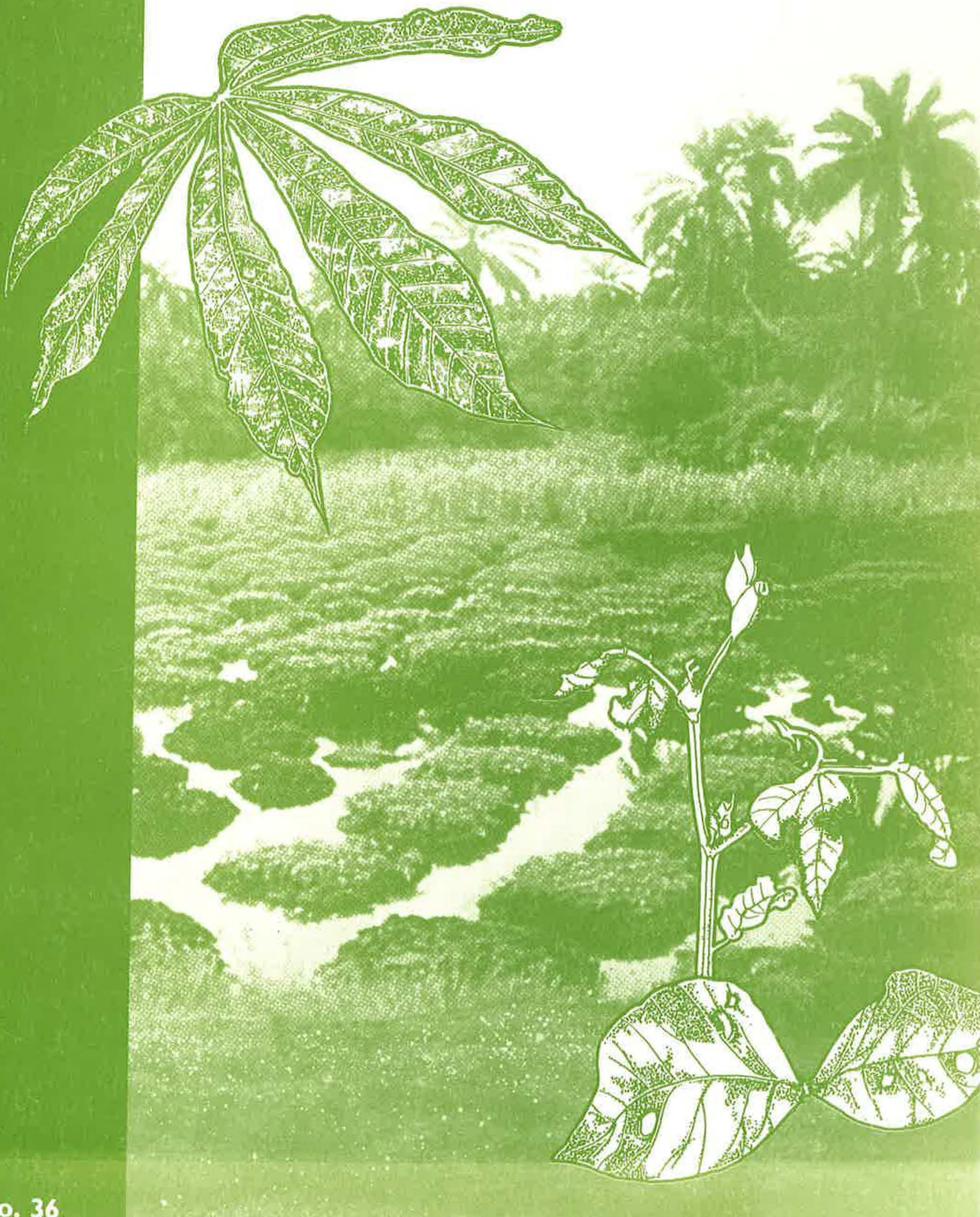
The relative importance of crop pests in sub-Saharan Africa (NRI Bulletin No. 36)

Natural Resources Institute

THE RELATIVE IMPORTANCE OF CROP PESTS IN SUB-SAHARAN AFRICA



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THE RELATIVE IMPORTANCE OF CROP PESTS IN SUB-SAHARAN AFRICA

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NRI
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The Natural Resources Institute (NRI) is the scientific arm of Britain's Overseas Development Administration. NRI's principal aim is to increase the productivity of renewable natural resources in developing countries through the application of science and technology. Its areas of expertise are resource assessment and farming systems, integrated pest management, and food science and crop utilization.

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I am also indebted to all those who suggested useful contacts and helped in the practical arrangements for the study tour.

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Summaries

SUMMARY

The aim of this study was to assess the relative economic importance of insect-vectored plant diseases and other pests (harmful organisms) in each farming system of sub-Saharan Africa. The first steps were to divide sub-Saharan Africa into ten agro-ecological zones and list the major and secondary crops in each zone (Fig. 4, fold out map, and Tables 3 to 6). Through study of the literature and consultation with experts in UK and Africa, pests in each zone were then assigned to ranks indicating their relative economic importance in that zone (Tables 7 to 25, odd nos.).

On this basis the most serious pests affecting each major crop were listed in order of importance for each zone (Tables 8 to 36 even nos.). By using a rudimentary scoring system, an estimate was made of the relative importance of insect-vectored plant diseases in sub-Saharan Africa as a whole. The African cassava mosaic and maize streak diseases are much the most important of such pests, followed by groundnut rosette (Table 30). A rather tentative estimate was made of the relative importance of the different zones for insect-vectored plant diseases. The two semi-arid zones appeared to have the least problems. (Table 31).

The study stresses the dynamic nature of the pest situation and examines the factors likely to lead to changes in the relative importance of pests. It also summarizes the geographical features and the farming systems in each zone and their relationship to pests and their control.

RÉSUMÉ

Le but de cette étude était d'évaluer l'importance économique relative de maladies des plantes transmises par des insectes et d'autres ennemis (organismes nuisibles) dans chaque systèmes d'exploitation en Afrique au sud du Sahara.

Les premières étapes consistaient à diviser l'Afrique au sud du Sahara en dix zones agro-écologiques, ainsi qu'à énumérer les cultures principales et secondaires de chaque zone (Fig. 4, carte dépliante, Tableaux 3 à 6). Une étude approfondie de la littérature et des consultations avec les experts au Royaume-Uni et en Afrique ont permis de classer les ennemis de chaque zone selon leur importance économique relative dans cette zone (Tableaux 7 à 25, nos. impairs).

Sur cette base, les ennemis les plus nuisibles qui affectent chaque grande culture ont été énumérés par ordre d'importance pour chaque zone (Tableaux 8 à 36, nos. pairs). En se servant d'un système de notation rudimentaire, une évaluation a été faite de l'importance relative de maladies des plantes dont les vecteurs sont des insectes, pour l'ensemble de l'Afrique au sud du Sahara. Les maladies les plus nuisibles de toutes sont la mosaïque africaine du manioc et la striure ou streak du maïs, suivies par la rosette de l'arachide (Tableau 30). Une estimation assez approximative a été faite quant à l'importance relative des différentes zones pour les maladies des plantes dont les vecteurs sont des insectes. Les deux zones semi-arides semblent être les moins affectées par des problèmes (Tableau 31).

L'étude insiste sur l'aspect dynamique de la situation des ennemis et examine les facteurs qui pourraient mener à des changements de l'importance relative de ceux-ci. L'étude résume par ailleurs les aspects géographiques et les systèmes d'exploitation de chaque zone, ainsi que leurs rapports avec les ennemis et leur maîtrise.

RESUMEN

Este estudio tuvo como objetivo la evalución de la importancia económica relativa de las enfermedades de las plantas transmitidas por insectos y de otras plagas (organismos nocivos) en cada uno de los sistemas agrícolas del Africa Subsahariana.

Los primeros pasos fueron la división del Africa Subsahariana en diez zonas agroecológicas y la enumeración de los cultivos importantes y secundarios de cada zona (Fig. 4, mapa doblado y Tablas 3–6). Mediante el estudio de la bibliografía y en consulta con expertos británicos y africanos, se llevó a cabo una clasificación de las plagas en cada zona, indicando su importancia económica relativa para cada una (Tablas 7 a 25, números impares).

Sobre esta base, se obtuvo para cada zona una enumeración de las plagas más serias que afectan a cada cultivo principal, en orden de importancia (Tablas 8 a 36, números pares). Mediante el empleo de un rudimentario sistema de puntuación, se calculó la importancia relativa de las enfermedades de las plantas transmitidas por insectos en la totalidad del Africa Subsahariana. El mosaico de la mandioca africana y la veta del maíz son, con creces, la más importantes de estas plagas, seguidas de la roseta del cacahuete (Tabla 30). Se realizó un cálculo un tanto tentativo sobre la importancia relativa de las distintas zonas para enfermedades de las plantas transmitidas por insectos. Las dos zonas semiáridas parecen ser las que experimentan menos problemas (Tabla 31).

Este estudio subraya la naturaleza dinámica de la situación de las plagas y examina distintos factores que, probablemente, llevarán a cambios en la importancia relativa de las plagas. El estudio presenta asimismo un resumen de las características geográficas y sistemas agrícolas de cada zona y de su conexión con las plagas y control de las mismas.

The relative importance of crop pests in sub-Saharan Africa

1. INTRODUCTION

1.1 Objectives

This study had the following objectives:

1. To rank the main insect-vectored plant diseases in order of importance in each farming system of sub-Saharan Africa.
2. To rank the most important insect-vectored plant diseases in relation to other major pests in each farming system of sub-Saharan Africa.
3. To indicate which farming systems in sub-Saharan Africa are worst affected by insect-vectored plant diseases in so far as sufficient information on losses is available.

In this study pests are defined in the wide sense of harmful organisms, i.e. pathogens, invertebrate pests, vertebrate pests (rodents, monkeys, birds etc.) and weeds. Pre and post-harvest pests are included. Insect-vectored plant diseases are nearly all caused by viruses but some are associated with mycoplasmas or xylentia bacteria. The full terms of reference are given in Appendix A.

The commissioning of the study arose out of two areas of concern to NRI. The first related to project T0063 on insect-vectored plant diseases in sub-Saharan Africa. Under this project a database on these diseases is being compiled and this study was needed to help plan priorities for any further expansion of the database and for research which made use of it.

The other area of concern was that of the Pest and Vector Economics Section which needed guidance on the relative importance of pests to help plan the allocation of the Section's resources and advise on resource allocation within the Integrated Pest Management Strategy Area.

Since assessments are made with reference to farming systems, the study should help identify the farming systems in which it would be most suitable to conduct research as it moves from the basic and strategic to the more applied and adaptive.

1.2 The concept of a pest's importance

It is obviously necessary to define what is meant by importance of a pest in this study. Pests are a problem if they cause crop losses, hence importance is defined as economic importance. This also provides a common factor for comparison across all crops and all pests. Economic importance is determined by:

- actual losses with existing control measures
- the cost of existing control measures
- reduction in value of output from having to deviate from the cropping pattern which would have been optimum without pests (substituting less productive crops which are less affected by pests or not growing crops at certain times)
- reduction in yield potential of cultivars through breeders having to incorporate pest resistance at the expense of yield and farmers having to grow more pest-resistant but lower-yielding varieties.

The first two factors are responsible for most of the economic loss and were those given most consideration by respondents when ranking pests.

Some pests cause fairly consistent losses from year to year, others are more sporadic, causing little or no loss in one year and serious or even devastating losses in other years. For two pests causing the same percentage losses averaged over a number of years the more sporadic one is considered to be the more important. A farmer may take a long time to recover from a bad year or never fully recover, whereas he is likely to find it easier to cope with steady, more predictable losses.

The concept of economic loss takes account of risk factors affecting the farmer (as in the case just cited) but in other respects refers to loss in relation to the whole country i.e. conceptually, loss measured in shadow prices rather than market prices which may be distorted by price regulations, taxes etc.

2. THE FARMING SYSTEMS FRAMEWORK

2.1 Factors considered in choosing the framework

The term 'farming systems' is most commonly used in connection with farming systems research. It describes the system of farming used in farms with broadly similar characteristics in terms of crops grown, livestock kept and management practices. These in turn will be determined by resource endowment and the natural and socio-economic environment.

In farming systems research, the farming system as normally defined covers a relatively small geographical area. If farming systems similarly defined were to be used as the basis for this study, it would become quite unmanageable within the limits of time and resources available.

There is one notable exception to the study of small-scale farming systems in the tropics. The categories of Ruthenberg (1980) are based largely on management systems, particularly such aspects as length of fallow, inclusion of pastures, irrigation etc. This system was considered for the present study but rejected as there was thought to be insufficient homogeneity of pest problems within such systems.

Since most pests have a fairly limited range of hosts, the types of crops grown are a major determinant of the pest challenge. The other main determinant is the climatic conditions. As these conditions are also a major determinant of the types of crops grown, it follows that agro-ecological zones described primarily in terms of climate will provide an appropriate framework for a study of pests.

Accordingly, the approach taken has been to divide sub-Saharan Africa into agro-ecological zones and to make a separate pest ranking for each one. Within the zones the effect of different management practices on the rankings can then be considered in order to relate them more closely to the concept of farming systems. To a limited extent this is done in this study but the short time available resulted in rather sparse consideration of the effects of different management practices. Hence the framework of the study is largely one of agro-ecological zones rather than farming systems in the true sense.

Irrigation is obviously a management factor which makes a profound difference to the farming system and creates discrete agro-ecological conditions markedly different to the surrounding rain-fed area. Nevertheless the irrigated farming system is affected by the climatic conditions, and a number of irrigated zones would need to be differentiated. Separate consideration of so many zones was beyond the capacity of this study's resources, so irrigated agriculture, in particular such locally important areas as organized irrigation schemes and the Niger inland delta in the Sahel, is largely excluded. The exception is swamp cultivation in zones A5 Forest, A4/5 Forest/Savanna Transition and A6 East Coastal Lowland, where swamp and rain-fed cultivation are more closely related and tend to merge into each other in conditions of free flooding or partial water control. Some reference will also be made to the effect of irrigated crops on the pest challenge in areas with both irrigated and rain-fed cultivation.

The study also excludes Madagascar and offshore islands such as Zanzibar and Pemba and the more isolated and southerly countries of Swaziland and Lesotho. South Africa was also excluded.

2.2 The framework chosen

No established system for dividing sub-Saharan Africa into agro-ecological zones could be found. FAO was consulted and agreed that one was needed but they have not yet developed such a system.

The basis of that devised for this study was the provisional worldwide system worked out by John Bennet of NRI (personal communication) and the system used by IITA for West and Central Africa. John Bennet's system consists of six zones based on altitude, annual rainfall and length of dry season. IITA's system is published as a coloured map in their 1987/8 annual report and uses the system based on vegetation presented by Davis (1973). The vegetation system correlates fairly closely with rainfall and so it was possible to combine the two systems in that devised for this study. Since IITA has a major responsibility for research over a large area of Africa (focussing on West and Central Africa) and was to be an important source of information on pests, incorporating their system of zoning made good sense. Study of rainfall and topography maps, particularly those in the *Times Atlas of the World* (1977) and local information gathered during the tour of African countries, resulted in further refinements.

The boundaries of the zoning system are given in Fig. 4. Tables 3 and 4 describe the zones in terms of climate and altitude and Tables 5 and 6 give the major and secondary crops. Experts consulted during the tour were able to recognize the zones as they corresponded reasonably well with local agro-ecological categories and they could make pest rankings for each separate zone. They were also able to provide some details of the agro-ecological-climatic conditions and farming systems of the zones through discussions and references to relevant literature. Zones A2, A3, A4, A4/5 and A5, extending from West Africa eastward into Sudan and Central Africa, are nearly all lowland. They form a simple system with zones running more or less west-east, becoming more humid moving south from the Sahel into the equatorial forest. Only A4/5 is rather broken up.

In East and southern Africa the zones are broken up by changes in altitude, which affects temperature and rainfall, and along the coast there is the influence of the monsoon. In all zones there are of course local areas which deviate from the general pattern and these are most frequent in East and Central Africa.

The geographical separation of different parts of the same zone in East and Central Africa increases the diversity within zones, particularly that of cropping patterns. In the pest rankings this is handled by noting 'particularly in. . .' against some pests.

3. METHODOLOGY OF ASSESSING RELATIVE IMPORTANCE

3.1 Literature study

A search of literature on pests and crop losses was made. Most articles focus fairly narrowly on one crop, often reporting the results of one trial. There is a good deal of literature on crop losses but most of it is about methodology. Wider reviews contain frequent remarks such as 'In Africa, little information on sorghum grain yield losses caused by insects is available' and give few quantitative data. Those available usually refers to a local situation with little indication of how well this reflects the general situation in farmers' fields. It is of little help in generalizing across the broad agro-ecological zones forming the framework of this study. Like pieces of a jig-saw puzzle, a few fit together but most of them are missing and no pattern can be discerned from this source alone.

However, some reports proved to be very useful, e.g. Namponya (1989) covering a SACCAR regional workshop with problems reviewed at country or regional level, a report of a mission to review Kenya's pest problems (FAO, 1981) and recent surveys by INIBAP of the pest problems of bananas by short visits to banana-growing countries of East and West Africa (INIBAP 1986, 1987, 1988; Sebasigari and Stover, 1988).

Crop reference books (e.g. Wrigley, 1988, on coffee) also proved useful as they have fairly comprehensive sections on pests and diseases giving some indication of relative importance and geographical incidence. They were used particularly to provide more information about some export cash crops given rather less coverage during the African tour. *Pests and Diseases of Tropical Crops*, Vol. 2 (Hill and Waller, 1988) was most useful as a check on other information as it gives thorough coverage of all crops included in this study, crop by crop and pest by pest, with comments on importance and geographical distribution of the pest. *Virus Diseases of Important Food Crops in Tropical Africa* (Rossel and Thottapilly, 1985) was useful for a detailed description of the main viruses but contained rather limited information on importance.

3.2 Consultation with experts

A number of experts in the UK were consulted, mostly within NRI or associated with the Institute. Some gave fairly general advice about pests without attempting any ranking of importance. Contacts in Africa were suggested and some advice on methodology was given. A useful ranking of viruses on a world-wide basis, and rankings of weeds and nematodes by agro-ecological zone, were obtained.

The main part of the study consisted of a four week tour of sub-Saharan Africa, visiting five countries. Emphasis was put on consulting experts in regional programmes to improve the coverage, but experts in national programmes were also consulted on the situation in individual countries. Experts were asked to rank pests separately in each zone covered by their present work or past experience. Some gave rankings for individual crops across a number of zones in a region, others gave rankings across the parts of zones in their own country, either for all crops or one crop. In one case an expert (in IITA) was able to give rankings across all crops for a number of zones, thus providing information directly categorized according to the study framework.

Interviews were started by providing the zonal map, zonal definitions and lists of major and minor crops. The 'fit' of the zones to the situation in the areas considered by the experts was discussed as well as the crop lists, and more detailed information was obtained on the distribution of crops within the zone. All necessary adjustments were made. The meaning of 'importance' was explained and it was pointed out that in making rankings both the relative importance of crops and the relative importance of the pests attacking each crop had to be taken into account. Respondents had to rely on their own experience and what they knew from others and from the literature, including unpublished reports of trials and surveys. They were not asked to quantify losses and none tried to build up their assessments by systematic mathematical manipulation of quantitative data. Nowhere is sufficient data available to do this. Rather the approach was more holistic, with the emphasis on relative rather than absolute importance.

Respondents were often able to provide useful references and copies of reports. These sometimes contained a few quantitative estimates or even measurements of crop losses.

All this information from literature and the various types of assessments made by experts was then synthesized by the author to produce the pest rankings presented later. In this synthesis the FAO production yearbook figures for production by crop and country, combined with knowledge acquired on the geographical distribution of crops within countries, was useful in making some quantitative check on the relative importance of crops (Table 32).

A list of institutions visited and experts consulted is given in Appendix B.

3.3 Seminar and postal inquiries

When the pest ranking lists had been compiled the results of the study to date were presented at a small seminar in NRI attended by relevant staff. Some minor adjustment in rankings was suggested and the form in which the study should be presented and its possible uses were discussed.

To get additional information about crops or zones given less coverage in the tour and to widen the base of respondents, letters were then written to a number of institutions not contacted earlier to ask them to check the rankings for the crops they covered. Their replies were then taken into account in making the final draft of the report.

3.4 Some limitations of scope

It was difficult to assess the importance of vegetables in the various zones, partly because they are such a heterogeneous group. They should probably have been listed as secondary crops in some other zones besides the Sahel, zone A2, where okra is included, and the Mountains, zone B2. Consequently vegetable pests are probably underestimated. However, potatoes are considered separately and are adequately covered. The importance of rainfed sugarcane and pineapples may also have been somewhat underestimated.

Rather little information was found about mammals such as pigs, rodents and monkeys and their rankings were not finally assigned with much confidence. Pigs may well be underestimated. Rodents are some of the more important post-harvest pests, but except in the case of the cutting-grass (*Thryonomus swinderianus*) and the root rat (*Rattus rattus*) their importance pre-harvest was not clear.

4. THE FARMING SYSTEM AND PEST RANKING IN EACH ZONE

4.1 A dynamic situation

4.1.1 Causes of changes in pest importance

Tables 7–31 give a current assessment of pest importance. However, the impact of any research or development of control measures will be in the future. As stated in a different research context, we are engaged in 'hitting a moving target' (Maxwell, 1984). It is therefore necessary in any consideration of the pest situation to realize that it is dynamic and likely changes need, as far as possible, to be forseen. Whilst with varying degrees of confidence some predictions can be made, it is obvious that a great many changes will not be predicted. The pest situation needs constant monitoring; minor pests can develop into major ones in the course of a few years and new pests can appear. The recent rise of important pests such as green spider mite and mealybug on cassava and black sigatoka on bananas are examples.

Some of the main factors responsible for changes in the relative importance of pests are summarized below:

(a) Changes in the relative importance of crops, e.g. the increasing importance of cassava, the decline of sisal.

(b) Population growth resulting in a decline in the length of fallow periods. The general effect is to increase the incidence of pests, particularly soil pests, through a greater continuity in host crop availability. On the other hand vertebrate pests such as monkeys and pigs will be reduced.

(c) Extension of the cropping season through double cropping and asynchronous planting often made possible through irrigation and new varieties with shorter or longer maturities. This has a similar effect to (b) i.e. of increasing pest incidence by providing a continuous host crop presence.

(d) Changes in agronomic practice such as tillage methods (especially affecting weeds), fertilizer use, plant spacing, planting date, etc. Such changes may increase or decrease pests. For instance, addition of fertilizer may increase plant vigour but at the same time increase weed growth. Heavy applications of nitrogen may also increase fungal diseases and populations of sucking insects by encouraging growth of foliage and the creation of a more humid micro-environment.

(e) Chemical pest control may upset the balance of pests and predators, resulting in minor pests becoming important. Chemical and other methods of pest control may also achieve a long term success in controlling target pests. However, chemical control alone frequently achieves a reduction in the incidence of the target pest in the early stages followed by a serious increase in the pest as it develops resistance to the control chemical faster than its predators.

(f) A change from intercropping to monocropping usually results in an increase in the pests of the monocrop due to an increase in the density of the host crop and the removal of interference by the intercrop.

(g) An increase in size of monocropped fields will tend to reduce the spread of some vector-borne virus diseases. 'This is because the perimeter/area ratio is least for large fields and the plants around the margin are at greater risk from vectors introducing virus from adjacent crops, weeds, or natural vegetation. Moreover, incoming vectors tend to be deposited on plants around the margin...' (Thresh, 1982).

(h) An increase in the popularity of a crop will not only increase the relative importance of the crop and therefore that of its pests, but the pest incidence on the crop is also likely to increase in response to the greater frequency of the crop's cultivation in the area.

(i) The movement of a crop into a new area may expose it to a different range of pests.

(j) Climatic changes such as those that have occurred in the Sahel in recent years and longer term changes such as the 'greenhouse' effect.

(k) New pests may be introduced, e.g. from another continent, as was the case with green spider mite and mealybug on cassava in Africa.

(l) With greater use of improved varieties of crops, there is a tendency towards a reduction in the number of varieties grown and less genetic diversity in individual plots and in the wider neighbourhood. The situation is exacerbated if hybrids replace outcrossing landraces. More virulent pest strains build up unchecked and increase the importance of the pest.

(m) The breeding, dissemination and adoption of resistant varieties will decrease the importance of the pest to which the varieties are resistant.

(n) New 'improved' cultivars may prove to be susceptible to minor pests which then become major ones. Breeders and pathologists at research stations in Africa tend to be well aware of this and lay great stress on screening new varieties to avoid susceptibility to minor as well as major pests. The need to do this was made very strongly at IITA during the study tour where one respondent in reply to the question 'which are the most important viruses' replied 'all viruses are important'. The importance of breeding for pest dynamics has been emphasized by Buddenhagen (1983) who wrote 'The importance of crop diseases today and, say, 25 years from today, is largely determined by those who decide from which plants a new crop variety will be generated'.

The influence of agricultural development on crop diseases has been well reviewed by Waller (1984) and in relation to viruses by Thresh (1982) who both make most of the points above.

In discussing the relative importance of pests in each zone in paragraphs 4.2 – 4.11, some attempt is made to predict the more obvious changes to be expected in the pest situation, but the issue could not be studied in any depth.

4.1.2 Programmes for breeding resistant varieties and multiplication and distribution of planting material

These programmes are probably the most important measures being undertaken for pest control in sub-Saharan Africa. They are especially suited to a predominantly peasant agriculture with little cash available for inputs and generally weak extension services. A number of international and regional centres are concentrating a large part of their resources on resistance breeding programmes; they also lend support to national programmes for breeding and selecting material suitable for their own environments. There are national government programmes for production of seed and multiplication of planting material, and private seed companies operate in a few countries such as Zimbabwe.

Amongst the more important of the international and regional programmes for food crops are:

(a) IITA at Ibadan, Nigeria, covering cassava, maize and cowpeas with more limited programmes on soybeans, yams and plantains.

(b) The CIMMYT germplasm development centre at Harare, Zimbabwe, for maize and wheat in East and southern Africa.

(c) The ICRISAT Sahelian Centre at Niamey, Niger, covering sorghum, pearl, millet, groundnuts and (in collaboration with IITA) cowpeas.

(d) The SADCC/ICRISAT Programme at Bulawayo, Zimbabwe, covering sorghum and pearl millet.

(e) The SADCC/ICRISAT Programme at Chitedze, Malawi, covering groundnuts.

(f) The SADCC/CIAT Programme at Arusha, Tanzania, covering beans.

There are also several French supported institutions in West Africa covering both food and export crops.

At IITA the early emphasis in maize improvement was on resistance to two important diseases of the lowlands, lowland rust (*Puccinia polysora*) and lowland blight (*Helminthosporium maydis*). IITA open-pollinated varieties resistant to these diseases have been adopted in Nigeria and several other African countries. Whereas these two diseases had been recognized for decades as the most important constraints to maize production in lowland Africa (IITA, 1989) they are now no longer so in West Africa, as can be seen from the pest rankings for maize in Tables 11 and 13. Since 1975, IITA has given major emphasis to resistance to maize streak and, in collaboration with CIMMYT, has produced high-yielding, streak-resistant varieties and hybrids for all the relevant agro-ecological zones in Africa.

IITA has also had considerable success in producing cassava cultivars with resistance to cassava mosaic virus. This material is distributed to programmes in other countries both as *in vitro* clones and as seed for further breeding and selection. In Nigeria IITA mosaic-resistant clones have been adopted over wide areas. Resistance to cassava bacterial blight has also been incorporated in these mosaic-resistant varieties.

IITA has only achieved moderate levels of resistance to cassava mealybug and green spider mite through breeding, but the programme for biological control of mealybug has been highly successful.

An alternative or complementary strategy for controlling cassava mosaic virus is to multiply disease-free planting material of locally popular cassava varieties and distribute them to farmers to maintain free of mosaic virus by roguing. In areas of heavy virus pressure such as West Africa some degree of resistance in the cultivars distributed is likely to be required. Such programmes are being adopted in several countries in East and southern Africa and in one or two in West Africa as well.

Programmes of breeding and distribution of resistant varieties are being undertaken for a wide range of crops. Progress with such programmes, and the degree to which the resistant varieties developed incorporate the other qualities desired by farmers, will determine the rate of adoption of resistant varieties and have a considerable effect on the future relative importance of pests. In the discussion below on probable future changes in the pest situation in each zone, attention is drawn chiefly to the effect of programmes to control maize streak and the principal cassava pests, but similar speculation could be made about the effect of other programmes.

4.1.3 Post-harvest losses and their trend

Post-harvest losses at farm level in traditional stores are at present relatively low. In a review of studies using an acceptable methodology, Tyler and Boxall (1984) report a total of five studies in the sub-Saharan African countries covered by this report – Zambia, Kenya, Malawi and Tanzania. Leaving out the study in Tanzania in which exceptional losses were caused by the larger grain borer (see below), the remaining four studies recorded weight loss in maize and sorghum averaging 3% for farm level storage periods up to nine months[1].

However, particularly with cereals, the trend is for most new, higher yielding varieties to store much less well than traditional varieties. As these new varieties are adopted on a wider scale, storage losses can be expected to increase considerably.

The advent of the larger grain borer in East and West Africa is also likely to lead to higher overall storage losses. If untreated this pest increases losses in traditionally stored maize from around 3% to 9–10%, and causes even greater losses in dried cassava.

These two examples demonstrate that the post-harvest situation is dynamic, and unfortunately deteriorating.

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[1]There will also be a loss of quality which will be particularly high for grain stored for long periods.

4.2 The meaning of conventions adopted in the pest ranking tables

In Tables 7 to 25, odd nos., pests are divided into groups numbered from 1 to 5 (or less). These numbers indicate ranks, or ranking groups, of pests. Normally any pest listed in the first ranking group is more important than pests listed in the third ranking group, and so on. Sometimes the expression 'as a group' is used, as for instance in Table 11 covering zone A4. This means that the group of pests is being compared with other single pests. For instance, in Table 11 cowpea insects as a group are more important than yam mosaic virus.

Where (a), (b), (c), etc. are used this indicates that (a) is more important then (b) and (b) is more important than (c), etc. Rather than putting millet head miner and grasshoppers in two ranks, this system is used in Table 7, rank 1, in order to give sufficient importance to the other ranks, particularly when scores are assigned later to each rank.

Throughout the tables, cassava mosaic virus is used to indicate African cassava mosaic virus. Where sweet potato virus complex is listed, this is not always clearly distinguished from sweet potato feathery mottle virus which is closely related serologically to sweet potato vein clearing virus, the aphid transmitted component of sweet potato virus complex.

4.3 Sahel, zone A2

4.3.1 The farming system

The Sahel lies immediately south of the Sahara and it is the driest zone north of the equator in which rainfed crops can be cultivated. Mean annual rainfall is only 250 mm–500 mm (see Fig. 1).

The population density is low. Fallow periods are long, but shorter on the best land and close to the homestead. The income of many families is supplemented by remittances of members working further south. Livestock are very important providing some reserve of wealth on which to draw when crops fail from drought or locusts, as well as draft power. Livestock are also owned by nomads and in some areas there are traditional arrangements by which the nomads graze their livestock on farmers fields, thereby adding manure.

The dominant problem of a low and erratic rainfall makes the Sahel and the corresponding A7 semi-arid zones in East and southern Africa the most difficult areas for farming of any in sub-Saharan Africa.

In drought years farmers may produce less than three months grain supply. These are some of the most resource-poor farmers in Africa. The small families lacking draft animals are the poorest. They can cultivate less land and have more difficulty sparing family members to work as migrant labourers in the south. Cash inputs are extremely low. There are, however, some larger, richer families with large farms, better land and more draft animals, who spend rather more on cash inputs. Moving south, as rainfall increases, there is some improvement in prosperity.

Pearl millet is the dominant crop and in the north covers about 75% of the cropped area. Among the cereals the proportion of sorghum and then maize increases to the south. Cowpeas and groundnuts are the main pulses, with cowpeas predominant in the drier areas. Crop residues, particularly cowpea, are important as fodder for livestock. Cowpea leaves and young pods are also eaten as vegetables.

The flood plain of the river Niger in Mali and Niger, and the area of higher soil moisture south of Lake Chad, do not suffer from the same drought problems and a wider range of crops including irrigated rice are grown. They are excluded from the description given here.

4.3.2 The pest situation

Insect attack is the dominant pest problem, with millet head miner persistent every year and grasshoppers devastating every five years or so. With very low yields and the present very low cash inputs, the prospect for insecticide use is limited.

Moving south, as sorghum begins to displace pearl millet, sorghum pests become increasingly important. Birds become more of a problem to sorghum and millet since they nest along the Niger. Sorghum is vulnerable at the milk stage.

The parasitic weed *Striga* is the worst weed problem, with different species attacking cereals and cowpeas. Weeds as a group are assessed in the first rank. Plots which are not growing well may be left unweeded.

The various pests are ranked for importance in Table 7. Insect-vectored plant diseases are printed in bold type.

Apart from scaring birds and weed control through tillage and hand weeding, farmers practice virtually no pest control. Pest and disease problems of legumes are probably reduced somewhat by growing them as a minor intercrop with cereals and the practice of fallowing helps to control soil pests. In the south, where yields are higher, there may be a little more insecticide used. No information was collected on rodent control.

The description above is typical of the Mali/Niger area. There may be some variation towards the Sudan end of the zone.

Crop losses from millet head miner are reviewed in Gahukar *et al.*, 1986. The following figures are quoted:

Senegal	1974–76	13–85%
	1981–82	3–82%
	1982	15–20%
Niger	1981	6%

Combining all these figures gives a mean range of 10–56%. The estimate of 30–60% loss given by Dr N Jago when interviewed for this study, based on four seasons experience of extensive trials on farmers fields in Mali, gives a narrower and more helpful range. Gahukar refers to the 1982 loss above as 'only 15–20%' implying the mean of the three earlier years quoted was higher. The mean of Dr Jago's estimate, 45% loss, may be the best available for the whole zone.

It will be apparent from the above that attempting to make quantitative estimates of loss at the zonal level is a decidedly inexact science, and this is a case where comparatively good data is available.

Dr Jago, in the same interview, estimated that in a bad area of grasshopper attack, which occurs roughly once in five years, losses across all crops would be between 70–90%

Sissoko Moussa (1985) reports mean losses from birds in Mali to be 24.6% for pearl millet and 7.6% for sorghum amd says local damage can be much higher, but it is not clear whether these are mean figures for the whole of Mali. Whatever the correct figures for loss of yield, the labour cost of bird scaring, and the constraints put on breeding higher yielding varieties by the need to avoid susceptibility to bird attack, are also substantial costs attributable to birds in this and other zones in which they are important pests.

Of all zones, this and the corresponding semi-arid zone A7 in East and southern Africa, are least affected by viruses (see Table 31). In the Sahel, cowpea suffers from cowpea aphid-borne mosaic and groundnut from groundnut rosette, but these do not feature high in the pest rankings because the cereal crops, unaffected by viruses, are so dominant. The assessment of these as the least virus affected zones should be qualified by the comment that there has been very little investigation of virus problems in these zones.

Table 8 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

4.4 Sudan Savanna, zone A3

4.4.1 The farming system[1]

This zone has a higher and rather less erratic rainfall (500–900 mm) than the Sahel (Fig. 1). Rainfall is unimodal and the growing period is 90–140 days (Fig. 2).

The soils are mostly alfisols with moderate nutrient and organic matter content and a good response to fertilizer. To maintain fertility with low inputs they need about 65% of the rotation cycle to be fallow. There is sufficient land for this to be achieved in most of the zone.

The population density is higher than in the Sahel. It is 10–50 persons/km^2 in Nigeria.

A wider range of crops is grown, with sorghum, groundnuts, cowpea and cotton dominating. Tobacco is grown as a cash crop in some areas. Sesame is mostly grown in the Sudan.

Livestock are important with draft oxen used extensively. Cowpea and other crop residues are used as fodder and cowpea residue is sold as a cash crop.

Cowpeas are usually intercropped with sorghum or millet and occasionally with groundnuts as an additional intercrop. Both cowpeas and groundnuts are a source of marketable surplus for supplying the coastal regions and groundnuts are also an important export crop.

4.4.2 The pest situation

The pest ranking for the zone is shown in Table 9. Weeds, groundnut diseases and insect attack on cotton and cowpeas are the worst problems. The parasitic weeds *Striga* and *Alectra* cause considerable losses. With groundnuts as a major crop, groundnut rosette, vectored by *Aphis craccivora*, is the most important virus, rivalled amongst groundnut pests by groundnut leafspot. Birds are important pests of sorghum and millet.

Insect-vectored plant diseases are grouped in order of importance in Table 27. After groundnut rosette, maize streak/mottle and cassava mosaic are the next most important insect-vectored viruses, followed by cowpea aphid-borne mosaic and the sweet potato virus complex. Cowpea golden mosaic, cowpea yellow mosaic and cotton leaf curl virus are of lesser importance. The term maize streak/mottle is used because maize streak is sometimes confused with maize mottle (considered to be the same virus as chlorotic stunt), both are vectored by leafhoppers (*Cicadulina* spp.) and resistance to both is incorporated in new varieties at IITA by the same screening procedure. Maize streak is much the most important of the two viruses. Symptoms of maize streak are only produced in leaves that have grown after infection, therefore the later the infection the less the damage. Early planted maize suffers less than late planted.

Cotton leaf curl virus is restricted to the *barbadense* cottons and has been a problem in Sudan. Since the introduction of cotton varieties resistant to the virus, the honeydew produced by the whitefly vector has become more important than the virus. Following the use of broad spectrum insecticides and the control of jassids (whitefly competitors), whitefly have become a more important cotton pest in Sudan and other cotton growing areas (Munro, 1987, p.174).

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[1]Much of the information on climate, soils and population for zones A3 to A5 was obtained from Goldman (1986).

Most farmers use insecticides to control insect cotton pests, but for other crops, as in most of sub-Saharan Africa, pest control is mainly limited to tillage, weeding, bird scaring, fallows and intercropping. Indigenous cultural practices and varieties have probably also evolved to incorporate some level of adaptation to the pest challenge. Seed dressing has been reported to be a common practise amongst some farmers in South Darfur, western Sudan (Hebblethwaite and Logan, 1986), but the extent of this practice was not investigated.

Some estimates were obtained from experts at IITA on cowpea pest losses, which indicated losses in the order of 800kg/ha from insects and 500 kg/ha from diseases with several-fold increases in overall yield in sprayed plots. Despite the high losses from insects on cowpeas, few farmers use insecticide. A small minority apply three insecticide sprayings to pure stands of improved varieties for which the benefit/cost ratio is attractive. The period for which cowpeas can be stored is limited by bruchid attack.

In the future, parasitic weeds and nematodes can be expected to increase with shorter fallows induced by higher population. There may be some reduction in maize streak/mottle, cassava mosaic and cowpea viruses through greater adoption of IITA resistant varieties.

Table 10 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

4.5 Guinea Savanna, zone A4

4.5.1 The farming system

This zone is frequently sub-divided into the Northern Guinea Savanna (NGS) and the Southern Guinea Savanna (SGS). It is considered as a whole in this study but some reference will be made to variations between the two. The extent of the two halves is shown in Fig. 3.

Annual rainfall increases from 900 mm to 1500 mm moving north to south, with a lengthening rainy season. The NGS is mostly monomodal and the SGS partly bimodal (see Fig. 3). The variability of the beginning and end of the rainy season is greater in the NGS. In the bimodal SGS, crop water requirements do not match well with rainfall pattern and there is uncertainty in the start of the first rainy season and a risk of an early end to the second season.

Insolation levels are high, with hot days and lower night temperatures producing high potential photosynthesis.

The soils are mainly alfisols and related soils with entisols, vertisols and acidic soils in some areas. There is some erosion hazard during heavy rain. There is a good response to fertilizer. Whilst with low inputs about 65% of the rotation cycle needs to be fallow, the conditions are good for returns to high inputs which would allow fertility to be maintained with a short fallow or, in good conditions, continuous cultivation. The fallows are mainly grass.

These agro-ecological conditions make this a high potential zone, possibly the highest potential in sub-Saharan Africa. Surprisingly the population density is relatively low with a mean of 43 persons/km^2, possibly due to slave raiding in former times. The combination of high potential productivity, good response to inputs and low population suggest that marginal returns to technical innovations are likely to be high (Goldman, 1986). Somewhat more costly pest control measures may be justified for this zone.

Maize, sorghum, yams and cassava are the major crops. The NGS was traditionally a sorghum area but in the last ten years or so Nigeria has experienced a big increase in maize production, much of it with tractor ploughing. The upsurge can probably be attributed to better roads for transporting fertilizer from the coast and maize to the high population coastal zone, money from the oil-boom for investment and improved varieties.

The SGS is the main yam zone; the largest concentration of yams is in Nigeria. Cassava is also important there and is increasing. Yam production is expected to remain static as its labour costs are high.

There is a wide range of secondary crops (Table 5) with rice assuming greater importance as inland valley swamps become more frequent.

The description of the zone given above has rather a Nigerian bias although this is somewhat justified as nearly half the zone's population is in Nigeria.

4.5.2 The pest situation

The pest ranking for the zone is shown in Table 11. Two groups of pests are placed in the first rank, weeds and cassava pests. Nematodes as a group are placed in the second rank of importance. As some pests are treated as members of a group and others are ranked as individual pests, care needs to be taken when comparing importance. For instance, whilst the three cassava pests are assessed to be more important as a group than maize streak/mottle, it can not be deduced that cassava mosaic is a worse problem than maize streak/mottle.

The parasitic weeds are more important in the Northern Guinea Savanna, and grasses in the Southern Guinea Savanna where *Imperata cylindrica* is the worst weed species. It is encouraged by burning and shifting cultivation.

Nematodes are important on yams and a wide range of crops. Cassava mosaic and maize streak/mottle are the worst virus diseases, followed by groundnut rosette and then yam mosaic, sweet potato virus complex and cowpea aphid-borne mosaic.

In the future, both maize and cassava are likely to increase in importance in the zone. Consequently their pests might be expected to become increasingly important for the zone, but, taking an optimistic view, increasing adoption of IITA maize varieties resistant to streak and mottle and of cassava varieties resistant to mosaic and bacterial blight will have the opposite tendency of reducing the importance of these three pests. However, as little progress has been made with resistance to cassava mite or with its biological control, cassava mite may become more important in the zone. Through increasing population pressure and shorter fallows an increase in nematodes and parasitic weeds may be expected.

Table 12 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

4.6 Forest/Savanna Transition, zone A4/5

4.6.1 The farming system

This is the transitional zone between savanna and forest and shares some of the characteristics of each. Being mostly derived from forest clearance for agriculture it probably shares more features with the forest. Annual rainfall is 1300 to 1800 mm and is mostly bimodal. The crop growing period ranges from 240 to 330 days, with two crops possible in most areas (Figs. 1–3).

The following description is more typical of the northern band of the zone as little specific information was obtained about the southern band covering southern Zaire etc.

The heart of the cropping system is maize and cassava intercropped. Both are planted at the beginning of the first rainy season and the maize fills the gaps between the cassava plants during their first four months of rather slow early growth. This reduces soil erosion, economizes on weeding and produces a combined output considerably greater than if each crop was grown separately. Yams are also very important and rice, both upland and swamp, is a major crop. Most of the treecrops of the forest zone are also grown as secondary crops.

More of Zaire's 16 million tonne cassava crop is grown in this zone than in the Forest zone A5, which is too wet to be ideal for cassava.

4.6.2 The pest situation

The pest ranking for the zone is shown in Table 13. Maize and cassava pests are in the first rank for importance. With humid conditions making drying difficult, first season maize suffers from most storage pests. Recently this problem has been made worse with the arrival in Togo of the greater grain borer, *Prostephanus truncatus*, which causes much more loss than other post-harvest maize pests. Drying conditions would be better for second season maize, but this crop suffers severely from maize streak and stemborers and so rather little is grown. Maize streak is also worse on late-planted first season maize. As in the Guinea Savanna, grasses and parasites are the worst weeds.

Pests of oilpalm, coffee, bananas, plantains and cocoa become significant as these crops become important.

Maize streak/mottle and cassava mosaic are much the most important insect-vectored viruses. The yam cultivars grown in the zone seem tolerant to yam mosaic virus which produces few symptoms in yams grown in Nigeria (Rossel and Thottappilly, 1985). Yam mosaic virus and cocoa swollen shoot are both listed in the third rank but cocoa swollen shoot may be the more important of the two because of the severe damage caused in Ghana and Togo.

Future changes are expected to be similar to those in zone A4, the Guinea Savanna; parasitic weeds, nematodes and green cassava mite are likely to get worse. Maize streak/mottle is likely to be reduced with greater adoption of resistant varieties and no reason to expect an increase in the relative importance of maize. Black sigatoka on bananas and plantains has only reached the zone recently and is likely to continue to increase in importance.

Table 14 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

4.7 Forest, zone A5

4.7.1 The farming system

Annual rainfall ranges from 1500 mm to extremes of 3000–4000 mm. It is mostly monomodal with a short or absent dry season. It is continually humid except in western parts such as Sierra Leone where the dry Hamatan wind blows from the Sahara in the dry season. The growing period ranges from 270 days to all year round.

The continuous humid conditions make drying and storage of grains and other crops difficult. The heavy rainfall causes problems of leaching, erosion, waterlogging and structural deterioration of many soils. There are acidic ultisols and oxisols in at least 50% of the zone. In many coastal areas there are coconut sands and mangrove and freshwater swamp soils. Inland valley swamps are important in the zone.

As the population grows and more of the area comes under continuous cultivation, maintenance of fertility becomes an increasing problem. Even with chemical fertilizer, fertility can not be maintained under continuous cropping without adding organic material, especially for acidic soils. In most areas cattle are limited by tsetse and so insufficient farmyard manure is available. Alley farming, in which mulch is provided by hedge prunings, is a promising strategy being developed by IITA, although at present there are difficulties in finding suitable hedgerow species for acid soils.

The traditional multi-storey cropping systems incorporating tree crops also help to maintain soil fertility by recycling leached nutrients.

Insolation during the growing period is often limited by cloud cover. This reduces the productive potential below that of the Guinea Savanna, but the high rainfall and long growing period ensures that the potential remains high.

This zone has the highest population (73 million in 1985) of any of the ten into which sub-Saharan Africa has been divided. In comparison with the Guinea Savanna the mean population density is higher in Ghana and much higher in Nigeria. In 1985 the Forest zone of Nigeria had a population of 48 million and a population density of 223 persons/km^2 (Goldman, 1986).

There is a wide range of major crops. Cassava is well adapted to acidic soils of low fertility; it is much the most important arable crop and its importance will grow as the population increases, fallows are reduced and soil fertility declines. Yams are also important from the Central African Republic to Côte d'Ivoire with the greater proportion grown in Nigeria.

Rice is an important cereal in Sierra Leone, Guinea, Liberia, Côte d'Ivoire and Nigeria, and to a much lesser extent in Cameroon and Zaire. Both upland rice and inland valley swamp rice are grown. In inland valley swamps, mounds or ridges are raised in the dry season for the cultivation of short duration cassava (for eating fresh), maize, groundnuts, vegetables and sweet potatoes. As well as providing drainage, the mounds provide a quick means of preparing the inland valley swamps for planting wet season rice as they are easy to breakdown and scatter. Mangrove swamp and deepwater rice are found in some coastal areas, but are excluded from this study. Bananas and plantains are important in Guinea, Côte d'Ivoire, Ghana, Nigeria, Gabon and Zaire.

Wild oil palms are tended and harvested over much of the zone. Improved plantations are also grown, particularly in Côte d'Ivoire.

Cocoa is important in Côte d'Ivoire, Ghana, Nigeria and Cameroon and robusta and liberica coffee in Côte d'Ivoire, Zaire and Central African Republic. Rubber is very important in Liberia, which has an exceptionally high rainfall.

Export crops on plantations are usually grown in pure stand or with plantains or bananas intercropped to provide shade for young plants. Most of the small-farm cropping system is one of multiple intercrops. Tree crops and bananas/plantains often form part of the intercrop in a multistorey system which provides good ground cover and recycles nutrients. Tree crops and plantains or bananas are important in the garden around the homstead which is farmed intensively under permanent cultivation. Fertility is maintained by adding household refuse and human and farmyard manure in such gardens.

Most of the arable crops are of long duration, but maize is a short duration crop, grown principally to provide fresh cobs as the first food crop available after the dry season. Growing maize for mature grain would meet severe drying problems and a second crop would be heavily attacked by maize streak and stalkborer.

4.7.2 The pest situation

The pest ranking for the zone is shown in Table 15. Weeds as a group feature in the first rank of pests. Important species include *Cynodon dactylon, Imperata cylindrica, Cyperus rotundus, Commelina benghalensis* and *Chromolaena odorata*. The latter is a particular problem in plantations of oilpalm, rubber and cocoa.

Owing to the importance of cassava, cassava mosaic and cassava bacterial blight are also in the first rank. The wet conditions are ideal for bacterial blight but less so for green spider mite which is put in the second rank of pest importance. The three main cocoa pests are also placed in the second rank.

Black sigatoka, in the second rank of importance, has recently spread across the zone as a serious disease of plantain and banana. Yield losses are estimated at 30–50% (IITA, 1988, p. 26).

Rodents are particularly important in this zone and are placed in the second rank. The roof rat (*Rattus rattus*) is omnivorous but does most damage to coconut, cocoa, oil palm and sugar cane. Oil palm fruits are eaten *in situ* and young coconuts are eaten on the palm when they usually fall (Hill and Waller, 1988). Cutting-grass (*Thryonomus swinderianus*) is an important rodent pest of rice, cutting many more stems than it eats. It will also attack oilpalm seedlings up to three years from planting (Hartley, 1977).

Cassava mosaic is the most important insect-vectored virus, followed by cocoa swollen shoot which is particularly serious in Ghana. Swollen shoot is much less important in Côte d'Ivoire, the largest cocoa producer. A number of viruses are placed in the fourth rank. Banana bunchy top is widespread for hundreds of kilometres from Kinshasa (Zaire) to the Atlantic coast (Sebasigari and Stover, 1988).

As high value cash crops are grown in this zone there is more chemical pest control, particularly on estates. Since the 1940s, cutting out of affected trees has been the principal method of swollen shoot control in Ghana. After some recent neglect, this strategy is now being intensified with World Bank assistance. Bird scaring, and making low fences and traps to control cutting-grass are important operations in protection of the rice crop.

In the future, the situation is likely to be similar to that in the transition zone A4/5; black sigatoka and nematodes increasing and maize streak decreasing. Cocoa swollen shoot will hopefully be decreased by the control programme. Monkeys are likely to decrease as human population grows. In eastern Sierra Leone and in Liberia, monkeys are hunted for smoking and human consumption and they are also eaten in some other parts of the zone. Cutting-grass are eaten too and so might decrease as well.

Table 16 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

4.8 Semi-arid East and South, zone A7

4.8.1 The farming system

Part of this zone lies in eastern Africa forming an irregular contiguous area from the central Tanzanian plateau, through Kenya's eastern plateau to southern Somalia and southern and eastern Ethiopia (see Fig 4). The second contiguous zone lies further south, covering Botswana, northern Namibia, southern Zambia, all except the central plateau and eastern highlands of Zimbabwe, and parts of western Mozambique.

Annual rainfall ranges from 250 to 750 mm. It is unimodal in the southern area and bimodal in most of the northern area. In Botswana the rainy season consists of intermittent rains spread between October and April. At Dodoma in Tanzania, where the rains are still unimodal, the rainy season is shorter, running from early December to April and part of the total may fall in torrential storms. In the more southerly latitude of Botswana the winters (May to August) are colder. During the growing season open water evaporation is higher in Botswana than at Dodoma and at no period of the year is there a positive water balance.

Altitude ranges from sea level to 1500m, with parts of the zone at the same altitude as B1, the plateau zone. The Zimbabwe plateau, Tanzania and Ethiopia are high areas; the valleys of the Limpopo, Zambezi and Luangwa and the Somali coast are lower areas.

The low and erratic rainfall underlies all problems in the zone. Farmers rely on a combination of livestock, arable cropping and frequently off-farm employment, perhaps with some family members/migrant workers. In the areas of lowest rainfall, such as Botswana, most farmers do not produce enough crops for subsistence and only have surpluses to sell in exceptionally good years. Little or no cash is used for inputs; if it is used it is likely to be spent on seed and/or hire of draft livestock or tractors.

Timeliness of land preparation and planting is crucial. Farmers without their own draft power tend to do worse as timeliness is less easy to achieve with hired or borrowed draft power and only a small area can be cultivated by hand. Achieving penetration of moisture, reducing run off and dealing with surface capping are important factors in soil management. Farmers normally have to wait for rain to soften the soil to plough; they usually go on to plant in order to establish the crop early, but the rain may then stop and the seedlings die. Thus replanting is fairly frequent. In most areas double ploughing will increase yields considerably. The first ploughing can be done in the dry season if tractor power is available, and in Botswana this has been found to be an effective method of controlling the troublesome weed *Cynodon dactylon*, with an effect lasting two or three seasons. An early rain, insufficient for planting, can also be used for first ploughing.

A labour bottleneck develops over the period of ploughing, planting and first weeding. In Botswana many farmers adopt the strategy of ploughing and planting the maximum acreage and not weeding at all, trading yield for acreage. Population density is low in most of the zone and so fallow periods can be long; labour is the limiting resource rather than land. However in some areas such as Natural Region IV and part of Natural Region III in Zimbabwe's national zoning system, population pressure is already a problem and land degradation is increasing.

Table 6 gives the crops grown. Sorghum and pearl millet are the main cereals. Cowpeas, the most important legume, are usually grown as an intercrop. In Botswana with its long season of intermittent rain, sorghum is the main crop and little pearl millet is grown. In Kenya, pigeon peas are an important crop and in Kenya and Ethiopia more maize is grown than in the rest of the zone. One of the reasons for doing so in Ethiopia is that maize escapes attack by birds.

In Somalia, sorghum is the main crop in the rainfed areas but a considerable amount of the crop production comes from a number of irrigated valleys in which maize and sesame are grown in rotation, with rice as a new crop in the Middle Shebelli Region. There are irrigated areas in other parts of the zone such as the Mwea-Tebere irrigation scheme in Kenya and the Chiredze area of S.E. Zimbabwe. Pest problems are likely to be different in such irrigated areas and they are excluded from the study.

4.8.2 The pest situation

The pest ranking for the zone is given in Table 17. Due to the zone being geographically rather diverse, the ranking is not extended beyond two ranks and for the second rank the areas in which the pest is particularly important are indicated.

Birds are a major pest in the zone as the two main cereals, sorghum and pearl millet, are susceptible. *Quelea* spp. are the most important bird pests. *Chilo partellus*, which thrives at lower humidity than *Busseola fusca*, is the most important stem borer. Weeds are a particular problem in Botswana. *Striga* is widespread throughout the region, particularly *Striga asiatica* as a parasite of sorghum. A.T. Obilana gives the following distribution of the three most important *Striga* species in the SADCC countries (which exclude Kenya, Somalia and Ethiopia):

Table 1

Distribution and possible hosts of *Striga* species occurring on cereals in SADCC region

Species	Distribution	Hosts
S. asiatica	All countries in SADCC except Lesotho	Sorghum, pearl millet, finger millet, maize, upland rice, sugarcane and wild grasses
S. hermonthica	Tanzania, Angola, Mozambique	Sorghum, pearl millet, m. maize and wild grasses
S. forbesii	Tanzania, Botswana, Zimbabwe, Swaziland and possible Angola and Mozambique	Sorghum, maize, rice and few wild grasses

Source: Obilana (1989)

Striga hermonthica is a major problem in the northern lowlands of Ethiopia and some *Striga asiatica* is found in the coastal area of Kenya.

In Botswana there have been severe attacks of the following pests in recent years:

Year	*Pest*
1985/6	Locusts } Brown, Red and African migratory
1986/7	Locusts } Brown, Red and African migratory
1987/8	Birds
1988/9	Birds, rats

The previous locust attacks were in 1965. In 1985/6 and 1986/7 there were attacks of armoured crickets (corn crickets).

Viruses are of little importance in the zone. Cowpea aphid-borne mosaic virus causes some loss to cowpeas. In Kenya, where cassava is somewhat more important, cassava mosaic is the most important virus. In some SADCC countries, maize dwarf mosaic virus A, transmitted mechanically by the corn leaf aphid (*Rhopalosiphum maidis*), is found on sorghum. As most new sorghum cultivars are susceptible to this virus, it may become more important.

Government departments and international institutes such as the Desert Locust Control Organization of East Africa, mount control programmes for migratory pests, particularly locusts, armyworms and birds. Due to the low productivity of the zone, farmers practice very little pest control other than the usual agronomic practices of tillage, weeding, intercropping, birdscaring, etc..

In the future, root-lesion nematodes are likely to increase in importance as the population density grows and fallow periods are shortened or disappear.

Table 18 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

4.9 East Coast, zone A6

4.9.1 The farming system

This zone runs along the coastal area of Kenya, Tanzania and Mozambique; it extends further inland in southern Tanzania and northern and central Mozambique. A narrow strip runs north into Malawi up the Shire valley and along the shore of Lake Malawi (Fig. 4). Most of the zone is below 500m in altitude.

The annual rainfall varies from 750 mm to 1500 mm over most of the area, but in pockets along the lake shore in Malawi it rises to 2000 mm. In northern Tanzania and Kenya it is bimodal with a more humid tropical climate. The growing period is 150 to 280 days over most of the zone, but it is lower at 90 to 150 days at the extremities of the zone in Kenya and southern Mozambique. The growing period is longest near the mouth of the Zambezi in Mozambique (see Fig. 2).

The rural population density is fairly high at 30 to 150 persons/km^2 over most of the zone, but it is less in the more inland parts of Tanzania and N. Mozambique.

The range of treecrops and arable crops grown is given in Table 6. Cassava, maize, sorghum and rice are grown as starchy staples. Cassava is particularly important in Mozambique, Mtwara (the most southerly region of Tanzania) and on the Kenya coast. Rice is an important crop in Tanzania. In irrigated cultivation, water control varies from full control to the free flooding of small valley bottoms normal in southern Tanzania. Rainfed rice is also grown, usually as part of a crop mixture. Cashew is an important cash crop in Mozambique, southern Tanzania (particularly on the Makonde plateau) and on the Kenya coast.

Coconut is grown along the whole coastal strip of the zone and is both eaten fresh and made into copra for oil extraction. Mango is ubiquitous; in Kenya improved varieties are produced on a commercial scale. Sesame is an important cash crop in southern Tanzania. Cowpeas are the most important legume, although a variety of other legumes are also grown including groundnuts in Mozambique where they make an important contribution to the diet. Cotton is grown in northern Tanzania/southern Kenya and along the strip of the zone in Mozambique from latitutude 21° to 25° south.

In northern Tanzania and the Kenya coast arable cultivation is mostly permanent or with short fallows. Further south in Tanzania, fallow periods for arable crops tend to be longer, reaching as much as ten years in some areas such as the more sparsely populated parts of the Makonde plateau. Extensive areas are infested with tsetse. In southern Tanzania nearly all cultivation is done by smallholders with hoe and cutlass. Little information was gathered about the farming system in Mozambique.

4.9.2 The pest situation

The pest ranking for the zone is given in Table 19. With the importance of cassava as a staple food crop in much of the area, the two main pests of cassava, green spider mite and cassava mosaic, are put in the first rank. The powdery mildew, *Oidium anacardii,* has caused a great deal of loss in Mozambique and Tanzania in the last fifteen years or so. Weeds as a group are put in the first rank, although they are rather less of a problem in established treecrops.

A wide range of pests of treecrops and arable crops make up the second, third and fourth ranks.

Amongst insect-vectored plant diseases, cassava mosaic is the most important followed by maize streak (see Table 28). Incidence of maize streak is particularly high in Malawi. A number of other viruses are of rather less importance and are placed in the fourth rank for all pests.

In southern Tanzania a World Bank supported programme is organizing the control of powdery mildew on cashew through dust-blowing sulphur and the distribution of more resistant varieties of cashew.

In Kenya, the control of cassava mosaic by distributing disease-free cuttings and roguing infected plants is feasible (Bock and Guthrie, 1978). Some attempt has been made to do this in Kenya and Mtwara region of Tanzania. Cassava mealybug is advancing into Tanzania and Mozambique and is likely to cause considerable damage in the first three or four years of its arrival. Thereafter it can be expected to be brought under partial control by released and indigenous predators. Maize streak is unlikely to be reduced by the distribution of resistant maize varieties.

Table 20 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

4.10 Plateaux, zone B1

4.10.1 The farming system

This zone extends from Angola, across Zambia, S.E. Zaire and Malawi into N.W. Mozambique and Ruvuma region of Tanzania. It also covers most of N.W. Tanzania and has an outlying area in Zimbabwe. A rather narrow strip around the western shore of Lake Malawi, extending South into the Shire valley, is at a lower altitude and forms part of zone A6, the East Coast, (as shown in Fig. 4).

The annual rainfall varies from 750 mm to 1500 mm. It is towards the lower end of this range in Tanzania and along the southern border of Angola and Zambia, adjacent to the semi-arid zone A7. In northern Tanzania and in Kenya and Uganda, rainfall is bimodal. In the rest of the zone there is a single rainy season lasting from four to seven months. The growing season is 150 to 250 days. The natural vegetation is mostly dry tropical scrub and thorn forest.

The population is less than 15 persons/km^2 over most of the area rising to over 100/km^2 in Malawi and Kitanga (S.W. Zaire). Livestock are of some importance in the areas clear of tsetse flies. Manual, oxen and tractor cultivation are all employed. Irrigation from small dams is common in the commercial sector in Zimbabwe. In most of the area fallow periods are quite long, with shorter periods and continuous cultivation in the more densely populated areas. In some areas such as the Malawi plateau, small farm owners plant most of their crops in pure stand rather than intercropped. There are many large commercial farms in this zone in Zimbabwe and in Malawi.

The major and secondary crops grown are shown in Table 6. Maize is the dominant cereal. Finger millet is grown in wetter and more acid soils such as northern Zambia and is also popular in Ruvuma region of southern Tanzania. There is some rice grown in river valleys in the Tanzanian part of the zone. Cassava is an important food crop from Angola eastward into northern Zambia.

Groundnuts are important as a food and export crop in Malawi, the eastern province of Zambia and Zimbabwe. Large farm owners in Zimbabwe grow confectionary groundnuts for export in rotation with tobacco. The groundnuts help to prevent the build up of rootknot nematodes. Irrigation allows long season varieties to be planted early to take advantage of the high insolation before the start of the rains. Groundnuts are also grown in Tanzania south of Lake Victoria.

Tobacco is mainly concentrated in Zimbabwe and Malawi. Cotton is grown in Angola, Zambia, Tanzania and Zimbabwe, with the latter country much the largest producer. Sweet potatoes are a crop of secondary importance, grown mainly in Angola and Tanzania. Some are also grown in Malawi, often planted late after failure of the maize crop. Soyabeans have recently become a commercial crop in Zimbabwe and is grown mostly on large farms. Coffee is grown in a small part of the zone, to the west of Luanda in Angola.

4.10.2 The pest situation

The pest ranking for the zone is shown in Table 21. Weeds as a group, including the cereal parasite *Striga*, and the maize stalkborer, *Busseola fusca*, are in the first rank. *Striga asiatica* is the most widespread of the *Striga* species although in Tanzania and Angola *Striga hermonthica* is also found. Both species parasitize maize, sorghum and pearl millet while *Striga asiatica* also attacks finger millet. Other important weeds are the perennial grass *Digitaria abyssinica* and the sedges *Cyperus rotundus* and *Cyperus esculentus*. The sedges are a particular problem in high input systems, especially where there is irrigation.

Second rank pests, include rootknot and root lesion nematodes as well as pests specific to the major crops. *Botryodiplodia theobromae*, one of the maize stalk and ear rots put as a group in the second rank of importance, was reported by the Plant Protection Research Institute of Zimbabwe to be the second most important disease of maize in commercial areas.

The larger grain borer, a serious storage pest of maize and dried cassava, is also placed in the second rank. Coming from S. America, it has recently spread throughout the zone in Tanzania and is threatening neighbouring countries. Quite good control has been achieved in farm stores in Tanzania by farmers shelling their maize and mixing it with insecticide before putting it in store. Efforts are being made to develop biological control using S. American predators.

The most important insect-vectored plant disease is maize streak virus (Table 28). Maize mottle virus is grouped with maize streak as it is also transmitted by the leafhopper *Cicadulina* spp. and has been found in the area (Rossel, 1984). Cassava mosaic, groundnut rosette and bean common mosaic virus are the next most important viruses followed by maize dwarf mosaic virus, which has recently grown in importance as a maize disease in Malawi, especially near Liwonde in the south east of the country. Both Zambia and Tanzania have programmes for multiplying mosaic-resistant cassava varieties and a programme of distribution of disease-free cassava cuttings is being carried out in Luapula district of Zambia.

In the future, there is likely to be an increase in nematode problems as yields decline with growing population and shorter fallows. Shorter fallows are also likely to lead to a decline in fertility and, in the wetter areas, to a rise in soil acidity. Cassava cultivation is likely to increase in response to these trends and this may lead to green cassava mite increasing in importance as no effective measures for its control have yet been devised. Maize dwarf mosaic virus is also likely to continue increasing in Malawi. Taking an optimistic view, the distribution of plant varieties resistant to maize streak, maize mottle and groundnut diseases may result in some reduction in these pests. The larger grain borer is expected to spread to other parts of the zone and to maize growing areas in adjacent zones.

Table 22 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

4.11 Uganda and Lake Victoria Shore, zone L1

4.11.1 The farming system

The boundaries of this zone are shown in Fig 4. The annual rainfall is 1000 mm to 1500 mm, with two rainy seasons and precipitation exceeding evapotranspiration for longer than six months. The growing period varies from about 200 to 300 days increasing from the south east to north west. The altitude varies little, being 1135m at the lake shore with a maximum of 1300m.

The natural vegetation is mostly savanna (grass and scrub) with some tropical rainforest in a strip of southern Uganda to the west of Lake Victoria. The population density around Lake Victoria and in West Lake region of Uganda (north of Lake Albert) is high (60 to 150 persons/km^2); elsewhere it is less.

Permanent cultivation or short fallow periods are the practice in the areas of high population density. Most cultivation is manual, but oxen and some tractors are also used. Cattle are important in the zone, particularly within 100 km of Lake Victoria.

Crops are listed in Table 6. Bananas, cassava, sweet potatoes and robusta coffee are the most important crops. The bananas are mostly type AAA Lujugira-Mutika clones, with some cultivars suitable for cooking and some for making beer. Robusta coffee is grown to the north-east and east of Lake Victoria from Kampala to 150 km south of the Tanzanian border.

Finger millet, cotton, beans and groundnuts are the next most important crops. This zone produces more sweet potatoes and finger millet than any other. Most of the cotton is grown in Tanzania on the south side of the lake. Sorghum, maize and surgarcane are secondary crops.

Intercropping is a common practice; for instance, coffee is frequently intercropped with bananas, and beans with maize or bananas.

The 1987 FAO crop production statistics for Uganda, listed in Table 32, gives some useful clues to the importance of different crops, as a large part of the zone's production comes from Uganda.

4.11.2 The pest situation

The pest rankings are shown in Table 23. Weeds as a group, two cassava pests and banana nematodes are put in the first rank. Cassava mealybug is spreading from the west but has not yet reached Kenya. Yellow sigatoka disease of bananas only warrants place in the fourth rank of importance, but black sigatoka remains a serious threat. It is a much more damaging banana disease and is already prevalent in neighbouring Rwanda and Zaire.

The insect-vectored plant diseases are grouped in order of importance in Table 28. Cassava mosaic virus and sweet potato virus complex are the most important. The banana streak virus in the Bukoba area was reported in a survey carried out by INIBAP in 1987 (Sebasigari and Stover, 1988). It was thought that it might be widespread and a survey was recommended.

It is worth mentioning that one of the most serious problems of bananas in the zone is declining yield and bunch size related to nutritional and mineral deficiencies. Magnesium deficiency results in root rot and poor roots and can contribute to and be confused with nematode root rot (Sebasigiri and Stover, 1988, p12).

In the future, the cassava mealybug is likely to become a worse problem in the short term as it spreads across the zone. In the longer term the problem should be diminished as natural and released predators bring it under partial control. Black sigatoka disease is likely to enter the zone and spread eastwards and, in the near future, become a first rank pest. After their November 1987 survey, Sebasigari and Stover predicted that black sigatoka would reach the Kigesi district of Uganda in 1988 and spread to other areas of the country over the next two or three years (Sebasigiri and Stover, 1988). The information obtained on black sigatoka for this study was not recent enough to check whether this had in fact happened.

Table 24 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

4.12 Mountains, zone B2

4.12.1 The farming system

This zone is made up of a number of separate highland areas over 1500m in altitude (see Fig. 4). They are located in Ethiopia; Kenya/N. Tanzania; Rwanda/ Burundi/E. Zaire/ S.W. Uganda; S. Tanzania/N. Malawi; Angola; E. Zimbabwe;

and Cameroon. There are also several small areas in Malawi such as Dedza and Mulanje which are part of the zone but are too small to appear in Fig. 4.

The annual rainfall over most of the areas varies from 750 to 1800 mm. The Cameroon area is much wetter with 1800 mm to over 5000 mm of rain (Fig. 1)

The crop growing period is shown in Fig. 2. In this zone, it varies from 90 days in parts of Kenya and Ethiopia to nearly all the year round in south west Ethiopia, eastern Zaire and Cameroon.

The population density is highest in Rwanda and Burundi where it exceeds 150 people/km^2. It is also high in Kenya, Ethiopia, Zimbabwe and the part of the zone in Angola. However, it is much lower in southern Tanzania and Cameroon.

Cattle are important in most of the zone. Cultivation is by hoe, draft animals and tractor, with the latter used more in Kenya and Zimbabwe. Continuous cultivation or cultivation with short fallow periods is practised in the areas of denser population. In some areas such as Kenya, mixed farming is common with several years of grazed grassland ('leys'), alternating with arable crops.

Agriculture in Kenya and Zimbabwe is more developed than other parts of the zone with intensive production of commercial crops. A considerable number of large farms are found in these areas.

The crops grown in the zone are shown in Table 6. The cropping pattern reflects the cool temperatures associated with the high altitude. The distribution of crops is shown in more detail in Table 2 below.

Table 2

Distribution of crops in Mountains, zone B2

Crop	Countries in which important
Maize } often Beans } intercropped	All
Bananas	N. Tanzania, Uganda, E. Zaire, Burundi, Rwanda
Sweet potatoes	Rwanda, Burundi, Uganda
Wheat	Ethiopia, Zimbabwe, Kenya
Barley	Ethiopia, (Zimbabwe and Kenya for brewing)
Coffee	All
Tea	Kenya, Tanzania, Zimbabwe
Potatoes	All
Pyrethrum	Kenya, Tanzania
Ensete	Ethiopia
Teff	Ethiopia
Broad Beans	Ethiopia
Vegetables	Most
Fruit Trees	Most
Peas	Most
Tobacco	Zimbabwe
Sunflowers	Tanzania

Ensete (*Ensete ventricosum*) is a banana-like plant suitable for the altitudes of 1800 m to 2600 m which in Ethiopia have enough rainfall but are too cold for bananas. The starchy pulp extracted from the pseudostem and corm is eaten and not the fruit. Teff (*Erogostis tef*) is a type of grass which produces a fine grain.

Table 6 and the description of the farming system fits the part of the zone in Cameroon less well. With its much higher rainfall, it shares some of the features of the forest zone A5, producing cocoa, cassava, yams and cocoyams besides maize, bananas, coffee and potatoes.

In the less commercialized farms of zone B2 intercropping is common, particularly maize with beans, which is the basis of the local diet in many areas.

4.12.2 The pest situation

The pest ranking for the zone is shown in Table 25. Weeds as a group, coffee berry disease and maize stalkborers are placed in the first rank. Coffee berry disease is worst in Kenya but it is a problem in all the arabica coffee areas, including Cameroon.

The insect-vectored plant diseases are grouped in order of importance in Table 28. None of them are sufficiently important to be put in the first or second ranks. The most important are maize streak and mottle, barley yellow dwarf virus found on barley and wheat, and the potato viruses group of which potato leaf roll virus and virus Y are the most important. Bunchy top of bananas has been confined to the Bujumbura and Bugarama valleys in Burundi and Rwanda for the last twenty years. Sebasigari and Stover (1988) report that it affects Pisang awak (ABB) and the East African AAA group of bananas with an incidence varying from less than 5% to 20%. It should be noted that these two valleys, like many in Rwanda and Burundi, are within the geographical boundaries drawn for the mountain zone B2 but are in fact at lower altitude (800–1200 m). Bean common mosaic virus causes mosaic in susceptible varieties of beans and in these it is seed borne. It also causes a lethal necrosis called 'black root' in mosaic resistant varieties which is not seed borne (Allen D.J., personal communication).

In the future, rootknot nematodes are likely to increase in importance as fallow periods are shortened with a growing population. Maize streak and mottle may reduce in importance if the CYMMIT and national programmes for breeding and introducing resistant varieties of maize are successful.

Table 26 gives the pest rankings for the zone for each of the major crops affected by a number of pests.

5. RELATIVE IMPORTANCE OF INSECT-VECTORED PLANT DISEASES ACROSS ZONES

For each of the prominent insect-vectored plant diseases, Table 29 summarizes the zones in which they reach the various ranks of importance. Scores are allocated to the ranks and the aggregate score for each pest is calculated as a crude measure of the importance of the pest in sub-Saharan Africa. The measure is crude because the weight to be given to the difference between ranks was a matter of judgement and the scoring system assumes that it is uniform across all the zones and pests; all the zones are also assumed to be of equal importance, which is unlikely.

Comparing the aggregate scores, cassava mosaic and maize streak/mottle have much the highest scores with 96 and 72 respectively. Groundnut rosette is on its own with a score of 39 and the rest are in a group of much lesser importance with scores of 22 down to 5.

Despite the crudity of the system, the general pattern is sufficiently clear to say with confidence:

(a) Cassava mosaic and maize streak/mottle are much the most important insect-vectored plant diseases.

(b) Groundnut rosette is the next most important, but considerably less so than cassava mosaic and maize streak/mottle.

(c) The remaining insect-vectored plant diseases are of considerably less importance that the first three. With somewhat less confidence one can say that sweet potato virus complex, cowpea aphid-borne mosaic and cocoa swollen shoot are the most important of these remaining viruses.

This outcome is summarized in Table 30.

It confirms the wisdom of the decision for ODNRI project T0063 to concentrate initially on cassava mosaic and maize streak in compiling the database on insect-vectored plant diseases in sub-Saharan Africa and to add groundnut rosette as the next priority. It also suggests that if the scope of the database is to be widened, sweet potato virus complex, cowpea aphid-borne mosaic and cocoa swollen shoot should be the next candidates for inclusion.

6. RELATIVE IMPORTANCE OF AGRO-ECOLOGICAL ZONES FOR INSECT-VECTORED PLANT DISEASES

Using the same scoring system described in section 5, Table 31 gives the aggregate scores for insect-vectored plant diseases in each zone. This shows very clearly that such pests are much less important in the two semi-arid zones A2 (Sahel) and A7 (Semi-arid East and South). However the warning already given should be borne in mind that this low score might conceivably be affected by a lack of study of such pests in these areas.

Bearing in mind the crudity of this scoring system, the remaining zones can not be separated with much confidence. Nevertheless there is some suggestion that zones A3, A4/5, A5 and A6 are more affected by insect-vectored plant diseases than zones A4, B1, L1 and B2. The main factor in this difference appears to be the greater importance of cassava and cassava mosaic in zones A4/5, A5 and A6. In each of these zones cassava mosaic is placed in the first rank of pest importance.

7. FUTURE WORK

7.1 Revision and updating of this study

This study could be further refined by obtaining ranking assessments from a wider range of experienced informants. Accordingly, reactions to this *Bulletin* are invited and a format for suggesting changes to the rankings is included as Appendix E. Such changes could be suggested either because the original assessment is considered incorrect or because a change in the actual pest situation has occurred.

If enough revisions accumulate to warrant it a revised edition of the *Bulletin* will be issued. Until that time any readers who wish to update the *Bulletin* can write to the Head of Pest and Vector Economics Section, ODNRI, for any ranking revisions made.

7.2 Possible further studies

If further studies are to be undertaken, it is suggested that the most fruitful approach would be to select regions within sub-Saharan Africa for more detailed and thorough study. The more diverse zones could be sub-divided and an attempt made to establish the relative importance of crops on a quantitative basis. Although often rather unreliable, official statistics could be collected for crop output by the smallest area available, such as a district. Using this data, crop production per zone could be calculated thus making a judgement on how to allocate the production of a district that cuts across zones. Output could then be priced using the usual shadow pricing procedures of cost/benefit analysis. If desired, weightings could be given for such factors as contribution to diet and income level of producers. It would require a considerable amount of work to make the studies necessary to establish the right prices to assign to subsistence crops (e.g. such factors as the value of green maize as the first crop available at the end of the hungry season) and some short cuts to give more approximate answers might be necessary.

The relative importance of pests could then be estimated through study of the literature and the consultation of a wider range of experts than was possible for this study. If experts were first given the relative importance of crops in quantitative terms they should be able to make a better judgement of the relative importance of pests across all crops in the zone. This could also be attempted in stages, taking one crop at a time, making a judgement of the quantitative importance of each pest to the crop, then weighting this quantity by the value of the crop output. Clearly the more information available on pest losses the more successful this staged approach would be.

Reliability could also be improved by tabulating the pest ranking estimates given by each expert at the first interview and allowing them time to make revisions.

The result of a more thorough and quantitative study such as that described above could be used with somewhat more confidence as evidence in deciding how resources should be allocated for crop protection. However, the study itself would require considerable resources and the reliability of the outcome would be difficult to predict in advance. In deciding whether such a study was justified, thorough consideration would need to be given to how the results were to be used.

It should be noted that a further advantage of quantifying the importance of crops would be to give a measure by which to judge the relative importance of zones. It would allow estimates of the relative importance of pests to be extended across zones and to be made for the total area studied as a whole, e.g. for sub-Saharan Africa, in a much less crude (but more costly) way than that done for insect-vectored plant diseases in the present study.

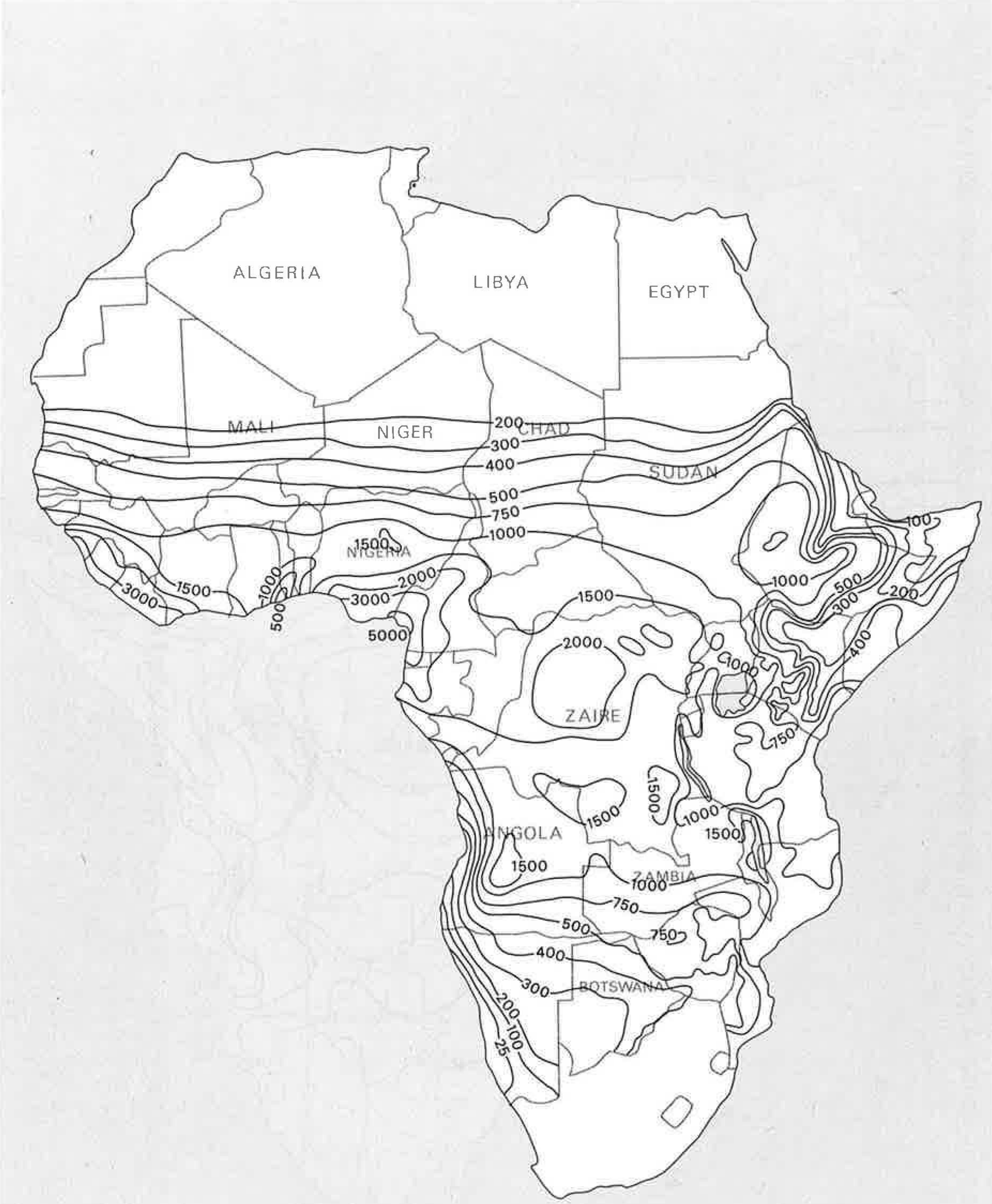

FIGURE 1 Mean Annual Rainfall in sub-Saharan Africa

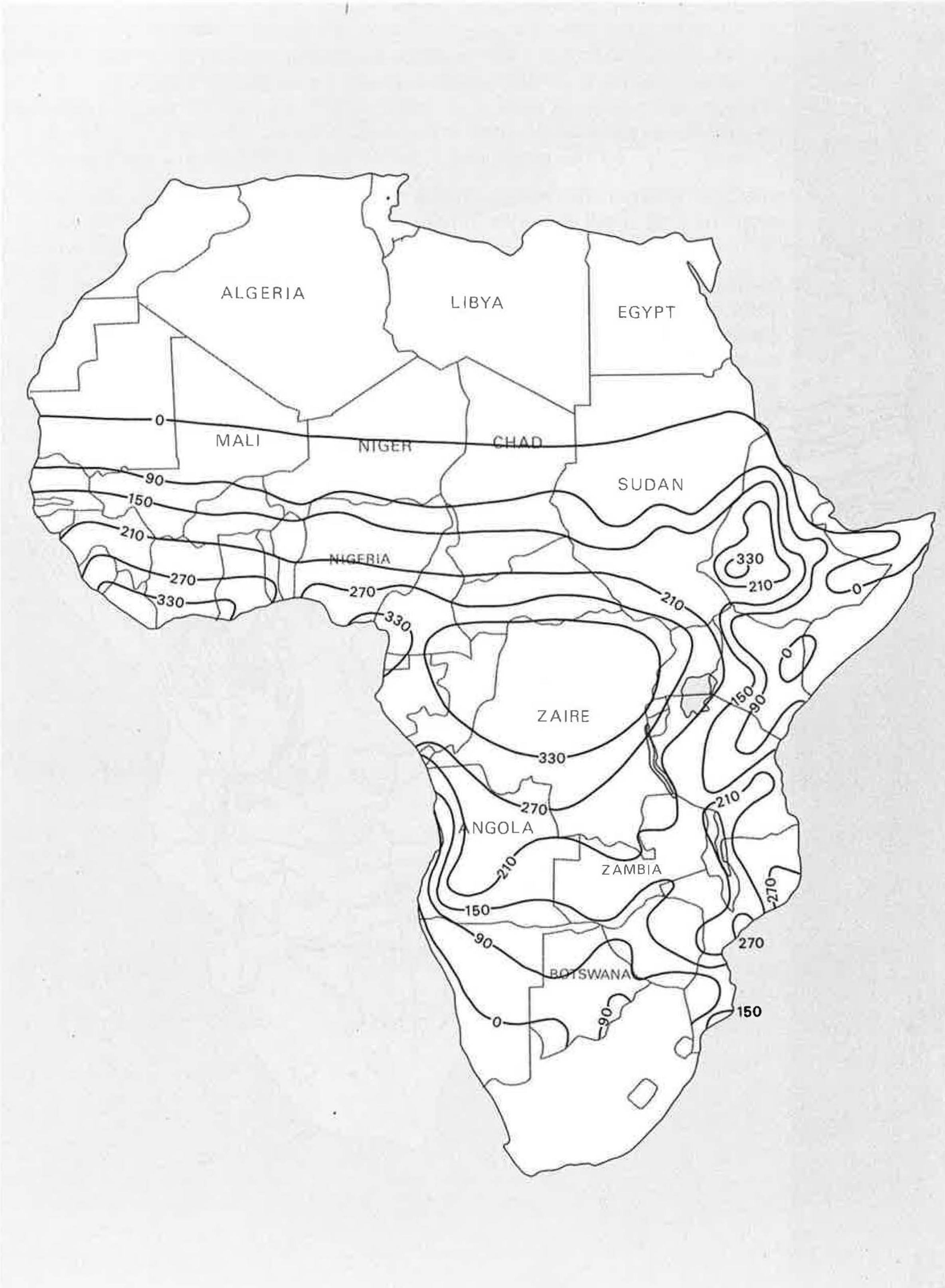

FIGURE 2 Length of crop growing periods (no. of days) in sub-Saharan Africa (from FAO, 1978)

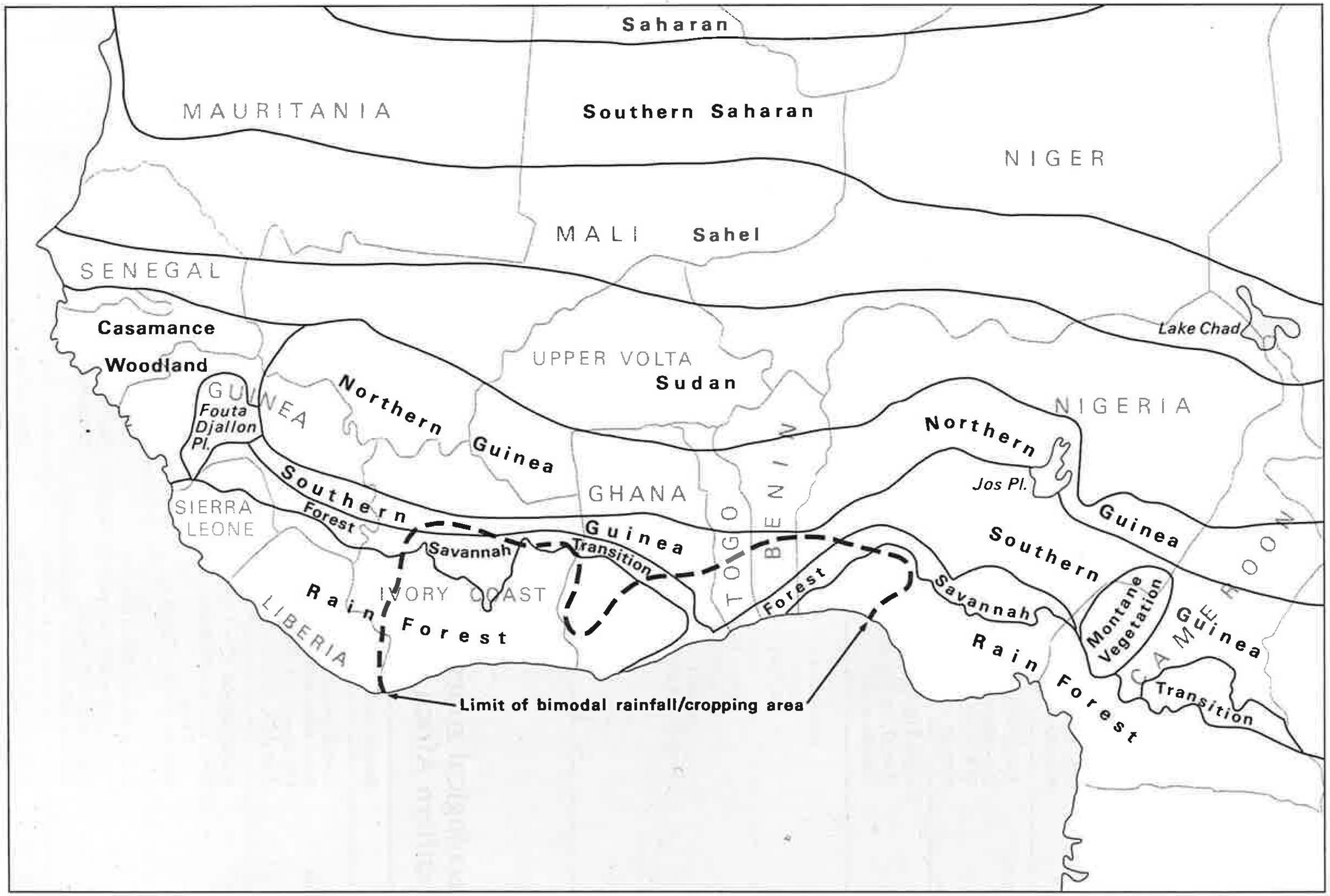

FIGURE 3 Vegetation zones of West Africa (from Harrison Church, 1980 and "Atlas de la République Unie du Cameroun") with bimodal rainfall/cropping area (after Lawson, 1979)

Table 3

Agro-ecological zones and crop management systems in West and Central Africa

Zone	Rainfall and altitude	Crop management
Sahel A2	Annual rainfall 250–500 mm Rains unreliable Dry season >8 months Altitude <900 m (3000 ft)	Grazed fallows Fallow period shorter close to village
Sudan Savanna A3	Annual rainfall 500–900 mm Dry season 8 months Altitude <900 m (3000 ft)	Shifting cultivation Short fallow Permanent cultivation
Guinea Savanna A4	Annual rainfall 900–1500 mm Dry season 5–7 months Most of zone unimodal Altitude <900 m (3000 ft)	Shifting cultivation Short fallow Permanent cultivation Perennial crops
Forest/Savanna Transition A4/5	Annual rainfall 1300–1800 mm Dry season 4 months One or two rainy seasons Altitude <900 m (3000 ft)	As for A4
Forest A5	Annual rainfall 1500–4000 mm Virtually no dry season Altitude <900 m (3000 ft)	As for A4 but perennial more common

Table 4

Agro-ecological zones and crop management systems in East and southern Africa

Zone	Rainfall and altitude	Crop management
Semi-arid East & South A7	Annual rainfall 250–750 mm Rains unreliable Dry season >8 months Altitude <1500 m (5000 ft)	Grazed fallows Fallow periods shorter close to village
East Coast A6	Annual rainfall 750–1500 mm Two rainy seasons in Kenya and N. Tanzania Altitude <900 m (3000 ft)	Shifting cultivation Short fallow Permanent cultivation Perennial crops
Plateaux B1	Annual rainfall 750–1500 mm Single rainy season except in N. Tanzania Dry season 5–8 months Altitude 900–1500 m (3000–5000 ft)	Shifting cultivation Short fallow Permanent cultivation
Uganda and Lake Victoria Shore L1	Annual rainfall 1000–1500 mm Two rainy seasons Positive water balance >6 months Altitude 1135–1300 m (3700–4300 ft)	Short fallow Permanent cultivation Perennial crops
Mountains B2	Annual rainfall 750–1800 mm One or two rainy seasons Altitude >1500 m (5000 ft) (Rainfall in Cameroon 1800–5000 mm)	Permanent cultivation Perennial crops Grazed leys

Table 5

Cropping pattern in West and Central Africa

Zone	Major crops	Secondary crops
Sahel A2	Pearl millet (dominant in North) Cowpeas	Groundnuts Sorghum (more in South) Okra
Sudan Savanna A3	Sorghum Groundnuts Cowpeas Cotton	Maize Cassava Sweet potato Tobacco Sesame Pearl millet
Guinea Savanna A4	Maize Yams Sorghum Cassava	Groundnuts Cowpeas Cotton Rice Sweet potato Citrus Cocoa (riverine) Cashew
Forest/Savanna Transition A4/5	Cassava } intercropped Maize } Yams Rice	Banana and plantain Cocoa Coffee Oilpalm Cocoyam Sweet potato Cowpeas Cashew
Forest A5	Cassava Banana and plantain Yams Oilpalms Rice Coffee (robusta and liberica) Rubber (Liberia) Cocoa	Coconut Maize Cocoyams Cola nut (Nigeria)

Table 6

Cropping pattern in East and southern Africa

Zone	Major crops	Secondary crops
Semi-arid East and South A7	Sorghum Pearl millet Cowpeas	Groundnuts Bambarra groundnuts Pigeon peas Maize Chickpeas (Ethiopia) Cassava Sweet potato Cotton
East Coast A6	Maize Cassava Cowpeas Cashew Coconut Rice (Tanzania) Cotton	Sweet potato Sorghum Sesame Pawpaw Groundnuts Mango Citrus
Plateaux B1	Maize Cotton Tobacco Groundnuts Cassava	Beans Sweet potato Sunflower Finger millet Sorghum Soyabeans (Zimbabwe)
Uganda and Lake Victoria Shore L1	1st Bananas Cassava Sweet potatoes Robusta coffee 2nd Finger millet Cotton Beans Groundnuts	Sorghum Maize Sugarcane
Mountains B2	Maize Wheat Beans Barley Arabica coffee Tea Bananas Broad beans (Ethiopia) Potatoes Ensete (Ethiopia)	Sunflower Sweet potato (Rwanda and Burundi) Vegetables Tree fruits Pyrethrum Teff (Ethiopia) Tobacco Peas Casssava (Rwanda and Burundi)

Table 7

Pest ranking in Sahel – zone A2

1.	(a) Millet head miner (*Heliocheilus* or *Raghuva albipunctella*) (b) Grasshoppers (*Edalis senegalensis* and *Krausaria angulifera*)
2.	Stem borers (*Acigona ignefusalis*) on millet Blister beetles (Meloidae) on millet Birds eat millet and sorghum Cowpea flower thrips (*Megalurothrips sjostedti*) *Striga* parasitic weeds as a group (a) *S. hermonthica* on millet, sorghum, maize (b) *S. gesnerioides* on cowpeas
3.	Aphids causing physical damage to cowpeas and as vector of **Cowpea aphid-borne mosaic** *Cynodon dactylon* (perennial grass) *Meloidogyne* spp. on cowpeas etc. Charcoal rot (*Macrophomina*) on cowpeas **Groundnut rosette** *Pratylenchus brachyurus* nematode on groundnut
4.	Pod borers (*Maruca testulalis*) on cowpeas Bruchids (*Callosobruchus* spp.) as storage pest of cowpeas Bacterial blight (*Xanthomonas campestris*) on cowpeas Rodents Sorghum midge (*Contarinia sorghicola*) *Acacia* spp. as weeds Stem borers on sorghum *Aspergillus* spp. (producing aflatoxin) on groundnut Peanut clump on groundnuts

NB (a) Above is more typical of the drier northern area. In the less arid and more southerly area sorghum pests become somewhat more important and millet pests less so as sorghum begins to replace some millet. Birds also increase.

(b) If weeds are considered together as a group, as is done in other zones, they will be in the first rank.

Table 8

Sahel, zone A2: ranking of pests by crops

Crop	Pests specific to crop: Ranking group among all pests	Pests specific to crop: Pest	General pests (unranked)
Pearl Millet	1 (a)	Millet head miner	Grasshoppers Weeds Rodents
	2	Stem borers Blister beetles Birds *Striga hermonthica* parasitic weed	
Cowpeas	2	Flower thrips	Grasshoppers Weeds Rootknot nematodes Rodents
	3	*Striga gesnerioides* parasitic weed Aphids & Cowpea aphid-borne mosaic	
	4	Pod borers Bruchids Bacterial blight	
Sorghum	2	Birds	Grasshoppers Weeds Rodents
	3	*Striga hermonthica* parasitic weed	
	4	Sorghum midge Stem borers	
Groundnuts	3	Groundnut rosette	Grasshoppers Weeds Rodents

Source: Table 7

Table 9

Pest ranking in Sudan Savanna – zone A3

1.	Weeds, including *Striga hermonthica* on sorghum, millet, maize *Striga gesnerioides* on cowpeas *Alectra vogelii* on groundnuts, cowpeas, tobacco **Ground rosette** Groundnut early and late leafspots (*Mycosphaerella* spp.) Cotton insects (particularly bollworms and stainers) Cowpea insects (particularly thrips, *Megalurothrips sjostedti*)
2.	**Maize streak/mottle** Birds Sorghum midge (*Contarinia sorghicola*) *Aspergillus*, spp. (producing aflatoxin) on groundnuts Termites on maize, groundnuts etc. Cassava green spider mite (*Mononychellus tanajoa*) **Cassava mosaic** Rootknot nematodes (*Meloidogyne* spp.) on cowpeas, sweet potato, cotton, tobacco, etc. Cowpea diseases particularly scab, (*Elsinoe phaseoli*) and including: **Aphid-borne mosaic virus** **Golden mosaic virus** **Yellow mosaic virus** Sorghum leaf diseases, including downy mildew (*Peronoscleropspora sorghi*)
3.	Peanut clump on groundnuts Millepedes on groundnut and millet Sweet potato weevil (*Cylas* spp.) **Sweet potato virus complex** **Tobacco mosaic virus** *Pratylenchus brachyurus* nematode on groundnut Stemborer (*Busseola fusca*) on sorghum and maize Rodents Sorghum shootfly (*Atherigona soccata*) Charcoal rot (*Macrophomina*) on sorghum and cowpeas Whitefly (*Bemisia tabaci*) on cotton, contaminating lint with honeydew and as vector of **cotton leaf curl virus**

Table 10

Sudan Savanna, zone A3: ranking of pests by crop

Crop	Pests specific to crop: Ranking group among all pests	Pests specific to crop: Pest	General pests (unranked)
Groundnuts	1	Groundnut rosette Groundnut early & late leafspots	Weeds Termites Rodents
	2	*Aspergillus* spp.	
	3	Peanut clump *Pratylenchus brachyurus* nematodes *Alectra vogelii* parasitic weed	
Cowpeas	1	Insects, particularly thrips	Weeds Rootknot nematodes Rodents
	2	Diseases, particularly scab	
	3	Charcoal rot *Alectra vogelii* parasitic weed	
Cotton	1	Insects, particularly bollworms and stainers	Weeds Rootknot nematodes
Sorghum	1	*Striga hermonthica* parasitic weed	Weeds Rodents
	2	Sorghum midge Sorghum leaf diseases, including powdery mildew	
	3	Stemborer (*Busseola fusca*) Sorghum shootfly Charcoal rot	

Source: Table 9

Table 11

Pest ranking in Guinea Savanna – zone A4

1. Weeds as a group:
   (a) *Striga* parasitic weeds: *S. hermonthica* on maize, sorghum, millet
   S. gesnerioides on cowpeas
   (b) Perennial grasses and sedges, particularly *Imperata cylindrica*
   Cynodon dactylon
   Pennisetum polystachion
   Panicum maximum
   (c) Annual grasses and sedges
   (d) *Alectra vogelii* on groundnuts and cowpeas
   Cassava pests as a group:
   - **Mosaic**
   - Bacterial blight (*Xanthomonas campestris* pv. *manihotis*)
   - Green spider mite (*Mononychellus tanajoa*)

2. **Maize streak/mottle**
   Termites, particularly on maize
   Nematodes of yam as a group:
   - *Scutellona bradys*
   - *Pratylenchus* spp. (also on groundnuts, maize, cotton)
   - *Meloidogyne* spp. (also on cassava, cowpeas, cotton)

3. **Groundnut Rosette**
   Groundnut leafspots (early and late, *Mycosphaerella* spp.)
   Cotton bollworms and stainers
   Birds on rice and sorghum
   Cassava mealybug (*Phenacoccus manihoti*)
   Cowpea insects and diseases as a group, including:
   Aphid-borne mosaic
   Golden mosaic
   Yellow mozaic
   Yam necrosis
   Downy mildew (*Peronosclerospora sorghi*) on maize and sorghum
   Ear and stalk rots (*Botryodiplodia, Fusarium, Macrophomina*) on maize
   Rodents

4. **Yam mosaic virus**
   Yam storage rot (*Botryodiplodia theobromae* and *Fusarium* spp.)
   Yam beetle (*Pryonoryctes caniculus*)
   Yam storage insects
   Cassava anthracnose (*Glomerella manihotis* and *G. cingulata*)
   Cassava root-rot (*Rigidoporus lignosis* and *Phytophthora* spp.)
   Cocoyam root-rot (*Pythium myristylum* etc.)
   Sweet potato virus complex

Table 12

Guinea Savanna, zone A4: ranking of pests by crop

	Pests specific to crop		
Crop	Ranking group among all pests	Pest	General pests (unranked)
Maize	2	Maize streak/mottle	Weeds Termites *Pratylenchus brachyurus*
	3	Ear & stalk rots Downy mildew	
	4	*Striga hermonthica* parasitic weed	
Cassava	2	Cassava mosaic Cassava bacterial blight Green spider mite	Weeds Rootknot nematodes
	3	Cassava mealybug	
	4	Cassava anthracnose Cassava root rot	
Yams	2	Nematodes	Weeds Termites
	3	Yam necrosis	
	4	Yam storage rot Yam beetle Yam storage insects	

Source: Table 14

Table 13

Pest ranking in Forest/Savanna Transition – zone A 4/5

1. Maize storage pests (*Sitophilus granarius* and *Prostephanus truncatus*)
   Maize stem borer (mostly *Eldana* and *Sesamia*)
   Ear and stalk rots (*Botryodiplodia, Fusarium* and *Macrophomina*) on maize
   Maize streak/mottle
   Cassava mosaic
   Cassava bacterial blight (*Xanthomonas campestris* pv. *manihotis*)
   Cassava green spider mite (*Mononychellus tanajoa*)
   Weeds (as in A4)

2. Birds on rice
   Cassava mealybug (*Phenacoccus manihotis*)
   Black sigatoka (*Mycosphaerella fijiensis*) on banana and plantains
   Yam nematodes (*Scutellonema bradys, Pratylenchus* spp.,
   Meloidogyne spp.) – some on other crops

3. Cassava anthracnose (*Glomerella* spp.)
   Cassava root-rot (*Rigidoporus lignosis* and *Phytophthora* spp.)
   Yam mosaic virus
   Yam necrosis
   Banana weevil (*Cosmopolites sordidus*) on bananas and plantains
   Root nematode (*Radopholus similis*) on bananas and plantains
   Aspergillus spp. (producing aflatoxin) on maize
   Blight (*H. maydis*) on maize
   Lowland rust (*Puccinia polysora*) on maize
   Downy mildew (*Peronosclerospora sorghi*) on maize
   Cocoyam root rot (*Pythium myriostylum* etc.)
   Fusarium wilt (*Fusarium oxysporum* f.sp. *elaidis*) on oilpalm (particularly S. Zaire)
   Bacterial bud rot (*Erwinia lathyri*?) on oilpalm (particularly S. Zaire)
   Rodents
   Coffee leaf rust (*Hemileia vastatrix*)
   Black pod (*Phytophthora* spp.) on cocoa
   Capsids (*Sahlbergella singularis*) on cocoa
   Swollen shoot of cocoa
   Cowpea diseases
   Cashew flower die-back in Nigeria (cause unclear)

Table 14

Forest/Savanna Transition, zone A4/5: ranking of pests by crop

	Pests specific to crop		
Crop	Ranking group among all pests	Pest	General pests (unranked)
Maize	1	Storage pests Stemborers Ear and stalk rots Maize streak/mottle	Weeds Rodents
	3	Blight Lowland rust Downy mildew *Aspergillus* spp.	
Cassava	1	Cassava mosaic Cassava bacterial blight Green spider mite	Weeds
	2	Cassava mealybug	
	3	Cassava anthracnose Cassava root-rots	
Yams	2	Yam nematodes	Weeds Rodents
	3	Yam mosaic virus Yam necrosis	
Rice	1	Birds	Weeds Rodents
Bananas and Plantains	2	Black sigatoka	Weeds Rodents
	3	Banana weevil Root nematode	

Source: Table 13

Table 15

Pest ranking in Forest – zone A5

1. Weeds
   Cassava mosaic
   Cassava bacterial blight (*Xanthomonas campestris* pv. *manihotis*)

2. Cassava green spider mite (*Mononychellus tanajoa*)
   Black pod (*Phytophthora* spp.) on cocoa
   Capsids (*Sahlbergella singularis*) on cocoa
   Swollen shoot on cocoa
   Birds on rice
   Yam nematodes (*Scutellonema bradys, Pratylenchus* spp.,
   Meloidogyne spp.) – some on other crops
   Black sigatoka (*Mycosphaerella fijiensis*) on bananas and plantains
   Rodents

3. Coffee leaf rust (*Hemileia vastatrix*)
   Cassava mealybug (*Phenacoccus manihoti*)
   Banana weevil (*Cosmopolites sordidus*) on bananas and plantains
   Root nematodes (*Radopholus similis*) on bananas and plantains
   Maize storage pests
   Monkeys

4. **Banana bunchy top virus**
   Cola storage diseases
   Rice yellow mottle
   Yam mosaic virus
   Yam necrosis
   Cocoyam root rot (*Pythium myriostylum* etc).
   Maize-streak/mottle
   Maize stem borer (mostly *Eldana* and *Sesamia*)
   Ear and stalk rots (*Botryodiplodia, Fusarium, Macrophomina*) on maize
   Cassava anthracnose (*Glomerella* spp.)
   Cassava root rot (*Rigidoporus lignosis* and *Phytophthora* spp.)
   White root disease (*Rigidoporus lignosus*) on rubber
   Pink disease (*Corticum salmonicolor*) on rubber
   Oilpalm dry basal rot (*Ceratocystis paradoxa*) in Nigeria
   Oilpalm leaf miner (*Coelaenomenodera elaeidis*)
   Oilpalm blast (*Pythium and Rhizoctonia* spp.) on nursery plants
   Rhinoceros beetles (*Oryctes* spp.) on coconut and oilpalm
   Palm weevils (*Rhynchophorus* spp.) on coconut and oilpalm
   Cape St. Paul wilt (mycoplasma-like-organism) on coconut from Ghana to Nigeria
   Cucumber mosaic virus of bananas in Cameroon and Côte d'Ivoire
   Root rot (*Armillaria melea*) on rubber
   Rice blast (*Pyricularia oryzai*)
   Gall midge (*Orseolia oryzivora*) on rice
   Mistletoe (*Loranthus* spp.) on cocoa

5. **Cowpea golden mosaic virus** of cowpeas (near Port Harcourt in Nigeria)

Table 16

Forest, zone A5: ranking of pests by crop

	Pests specific to crop		
Crop	Ranking group among all pests	Pest	General pests (Unranked)
Cassava	1	Cassava mosaic Cassava bacterial blight	Weeds Rodents
	2	Green spider mite	
	3	Cassava mealybug	
	4	Cassava anthracnose Cassava root rot	
Bananas and Plantains	2	Black sigatoka	Weeds
	3	Banana weevil Root nematodes	
	4	Banana bunchy top virus Cucumber mosaic virus	
Yams	2	Yam nematodes	Weeds Rodents
	4	Yam mosaic virus Yam necrosis	
Rice	2	Birds	Weeds Rodents
	4	Rice yellow mottle virus Rice blast Gall midge	
Cocoa	2	Black pod Capsids Swollen shoot virus	Weeds Monkeys Rodents
	4	Mistletoe	

Source: Table 15

Table 17

Pest ranking in Semi-arid East and South – zone A7

1. Birds Stem borers (mostly *Chilo partellus* and *Busseola fusca*) Weeds (particularly *Striga asiatica* on cereals)	
	Particularly in:
2. Root-lesion nematodes (*Pratylenchus* spp.) on cereals and groundnuts.	Zimbabwe
Armoured crickets (*Acanthoplus, Enyaliopsis* spp. and *Hetrodes pupus*) on cereals	Zimbabwe and Botswana
Sugarcane aphid (*Melanaphis sacchari*) on sorghum	Botswana
Rats	Botswana
Locusts (infrequent)	Botswana
Storage insects (particularly weevils and grainborers)	Kenya, Zimbabwe, Botswana
Armyworm	Tanzania, Zimbabwe, Kenya
Podborers (*Maruca testulalis*) on pigeon pea and cowpea	Kenya, Tanzania
American bollworm (*Heliothis armigera*) on cereals, legumes and cotton	Tanzania, Kenya, Botswana
Sorghum diseases as a group, including rust (*Puccinia purpurea*) smuts (*Sphacelotheca* spp. and *Tolyposporium ehrenbergii*) sooty stripe (*Ramulispora sorghi*) leaf blight (*Cochliobolus heterostrophus*) **maize dwarf mosaic virus A**	
Pearl millet diseases as a group, including downy mildew (*Sclerospora graminicola*) ergot (*Claviceps fusiformis*) rust (*Puccinia penniseti*) smuts (*Tolysporium penicillariae* and *Sphacelotheca destruens*)	
Cowpea pests and diseases, including **cowpea aphid-borne mosaic virus**	
Rootknot nematodes (*Meloidogyne* spp.) on cowpeas and other crops	
Cotton pests	

Table 18

Semi-arid East and South, zone A7: ranking of pests by crop

Crop	Pests specific to crop: Ranking group among all pests	Pests specific to crop: Pest	General pests (unranked)
Sorghum	1	Stemborers	Weeds Birds
	2	Sugarcane aphid Sorghum diseases	Rootlesion nematodes Armoured crickets Rodents Locusts Armyworm American bollworm
Pearl millet	1 2	Stemborers Pearl millet diseases	As for sorghum
Cowpeas	2	Pod borers Other cowpea pests and diseases	Weeds Rootknot nematodes Rodents Locusts American bollworm

Source: Table 17

Table 19

Pest ranking in East Coast – zone A6

1. **Mosaic** on cassava
   Green spider mite (*Mononychellus tanajoa*) on cassava
   Powdery mildew (*Oidium anacardii*) on cashew in Mozambique and Tanzania.
   Weeds (less problem with treecrops)

2. Mealybug (*Phenacoccus manihoti*) on cassava
   Rhinoceros beetle (*Oryctes boas* and *O. monoceros*) on coconut
   Coconut bug (*Pseudotheraptus wayi*) on coconut and cashew
   Lethal bole rot (*Marasmiellus cocophilus*) on coconut
   Armyworm (*Spodoptera exempta*)
   Maize streak
   Maize blight (*H. maydis*)

3. Sorghum midge (*Contarina sorghicola*) on sorghum
   Rice blast (*Pyricularia oryzae*)
   Late leaf spot (*Mycosphaerella berkeleyi*) on groundnut
   Rust on groundnut (*Puccinia arachidis*)
   Stem borers (particularly *Chilo partellus*) on maize
   Stalk rot (*Fusarium* spp.) on maize
   Die-back complex (*Helopeltis* spp. and *Phomopsis anacardii*) causing die-back on cashew
   Anthracnose (*Collectrichum gloesporodes*) on mango and causing die-back on cashew and pawpaw
   Cowpea podborers (*Maruca testulalis* and *H. armigera*)
   Cowpea thrips (*Megalurothrips sjostedti*)
   Cowpea scab (*Elsinoe phaseoli*)
   Sugarcane stalkborer (*Eldana saccharina*) on sugarcane
   Sugarcane scale (*Aulacaspis tegalenis*) on sugarcane
   Cotton insects
   Rodents

4. Early leaf spot (*Mycosphaerella arachidis*) on groundnut
   Downy mildew (*Peronosclerospora* spp.) on maize in South Mozambique
   Yellow mottle virus on rice (Malawi)
   Sweet potato weevil (*Cyclas* spp.) on sweet potato
   False codling moth (*Cryptophlebia leucotreta*) on citrus
   Phytophthera spp. on citrus and pawpaw
   Mango weevil (*Stenochetus mangiferae*) on mango
   Rosette on groundnut
   Cowpea aphid-borne mosaic
   ***Tristeza* virus** on citrus.
   Citrus greening disease (xylem-limited bacterium vectored by Psyllidae)
   Papaya ring spot virus causing **pawpaw mosaic**
   Black sigatoka (*Mycosphaerella fijiensis*) on bananas and plantains
   Mycoplasma-like-organism similar to Cape St. Paul wilt of coconut in Tanzania
   Pigs and warthogs
   Birds on rice and sorghum

Table 20

East Coast, zone A6: ranking of pests by crop

Crop	Pests specific to crop: Ranking group among all pests	Pests specific to crop: Pest	General pests (unranked)
Cassava	1	Cassava mosaic Green spider mite	Weeds Pigs Rodents
	2	Cassava mealybug	
Maize	2	Maize streak Maize blight	Weeds Armyworm Rodents
	3	Stemborers Stalk rot	
	4	Downy mildew	
Rice	3	Rice blast	Weeds Rodents
	4	Yellow mottle virus	Armyworm
Cashew	1	Powdery mildew	Weeds
	3	Die back complex	
	4	Coconut bug Anthracnose	
Coconuts	2	Coconut bug Lethal bole rot Rhinoceros beetle	Weeds Rodents
	4	Mycoplasma-like-organism	
Cowpeas	3	Podborers Thrips Scab	Weeds Rodents
	4	Cowpea aphid-borne mosaic virus	

Source: Table 19

Table 21

Pest ranking in Plateaux – zone B1

		Particularly in:
1.	Weeds (including *Striga*) Maize stalkborer (particularly *Busseola fusca*)	
2.	**Maize streak/mottle**	Zambia, Zimbabwe
	Maize leaf blight (*H. turcicum*)	Malawi, Tanzania
	Maize rust (*Puccina* spp.)	Malawi, Tanzania
	Maize ear rot and stalk rots (*Fusarium, Diplodia, Botryodiplodia, Macrophomina*)	
	Bollworms on cotton (particularly *Heliothis armigera*, also on other crops)	
	Rootknot nematodes (*Meloidogyne* spp.) on tobacco, beans, cotton, soya, etc.	
	Early leafspot (*Mycosphaerella arachidis*) on groundnuts	
	Aphis craccivora (sucking damage to tobacco and vector of **groundnut rosette** and **bean common mosaic virus**)	
	Armyworm (*Spodoptera exempta*)	Tanzania
	Root lesion nematodes (*Pratylenchus* spp.) on maize and groundnuts	
	Mealybug (*Phenacoccus manihoti*) on cassava	
	Green spider mite (*Mononychellus tanajoa*) on cassava	
	Larger grain borer (*Prostephanus truncatus*) on maize and cassava	Tanzania
3.	Cutworms (*Agrotis* spp.) on maize	Zimbabwe
	Whitegrub (*Eulipida mashona*)	Zambia, Zimbabwe
	Cotton stainers (*Dysdercus* spp.) on cotton	
	Termites	Malawi, Zambia
	Late leaf spot (*Mycosphaerella berkeleyi*) on groundnuts	
	Rust (*Puccinia arachidis*) on groundnuts	
	Groundnut rosette	
	Brown spot on tobacco (*Alternaria longipes*)	
	Beanfly (*Ophiomyia* spp.) on beans	
	Bean common mosaic virus	
	Cassava mosaic	
	Rodents	
4.	**Maize dwarf mosaic virus** on maize	Malawi, particularly Liwonde
	Groundnut leafhopper (*Hilda patruelis*) on groundnut	Zimbabwe
	Tobacco mosaic virus	
	Maize ladybird beetle (*Epilachna similis*)	Tanzania
	Rust (*Uromyces appendiculatus*) on beans	
	Common bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) on beans	
	Bacterial blight (*Pseudononas syringae* pv. *glycinea*) on soya bean in Zimbabwe	

Table 22

Plateaux, zone B1: ranking of pests by crop

Crop	Pests specific to crop		General pests (unranked)
	Ranking group among all pests	Pest	
Maize	1	Stalkborer	Weeds Armyworm
	2	Maize streak/mottle Maize leaf blight Maize rust Maize ear & stalk rots	Rodents Termites American bollworm
	3	Cutworms Root lesion nematodes	
	4	Maize dwarf mosaic virus Ladybird beetle	
Groundnuts	2	Early leaf spot	Weeds Rodents
	3	Late leaf spot Rust Groundnut rosette Whitegrubs	Termites American bollworm
	4	Groundnut leafhopper Root lesion nematodes	
Cassava	2	Cassava mealybug Green spider mite	Weeds Rodents
	3	Cassava mosaic	
Tobacco	3	*Aphis craccivora* Brown spot	Weeds Rootknot nematodes
	4	Tobacco mosaic virus	

Source: Table 21

Table 23

Pest ranking in Uganda and Lake Victoria Shore – zone L1

1.	Cassava mealybug (*Phenacoccus manihoti*) on cassava Green spider mite (*Mononychellus tanajoa*) on cassava Weeds (incl. *Striga* in Kenya) Nematodes (mainly *Pratylenchus goodeyi* and *Radopholus similis*) on bananas
2.	**Cassava mosaic virus** **Sweet potato virus complex** *Alternaria* on sweet potatoes Beanfly (*Ophiomyia* spp.) on beans Bollworms (on cotton; *Heliothis armigera* also on beans, maize, vegetables, fruit etc.) *Meloidogyne* spp. (particularly *M. incognita*) on sweet potato, beans, cotton, vegetables etc Banana weevil (*Cosmopolites sordidus*) on bananas
3.	Bacterial Blight (*Xanthomonas campestris* pv. *manihotis*) on cassava Sweet potato weevils (*Cylas* spp.) on sweet potato Coffee leaf miner (*Leucoptera meyricki, L. caffeina*) Common blight (*Xanthomonas campestris* pv. *phaseoli*) on beans Early leaf spot (*Mycosphaerella arachidis*) on groundnut Leaf blast (*Pyricularia setariae*) on finger millet **Maize streak/mottle** Coffee leaf rust (*Hermileia vastatrix*) Panama disease (*Fusarium oxysporum*) on bananas Rodents
4.	Cotton stainers (*Dysdereus* spp.) on cotton **Bean common mosaic virus** on beans Rust (*Puccinia arachidis*) on groundnut **Rosette on groundnut** Maize blight (*Helminthosporium* spp.) Rust (*Puccinia polysora*) on maize Stemborers on finger millet, sorghum, sugarcane, maize **Sugarcane mosaic virus** on sugarcane and maize Armyworm (*Spodoptera exempta*) Yellow Sigatoka (*Mycosphaerella musicola*) on bananas
5.	**Cowpea aphid-borne mosaic virus** **Banana streak virus** (Bukoba area of Tanzania)

Table 24

Uganda and Lake Victoria Shore, zone L1: ranking of pests by crop

Crop	Pests specific to crop		General pests (unranked)
	Ranking group among all pests	Pest	
Cassava	1	Cassava mealybug Green spider mite	Weeds
	2	Cassava mosaic	
	3	Cassava bacterial blight	
Bananas	1	Nematodes	Weeds
	2	Banana weevil	
	3	Panama disease	
	4	Yellow sigatoka	
	5	Banana streak virus	
Sweet Potatoes	2	Sweet potato virus complex *Alternaria*	Weeds Rootknot nematodes
	3	Sweet potato weevils	
Groundnut	3	Early leaf spot	Weeds Rodents
	4	Groundnut rust Groundnut rosette	

Source: Table 23

Table 25

Pest ranking in Mountains – zone B2

1.	Coffee berry disease (*Colletotrichum coffeanum*) Weeds (particularly *Cyperus* spp., *Avena* spp., *Digitaria abyssinica, Commelina benghalensis*) Maize stalkborers (particularly *Busseola fusca*)
2.	Nematodes (mainly *Pratylenchus goodeyi* and *Radopholus similis*) on bananas in Rwanda, Burundi, Tanzania, Zaire and Uganda and Ensete highland bananas in Ethiopia *Meloidogyne* spp. on vegetables, potatoes, flowers, coffee, pyrethrum, etc. Maize rust (*Puccinia polysona*) Rootworms/cutworms (*Agrotis ipsilon*) on maize, etc. Antestia bugs (*Antestropsis* spp.) on coffee Anthracnose (*Colletotrichum lindimuthianum*) on beans Armyworm (*Spodoptera exempta*) Angular leaf spot (*Phaeoisariopsis griseola*) on beans Late blight (*Phytophthora infestans*) on potatoes *Armilleria mellea* root rot on tea and coffee American bollworm (*Heliothis armigera*) on beans, sunflower, peas, maize, vegetables, fruit, wheat, etc. Black sigatoka (*Mycosphaerella fijiensis*) on banana in Rwanda, Burundi, Tanzania and Zaire
3.	**Maize streak/mottle** *Sitophilus* weevils post harvest on cereals Maize smut (Kenya) *Tanymecus dilatacollis* on maize (Kenya) Coffee leaf rust (*Hemileia vastatrix*) **Barley yellow dwarf** on wheat and barley Haloblight (*Pseudomonas syringae* pv. *phaseolicola*) on beans Ascochyta blight (*Phoma exigua* var. *diversispora*) on beans Tuber moth, **viruses**, bacterial wilt, blackleg on potatoes (separately) Banana weevil (*Cosmopolites sordidus*) Coffee leafminer (*Leucoptera* spp.) on coffee Green spider mite (*Mononychellus tanajoa*) on cassava (Rwanda and Burundi) Bacterial blight (*Xanthomonas campestris* pv. *manihoti*) on cassava (Rwanda and Burundi) Wheat rust (*Puccinia* spp.) on wheat and barley Leaf spot (*Pestalotiopsis quepini*) on tea **Sweet potato virus complex** on sweet potato Rodents
4.	**Sugar cane mosaic** on maize **Bean common mosaic** on beans Birds (*Quelea* spp., doves, pigeons) on wheat and sunflower Septoria leaf and glume blotch (*Septoria tritici* and *S. nodorum*) on wheat **Tristeza virus** on citrus **Citrus greening disease** (xylem-limited bacterium) vectored by Psyllidae **Bunchy top on bananas** (Bujumbura & Bugarama valleys in Burundi & Rwanda) Panama disease (*Fusarium oxysporum*) on bananas in Zaire, Tanzania. Cigar end rot (*Trachysphaera fructigera* and *Verticillium theobromae*) on bananas in Zaire, Burundi and Rwanda Bacterial wilt on Ensete in Ethiopia
5.	**Veg. viruses (turnip mosaic** on cabbages, **yellow dwarf mosaic** on onions) **Cassava mosaic virus**

Table 26

Mountains, zone B2: ranking of pests by crop

Crop	Pests specific to crop: Ranking group among all pests	Pest	General pests (unranked)
Maize	1	Stalkborers	Weeds American bollworm Rodents
	2	Maize rust Rootworms/cutworms	
	3	Maize streak/mottle *Sitophilus* weevils post harvest Maize smut *Tanymecus dilatacollis*	
Wheat	3	Barley yellow dwarf virus Wheat rust *Sitophilus* weevils post harvest	Weeds Birds Rodents Armyworm
	4	Septoria leaf and glume blotch	
Bananas	2	Nematodes Black sigatoka	Weeds
	3	Banana weevil	
	4	Bunchy top Panama disease Cigar end rot	
Beans	2	Anthracnose Angular leaf spot	Weeds American bollworm
	3	Haloblight Ascochyta blight	
	4	Bean common mosaic virus	
Arabica coffee	1	Coffee berry disease	Weeds Rootknot nematodes
	2	Antestia bugs	
	3	Coffee leaf rust *Armilleria mellea* root rot Coffee leafminer	
Potatoes	2	Late blight	Weeds Rootknot nematodes
	3	Tuber moth Bacterial moth Blackleg Viruses	
Ensete	4	Bacterial wilt Nematodes	Weeds

Source: Table 25

Table 27

Ranking[1] of insect-vectored plant diseases by zone in West and Central Africa

Zone	Disease	Ranking group among all pests
Sahel	Groundnut rosette	3
A2	Cowpea aphid-borne mosaic	4
Sudan	Groundnut rosette	1
Savanna	Maize streak/mottle	2
A3	Cassava mosaic	2
	Sweet potato virus complex	3
	Cowpea aphid-borne mosaic	3
	Cowpea golden mosaic	4
	Cowpea yellow mosaic	4
	Cotton leaf curl virus	4
Guinea	Cassava mosaic	2
Savanna	Maize streak/mottle	2
A4	Groundnut rosette	3
	Yam mosaic virus	4
	Sweet potato virus complex	4
	Cowpea aphid-borne mosaic	4
	Cowpea golden mosaic	5
	Cowpea yellow mosaic	5
Forest/Savanna	Maize streak/mottle	1
Transition	Cassava mosaic	1
A4/5	Cocoa swollen shoot	3
	Yam mosaic virus	3
	Cowpea aphid-borne mosaic	4
	Cowpea yellow mosaic	5
Forest	Cassava mosaic	1
A5	Cocoa swollen shoot	2
	Banana bunchy top	4
	Rice yellow mottle	4
	Cape St. Paul wilt of coconut	4
	Yam mosaic virus	4
	Maize streak/mottle	4
	Cucumber mosaic of bananas & cowpeas	4
	Cowpea golden mosaic	5

Source: Tables 7 to 15 (odd nos.)

Note: [1] Order of listing diseases within the same ranking group has no significance

Table 28

Ranking[1] of insect-vectored plant diseases by zone in East and southern Africa

Zone	Disease	Ranking group among all pests
Semi-arid East and South A7	Maize dwarf mosaic virus A of sorghum	4
	Cowpea aphid-borne mosaic	4
East Coast A6	Cassava mosaic	1
	Maize streak	2
	Rice yellow mottle	4
	Groundnut rosette	4
	Cowpea aphid-borne mosaic	4
	Tristesa on citrus	4
	Citrus greening disease	4
	Papaya ring spot virus	4
	Mycoplasma-like organism on coconut	4
Plateaux B1	Maize streak/mottle	2
	Cassava mosaic	3
	Groundnut rosette	3
	Bean common mosaic	3
	Maize dwarf mosaic virus on maize	4
Uganda and Lake Victoria Shore L1	Cassava mosaic	2
	Sweet potato virus complex	2
	Maize streak/mottle	3
	Bean common mosaic	4
	Groundnut rosette	4
	Sugarcane mosaic virus on sugarcane & maize	4
	Cowpea aphid-borne mosaic	5
	Banana streak virus	5
Mountains B2	Maize streak	3
	Barley yellow dwarf on wheat & barley	3
	Potato leaf roll and other potato viruses	3
	Sweet potato virus complex	4
	Sugarcane mosaic virus of maize	4
	Bean common mosaic	4
	Bunchy top virus of bananas	4
	Citrus greening	4
	Tristesa virus of citrus	4
	Vegetable viruses (turnip mosaic on cabbages, yellow dwarf mosaic on onions)	5
	Cassava mosaic	5

Source: Tables 17–25 (odd nos.)

Note: [1] Order of listing diseases within the same ranking group has no significance

Table 29

Zones in which insect-vectored plant diseases are in pest ranking groups indicated

Disease and aggregate ranking scores	Rank 1st	2nd	3rd	4th	5th
	Score				
	(20)	(10)	(5)	(2)	(1)
Cassava mosaic (96)	A4/5 A5 A6	A3 A4 L1	B1		B2
Maize streak/mottle (72)	A4/5	A3 A4 A6 B1	L1 B2	A5	
Groundnut rosette (39)	A3		A2 A4 B1	A6 L1	
Sweet potato virus complex (22)		L1	A3 B2	A4	
Cowpea aphid-borne mosaic (16)			A3	A2 A4 A4/5 A6 A7	L1
Cocoa swollen shoot (15)		A5		A4/5	
Yam mosaic (9)			A4/5	A4 A5	
Sugarcane mosaic/ maize dwarf mosaic (8)				A7 B1 L1 B2	
Barley yellow dwarf (5)			B2		
Potato virus diseases (5)			B2		

Source: Tables 27 and 28
NB Numbers in brackets are ranking scores

Table 30

Relative importance of insect-vectored plant diseases

Ranking group[1]	Virus disease
1	Cassava mosaic Maize streak/mottle[2]
2	Groundnut rosette
3	Sweet potato virus complex Cowpea aphid-borne mosaic Cocoa swollen shoot
4	Yam mosaic Sugarcane mosaic/maize dwarf mosaic Barley yellow dwarf Potato virus diseases

Notes: [1] Among insect-vectored plant diseases
[2] Maize streak is much more important than maize mottle
Source: Table 29's aggregate ranking scores

Table 31

Aggregate scores[1] for insect-vectored plant diseases by agro-ecological zone

Zone No.	Zone title	Score
A3	Sudan Savanna	56
A4/5	Forest/Savanna Transition	53
A6	East Coast	44
A5	Forest	43
A4	Guinea Savanna	33
L1	Uganda and Lake Victoria Shore	33
B2	Mountains	29
B1	Plateaux	27
A2	Sahel	7
A7	Semi-arid East and South	4

Note: [1] Scoring system: First rank of pest importance 20
Second rank of pest importance 10
Third rank of pest importance 5
Fourth rank of pest importance 2
Fifth rank of pest importance 1
Source: Tables 27 and 28

Table 32

1987 FAO crop production statistics for countries of sub-Saharan Africa ('000 tonnes)

1987	Wheat	Rice	Barley	Maize	Millet	Sorghum	Potatoes	Sweet Potatoes	Cassava
Angola	2	20		300	60		40	180	1,970
Benin		9		278	22	87		28	565
Botswana	1			2	1	8			
Burk. Faso		22		131	632	848		25	32
Burundi	15	20		165	62	220	47	615	555
Cameroon	1	123		380	400		172	150	690
C. Afr. Rep		9		64	70		1		392
Chad	3	25		34	510		14	41	306
Congo		3		8			2	14	630
Côte D'Ivoire		595		415	44	25	24	12	1,500
Ethiopia	800		900	1,450	180		220		
Eq. Guinea								36	56
Gabon		1		10				2	260
Gambia		32		20	104				6
Ghana		88		553	121	151			2,943
Guinea		480		45		4		70	500
G. Bissau		155		25	20	35			
Kenya	185	40	18	1,900	50	130	730	380	540
Lesotho	19		1	95	1,134	31			
Liberia		210							330
Malawi	1	34		1,225		154	276		200
Mali	2	190		143				57	73
Mauritania	1	20		8	78		1	2	
Mozambique	3	55		300	5	150	65	50	3,350
Namibia	1			48	42	7			
Niger	8	60		9	1,020	360		33	200
Nigeria	100	1,500		1,400	3,000	4,500	42	260	14,000
Rwanda	5	5		102	2	150	181	799	390
Senegal		121		108	769		13	5	53
Sierra Leone		499		9	18	18		14	116
Somalia	1	5		282		203		4	39
Sudan	157	1		25	120	1,300	5		70
Swaziland	1	3		92		2	7	2	
Tanzania	72	571	5	2,359	297	663	220	330	5,500
Togo		19		145	83	130		4	344
Uganda	10	38		357	490	330	340	2,540	4,500
Zaire	21	302		777	31	36	44	375	16,091
Zambia	13	13	2	954	30	26	3	23	230
Zimbabwe	215	1	30	1,094	81	53	29	1	86

Table 32 (continued)

1987	Yams	Cocoyams	Beans	Groundnuts	Seed cotton	Coconut	Palm oil	Vegetables	Fruit
Angola			40	20	33		40	227	425
Benin	829	2	40	51	89	20	38	142	158
Botswana				1	3		2	16	11
Burk. Faso	28			146	175			128	70
Burundi	7	122	315	80	7			188	1,517
Cameroon	400		116	140	115	4	98	437	1,209
C. Afr. Rep	199	60		146	37		2	52	177
Chad	229	9	40	105	110			77	117
Congo	15		5	16			16	39	253
Côte D'Ivoire	2,900	268		120	213	400	215	391	1,894
Ethiopia	230		30	50	67			560	215
Eq. Guinea						8	5		19
Gabon	87	58		9			3	29	192
Gambia				120	3		3	8	4
Ghana	1,000	650		128	3	110	55	717	838
Guinea	61	32		75		15	45	420	677
G. Bissau				30	5	25	3	20	42
Kenya			?	9	36	72		467	735
Lesotho			3					26	15
Liberia	18	18		3		7	35	77	130
Malawi	13		65	190	42			221	403
Mali				60	220			245	12
Mauritania	3			2				9	14
Mozambique				65	52	415		196	358
Namibia								28	33
Niger				42	4			165	43
Nigeria	19,000	2,100		740	110	100	730	3,960	3,100
Rwanda	8	50	141	18				192	2,168
Senegal				876	50	5	6	102	84
Sierra Leone		22		19		3	44	186	153
Somalia			29	6	6	1		33	252
Sudan	115		3	434	546			943	828
Swaziland			1	1	32			13	130
Tanzania	9		300	60	147	340	4	1,062	2,931
Togo		25	21	36	75	14	14	79	48
Uganda			400	120	36			319	8,494
Zaire	225	34	80		77		165	542	2,589
Zambia				14	57			254	93
Zimbabwe			45	79	300			145	132

Table 32 (continued)

1987	Sugar Cane	Bananas	Plantains	Cashew	Coffee	Cocoa	Tea	Tobacco	Total pulses
Angola	320	280	0	1	16			3	40
Benin		13		1	4				46
Botswana									14
Burk. Faso	330							1	180
Burundi	7	1,440			34		3	4	353
Cameroon	1,289	67	986		102	120	2	5	126
C. Afr. Rep		84	66		21			1	7
Chad	290								58
Congo	510	35	65		2	2			8
Côte D'Ivoire	1,750	136	1,400	4	260	570		2	8
Ethiopia	1,650	75			178			3	885
Eq. Guinea		19			7	7			
Gabon	140	8	175		1	2			
Gambia									4
Ghana	110	22	700		2	210		2	11
Guinea	200	107	350		15	4		2	50
G. Bissau	6		25	10					2
Kenya	4,000	146	268	12	109		160	5	460
Lesotho									6
Liberia	155	80	33		10	4			3
Malawi	1,600	80	113		5		40	70	320
Mali	220							1	57
Mauritania									24
Mozambique	670	80		30	1		12	3	60
Namibia									6
Niger	110							1	256
Nigeria	1,550		1,800	37	4	130		12	1,050
Rwanda	32		(2,130)		41		8	3	150
Senegal	700	6							37
Sierra Leone	70		28		15	11		1	35
Somalia	370	80							29
Sudan	5,000	63							112
Swaziland	4,000	1							3
Tanzania	1,075	1,200	1,200	20	51	2	19	18	385
Togo		16			11	12		2	28
Uganda	600	450	(8,000)		205		4	4	528
Zaire	1,087	338	1,510		102	5	5	8	127
Zambia	1,250	1			1			4	6
Zimbabwe	3,800	68			13		17	128	48

Source: FAO 1987 Production Yearbook

NB Cooking and beer bananas are evidently included with the figures in brackets listed under plantains for Rwanda and Uganda.

Appendices

APPENDIX A

Terms of reference: The assessment of the relative importance of insect-vectored plant diseases (IVPD) in the farming systems of sub-Saharan Africa

Objectives (See page 3.)

1. To rank the main insect-vectored plant diseases (IVPD) in order of importance in each farming system of sub-Saharan Africa.
2. To rank the most important insect-vectored plant diseases (IVPD) in relation to other major pests[1] in each farming system of sub-Saharan Africa.
3. To indicate which farming systems in sub-Saharan Africa are worst affected by insect-vectored plant diseases (IVPD) in so far as sufficient information on losses is available.

The study will indicate the farming systems to which research on IVPD is most relevant. It will also indicate the farming systems most affected by other major pests.

Plan of work

(1) Establish a framework of farming systems. This will be done by:
- reference to ODNRI's definition of farming systems already made for the corporate plan
- studying literature on existing schemes of farming systems
- consulting IITA, CIMMYT etc. through correspondence.

(2) Consult ODNRI experts to obtain basic technical data on IVPD.

(3) Search reference books on major crops for relative importance of specific pests in different farming systems.

(4) Consult IVPD experts to obtain for each farming system:
- relative ranking of IVPD
- IVPD control measures and their effectiveness
- ranking of IVPD in relation to the most important of the other pests.

(5) Consult other pest experts about the most important pests in each farming system.

(6) Search wider literature references. Most of these are likely to have a fairly narrow focus. The search will cover both references related to pests and surveys of particular farming systems and sub-systems.

(7) Visit various institutions in Africa for discussions and studies of references. Tour will probably include IITA in Nigeria; BDDEA,CIMMYT and KARI in

[1] i.e. pathogens, invertebrate pests, vertebrate pests (rodents, birds etc.), weeds.

Kenya; BDDSA,ICRISAT groundnut programme and IITA rootcrop network in Malawi; dryland farming project and SADCC programme in Botswana.

(8) Present findings at a workshop in ODNRI. Appropriate ODNRI scientists and the experts consulted in (4) & (5) above will participate. They will discuss the findings and help refine them.

(9) Write final report in the light of the studies and outcome of the workshop.

Duration

About four months i.e. until end of August 1989.

Provisional timetable

April 24 – May 12	– Draft, discuss, revise and agree TOR – Learning WORD WP program – Initiate database searches for references – Order reference books etc. – Obtain basic data on IVPD – Contact FAO, CIMMYT etc. for information on farming systems framework – Contact institutions in Africa to arrange visits – Arrange meetings with experts (items 4 & 5 in work plan)
April 24 – May 19	– Establish farming systems framework
May 1 – June 16	– Study books and references
May 22 – June 16	– Consult experts in UK
June 17 – July 12	– Overseas visits
July 13 – August 7	– Analysis and preparation for workshop
August 8	– Workshop
August 9 – August 31	– Synthesis and production of report

Output

A report which:

(a) Gives a farming systems framework for sub-Saharan Africa, briefly describing the salient features of each system, including the importance of resource-poor farmers.

(b) For each farming system
- ranks the main IVPD in order of importance, giving some indication of actual losses, control measures used and effectiveness of control
- ranks the most important IVPD in relation to other major pests
- comments on what crops are affected, their relative importance in the system and the circumstances in which the pest is most harmful.

(c) Gives some indication of which farming systems are worst affected by IVPD. The extent to which this can be done will depend on being able to get sufficient information about losses.

APPENDIX B

Institutions and persons consulted during study

United Kingdom

ODNRI and associated staff
- M. J. Jeger, Head of Plant Food Commodities Dept., ODNRI
- J. M. Thresh, Virologist, Institute of Horticultural Research, East Malling
- J. Bridge, Nematologist, Commonwealth Institute of Parasitology, St. Albans
- P. J. Terry, Head of Tropical Weeds Unit, Long Ashton Research Station, Bristol University
- C. R. Riches, Tropical Weeds Unit, Long Ashton Research Station, Bristol University
- N. D. Jago, Grasshopper Taxonomy & Ecology, ODNRI, & Project Leader, Mali Millet Pest Project
- J. M. Richie, Grasshopper Taxonomy & Ecology, ODNRI
- D. M. Teverson, Bean Haloblight Project, Institute of Horticultural Research, Wellesbourne

(Other staff were also consulted but did not make a direct contribution to pest rankings).

Nigeria

International Institute for Tropical Agriculture (IITA)
- D. S. C. Spencer, Resource & Crop Management Programme Director
- I. W. Budenhagen, Maize Programme Director
- S. K. Hahn, Root, Tubers & Plantain Programme Director
- H. W. Rossel, Virology Unit
- J. H. Mareck, Maize Breeder
- T. L. Lawson, Agroclimatologist
- M. C. Palada, Agronomist, Rice-based Farming Systems
- J. Smith, Agricultural Economist
- L. E. N. Jackai, Entomologist, Grain Legume Programme
- H. C. Ezumah, Agronomist
- K. Mulongoy, Soil Microbiologist
- J. B. Suh, Research Liaison Scientist and ex Project Leader SAFGRAD
- T. M. Masajo, Rice Breeder
- I. O. Akobundu, Weed Scientist
- T. Mesfin (visiting from Ethiopia)

Cocoa Research Institute of Nigeria
- S. T. Olatoye, Director
- M. O.K Adegbola, Asst. Director
- O. A. Olunloyo

Kenya

CIMMYT
- W. Mwangi, Regional Economist
- B. Gebrekidan, Regional Maize Breeder

International Potato Centre (CIP)
- G. Hunt, Training and Post-harvest Technology
- E. N. Fernandez-Northcote, Virologist
- L. Skoglund, Pathologist

National Agricultural Research Institute, Maguga
- F. M. Wambugu, Virologist
- J. G. M. Njuguna, Pathologist

National Agricultural Laboratories
- G. N. Kibata, Entomologist, Crop Protection Research Co-ordinator
- D. N. Mburu, Weed Scientist
- J. H. Ndentu, Entomologist

Malawi

SADCC/ICRISAT Groundnut Programme
K. R. Bock, Virologist, Programme Director
G. L. Hildebrand, Principal Groundnut Breeder
East & Southern African Root Crops Research Network
M. N. Alvarez, Plant Breeder, Co-ordinator
Chitedze Agricultural Research Institute
C. Kisyombe, Pathologist
P. Ngwira, Virologist
Rockefeller Foundation
M. Blackie, Economist

Botswana

SACCAR
M. L. Kyomo, Director
D. E. Gollifer, Coordinator SACCAR Land & Water Management Programme
C. R. Namponya, Information Officer
D. Wangchinga, Entomologist, Manpower Development Officer
Department of Agricultural Research
L. Gakale, Director
D. Norman, Team Leader, Agricultural Technology Improvement Project
M. Phillips, Weed Scientist
A. Pain, Team Leader, Botswana Land & Water Management Project
Plant Protection Section, Crop Production Division
T. S. Moruti, Head of Non-migrating Pests Control Unit
M. Modise, Post-harvest Officer

Zimbabwe

SADCC/ICRISAT Sorghum & Millet Programme
K. Leuschner, Entomologist
S. C. Gupta, Millet Breeder
A. J. Obilana, Sorghum Breeder
W. A. J. de Millinao, Pathologist
C. Manthe, PhD student from Botswana studying aphids
CIMMYT
A. Lowe, Regional Economist
S. Waddington, Regional Agronomist
H. Pham, Maize Breeder
Plant Protection Institute
S. S. Mlambo, Director
S. Z. Sithole, Entomologist

Persons commenting on early drafts of pest rankings

J. M. Waller, ODA Plant Pathology Liaison Officer, CAB Int. Mycological Institute, Kew
M. A. Ward, Crop Pest Management Section, ODNRI
R. W. Smith, Senior Agric. Adviser (Research), ODA
L. Burbage, Fruit, Vegetables & Root Crops Section, ODNRI
D. J. Allen, SADCC/CIAT Bean Programme, Arusha, Tanzania
R. Gibbons, Executive Director, ICRISAT Sahel Centre, Niamey, Niger
A. Asare-Nyako, Deputy Chief Executive, Ghana Cocoa Board

APPENDIX C

Main insect-vectored plant viruses and their vectors

Virus	Vectors	Seed transmitted
African cassava mosaic gemini virus	Whiteflies (*Bemisia tabaci*)	No, but transmitted by cuttings
Maize streak gemini virus	Leafhoppers (*Cicadulina mbila*, *C. triangula* and other *Cicadulina* spp.)	No
Groundnut rosette virus (two strains, chlorotic and green)	Aphids, mainly *Aphis craccivora*, but also *A. gossypii* and *A. spircola*. Only transmitted if aphids also transmit groundnut assistor virus, which causes no symptoms	No
Sweet potato virus complex	Aphids transmit the component sweet pototo vein-clearing virus and whiteflies the component sweet potato chlorotic stunt. Both components must be present for symptoms to occur. The aphid transmitted disease sweet potato feathery mottle is closely related sereologically to sweet potato vein-clearing virus	The aphid transmitted component can be transmitted by cuttings. Author unclear if whitefly transmitted component can be transmitted by cuttings too
Cowpea aphid-borne mosaic polyvirus	Aphids (*A. craccivora, A. fabae, A. gossypii, Macrosiphum euphorbiae, Myzus persicae*)	Yes
Cocoa swollen shoot virus	Mealybugs (Pseudococcidae)	No
Yam mosaic virus	Aphids	No, but transmitted by tubers
Maize dwarf mosaic virus/sugarcane mosaic polyvirus	Aphid (*Rhopalosiphum maidis*)	MDMV: Yes SMV: Not known
Barley yellow dwarf luteovirus	Aphids	No
Potato viruses	Aphids, mainly *Myzus persicae*	No, but transmitted by tubers

Sources: Rossel and Thottappilly, 1985; Fauquet & Thouvenel, 1987; Hill & Waller, 1988

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APPENDIX E

Format for suggested changes in pest rankings

NRI Bulletin 'The relative importance of crop pests in sub-Saharan Africa'

1. Name and address of proposer.
2. Position held by proposer.
3. Very brief summary of experience relevant to the pest and the agro-ecological zone.
4. Suggested change, mentioning zone, pest and crop. This can be the addition or deletion of a pest or a change in the ranking of a pest already listed, or a change in the crops it affects.
5. Amplifying remarks. Include whether the original assessment in the Bulletin is considered to have been incorrect, or if the change proposed is made as a result of a change in the actual pest situation. If the latter, indicate how this change has developed over time and any ideas on the cause.

   Give the reason for proposing a change in pest rankings. Give the proper reference for any literature suggesting the changed assessment.

   Send the suggested change to:

   Head of Pest and Vector Economics Section
   Natural Resources Intitute
   Central Avenue
   Chatham Maritime
   Kent ME4 4TB
   United Kingdom

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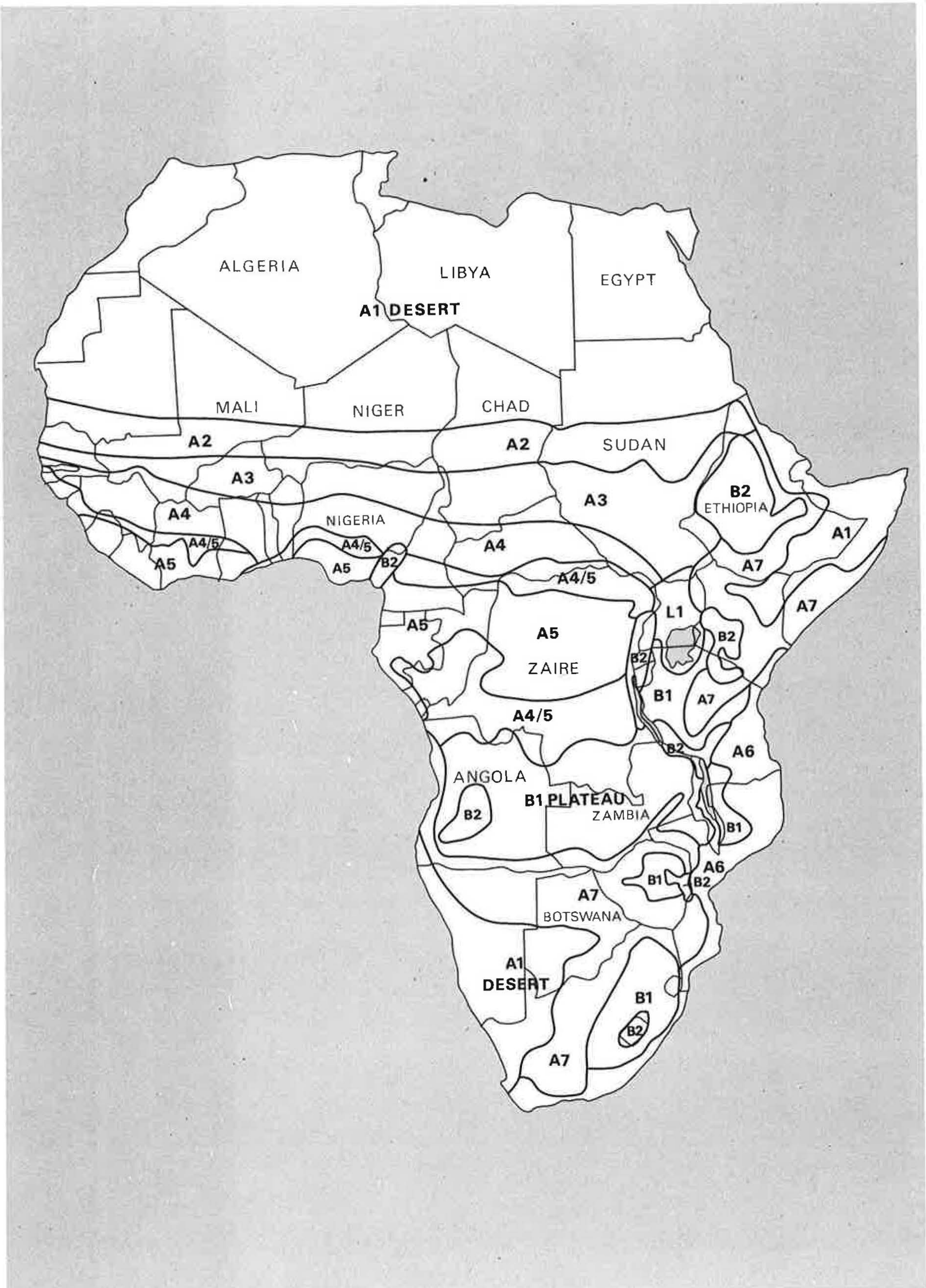

FIGURE 4 Agro-ecological zones of sub-Saharan Africa