The Role of Phytopathological Research in Developing Countries

G. Viennot-Bourgin

Laboratoire de pathologie Vegetale, Institut nationale agronomique, Paris, France.

The purpose of this report is to define the contribution made by phytopathologists towards improving conditions for humans and domestic animals in developing countries. We are aware of the difficulties involved in such a task, but we undertake it gladly. In doing this, we largely refer to the abundant documentation which reflects the considerable efforts made in developed countries by specialized institutes, agencies, and foundations to solve phytosanitary problems. Special tribute has to be paid to the Food and Agriculture Organization of the United Nations which, according to the 1951 Plant Protection Convention, has created a network of regional organizations facilitating the activities of experts and the establishment of research centers. Information on pathogens has been exchanged reasonably well between countries aware of the importance of plant protection, and this has yielded beneficial results. Finally, we shall take into consideration our own experience, bearing in mind that in many cases it remains incomplete.

1. *Climate, crop cultures and diseases.*—

A biologist has some difficulty in distinguishing between developing and developed countries. In almost all temperate climates where the so-called developed countries are located, there is a constant and strengthening human relationship and one could expect that under these conditions life should be running smoothly and free from disasters. However, we know that man is living in a permanently unsatisfactory state, the extent of which is not alleviated by the tools his genius has created. It must also be stressed that even in these countries remote places still remain where communities are isolated from the modern world and practice systems which can be compared to those in use in the Kalahari Desert, in Northern Australia, or in the Arctic where huntsmen and food collectors still exist.

We shall consider here in greatest detail, the countries characterized by inadequate protein supply and representing a wide pattern of dispersed races with unique ethnic characteristics that render the introduction of modern agricultural technology very difficult. The population of these countries suffers almost constantly from malnutrition and has to face hunger in cases of climatic disasters or because of pest outbreaks, since there are no reserves to bridge critical periods of shortage.

Most of the developing countries are often characterized by differentiated climates which delimit ecological regions evidenced by particular vegetation patterns, which reflect areas suitable for agricultural production or those where advantage can be taken of the wild flora. In Africa, for instance, the food range of the populations is clearly defined according to climatic conditions. In the hot and dry climate prevailing in the Saharan (deserts and subdesert steppes) and the Sahelien and Sudanese regions, the basic food consists of millet, sorghum, maize, and rice; whereas, in the hot and humid Guinean regions, plants with rhizomes like cassava and yams, and also bananas, etc., are the dominant crops.

Recognition of this fact facilitates the evaluation of the extent and kind of diseases that may be expected in specific areas. Accordingly, fungi and bacteria will generally find optimal conditions in areas with very high humidity. An intense parasitic or saprophytic activity is detrimental to all aerial parts of the plants. Thus, one single leaf always bears several juxtaposed or associated species which may be competitors. The simultaneous presence of various developmental stages and the luxuriance of fructification forms are responsible for an abundance of inoculum.

In cases where there is sufficient humus or organic material accumulated for agricultural purposes, the high humidity allows for the development of the mycelium on or just underneath the soil surface. Layers of mycelium and the development of rhizomorphic forms will occur, bringing about the reduction of antagonisms due to the disappearance of numerous species.

Crops established in humid areas are frequently exposed to severe bacterial infection which is unknown in semi-arid areas, even where irrigation is practiced. The almost constant high humidity with condensation during the night, as well as rain and wind largely favor the dissemination of the inoculum and, thus, the passive infection through stomata or hydathodes of pathogens such as *Pseudomonas lachrymans*, *Xanthomonas campestris*, *X. oryzae*, or *P. citri*). Certain bacterial diseases have a wide geographic dissemination; for instance, *P. solanacearum* extends between the 40th Parallel North and the 40th Parallel South, and from the sea level up to 7,000 feet. One of the strains of this bacterium induces the wilt disease of the Solanaceae while another is responsible for the Moko disease of bananas. In all cases, this pseudomonad destroys the carbohydrate sources which are indispensable for the populations of Central and South America.

In dry regions, fungal or bacterial diseases are less important, but insects become more abundant. Although the spots on the leaves are frequent (*Helminthosporium* spp., *Gloeocercospora* spp., *Colletotrichum* spp., etc.) and are responsible for a premature reduction of the foliage, it becomes apparent that the reserve storage organs are also often diseased. Six species of Ustilaginales are thus known to occur in the ears of *Sorghum*, while *Sclerospora graminicola*, *Tolyposporium penicillare*, *Fusarium* spp., *Balansia claviceps*, and *Sphacelia* sp. destroy the inflorescences of *Pennisetum typhoideum*.

The crops of these regions are also prone to physiological, abiotic injury often occurring as a consequence of sudden variations in temperature and big rain drops. Typical, for instance, is tip burn, a marginal necrosis resulting from the passage from a humid night to intense sunshine. It can be observed also that certain pathogens have an increased activity because of soil management practices, irrigation, and the incorporation of organic material into the soil, etc. Unusual cultural techniques may result in severe organic disorders and consequently in heavy damage.

Deleterious effects on the aerial parts of the plants are due not only to poor soil management, but also to a water deficiency in the soil or in the plant at precise growth periods as a consequence of poor irrigation techniques or lack of precipitations. These conditions favor the development of pyriculariosis in rice. Alternating dry and humid periods induce cracking of groundnut shells, which increases the frequency of invasion by *Aspergillus flavus*. The amount of aflatoxins in seeds is then substantially increased. In this connection, it mst be stressed that the flooding of the soil during a prolonged period of time did not bring about a substantial reduction in *Fusarium oxysporum* f. *cubense* inoculum in the soil of banana plantations. However, it seems that in Dahomey, *Pseudomonas solanacearum* cannot survive if the soil is flooded for several months. Additionally, there is substantial evidence that *Phytophthora cinnamomi* is a very serious disease in poorly drained soils, whereas, in light and aerated soils it remains insignificant. It is appropriate to mention here the impact of certain soil constituents (and, in particular, of micro-elements) on diseases, even if the available data are still scarce. In India, it seems that zinc salts hamper the development of *Sclerospora sacchari* on maize, while a zinc deficiency induced the "rosette of pecan" and the "zonal chlorosis" of citrus. Minute amounts of fungicides and insecticides have favorable or detrimental effects on the activity of *Rhizobium* spp.

Since a large number of developing countries often have to face difficult climatic conditions that do not permit high yields, careful consideration should be given to any modification of the established equilibrium in arable soil. Any change must indeed rely on sound investigation which may be long and delicate. Too often, certain initiatives led to a degree of soil sterility which was definitely worse than the one registered under natural conditions as practiced by the natives. In most of the developing countries the grower suffers directly from diminished quality and quantity of his crops. Only very exceptionally is he in a position to correct a situation resulting from a disaster like climatic accidents, floods, fires, and epiphytotic diseases. It is understandable why any effort towards improving cultural techniques and, in particular, crop protection measures (the effect of which is not readily recognizable), cannot easily be accepted or financed.

Under the present conditions, more than 180 natural or partly processed products from the tropics are used for very different purposes, i.e. timber, stimulants, fresh or dried fruits, seeds for consumption, plant fibres, drugs, essential oils, perfumes, oil products, spices, etc. Perishable food and feed-stuff amount annually to a total of about 212 million tons. The above list has to be completed by those commodities which represent an integral part of the food consumed in the country itself like cassava, yams, taro, spices, cereals, various herbs, etc. which are rather uncommon on European or North American markets.

The study of diseases on crops for local consumption has, generally speaking, not received special attention in developing countries. This gap is due to the fact that these commodities are mostly not exported and therefore of no direct interest to the governments. This is true as long as expensive imports, for instance of rice and sugar, have not been required to complement the normal diet. In certain countries, however, there is a trend towards encouraging such studies.

On the other hand, so-called industrial crops often benefit from substantial financial investment and from an appropriate management mostly assured by national or international organizations. Short-term plant protection techniques are applied on extended areas and the success of the implementation of these technologies depends essentially upon the knowledge of two elements: (i) pest and disease distribution on the plantation, and (ii) potential dangers inherent in pests and diseases existing in the vicinity or in other regions. This needs proper identification of the diseases and a good knowledge of the epidemiology, including the mode of transmission and dissemination. The studies and the experiments have to be conducted by specialists, preferably under ecologically favorable conditions. In the second step, it is necessary to carry out local and regional investigations and to collect samples for identification. On the plantations, this work can be taken care of by specialized inspectors and, to some extent, by the growers themselves. Based on this information, the phytopathologist will recommend the measures which should be taken: protection of areas free from the disease (exclusion of inoculum), eradication, direct protection of the plants, use of resistant varieties, improvement of cultural techniques and therapeutic measures.

2. *Protection by biological process.*—

The physical or chemical eradication methods have brought about only temporary results, whereas the isolation of infected areas has so far prevented, for instance, the spreading of the Fiji disease on the East coast of Madagascar Island.

Using resistant or tolerant varieties resulting from clonal selection or hybridization is, no doubt, a very successful means of biological control. The work accomplished by the Queensland Bureau for Sugar Research is a remarkable example in this respect. Varieties of *Pennisetum typhoideum* resistant to *Sclerospora graminicola* which caused severe losses in the Haute-Volta, and in Senegal and Niger proved extremely advantageous.

The research conducted on *Fusarium oxysporum* f. *elaeidis* attacking the oil palm trees can be considered as a model. This disease, observed for the first time in Zaire where it affects today 25% of the trees, is widespread in almost all countries of West Africa. In the Dabou Savanna of the Ivory Coast, 10,000 palm trees have been destroyed and, as a consequence of this disaster, a vast programme of research on suitable germ plasm has been set up. To reduce the losses due to *Fusarium oxysporum* f. *albedinis* on date-palm trees in the oasis of Morocco and Algeria, vegetative reproduction of resistant or tolerant cultivars is currently being carried out.

In Guinea, production of *Coffea canephora* has been endangered by the tracheo-mycosis due to *Fusarium xylarioides*. In 1958, it dropped to 7,700 tons. Thanks to FAO this species has been replaced by the *robusta* variety, and in 1971 the yield reached nearly 43,000 tons. As a result of studies undertaken since 1955 by the Coffee Rust Research Center in Oeiras (Portugal) it was possible to prevent the disaster which could have resulted from the introduction in 1970 of *Hemileia vastatrix* in Brazil. Strict phytosanitary measures always pay in the long run, as illustrated by an example in Ghana where the average yield of fermented dry coffee is only 250 kg/ha; whereas, in regularly treated groves, 450 kg and more can be obtained.

Finally, it has to be recalled that *Helminthosporium oryzae* was responsible for the great 1943 famine in Bengal, which led to the "grow more food" campaign in India. This project included measures like the establishment of a permanent agricultural research supported by the Government, the development of agricultural techniques (irrigation, choice of healthy seeds, fertilization) and a plant protection system with the appropriate equipment. By 1972, 100 helicopters were available for aerial pesticide application.

The study of the conditions in which *Aspergillus flavus*, producing aflatoxins, develops has been undertaken in Senegal which produces in normal years 1 million tons of groundnuts. It has thus been possible to define two periods of contamination. The first takes place when the shells are still in the soil or starting to dry; the second occurs during the period of storage in piles, especially if the rain is abundant. The judicious choice of harvesting time and the improvement of storage facilities resulted in a low content of aflatoxins.

The introduction of new varieties or cultivars from other areas is not always successful and several recent experiences show that new selections do not bring about the final solution to the complex problems of resistance breeding against diseases. It is probable that the introduction of varieties from abroad originated the Fiji disease of sugar cane in the South of Australia and of *Sclerospora sacchari* in the North. The maize varieties with a high lysine content are particularly susceptible to seed-rot. Recently, experimental plots planted in Nigeria with cassava (*Manihot utilissima*) selected for higher protein contents have been ruined by a *Pseudomonas* sp. which had previously not been recorded (Circular of the Interafrican Phytosanitary Council of 3 October 1972). It appears also that the flavor of rice selected for resistance or tolerance to *Pyricularia oryzae* is not always accepted by the natives. On the other hand, resistance to fusariosis of bananas in the variety Dwarf Cavendish on the Canary Islands, where it has been cultivated for 50 years, is still incomplete.

The semi-dwarf wheat varieties, which are generally characterized by a reduced size and homogenous stalks, provide an abundant and tight foliage which retains the humidity and creates ideal conditions for the development of pathogens. In North Africa and the Near East, these high-yielding wheat varieties turned out to be particularly susceptible to *Septoria tritici* and to certain rust strains. This, in turn, confronts the phytopathologist with new problems. In the State of Punjab a new disease due to *Pythium irregulare* has been found in 1968 on semi-dwarf wheat varieties. The fungus induces dwarfing of the plant which is due to a toxic metabolite of the pathogen.

For certain crops, there seems to be a certain inability to improve yield and by using new techniques to develop defense mechanisms against diseases. Up to now fertilization in cacao plantations has given only deceptive results without any economic return.

In California, *Persea* species show a good resistance to *Phytophthora cinnamomi* but it has not been possible, so far, to overcome the incompatibility of the grafting with *Persea americana*. Similar problems exist for certain *Citrus* varieties resistant to tristeza.

3. *Protection by chemicals.—*

For crops of high value, fungicides have received some attention in developing countries. Information and advice issued by institutes or by individual experts have been strengthened by actions taken by numerous chemical firms, for which new and important markets were thus opened. In practice, however, only a relatively limited amount of active ingredients is used, representing a total which remains well below the quantities really needed for adequate protection.

There are various reasons for this situation, and a first step towards an improvement would consist in governments facilitating the import of processed chemicals by reducing the import taxes. The processing in the importing country would indeed limit the range of available suitable compounds. An important factor is also the availability of storage facilities for fungicides, which should be adequately packed and protected against climatic influences. Provisions should also be made to assure that the packaging material can be destroyed after usage. The lack of appropriate application equipment or its premature deterioration due to insufficient maintenance or care represents another obstacle. Finally, the pesticide should be made available in ready-for-use packages providing the correct dosage rate for the commonly used volumes and application equipment. This, in turn, also notably increases the prices.

Consideration has to be given to possible accidents involving mainly the operators, since the scarcity of water does not encourage the use of safety precautions. Seed-dressing already provides a significant means of controlling pathogens in practice. This technique applied on groundnut seeds with a mixture of fungicides and insecticides is now in use in many countries. The increase in yield that it provides is rather modest, if the first growing phase takes place under optimal conditions. However, in the Sudano-Sahelien region where the precipitations are irregular, increases of 20 to 25% have been registered. In North Africa, Iran, and India seed treatments directed towards controlling *Tilletia* spp. and *Ustilago nuda* are performed on the basis of grower corporations and yield beneficial results. The covered smut, *Sphacelotheca sorghi* of sorghum, which in Togo is responsible for the destruction of up to 50% of the yield, is kept under control by seed-dressing. The same holds for the loose smuts caused by *S. cruenta*. For the control of the fungi mentioned, copper salts, formol, organo-mercurials, and (in particular) thiram are mostly used. In India, sorghum seeds are dressed with powdery sulphur. Seed treatment of cotton against *Xanthomonas* spp. has not only increased the yield but also has produced longer fibers.

Fungicide applications to foliage are performed in accordance with a calendar scheme based on regular field observations. In the case of cercosporiosis on groundnuts in Cameroon, it has been observed that in treated fields the yield is of the order of 4,500 kg/ha and without treatment, 2,500 kg/ha. In the case of *Cercospora musae*, control on banana trees started with Bordeaux mixture 40 years ago. Since 1953 in Guadeloupe the use of mineral oils as emulsions with copper or dithiocarbamate, mostly applied from the air, has become widespread. Presently preference is given in Africa to the spraying of benomyl emulsion because of its better effect and absence of phytotoxicity. Control and protection of the coffee rust, *Hemileia vastatrix*, are still obtained with Bordeaux mixture at 1 or 2% or with commercial copper fungicides which are applied three to five times a year. In Tanganyika the application of the full spray program on small acreages brought a yield increase of 109%.

Formulations based on antibiotics gave unsatisfactory results in certain regions, mainly in rainfed rice cultures where pyriculariosis has to be controlled. In the Cameroon, cacao production is estimated at 170,000 tons for plantations covering 400,000 ha. It is thought that without treatments losses due to *Phytophthora palmivora* could be as high as 50%. Notwithstanding the use of 700 tons of copper-4-oxychloride, the annual loss can still reach 45,000 tons.

Although it is difficult to find a final solution to these problems, it can be said that in the rather privileged regions good agricultural practice can alleviate the difficulties. In cases where good basic principles are not respected, the risk of economic failures is greatly enhanced. The history of plant pathology brings many impressive testimonies of problems resulting from monocultures or at least to the weakness of this cultural system. A classical example of this is the famous exodus from Ireland in 1845 as a consequence of *Phytophthora infestans*. This ruined the whole potato production which, since 1565, had represented the essential crop in that country. In Ceylon, the first years following the appearance of *Hemileia vastatrix* in 1868 were characterized by such severe losses that coffee cultures had to be replaced by tea cultures. These latter started in 1878 and became a real economic success.

Senegal is presently an important importer of wheat, rice, and maize although millet, sorghum, and maize were formerly produced in the country. Exports of groundnuts have replaced these crops, but now the authorities are aware of the danger involved in neglecting basic food supply and recognize that a compromise must be found. This is why, since 1960-61, agricultural research has been oriented towards developing food crops which had previously been neglected.

An important pathological feature in developing countries concerns pathogens that induce moulds and rots in storage and during the marketing phase. Locally, commodities like tubers, roots, rhizomes, certain seeds, vegetables, and fruits assure the food supply. During harvest, the products are exposed to numerous mechanical injuries and to attacks by insects, rodents, etc. Transport conditions involving repeated handling and exposure to sun and dust substantially increase the risks of contamination. On certain fruits like eggplants, tomatoes, spices, husks (pulps), and others, anthracnoses produced by *Colletotrichum* spp. and *Glomerella cingulata* develop which are followed by species of *Fusarium*, *Penicillium*, and *Cladosporium* while bacteria like *Erwinia carotovora* produce wet rots and fermentations which are rapidly generalized. In the last stage a total destruction attack by species of *Aspergillus* and *Rhizopus* occurs. Considerable losses due to rots are yearly registered on all perishable food like cassava, yams, sweet potatoes, plantain bananas which represent the nutritional basis of almost 400 million inhabitants.

For the total world production, it has been estimated that preharvest losses amount to 20% and that another 10% occurs between harvest and consumption. According to a more recent estimation, 30 million tons of food produced in the tropics is yearly lost. This figure does not include cassava, and the annual loss in yams reaches 15% in Western Africa. In India, 40% of the mangoes are destroyed between harvest and consumption, while for bananas it is considered that one-third of the production is consumed locally, one-third destroyed by rots and one-third exported.

Many tropical commodities, particularly fruit and vegetables, suffer from lack of long distance transport and storage. Most of them have low prices which do not allow for storage in conditioned warehouses. For many of them, the period preceding the marketing is detrimental since they are attacked by latent parasites like *Gloeosporium* spp., *Colletotrichum* spp., *Deightoniella torulosa*, *Verticillium theobromae*, and *Botryodiplodia theobromae*; or by pathogens which appear later on like *Fusarium* spp., *Alternaria* spp., *Gloeosporium musarum*, *Mucor* spp., *Rhizopus* spp. and *Trachysphaera fructigena*.

Very simple and systematically applied methods can certainly assure a good quality and appearance as well as a good nutritional value of products intended for export in developing countries. In Ghana the use of boxes containing dried grass turned out to be very convenient for the transport of tomatoes. The rate of rot which initially amounted to 16% could thus be reduced to 3%. Accordingly, heavy losses of the order of 80% were registered on banana exports from Taiwan to Japan as a consequence of *Botryodiplodia theobromae*, *Gloeosporium musarum*, *Ceratocystis paradoxa*. Because of the development of special ship loading techniques and treatments with systemic fungicides as recommended by FAO experts, it became possible to prevent almost all of these losses.

4. *Current problems.*—

Once the pathogen has been identified, an efficient control method may not be available. It is known, for instance, that in Colombia *Monilia roreri* can destroy 65% of the cocao production and *Phytophthora palmivora* 35%. In Surinam and British Guyana certain plantations are destroyed by *Marasmius perniciosus*. Ten treatments are needed for the control of *Phytophthora* while no efficient method is available for controlling the three other parasites. It also appears that *Colletotrichum coffeanum* attacking the coffee plantations is much more detrimental in Africa than it is in Asia, apparently because different physiological races are invovled.

The occurrence of *Hemileia vastatrix* in South America has raised anew the problem resulting from *Mycena citricolor* and *Pellicularia koleroga*. This latter parasite is in itself responsible for losses ranging from 10 to 80% depending upon the region concerned. The spreading of *Cercospora musae* since 1969 in Bolivia has also brought about the problem of *Stachylidium theobromae*. On the other hand, it should be stressed that the causal agent of skin spots on hard wheat has not yet been found. In British Guyana *Xanthomonas albilineans* is responsible for more than 25% losses on sugar cane, and the chlorotic streak virus, as well as the recently detected ratoon stunting disease, need new research. Studies on virus transmissions have to be continued because of the repercussions of these diseases on growth and yield. This is the case for the cassava virus in Nigeria which reduces the yield by 20%. In the Far East, emphasis is laid on the study of the numerous rice viruses and their specific vectors and concomitantly on the development of resistant varieties. The virologist has to face a hugh task for the identification of viruses on *Citrus* in Asia, including vector research and the selection of suitable cultivars.

Certain secondary pathogens suddenly can cause major diseases. It is most probable that *Exobasidium vexans* is the causal agent of the leaf curl on tea which has been reported in Papouasia since 1964. As for *Colletotrichum gloeosporioides* and *C. dematium*, both polyphagous species, they are regarded as responsible for the premature defoliation of *Hevea* in Malaysia. Since 1965, *Verticillium dahliae* has provoked the sudden dieback of cacao on extended areas of plantations in Uganda. *Puccinia arachidis*, which was unknown up to 1969 in the Punjab, rendered the groundnut cultures impossible in the Antilles because of its detrimental effects. The cultivar 'Ricin R 63' from Dahomey showed foliage wilting symptoms when cultivated in Togo; it is thought that several fungi may be responsible for this phenomenon.

An example of an unusual geographic distribution pattern is illustrated by the disease causing defoliation on pines and caused by *Dothistroma pini* (= *Scirrhia pini*). This fungus occurs in North America, Chile, Kenya, Great Britain, Yugoslavia and (since 1964) in New Zealand.

Another devastating effect is registered in the Southwest of Australia where 80,000 ha of *Eucalyptus* forests representing about 1,400,000 trees have been destroyed by *Phytophthora cinnamomi*. Every year the diseased areas increase by roughly 4%.

Finally it should be stressed that certain crops in developing countries suffer from serious diseases, the epidemic character of which has been confirmed by their development and continuous extension, but for which the causal agent has not yet been identified. These are mostly wilt diseases and represent a continuous threat, particularly in remote areas, as is the case on coconut trees attacked by cadang-cadang in the Philippines, Kaincope in the Togo, lethal-yellowing in Jamaica, root-wilt in India and perhaps the Kribi disease in Cameroun. On San Miguel Island, the number of coconut trees amounted to 250,000 in 1937 when the cadang-cadang disease was first recorded. This number has been drastically reduced to 80 apparently healthy trees in 1962. Various hypothesis have been considered including fungus, mycoplasmosis, nematodes, nutrient deficiency, abiotism, physiological disorders linked with the soil or the climate, etc. It is still not possible, at this stage, to say whether the disease (which has many symptoms) is caused by more than one causal agent.

The dieback of the cacao tree represents a mixture of various disease symptoms from which the ordinary dieback due to inadequate cultural measures, the *Botryodiplodia theobromae* recently recorded in New Guinea, could be isolated. On the other hand, it is observed that several fungi are present on young oil palm trees suffering from blast.

In Colombia and Peru, it was necessary to abandon the hypothesis that the decay of the terminal shoot of the oil palm tree is due to potassium deficiency. This rot induces a sudden decline which ruins the trees within a few weeks.

Many diseases are considered to be of abiotic origin simply because their causal agent is not exactly known. However, often there are symptoms which tend to indicate that a parasite is involved. In the case of *Helminthosporium oryzae* which is responsible for brown spots it is not excluded that other causal agents are involved.

5. *Conclusions.—*

These considerations show how important it is to consider phytopathological problems on an international level, in order to assure progress in all the different disciplines including morphology, physiology, organoleptic aspects, and economy.

For a period of more than 30 years, a considerable number of initiatives and actions have been taken jointly by different countries with a view to improvement of the phytosanitary situation in developing countries. Positive, and sometimes spectacular, results have been obtained, but mostly only locally. They consist essentially of improved crops or new varieties resulting from initiatives or from subsidies given by foreign financial organizations. The industrial or plantation crops which were developed by a joint effort of agronomists, geneticists, physiologists, pathologists, and entomologists represent, for the country concerned, an evident economic asset that is worth the investments made. In these plantations, the phytosanitary situation may be compared to conditions encountered in developed countries. There is a difference, however, in that the dangers inherent to monocultures are enhanced because of the favorable ecological conditions favoring the development of pathogens.

For a given pathogen and a given crop, the damage will be much higher in a "poor" country. As an example, *Uromyces appendiculatus* on *Phaseolus* and *Vigna* may be noted. This rust induces defoliation and can thus ruin the crops in many African countries and in the Antilles, while it is only of minor significance in Europe. Similarly, the ubiquitous *Septoria tritici* is considered to be at most the weak saprophyte in temperate areas, whereas it is a dangerous plant parasite in Africa and the Middle East.

The growing interest in phytopathological research in developing countries and the introduction of biological and chemical control methods should concentrate more intensely on those crops which are essential as food supply for millions of people. Progress is currently being made in the study of diseases of main cereals; but for plants producing tubers and rhizomes as well as for leguminous plants, and the plantain bananas, the studies still are insufficient. Gene banks for plants grown in various countries have to be established. It is necessary also to set up centers for the development of plants and seeds such as in Dahomey, thanks to the initiative taken by FAO. These centers consider certain important food crops, including vegetables, and assure the distribution of healthy seeds and cuttings.

It is indispensable that governments be aware of the possibilities offered to save valuable crops from destruction because of scientific and technical progress made in phytopathology. To achieve this it is important to increase and complete the research teams and make available to them proper installations and means allowing for rapid identification of the pathogens and subsequent choice of appropriate control measures. We should not repeat the disastrous experience of the tracheomycosis of the coffee tree, a disease which was suspected in 1935, and against which the first control means were applied only ten years later when the whole of West Africa was already contaminated.

An adequate reporting system and a continuous surveillance should prevent illicit introductions such as the smut of sugar cane, the white tip and *Rhynchosporium oryzae* on rice in Africa.

In this connection it is to be stressed that *Puccinia arachidis* represents a serious potential danger for the African continent which, like Asia and Indonesia, is also threatened by particularly detrimental diseases of American origin which attack cacao and rubber trees.

It appears that a generous development of well-equipped teams and a close contact with institutes and foundations in developed countries provides the only safeguard for rapid and economic action in cases of outbreaks of diseases of plants.