TASKS FOR THE EIGHTIES

A Long-range Plan

International Institute of Tropical Agriculture
Oyo Road, PMB 5320
Ibadan, Nigeria

About IITA

THE International Institute of Tropical Agriculture (IITA) — one of the major links in a world-wide network of agricultural research and training centers —was established as an autonomous, non-profit corporation on July 27, 1967, by a decree of the Government of Nigeria. It allotted 1,000 hectares of land for the IITA site, and the Ford Foundation provided initial capital for buildings and development.

IITA was formally organized at the first meeting of its Board of Trustees in Ibadan during July 1968. The Institute is governed by an international Board of Trustees, the membership of which includes representatives from developing countries in areas of IITA's concern.

Principal financing of the Institute (and the other centers) is arranged by the Consultative Group on International Agricultural Research (CGIAR)—an informal group of donor countries, development banks, foundations, and agencies. Currently, support for IITA's research and training core program is being provided by the Canadian International Development Agency (CIDA), Overseas Development Ministry of the United Kingdom (ODM), U.S. Agency for International Development (USAID), Ford Foundation, World Bank, International Fund for Agricultural Development (IFAD), and the governments of Australia, Belgium, Japan, Netherlands, Nigeria, Norway, and the Federal Republic of Germany.

PN-AAA-796
ISN 22413

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June, 1981

Foreword

Food problems loom as large today as at any time in history. The vocation of the International Institute of Tropical Agriculture (IITA) is to help in solving those problems where they are most acute: in the tropical areas of the world. Of all tropical regions, it is Africa that is at present experiencing the greatest difficulties. Inevitably, the Institute's location in Africa leads us to concentrate first and foremost on the problems of our host continent.

The outlook for African agriculture is a cause of deepening anxiety among African governments and the international community at large. Food production per head of the population of the region has been declining continuously throughout the seventies, and is now about 10% less than at the beginning of the decade. Food imports, mainly for cities swollen not only by population increase but also by the drift from rural areas, have been growing at an unsustainable rate - in 10 years they have more than doubled in volume, and risen five times in value. The underlying weaknesses of agricultural production have been exacerbated by a series of natural and man-made disasters. In the closing months of 1980, no less than 26 countries in sub-Saharan Africa were faced with abnormal food shortages of varying degrees of severity.

Against this background, the long-range plan of the International Institute of Tropical Agriculture assumes a particular significance. The lack of an economically viable and ecologically safe technology for maintaining high levels of food production in the humid and sub-humid tropics is far from being the only reason for the dismal performance of agriculture in Africa - but it is a very important factor. And it is the prime task of IITA to develop just such a technology.

The history of IITA goes back to 1967 when the Nigerian Government, on the basis of proposals worked out with the Ford and Rockefeller Foundations, established the Institute with a grant of 1,000 hectares of land near Ibadan. It is now a member of the system of international agricultural research centers for which support is provided by governments, development agencies and foundations through the Consultative Group on International Agricultural Research (CGIAR). It is the largest international research station on the African continent, and is working on some of the world's most pressing development problems.

The Institute's research mandate, as approved by its Board of Trustees, is in three parts. IITA is responsible for developing "viable alternatives to shifting cultivation which will maintain the productivity of the land under continuous cultivation" in the humid and sub-humid tropics, that is to say in all tropical regions where precipitation exceeds evaporation for five or more months in the year. In the second place, the Institute has a global mandate for research in all continents and climatic zones on the improvement of three crops: cowpeas, yams and sweet potatoes. Finally, IITA is to carry out research in Africa directed toward the improvement of maize, rice, cassava and soybean; these are crops on which other institutions (inside or outside the CGIAR) are working at global level.

The advent of a new decade provides an opportunity to review what has been accomplished, to take a hard, analytical lock at the complex problems facing agriculture in the humid and sub-humid tropics, and select the most important tasks which the Institute should tackle in the years ahead. This is what we have attempted to do in the present paper, which focuses on objectives for the years 1985 to 1990. At the same time we have in this way responded to a recommendation that long-range plans be drawn up by all the international centers in the CGIAR system.

It is necessary to introduce a strong note of caution into an analysis extending so far ahead. Perceptions of how to solve the problems of African agriculture are still evolving - and although these are not the only problems with which IITA is concerned, they are certainly the most important. The rate of progress in biological research is, by its very nature, unpredictable. And the scope of IITA programs will doubtless be influenced by other factors which it is impossible to foresee. The degree of uncertainty which must always affect long-term forecasts is magnified, in our case, by the fact that we can only guess at the level of resources that will be available to us. The last three years have been a period of painful retrenchment, with a combination of accelerating inflation and adverse movement of exchange rates cutting deeply into the real value of our financial resources. At a time when the situation of African agriculture is deteriorating rapidly, and when a build-up of research would be one of the most cost-effective responses by the international community, the Institute's program has had to be reduced in real terms by more than 25%.

What we have produced, therefore, is not a plan in the customary sense of the term. Rather, it is an attempt to chart the general directions in which, from the troubled perspective of 1981, it would appear that IITA should move in the years ahead. We have analyzed certain broad policy issues, and suggested answers. We have outlined the agricultural problems which the Institute can reasonably attempt to tackle. And we have indicated the additional scientific manpower and financial resources which are necessary if our objectives are to be achieved.

In the preparation of the report, there have been extensive consultations among the scientific staff of the Institute. The Program Committee of IITA's Board of Trustees was consulted at various stages. Use has also been made of previous analyses of IITA's program, such as the Quinquennial Review conducted by the Technical Advisory Committee (TAC) of CGIAR in 1977, and the TAC Review of Farming Systems Research at the international agricultural research centers. The final text has been approved by the IITA's Board of Trustees at its 14th meeting on 8 May, 1981. There has been no formal process of consultation with governments or national research staff, but priorities at national level are well understood by the Institute on the basis of our frequent working contacts, including those that arise out of our international programs. They will be the most important single factor influencing the future work of IITA.

E.H. Hartmans
Director General

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I. Barriers to agricultural progress in Africa

While the dramatic problems facing African agriculture are not the only concern of IITA, they are inevitably the prime focus of its work. A brief analysis of these problems may help to situate the tasks of the Institute in the broader context of African development.

African agriculture is held back by a series of barriers to progress: barriers of policy, of institutions, of infrastructure, of social standing and of technology. The many factors which make up each of these barriers overlap and inter-connect. Difficulty and complexity result from the fact that all barriers - and not merely one or two of them - must be removed if agriculture is to move forward into a period of accelerated growth.

The situation is not fundamentally different, in many respects, from that in other developing regions. In Africa, however, almost every problem is more acute than elsewhere. Top soils are more fragile, and more subject to erosion and degradation. Irrigation covers a smaller fraction of the cultivated area - Spain alone has as much irrigated land as all the developing countries in sub-Saharan Africa-leaving agriculture exposed to the vicissitudes of an irregular rainfall pattern. The infrastructure, both physical and institutional, is weaker. The shortage of trained people is more serious. The flight from the land is more precipitate. The role of agriculture in the total economy is greater, leaving less elbow room for balanced economic development. In one respect, namely the failure to develop farming systems capable of high and sustained rates of production growth, the problems of Africa have reached the stage of crisis. It may be useful to examine each of the barriers to progress in turn.

Policy barriers

A serious effort is being made in a few countries to tackle internal policy barriers, such as too low a priority to agriculture in national development plans, and a price structure which puts a premium on cheap food for the urban poor rather than on price incentives to farmers. In most parts of Africa, however, major policy changes are still required before there can be a reasonable expectation of achieving a high rate of agricultural growth. At the same time, external policy barriers - inadequate levels of official development assistance for agriculture, and a structure of global economic relations which creates maximum vulnerability in the poorest countries - remain an extremely important constraint. There is some degree of consensus at global level on what needs to be done, but scanty progress has been made toward achieving even the modest goals that have been established.

Inadequate institutions

The barrier created by inadequate institutions can be fully removed only over an

extended period of time. In virtually all countries, severe shortages of trained manpower must be overcome before the institutions established for research and extension, credit, input delivery, co-operative and other rural organizations, can be built up to a satisfactory level of staffing. Systems of land tenure are, in many areas, based on the concept of ownership by the community, which allocates land for use by families. While this avoids the inequity in patterns of land ownership found in other regions, it also acts as a brake on investment for land improvement. Where social and cultural patterns permit, it needs to be exploited for the development of forms of co-operative action.

Lack of infrastructure

The lack of infrastructure - especially feeder roads and transportation facilities - is a greater barrier to development in Africa than in any other continent. The Nigerian study "The Green Revolution: A Food Production Plan for Nigeria" states categorically that the inadequacy of the feeder road system "...represents the most serious constraint to agricultural development in Nigeria today". Where access is difficult, not only may farmers be unable to market increased production, but the provision of inputs and improved rural services becomes problematical.

Agriculture ranked low

Of all the barriers we have listed, perhaps the most intractable is that created by the low social standing of agriculture. The image of agriculture is all too often that of an archaic pursuit from which it is the aim of development to escape. The young, the educated and the enterprising are being lured away from rural areas to the towns. Able people are reluctant to take up positions in organizations devoted to the problems of farmers. The effect is destabilizing. It makes agriculture more difficult to modernize, and the more agriculture stagnates the less able it is to attract or retain the dynamic elements in the population.

Technological barrier

While the constraints to progress so far reviewed provide the backdrop to IITA's work, the technological barrier is the Institute's direct concern. There are, of course, innumerable technical problems to be overcome, but faltering farming systems offer perhaps the greatest single challenge to agricultural technology in the humid and sub-humid tropics of Africa.

Until recent times, farming in most of tropical Africa was carried out through shifting cultivation. Trees or bush would be felled and burnt, the ash providing extra fertilization to the soil. The cleared land would be briefly cultivated and then left fallow for a lengthy period, sometimes ranging up to 20 years or even more, while the farmers moved on to a new area. Not more than one-third of the available land, and often a much smaller fraction, would be under cultivation at one time. Shifting cultivation was a stable and ecologically a balanced system, technically suited to tropical conditions. It did, however, have the over-riding weakness that it could support only a very low population density.

Under the pressure of population growth, cultivators have extended the area cropped at the expense of fallow. Shifting cultivation of the classical type has now given way in most areas to an accelerated bush fallow system in which up to two-thirds of the land is cropped, and fallow periods are greatly reduced. Bush fallow is not a stable system if, as is frequently the case, the fallow periods are shorter than the critical minimum, often about five years, needed to restore soil fertility. Furthermore, chemical fertilizers are ineffective on farms which, as in many parts of the continent today, have soils of poor texture, high in acidity and low in organic matter. Soil fertility in many parts of the humid and sub-humid tropics of Africa is undergoing a slow decline, which is likely to continue for many decades and culminate in breakdown unless timely action is taken.

The basic problem is that there is no practical and economic technology suitable for general application which will permit the passage from fallow system to permanent cultivation of food crops. Rice can be grown intensively in fertile valley bottoms - but this is a small and underutilized part of the total arable area. Permanent cultivation systems based on tree or bush crops can be adopted and are especially suitable in the high-rainfall zone, but apart from bananas or plantains the emphasis is usually on export-oriented non-food crops such as cocoa, coffee or oil-palm. Where neither of these two lines of development is a practical possibility, fallow systems are in an impasse.

Nor are large-scale modern schemes in any better shape. Most soils and ecosystems in the African tropics are extremely fragile. Mechanical bush or forest clearance which results in serious soil disturbance will lead to massive erosion under the impact of violent tropical rainstorms. Soil compaction caused by the passage of heavy agricultural machinery will in turn lead to excessive run-off of rainwater. The maintenance of organic matter in the soil, a necessary condition for fertility, encounters special difficulties when bare soils attain very high temperatures. Even the initial fertility of most soils in the African humid and sub-humid tropics (particularly highly weathered Alfisols, Ultisols and Oxisols) is low. Difficulties of soil management have caused innumerable large schemes to founder.

These are by no means the only factors which create special problems for the African farmer. Plant diseases and pests are favored by the combination of high temperatures and high humidity. Primitive tools limit the farmer's effectiveness, and labor bottlenecks at peak periods of activity become a major constraint. Agronomic practices in traditional agriculture represent a low level of management only in the sense that they do not rely on modern inputs; in fact they are often quite complex as well as rational, and do not lend themselves easily to improvement by outsiders.

Improved technology essential

Without an improved technology adapted to the particular conditions of Africa, it will be very difficult to get agriculture moving. On the other hand, without internal and external policy measures to promote agriculture, without better rural

institutions, without the infrastructure needed for the distribution of inputs and the marketing of increased production, without at least a nucleus of young and enterprising farmers, technological developments are unlikely to be translated into increased output from farmers' fields. All barriers to progress are thus linked together. The salient feature of technology is that no other constraint lends itself so well to an all-out attack by the international community. At its Lagos meeting in April 1980, the OAU Assembly of Heads of State and Government recognized that "science and technology have a pivotal role in the development of agriculture". If the world is ready to step up its aid to African agriculture, there is probably no more effective action it can take than to provide adequate levels of support to the international and national research centers of the continent.

FAO takes a look

A comprehensive approach towards the problems reviewed above was adopted by FAO in its "Regional Food Plan for Africa" (document ARC/78/5 of July 1978). The analysis showed that in 1962-64 Africa imported only 2% of its food supplies. By 1972-74 the proportion had risen to 10% and was still going up; if there was no policy change it could be projected to reach 19% by 1985. The Plan put forward a series of measures which, if adopted by governments, could succeed in reversing the trend. In the view of FAO it would be feasible for Africa as a whole to reduce its food import requirements to 6% of total supplies (a Self-Sufficiency Ratio of 94) by the middle of the decade. The proposed measures were short-, medium- and long-term in nature, and included improved production practices and supporting services, the promotion of substitute foods for imported products especially wheat and bread, soil and water conservation, the development of infrastructure, and the strengthening of research. The measures would have to be taken for the most part by individual governments at national level, with the Regional Food Plan providing an overall framework within which compatible policies and approaches could be worked out.

The FAO Maximum Feasible Production and Demand (MPD) estimates give an idea of the order of magnitude of the changes that could come about if the agricultural problems of Africa are tackled effectively. Table 1 shows estimated ranges in the land use pattern up to 1990 for selected major commodities. It will be noted that the area under cereals in all Africa is estimated to go up from 61 million hectares in 1975 to 78.5 million hectares in 1990, with the biggest relative increases in rice (60%) and maize (37%). Large increases are also expected for root crops (33%) and pulses (38%).

Table 2 shows the estimated contribution of area, yield, and changes in cropping patterns to production increases up to 1990. It will be seen that extension of the cropped area is foreseen as the major contributor to increased production; its annual growth rate is expected to be constant at about 2% per year. The overall annual growth rate of yields is estimated to rise to 1.1 per cent. The Plan assumes that "in the case of crops, vast increases can be obtained by the rapid introduction and spread of better farming systems, improved technologies and larger use of related inputs ...".

Table 1. Estimated (MPD) [1] land use pattern for selected major food commodities in Africa between 1975 and 1990.

	1975	1985	1990	Percent change 1975-1990
	Million Hectares			
Arable area	230.3	249.8	263.6	14
Cropped area	118.6	143.3	157.8	33
Cropped area as percent of arable area	51.5	57.4	59.9	
Cereals	61.0	72.0	78.5	29
- Wheat	7.2	8.6	9.2	28
- Rice	4.5	6.1	7.2	60
- Maize	13.4	16.6	18.3	37
- Millet/Sorghum	29.2	32 9	35.5	22
- Others	6.7	7.3	8.3	24
Rootcrops	10.3	12.7	13.7	33
Pulses	11.7	14 5	16.2	38

[1]: Maximum feasible production and demand

Source: Adapted from FAO "Regional Food Plan for Africa" (1978)

Table 2. Estimated contribution of area, yield and cropping pattern changes to output increases between 1975 and 1990

Subregion	Area	Yield	Cropping pattern	Total
	Percent			
Northern	55	45	-	100
Sahel	46	37	17	100
Western	59	41	-	100
Central	58	25	17	100
Eastern and Southern	55	33	12	100
Total Africa	53	39	8	100

Source: FAO "Regional Food Plan for Africa" (1978)

This brief summary of certain elements in the "Regional Food Plan for Africa" may give an idea of the role which IITA can play. Land clearance can be expected, on the FAO estimates, to proceed at a rate of about 20 million hectares in a decade. Of this, a substantial part will be in the humid and sub-humid zones, and much of it will be done mechanically. IITA studies, described later, show the extreme importance of correct technology for land clearance if soils are not to be seriously

damaged. Table 1 also shows an intensified use of arable land, the proportion cropped going up from 51.5% in 1975 to 59.9% in 1990; this will lead to accelerated soil degradation in certain areas unless techniques for the maintenance of soil fertility, such as those on which IITA's Farming Systems Program is doing research, can be perfected and rapidly brought into widespread use. Finally, the estimates for yield increases for the main crops depend on two factors.The first is the introduction of improved varieties suitable for adoption by the small farmers who account for by far the greatest part of agricultural production in tropical Africa; this is, of course, the purpose of IITA's crop improvement programs. The second factor is an improvement in agronomic practices within the framework of better farming systems, and this is one of the main objectives of the Institute's Farming Systems Program.

While IITA would not wish to exaggerate the potential impact of its work, it is nevertheless clear that the Institute is working on the central problems of agricultural technology in Africa. If all national and international organizations active in this field are enabled to step up their work in the eighties, significant progress can be made toward lifting the technological barrier to agricultural progress.

II. The main directions of IITA's past work

The Institute has three main lines of activity: research, training and, collecting and preserving plant genetic resources. Research, which accounts for by far the greatest part of the total, is divided into four programs. The Farming Systems Program is devoted essentially to the search for an alternative to shifting cultivation; it takes in a wide range of disciplines and includes such areas of research as land management and agronomic practices. The objective of the crop-oriented programs is to develop improved varieties. The Root and Tuber Improvement Program is working on cassava, sweet potato, cocoyam and yam; the Grain Legume Improvement Program on cowpea and soybean; and the Cereal Improvement Program on maize and rice.

The overall research program got underway in 1970, and its present structure has evolved over the years. After a decade of activity, it is possible to make a first assessment of what has been accomplished, and to see where the individual research programs are going. Future research tasks are pursued in more detail in later sections.

The African farmer is interested first and foremost in yield stability. He prefers a safe but modest yield to an erratic high one. The chief threats to stable yields come from diseases and pests, which flourish in conditions of high temperature and high humidity. The basic objective of all three crop improvement programs has thus been the development of varieties which combine a satisfactory level of genetic resistance to specific diseases or insects with high but stable yields. The task is greatly complicated by the fact that all crops on which IITA is working are subject to major attacks from diseases and insects found in Africa but not in other regions (or not in the same form). There are thus considerable limitations on the extent to which IITA can utilize research done in other international centers.

Root crops

The first 10 years of endeavor have seen significant progress on most crops. IITA has released clones of cassava that are resistant to the two main diseases encountered in Africa, cassava mosaic and cassava bacterial blight, and combine this with high yields. The Institute's cassava breeding material is undergoing widespread testing, and selected varieties have so far been adopted by five countries; they produce yields that are several times higher than those normally obtained locally. The varieties of sweet potato developed at IITA give even more striking results: they combine resistance to the basic African disease, the sweet potato virus, with much improved yields, and are highly acceptable to consumers. After several years of testing they have so far been released in three countries; in Sierra Leone they are giving 15-20 tons per hectare in four months or three to four times the yield of local varieties. IITA's work on tissue culture and virology has opened the way to the international movement of vegetative material hitherto precluded by quarantine regulations.

Grain legumes

A series of cowpea varieties developed at IITA combine resistance to the principal diseases encountered in the humid areas with yields far higher than those normally achieved by farmers. They are gradually being adopted in tropical America and in Africa. In maize, the Institute's researchers have solved the problem of lowland maize rust and maize blight, and the IITA populations are being extensively grown in Nigeria. In some areas of Nigeria indeed maize has become the dominant crop since IITA seed was provided directly to farmers in mini-kits under the National Accelerated Food Production Project. More recently, the Institute has developed maize populations with resistance to the most important maize disease in Africa, the streak virus; they are being put into international trials this year.

Slower progress has been made with cocoyams and yams, which present the breeder with particularly difficult problems. The complex problem of rice blast in Africa has so far defied a satisfactory solution. Research on soybeans, while promising, is still at an early stage.

Farming systems

The most intractable problems of all are those facing the Farming Systems Program. In the search for alternatives to shifting cultivation, or for a system which will permit continuous cultivation in the humid and sub-humid tropics, the first 10 years have seen much useful basic work carried out. The essential problem of soil management is better understood. Improved techniques of land clearance have been identified. Promising approaches are being worked on, particularly minimum tillage and various types of planted fallow. Considerable efforts are being made to develop improved cropping systems. While progress is encouraging, it is nevertheless clear that many more years of work are still required if a comprehensive solution is to be found. This need cause no surprise. The African farmer has given many proofs of his ingenuity, but has found no way of overcoming the progressive decline in yields that results when fallow periods are reduced below a critical level. As for large farming enterprises, despite the capital and skills which have gone into them, their long-term productivity has in general been far from impressive. IITA is confident that building on the research carried out in the last decade, it can achieve significant results in the eighties.

Training

Besides research, IITA has a substantial training program which draws upon the discoveries and expertise of its scientists. Considering the severe shortages of trained staff in virtually all African countries, the Institute believes this program has already made a significant contribution toward the development of the continent. By the end of 1980, a total of 1,271 people from 39 African countries had participated in IITA training programs, two-thirds of them in group courses on crop production or related subjects such as soil and water conservation, the remainder in various forms of individual training often including direct

participation in research activities. A further 186 trainees came from other regions. In connection with its training program, the Institute has made co-operative arrangements with 42 universities, the majority in Africa.

IITA is also engaged in the systematic collection and maintenance of plant genetic resources. Between 1976 and 1980, 38 plant collecting missions were organized in 18 countries and over 20,000 samples of germplasm collected. The Institute maintains the world's premier collection of cowpea germplasm, and has registered 3,700 accessions of rice collected in Africa. IITA also maintains a collection of cassava and yam clones.

Mention should also be made of the Institute's function in improving communications among the scientific community. Every year a series of conferences, workshops and seminars is organized, primarily on subjects connected with the research program. Of particular importance for the training program is the existence of a comprehensive library, containing almost 20,000 volumes. The library fulfils a wider role by putting out annotated bibliographies on subjects of direct concern to tropical agriculturalists.

While the first 10 years of research at IITA give no grounds for complacency, the results achieved permit the Institute to feel that it has made, and is continuing to make, a significant contribution toward resolving some of the key problems associated with tropical agriculture, especially in Africa.

Before looking at the problem of resources, it is necessary to examine some of the strategic program choices which must be faced as the Institute enters a new decade.

III Some policy issues regarding future programs and priorities

The preparation of a long-range plan calls for a questioning of assumptions and a re-examination of basic issues. For instance, is IITA's mandate well adapted to the problems that are emerging, or should changes be proposed? The staff of the Institute feels that the tasks assigned to IITA are already diverse, and it would not appear sensible to tackle new problems. In a period of resource scarcity, there may rather be a case for concentration by eliminating completely certain lines of activity. This could become necessary in IITA if further program cuts are forced on the Institute by financial difficulties, but after the drastic reductions of the last three years the Institute aims for rebuilding not for further program dismantlement. IITA is therefore not suggesting any fundamental change in the structure of its overall program.

Another question which arises is the balance between the Institute's global mandate for work in all continents on certain subjects, and its specifically African responsibilities. In fact, there is at present no real conflict between the two. The global mandate for crop improvement is limited to cowpeas, sweet potatoes and yams. For cowpeas, there is a divergence between regions regarding consumer preferences for seed type, but the breeding program takes full account of different requirements. In sweet potatoes there are also some significant differences between consumer preferences in Africa and those in other parts of the world. With regard to yams, different species are preferred in different continents, and even in differents parts of Africa. The program will concentrate on the most important problems facing the future of yams; priority will inevitably be given to West Africa, which is the major producing region, but work will also be carried out for instance, on water yams, which are of primary interest to Asia and the Caribbean. With regard to farming systems, the problems are so complex and so urgent in Africa that IITA does not intend to become heavily involved in work in other regions, even though authorized to do so by its mandate. The question is dealt with in more detail in the sections devoted to the particular programs concerned. It will be seen that the balance to be struck in each case emerges naturally and almost inevitably from the nature of the problems being tackled.

Need for on-site and off-site research

A more complicated issue arises out of conflicting requirements, on the one hand to do more research in representative ecologies outside the main station, and on the other hand to make maximum use of the very considerable investment in the center at Ibadan - particularly at a time of tight resources. The solution must be to maintain and, resources permitting, increase the tempo of work at Ibadan, but at the same time build up the effectiveness of the testing sites where the Institute is cooperating with national centers and universities. The focus would remain in Nigeria. Besides the high-rainfall sub-station at Onne it is proposed to improve the

facilities, including the out-posting of a staff nucleus, at sites located at Ikenne, Mokwa, Gusau and Zaria or Funtua. This would be done, if possible, through core supplementing special projects. A submission has been made on this subject to the EEC. IITA would also attempt to make better use of international programs to spread research coverage to other areas.

A particular aspect of this question is the relation between IITA's work at Ibadan and its responsibility for research in the humid zone. Unlike the transitional area in which IITA is situated, the rain-forest zone is dominated by extremely infertile, strongly leached Ultisols and Oxisols. Permanent cultivation of food crops is possible only through frequent applications of multi-element fertilizers and liming. Periodic tree fallow may still be required, both to recycle plant nutrients leached below the surface horizon and to correct deterioration in the subsoil structure. Large-scale mechanized clearance of rain forest areas marked by strongly acidic and kaolinitic soils is rarely a viable undertaking, particularly in a rolling topography with steeper slopes. The basic line of development for such areas is through agro-forestry, or tree crop plantations.

Much, though not all, research on problems of the humid zone needs to be carried out in the zone itself, and cannot be done effectively at IITA. For this purpose the Onne sub-station was established in 1975 in a high-rainfall, acid-soil area. The sub-station is currently being improved through an increase in staff accommodation, and work at Onne will be progressively stepped up in the eighties. Besides serving as a site for crop trials, original work on specific problems of the humid areas will be undertaken. It is hoped, for instance, that with support from IFAD it will be possible to intensify work on plantains, aimed essentially at developing stable and productive plantain-based cropping systems.

It seems appropriate to re-examine the extent to which the Institute should direct research toward problems mainly of concern to small farmers, and how far it should involve itself in research which is likely to be of benefit principally in large-scale schemes. Clearly, small farmer development is essential in most African countries, not only for economic and social reasons but also to preserve soils which are being run down in many areas by the excessive reduction of fallow periods. At the same time, many African governments feel that a quick solution to the problem of national food deficits, affecting mainly urban populations, can best be achieved through large-scale, mechanized schemes.

In the view of IITA there is not necessarily a conflict between the two approaches. There are areas of good agricultural potential and low population density, where large agricultural schemes could be established without displacing small producers. Furthermore, group action among small farmers can lead to the creation of production units which, if properly planned and organized, could have many of the attributes, and capacity for adopting new technology, of large commercial farms.

While the ideal remains a scale-neutral technology, in practice the most important feature of a new technology is the level of management it requires. In

general, IITA will continue to aim at low-management minimum-input technology intended for use in traditional agriculture. At the same time, a small but significant part of the program will be devoted to problems likely to arise in the modern, high-management sector. Examples are IITA's work on mechanized land clearance, and research on hybrid maize.

Core and international programs

Another issue that should be clarified is the relationship between the core program and international programs. IITA is essentially a research institution engaged in the development of new technology. On the other hand, the Institute will fulfil the purpose for which it was set up only if its technology is fully utilized by potential beneficiaries. Transfer of technology is probably more difficult in Africa than in any other continent, because of difficulties in communications and institutional weaknesses.

IITA feels that the core program should continue to be devoted to research, as well as other lines of substantive work such as training and the conservation of genetic resources. At the same time the core scientists should, as hitherto, devote a part of their work to fostering international research networks. In coming years a more systematic effort should be made to develop international programs with a triple objective: to bring IITA technology to national centers for intensive testing and adaptation; to strengthen national research capacity; and to provide feed-back to IITA which will be useful for orientation of future research. Co-operation with ISNAR and other organizations will be essential. This and other related issues are dealt with in more depth in Section XI on International Programs.

In addition, IITA should interest itself more in the transfer of technology from national research centers to farmers' fields, via extension services, farming systems projects and other approaches. The Institute would not wish to become directly operational in such activities at country level, but would be ready to collaborate with national programs or services, and to provide limited assistance in such fields as methodology, planning and training. For instance, from its association with the Nigerian National Accelerated Food Production Project, the Institute has derived experience in the use of so-called mini-kits for bringing technology to farmers. IITA can also offer advice on methods of accelerated multiplication of approved cassava clones for farm use. Such activities could be incorporated as an element in cooperative programs with individual countries.

Some general considerations

Finally, it may be useful to advance certain general considerations that affect the choice of priorities for future programs. While the Institute does not wish to suggest a rigid formula for decision making, the main criteria to be taken into account may be listed. The first element may appear obvious, but is nevertheless sometimes overlooked. Ongoing work to which substantial staff time and other resources have been devoted should be completed as an overriding priority except in case of an emergency. Switches from one activity to another according to

changed ideas about their relative importance should be avoided as a general rule; flexibility may appear a virtue, but in research it may lead to zero accomplishment. On the other hand, a line of research which appears to have run into a dead end should be abandoned; failure should be admitted, and resources transferred to more promising lines of enquiry.

In pursuing ongoing activities and embarking on new lines of work, the research objectives need to be clearly spelt out and related to the overall objectives of the particular program and of the Institute. Resources required, and the probability and potential economic impact of success, should be carefully examined. The time span for reaching the objectives should be reasonably clear. Preference should be given to research of interest to a wide range of countries in IITA's mandate area, which it would be rational to conduct centrally at an international institute. Similarly, IITA should pursue types of activity, for instance germplasm collection, which will benefit countries in the conduct of their own research.

These guidelines have been followed in the elaboration of the proposals included in the present long-range plan.

IV. The question of resources

The core budget of IITA is approved first by its Board of Trustees and then by CGIAR, which serves as a clearing-house for voluntary contributions to all the international centers supported by it. Outside the core program, special contributions are made directly to the Institute for specific purposes; these are known collectively as International Programs.

In recent years, the core budget has expanded in dollar terms, but contracted dramatically in terms of the activities it could finance. This is the result of accelerating inflation both worldwide and particularly in Nigeria, combined with a strengthening of the Nigerian currency against the dollar. The following figures speak for themselves.

	1978	1981	Percent change
Core operational budget	$11,579,800	$15,796,200	+36
Man years of senior scientific staff available under core budget for main susbtantive programs	56.5	42.0	-26

Research programs under-manned

Since the "man years" of senior scientific staff is the most accurate index of substantive activity, it will be seen that the Institute has undergone a program cut of more than a quarter despite the availability of substantially increased contributions. It has not been possible to build up the number of junior scientists to compensate for the decline in senior staff; their number in 1981 is not materially different from that in 1978. As a result, all the Institute's research programs are seriously under-manned. For example, the cereals program to function effectively should have two teams (one for maize and one for rice) each consisting of two breeders, one pathologist, one entomologist and one agronomist; instead of ten man years of senior scientists, the program will in 1981 have only 5.5 man years.

Financial problems

IITA's financial problems have been exacerbated by its unusually heavy infrastructural costs. For instance, pending the strengthening of the public utilities in Ibadan, the Institute is compelled to provide all its own water and a large part of its electricity. The cost of electricity alone is at present about $100,000 per month. Labor costs have also gone up extremely fast, and the Institute has had to lay off more than 10% of its permanent labor force. The cost of operating the main station, at about $5 million per year, now accounts for almost one-third of the core

operational budget, probably a higher level in both absolute and proportionate terms than is to be found in any other CGIAR center. All possible economies have been made, and further significant savings are difficult to visualize in the near future without prejudicing the substantive work of the Institute. In recognition of the financial difficulties of IITA, the Nigerian Government in December 1980 generously made a special contribution of one million naira, equivalent to about $1,900,000.

In looking ahead over the decade of the eighties, the only thing that can be said with any confidence about cost levels is that the extreme volatility of the last three years shows no signs of abating. About two-thirds of the Institute's budget is spent in Nigeria, and economic factors in IITA's host country will thus be of major importance. The extraordinary economic development of Nigeria is accompanied by very strong inflationary pressures; these may, of course, diminish but the experience of other countries suggests that they are more likely to intensify. It is equally difficult to predict the course of the exchange rate between the Naira and the dollar; in terms of purchasing power the Naira looks high, and in fact has been falling during the first few months of 1981, but the history of the seventies shows that exchange rates do not necessarily move in response to economic considerations. The combined effect of inflation and exchange rate fluctuations will be the determining factor for IITA's cost levels; with both elements being in practical terms unpredictable, any estimate or range of estimates for the period up to 1990 is subject to such an enormous margin of error as to be virtually meaningless.

Considering that the Institute has undergone a 26% program cut in the last three years, and faces unpredictable and probably highly volatile cost levels in the future, it does not seem useful to attempt to base a long-range plan on the five-year indicative planning figures of the CGIAR, embodying as they do the concept of moderate growth in real terms. What IITA needs is financial rehabilitation. The basic message of the present document is therefore the urgency of achieving once again a rational program level - rational in relation to the Institute's infrastructure, and rational in the light of the pressing research needs of African agriculture.

The process of program re-building should start in 1982, with a substantial increase in the number of the senior scientific staff, should continue in 1983 and be completed in 1984; no further increase is planned for 1985. The steps envisaged are summarized in Table 3. As compared with 1978, there is a moderate final increase in the level of the main substantive programs, equivalent to about 13% over the period of 7 years (from 56.5 man years in 1978 to 64.0 man years in 1985). The increase in administration, other support services and operations includes provision for the strengthening of internal management in such fields as programming, budget control and audit.

Over the same period, it is planned to double the number of junior scientists from 20 to 40. This will result in a significant change in the ratio of seniors to juniors. As long as the core budget can finance an adequate number of senior scientists to ensure continuity and direction, it is feasible and desirable to build up

the number of juniors. Not only can they make an excellent contribution to the work of the Institute at relatively modest cost, but the arrangement also provides a growing number of young men and women with experience in research on problems of tropical agriculture.

The financial implications of the above proposals are spelt out in the Mid-Term Budget 1981-82 and may be summarized as follows:

	1981	1982	1983	1984	1985
Core operational budget in constant 1981 dollars	15,796,200	16,826,800	17,710,700	18,215,800	18,215,800
Core operational budget at average 20% rate of annual cost increases	15,796,200	20,005,200	25,503,400	31,476,900	37,772,300

It will be noted that the cost of program re-building comes to less than $2.5 million at 1981 cost levels - not a major sum by international standards, but one that would have a major impact on IITA's effectiveness. Much bigger are the amounts potentially involved in coping with cost increases, and it must be emphasized that the assumption of a 20% rate of annual rate of increase is arbitrary, and has little more than an illustrative value.

Achievement of the objectives set in this document for the various research programs and sub-programs will depend in the first instance on program re-building being carried out along the above lines. It will not be possible to attain the objectives with the Institute's current much reduced level of scientific staff.

Capital expenditure

All figures so far quoted refer to the core operational budget. Capital expenditure will be kept to a minimum, and will tend to decline in real terms over the period. No major new construction is planned at present, and the maintenance of existing installations is charged to the operating budget. In the Mid-Term Budget 1981-82, capital expenditures of about $1 million per annum in current dollars are foreseen up to 1985. The only new project to which priority is attached is an extension of the irrigated area at IITA. It is estimated that bout $600,000 in 1981 dollars will be required for the replacement of pumps and the extension of both underground mains and surface piping, resulting in a total irrigated surface of about 145 hectares. A possible need for additional dormitory facilities for junior scientists and trainees will be reviewed in the light of program developments.

Table 3. Senior staffing levels 1978 and 1981-85

	Man years of senior scientists					
	Actual	Current	Proposed Budget		Projections	
	1978	Est.1981	1982	1983	1984	1985
Research:						
Farming Systems	17.0	10.5	13.0	14.0	15.0	15.0
Cereals Improvement	8.0	5.5	8.0	9.0	10.0	10.0
Grain Legume Improvement	10.0	9.0	9.0	9.0	10.0	10.0
Root & Tuber Improvement	8.0	5.0	8.0	10.0	11.0	11.0
Research Support *	7.5	7.0	7.0	7.0	7.0	7.0
Total Research	50.5	37.0	45.0	49.0	53.0	53.0
Genetic Resources	3.0	1.0	2.0	3.0	3.0	3.0
Training	1.0	1.5	4.0	4.0	4.0	4.0
Library, Documentation and Information	2.0	2.5	4.0	4.0	4.0	4.0
Total for main substantive programs	56.5	42.0	55.0	60.0	64.0	64.0
Administration, other support services, operations	7.0	8.5	9.0	11.0	11.0	11.0
Grand total	63.5	50.0	64.0	71.0	75.0	75.0

* Excluding Genetic Resources which is shown separately.

From the above analysis it is clear that if IITA is to be put on a sound financial footing it is going to need resource levels considerably in excess of those contemplated in the forward planning of the CGIAR. The basic policy issue, therefore, is the priority which donors - many of which have serious bugetary problems of their own - are going to place on agricultural research in general and IITA in particular.

If donors feel it is important to rehabilitate IITA's finances, they could plan to increase their support in real terms, so as to permit program re-building to take place. Advance planning of contributions might provisionally be based on the figures in Table 4. Should this not be possible through the mechanism of the CGIAR, the Institute will try to obtain the necessary funds in the form of special core-supplementing grants.

In addition, it would seem advisable to plan in advance for the possibility of another upsurge in cost levels within a budget period. A large reserve for such a contingency within the Institute's budget is unlikely to be a feasible proposition. It is therefore suggested that individual donors be ready to make *ad hoc* contributions from whatever reserve may be established within their overall aid budget, if IITA should again be faced with serious financial difficulties. Indeed, without the recent

Table 4. Provisional estimate of IITA financial requirements 1982-1985 (US$ Thousands)

	1982	1983	1984	1985
Net core funds required *	19,805.2	25,263.4	31,188.9	37,426.7
Net capital funds required	993.8	1,130.6	1,002.8	1,124.6
Total funds required from CG donors	20,799.0	26,394.0	32,191.7	38,551.3

* Net of estimated earned income. Fuller particulars are given in the Mid-Term Budget 1981-82. A 20% annual rate of cost increase is assumed.

contribution of this nature from the Nigerian Government, the Institute would be facing very grave problems in 1981.

The Institute recognizes that the problem cannot simply be left to the goodwill of its traditional donors. The management of IITA envisages a series of further measures for coping with the current financial crisis. These include continued cost cutting, and approaches to new sources of finance. However, the problem may well prove to be a long-term one, which can only be solved by a fresh approach to the financing of the Institute - and for this the help of IITA's major supporters will be indispensable.

V. Development of the program for improving roots and tubers

Roots and tubers have long suffered from an unjustified neglect on the part of agricultural research, considering that they dominate agriculture over much of the humid and sub-humid tropics. Even today, when African governments are struggling to overcome their weaknesses in research capacity, roots and tubers receive less attention than would be justified by their economic importance and social impact. Consequently, IITA's program has a particularly high value for many of the African countries where roots and tubers are staple food. The program places special emphasis on training and international cooperation, with a view to strengthening national research capacity in this sector.

Roots and tubers are biologically well adapted to tropical conditions. They do, however, have clear disadvantages in comparison with cereals: they are perishable, they are more difficult to prepare and cook, and they have a lower protein content. There are already many signs - commented on elsewhere in this report - of a shift in consumer preferences away from root crops and toward cereals. It would be most unfortunate if this were to assume massive proportions because in the humid tropics not even rice could be grown as widely as cassava is at present. Long-range policy must therefore be to seek ways around the genetic defects of root and tuber crops. IITA is following the path of genetic improvement and better agronomic practices. It is important for other organizations to step up work on different aspects of the problem, particularly with regard to storage and processing. The prospects for cassava, for instance, could be transformed if it were possible to combine high-yielding, low-HCN cassava (an IITA breeding objective for the eighties) with methods of small-scale processing for the production of a cassava-based equivalent of bread.

As in the case of other crops, roots and tubers in Africa suffer severe losses from diseases and pests. The main priority of IITA's research during its first 10 years has been the search for genetic resistance to those diseases and pests of chief economic significance, in combination with improved yields. This work, extended in some cases to biological control of pests, will have to continue into the new decade. Gradually, however, the emphasis will shift toward development of sweet cassava with consumer-preferred characteristics.

Work on genetic improvement will be complemented by research under the Farming Systems Program. It is, for instance, important to know whether mechanical harvesting of root and tuber crops is possible without soil damage. Further work will also be done on labour requirements during other parts of the cycle, with a view to developing mechanical aids for small-scale cultivation.

IITA has a global mandate for improvement of sweet potatoes and yams, while

for cassava and cocoyams, the emphasis is on Africa. At global level, cassava improvement is the responsibility of the Centro Internacional de Agricultura Tropical (CIAT).

Before describing plans for research on each of the four crops it may be helpful to amplify the remarks on tissue culture made in section II above.

Role of tissue culture

The characteristics of vegetatively propagated crops remain constant from generation to generation, since they are grown from genetically homogeneous clones. This means that a good genotype can be propagated without having to carry forward several generations of in-breeding to attain genetic uniformity. On the other hand, the planting material can be a connecting bridge for pathogens borne in the tissue of the parent plant, which will pass to the progeny. The probability of this happening depends on a number of factors, such as time of propagation from the parent stock, inherent susceptibility of the plant, and prevalence of the pathogen in the growth environment.

In improving the cassava, sweet potato, cocoyam and yam, IITA is faced with the task of using sexual propagation to make crosses to achieve genetic advance, and then employing clonal propagation to exploit the improvement made. An international exchange of germplasm is crucial for rapid progress, but well-meant quarantine regulations preclude importation of elite germplasm in vegetative form, thereby seriously slowing down the international impact of genetic advances. Quarantine policy needs to weigh, in each case, the advantages of receiving improved germplasm against the risks of introducing new pathogens and insect pests.

Tissue culture laboratory established

The establishment of the tissue culture laboratory at IITA in 1977 was a response to the needs of the program for improvement of root and tuber crops. The laboratory serves three main functions. The first of these is rapid propagation. For example, an elite seedling of yam may produce a small tuber which is put in a 'hill-trial'. The second year it is possible to get enough planting material to grow a small replicated trial in one location. The prospects of a multi-locational trial are, however, still far off since several generations (each lasting a year) will be needed simply to provide enough vegetative material for trials in various locations. In sharp contrast, the selected seedling can be rapidly propagated in tissue culture so as to telescope the whole process into a far shorter period.

The second function of the tissue culture laboratory is germplasm conservation, a key factor in crop improvement. The maintenance of the germplasm of cassava, sweet potato, cocoyam and yam normally requires an annual field planting of each clone. The build-up of pathogens may lead to a progressive decline in vigor, and root and tuber rots during the intervening storage period often result in the permanent loss of precious accessions. The tissue culture

laboratory makes it possible to preserve germplasm as *in vitro* plantlets needing to be transferred to fresh medium only once in 12-18 months. This procedure minimizes both losses and labor, and yet permits the generation of a field grown plant from the desired accession in 3-4 months.

The laboratory's third and at present most important function is carried out in close association with the Virology Unit and consists of producing disease-free materials for international exchange. The Virology Unit is responsible for etiology, isolation and purification, serology and indexing techniques in respect of the major virus diseases. Once these steps have been gone through for a disease of concern to the quarantine services, the plantlets grown in tissue culture can be categorically described either as carrying virus or as disease-free. The material which is identified as virus-free is given a phytosanitary certificate by the quarantine services and can then be rapidly propagated under aseptic conditions and made available to users in full confidence that it will not transmit diseases, particularly viruses.

Procedures for producing virus-free material through meristem-tip culture have been developed for sweet potato and cassava, and some elite clones have been produced virus-free. Requests for such material have already been received from more than 20 countries. Distributing clones to national programs started this year, 1981, to all countries for sweet potato, but only to African countries in the case of cassava. Before cassava material can be sent to other continents, some of the problems of etiology of cassava mosaic disease will have to be solved. This disease has not been reported from Latin America.

By 1985, the best clones of cassava and sweet potato produced by IITA should have been distributed to all interested countries, and tested for performance under local conditions.

Cassava

At about 45 million tons in 1979, production of cassava in Africa exceeded that of any other crop. The area under cassava has expanded by 20% in the last decade, but yields have, if anything, shown a very slight tendency to decline. Total output has thus risen more slowly than population. Cassava has both great advantages and serious drawbacks. It is a cheap source of calories and a relatively easy crop to produce. Both leaves and tubers are edible. It does well in relatively infertile soils, and can resist prolonged drought. Complete crop failure is very rare. On the negative side, cassava roots and leaves contain hydrogen cyanide and are highly toxic unless properly processed. Tubers cannot, unless dried, be stored for more than a few weeks out of the ground, and are difficult to transport over long distances except in processed form; cassava is usually left in the ground unharvested until needed, thus immobilizing land. It contains only about one or two per cent of protein, and for nutritional purposes must therefore be supplemented by pulses or other high-protein foods. And in Africa it is subject to a series of widespread and serious diseases and pests, which can have a devastating effect on yields.

Mosaic disease and bacterial blight

In the 1970's IITA concentrated on genetic resistance to two major diseases: cassava mosaic and cassava bacterial blight. Three clones have been identified as having satisfactory performance in terms of both resistance and yield and are being made available to farmers in Nigeria. In Gabon, Sierra Leone, Tanzania and Zaire, elite cassava varieties transferred via seeds have been selected from IITA breeding material and recommended for adoption by farmers. Selection is underway in other countries.

Mealybug and green spider mite

While levels of resistance to cassava mosaic and cassava bacterial blight can still be improved, the threat of these diseases has been much reduced. However, two relatively new forms of infestation have spread rapidly in recent years, and now constitute a major peril for African cassava producers. These are the cassava mealybug and green spider mite. The mealybug was first reported in Zaire in 1973, and green spider mite in Uganda in 1972. They have now reached most cassava-growing areas of Africa. Research for means of defence against these two insects is expected to account for a substantial part of IITA's work on cassava in the first part of the new decade. Two approaches are being pursued: genetic resistance and biological control.

Anthracnose is a disease affecting cassava in Africa and other regions. Here, IITA plans to develop screening methods for identifying sources of resistance, to incorporate this characteristic in the breeding material and clones which IITA is making available to national programs.

When a reasonable degree of control over the main diseases and pests has been achieved, increasing attention will be given to improvement of other agronomic characteristics. The disease-resistant varieties already developed are also relatively high-yielding, and the search for higher yields on farmers' fields will be pursued through better agronomic practices. This will be a task of the Farming Systems Program. However, to give greater flexibility to the use of cassava in cropping systems, the breeders will attempt to develop early-maturing varieties which can be harvested before the impact of the dry season is felt.

Sweet and bitter clones

Most of the cassava now grown is "bitter", i.e., it has a relatively high hydrogen cyanide (HCN) content. "Sweet" cassava has a lower HCN content, and is consequently easier to prepare, but the available sweet clones, in general, give lower yields. The development of a high-yielding sweet cassava, which is also resistant to the major diseases and pests, is a breeding objective to which attention will increasingly be devoted in coming years. Improved starch quality will also be sought since this is necessary if there is to be a practical possibility of developing a cassava-based form of bread for urban populations.

The geographic focus of IITA's work so far has been on the lowland tropics.

Cassava is also grown to a limited extent in the East African highlands, and it is planned to test the IITA material for adaptability to that ecosystem. The potential is considered very great, but suitable high-yielding clones are not at present available.

The major objectives for cassava improvement in the eighties are as follows: *By 1985, IITA should have achieved effective means to control cassava green spider mite and mealybug, by genetic and/or biological means. By 1990, IITA should have available cassava clones and populations that offer high and stable yields as well as resistance to major diseases and pests, that are suitable for the main cassava-producing areas of Africa, and that are of improved quality.*

A more detailed schematic representation of past and planned work on cassava improvement is given in Figure 1.

Sweet potato

The sweet potato is grown in all continents and is especially popular in Asia. In Africa, the largest producers are Burundi, Rwanda and Uganda. While it is a minor crop in most other African countries, it would appear to have considerable potential, not least because it is relatively quick-maturing, being ready for harvesting after about four months.

During the seventies, IITA developed a series of improved varieties which were provided in the form of true seed to countries in Asia, Africa and the Americas. Test results, as mentioned earlier, have in general been very satisfactory. The effect of the Institute's work has been felt mainly in Africa, but even there the potential of the new varieties has not yet been exploited fully. First priority in the new decade will, therefore, be given to continued international testing in co-operation with national programs.

Research will be aimed in the first instance at improving the shelf life of the sweet potato in tropical conditions. The factors which affect keeping quality will be investigated, and the keeping quality of existing varieties will be systematically tested. The development of varieties with a good shelf life could lead to a considerable expansion of interest in this crop. At the same time, IITA will continue the search for higher levels of resistance to the sweet potato weevil and vrius complex. Tests will also be carried out for resistance to anthracnose, a disease which is severe in highland areas; resistance will, if possible, be bred into existing varieties. Finally, germplasm will be screened for performance under humid soil conditions.

The major objective for work on sweet potatoes is the following: *By 1985, IITA should have available sweet potato varieties with improved keeping quality and higher levels of resistance to the sweet potato weevil, viruses and nematodes.*

There are some differences in consumer preferences between Africa and Asia.

IITA's work has so far been oriented mainly toward African requirements. In the second half of the decade it is planned to exercise the Institute's global responsibility by seeking improvements in line with Asian preferences.

Figure 1 shows the timing of IITA's past and planned research on sweet potato improvement.

Cocoyam

The two main cocoyams, *Colocasia* sp. and *Xanthosoma* sp. are grown in all tropical regions of the world. *Colocasia* originated in Asia and its spread has taken place in stages since pre-historic times. *Xanthosoma* comes from tropical America, and has been introduced only recently to Africa and other regions. In Africa *Xanthosoma* is preferred to *Colocasia* and is tending to displace it. Generally speaking, the cocoyams are a basic staple in Africa, a vegetable in Asia and a supplemental food in tropical America.

Of all roots and tubers, the least research has been done on the cocoyams, and only three African countries are currently working on this crop at national level. There is, however, much potential for improvement. A large number of cultivars of both *Colocasia* and *Xanthosoma* are being grown, showing wide variations in such characteristics as shape and texture of the tuber, fertilizer and water requirements, storage properties, and resistance to pests and diseases. Some progress can be achieved by the selection and diffusion of elite cultivars. However, an effective long-range program in cocoyam must be based on the development of Gibberellic Acid - induced flowering, hybridization, seed setting, the raising of seedlings and evaluation. IITA is in the lead in work on this approach. The genetic base of the breeding program has been broadened by the introduction of seeds from the Pacific and Caribbean areas, and the achievement of crosses with Nigerian clones. True seed has been produced and distributed for international testing.

The main breeding objective at present is resistance to cocoyam root rot die-back complex, or cocoyam blight, which is severely affecting *Xanthosoma* in the forest areas of Africa. Emphasis is being placed on the selection of elite cultivars showing blight-resistance, but genetic improvement will also be sought.

Additional breeding objectives for work in the eighties will include high yield, improved culinary characteristics, adaptability to a range of environments, and maximization of storage life.

The resources devoted to cocoyams will be much less than those for cassava, sweet potato and yam, all of which have greater economic importance. Only a modest objective is set for cocoyams, defined as follows: *By 1985, IITA should have identified clones of* Xanthosoma sp. *showing satisfactory levels of resistance to blight.*

Research in blight resistance will take place in Cameroon, where the disease pressure is reportedly the highest. Sources of resistance will be sought in germplasm

collected from other parts of the world, notably Central and South America.

IITA's past and future work on cocoyams is portrayed in Figure 1.

Yams

Yams are a traditional crop in West Africa, which accounts for about three-quarters of world production. However, their future is being prejudiced by two major drawbacks. The first is a high labor requirement, deriving in large part from the fact that the vines, which climb to a height of over four metres, generally need to be supported on stakes if a satisfactory yield is to be achieved Secondly, about a quarter of the crop has to be set aside for use as seed yam. Both of these problems can, it is believed, be solved through research. Work on yam varieties which will provide a satisfactory yield with minimum staking is in particular being pursued in IITA.

Several species of yam are widely grown. IITA is concentrating on the white yam (the preferred species in West Africa), the water yam (grown in Asia and part of the Caribbean), and the cluster or trifoliate yam (popular in Cameroon and part of Central Africa), with the highest priority being given to white yam.

Besides seeking genetic improvement, IITA plans to work through the Farming Systems Program on improved agronomic practices for yam production. This is a subject on which relatively little work has been done so far. The basic objective will be a reduction in labor requirements as well as improvements in yield. One of the possibilities to be investigated is mechanical harvesting; this will require the development, through genetic improvement, of a variety with a suitably shaped tuber, and some progress in this direction has already been made.

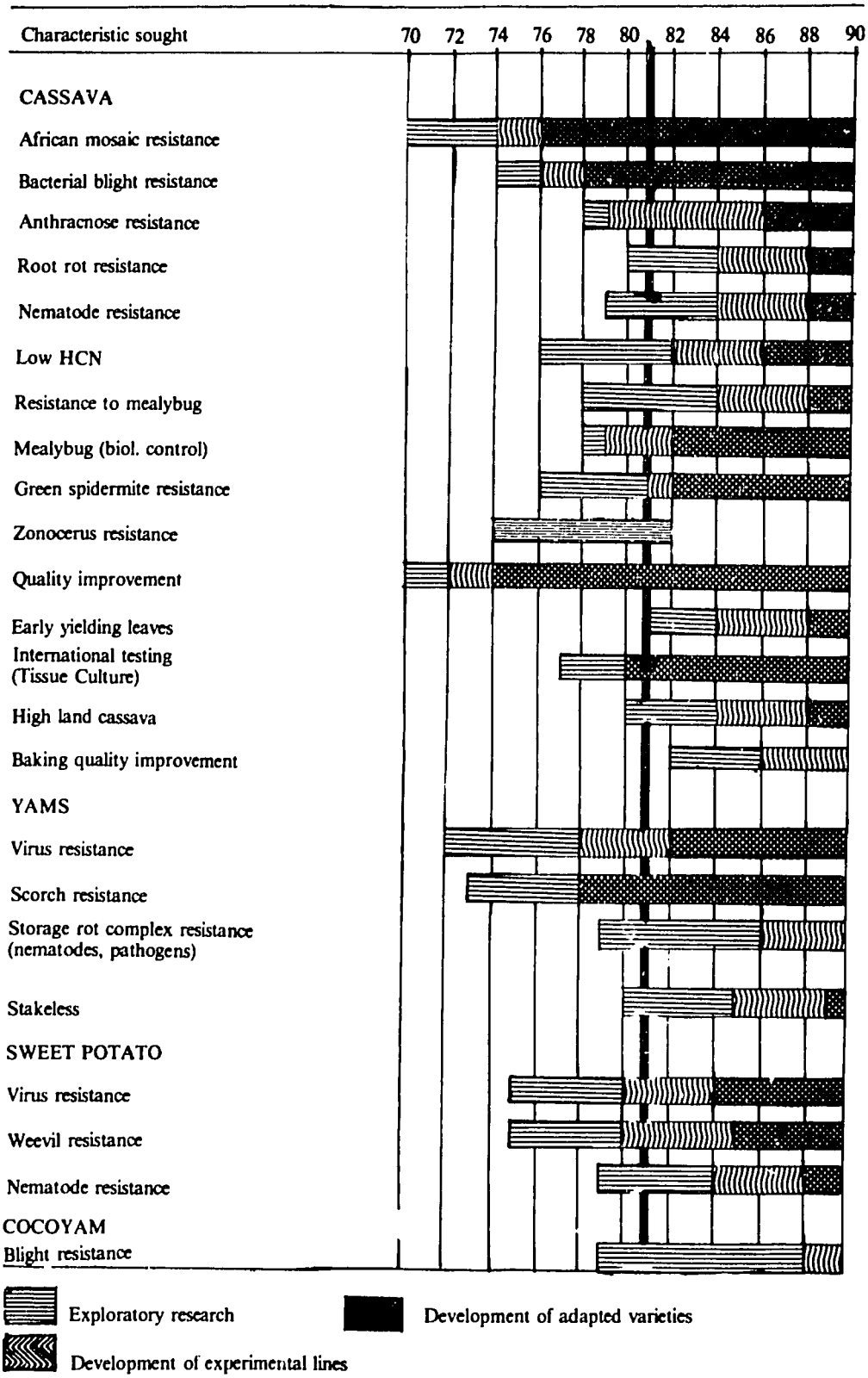
Like other root crops, yams have a limited storage life. Efforts will be made to improve keeping quality through resistance to nematodes and fungal diseases.

Despite the esteem in which they are held in West Africa, yam genetic improvement is very new and there is a serious shortage of specialized yam breeders under national research programs. This is possibly because of the extremely slow rhythm of selection and improvement, which makes yam breeding a frustratingly long-term process. While the resources which IITA can devote to yams are relatively limited, the Institute's work can make a significant contribution over time.

An intensive attack on the problems of yam improvement is felt desirable in West Africa, but would need the mobilization of very substantial resources. While IITA can hardly undertake such an enterprise single-handed, it will be ready to work with appropriate national institutes which may be prepared to take an initiative in the matter. IITA's contribution could consist not only in co-ordinating and/or undertaking research, but also in helping to mobilize the necessary funds.

As IITA's mandate is world-wide in scope, attention will continue to be paid

Fig. 1 Past present and long-range plans of the Root and Tuber Improvement Program 1970-1990



to the needs of other regions, for instance through research on the water yam. Research will be directed toward the inducement of flowering and the development of fertile seeds, a goal which has not yet been attained for this species, and which would open up new possibilities of genetic improvement.

The following limited objective has been defined for research on yams: *By 1985, IITA should have developed white yam varieties giving reasonable yields with minimum staking, and with improved keeping quality.*

No precise objectives are set for the second half of the decade. In view of the multiplicity of possible lines of research, the relatively slow rate of progress which is feasible, and the limited resources which IITA can devote to this crop, it will be necessary to re-assess priorities around the mid-point of the decade. It is likely, however, that further work will be required on the elimination of staking. Further objectives might include the achievement of a satisfactory technology for true seed production, and consumer-preferred characteristics such as suitability for pounding.

As for other root and tuber crops, Figure 1 shows the past and planned work of IITA on yam improvement.

VI. Development of the grain legume improvement program

Grain legumes have long formed an integral part of tropical diets, their nutritional quality being particularly important in areas where roots and tubers are the basic staple. IITA has global responsibility of improving cowpeas, and a more limited mandate for work on soybeans in Africa. In its early years the Institute explored the possibility of genetic improvement of a range of grain legumes, including pigeon peas and lima beans that are important in farming systems of the humid and sub-humid tropics. The program has, however, gradually been consolidated, and now concentrates primarily on cowpeas which absorb about 60% of available resources, and in second place on soybeans.

Genetic improvement in cowpeas and soybeans is reinforced by parallel research on symbiotic nitrogen fixation. There have been few studies of populations of rhizobia in tropical soils, and therefore little is known about their diversity, their survival in harsh dry environments between the cropping seasons or in acid soils, their range of hosts, or the effectiveness of symbiosis with selected crop hosts in terms of N-fixation. With the cost of nitrogenous fertilizers escalating, the importance of study of these topics is self-evident.

It is known that cowpeas form nodules with a wide range of rhizobia, and that inoculation of cowpeas with introduced strains of rhizobia is not usually accompanied by increased yield. However, as progress is made in breeding for resistance to insects and diseases, with resulting yield increases, the nitrogen demand by the plant will go up. It is then that advances in rhizobial research will be of greatest benefit.

Basic studies on the physiology of N-fixation, particularly in cowpeas, form part of this work. There is a need for simple and reliable methods to measure nitrogen fixation in the field; most of those now in use have serious limitations, and work is in progress to find new and better methods.

Soybean varieties which do not need inoculation with *Rhizobium japonicum* are being developed. Meantime, a better understanding of host/strain specificity will help to ensure high yields from the varieties of US origin that need inoculation with introduced strains of rhizobia. This work also represents an alternative approach to the problems of soybean cultivation in Africa, that will be of the greatest value should there be no further progress with efforts to breed soybean varieties that will nodulae effectively with indigenous African rhizobia. If, on the other hand, the initial promise of the breeding effort is confirmed, this research can be phased down.

Faced with this wide array of problems, some of which need sophisticated laboratory facilities, IITA is working in collaboration with the Boyce Thompson Institute, USA, Cornell University, USA, and the University of Western Australia.

TASKS FOR THE EIGHTIES

A Progress Report on IITA's Long-range Plan

January, 1982

International Institute of Tropical Agriculture
Oyo Road, PMB 5320
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INTRODUCTION

IITA's Long-range Plan, entitled "Tasks for the Eighties," was prepared in the first quarter of 1981. Since that time, events have forcefully emphasized the urgency of the challenge facing the Institute, and the need for increased support to its activities.

In Africa — where the humid and subhumid tropics are IITA's primary area of concern — serious foreign exchange difficulties have made it still more difficult for many countries to cover their production deficits with food imports. While the drought of the previous years has fortunately not recurred, African agriculture remains highly vulnerable to natural setbacks. These may include outbreaks of pests and diseases, and the spread of the cassava mealybug now represents a major danger to cassava production in many parts of the continent. There is also new evidence that the rice yellow mottle virus can imperil intensive rice production. Many African nations thus face problems, not merely in building up food production to meet demand, but even in protecting and maintaining existing production levels.

At the same time, world inflation and the economic difficulties of donor countries have led to a fall in real terms in the aid flow to developing countries — with multilateral institutions being particularly hard-hit. The decline in the volume of assistance makes it more important than ever to channel the available funds toward activities which can make maximum impact, and which can contribute most toward self-sustaining growth on the part of the poorest nations.

While IITA can hardly be expected to have impartial views on the subject, it nevertheless appears indisputable to the staff of the Institute that agricultural research should be among the top priorities at both national and international levels. The worsening financial difficulties of the Consultative Group on International Agricultural Research (CGIAR), and of the individual centers supported through it, are thus paradoxical. Failure to fund research means failure to develop the technology required to intensify food production, and in the absence of a suitable technology food shortages can only worsen over the longer term. Financial savings made now by cutting funds for research will create far greater problems at a future date. This is particularly clear in the case of Africa, where most countries are at the early stages of developing an effective production sector, and where the lack of a technology for achieving steady increases in yields without detriment to soils is a major barrier to progress.

The research objectives set forth in the Long-range Plan for 1985 and in some cases for 1990 remain valid, although there will be some shift of emphasis in the Farming Systems Program. In the following paragraphs a brief account is given of progress since the Plan was prepared, and near-term prospects are assessed.

ROOTS AND TUBERS

Within the program for research on root and tuber crops, main priority is given to cassava, the most important staple food in economic terms in the humid and subhumid tropics of Africa. Mention was made above of the spreading devastation caused by the mealybug. The green spider mite is another pest which now constitutes a serious danger for cassava production. The Institute's research objective for 1985 is to

have achieved effective means of controlling both these pests, using either or both of two approaches: genetic resistance and/or biological control.

Progress has been highly encouraging, although preliminary results remain to be confirmed by wider testing. Several natural enemies of the mealybug have been identified in Latin America, and tested as a means of biological control. Two have shown an ability to establish themselves in the IITA fields, and to destroy the mealybug population. Sources of genetic resistance to both the mealybug and the green spider mite have also been found. In one case, the mechanism is a high hair density on the leaf surface. In the other case, a highly resistant clone was found by IITA scientists in Zaire, but the mechanism of resistance is so far unclear. It is planned to combine the genetic and biological approaches in an all-out attack on the mealybug, which can be considered as Africa's worst single agricultural pest at the present time.

Among the other root crops on which research is underway, special mention may be made of work on the cocoyam *Xanthosoma sagittifolium*. The objective is to identify by 1985 clones showing satisfactory levels of resistance to cocoyam blight, a disease which is causing major damage in the forest areas of Africa. IITA scientists working in both Nigeria and Cameroon have obtained preliminary indications of sources of genetic resistance. While much work remains to be done, it looks at this stage as if there may be good possibilities of combining genetic resistance with other desirable agronomic characteristics.

GRAIN LEGUMES

The major portion of research under the Grain Legume Improvement Program is devoted to insect resistance in the cowpea. The 1985 objective is to have developed lines that show separate resistance to thrips, *Maruca* and bruchids and that are suited to the consumer requirements and ecological conditions encountered in the world's main cowpea growing regions. If this can be achieved, a solution will be in sight for the main causes of pre- and post-harvest losses, especially under the low-management conditions of small African farms, which account for the bulk of the world's cowpea production.

The target looks feasible, with recent progress being steady rather than spectacular. A moderate level of thrips resistance has been combined with acceptable seed quality and high yield. The line concerned (designated TVx 3236) is being multiplied on a large scale in northern Nigeria for distribution to farmers, while IITA research will continue the hunt for higher levels of resistance. *Maruca*-resistant lines are at an advanced stage of development, and eight years of work on resistance to the bruchid, a storage pest, have now reached the point of significant pay-off. In the course of 1982, world-wide tests are to be organized of a line which, in IITA trials, has shown excellent agronomic characteristics as well as bruchid resistance.

Earlier work by IITA scientists is, in the meanwhile, beginning to make a decisive impact on farmers' fields around the world. For instance, cowpea varieties originating from IITA breeding lines have recently been released in Brazil, Tanzania, Upper Volta and South Yemen following extensive trials which revealed major yield potential.

A new area of research, based on work carried out under an IITA co-operative program in Tanzania, is the development of a line of early-maturing cowpeas. Current results are highly promising. The cowpeas are ready for harvesting in 60 days rather than the usual 90; the pods are all carried above the foliage and ripen synchronously, so that harvesting is relatively easy, and lends itself to mechanization. Yield can be as high as 1.5 tons per hectare despite the exceptionally short growing period. If further testing confirms the potential of this line of cowpeas, the impact could be very great.

IITA is engaged in pioneering work on the development of soybeans which can be grown in tropical conditions without the need for inoculating seed with imported rhizobia. While success has been achieved in the fundamental aim of evolving varieties which will nodulate freely with the rhizobia found in African soils, it now appears that further work is required on agronomic aspects, and on adaptation to different ecological conditions and levels of soil fertility. The 1985 objective is to develop soybean lines which nodulate freely with indigenous African rhizobia, which possess a satisfactory level of seed storability, and which can be grown in a range of ecological conditions. This target may still be feasible, although it must be pointed out that the program has been badly hit by the financial problems — and consequent staff shortages — which have affected IITA as a whole.

CEREALS

The Cereals Improvement Program, building on the work of the International Maize and Wheat Improvement Center (CIMMYT) and the International Rice Research Institute (IRRI), seeks improved varieties of maize and rice adapted to African agro-ecological conditions. The main focus of maize research is resistance to the streak virus, a widespread disease which does great economic damage. The objective is to have, by 1985, streak-resistant varieties of white and yellow maize, both early maturing and medium maturity and with good yield potential, suitable for the main maize-growing ecosystems of Africa. Rapid progress has been made in the last two years, and the target is confidently expected to be achieved.

IITA has also initiated research on hybrid maize for use on relatively large commercial farms. The aim is to have by 1985 an initial series of lines suitable for use at national level in the development of top crosses, the simplest form of hybrid. Here again, the achievement of the objective appears feasible. Special arrangements have been made for IITA to play a major role in a Nigerian program, of which the short-term target is to release the first set of maize hybrids for farm use in 1985. The IITA contribution, which will be strongest in the early phases, will receive financial support from the Nigerian Government.

In the case of rice, separate breeding targets for 1985 have been set in respect of hydromorphic areas, shallow swamp areas, and upland cultivation. In general, these relate to yield and resistance to the main stresses encountered in the different ecosystems. The program has been achieving promising results in upland rice, the fruit of several years of work. Improved intermediate statured cultivars having good levels of resistance to blast and drought have been developed, and are now being extensively evaluated by national and international programs. The semi-dwarf plant type with thick and

deep roots is also undergoing development. The rice program has suffered from staff shortages as a consequence of the financial situation, and it is by no means sure that all the 1985 targets can be reached.

FARMING SYSTEMS

The Farming Systems Program is engaged on the long-term task of designing improved technologies which will permit the maintenance of intensive food production in the humid and subhumid tropics without loss of soil productivity. Research is directed mainly towards smallholder farming systems for Africa, but some research is also carried out on the problems faced by large-scale production schemes. In the course of the past year, the program has come under new leadership, and this has led to a reappraisal of objectives and priorities for the medium-term future.

A great deal of basic research has been carried out during the last ten years on key aspects of soil performance and soil management in the African tropics, and the interactions among soils, plants and environments. The knowledge so acquired has been translated into specific technical approaches such as alley cropping, live mulches and zero tillage, on which work is still underway. The program is thus developing building blocks which can be assembled into improved technological options. The emphasis is now shifting toward "downstream" or farm-level research, designed to test IITA technology in actual farming conditions. This will, at the same time, identify specific production constraints and feed back information to IITA on requirements for problem-solving research. IITA scientists hope to launch a program along these lines in three African countries during 1982 with the support of extra-core funding.

The modification of the original medium-term objectives thus goes in the direction of greater concentration, a more systematically interdisciplinary approach to specific problems, and greater investment of effort in farm-level research in typical ecosystems.

The long-range plan attached considerable importance to the development of a Farming Systems Network for West Africa (originally entitled Cropping Systems Network.) Progress is being made, with the backing of several interested donor governments and programs. Another important activity financed by an extra-core contribution is the identification and assessment of hydromorphic areas suitable for rice production. In a second stage, this project will proceed to the planning of actual development in these areas.

TRAINING

The Institute's research activities are complemented by its training program. This is given a high priority by IITA because of the acute need for trained personnel in most countries of the humid and subhumid tropics, and in virtually every country of tropical Africa. Indeed the possibility for the Institute to have a significant impact on African agriculture depends in part on the strengthening of national research and extension programs.

During 1981, about 250 people were given training through group courses in sub-

jects such as reduced tillage systems, nitrogen fixation and legume production, storage (in conjunction with FAO), tissue culture (in conjunction with CIP and CIAT), fertilizer efficiency in the tropics (in conjunction with IFDC) and courses in cowpea, rice and tropical root crops production and extension. In addition, some 100 people benefitted from various forms of individual training — more than half of them postgraduate students engaged in degree-related research.

A major expansion of the training program is envisaged if special contributions can be obtained.

INTERNATIONAL PROGRAMS

The emphasis of International Programs is on two fundamental aims: to strengthen two-way linkages between IITA and national programs; and to build up, at the same time, the capacity of countries to handle their agricultural research problems. Bearing in mind the large number of countries in tropical Africa, and the limited extent to which the Institute can handle projects involving out-posted staff, particular importance attaches to core-supplementing grants which permit joint participation by countries and IITA in research activities, or which finance additional training by the Institute.

Since the long-range plan was drawn up, the total volume of International Programs, measured in financial terms, has remained roughly constant. However, the last twelve months have seen the Institute starting to benefit from certain strategically important contributions, which not only strengthen its own work, but also enable it to have a wider impact at national level. Foremost among these is a special contribution from the European Economic Community, which has permitted the launching throughout Africa of an international multi-locational testing program for improved varieties of rice, maize, cowpeas and soybeans.

A first Joint Planning Meeting has been held with African countries and other international programs, and special planning and evaluation committees have been set up for each crop. These committees consist of the interested international organizations, together with one representative for each crop from each of the main geographical regions of Sub-Saharan Africa. The first substantive activities undertaken have been in-service training of technicians from participating countries, and the next phase will see the start of work on multi-locational breeding and testing.

Several other major program proposals have been prepared for consideration by possible donors.

FINANCIAL DEVELOPMENTS

As explained in Chapter IV of "Tasks for the Eighties," the Institute's overall program has been falling in real terms since 1978. In the earlier part of the period, the factors involved were unique within the CGIAR system: a combination of violently accelerating inflation in IITA's host country, combined with adverse movements in exchange rates which, instead of compensating for inflation, magnified its impact through a strengthening of the Nigerian naira against the dollar. The already serious

result of these two developments became dramatic when there was a general shortfall in contributions to the CGIAR, affecting all centers. Over the period since 1978 the level of IITA's research program, measured in man-years of senior scientists, has fallen by over a quarter as a result of financial difficulties.

The long-range plan envisaged that 1982 would see the start of program rebuilding. Unfortunately, this hope has proved to be excessively optimistic. On the contrary, the financial problems of the CGIAR system have deepened, and all international centers have experienced serious budget cuts in real terms in 1982. IITA has been spared the full brunt of the new crisis because of the major reductions it had already undergone, but the total program is now far below the capacity of the Institute. It is to be hoped that 1983 will, at last, see a decisive improvement in the financial situation.

This collaborative effort was made possible by a global project funded by the United Nations Development Program from 1978.

Cowpeas

The cowpea is believed to have originated in West Africa, which is still its major production area, but it is now grown in all tropical regions. The preferred type of cowpea is heavily influenced by the use to which it is to be put. In Africa, cowpeas are frequently soaked, the testas are removed by rubbing, and they are then ground in order to make dough. To facilitate this process, large cowpeas with rough or wrinkled testas are preferred. In other tropical regions, and to some extent also in Africa, cowpeas are cooked directly as vegetables. Where this is the practice, the preference goes toward cowpeas with smooth seed. The cowpea requires less cooking time than most other legumes, an important advantage in areas where firewood is in short supply.

The cowpea is adapted to a wide range of environments, from the semi-arid areas to the humid zone. Its nutritive qualities are rated highly. All the nitrogen in the protein comes from the atmosphere, without the need for expensive nitrogenous fertilizers. Offsetting these advantages, however, is the fact that the cowpea is extremely vulnerable to pests and diseases.

IITA's early work on cowpea improvement was mainly devoted to basic research on crop physiology, and to the development of host plant resistance to insects and diseases. Cowpea diseases are one of the most conspicuous constraints in the more humid tropical environment. Sources of resistance to most of the important diseases, and many combined sources of resistance, were identified and incorporated in breeding lines. Many of the 92 elite lines distributed in international trials since the mid-seventies have high levels of combined resistance to the principal bacterial, fungal and virus diseases.

With the eighties, the orientation of the program is shifting toward insect resistance, with the emphasis on insects encountered in Africa. This reflects a strategy aimed, in the first instance, at achieving yield stability through resistance to the main diseases and pests. These characteristics must be incorporated in a range of lines adapted to consumer preferences regarding seed type. In a final stage yield promotion will become the primary objective, starting from the largely unrealized yield potential of the existing improved lines. Of key importance for the breeding program are the 15,000 cowpea accessions in IITA's working collection of germplasm.

Cowpea pests in Africa are numerous; attack the crop at all stages of growth and also in post-harvest storage. The most important of those on which attention will be directed in the eighties are briefly described below.

Flower thrips are minute black insects which, as their name implifies, feed on flowers and flower buds. They lay eggs in the buds, and since their entire life cycle takes only 14-18 days a very high level of infestation can build up rapidly,

sometimes resulting in the loss of an entire crop. The levels of resistance so far found are relatively low. An improved methodology will be employed to seek new sources of resistance in the germplasm collection. Once identified, these will be used to make specific crosses to confer thrip resistance on the elite breeding material.

Maruca (pod borer) is a nocturnal moth, which lays its eggs on flower and leaf buds and in flowers. The larvae feed on tender parts of the stem, as well as on flowers and pods. The *Maruca* can cause extensive damage, and is a major pest in Africa and south-east Asia. While two sources of resistance were identified in ealry field trials, it was speedily evident that further progress would depend on the development of artificial rearing and infestation methods. Difficulties were experienced in bringing about the mating of *Maruca* in captivity, but it now looks as if they can be overcome. The screening of the germplasm collection for further sources of resistance is currently underway.

There are four different pod sucking bugs which, by sucking the sap from green pods, cause them to shrivel and dry prematurely with loss of seed. Some resistant lines have been identified, and over the next four to five years the entire collection of cowpea germplasm will be systematically examined in the laboratory for resistance to pod sucking bugs. Promising lines will then be tested in the screen-house, and after further selection, field testing of the best strains will be carried out over several years. At the same time, the ecology of the bugs will be examined in the northern savanna. The secondary hosts will be identified and their migration pattern will be ascertained.

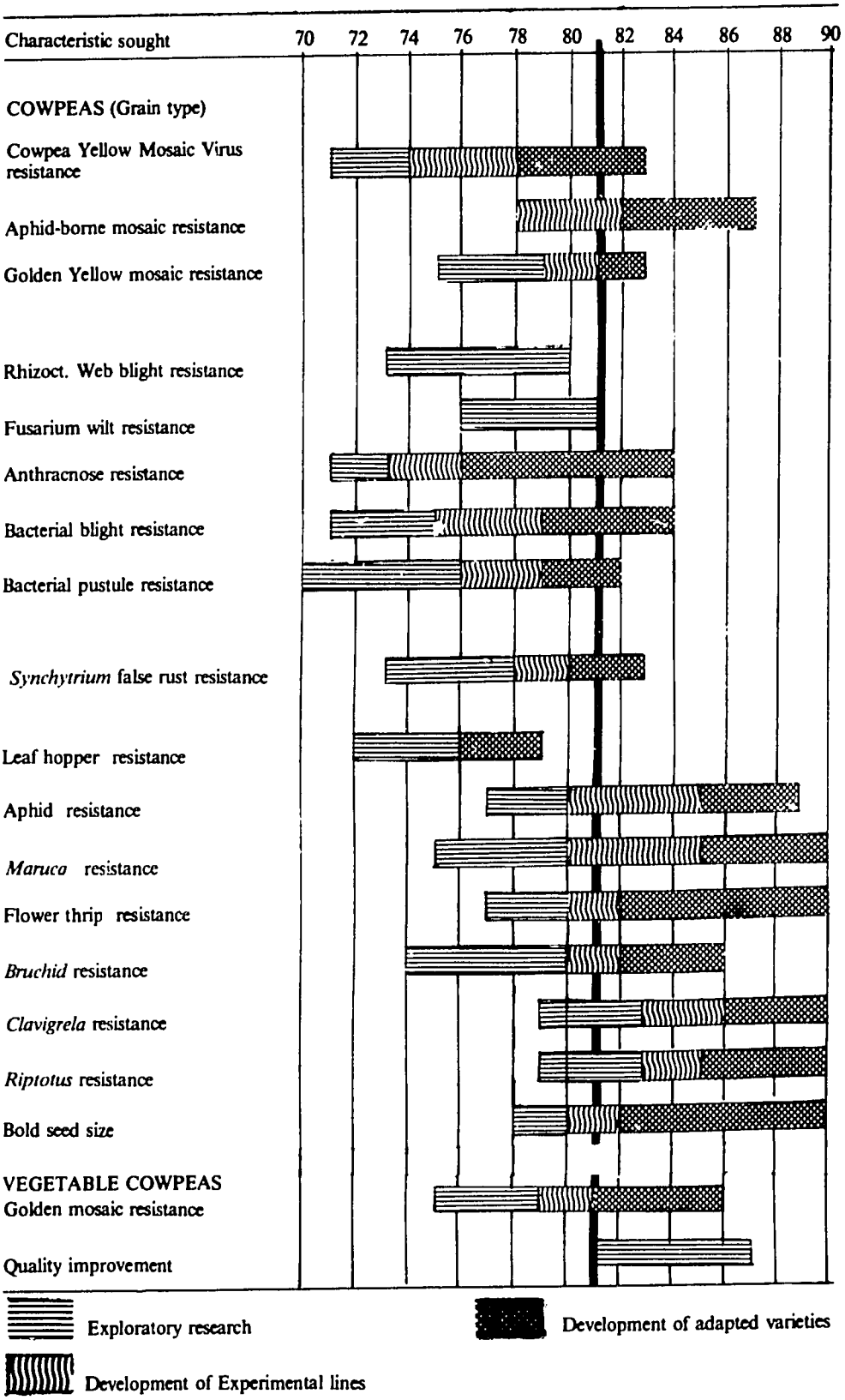
Among all cowpea pests, one of the most economically important is the cowpea storage *bruchid*, which lays its eggs on the surface of the seed while the crop is still in the field. After hatching, the larvae burrow inside the seed to complete their development, and emerge as mature adults. When infested seed is put in storage, the process continues and 30% losses of stored cowpeas are common. A source of resistance in the seed has been identified by IITA, and it has been shown that the mechanism consists of an abnormally high level of trypsin inhibitor. In another case, the pod appears to offer resistance to bruchid attacks although the mechanism is still uncertain. The germplasm collection will be screened for further sources of resistance, and pod and seed resistance will be combined by breeding and further selection.

The work on pest resistance described above must in all cases be combined with the search for acceptability to consumers. In practice, this means that resistance must be combined with at least two basic seed types, the large, white cowpea with rough testa generally preferred in Africa, and the smooth, colored seed preferred in other regions.

IITA also plans to do more work on resistance to the cowpea severe mosaic virus, which is widespread in tropical and sub-tropical America. Research is planned on the problem of seed transmission of legume viruses.

IITA's past and planned work on cowpea resistance to diseases and pests is portrayed schematically in Figure 2.

Fig. 2 Past progress and long-range plans of the Grain Legume Improvement Program 1970-1990



An integral part of the program is a system of multilocational breeding and international testing. Since 1977, selection and testing of early and advanced breeding lines have been carried out at selected sites representative of the major ecological zones of the region. More than 90 elite lines have been developed in this way, the best being designated as VITA lines. These elite lines have been sent in international trials and nurseries to locations in 80 countries. While the majority of locations were in Africa and Latin America and the Caribbean, trials have also been made in Asia, Europe and North America. In the course of this activity a network of co-operators has been formed. Collaborative research on cowpeas is underway in Upper Volta, Niger, Mali,Sierra Leone and Tanzania through special projects, and in Brazil through the out-posting of an IITA cowpea breeder. A survey has been made of the actual and potential production areas in Central America and the Caribbean. This work will be carried forward in the eighties.

A special word may be said about the Semi-Arid Food Grain Research and Development Project (SAFGRAD). The project was set up in 1977 under the auspices of the Organization of African Unity's Scientific,Technical and Research Commission, and with financial support from the United States Agency for International Development. The project covers 25 member states of the OAU and has, as its main objective, the attainment of self-sufficiency in food in semi-arid Africa. SAFGRAD headquarters are at Ouagadougou in Upper Volta. While the international center most directly involved is ICRISAT, IITA is participating in research and training on both cowpeas and maize. With SAFGRAD funding, supplemented by the International Development Research Centre (IDRC), IITA has out-posted five scientists to Upper Volta, a cowpea breeder and agronomist, a maize breeder and agronomist, and an entomologist to work on both crops. The project has proved an excellent channel for co-operation with African countries with which IITA otherwise has limited contacts, since they lie outside the humid and sub-humid areas.

The major objectives for research on cowpeas in the coming years are the following:

By 1985, IITA should have developed lines of cowpea that show separate resistance to thrips, maruca *and* bruchid *and that are suited to the consumer requirements and ecological conditions encountered in the world's main cowpea-growing regions. By 1990, the lines developed up to 1985 should be still further improved by combining these separate resistances and incorporating the already available high levels of resistance to other diseases and pests of major economic significance.*

Soybeans

Recent years have seen considerable growth in interest in soybeans in Africa. At world level, output has more than doubled in the seventies, the most important factor in this development being the value of soybeans, containing 40% protein, for processing into livestock feed. However, it needs to be recalled that in Asia, where

soybeans originated, both protein and oil go mainly for direct human consumption.

Soybeans have not so far been produced in Africa on a significant scale. In 1979, the total grown by developing countries south of the Sahara was just under 100,000 tons. Nevertheless an FAO study suggests that, in agro-ecological terms, about 145 million hectares are suitable or very suitable for growing soya under low-input farming; under high-input systems the figure is almost 270 million hectares. The area largely overlaps that which is adapted to maize. The African farmer has demonstrated many times over his readiness to accept new crops if an economic opportunity exists. Soybeans can be expected to find a ready market in connection with the poultry industry, and may to some extent be incorporated directly in traditional diets, as has already happened on a small scale in some areas. The attractions of the crop lie in its high nutritional value, the possibility of obtaining very good yields if conditions are right, and its suitability for industrial processing.

There are two major difficulties, apart from unfamiliarity, that have so far prevented the widespread adoption of soybeans in African conditions, and in other tropical areas also. Soybeans like other legumes depend for their growth on the fixation of atmospheric nitrogen by rhizobia in the soil if expensive nitrogen fertilizers are not be used. The high-yielding varieties of soybean now available are not adapted to the rhizobia found in African soils, and require inoculation of the seed with imported cultures of rhizobia. A basic research objective is thus to identify cultivars which nodulate effectively with indigenous African rhizobia.

The second problem arises out of the difficulties in storing soya seed. The identification or development of varieties which combine good seed storability with adaptability to African rhizobia, and which give satisfactory yields, would open the way to the spread of soybeans as a practical crop for small farmers and large enterprises alike.

IITA adapts soybeans to tropics

IITA is the only organization working on the adaptation of soybeans to the tropical environment. Research was started in 1972, and was focused initially on identifying varieties with superior yield potential in the humid tropics. This early work not only confirmed the existence of a high production potential, but also identified the two constraints mentioned above. In 1976-77 soybean germplasm was screened for superior seed storability and for the ability to nodulate with rhizobia indigenous to Africa. A major breeding thrust for the development of these two characteristics began in 1978. This effort is in its early stages but the first results can be considered promising. Several breeding lines with improved storability and the ability to use African rhizobia have been identified, but further testing is required. Trials are being carried out at six locations in Nigeria, each typical of a different ecology. They range from the Onne sub-station in the humid zone up to the semi-arid area.

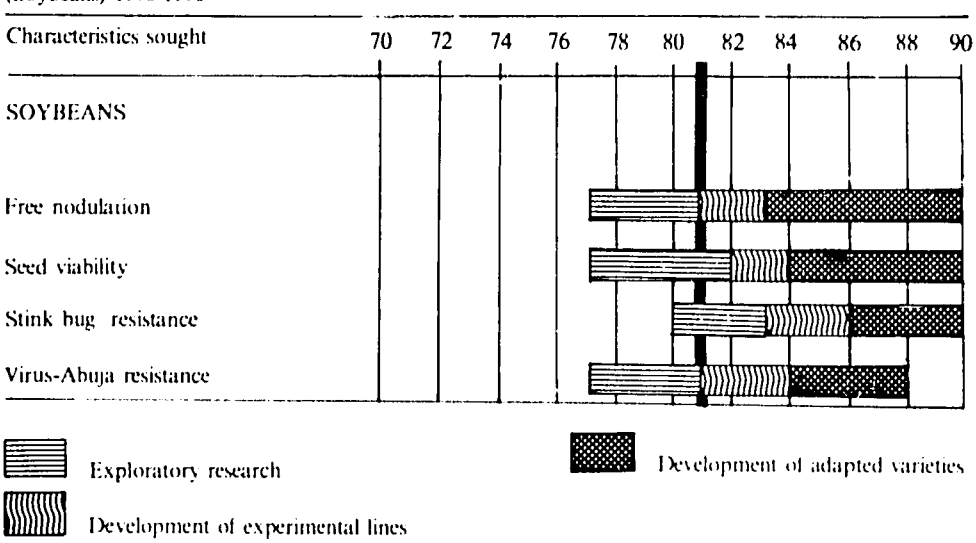
The main priority will continue to be the development of varieties suitable for

the widest possible range of environments which possess good seed viability, enabling the seed to be stored from harvest to the next planting season without serious risk of loss in planting quality, and which produce good yields without having to be treated with a rhizobial inoculant. At the same time research will be continued on resistance to field weathering, which causes deterioration of seed before the harvest. Seed of good storability will be evaluated for tolerance to the high soil temperatures, sometimes exceeding 40°C, which may be experienced during the germination phase. Variations in tolerance of acid soils will be examined. And advanced breeding lines will be evaluated for their resistance to pod shattering, a serious risk in dry environments.

By 1985 it is reasonable to hope for substantial progress toward all these objectives. There will, however, undoubtedly remain many obstacles to achieving potential yields in practice. First and foremost among these is the risk from pests. IITA trials at one location have shown, for instance, the amount of damage that can be done by stinkbugs. Studies to determine the prevalence of these insects in West Africa are being initiated. Insect control by trap-cropping is also under investigation. Breeding for insect and possibly disease resistance is likely to become the major concern during the second half of the decade.

Figure 3 shows the timing of past and planned research on soybeans.

Fig. 3. Past progress and long-range plans for the Grain Legume Improvement Program (Soybeans) 1970-1990



The major objective for work on soybeans is defined as follows:

By 1985, IITA should have developed soybean lines which nodulate effectively with African indigenous rhizobia, which possess a satisfactory level of seed storability, and which can be grown in a range of different ecological conditions.

Considering the early stage of research on this crop, it does not yet appear practicable to set a specific objective for 1990.

VII. Development of the cereal improvement program

The IITA research program has, since its earliest days, included work on maize and rice. Both these crops are of fundamental importance in the African economy, and both still have an immense potential, in terms of yield improvement as well as expansion of the area cultivated.

At global level research on maize is the responsibility of the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), and research on rice is the responsibility of the International Rice Research Institute (IRRI).

Inter-institutional cooperation

It may be helpful to think of maize and rice research in Africa as a continuous process, underway on four levels. The basic work is contributed by the global institutes, CIMMYT and IRRI, through their programs for germplasm conservation and improvement. Working with breeding materials both from the global centers and from African sources, IITA researchers seek solutions to specifically African problems such as maize streak and stem borers and the African forms of rice blast and yellow mottle virus. Both CIMMYT and IRRI have out-posted scientists to IITA to assist in this process. At this second level, corresponding to Africa-specific research, the Institut de Recherches Agronomiques Tropicales (IRAT), which has a substantial program in francophone countries, will also associate itself with IITA in working on rice, and will out-post a scientist to IITA shortly. The third level in the research process consists in organized, multilocational testing. While some of this work is done by IITA directly, maximum benefit is derived from two regional arrangements. The SAFGRAD project has already been described in section VI above; it is the main vehicle for multilocational maize testing in the semi-arid areas. In the case of rice, the West Africa Rice Development Association (WARDA), a 15-member intergovernmental body which receives part of its budget support from the CGIAR, organizes trials throughout its area. To facilitate day-to-day co-operation, IITA has out-posted a scientist to WARDA. Finally, the fourth level in the research process is that of national programs, through which improved breeding materials ultimately reach farmers' fields. There is, of course, ample feed-back between the various levels, and although the arrangements may at first sight appear complex, in practice they work well. The network of out-posted scientists, carrying out both research and liaison functions, is particularly effective in ensuring that all resources - financial, human and genetic - are employed as effectively as possible within the framework of a rational division of labor.

Before outlining the research program for the eighties it may be useful to draw attention to a major development in the pattern of consumption of cereals in Africa. Increasingly, national food deficits are being made up by imports of wheat.

In 1979, wheat imports by sub-Saharan Africa came to over three million tons, accounting for almost 60% of all cereal imports. The result is that urban populations are acquiring a taste for a food that most African countries in the humid and sub-humid zones can produce either not at all or only in very small quantities. There is no evidence to suggest that wheat could be adapted to the temperature regimes found in these areas. As mentioned in connection with the FAO "Regional Food Plan for Africa" in section I, the policy approach must therefore be to seek substitutes for bread. The possibility of using a cassava-based product was mentioned in section V above. To some extent rice may also be accepted as a substitute. At the present stage it seems likely that a series of solutions will be found, varying from area to area. The problem is mentioned here because, as solutions are worked out, they can be expected to affect the demand for alternative staple foods, thus in turn influencing government priorities and, to some extent, the pattern of agricultural development. Because of its importance, this is a matter that will have to be followed closely in the eighties.

Maize

In terms of area harvested, maize is one of the leading crops cultivated in Africa south of the Sahara. Yields, however, are very low at around one ton per hectare, and so far have shown no signs of rising. Production in the seventies grew slowly and imports of maize by sub-Saharan Africa amounted in 1979 to about 650,000 tons.

While maize is widely used for human consumption, it is also in increasing demand as poultry feed. Even countries which are not traditional maize eaters are becoming interested in growing it, so as to avoid reliance on imported supplies for their poultry industry. There is also much interest in basing large production schemes on maize. In such projects maize is easier to cultivate than rice, since it does not require accurate water control and lends itself better to mechanization. Furthermore, modern management techniques can achieve enormous increase in yield: the 1979 average for the United States was about seven times higher than that in sub-Saharan Africa.

Hybrid maize still some years off

Top yields depend in large part on the use of hybrid maize. Hybrid seed, which has to be bought afresh each year, will be available to farmers only where there is a well organized seed industry. In most African countries, the industry is still at the fledgling stage, and the development of hybrid maize is still some way off in the future. The IITA maize program is therefore devoted mainly to population improvement, aiming particularly at resistance to diseases and pests. In addtion, a relatively modest complementary effort is underway on the development of top-cross hybrids, a transitional technology which can be handled by a young seed industry and which is likely to be of main interest (at least initially) to larger-scale commercial farms.

TZB and TZPB

In the mid-seventies, IITA developed the TZB and TZPB populations resistant to tropical maize rust and maize blight. In recent years, attention has been directed toward maize streak virus, an endemic disease transmitted by *Cicadulina* leahopper species and found mainly in Africa. The Institute has developed two improved populations of white and yellow maize respectively which combine a good level of resistance to streak with satisfactory agronomic characteristics. They were tested at five locations in Nigeria during 1980, and in 1981 will go out for international trials in various countries including Benin, Cameroon, Ghana, Ivory Coast, Nigeria and Upper Volta. Through IITA/CIMMYT joint action, CIMMYT populations and selected varieties from national programs will be converted to streak resistance by back-crossing. Progress so far has been limited to maizes of medium maturity grown in the humid and sub-humid tropics. Further work will be needed on early maturing types, and on maize for mid-altitudes and semi-arid areas.

Some maize diseases and pests

Another virus disease, known as maize mottle/chlorotic stunt, has been found to be transmitted by the same *Cicadulina* leafhopper species. The screening methods used in the search for streak resistance have also covered resistance to this disease, and the Institute's improved populations of white and yellow maize show good levels of combined resistance to maize mottle/chlorotic stunt as well as to streak. Two other virus diseases of worldwide distribution, maize stripe virus transmitted by the planthopper *Peregrinus maidis,* and maize dwarf mosaic virus transmitted by aphids, have been reported in parts of Africa, and may become a research priority at a later date.

Downy mildew is a major problem in Asia, and has now appeared in pockets in some countries in Africa. It has been reported from Nigeria and Zaire, and must be considered a serious potential danger for the continent. IITA will aim at developing populations with combined resistance to downy mildew and streak suitable for the ecosystems in which the disease has appeared.

Among African maize pests, those which do the most damage in economic terms are the three major stem borers. They lay their eggs on the maize plant, and a large part of the damage is caused by the larvae after they have hatched. *Eldana* begins to infest maize at the flowering stage and causes damage mainly on the stalk (60%), and the ears (40%), while *Sesamia* and *Busseola* attack the young seedlings, often causing a dead heart in susceptible plants. *Sesamia* is found particularly in humid areas. IITA will step up its search for genetic resistance when the insect-rearing facility now under construction is available, and artificial infestation becomes feasible. Priority will be given to work on *Sesamia* and *Eldana.* It is not certain that genetic resistance can be obtained, and this is a long-term undertaking, which is likely to continue throughout the decade.

As soon as resources permit, work will be intensified on ear rot and stalk rot. Some of the pathogens are still unknown and will need to be identified in the next stage of the work. Research techniques will have to be worked out.

In the course of the eighties, genetic improvement will continue to be focused on the requirements of different ecologies and farming systems, particularly for inter-cropping. In the semi-arid areas, where IITA is engaged in co-operative research under the SAFGRAD project, early maturity is the primary objective. Maize sown at the beginning of the season and harvested early faces a reduced risk of drought and is available for consumption while sorghum is maturing. The Institute has not yet carried out research at mid-altitude, which is particularly important for East Africa. It is hoped that arrangements for this work can be made initially in Cameroon, where IITA is about to embark on a major co-operative program in cereals, possibly leading to a joint IITA/Cameroon sub-station.

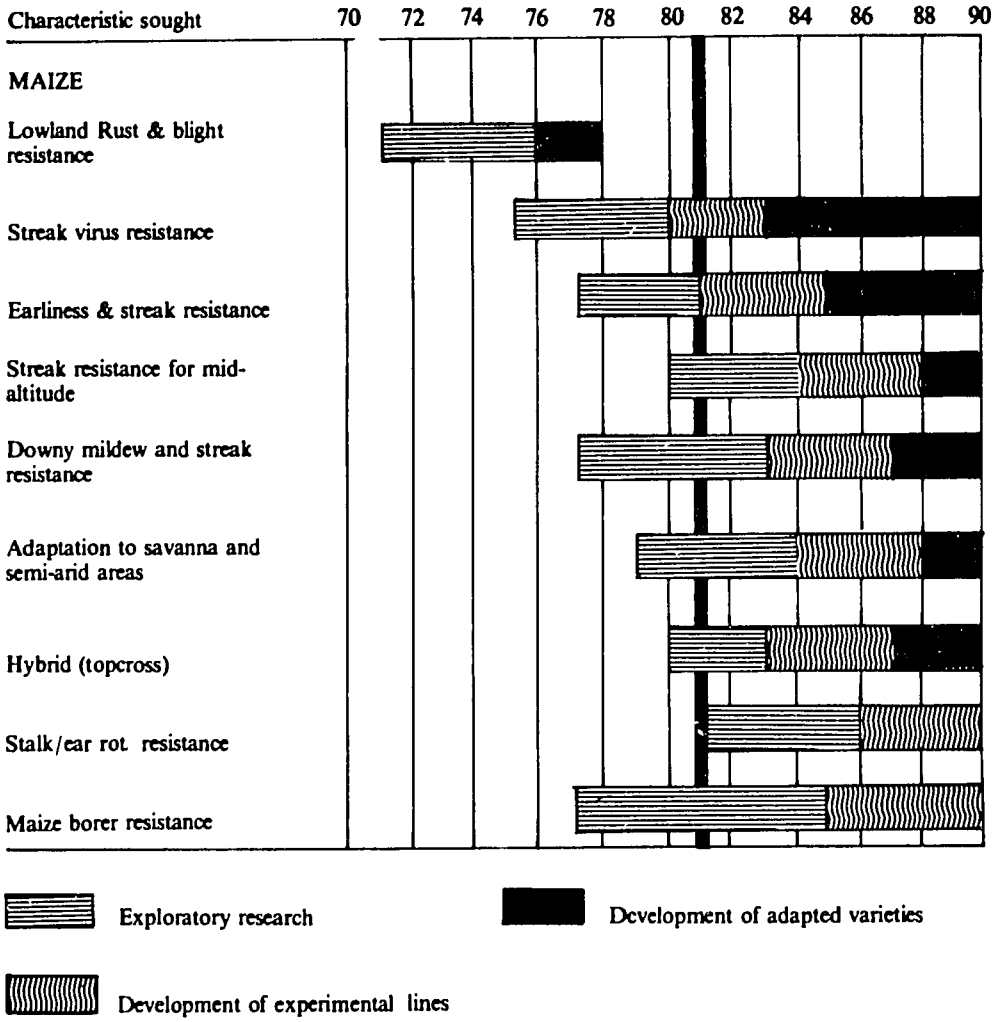
The overall objectives adopted for maize population improvement are: *By 1985, streak-resistant varieties of white and yellow maize, both early-maturing and medium-maturity and with good yield potential, should be available for the major maize-growing ecosystems in Africa. By 1990, IITA should have maize populations with a reasonable level of resistance to the principal diseases and pests, including ear rot and stalk rot, encountered in the major maize-growing ecosystems in Africa.*

In parallel with the work on population improvement, IITA will develop hybrid maize for use on relatively large-scale commercial farms. The high degree of interest in this type of production is attested by the numerous enquiries being received by the Institute. As alreay mentioned, a well developed seed industry is necessary for the provision of hybrid seed from double or single crosses. An intermediate solution in such circumstances is the use of top crosses (the crossing of a single inbred line with a variety). The yield benefit is less, but seed production is far simpler. For this purpose, IITA will develop a series of lines which can be made available to countries for crossing with local varieties. Evidently the lines must possess good characteristics such as yield potential, disease resistance and combining ability. In view of the wide range of ecological conditions found in Africa a large number of lines will be needed, allowing national research stations or seed industries to select those which best suit their requirements. Once the initial series of lines has been built up, continuous work will be needed to improve their characteristics. The objectives adopted for research on top-crosses are the following:

By 1985, IITA should have an initial series of lines suitable for use in top crosses at national level. By 1990, the series should be improved and extended so as to offer maximum levels of yield and disease resistance in the major ecosystems where commercial maize production is being undertaken.

IITA research on maize is portrayed in Figure 4.

Fig. 4 Past progress and long-range plans of the Cereal Improvement Program (Maize) 1970-1990



Rice

Of the 20 identified species of the genus *Oryza*, six are of African origin. *Oryza glaberrima* is believed to have been domesticated at least 3,000 years ago, and is still in production in a few areas of Africa today. IITA's Genetic Resources Unit has registered some 1,500 accessions of it. Gradually, however, *Oryza glaberrima* is being displaced by *Oryza sativa*, the basic Asian rice, which produces better yields.

The area under rice in Africa as a whole is still relatively limited. At less than five million hectares, it is about a third of that under sorghum, about 30% of the millet area, and less than a quarter of that under maize. Nevertheless demand for rice has been growing strongly. In large part this reflects a dietary shift connected with urbanization. Production during the seventies expanded more slowly than demand, although it kept pace with population growth. Four-fifth of the increase came from an extension of the area harvested, and only one-fifth from improved yields. At around 1.4 tons of paddy per hectare, yields are substantially below those of the other developing regions. This reflects in part the fact that much rice in Africa is grown in upland conditions, exposed to drought and disease stresses and cultivated at low levels of management.

Yield increases in Asia over the last 15 years have been brought about in large part through the introduction of improved varieties based on the concept of the semi-dwarf plant type developed at the International Rice Research Institute (IRRI). Such varieties have been introduced to Africa, and are doing well in some countries, especially under irrigation. They are, however, susceptible to African pests and diseases, particularly in upland and without adaptation are suited to only a few of the areas of cultivation.

A distinctive feature of rice production in Africa is that, whereas most of the crop is grown in upland conditions (almost two-thirds of the rice area in West Africa is upland, according to WARDA studies), yet the long-term potential for rice development is rather in lowland areas. The predictable evolution is from marginal and unstable upland cultivation toward lowland and paddy rice. Upland rice may increasingly be replaced by other crops.

The effective development of rice production in Africa will need widespread improvement of agronomic practices and substantial investment in water control. It will also require a range of improved varieties adapted to the many ecosystems in which rice is grown, including hydromorphic valley bottoms, shallow swamps, irrigated lowlands, mangrove swamps, deepwater and floating rice.

A brief description was given above of the arrangements for liaison and co-operation between the international organizations working on rice in Africa. It is important that all organizations be enabled to step up their activities in view of the rising importance of rice in the African food economy. It is logical to expect the trend of consumer preference in much of Africa to continue moving away from other crops toward rice. The advantage of rice derives from two factors: it is easier to prepare than root and tuber crops (particularly important for an increasingly mobile population); and it is easier to store than maize. Furthermore rice can be cultivated intensively and continuously under tropical conditions. As shown above in section I, the FAO "Regional Food Plan for Africa" foresees more rapid growth in the area under rice than in that under any other major crop.

In 1980 TAC conducted a review of the distribution of functions among the international organizations with regard particularly to upland rice. The question was also discussed by the IITA Board of Trustees. As a result, a modified pattern of

activities will emerge in the eighties. IITA's main priority in West Africa will be hydromorphic rice, and in second place shallow swamp rice. Work devoted to upland rice in West Africa will be progressively reduced. Other organizations are in a position to cary on this work. At the same time, the Institute will increasingly concern itself with the problems of rice in all ecologies in East and Central Africa. These two sub-regions together produce a quantity of rice of the same order of magnitude as West Africa. Production is, however, unevenly divided, with Madagascar accounting for about three-quarters of the total. Other major producers are Tanzania and Zaire with around 200,000 tons each, while quantities between 10,000 and 20,000 tons annually are produced by Angola, Cameroon, Central African Republic, Chad, Kenya, Malawi, Mozambique and Uganda.

Hydromorphic rice

Hydromorphic rice, which will become IITA's major priority, is grown in valley bottoms where the water table during the rain season occasionally rises above ground level. In hydromorphic valleys, the water is supplemented through interflow in addition to rainfall. This has the advantage that rice is less likely to be exposed to drought stress if the rains are interrupted by a dry spell. Furthermore, valley bottoms tend to be more fertile than uplands, since they contain large amounts of top soil along with nutrients washed from the hillsides by erosion. What is lost to the hills becomes a gain to the valley. Traditional agriculture has nevertheless tended to by-pass the valleys, among other reasons because of health hazards.

Thus hydromorphic rice is at present grown on only some 58,000 hectares in West Africa, accounting for 2.5% of the total rice area. Detailed information on the potential area of cultivation is lacking, but it is believed to amount to perhaps two million hectares. Rice is the only staple food which can be grown under the conditions normally encountered in such areas, which can clearly make highly significant contribution toward an improved growth rate of rice production. Indeed hydromorphic cultivation is to be seen as an important transitional phase in the development of highly productive systems with a greater or lesser degree of water control.

The key problems for the development of hydromorphic soils are land development and management, and water control. As already mentioned, this will become a priority area of work for the Farming Systems Program, in cooperation with the Cereal Improvement Program. If IITA can make available a recommended package including methods of clearance and land management, appropriate varieties and effective agronomic practices, it should become easier for governments to consider launching a systematic program for the development of hydromorphic rice production. Such a program might be undertaken with the support of FAO, the World Bank and other development agencies.

Lowland rice

The Institute's second priority will be lowland (swamp) rice. Nutritional im-

balances, especially iron toxicity, are a problem that frequently occurs in ill-drained swamps. Improved drainage and suitable management techniques can reduce the problem considerably, but in many circumstances the cheapest and most practical solution is the use of tolerant varieties. One such variety has been developed and released through IITA's co-operative project in Liberia, and IITA will aim at carrying the work forward by breeding resistance to iron toxicity into the varieties it may recommend for swamp areas.

IITA's research on resistance to Rice Yellow Mottle Virus (RYMV) may be particularly useful for swamp rice. RYMV was first reported in East Africa, and subsequently in some West African countries. It has never been reported outside the continent. There is therefore a need for conducting research on this virus in Africa in order to avoid the possibility of an epidemic. The preliminary research of IITA suggests that it should be possible to breed genetic resistance into susceptible cultivars.

Upland rice

While IITA's work on upland rice will, as already mentioned, gradually be reduced in scope, there is a substantial research program already underway. This will be brought to completion and will benefit the concentrated effort on the problem that is being made at Bouake (Ivory Coast) by WARDA and IRAT. Directed toward resistance to stresses that are most acute under upland conditions (blast disease and drought), the work will also have applications in other eco-systems.

A distinction needs to be drawn between upland areas where there is a risk of drought stress, and "safe" upland areas. For the former, the main objective will be drought tolerance, already being sought through the development of a thicker and deeper root system. For "safe" areas, the emphasis will be on the search for an improved plant type such as the semi-dwarfs which have done well in other ecologies. Disease resistance is also of particular importance for upland rice.

Rice diseases

The most important rice disease in Africa is blast. At the seedling and vegetative stages of plant growth the disease takes the form of leaf blast, while at the reproductive stage neck blast or panicle blast is likely to be encountered. While blast is prevalent in other regions, many varieties which are resistant in Asia are vulnerable in Africa. Within Africa there is again variability in the strains of the pathogen, and there is no stability in resistance even within the continent. Indeed variability is found over extremely short distances, and even at a single locality may vary with time during the growing season. The attainment of a satisfactory level of resistance in a commercial variety is thus a particularly difficult task. A number of

varieties have been developed by IITA, IRAT and national institutes that show la broad spectrum of resistance to the pathogen. IITA will continue the search in the eighties.

A major problem to be tackled by IITA is sheath blight, a disease which is especially severe in the humid zone. High levels of management, such as close planting and heavy fertilization, tend to increase its incidence. The severity of sheath blight has been increasing in recent years. So far no source with a high degree of resistance has been identified.

Leaf scald has been reported from most of the major rice producing countries in West Africa, and appears to be on the increase in the high rainfall zone. It is mainly prevalent in upland rice, but also in lowland, and sources of resistance will be sought by IITA.

In research on diseases such as sheath blight and leaf scald, the Institute will be co-operating closely with IRRI.

Panicle or grain discoloration is associated with several species of fungi, moisture stress and nutrient disorder. Its occurrence may be initiated by sucking bugs which apparently puncture the grain and allow the fungus to enter. It does not affect all varieties developed by IITA. The work on identifying the causes and mechanism is at a preliminary stage and will be stepped up.

Pests of rice

Reliable information on rice losses inflicted by insect pests in Africa is difficult to obtain, but four species of stem borer - the stripe borer, the pink borer, the white borer and the stalk-eyed fly - are known to be the most destructive of all. The army worm, leaf folder, rice bugs and case worm are pests of generally minor importance, but cause serious yield losses in isolated areas in certain years. Use of insect-resistant varieties wherever possible offers a simple and effective control method. For lepidopterous stem borers only intermediate levels of resistance have been achieved at IRRI and elsewhere, but when combined as necessary with the use of insecticides they have proved to be effective and economically viable in coping with high epidemic conditions. Work at IITA on the stripe borer and stalk-eyed fly is at a preliminary stage and will be stepped up. Studies will be initiated on yield losses, as well as on the biology and ecology of the most important insects, together with tests of the efficacy of commercial insecticides.

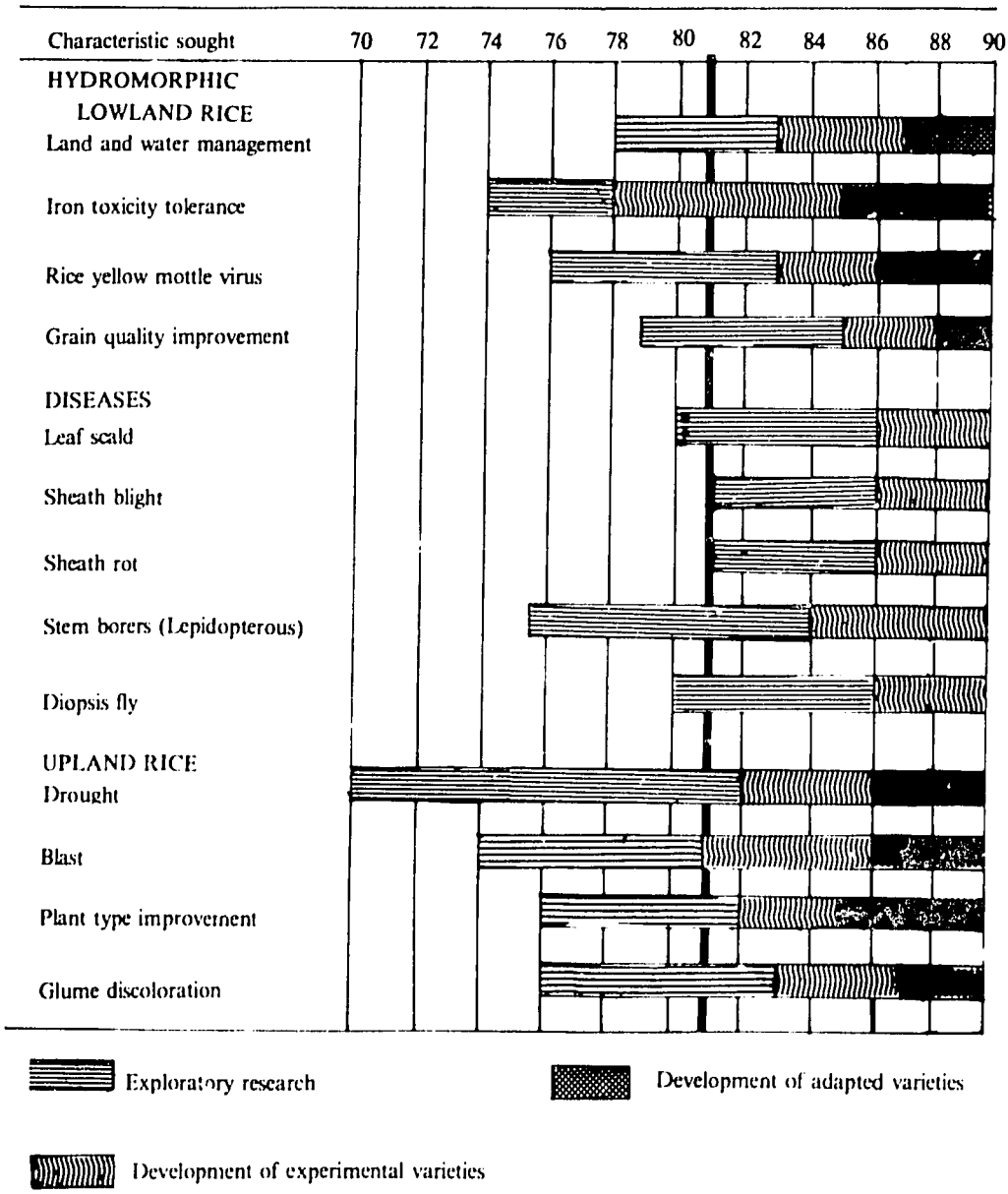
There are also important issues of consumer preference. Urban populations of Africa are used to consuming parboiled long grain rice imported from other regions. Import substitution will depend in part on the development of translucent long grain types adapted to African conditions, and these are being sought by IITA in its genetic improvement program.

In the course of the decade the Institute will strengthen its links with East and Central Africa, and may have to modify its priorities to accommodate the needs of

those sub-regions. There are some indications, for instance, that breeding for cold tolerance could be important in East Africa, and might be of interest in parts of West Africa also. If so, such work can be undertaken in collaboration with IRRI.

The main directions of IITA's rice research are shown in Figure 5.

Fig. 5 Past progress and long-range plans of the Cereal Improvement Program (Rice) 1970-1990



The major objectives of the rice program are defined as follows: *By 1985, IITA should have achieved:* (a) *for hydromorphic areas, improved varieties offering reasonably high yields even at a low level of management, and performing well under conditions of fluctuating water table; (b) for shallow swamp areas, improved varieties with tolerance of iron toxicity and resistance to specific African pests and diseases; (c) for upland areas exposed to drought risk, varieties showing an improved level of drought and blast resistance; (d) for "safe" upland areas, varieties with an improved plant type and resistance to diseases.*

In view of the substantial program shifts which will occur in the course of the decade, it is felt premature to set an objective for 1990. Rather, it is suggested that the program be reviewed, and a fresh set of priorities established around the mid-point of the decade.

VIII. Development of the farming systems program

The Farming Systems Program is a multi-disciplinary research effort, aimed at developing a series of technological innovations which will permit the maintenance of high levels of food production in the humid and sub-humid tropics with minimum loss of soil productivity. While research is directed mainly toward the bush fallow system, some of the technology being developed is sufficiently flexible to be utilized in various scales of production, and certain techniques of land management are suited mainly for large-scale enterprises that in many areas are complementary to small holdings. The emphasis is placed on minimizing the need for energy and other costly inputs.

The program is largely devoted to building up a better knowledge of the natural resource base, and to the development of improved components of farming systems. Work is concentrated on key components where improvements are likely to be attractive to farmers and to have a significant effect on overall efficiency and output. It is not considered practical to expect farmers to adopt complex technological solutions which would require a complete change in their farming system.

The Farming Systems Program provides support to the crop improvement programs in such areas as agricultural economics and agronomy. The interaction between programs will be intensified in coming years. Two examples have already been given in connection with the improvement of roots and tubers. The crop improvement program will try to develop an early-maturing cassava in order to provide greater flexibility to cropping systems, while the Farming Systems Program will complement research on the genetic improvement of yams by developing improved agronomic practices, and investigating the possibilities of mechanization.

The early years of the Farming Systems Program were devoted in part to collecting data on actual farm situations, and to identifying problems which could be tackled by IITA. This was followed by an extended period of on-station experimentation, which is still underway. This, as mentioned earlier, is the type of research frequently described as "upstream". In the coming years, the work will again move back toward farmers' fields.

Multilocational testing

What is needed in the next stage is a technique equivalent to multilocational testing as practiced under crop improvement programs. The approach which is being adopted is the establishment, in cooperation with national programs, governments and other international organizations, of a Cropping Systems Network. The network will include experimental areas carefully selected so as to be typical of the main farming situations found in West Africa, with a possibility of

extension to other parts of the continent at a later stage. The choice of sites or "benchmark areas" will take into account not only soils and climatic factors but also socio-economic considerations, such as crop preferences. It is envisaged that IITA and other organizations active in this field would have an opportunity of moving into "downstream" work through such an arrangement. It must be emphasized that research would take place entirely on farmers' fields, with technological innovations devised outside the country being tested by farmers with the guidance of government extension service, or such other office as might be designated. A detailed proposal for such a cropping systems network is being prepared, and will be available later this year.

"Downstream" work

"Downstream" work of this type has the additional advantage of supplying feedback information to IITA and thus of providing elements for a re-orientation of the research program if necessary. In a broader and more systematic way than in the past, IITA's agricultural economists will also monitor the trends of change in farming systems in IITA's areas of interest. Two factors which seem capable of producing fundamental changes are the very rapid increase in the average age of the active farm population as young people move away to the cities, and the growth of off-farm work among family members who stay at home. These two trends taken together emphasize yet again the importance of the labor component of small-scale farming. The traditional mixed cropping systems are highly labor-intensive, and do not at present lend themselves easily to mechanization. The extent to which they can survive is likely to depend over the next decades on the willingness of the young to carry on traditional systems of agriculture. This is an issue of such key importance that it will need to be carefully followed.

"Upstream" program

The "upstream" program at IITA will continue the work of the seventies, with greater concentration on a smaller number of activities. It will be structured in three sub-programs: land clearance and development; post clearance land management and cropping systems.

Land clearance and development

Under the land clearance and development sub-program a considerable body of scientific knowledge has been built up over the last 10 years. The subjects treated include a pre-clearance characterization of soil and land quality, and a comparison of the effect of different techniques of land clearance on soils and hydrology.

For clearing land with the least possible ecological damage, no method surpasses the traditional slash-and-burn. However, manual methods are obviously impractical for large-scale clearance. Land clearance studies conducted at IITA have demonstrated the erosive effect, and the related disruption of the hydrological balance, resulting from the mechanized techniques now being most widely used, which involve up-rooting trees. On highly erodible Alfisols, use of a shear

blade to cut trees and bushes at ground level reduces erosion losses to a minimum and by lowering the run-off of rain water it also increases the moisture available for crop growth. Since the stumps and roots are left in the ground, this technique cannot be combined with conventional methods of mechanized cultivation, but calls rather for the use of minimum tillage practices. It is necessary to identify the land forms and soil types to be cleared, and the cropping systems to be adopted, before clearance starts. The choice of clearance technique is to be regarded as one aspect of overall land management policy.

In the eighties, more emphasis will be given by IITA to the development of hydromorphic valley bottoms, uplands in the high-rainfall area, and the sub-humid zone (derived savanna and southern Guinea savanna). The particular interest in hydromorphic areas results from their largely untapped potential for rice production, analyzed in more detail above in connection with the Cereal Improvement Program. Their development poses special problems because of the lack of available technologies for water control at the farmers' level.

The objective of the land clearance and development sub-program is as follows: *By 1985, IITA should identify practical and economical techniques for clearing and developing land with minimum ecological damage in the humid and sub-humid tropics, including hydromorphic valley bottoms.*

This sub-program will be particularly important in view of the possibility that 20 million hectares may be cleared annually in Africa as a whole, as mentioned in section I above. The findings are expected to be relevant not only in Africa but also in other tropical regions, and appropriate contacts will be developed when IITA has a series of packages to recommend.

No specific target is set for this sub-program for 1990, but it is hoped that by that date quantitative models can be developed to predict changes in soil properties, in runoff and erosion, and in hydrology, resulting from different methods of land clearance and developement. This will provide guidelines for the selection of practical and economic techniques that cause minium ecological damage.

Post-clearance land management

The sub-program devoted to post-clearance land management will seek improved techniques for minimizing erosion, and maintaining soil productivity for sustained crop production. The long-term objective remains the development of technologies permitting continuous cropping in the humid and sub-humid tropics. The sub-program will pursue the three main approaches already adopted in the seventies: minimum tillage; managed fallows; and live mulch.

The merits of minimum tillage techniques have long been widely recognized, and are particularly important in the humid and sub-humid tropics. Working on Alfisols, IITA has developed a minimum-till package for maize grown in the

transitional forest zone. It involves the substitution of herbicides for plowing and mechanical weed control, while crop residues provide mulch to protect the soil from the erosive impact of tropical rainstorms, to promote high infiltration rates, to keep down soil temperatures, and to maintain acceptable levels of soil organic matter. Appropriate equipment is being developed and tested for seeding through the mulch. Adequate mineral fertilization is required, and the use of effective herbicides is essential. On the IITA station, yields have been impressive for 4-5 years but have dropped substantially later. This is attributed partly to the effect of soil compaction caused by the use of agricultural machinery for harvesting and mowing and possibly also to soil acidification. Further experimentation is required to determine the factors involved. In the coming years, the work will be shifted off-site, and using the experience acquired at IITA, techniques will be sought for minimum tillage in the different environments of the humid zone and the northern sub-humid areas. The work will also be extended from maize to other crops.

Another approach to the problems of post-clearance land management consists in the use of managed fallow. Small farmers have long planted shrubs or trees to improve on the natural fallow vegetation. IITA is attempting to exploit this technique scientifically, by identifying the tree or shrub varieties which perform best in both agronomic and economic terms. *Leucaena* has proved to have considerable merits for soil re-building; its economic value can be greatly enhanced by the use of the stem as *in situ* stakes for yam production in rotation with maize, and it can also provide firewood. Much experimental work has already been carried out on alley cropping, or the establishment of permanent rows of fallow shrub. *Leucaena* is well suited to this technique; the tops are cut after the dry season, the stems are cleaned for use as stakes or firewood, and the lighter material is spread on the field as mulch. During the growing season the shrub can be pruned back several times. A *Leucaena*-maize-yam alley cropping system is currently undergoing preliminary farm trials in various parts of Nigeria. Based on feed-back from farm level it is hoped to have the technique ready by 1983, and the emphasis will then be on its popularization at national level. At the same time research will continue on the comparative value of other fallow plants.

The use of live mulch is the third land management technique that is being investigated. A leguminous cover crop, through which the food crop is sown without tillage, serves three basic purposes. By protecting the soil during the rainy season, it minimizes erosion. It stifles weeds, and avoids the need for either herbicides or weeding operations. And by fixing nitrogen biologically it reduces the need for costly nitrogenous fertilizers. There is some evidence that it stabilizes organic matter in the soil, and may thus hold off a decline in yields. The machines at present used for zero-tillage maize production may need modification for live mulch, and experiments on this are currently underway. The most suitable cover crops for live mulch are perennial legumes, and once they are established in the field little management is required. The species that have so far shown most promise are climbing legumes, which need to be sprayed with a growth retardant each time the field is cropped. In the course of the next few years, research will be continued on agronomic practices for the establishment of the legume, the ecological boundaries

within which the various legumes can be grown, the range of food crops which can be rotated in a field with live mulch, and techniques for combining live mulch with zero tillage. Particular attention will be paid to the more humid areas, to screening legumes that will exhibit minimum competition for moisture with the crop, and to the search for suitable legumes that do not need chemical control of climbing.

The sub-program will give special attention to the management of hydromorphic soils. The main emphasis will be on water control. Rice production is the most important but by no means the only use to which such areas are put, and the Institute will take a comprehensive approach to the management of hydromorphic areas.

Mention has already been made of IITA's machines for sowing maize through mulch in connection with minimum tillage techniques. Agricultural engineering is a relatively small but significant part of the program. IITA will not be carrying out research on mechanization for its own sake, but as a component of specific new technologies. In traditional agriculture, labor bottlenecks at peak periods of work are a major constraint to increased production. The emphasis is not only on increasing productivity but also on lightening drudgery under traditional systems through the provision of improved tools or simple mechanical aids. This line of activity is in urgent need of strengthening. In the African context, appropriate types of mechanization result in increasing the farm area which can be managed rather than in displacing labor.

A new area of research is the rehabilitation of degraded soils. Under the pressure of intensified cultivation, soils are being exhausted and eroded more widely than ever before. The traditional use of fallow is an effective, though very slow, way of restoring fertility, but under shifting cultivation soils were not allowed to reach the stage of degradation now frequently encountered. There is a need for techniques that are both applicable to heavily degraded soils and relatively quick-acting. IITA will be pursuing the search for such techniques in coming years, starting with experimentation on Alfisols at Ibadan; the approaches to be explored will include managed fallow, organic recycling and chemical amendments.

The objectives for the post-clearance land management sub-program are as follows: *By 1985, IITA should have developed an interim series of recommended practices for land management, permitting a high intensity of production of staple food crops in a wide range of ecologies in the humid and sub-humid tropics, with minimum loss of soil quality. This is a stepping stone toward a more ambitious target for 1990: By 1990, IITA should have developed a series of technological packages opening the way for the evolution of an improved bush fallow system or other ecologically stable farming system which can give rising levels of production within the framework of traditional agriculture; and permitting the development of a modern high-input sector without loss of soil quality.*

Cropping systems

The cropping systems sub-program introduces the important "downstream"

element through the Cropping Systems Network described above. In its early days, the cropping systems work was largely devoted to an analysis of planting patterns in space and time. Traditional agriculture shows an enormous diversity of practices. Indeed it is possible to find more than 50 different crops grown on a single small farm, and the number of combinations is almost limitless. Farming in this style has certain advantages for the small-holder. By spreading the risk over several crops he reduces the likelihood of total failure. By a judicious choice of early and late, short-season and long-season crops he makes the most efficient use of available sunlight, moisture and nutrients, as well as having a choice of foods available through much of the year. The interaction between crops can have the effect in some cases of reducing insect attacks. The complexity of such a system is thus, from one point of view, a source of strength. On the other hand it creates a new set of problems when the objective is not stability, but the capacity to sustain a continuous growth of output per unit of area and per unit of labor.

Among the innumerable cropping combinations to be found in West Africa, IITA has concentrated on a small number based respectively on cassava, maize, rice and plantains. Research has been carried out at IITA on such questions as optimum planting intensity, and the sequencing of crops in various combinations including maize/cowpea, maize/cassava and cowpea/cassava. Improved agronomic practices have been sought. Simple tools and equipment have been designed to increase the farmer's output. The character of this work will change in the eighties, as new forms of relevant technology become available under the crop improvement programs and the other sub-programs of farming systems.

During the period ahead, the many outlets which the Cropping Systems Net work is expected to provide will become the chief testing ground of IITA technology from the socio-economic as distinct from the agronomic view-point. The technological packges to be made available will include new varieties developed under the crop programs, as well as improved components of farming systems. The cropping systems sub-program will thus have two somewhat different functions: it will generate new technology in certain areas such as agronomy; and it will provide a service to the overall IITA program by arranging for the packaging and testing at farm level of technology emerging from all research programs.

The major objective of the cropping systems sub-program is formulated as follows: *By 1985 IITA should have available a series of basic technological packages aimed at enabling traditional mixed cropping systems to achieve increasing production levels; such packages may include new varieties and improved agronomic practices, and they should be tested on farmers' fields at representative or benchmark localities through a Cropping Systems Network.*

No separate objective is set for 1990, since it can be expected that the second half of the decade will be spent on bringing about continuous improvements in the basic structure of technological packages and testing arrangements established earlier. A more precise goal can, if it is felt appropriate at the time, be set at mid-decade.

IX. Genetic resources

IITA's mandate specifies that it is to "... take responsibility in collaboration with the International Board for Plant Genetic Resources (IBPGR) for the exploration, collection, conservation, documentation and evaluation of genetic materials of food legumes, root and tuber crops and rice in the humid and sub-humid regions of Africa ...". Germplasm collection and conservation is one of the classic functions of an international agricultural research center, and IITA's work in this sector is to be considered as still at an early stage.

In 1981 the number of accessions is expected to reach 25,000, mostly cowpea and rice. The Genetic Resources Unit will shortly take over a collection of soybean germplasm assembled in connection with the breeding program. All accessions are to be processed for storage at -20°C in the cold chamber (long-term seed store) which is now coming into operation. In addition, 12,000 of these accessions will be kept freely available in the working collection. Besides being responsible for the active management of the collection, the Genetic Resources Unit also handles the post-harvest preparation and dispatch of seed for international trials in connection with the crop improvement programs.

In considering the development of this work in the eighties, it is useful to bear in mind that a germplasm collection serves two distinct, though related, functions: it is a breeding tool for a crop improvement program; and it has the purpose of preserving sources of genetic diversity — even entire species — which run the risk of extinction under the impact of modern life.

Of the eight crops on which IITA is doing research; four are roots and tubers. In section VI above, an explanation was given of the way in which tissue culture can enable the Institute to conserve the germplasm of these crops. Clones of yam and cassava are at present maintained by the Genetic Resources Unit in the form of a living collection. They will be transferred to tissue culture as soon as feasible in the eighties. About 300 clones of sweet potato are already held in tissue culture, and a further 300 will be processed in the near future.

IITA designated sweet potato center

The IBPGR has recently designated IITA as the organization to establish a world germplasm collection of sweet potato. In view of its global mandate for genetic improvement of this crop, the Institute welcomes the action of the IBPGR. The financial and organizational implications are currently being worked out, and a decision will shortly be taken on whether it is feasible for IITA to proceed. Sweet potato germplasm could, to a certain extent, be collected in the form of seed. However, seed represents merely a source of genetic diversity; it cannot transmit the precise combination of characteristics associated with a particular variety. The establishment of a world collection would require the collection of clones, which would need to be processed into tissue culture and imported by IITA in that form.

Special arrangements with the Nigerian quarantine authorities would be needed to cover their subsequent handling. It is hoped that satisfactory arrangements can be made regarding these and other aspects of the undertaking, including coverage of the necessary costs. IITA is pursuing the matter with the other institutions concerned.

During the eighties, work will be continued on the evaluation and documentation of the existing collection. In consultation with the IBPGR further initiatives will be taken, including a resumption of field collection, which is currently suspended. The main emphasis will remain on cowpeas and other legumes, and rice found in Africa.

X. Training

As mentioned in section I above, shortages of trained manpower are among the most serious impediments to agricultural development in Africa. IITA's training program contributes first and foremost toward alleviating the problem at national level in sectors related to the Institute's work. Main priority is given to Africa, but participants are also taken from other areas. Of the 1457 beneficiaries of the program up to the end of 1980, 87% were from Africa. The program also acts as a medium for diffusing the results of IITA's research, while the Institute itself benefits from the work of participants following individual courses since they contribute to current research efforts.

IITA is not a substitute for a conventional agricultural college or training center. Rather, it seeks to give additional knowledge to technical personnel who have already received (or are receiving) their basic training elsewhere. In 1981, for instance, three group courses are being organized on crop production (cowpeas, roots and tubers and rice) and five on other subjects related to the Institute's research program (reduced tillage, nitrogen fixation, post-harvest technology, tissue culture and fertilizer usage). During the eighties, it seems reasonable to expect two trends to prevail. On the one hand, the numbers of people trained in agriculture, and potentially interested in IITA courses, will steadily increase, especially in Africa, as national training programs have a widening impact. At the same time, the type of training that can most usefully be provided by IITA will evolve toward more specialized subjects, as national centers become better able to offer instruction in fields that previously had to be handled by the Institute. The result is likely to be steadily increasing pressure on the openings which IITA can provide. The pressue is already acute, the number of applicants being far in excess of the number of places.

IITA feels that it should make the utmost efforts to step up its training program within the limits of its possibilities. The most important constraint is the fact that the types and quality of training provided depend on the quality of the Institute's research. It is important to keep research as IITA's primary activity. However, program re-building in research, as outlined in the previous sections above, will automatically increase the Institute's training capacity.

A number of steps are planned to increase the effectiveness of the training program. Training is already a component of many special projects, but in future there will be a more systematic approach toward linking training and international programs. Not only may courses be planned to suit the requirements arising out of such programs, but the projects themselves will be used as vehicles for communication with governments regarding the selection of trainees and follow-up after their IITA courses. Follow-up will, in general, be given greater attention. Participants can sometimes benefit disproportionately from relatively minor assistance, for instance through the provision of equipment after their return home, which can enable them to apply in practice what they have learned at IITA.

The facilities of the Institute will also be improved, in particular by the addition of equipment that will allow the use of audio-visual methods. IITA currently conducts its training courses in English and French. It will seek to develop a capacity to provide training in Portugese to open the way for the Portugese speaking countries of Africa to participate in the program. The estimates of resource requirements given in section IV above allow for a substantial strengthening of the Training Unit over the next two years.

Detailed plans cannot yet be made for courses during the decade, but subject matter coverage will be expanded and, as already mentioned, will probably become more specialized. Particular attention will be given to building up the training capacity of regional and national centers, by training trainers. Since many countries are at an early stage of establishing research institutes, it is planned to offer training in the organization and management of research programs. Courses are also planned in the socio-economic aspects of agricultural development, and in the transfer of technology. The basic principle to be followed will be complementarity to the work of national and regional centers. To ensure that this is realized in practice, contacts with these centers will be intensified. The possibility will be explored of utilizing facilities available in the region to organize some courses away from IITA in partnership between the Institute and a regional or national center.

The present capacity of the Institute to provide various types of training is approximately as follows:

Senior Research Fellows: 1—2 per year.
Degree-related Research Training: 50—60 students conducting reseach under the supervision of IITA scientists in co-operation with universities.
Non Degree-related Training: 10 man years of training for employees of departments of agriculture, universities, research institutes, international organizations and private agencies.
Vacation Student Research Scholars: 20 students for projects of up to 4 months (intended for students who have completed all but one year of pre-graduation studies).
Group Courses: 6—8 courses with a total capacity of 175-200 participants (intended both for technicians and for trainers, including extension workers).

Training in the eighties will be intensified within this well-established program structure.

XI. International programs

The title "International Programs" is used by IITA to describe all activities which are not included in the core budget approved by the Board of Trustees and the CGIAR, and which are financed by special contributions. These were previously termed "special projects". They can be broken down into three categories: core-supplementing grants, which amount in effect to an extension of the research program; training of scientists from national centers at IITA; and co-operative programs carried out in individual countries.

The volume of international programs has grown steadily, as shown below (all figures are rounded):

1973	$250,000
1974	$550,000
1975	$1,330,000
1976	$1,630,000
1977	$2,080,000
1978	$2,510,000
1979	$3,740,000
1980	$4,790,000

Earlier sections of this paper have documented the urgent need for IITA to rebuild a rational and balanced scientific program. Core-supplementing grants are a way for achieving this aim, insofar as it cannot be attained directly through the core budget. Not only do such grants strengthen the work of the Institute in its fields of research, but they also increase its capacity to carry out co-operative projects in countries. Training is normally a component of such projects, so all categories of international programs are inter-connected.

Cooperative programs largest category

By far the largest category is that of co-operative programs or projects in countries. Country projects are of great value to IITA, as well as (it is to be hoped) to the country where they are carried out. They serve multiple objectives: to bring IITA technology down to country level where it can be intensively tested and adapted to local ecological conditions; to strengthen national research capacity; and to provide feed-back to IITA for the development of its research program. The second of these objectives is particularly important in Africa, where research institutes in most countries are still in the very early stages of development. IITA can, of course, only build up national research capacity in the technical areas of its own program. During the 1980's, the Institute will strengthen working links with other organizations which have a broader mandate in this field, particularly with the International Service for National Agricultural Research (ISNAR) and with FAO. ISNAR is engaged in institution-building rather than in the general financing of national research projects; its activities may strengthen national research capacity in areas directly related to IITA's program. IITA, for its part,

undertakes specific projects which also have the effect of building up national research capability. The two institutions thus have fully complementary roles.

Several factors are likely to result in a substantial growth of demand for IITA international programs in the eighties. The Institute will have progressively more to offer in the way of new technologies. African countries will certainly be stepping up their efforts to resolve agricultural problems. And the potential contribution of IITA is likely to become better known to governments. It will therefore become increasingly necessary to reach a deliberate policy on the Institute's involvement in international programs. At one extreme, if IITA takes on too many country projects it can become a development agency rather than a scientific institution. At the other extreme, without international programs it will be cut off from the countries for which it is working, its technology will be under-utilized, and in the worst case its research may become irrelevant.

As in the case of training, IITA feels that its international programs should expand in response to requests, to the limit of what is possible without prejudicing its primary role of research.

At present, IITA is carrying out projects in seven countries (Cameroon, Ghana, Nigeria, Sierra Leone, Sri Lanka, Tanzania and Zaire), and participating in the SAFGRAD regional project based in Upper Volta. The Institute cannot unilaterally decide in which countries it is going to operate: this depends in the first instance on requests being received from the governments concerned, and secondly on the availability of funds from a donor. Nevertheless, IITA retains some discretion regarding the programs on which it is going to embark, and can therefore reasonably establish certain guidelines.

During the eighties, IITA will aim at developing a set of international programs extending to the maximum number of countries in its mandate area, while showing balance in the technologies utilized and the ecological zones covered. The main priority will continue to be accorded to Africa. As far as feasible, three criteria will be adopted in the choice of project: the relevance of IITA technology to the country's food problems, with preference being given to projects through which one or more of the Institute's programs could have a significant impact; the potential value of the project for building up national research capacity; and thirdly, the national food situation in the country concerned, with preference being given to countries facing a serious deficit. Projects will be undertaken only if they are in line with the basic priorities of the Institute; work of low priority will not be accepted merely because funds to finance it are available.

Links between international programs and the Institute's research and training programs will be systematically tightened. The inter-relationship with training was emphasized in the preceding section. So far as research is concerned, international trials of improved crop varieties, the proposed Cropping System Network, and international programs are to be considered as facets of what is virtually a single process. IITA will attempt to maximize its capacity to handle country projects by developing the most effective possible internal arrangements.

Subject to the availability of both government requests and donor financing, the major objective for international programs is defined as follows: *By 1985, IITA will have developed an expanded set of international programs, balanced in terms of the technologies utilized and the ecological zones covered, and involving activities at country level in possibly 12-15 countries.*

By 1990, the program should be extended still further, with the aim of providing direct assistance to the maximum number of countries in the Institute's mandate area which request it.

While they do not come within the definition of international programs, it may, nevertheless, be useful to point out the relevance of the many conferences, symposia and workshops organized by IITA. Depending on the subject matter, these may be intended to review the state of research by national centers and IITA on a particular topic, or to acquaint national scientific staff with the latest results acquired at the Institute. Contacts made in the course of such meetings may well lead to the development of co-operative programs with individual countries. This area of work will be continued vigorously in the eighties.

XII. Concluding remarks

This paper has outlined the scope and objectives of IITA's principal substantive programs in the years ahead, both on-site at IITA itself and internationally. While a brief account of some of the supporting services was given in section II above, detailed plans for these ancillary activities for instance the laboratories, the virology service, the library and documentation center, the communications and information sector - are left for consideration in another context. The continuous development of these services, and the intensification of their value not only to the Institute but also to the countries with which IITA co-operates, remain among the goals of management and the Board of Trustees.

The new decade will certainly see a further reinforcement of IITA's external linkages. Co-operation with other research centers in the system sponsored by the Consultative Group on International Agricultural Research has been mentioned at various points in this paper; collaboration will be strengthened all along the line. Relationships with countries in the humid and sub-humid tropics, especially of Africa, will be systematically developed, notably through international programs but also through other contacts. Links with the scientific community, in both developed and developing countries, will be tightened. Closer co-operation will be sought with development agencies, especially FAO and the World Bank. Last but not least, the Institute counts on receiving still greater understanding and support from donor governments, agencies and foundations in order to achieve its objectives.

These objectives, and their financial implications, have been set forth clearly. In relation to the present program of the Institute, they are ambitious but realistic. Compared with the problems of tropical agriculture, especially in Africa, they are minimal.

IITA has entered the eighties with a sense of purpose, and a conviction that it can make significant contribution toward the development of its mandate area. In co-operation with governments and other organizations, both national and international, it intends to make of the eighties a decade of achievement.

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