AGR/TAC:IAR/88/1

THE CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

Forty-Fifth Meeting, Rome (Italy), 7-12 March 1988

FAO'S REVIEW ON THE FUTURE OF ROOT AND TUBER CROPS, BANANAS AND PLANTAINS

(Agenda Item 10)

Objectives of the Discussion

Dr. C.H. Bonte-Friedheim, Assistant Director-General, Agriculture Department, FAO, presented the attached paper at ICW '87 in Washington, D.C. It reviews the situation in developing countries, points out the major constraints to increased productivity and utilization of root and tuber crops, plantains and bananas. Recommendations are made, aimed at governments and policy makers, researchers and research instituions working in, or for, developing countries, and donors. The CGIAR Chairman commended the paper to TAC for review and further deliberation.

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

March 1988

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

International Centers' Week - 1987

THE FUTURE OF ROOT AND TUBER CROPS, BANANAS AND PLANTAINS

C.H. Bonte-Friedheim

THE FUTURE OF ROOT AND TUBER CROPS, BANANAS AND PLANTAINS

I. INTRODUCTION

In May 1986, at the Ottawa CGIAR meeting the co-sponsors suggested that FAO introduce a paper for discussion on The Future of Root and Tuber Crops, Bananas and Plantains at Center's Week in October 1987. At that time the renaissance of several traditional tropical crops could not have been foreseen. In the meantime a large number of meetings have been held and many publications prepared, all dealing with roots, tubers, bananas and plantains. To-day's subject is therefore no longer as farsighted as it might have sounded in early 1986. As examples of some earlier meetings, discussions of the Committee on World Food Security (CFS) in 1986 and 1987 and of FAO's Committee on Agriculture in March this year can be cited.

A highly praiseworthy study, dealing however with only one crop, is CIAT's document of May 1987 on "Global Cassava Research and Development". It is recommended that those interested in working in the field of roots, tubers, bananas and plantains cooperate in order to prepare similar studies for many other crops belonging to this general category of important agricultural commodities and human foods. Such studies will be very useful for policy makers and researchers, for donors and for national and international organizations. The CIAT study might possibly be attacked as being over-optimistic on the demand side and on the crop's production potential, but such criticism is certainly not shared by all.

With regard to bananas and plantains, credit must be given to the Australian Centre for International Agricultural Research which, together with the International Network for Improvement of Banana and Plantain (INIBAP) and the Queensland Department of Primary Industries, arranged for a workshop in Australia in October 1986 dealing with banana and plantain breeding strategies. The report is certainly to be considered as a basic strategy paper regarding breeding aspects of bananas and plantains. The workshop did not deal with, and therefore the proceedings did not cover, the economic aspects of production on the one hand and demand possibilities on the other. It would be appreciated if INIBAP or others could also

organize a workshop on the many different development issues of these crops.

It is generally assumed that there is a united world-wide will to eradicate hunger, malnutrition and poverty from the face of the earth. Unfortunately still not enough is known about the many causes of malnutrition and poverty in rural areas in the hunger belt around the globe. There is considerable evidence that the gravest situations exist in the areas far away from tarmac or all-weather roads, during the rainy seasons before the harvests and among families with very limited land resources, with no capital and without access to credit. In the situations just described, visits by researchers and development agents are rare and not sufficient attention is given by them to the serious situation often prevailing in these areas. Yet in the developing countries of the humid tropics, and outside the rice production areas, the food produced and consumed in the rural, and especially in the isolated, areas consists to a very large extent of roots, tubers, bananas and plantains. The development target must be to improve the people's diet, quantitatively and qualitatively - and in the short-term this is certainly done best through existing crops. At the same time the rural population must start to actively participate in a cash economy, as far as possible through the sale of some of their crops.

It is a general conviction that most roots, tubers, bananas and plantains have in many agro-ecological zones comparative advantages over other crops. They have considerable potential as food and as cash crops with very high land and labour productivity, contributing in combination with vegetables and legumes to better nutritional standards of the population on the one hand and to national food self-sufficiency on the other. Only a few of these crops have any substantial potential for export, either fresh or processed.

In the past it was <u>not</u> the traditional crops, including roots, tubers, bananas and plantains, which received noticeable attention and support by donors, as the basic food in many of the tropical developing countries. On the contrary, considerable emphasis has been focused upon the growing

importance of rice, wheat and other cereal consumption. In many areas the increased cereal consumption has been in competition with or at the expense of the traditional crops. In the period between 1961 and 1981, the per caput consumption of wheat in tropical countries grew at an annual rate of almost 3 percent, while the consumption of roots and tubers declined at a rate of about 0.5 percent per year.

Any discussion, however important, will probably be inconclusive on the question of whether cereal imports grew because local food crop production did not meet requirements and demand, or whether local production was reduced because of lack of demand for these crops due to easy, often subsidized cereal availability. The present situation is clear: a growing national dependency on imported food with a corresponding diminishing reliance on traditional local crops that can produce excellent yields in tropical climates. In Sub-Sahara Africa for example, cereal imports rose by 9 percent a year to 9 million metric tons, at the phenominal cost of US $2.6 billion, in 1981-83.

The dominance of wheat can be easily seen from the Figure 1 which shows the location of the world's 15 largest flour mills. From the next Figure it will be noted that seven of these 15 mills are located in countries producing virtually no wheat; one producing sufficient wheat for one day's milling, another for 40 days' milling only. These large mills are, of course, in addition to other locally available milling capacity.

Cereals that were introduced in earlier times often supplemented traditional food crops, but seldom substituted them significantly. This general statement is presently no longer true, as can be noted from the role of roots and tubers in the Pacific as recently analyzed by FAO for the developing countries of Oceania. In that region taro is the most common tuber consumed. Roots and tubers provide approximately 22 percent of dietary energy, with annual per caput production at 293 kg. Consumption of traditional crops has been falling since the late 1960s, while at the same time increased amounts of cereals were or had to be imported, as can be seen from Figure 3.

FIGURE 1

LOCATION OF THE 15 LARGEST FLOUR MILLS IN THE WORLD

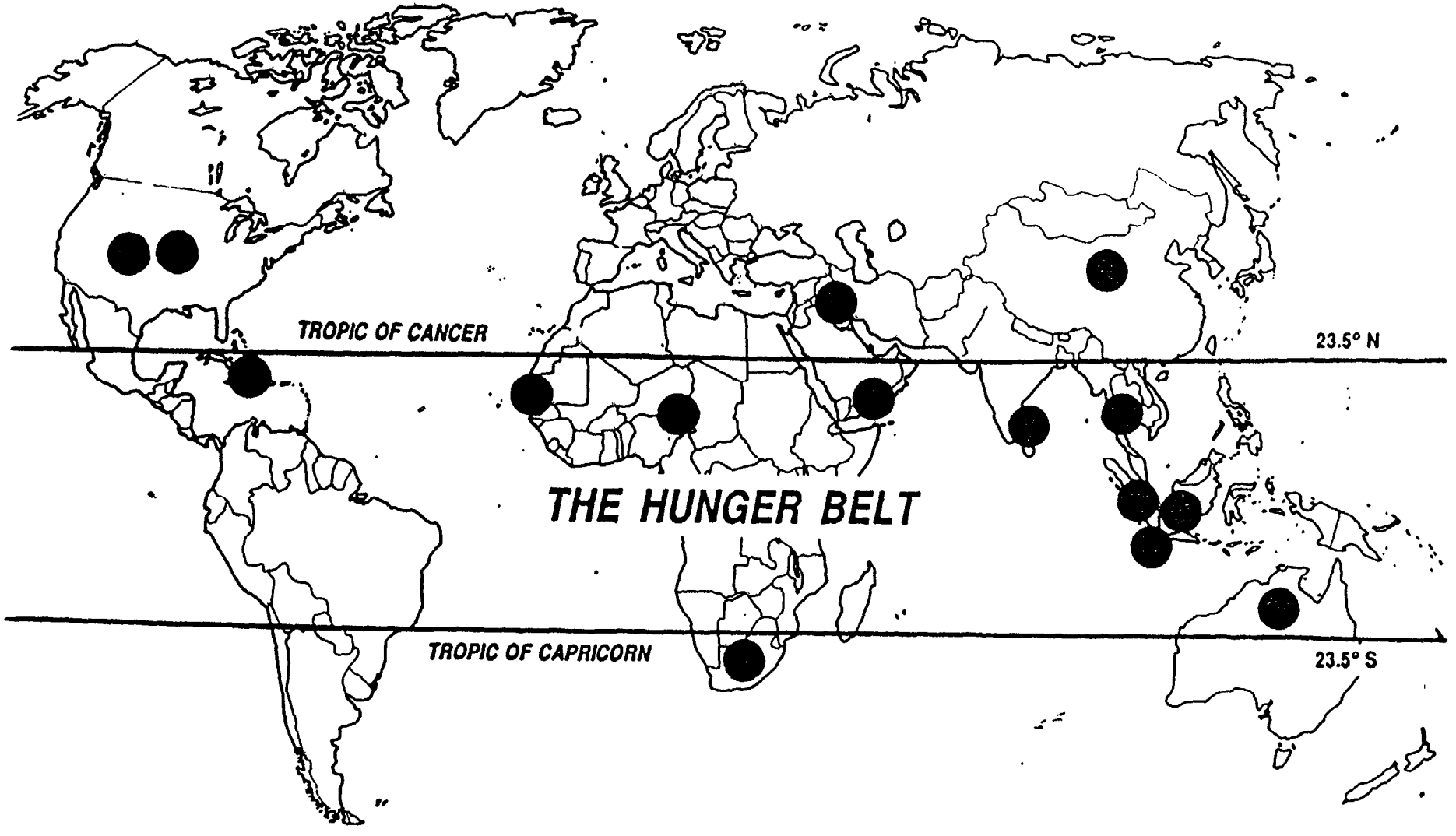
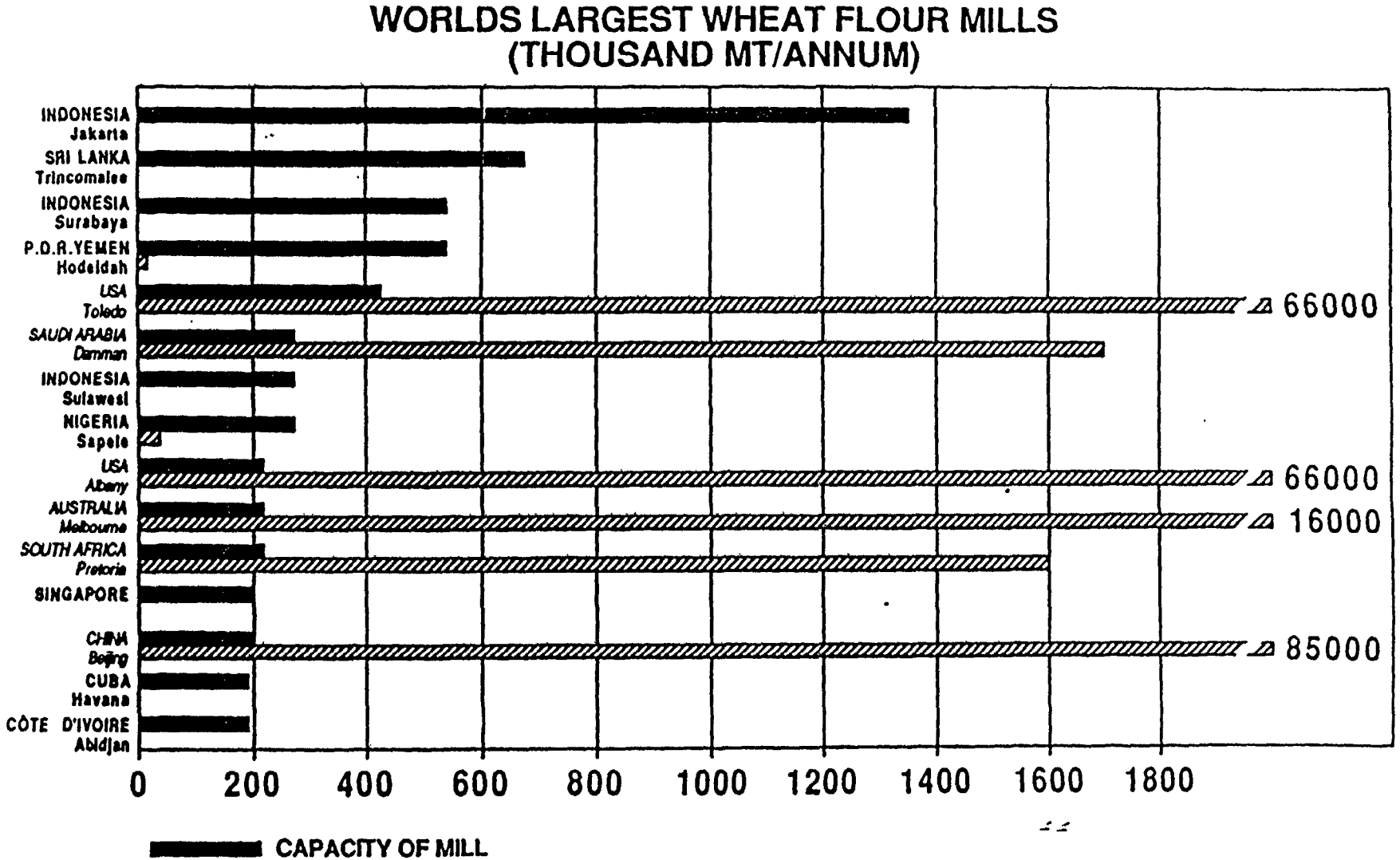
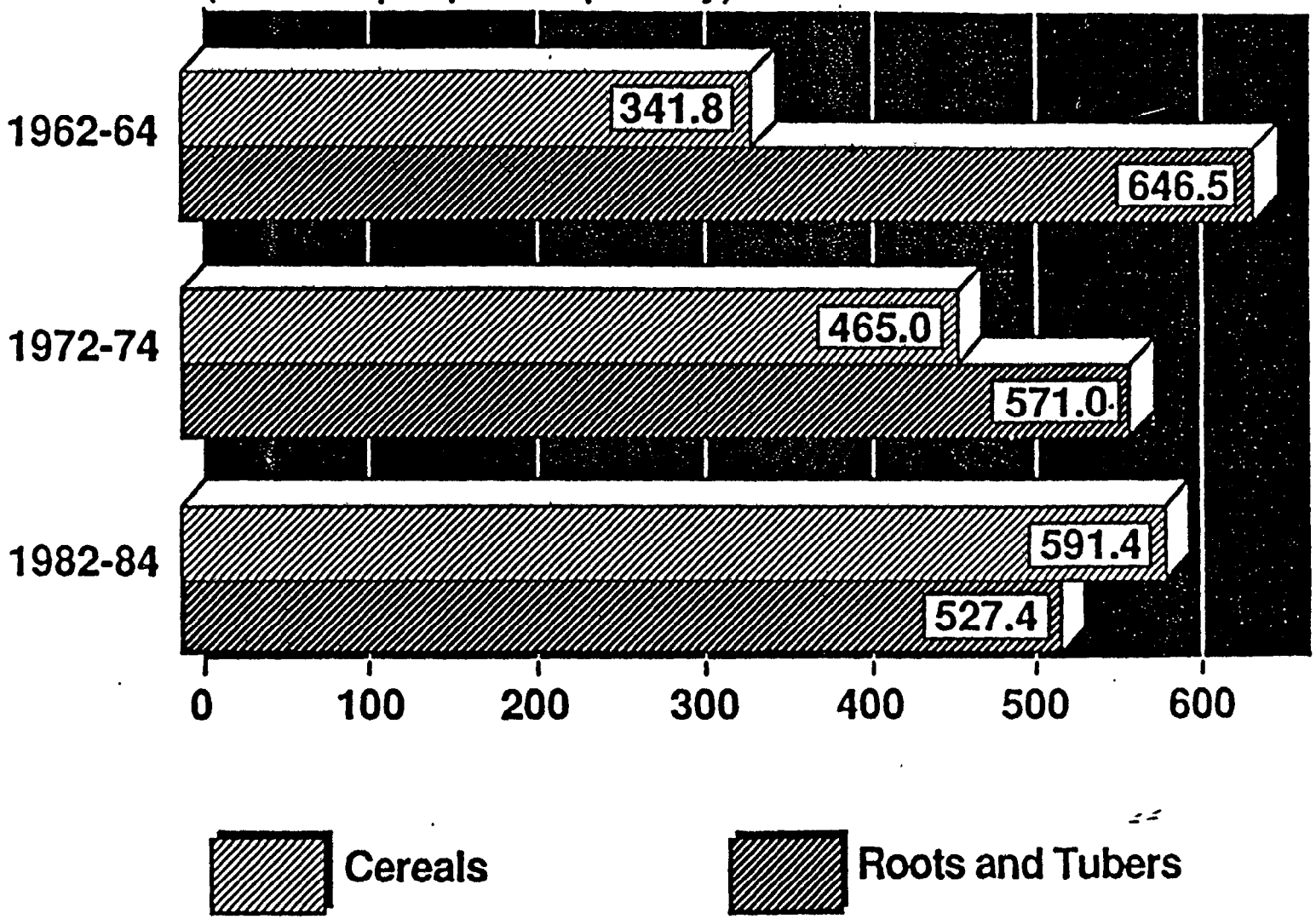


FIGURE 2


WORLDS LARGEST WHEAT FLOUR MILLS
(THOUSAND MT/ANNUM)
INDONESIA
Jakarta
SRI LANKA
Trincomalee
INDONESIA
Surabaya
P.D.R.YEMEN
Hodeidah
USA
Toledo
66000
SAUDI ARABIA
Damman
INDONESIA
Sulawesi
NIGERIA
Sapele
USA
Albany
66000
AUSTRALIA
Melbourne
16000
SOUTH AFRICA
Pretoria
SINGAPORE
CHINA
Beijing
85000
CUBA
Havana
CÔTE D'IVOIRE
Abidjan
0
200
400
600
800
1000
1200
1400
1600
1800
CAPACITY OF MILL
Based on 270 days production/year
COUNTRY PRODUCTION
Countries with zero production, reference - David Fellers in Tropical Foods:
Chemistry and Nutrition. Volume 2. Edited by Inglett and Chavalambous.
Other figures from 1985 FAO Production Yearbook

DECLINE IN CONSUMPTION OF ROOTS AND TUBERS IN DEVELOPING COUNTRIES OF OCEANIA

(Calories per person per day)



Total annual consumption of traditional tuber crops in the Pacific Islands has fallen by 8 percent to 206 kg per head since 1970. During the same period cereal consumption has increased by 40 percent, from 61 kg to 85 kgs per head and year. The total bill for cereal imports in the Pacific is now more than US $100 million a year, equivalent to about 6 percent of total exports. The costs to consumers may be even higher.

For the results of such development the 1987 World Food Report of FAO might be cited:

"The change has been detrimental to human health. While the area was once considered one of affluent subsistence, with food widely available even in the most vulnerable areas, it now has one of the highest incidences of nutrition-related disease in the world. Energy and protein malnutrition, obesity, cardiovascular disease, diabetes, dental decay and iron deficiency aneamia have become widepsread, particularly in urban areas. The incidence of these diseases has been directly related to the change from a fresh food diet, rich in fibre and micro-nutrients....."

It must be stressed at the outset that this topic on roots, tubers, bananas and plantains groups together a number of very different crops, some of them used exclusively as food crops, others as food and feed crops and some as food, feed and industrial crops. Common to all of them is the fact that they originate in non-temperate climatic zones. Therefore the discussion of the future of these crops will also concentrate on those climatic areas and consequently on the developing countries. This paper will purposely not deal specifically with potatoes since most potatoes, although originally from the highlands of the Andes, are grown in Europe and North America, where most research has been and still is being undertaken, inspite of CIP's commendable efforts in Peru. It is recognized however, and partly due to CIP's work, that potato production has the potential to move into warm, humid zones and lowlands, but more research seems required before production in these areas can always be successful.

A very brief description of present and planned activities of the IARCs seem in order. Three institutions deal to various degrees with five

or six crops included under the general heading of this paper. CIP's world-wide mandate for potatoes requires no elaboration. In addition CIP is increasingly involved with sweet potatoes as a complimentary activity to potatoes, making use of its available expertise and valuable experience in distributing disease-free vegetative material and in comparable work on pests and diseases. It should also be mentioned that so far less than 5 percent of CIP's core budget is earmarked for work on sweet potatoes. The institute plans to concentrate on germplasm collection and maintenance, disease control and support to breeders. It is assumed that CIP will cooperate closely with AVRDC which has a tradition of fine research work for sweet potatoes.

IITA is involved in research on cassava, sweet potatoe, yams, plantains and possibly coco yams. IITA is planning major programmes in cassava and yams plus important work for plantains. Coco yams are of minor importance and the work on sweet potatoes might be given to CIP. Regarding cassava emphasis will be on breeding varieties which will meet farmers requirements including suitability for intercropping, on improvement of tuber quality, on resistance to pests and diseases and on tolerance to drought. For yams IITA plans to continue mainly its collection and preservation of genetic parent material. In 1988 the institute will also begin core funded research on plantains especially on the evaluation of Central American and other varieties and their resistance to black sigatoka disease which is likely to become the major plantain production problem in Africa.

In CIAT's Programme and Budget for 1988 a major programme is outlined for cassava as the institute is finally convinced that it is "a crop whose time has come". The proposals are sound and lay the foundation for long-term work, covering most aspects related to cassava production and consumption. It is hoped that in spite of IITA's programme and the planned joint marketing study on Africa, care will be taken that this continent does in fact benefit most from the results of the cassava research. In Africa, more than in any other continent cassava is first and foremost a human food.

II. FACTORS INFLUENCING SUPPLY AND DEMAND

The renewed interest in these mostly traditional crops can be traced to a number of reasons, including the natural advantages of such traditional crops as compared to others. The most important reasons for the general interest in these crops can be grouped together into four categories.

On the Government side, there is a growing recognition that financial resources are not always available to import the necessary food, with no guarantee of food aid to fill the deficit, and that for national food security purposes the large small-farm sector with its traditional production of roots and tubers must be supported through appropriate policies and action. The producers with their tradition and experience use increasingly the natural advantages of these crops under marginal conditions, where they also respond well to improved practices. A large proportion of the consumers, mainly in the urban areas and especially from the privileged classes, are reverting to the crops of their ancestors. In spite of higher costs and prices, they show their pride in traditional foods. In the rural areas, however, many under-privileged consumers can only afford subsistence crops, possibly grown by themselves, especially if these crops provide sufficient calories and in addition have high quality leaves which can be used as vegetables.

Finally, researchers have come to the conclusion that the potential of many of these crops is largely unknown and could be very considerable, that new scientific methods, including biotechnology, could easily be applied to some of the research work. There is also better cooperation with economists on the one hand and engineers on the other in working towards increasing the benefits and reducing the costs at the farmers' level, at the marketing level and at the consumers' level, in order to benefit the individual as well as the national economy.

The question must be asked why, in spite of all the interest in and advantages of these traditional crops, the demand for them has not increased. On the contrary, it has often not even kept pace in proportion

to population growth. There are a number of reasons which can be easily identified and summarized as follows:

In the past consumption of the traditional crops has been linked with a low social status, typical for and generally represented by native populations, being little influenced by western civilization, which is generally associated with a high social status. This is true for most root and tuber crops, but does not apply to the banana and is changing in many countries with regard to the plantain.

In the urbanization process urban-dwellers often lack the labour and also the energy for the preparation of the traditional foods. They depend on a guaranteed supply of non-perishable convenience foods, easily prepared, if possible to be carried to the place of work, i.e. comparable to bread. Furthermore agricultural price policies of importing countries on the one hand, and subsidies of exporting countries on the other, have harmed the development of basically labour-intensive, highly perishable crops which require a developed transport and market infrastructure - especially during rainy seasons. Most of the crops are not only perishable but bulky and contain a large percentage of water.

In view of the fact that roots and tubers are mainly cultivated in a subsistance economy, with limited economic importance, and are traditionally considered as women's crops, little emphasis has been placed on research work. Improved high-yielding varieties, often resistant to certain diseases, have been tested in research stations but not enough effort has been placed on the selection of varieties which are adapted to the traditional inter-cropping system of food production. Post-harvest, on-farm storage and processing practices have also received too little attention.

Access by women farmers to the results of research in the selection of variety or improved cultivation practices is also limited. Experience has shown that when a crop is labelled "women's crops", the extension services are not adequately staffed or do not have the appropriate technological know-how to provide the assistance required by the farmers.

On the production side, because of little research, the planting material is often of poor quality and costs per planted area, including labour inputs, can be high for some roots and tubers. Pests and diseases, while seldom responsible for total crop failure, reduce yields considerably. Some of the crops are traditionally planted on marginal lands, resulting in low yields. Others, like cassava and yams, have very long growing periods. Some of the roots and tubers are intercropped, making it difficult to establish true yields per hectare, others are used in permanent mono-cropping systems, where without considerable fertilizer application rates yields decrease considerably over time.

The production, and especially the harvesting, transportation and processing of most roots and tubers are linked to some of the hardest physical work in tropical agriculture. Nearly all of this work is undertaken by women who would be the main beneficiaries of improvements. So far attempts at mechanization, above all of the harvesting work on small fields on the family farm, and for improved transportation and processing have not been very successful. It can be stated that one of the limitations to expanded production is the scarce available labour resources of the farmer and his family, especially the female members.

III. SPECIFIC CROP INFORMATION

Most roots and tubers crops originated in Latin America while bananas and plantains came from Southeast Asia, the Philippines and Malaysia. All of these crops spread very rapidly worldwide, introduced by sailors and traders. The introduction to and acceptance by farmers, isolated in the centre of Africa, or on the Indian sub-continent, or on islands in the Pacific and Caribbean, took place without help from any extension service or support from any research institute. No doubt these new crops, in spite of high labour requirements, benefitted the farmer and his family and were superior to his traditional food crops. It is not known in how far they were included in existing farming systems or necessitated and encouraged the development of new farming systems. Today these crops are the most important source of calories for the majority of rural people in all those areas where the population does not depend on rice, maize or wheat. Even

many rice, maize and wheat producers and consumers in rural areas are supplementing their grain diet with roots and tubers, bananas and plantains.

With regard to production, exports and imports, Table I provides information for 1961-63, 1974-76 and 1984-86. The growth rates for production seem considerable, with the exception of cocoyams and sweet potatoes. Surprisingly both crops had higher production in the mid-seventies than in the last two years. The reduction is especially large for sweet potatoes. There are also large regional differences. With the exception of yams and plantains it is clear that local food supply per caput has decreased for these important subsistence crops over the period 1961-63 to 1984-86, due to high population growth rates. In many countries even the rural populations consume now less of their traditional roots and tubers than 25 years ago. The total consumption and therefore production would be much higher but the urban populations are changing their dietary habits rather quickly, searching for convenience food with low labour and energy requirements for preparation. For farmers and middlemen some of these crops are very risky, being easily spoiled. The table also clearly shows that only dried cassava and bananas can be classified as export crops.

TABLE I : Production, Exports and Imports for Selected Roots, Tubers, Bananas and Plantains for 1961-63, 1974-76 and 1984-86

CROPS	1961-63 (in '000 mt)			1974-76 (in '000 mt)			1984-86 (in '000 mt)		
	Prod.	Expt. (mean)	Impt.	Prod.	Expt. (mean)	Impt.	Prod.	Expt. (mean)	Impt.
Cassava 1/	74,406	0	0	109,543	0	0	134,285	0	0
Cassava 2/	947	139	254	4,612	3,092	2,704	10,062	9,772	7,807
Coco Yam 3/	4,403	0.7	0.5	5,609	4	0.9	5,581	7	12
Yams	14,308	1	0.2	21,074	11	0.3	27,207	22	2
Sw. Potato	100,838	7	36	124,223	21	141	90,984	96	456
Bananas	22,268	4,055	3,860	33,008	6,395	6,295	40,676	7,063	6,981
Plantains	14,325	17	30	23,763	39	51	25,688	58	33

1/ Fresh Cassava; 2/ Dried Cassava; 3/ Taro

TABLE 1

	1961-63 mean (in '000mt)			1974-76 mean (in '000mt)			1984-86 mean (in '000mt)		
	PROD.	EXPT.	IMPT.	PROD.	EXPT.	IMPT.	PROD.	EXPT.	IMPT.
CASSAVA Fresh	74,406	0	0	109,543	0	0	134,285	0	0
CASSAVA Dried	947	139	254	4,612	3,092	2,704	10,062	9,772	7,807
COCOYAM (Taro)	4,403	0.7	0.5	5,609	4	0.9	5,581	7	12
YAM	14,308	1	0.2	21,074	11	0.3	27,207	22	2
SWEET POTATOES	100,838	7	36	124,223	21	141	90,984	96	456
BANANAS	22,268	4,055	3,860	33,008	6,395	6,295	40,676	7,063	6,981
PLANTAINS	14,325	17	30	23,763	39	51	25,688	58	33

Figure 4 provides information comparing acreage used in 1986 for these crops, including potatoes and the other major staple crops - rice, wheat and maize. Worldwide the relative share of wheat, maize and rice is over 90 percent compared to over 9 percent for our special crops, but there are considerable regional differences as can be seen from the Figure. There are even larger sub-regional differences which are not shown. In Asia the three main grains have a share of 93 percent, while in Africa the share is only 66 percent of all the land resources used for these grain crops and for roots, tubers, bananas and plantains. It is not possible to estimate research expenditure in the past for any of the four major crops: potatoes, wheat, rice and maize. However, if resources of a similar magnitude were to be made available for research on any of the other tropical root crops and plantains, then it must be possible to increase production considerably. First and foremost through higher yields, which in some countries would allow land to be released for other crops, and would result in higher land and labour productivity.

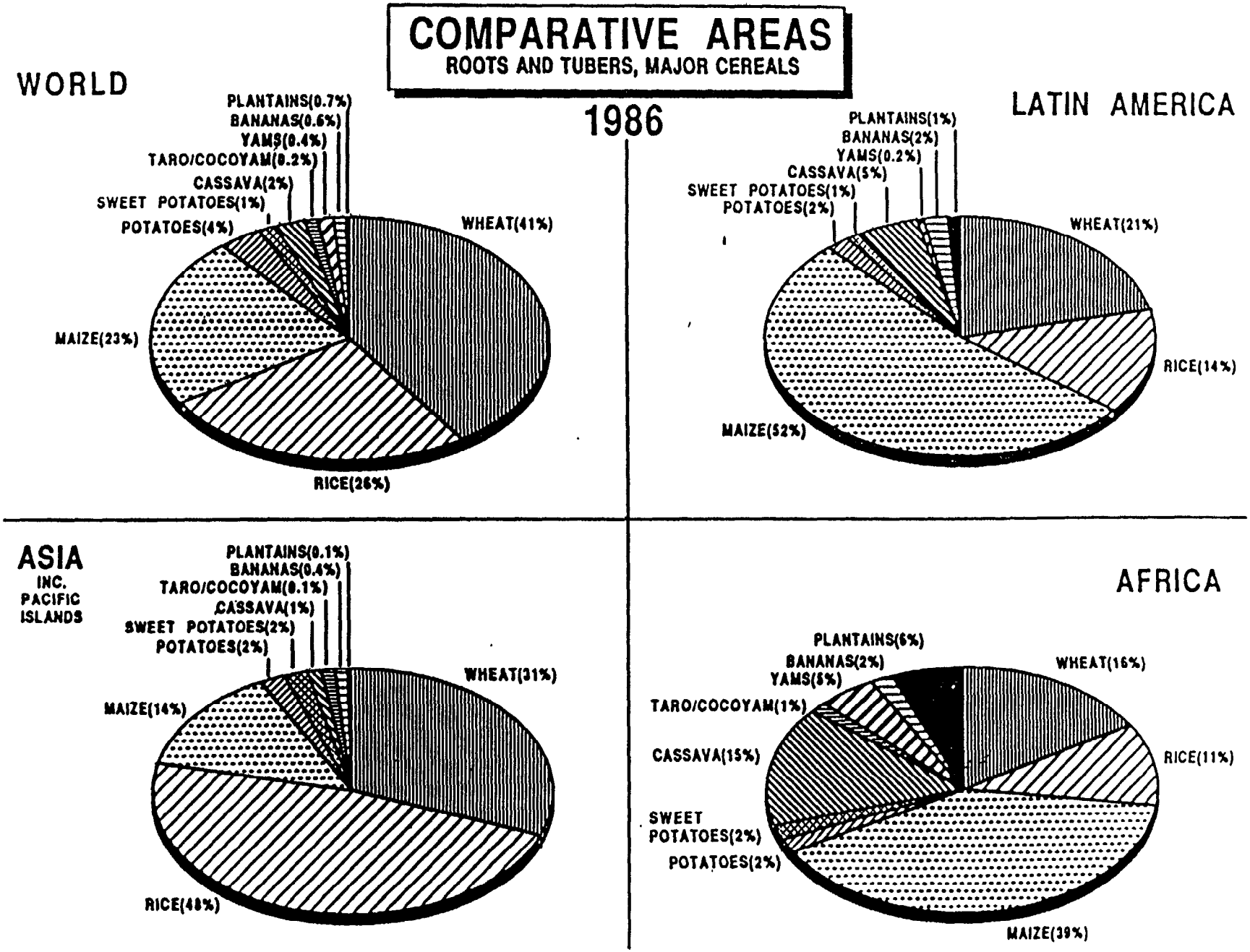
One pye diagram for each of these major crops has been produced showing developments between 1961-63 and 1984-86. Of course not all the figures are always totally reliable, especially for the earlier years. It must also be recognized that statistics on subsistence crops are not very reliable and there are good reasons for this.

This paper will deal with every crop individually, but briefly, identifying some of the difficulties as well as positive aspects for further development.

A) Cassava

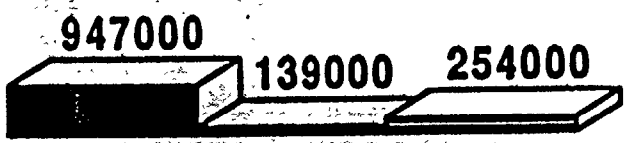
Figure 5 provides information on production, exports and imports of dried cassava in the early sixties and for 1984-86. The dried cassava is a processed food, ready for shipment or storage. The industrial process is simple and factories are inexpensive. Sun-drying is also possible but influences the quality. The production has increased 10 times from just under one million tons to over 10 million tons. With the exception of Tanzania, all previously large producers participated in the growth, and

FIGURE 4

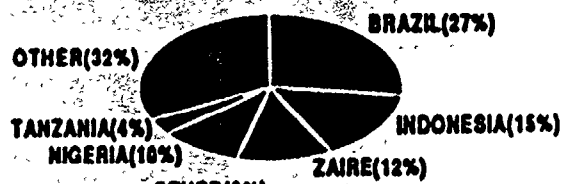

COMPARATIVE AREAS
ROOTS AND TUBERS, MAJOR CEREALS
1986
WORLD
PLANTAINS(0.7%)
BANANAS(0.6%)
YAMS(0.4%)
TARO/COCOYAM(0.2%)
CASSAVA(2%)
SWEET POTATOES(1%)
POTATOES(4%)
WHEAT(41%)
MAIZE(23%)
RICE(26%)
LATIN AMERICA
PLANTAINS(1%)
BANANAS(2%)
YAMS(0.2%)
CASSAVA(5%)
SWEET POTATOES(1%)
POTATOES(2%)
WHEAT(21%)
RICE(14%)
MAIZE(52%)
ASIA
INC.
PACIFIC
ISLANDS
PLANTAINS(0.1%)
BANANAS(0.4%)
TARO/COCOYAM(0.1%)
CASSAVA(1%)
SWEET POTATOES(2%)
POTATOES(2%)
WHEAT(31%)
MAIZE(14%)
RICE(48%)
AFRICA
PLANTAINS(6%)
BANANAS(2%)
YAMS(5%)
TARO/COCOYAM(1%)
CASSAVA(15%)
SWEET
POTATOES(2%)
POTATOES(2%)
WHEAT(16%)
RICE(11%)
MAIZE(39%)

(TONNES)

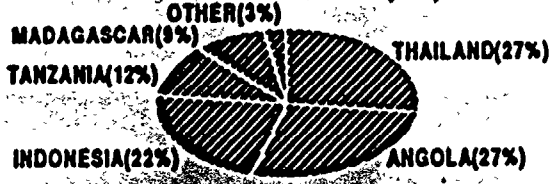
1961-63
(MEAN)



PRODUCTION

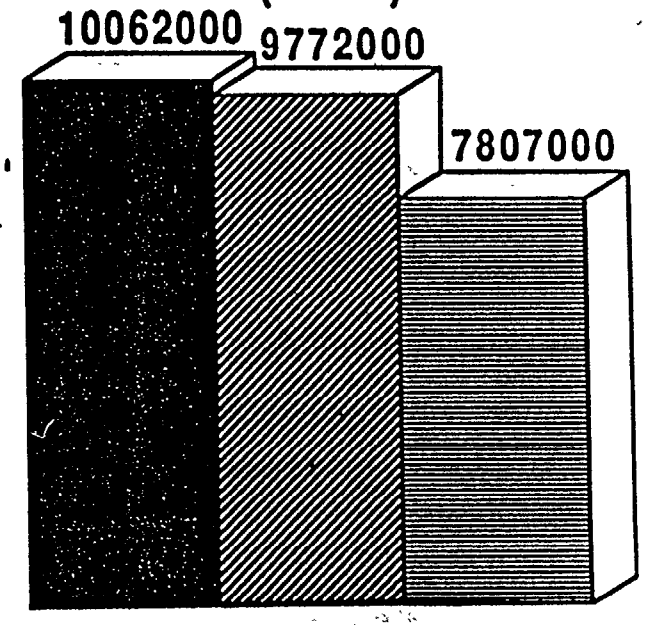


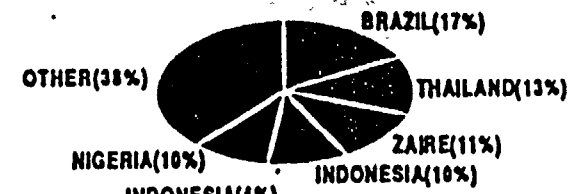
EXPORTS

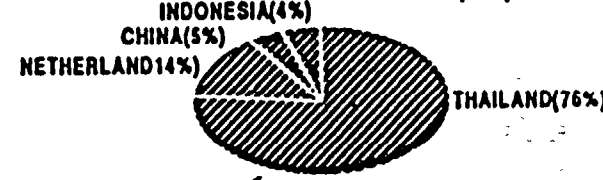


IMPORTS

1984-86
(MEAN)







remained the leading producers together with Thailand. On the export side the well-known story of Thailand must be mentioned, as this country has cornered more than three quarters of the market. While in the early sixties the United States still figured as an importer, dried cassava is now imported nearly exclusively by the EEC for animal feed purposes. On the import side the Netherlands are domineering but some of their imports - and likely more than shown - are re-exported, as can also be seen from the export graph.

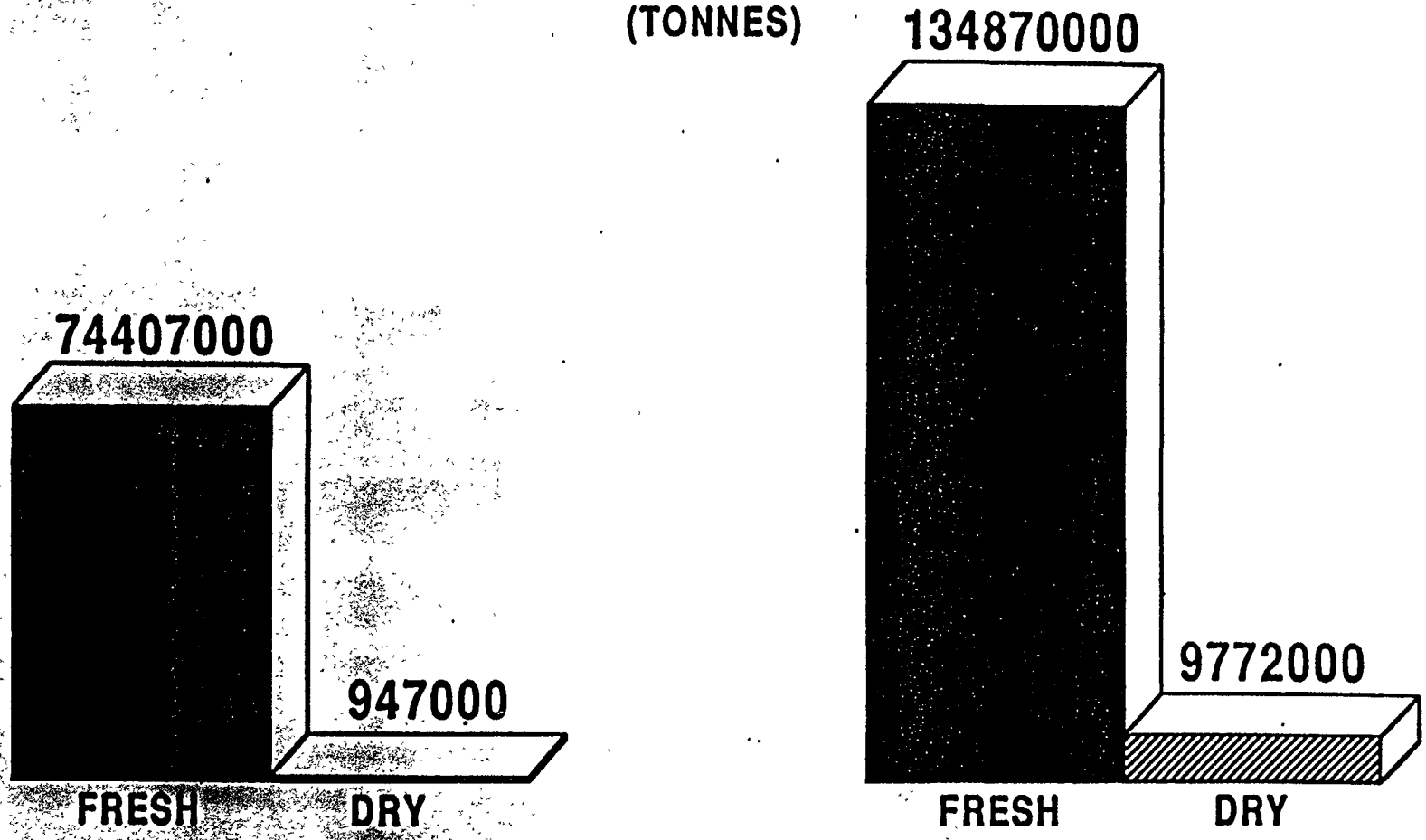
The cassava root will yield approximately 20-30 percent dried cassava, the peels can be estimated as between 10 and 25 percent of the raw weight, depending on the variety and the size, which in turn depends on soil fertility. The bigger the roots the smaller the percentage of peels, which of course can be used as animal feed in the vicinity of the processing facility.

The production of cassava is shown in figure 6. Deducting about 4 million tons for the equivalent dry matter for 1961-63 provides a production figure of about 70 million tons for that earlier period. Deducting about 40 million tons for the 1984-86 figures results in a production of 95 million tons. The growth rate for home consumption of cassava in developing countries for the 22 years is therefore not very impressive, from 70 to 95 million tons and much less than the population growth rate in the producing countries during the same period.

Cassava originated from Central and South America, although there are still discussious about its wild ancestors. The Spanish and Portugese carried the seed or stems to Asia and Africa where the plant was first observed in the 16th century.

The cassava plant has some advantages over any other crop. It is one of the world's most efficient convertors of solar energy into carbohydrates. The crop can survive and produce a reasonable harvest with limited rainfall - even under drought conditions. The plant is well adapted to acid, low fertility soils, characteristic of large parts of Africa. The final product, the root, can be left unharvested in the soil

CASSAVA PRODUCTION



for long periods. If the land is not needed, it can be used as a natural storage facility.

The cassava plant can be grown from seed or stem cuttings. It is a shrubby tree with a height of up to 4-5 metres and forms several tubers, each approximately 60 cm long and over 5 kilos in weight. Stem cuttings can be dry planted or stored for several months before planting. The plant and its tubers grow up to 30 months after planting. Whenever sufficient soil moisture is available total yields will increase over a long period. Tubers can be left underground up to four years without major deterioration in quantity or quality.

Farmers regard cassava as a famine insurance crop also because locust attacks do not seriously affect this plant. As a reliable food crop, cassava is replacing other roots and tubers in several parts of Africa and is competing with local cereals. While the cassava plant is a high quality starch producer, the protein content of the tuber is limited to one percent of dry weight. In some regions the green leaves, with a high protein content of 20 to 30 percent are also consumed as vegetables. Both sweet and bitter cassava varieties are produced, the latter having to be detoxified in order to eliminate cyanogenetic glucoside. Sweet varieties are eaten raw, boiled or fried, bitter cassava only after steeping. In addition cassava is an animal feed and can also be used for the production of starch, fructose, dextrine, single cell protein and alcohol. In 1975 the EEC imported 2.3 million metric tons and in 1985 nearly 5.9 million metric tons. Thailand was the largest exporter with 4.9 million metric tons in 1985. In 1982 however that country alone already exported nearly 7.4 million tons to the EEC.

Of the disease and pest problems, African virus mosaic, bacterial blight as well as green spider mites and the mealy bugs must be mentioned. The blight, the spider mites and the mealy bugs have all been introduced from South America into Africa. Nature rarely has biological enemies and farmers and researchers are seldom prepared for such newly introduced pests and diseases which can and do create considerable losses.

In addition to pests and diseases, future research should concentrate on the demand side, and on industrial and semi-industrial processing in rural areas with little transport costs. On the production side, the economics of input application, the response of the plant to very fertile soils and improved management practices, the possiblity of mixed cropping and the mechanization of harvesting should be investigated.

Poor and small farmers in Africa, Asia and Latin America use cassava as an important subsistence crop, as the food staple which often provides the largest share of the total calorie intake. In the urbanization process, consumption of fresh cassava has declined in many countries - partly due to the perishability of the root, partly to non-availability during much of the year, i.e. the rainy season, and partly to easy access to other, often subsidized food crops like cereals. Basically, cassava is not a convenience food and it often requires a large amount of hand labour and energy to provide traditional dishes. Due to the emigration of people from the Southern to the Northern Hemisphere, small export marketing possibilities for food exist and are still growing in the USA and in Europe. Costa Rica, for example, exports peeled, ready-to-cook, deep-frozen cassava to the USA by refrigerated truck.

B) Coco Yams (Taro)

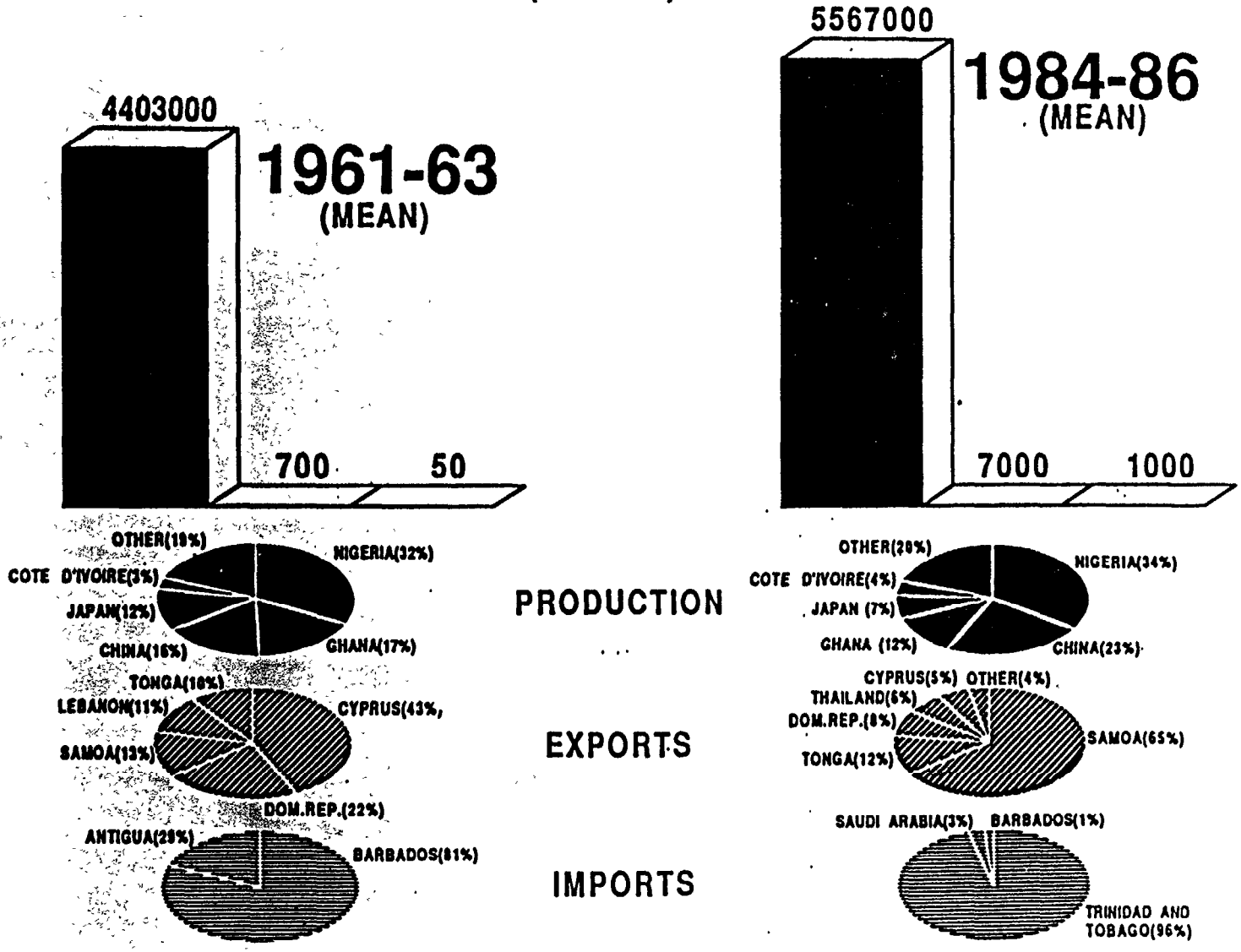
Figure 7 - This Figure shows that production has only increased by about 20 percent between 1961-63 and 1984-86. As with all the following root and tuber crops, the Figure also indicates very clearly that external trade in this particular root is of no importance. Out of five and a half million tons only seven thousand tons were exported. The increase in production in China, as well as the emergence of Japan as a producer, should be noted. The greatest importers are islands in the Caribbean.

Within the edible aroids, there are two important genera for cultivation. Colocasia has its origin in South East Asia and includes Colocasia esculenta var. esculenta, and C. esculenta var. antiquorum. The other originated from tropical America and includes Xanthosoma sagittifolium.

FIGURE 7

COCOYAMS (TARO)

(TONNES)



Colocasia esculenta: this is ideally suited to conditions in the continuously wet tropics and, like rice, may be planted either as a wet crop or on dry land. The largest production is in the humid regions of the Guinea coast of West Africa and Central Africa and in Madagascar but it is also of great importance to communities in many of the countries of South-east Asia and Oceania.

Xanthosoma sagittifolium: this grows well under seasonally wet but well drained soils. It originated in tropical America and subsequently spread to West Africa where it was incorporated into the agricultural systems as new cocoyam. In addition to its relative success in West Africa, it has penetrated Oceania due to its resistance to pests and diseases, to which C. esculenta is susceptible. The most important disease is the root-rot complex caused by Pythium myriostylum.

Similarly to yam and cassava, cocoyam can be boiled, baked or deep-fried in oil. The leaves and petioles are used as vegetables. Furthermore, cocoyam is a good animal feed.

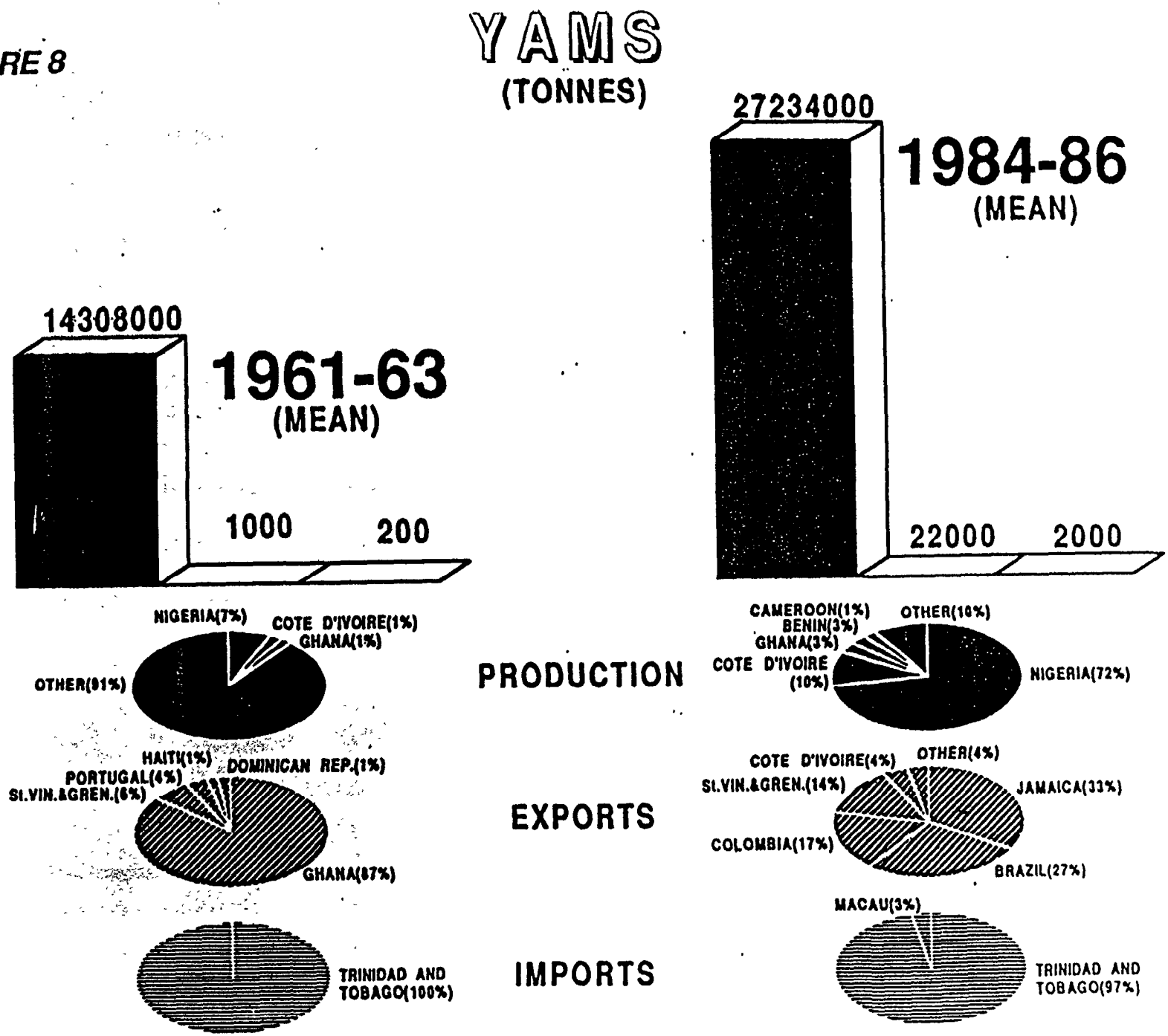
It is a lowland crop which prefers warm weather and high rainfall. Stem cuttings are used as planting material, and harvesting takes place after about 10 months.

C) Yams

Figure 8 - It will be noted that the production increase is nearly 100 percent from 14 millions tons to 27 million tons, but exports were only 22,000 tons. Nigeria has established itself during the last 25 years as the largest producer with nearly 75 percent of total world production. Trinidad and Tobago is more or less the exclusive importer.

Yams belong to the botanical genus Dioscorea with over 600 species. Of these, six are of economic importance - four of them particularly in tropical Africa. The latter are known as the white, the yellow, the water and the trifoliate yams. Yams are grown in fairly high rainfall areas, with at least 1,000 mm precipitation over a period of at least six months.

FIGURE 8


YAMS
(TONNES)
14308000
1961-63
(MEAN)
1000
200
27234000
1984-86
(MEAN)
22000
2000
PRODUCTION
NIGERIA(7%)
COTE D'IVOIRE(1%)
GHANA(1%)
OTHER(91%)
CAMEROON(1%)
BENIN(3%)
GHANA(3%)
COTE D'IVOIRE (10%)
OTHER(10%)
NIGERIA(72%)
EXPORTS
HAITI(1%)
DOMINICAN REP.(1%)
PORTUGAL(4%)
St.VIN.&GREN.(6%)
GHANA(87%)
COTE D'IVOIRE(4%)
OTHER(4%)
St.VIN.&GREN.(14%)
JAMAICA(33%)
COLOMBIA(17%)
BRAZIL(27%)
IMPORTS
TRINIDAD AND TOBAGO(100%)
MACAU(3%)
TRINIDAD AND TOBAGO(97%)

The crop's planting material is similar to that of potato, with planting of small tubers but in most cases with only parts of tubers, called "setts", which weigh between 200 and 250 g (potato planting material = 50/60 g). Yam has a vegetation period of 7-11 months. Average yields are 5-6 tons per hectare, but can even reach 40 tons per hectare.

Yam production is about the most labour-intensive root production known (up to 1200 women hour/ha) because of the preparation of the mounds as planting beds, the planting work itself, the weeding and particularly the staking and finally harvesting and transporting of the crop. The yam plants can grow vines up to 10 metres long, which need to be staked. Staking material can be expensive, and training the vines on to the stakes is also very labour-intensive. The individual tuber will weigh from 3 to 5 kg; some can weigh up to 15 kg. High yields require considerable applications of fertilizer.

D) Sweet Potatoes

Production as shown on Figure 9 has slightly decreased over the last 25 years from about 101 million tons to 91 million tons. Export is in the order of one-tenth of one percent. China is the largest producer of sweet potatoes and also the largest exporter. Sweet potatotes have established themselves as a vegetable in the diet of some Europeans as can be seen from import statistics. One possible explanation for widely differing trade figures could be that exports are raw while imports consist of canned sweet potatoes.

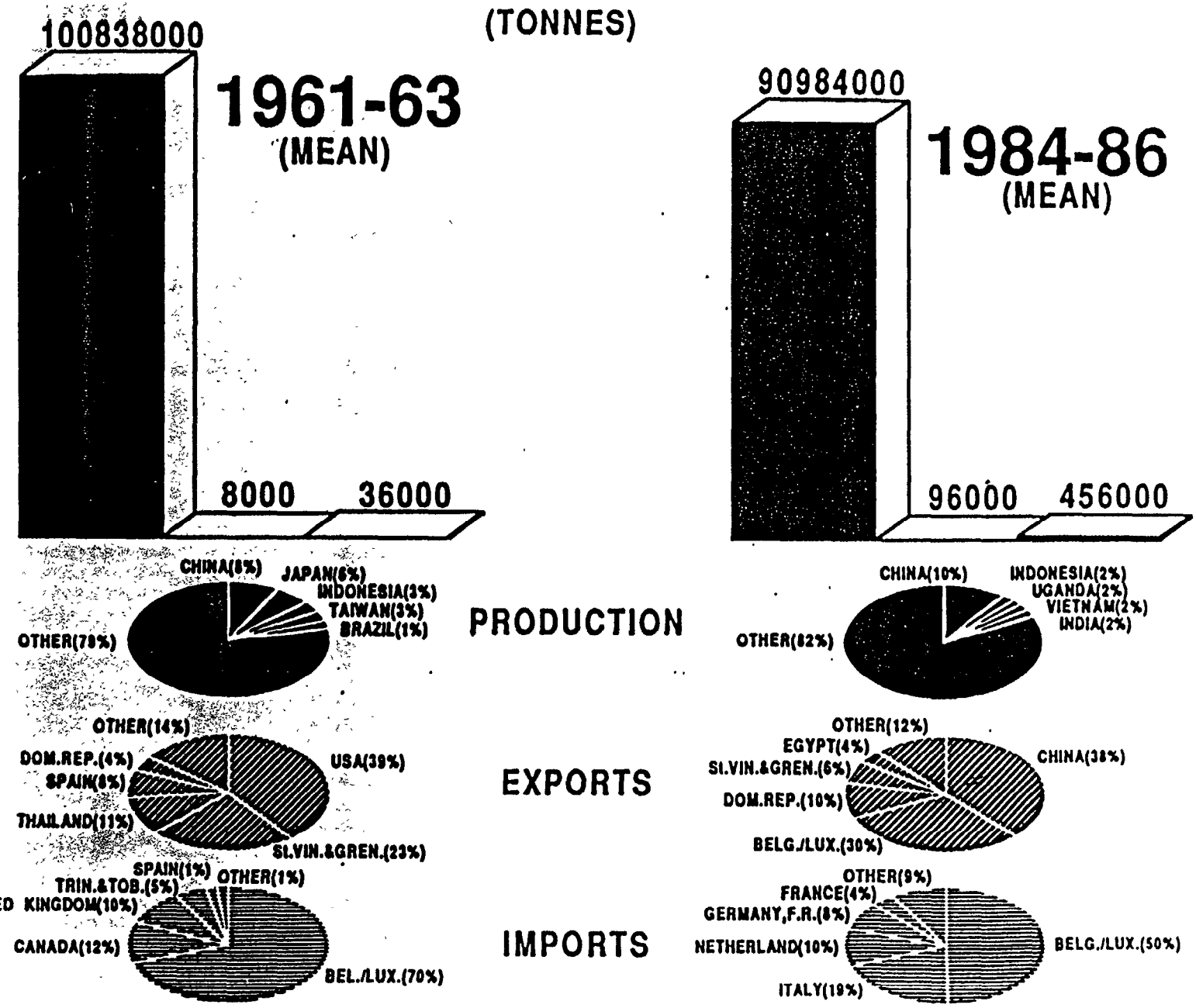
The sweet potato originated in tropical America and the Caribbean and was introduced some centuries ago to other parts of the world.

The plant is cultivated as an annual crop for its vines and its tuberized starchy roots. It is a good source of energy and vitamin A; however its protein content is relatively low. The crop is well adapted to the sub-tropics and the lowland humid tropics under low-input conditions. Depending on the variety and climatic conditions, the crop can be harvested in 3-6 months. The sweet potato has a number of other comparative advan-

FIGURE 9

SWEET POTATOES

(TONNES)



tages that makes it suitable for different but traditional cropping systems in developing countries. It propagates easily and inexpensively through vine cuttings, and covers the soil rapidly, thus overcoming weed and soil erosion problems. Current yield in Africa is 6 t/ha on the average which is considerably lower than potential yields demonstrated at experiment stations (40 t/ha). A single tuber weighs from 1 to 3 kg. The main diseases and insect pests are the sweet potato virus disease complex (SPVD), root-knot nematodes and the sweet potato weevil which remains as the major constraint to production and storage.

E) Bananas

Figure 10 - Production has nearly doubled in the last 25 years and has now reached 40 million tons of which about 16 percent, that is 7 millions tons, are being exported. The list of large producers is led by Brazil and India, while five countries have a share in total exports of more than 12 percent. In the last 25 years Japan has become a large-scale importer and hopefully other industrialized countries, especially in the Eastern Bloc, will import more bananas with rising standards of living.

Bananas are a special case under this general topic since a lot of research and development work has been done by a small number of multinational corporations. In contrast to the other crops, bananas are an export and a plantation crop and have become part of the diet of the people in developed countries.

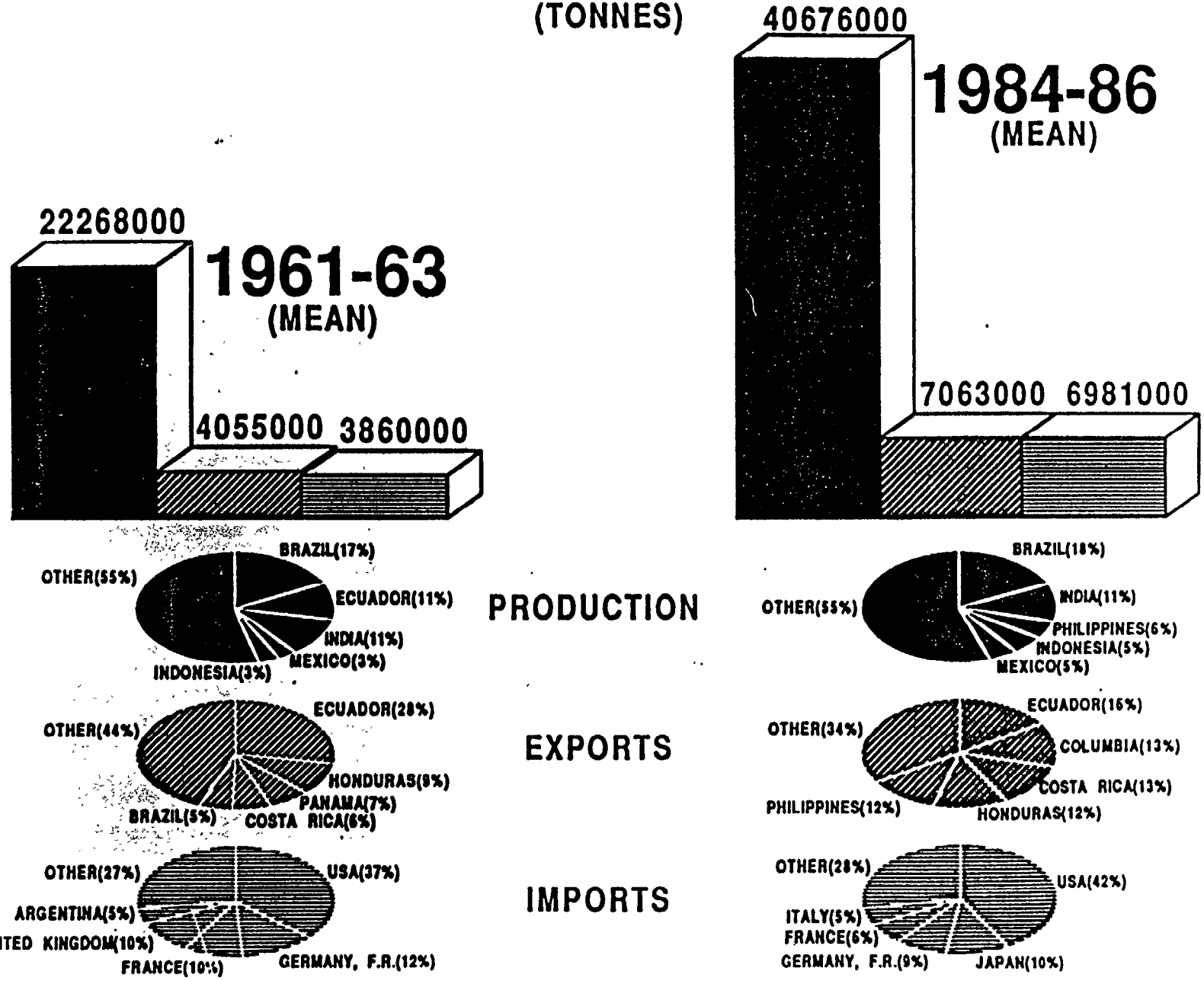
Among the edible bananas there are three major groups of triploids; these plants have three sets of chromosomes instead of two. The normal banana known in the western countries and enjoyed because of low starch and high sugar content when ripe, is made up of one genome only. Cooking bananas, however, have two different genomes.

Bananas and plantains are natives of Southeast Asia. The earliest records of their cultivation in India date back 2000 years. They are widely adapted to growing conditions in humid lowlands in India, Indonesia and Malaysia. They are believed to have reached the islands of the Western

FIGURE 10

BANANAS

(TONNES)



Pacific very early in history but did not cross the Pacific to reach tropical America and the Caribbean until perhaps 1000 years ago. Movement of these species westwards took place somewhat earlier. They are believed to have reached Madagascar and East Africa via the Indian Ocean trade routes and then progressed overland to West Africa.

Most of the world's bananas and plantains are grown for subsistence purposes and for local trade. In Asia, Africa and Latin America we find mixed cropping systems in small holdings which include these crops. Banana exports, however, in the past depended heavily on plantation production but more and more farmers are beginning to produce for export as well.

Major problems in banana and plantain production are the difficult and lengthy breeding programme to arrive at triploids. Another major bottleneck is the disease situation. Early this century it was the fusarium wilt and during the last 15 years a fungus, black sigatoka, has become responsible for considerable production losses and cost increases. Unfortunately the fungus is now also attacking plantains in Africa. Breeding of sigatoka resistant varieties must be one of the major research tasks during the next few years.

F) Plantains

Figure 11 - provides information on plantains or cooking bananas, where production nearly doubled. Uganda remained the largest producer but both Africa and Latin America are important production areas. So far exports are negligible. There is a small regional trade however, and the hope can be expressed that there is a considerable future possibility of exporting plantains to developed, industrialized countries, where they can enrich the diet and can be used to prepare fried plantains and other tasty foods. This will require consumer information campaigns.

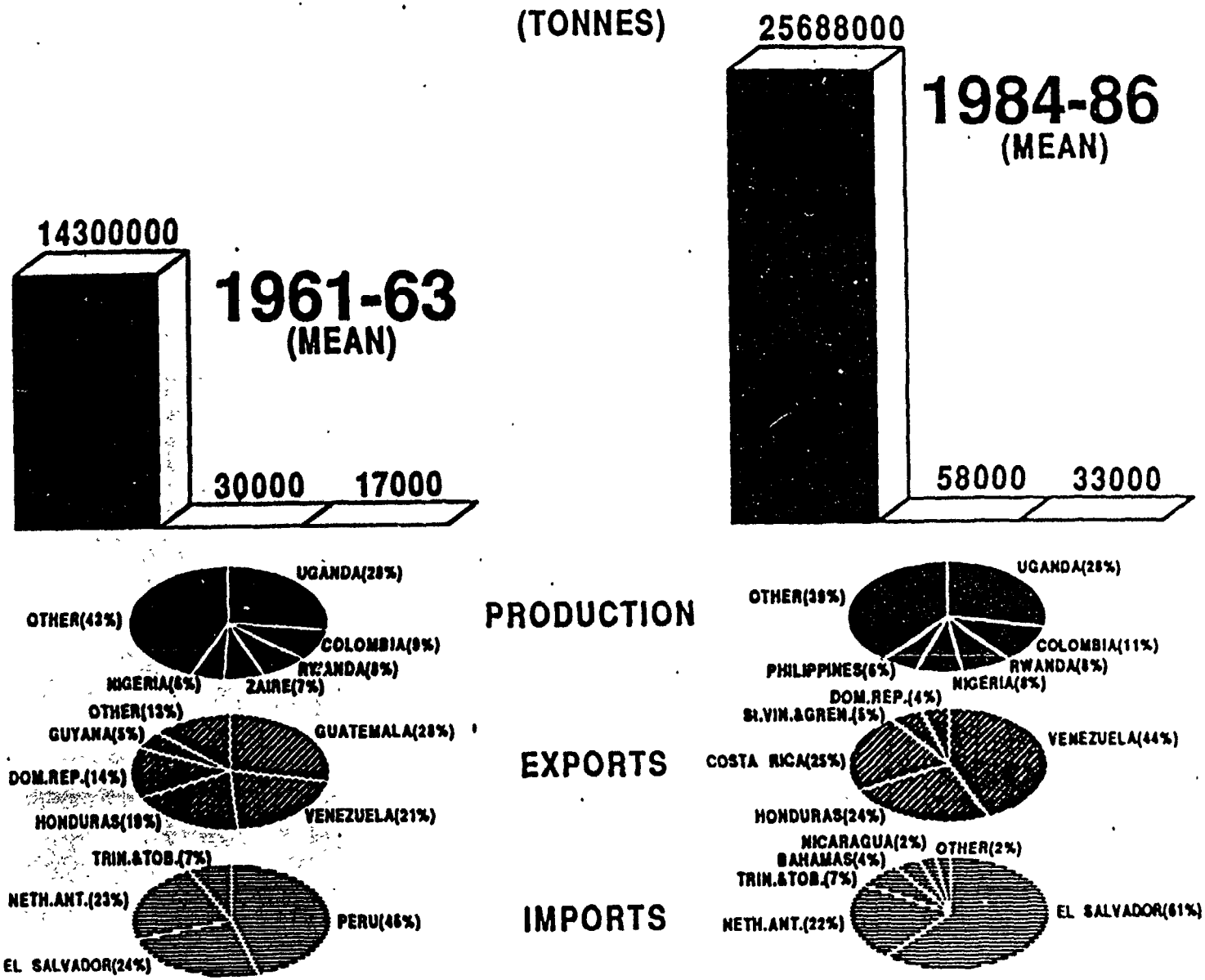
G) Potatoes

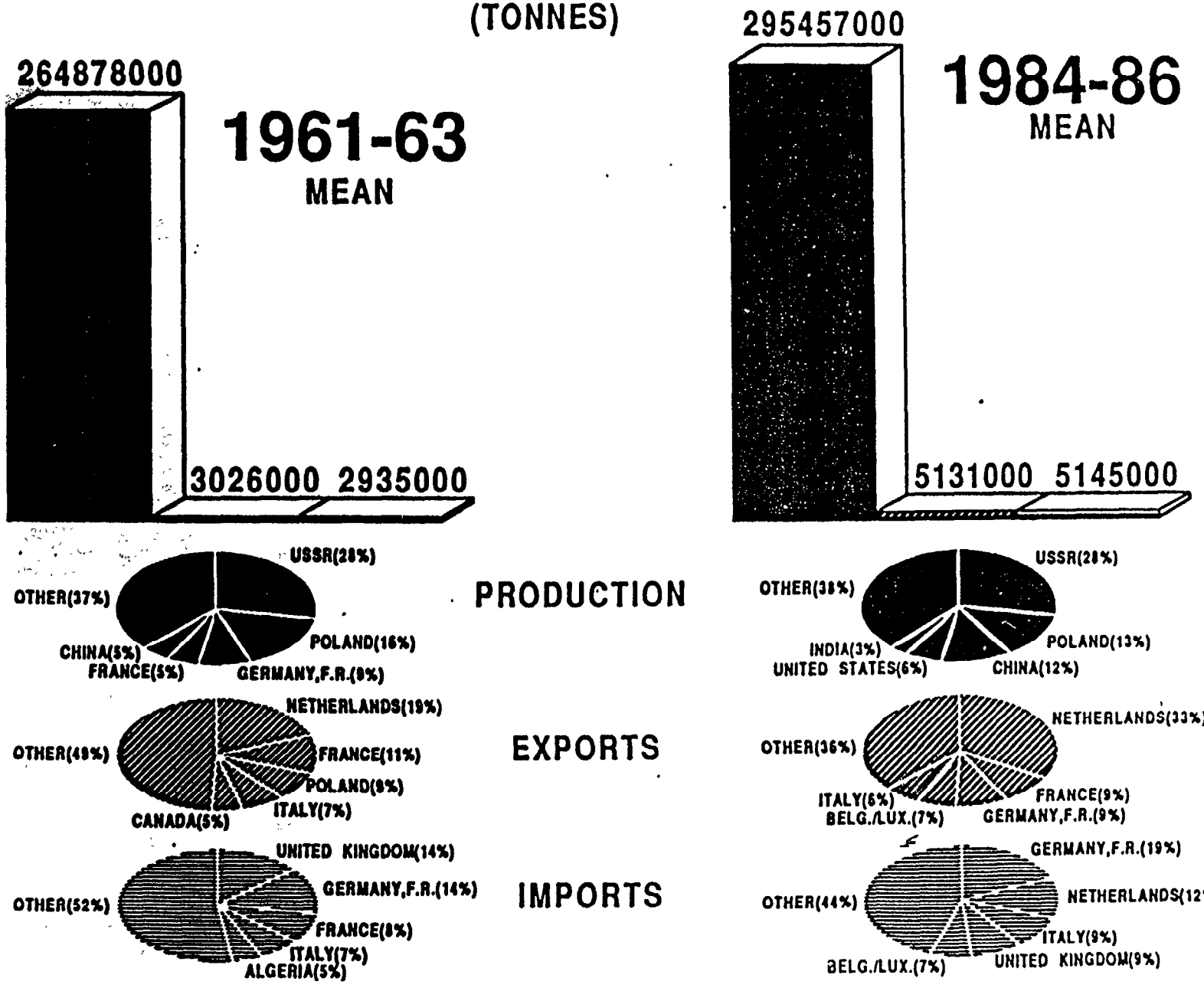
Figure 12 on potatoes indicates the importance of this crop. In 1961-63 the production amounted to 264 million tons thereby higher than the

FIGURE 11

PLANTAINS

(TONNES)




(TONNES)
264878000
1961-63
MEAN
3026000 2935000
295457000
1984-86
MEAN
5131000 5145000
PRODUCTION
USSR(28%)
OTHER(37%)
POLAND(16%)
CHINA(5%)
FRANCE(5%)
GERMANY,F.R.(9%)
USSR(28%)
OTHER(38%)
POLAND(13%)
INDIA(3%)
UNITED STATES(6%)
CHINA(12%)
EXPORTS
NETHERLANDS(19%)
OTHER(48%)
FRANCE(11%)
POLAND(8%)
CANADA(5%)
ITALY(7%)
NETHERLANDS(33%)
OTHER(36%)
ITALY(6%)
FRANCE(9%)
BELG./LUX.(7%)
GERMANY,F.R.(9%)
IMPORTS
UNITED KINGDOM(14%)
GERMANY,F.R.(14%)
OTHER(52%)
FRANCE(8%)
ITALY(7%)
ALGERIA(5%)
GERMANY,F.R.(19%)
OTHER(44%)
NETHERLANDS(12%)
ITALY(9%)
BELG./LUX.(7%)
UNITED KINGDOM(9%)

production of cassava, coco yams, yams, sweet potatoes, bananas and plantains together. There was only a very limited growth of 30 million tons until 1984-86. In many of the traditional producing countries in Europe the potatoe is becoming a vegetable in the daily diet instead of being a staple food. The two main producers are still USSR and Poland, however China has increased its production considerably from 5 to 12 percent. Exports and imports are of no importance measured against total production and consist to a high degree of planting material. Export and import trade is mainly between the European countries.

IV. THE FUTURE

In most tropical countries it should be possible to increase the production of roots, tubers, plantains and bananas, provided an effective demand exists or can be created. It must, however, be stressed again that while roots, tubers and plantains are good sources of dietary energy, they must be supplemented with other traditional food crops, such as leafy vegetables and legumes, to provide for a balanced diet.

In future, traditional crops, especially the roots and tubers, should no longer be regarded as poor man's crops. These crops can benefit greatly from advanced levels of husbandry and management. For high yields they also require considerable inputs, especially fertilizers. In the past most fertilizer trials in farmers' fields have concentrated on grains and therefore data on yield responses to fertilizers for roots and tubers are limited. However, for the period after 1977 some experience from FAO's Fertilizer Programme can be quoted. In nearly 500 observations in Zaire, applying 80 kgs per hectare each of N, P and K, the yields were raised from nearly 9 tons of cassava with 0 fertilizer to about 18.5 tons. In Indonesia good results were reported from 68 observations with 135 kg of N, and 46 kg each of P and of K, doubling the yields from about 6 tons to about 12 tons. In the same country the highest increases were reported with 90 kg of N, 45 kg of P, and 60 kg of K which resulted in yield increases from just under 7 tons per hectare to just under 18 tons. For yield levels of cassava and yam crops of approximately 10 tons per hectare, an average nutrient removal of 30 kg of N, 6 kg of P and 40 kg of K is

estimated.

Regarding bananas and plantains the INIBAP workshop mentioned in the introduction clearly identified major research areas covering regional needs, breeding strategies, diseases and pests and germplasm. Regarding international cooperation the proceedings state: "The proprietary rights of clonally propagated crops such as bananas and plantains cannot be adequately protected. Therefore it is recommended that banana and plantain breeding programmes should receive additional public (both governmental and international agency) funds for research, particularly to assist the welfare of small producers for whom these are important food and cash crops. If breeding programmes in different countries are willing to contribute selected material available for distribution and evaluation in various countries, the material should be suitably named so as to be easily identified with the breeding programme from where it orginated (as is the case with sugarcane varieties distributed worldwide). There is a need for continued and expanded information exchange amongst banana workers." .

The following recommendations are addressed to governments and policy makers in developing countries, to research institutes and researchers in all countries, and finally to donors. It is assumed that these recommendations require no explanations - but they could form the basis for a constructive discussion between all concerned. Most of these recommendations are not new but have been identified before. The very long list, which in no way claims to be all inclusive - reflects the seriousness of the problems, the long list of different crops and their wide, geographic coverage, the action required from various institutions involved, and finally it reflects somehow also the serious omissions of the past.

For the producing countries and their policy makers it is recommended to:

1) Support market studies for future demand of roots, tubers, bananas and plantains, based on population data and food consumption patterns.

2) Develop or enlarge a marketing information system to include major

traditional crops and take other measures necessary to reduce large seasonal price fluctuations, which could negatively effect production and consumption.

3) Design national price policies which will include important traditional food crops and will improve their competitive position.

4) Promote educational campaigns and other measures to increase the demand and knowledge about the correct utilization of the traditional crops and their products as valuable human food in rural areas and urban centres, as a subsistence crop and as a cash crop.

5) Consider reducing, if necessary even banning, imports of products (like potato chips or starch) that can easily be produced from local roots, tubers and plantains.

6) Develop incentives for producers, for example through easy and timely access to improved and healthy planting material, to orientate their production to market requirements, to improve the productivity of resources employed for these crops. Strengthen the capacities of training institutions to deal with the traditional crops and of the extension services to provide technical support to farmers, mostly women farmers and their husbands.

7) Assist those involved in marketing and transport to not only improve the supply to urban centres of fresh and processed food, based on these traditional crops, but also to reduce losses during all stages of marketing.

8) Encourage and if necessary enforce the use of locally available products for making bread and other flour products.

9) Support rural areas through technological improvement of the traditional transformation of crops done by women, in order to reduce the time and energy required for preparation of traditional foods. Provide assistance to create viable small-scale enterprises which

would not affect negatively the present earning capacity of women.

10) Promote the use of these crops not only for human consumption but, including their by-products, for animal feed, to substitute imports as far as possible and to develop the national livestock industry.

To researchers and their institutions the following recommendations are made:

1) Complete the collection and safe storage of germplasm of all traditional crops. Provide for full description and evaluation of the genetic material, facilitate the exchange of such material for research and breeding work.

2) Develop and conserve improved cultivars and assist national research institutions and extension services in testing and introduction of these improved cultivars under their specific national conditions.

3) Discuss with farmers, consumers and extension staff the major problems of these crops and set national priorities accordingly. Worldwide research work on yields and on improved suitability of roots and tubers for mechanized harvesting and for processing, on pests and diseases and on harvesting and processing technologies seem most important.

4) Improve existing family food preparation and indigenous processing practices for these traditional foods to reduce labour and energy requirements.

5) Create consumer acceptable convenience foods in order to widen the demand for products based on the traditional crops, including the substitution of cereal based food by composite or mixed food, consisting of traditional crops and cereals or pulses.

6) In addition to human consumption, investigate the potential and promote the use of these crops and their by-products as animal feed.

7) Improve the use of traditional crops for small and medium scale industrial processing, for example for starch and alcohol production.

8) Prepare economic studies on the contribution which could be made by roots, tubers, plantains and bananas to the national economy, to rural development, to food self-sufficiency, in import substitution and as export crops.

9) Improve the cooperation and exchange of information between researchers working on the same commodities.

The following recommendations are addressed to donors and developed grain exporting countries:

1) Support efforts to improve the competitive position of traditional food crops versus other crops and imported grain, especially in countries where roots, tubers, bananas and plantains can contribute considerably to food self-sufficiency.

2) Support developing countries in their national programmes for rural development and expansion of production and consumption of roots, tubers and plantains.

3) Facilitate imports as human food or animal feed of agricultural products and raw material based on or made from roots, tubers and plantains. Ensure that imports of these crops, especially bananas, are not subject to any special duties, quotas, import limitations or other restricting measures.

4) Provide funds for research, covering all aspects of production including breeding, disease control, and also storage, transportation and processing connected with these traditional crops.

5) Support the establishment of research networks, covering the traditional but often neglected crops like roots, tubers, bananas and plantains.

6) Share technology for processing and utilization of roots, tubers, bananas and plantains.

This paper is addressed to different groups of researchers and policy makers in developing as well as in developed countries. It has tried to justify the argument in spite of a growing programme at the IARCs considerable more attention must be given at international and national research centres to traditional roots, tubers, bananas and plantains. For several reasons it has concentrated on cassava, coco yams, yams and sweet potatoes among the roots and tubers. Potatoes were excluded deliberately, in spite of very good reasons for considerable future emphasis. No mention has been made of other roots and tubers, locally significant or still of little economic importance, with unknown potential not only as local food and cash crops but for possible introduction into other countries and other regions. An inventory of these crops and collection of their germplasm is a necessary first step to be undertaken by national scientists. National and international research is also required to investigate their nutritional and commercial potential.

The paper's title indicates that the future of these special crops is to be addressed. There is little doubt that FAO believes that roots, tubers, bananas and plantains in their natural growing conditions have a major role to play to improve the nutrition of the people, to introduce cash into rural areas from the sale of these crops to the urban centres, and to reduce the import bills for, and necessary aid-programmes of food.

The food exporting countries should be assured that further development of these crops may somewhat limit food exports to the root and tuber producing countries but these countries will not compete in the grain export markets. The grain exporting countries however face the possible competition from cassava which represents a valuable animal feed. Such competition must be recognised and solutions must be found. Similar problems exist with other commodities for example sugar and vegetable oils. Cassava has proved its potential as an export crop and its production should neither be curtailed nor limited to only a few developing countries.

Research and development work covering roots, tubers, bananas and plantains will succeed, provided there is the political will in the producing countries, provided there is the political will in the donor countries, many of whom are at the same time grain exporters, and finally provided the necessary resources become available. In the long term, the political will without resources will yield only limited research results and little development. Similarly, resources without the political will will not develop these traditional crops to their full potential.

It must be a major concern to all involved in some form or another with these traditional crops to attract and provide in the first instance the necessary resources for research and to ensure their best use. The need for more research is certainly in line with TAC's paper on "CGIAR Priorities and Future Strategies". It is felt that the size of the present or planned programme in the IARCs, or just coordination of research activities in another SPARR with a double "R" instead of a double "A" - a Special Programme for Agricultural Research on Roots - is not sufficient. The list of crops is too long, the geographical and country differences are too wide, and the problems are far too numerous. Serious attempts must be made to secure considerable additional resources to finance and support many different aspects of research on these crops. Such resources should be made available to national and international research institutions, and universitites, as well as to relevant industries - provided their proposals meet the following criteria:

1. they fit into an established general order of priority;
2. they are part of a sound research programme;
3. the research results are made freely available to all other interested parties.

There are many countries, institutes and institutions already involved in research and development of roots, tubers, bananas and plantains, others are interested but lack the necessary resources. There are different problems in the producing countries in all continents, many of them require decentralized research and development by national institutions. There are also specific production and processing problems where industry can parti-

cipate. It seems that additional resources assisting only one specialized research institute or several institutions would be the most appropriate method of supporting the development of these crops.

In this regard it is certain that effective plant quarantine measures and institutions will play an important role in agricultural research and development in Africa, especially for roots, tubers, bananas and plantains. In spite of in vitro exchange of genetic material, the need for quarantine measures and institutions exists. Many countries do not have the facilities either to send or to receive in vitro material. As a first step, a review of the situation in Africa is required, after which a number of different follow-up actions need to be taken including agreement and acceptance of the most appropriate plant quarantine procedures and the establishment of national, sub-regional or regional quarantine stations to assist in the importation of pest and disease-free planting material. These measures are urgent in order to support the exchange of vegetative material and to prevent more pests and diseases from being introduced into Africa, and they will require considerable financial and human resources. They are of high priority for any special action programme in support of traditional crops.

Finally two different questions must be raised.

First, the problems of roots and tubers, bananas and plantains are challenging the ingenuity of the researchers, the sensibility of the policy makers and administrators and the generosity of the donors. For the benefit of the less fortunate among the more than one billion people in the developing countries for whom these crops make all the difference and ensure their right to freedom from hunger and poverty, are we ready for the challenges?

And secondly: Research has moved slowly - sometimes too slowly - from the individual crop to the total enterprise and finally to the whole-farm approach. For the benefit of future generations has the time not come for an ecological zone approach, to safeguard the fragile environment and to ensure on a large scale sustainable development and protection of scarce resources not for our but for our children's COMMON FUTURE?