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# GLOBAL PROGRAMMES FOR DISEASE VECTOR CONTROL

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Summary The prevention and control of many vector-borne diseases are based largely upon the use of chemical pesticides, due to the limitations of the immunization and chemotherapeutic tools, when available, as well as to the insufficient development of genetic and biological methods for controlling the vectors. The most important diseases affect rural communities in the developing countries, especially in the tropical zone. In spite of the problems encountered, malaria eradication and control programmes have given lasting results, except in Africa. Concerted international approaches are being undertaken, or considered, for control of onchocerciasis and trypanosomiasis in Africa, and schistosomiasis will probably be the next candidate to be considered for control. Urban pest control is probably, after malaria control, the next largest public health user of pesticides. With the trend towards the establishment of a new international economic order, increased resources for the control of vector-borne diseases in the tropical zone are foreseen.

Résumé La prévention et le contrôle de nombreuses maladies transmises par des vecteurs sont largement basés actuellement sur l'emploi de pesticides chimiques. Ceci est dû tant aux insuffisances des agents immunisants et chimiothérapeutiques, lorsqu'il en existe, qu'à l'état encore rudimentaire des méthodes de lutte biologique et génétique en voie de mise au point pour la lutte contre les vecteurs. Les plus importantes de ces maladies affectent les collectivités rurales des pays en voie de développement, notamment en zone tropicale. En dépit des difficultés rencontrées, le programme de contrôle et d'éradication du paludisime a donné des résultats durables, sauf en Afrique. Des actions internationales concertées sont entreprises ou envisagées, pour la lutte contre l'onchocercose et la trypanosomiase en Afrique, tandis que la lutte contre la bilharziose pourrait bien constituer le prochain objectif. La lutte contre les vecteurs et nuisances en zone urbaine constitue probablement, après la lutte antipaludique, le principal marché pour les insecticides employés à des fins de santé publique. La tendance à l'établissement d'un nouvel ordre économique international devrait résulter en l'accroissement des ressources consacrées à la lutte contre les maladies à vecteurs en zone tropicale.

## INTRODUCTION

On a long-term basis it is hoped that the prevention and control of vector-borne diseases will increasingly rely upon immunization, chemotherapy, and appropriate modifications of the environment, complemented only by vector control in special instances. At present however, such an ideal approach is only technically and operationally feasible for a few of these diseases. Thus the prevention and control of most vector-borne diseases depends, and will continue to depend to a large extent for the foreseable future, upon vector control. Although genetic and biological methods might offer promise for controlling vectors, they are in their early stages of development and present operations are almost exclusively based on pesticide applications and some health sanitation. It must be furthermore stressed that the most promising of the biological control agents are microorganisms which will probably be used in the same manner as chemicals, thus constituting biological pesticides (WHO 1973).

In its broad sense the term "vector-borne diseases" includes all diseases transmitted by a vector, having an intermediate host, or an animal reservoir. The most important of these diseases affect rural and sometimes urban communities of the developing countries, especially in the tropical zone. Some diseases can also sporadically constitute a serious threat for the health of the people of developed temperate countries, such as tick- and mosquito-borne encephalitis, tick-, flea- and louse-borne typhus, plague, etc. The list of those permanently affecting the tropical areas is much longer and includes, over and above the diseases already mentioned, malaria, lymphatic filariasis, African trypanosomiasis, Chagas' disease, onchocerciasis, schistosomiasis, yellow fever, dengue haemorrhagic fever, etc. Most of these diseases occur over large areas, a number of them are zoonoses with animal feral reservoirs. Prevention and control operations, to give lasting results, must be undertaken on a sub-regional, regional, or even global basis and thus require very large resources, often far exceeding those that the affected countries can provide. Inter-country co-ordination and co-operation must play a large role in the planning, funding and implementation of the control operations, as well as of the associated applied research activities. By its very nature WHO is closely associated with many of these control projects and programmes, starting with the planning phase (WHO 1975).

## THE WHO ROLE

Although the Constitution of WHO stipulates that the Organization shall "act as the directing and co-ordinating authority on international health work" this does not imply any supranational authority. Thus WHO, while gathering technical information, developing methodology, proposing regulations and promoting co-operation, only assists governments on their formal request. Within this framework, global programmes for disease control and their vector control components are those whose implementation is recommended by the member countries through the World Health Assembly. These are then carried out at the national level by each country at its own will, and may be with or without any direct assistance or co-ordination from WHO. Similar situations can develop on a regional basis, as a consequence of recommendations made by the WHO Regional Committees.

The best known example of such a global disease control programme is the malaria eradication programme. It resulted from the implementation of many malaria control programmes all over the world, of which some achieved outstanding success within a few years, while some others were faced with immediate insecticide resistance problems. The unanimously agreed goal was therefore to eliminate the disease through simple

methods of vector control before insecticide resistance of the populations of vectors could become an insurmountable obstacle. Technical and other difficulties had been underestimated, slowing down the operations in many countries, allowing resistance to slowly develop. This has now jeopardized the programme over huge areas, inducing a redirection of the Organization's policy towards malaria control without time limits. Although eradication was not achieved on a world-wide basis, and maintenance of the present degree of control sometimes constitutes a problem, the concentrated effort made for a quarter of a century to fight this disease has, with Africa as the only exception, considerably reduced its socio-economic importance. Amongst the many activities related to the malaria control or eradication programme, WHO has developed control and application equipment, has trained specialists at all levels, has organized the purchase of supplies and equipment on behalf of some member countries, has channelled voluntary contributions towards developing countries needing them, has assigned WHO staff to national projects pending the training of national specialists, etc. This has resulted, except in Africa, in a rather well-co-ordinated global programme, having even evolved its own terminology and rules, with every national decision still being made on a purely voluntary basis (WHO 1974).

With a rather different, sub-regional approach, the Onchocerciasis Control Programme in the Volta River Basin area is another example of a large vector control operation for disease control. Onchocerciasis, the river blindness disease, constitutes one formidable obstacle to the economic development of the fertile river valleys in most countries of the African savanna belt, north of the Equator. In view of the enormous flight range of the vector, limited-scale control operations have failed, although an inter-country project covering 60,000 $km^2$ did show some promising results in the central and northern parts of the treated area. Thus seven countries decided to join efforts for implementing a 20-year 700,000 square kilometre control programme, with the assistance of agencies of the UN system (UNDP, FAO, IBRD and WHO) as well as of donor institutions and interested governments. For this control programme, of which WHO is the executing agency, a special fund was established under the custody of IBRD; UNDP, FAO and IBRD are responsible for the economic development projects made possible by the interruption of the transmission of the disease. The control operations are centrally managed from a headquarters in Ouagadougou, Upper Volta, and are carried out over the whole area by WHO teams on the behalf of the seven countries concerned. A joint co-ordination committee composed of all the parties to the special fund meets once a year to consider the results of the operations as well as the plans and budget proposed for the following year. If successful, this programme could constitute a model for most of the onchocerciasis-plagued areas of tropical Africa which represent over 20 times the size and population of the present control area (WHO 1973a).

Another ambitious programme is under advanced planning by FAO to control the animal trypanosomiasis, and possibly its vectors, from the entire savanna belt of tropical Africa, in association with UNDP, WHO, and other agencies; human sleeping sickness is endemic in the same areas and has the same vector. It will probably have its original planning, management and implementation structures. Many policy and administrative approaches will have to be considered once the control methodology, the specialized operators, and the appropriate long-term resources are available. From a purely socio-economic viewpoint, one of the most obvious targets for future control operations would be the vectors of lymphatic filariasis, the intermediate hosts of schistosomiasis, the vectors and reservoirs of Chagas' disease and body lice in louse-borne typhus areas, but many other targets could be justified upon socio-economic grounds on a sub-regional or inter-country basis (WHO 1973b, WHO 1966).

## SOME OF THE OBVIOUS TARGETS AND THE TECHNICAL PROBLEMS INVOLVED

### Malaria

Now that it is obvious that malaria eradication is not an attainable goal in a number of countries, anti-malarial vector control operations will probably be carried out for many years at a rather constant level, should the national and international resources permit. It is estimated at present that there are over 100 million people with malaria parasites, while the number of those at risk of infection should current control operations be interrupted, far exceed 1000 million. Although larvicides are increasingly used, and there is a renewal of interest in the use of larvivorous fish, the main vector control method continues to be the application of residual insecticide deposits inside houses and other premises to kill the mosquitos when they come to bite man, or soon after they have taken their blood meal. The most extensively used insecticide is DDT, with an annual average requirement of about 38,000 tons calculated as technical. However, due to the steady development of insecticide resistance to organochlorine insecticides, the use of malathion is increasing and this trend will probably continue. Propoxur is used in a few countries and fenitrothion is certainly another suitable alternative to DDT; a number of other insecticides have given promising results when tested in the WHO programme for the evaluation and testing of new insecticides and studied during large-scale trials under tropical conditions by the WHO Field Research Units. Unfortunately all suitable alternatives to DDT for residual house-spraying are more costly and less residual than DDT, which makes their operational use difficult if not impossible, for many developing countries (WHO 1974).

### Onchocerciasis

Onchocerciasis, which occurs only in Africa, Latin America and the Yemen, affects about 20 million people and can induce blindness at a relatively early age in a large proportion of the heavily infected persons. The control of the blackfly vectors is carried out by the periodic application of specially developed larvicides to their breeding places, usually fast flowing streams and rivers. In the lowlands of the tropical zone the applications are made weekly and these control operations could be required for up to twenty years to allow for the natural elimination of the parasite through ageing. Thus only insecticide formulations which are very safe for non-target organisms and do not accumulate through food-chains can be considered. Progress in developing suitable chemotherapy would shorten the duration of the control operations, but any individual programme would probably last nevertheless many years. The present control operation requires only about 25 tons of the larvicide per year calculated on technical. In case of success, the requirement could be much larger as other areas are treated since the amount of larvicide used is related to the water flow of the treated rivers and many of the vector breeding places in other onchocerciasis foci are very large rivers (WHO 1973a).

### Lymphatic filariasis

Lymphatic filariasis occurs in all tropical and subtropical regions of the world with widespread but uneven distribution. It affects at least 250 million people with acute and sub-acute illness as well as chronic incapacitation. In Polynesia it is transmitted by feral Aedes mosquito species against which, as yet, no sound control methodology has been developed. In some rural areas, especially in Africa, filariasis is transmitted by Anopheles mosquitos, like malaria; therefore the control methodology is also based on house-spraying. The prospects for successful control are much greater because the filariae do not multiply in the human body, while the malaria parasites do. The main filariasis foci, however, occur in areas where the disease is

transmitted by mosquitos belonging to the Culex pipiens complex. This mosquito breeds in polluted water and improvement in sanitation would be the ideal means of controlling it; since this can only be a long-term solution, the best means now is the periodic larviciding of the breeding places with an organophosphorus insecticide which is relatively stable in the polluted water; fenthion and chlorpyrifos have given excellent results in tropical areas, with weekly treatments at 1 ppm target dosage. Such treatment for filariasis control as part of pest mosquito abatement may indeed be a current procedure, as a preliminary survey carried out during 1974 by WHO showed that a large amount of larvicides were used to control urban pest mosquitos of the Culex pipiens complex (WHO 1974a).

African trypanosomiasis

Although only a few thousand new cases of this killing disease transmitted by tsetse flies are registered every year, the number of people at risk amounts to over 100 million and the cost of epidemiological surveillance, early detection and treatment is high. Animal trypanosomiasis is also transmitted by the tsetse fly and occurs in the same areas, thus control programmes for the animal disease allow the participation of the human disease control component. The only insecticides which have been proven fully effective for tsetse fly control and/or eradication operations are some organochlorine insecticides which are either rather acutely toxic to vertebrates, or environmentally objectionable, or both. They are applied to the vegetation of the tsetse fly resting sites, either at single high dosage or at repeated low or ultra-low dosages. An ambitious plan is under consideration by the UN Agencies to eliminate the tsetse fly from 7 million square kilometres of African savanna over a 40-year period, for veterinary purposes. Based on the existing methodology, it is estimated that this would require a few thousand tons of dieldrin, endosulfan and/or DDT a year. However, intensive research is now being started to develop better control methods and more environmentally acceptable insecticides for this control purpose.

Chagas' disease

The American trypanosomiasis is a zoonosis, with a large feral animal reservoir. The transmission from animal to man, and from man to man, is made by a few species of hematophagous triatomid bugs and occurs inside houses and in the surrounding environment. The disease occurs only in Latin America where it is very widespread and affects the cardiovascular system, the digestive tract, as well as other organs. Its prevalence and clinical severity are not well documented in the affected countries, but it undoubtedly constitutes one of the major public health problems of the Americas, with tens of millions of infected people and many more at risk. There is no safe and effective drug. Better housing conditions and environmental sanitation measures could reduce the man-vector-reservoir contacts, but pending this long-term solution, the main control approach is based on residual house-spraying similar to that for malaria control. However, for triatomid control most control operations were formerly carried out with dieldrin but now with benzenehexachloride, since DDT is not very effective. Certain vector species have developed resistance to the cyclodiene group of organochlorine insecticides and alternatives are under investigation; propoxur has given promising results.

Schistosomiasis

Schistosomiasis is caused by parasitic worms infecting the vascular system; the parasite has a complex life cycle involving water snails as intermediate hosts. One of the four species of schistosomes affecting man also has a large animal reservoir

and is thus a zoonosis. The disease exists in many tropical and subtropical countries of the world with an uneven distribution, but is especially widespread in Africa. Over 200 million people are infected and the disease has serious debilitating effects. Its spread is greatly favoured by the development of modern agricultural techniques involving irrigation, damming of rivers, fish pond culture, etc. The control of the intermediate snail hosts involves the application, several times a year, of molluscicides to the habitats of these snails. In view of the operational costs involved, as well as of certain unfavourable side effects of the treatments on non-target freshwater organisms, control operations to date have been mostly carried out in densely populated, or economically important areas of the developing countries, and systematic control operations have been implemented in the richest of the affected countries. There is a distinct trend towards the intensification of snail control operations as a consequence of the agricultural and economic development of tropical areas where the disease already occurs, and such development could increase its prevalence (WHO 1973b).

Arboviral diseases

Special mention must be made of a number of arboviral diseases having common epidemiological and control characteristics. Japanese B and American encephalitis, yellow fever and dengue haemorrhagic fever, are widespread mosquito-borne diseases with animal reservoirs (problematical for dengue) and cause outbreaks in human populations with relatively high fatality rates and permanent after-effects amongst a proportion of the affected people surviving the illness. The population at risk far exceeds 1000 million people and involves not only tropical and subtropical areas, but also some temperate countries, such as Japan and the USA. The most widely used vector control method is the ULV application of insecticides, either from the ground or by aircraft, to eliminate the adult mosquito population and stop the transmission of the generally short-lived viruses. Due to its very large safety margin for man and animals, malathion is the insecticide of choice, but a number of other insecticides have given very promising results during field trials, and their use is a matter of national regulations and cost-effectiveness analysis (WHO 1966, WHO 1971).

## PRODUCING THE TOOLS AND TRAINING THE PEOPLE

Expressed in terms of vector control for disease control, over and above pest control and urban sanitation problems, the needs of the countries of the tropical and subtropical zone are considerable. However, sometimes the control tools do not exist or require major improvements, and qualified planners, managers and operators are very scarce in most of the countries concerned.

WHO, through its network of collaborating laboratories, field research units, disease and vector control projects and programmes, and in close co-operation with the industry, leading scientific institutions world-wide, and the other UN agencies, especially FAO and UNDP, has carried out for many years a global programme for the evaluation of chemical pesticides and the development of the associated appropriate vector control methods for disease vectors. This has sought to improve techniques with known materials, to find new materials more acceptable for use in developing countries, as well as to find materials and methods for vector control not now available. While these activities have given satisfactory results in terms of vector control methodology, much remains to be done, especially with regard to resistance and environmental problems. Although active efforts have been made for training for vector control, results have been less than satisfactory in terms of staff for actual implementation of large scale control programmes by the national authorities; partly

because the training programmes have not been ambitious enough and partly because the lack of vector control career openings at the national level has allowed most promising individuals to leave their countries or be diverted to other careers. Furthermore, health has not been considered as an important component of the economic development planning and implementation at the national and regional level. It is only now after years of costly acquired experience, that one can see an increasing trend to give health and social problems their due place from the planning stage onwards; this can only favour the development of large scale disease and vector control activities.

As part of its policy to solve some of the vector control problems occurring with pesticides, such as resistance and environmental problems, WHO is developing a programme for the evaluation and testing of biological control methods. The development of microorganisms for vector control will have to be very similar to that followed for the development of chemical pesticides.

## PLANNING, FUNDING AND IMPLEMENTING CONTROL OPERATIONS

Once the appropriate tools and the trained operators are available for specific vector control problems, the decision to undertake national, inter-country and regional campaigns is with the respective governments. The first step is the identification of the diseases against which control operations should be organized, and the allocation of their priorities for control within the framework of a long-term country health programme; this has only just been undertaken by a handful of tropical developing countries. The second step is to make a cost-effectiveness analysis of some sort, to select the most promising control approach and then define the stages of planning, costing, staffing and implementing necessary to achieve the defined goal. Should the governments require, WHO can assist the national authorities concerned during each of these stages. The WHO Regional Committees, World Health Assembly, Expert Committees, Scientific Groups, etc. constitute excellent opportunities to compare experiences, exchange views, determine fields of common interest for subsequent joint actions, and to define global strategies and priorities for the control of vector-borne diseases. As such, WHO plays a catalytic and co-ordinating role which should not be underestimated. In addition, WHO sometimes assists, not infrequently, as a resources raising agency, inducing donor countries and institutions to assist other countries through the allocation of financial grants, the secondment of technical and scientific staff, the organization of training and research activities.

## THE FUTURE

What has been done to-date for controlling vector-borne diseases in tropical countries, with due respect given to malaria control and eradication operations where they were successfully carried out, represents only a minor part of what should be done. The resources devoted to pesticides and equipment for that purpose thus represent only a very small part of what will be required in the future if vector-borne disease control is to keep pace with the socio-economic development now envisaged for developing countries.

Many of the countries affected by these diseases have had limited resources in the past, and this stands true for the present for most of them. The situation is rapidly changing with the increasing prices of certain prime materials, and implies a major re-allocation of the world financial resources and permits the progressive implementation of new more inclusive vector control operations.

The recent UN acceptance of the need for a new international economic order should facilitate and speed up such a redistribution of the resources. We can thus hope that the near future will see the planning, costing and successful implementation of an increasing number of global programmes for the control of vector-borne diseases.

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# PESTICIDE SCHEMES IN INTERNATIONAL AGRICULTURE

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Summary In the past FAO activities in plant protection have centred around development and administration of the International Plant Protection Convention, technical efforts related to pesticide residue standards approved by the Codex Alimentarius Commission, pesticide specifications, measuring resistance to pesticides, standards for pesticide legislation, methods of measuring crop losses, and developing integrated pest control programmes on major crops. In addition, FAO has been executing agency for a variety of projects financed by various donor organizations which have dealt with strengthening national plant protection programmes and regional research projects on such things as the olive fruit fly, coconut rhinocerous beetle, grain-eating birds and rodents. Other FAO activities have included a wide variety of publications, specialized meetings, seminars and training courses.

As a result of the World Food Conference held in Rome in November 1974, a special consultation on pesticides and other crop protection problems was held in Rome in April 1975 and developed detailed resolutions for future programmes in fourteen different areas that fairly well cover the major issues involved in crop protection. The FAO Governing Bodies have approved a new International Inter-Agency Secretariat to coordinate the implementation of the programme on a coordinated basis with the various agencies, donors and governments involved.

Résumé Dans le passé les activités de la FAO dans le domaine de la protection des plantes ont surtout porté sur le développement et l'administration de la Convention Internationale de la Protection des Plantes, des contributions techniques relatifs aux normes sur les résidus des pesticides approuvées par la Commission du Codex Alimentarius, les spécifications de pesticides, l'enregistrement de données sur la résistance aux pesticides, l'harmonisation de la législation sur les pesticides, les méthodes de détermination des pertes de récoltes et le développement de programmes de lutte intégrée dans les cultures les plus importantes. En plus, la FAO a été l'agence responsable pour l'application d'une multitude de projets financés par plusieurs organisations donnatrices, qui visaient surtout le renforcement des programmes nationaux de protection des végétaux et des projets de recherche régionaux sur des sujets tel que la mouche de l'olive, l'oryctes du cocotier, les oiseaux granivores et les rongeurs. D'autres activités de la FAO comprennent un grand nombre de publications, des réunions de spécialistes, des séminaires et des cours de formation.

A la suite de la Conférence Mondiale sur l'Alimentation tenue à Rome au mois de novembre 1974, une consultation spéciale sur les pesticides et autres problèmes de la protection des végétaux a été tenue à Rome en avril 1975. Cette consultation a proposé des résolutions détaillées pour des

programmes futurs dans quatorze domaines différents et qui couvrent les principaux aspects de la protection des végétaux. Les organes d'administration de la FAO ont approuvé la constitution d'un nouveau secretariat international inter-agence pour coordonner l'application du programme sur une base coordonnée avec les divers agences, organismes de financement et gouvernements intéressés.

## PAST AND PRESENT ACTIVITIES OF FAO

The involvement in plant protection and matters dealing with pesticides by the Food and Agriculture Organization of the United Nations started shortly after it was charted. Initial actions led to the development of the International Plant Protection Convention, which came into force in 1952 and is administered by FAO. This was quickly followed by FAO actions to coordinate efforts to control plagues of the desert locust, which have periodically ravaged vast areas of Asia and the Near East and Africa.

Increasing concern about the various effects of pesticides led to the establishment of the FAO Committee of Experts on Pesticides in Agriculture in 1962 which recommended the establishment of FAO Working Parties of Experts: on Pest Resistance to Pesticides; on the Official Control of Pesticides; and on Pesticide Residues. In addition, a Panel of Experts on Integrated Pest Control was established in 1966. These Statutory Bodies of FAO have been very active and taken the leadership in their respective fields and, along with international conferences convened by FAO, have helped establish the state of knowledge in various specific areas and produced guidelines or standards for international use. In recent months these statutory bodies have been updated, broadened in scope and given new terms of reference for future actions.

A major service of FAO in the field of plant protection is provided through more than 500 documents and publications covering many of the most important questions in this field.

Other continuing activities of FAO include acting as Secretariat and providing technical support for the Codex Committee on Pesticide Residues of the FAO/WHO Codex Alimentarius Commission dealing with Food Standards. The Animal Division of FAO also has active programmes dealing with control of parasites and vectors of farm animals.

Routine activities of FAO include various methods of information exchange, training programmes and technical advisory services for Member Governments. A major media for information exchange is the FAO Plant Protection Bulletin published as a periodical. Many other speciality publications and reports are issued each year.

The training courses in various aspects of plant protection with emphasis on safe and efficient use of pesticides are conducted either on a regional or national basis and are usually of about two weeks duration.

Efforts to develop methods for measuring pest losses have been compiled into manual form and are being regularly updated.

FAO provides the Secretariat for Regional Plant Protection Organizations in the South East Asia and the Pacific Region, the Near East and Caribbean areas. These inter-governmental organizations act as policy making bodies for matters dealing with pesticides and plant protection in their regions.

In addition to these regular programme activities, FAO acts as the executing agency for projects financed by the United Nations Development Programme and through trust fund arrangements for various national donor countries.

These may either be large-scale projects where FAO is assisting countries such as Thailand, Korea, Malaysia, Sri Lanka, Bangladesh, India and Indonesia and others to establish comprehensive national institutions, or they may be specialized research projects such as the ones dealing with olive fly in Greece, the Rhinoceros beetle in the South Pacific, grain-eating birds in Africa or rodents in Pakistan. There are also a variety of small-scale projects usually involving only one or two experts on specialized aspects. These field projects involve more than 100 professionals predominantly entomologists stationed in countries throughout the developing world.

In addition, specialized assistance is provided through short-term consultant visits or missions including a team of experts usually recruited from outside of FAO.

## CHANGES OCCURRING IN INTERNATIONAL AGRICULTURE

The fear of serious world food shortages along with the impact caused by substantial increases in the price of basic agricultural commodities which occurred following the reduced world crop harvests in 1972 has had a major impact on the future. It will be some time before the results of current trends set in motion by these events can be fully assessed. The first major response of the international community was the holding by the United Nations of the World Food Conference in Rome in November 1974. This was one year ago and the actions arising out of this Conference are still to have their full impact on international agriculture. Contrary to what many of the general public of the world may feel, there is and has been considerable action resulting from this Conference. The current short harvest in parts of Europe and the Soviet Union are further reinforcing these activities.

The general actions resulting from the World Food Conference can be divided between new administrative structures and financial considerations. There were basically three new bodies that have so far arisen from the Conference, all of which are in their infancy. One is the Consultative Group on Agricultural Production and Investment. This is patterned after the highly successful Consultative Group on International Agricultural Research which has brought together all the donor nations and organizations to fund and oversee a chain of international agricultural research institutes such as the International Rice Research Institute, etc. It is too early to determine if the new consultative group will be equally successful in coordinating new investment for agriculture.

Another organization established is the International Fund for Agricultural Development. It has an initial pledge goal from donors of one billion SDR monetary units.

To coordinate the actions of all previous and new international organizations dealing with agriculture, the World Food Council was established and has had only an initial meeting.

From the standpoint of financial matters, the outgrowth of the general publicity and actions taken by the World Food Conference has been to bring large increases in financial commitment to the agricultural sector by developing country governments, donor governments and international organizations. Notable among these are a multi-billion dollar commitment by the World Bank, and the more than a billion dollars sought for the new Fund for Agricultural Development. There is no exact measure of the amount of new money committed yet, but it could well be in the order of a doubling of world investment in agriculture.

Almost all the impact of these large fund commitments is yet to come. It is probably not generally recognized the extent to which this new magnitude of investment in the agricultural sector will affect the supplies and perhaps costs of trained manpower, agricultural inputs and the strains which will be put on infrastructures of all kinds.

## POTENTIAL IMPACT ON FUTURE PROGRAMMES IN PESTICIDES AND CROP PROTECTION

The World Food Conference considered pesticides as one of the priority inputs required to improve world agricultural production. As a result the Conference passed a special "Pesticides Resolution". This resolution asked for various coordinated actions by the world community and requested FAO to call, on an urgent basis, an ad hoc Consultation to detail the needs and proposed methods of ensuring they were met. This 'ad hoc Consultation on Pesticides in Agriculture and Public Health" was held in Rome on 7 to 11 April 1975. It was attended by representatives of 52 countries, major pesticide manufacturers and various international and other organizations. The Conference adopted fourteen sets of recommendations. The implications of these recommendations on FAO and other international organizations are summarized below:

1. Pesticide Supply/Demand Information System FAO to establish a continuing supply/demand information system in collaboration with WHO and UNIDO.

2. Pesticide Residue Information FAO and WHO to strengthen their present joint programme which is the basis for residue tolerances in the Codex Alimentarius Commission.

3. Requirements and Standards for: Pesticide Registration; Application Methodology and Safe Use; Scheme for Development and Registration of Commercially Unattractive Products FAO, in collaboration with WHO and other appropriate organizations, to call specified ad hoc consultations within nine months to detail the needs in these areas and suggest necessary actions.

4. Problems of Pesticides in the Environment FAO to take a more active role in formulating international policy in this area.

5. Pesticide Supply and Emergency Operations FAO to increase the present authorized use of the Capital Fund of up to US $ 750,000 for emergency action to control livestock diseases and desert locust to US $ 1,000,000 and this to be broadened to cover other major pest and disease outbreaks, particularly those of migratory nature.

The World Food Council asked international donors to pledge an additional US $ 5,000,000 for standby assistance.

6. Assessment of Crop Losses FAO to increase its activity with Member Governments to obtain reliable data on pest losses through proper assessment methods.

7. Post-Harvest Loss Control FAO to increase activity through training, consultations, publications, etc. to reduce storage losses by use of currently known technology.

8. Investment in Pesticide Manufacturing and Formulating Facilities in Developing Countries FAO, UNIDO and other appropriate agencies, as well as industry, to encourage maximum investment in developing countries based on feasibility studies.

9. Integrated Pest Control FAO to implement the international programme developed by the FAO Panel of Experts on Integrated Pest Control in collaboration with UNEP.

10. Breeding for Pest and Disease Resistance FAO to implement a programme for strengthening national plant breeding activities for pest and disease resistance.

11. Strengthening National Plant Protection Programmes FAO to set up regional or sub-regional plant protection coordinating groups to assist developing countries

in strengthening their plant protection services and to assist donor agencies in channelling their resources.

12. Training in Pest Control FAO to strengthen training activities at the regional level through the establishment of regional training centres.

An item discussed at this ad hoc Consultation and deferred for study and action by the FAO Council (interim governing body) was how to ensure and coordinate the follow-up required by various agencies, donors, recipient governments and the pesticide industry. This resulted in the adoption of the following proposal by the June meeting of the FAO Council:

" To coordinate the required actions and to implement more effectively the programmes outlined by the ad hoc Consultation, it is proposed that FAO provides the headquarters and primary staff for an International Plant Protection Secretariat. This is to be obtained from the current Regular Programme staff, plus additions proposed in the 1976-77 Programme of Work and Budget. This Secretariat would also include members named by WHO, UNIDO, and other agencies or organizations as appropriate to provide a continuing mechanism for the improvement and coordination of activities among agencies, donors, industry, etc. at the international, regional and national levels, with the Executive Secretary provided by FAO.

Policy and overall guidance would be formulated by an International Advisory Board which would be named by the organizations included in the Secretariat, major donors to the programmes and internationally recognized authorities. The technical guidance to the International Advisory Board would be given by appropriate FAO and other UN agency committees, panels of experts and the regional plant protection organizations. This Board would be similar to that in existence for plant genetic resources."

As can readily be seen by examining the new initiatives proposed by the ad hoc Consultation, a major increased effort is called for which will require not only substantially increased actions by all relevant organizations and governments, but for efficiency will require major new methods to coordinate the actions.

At present major effort by a number of people and organizations is underway to develop the necessary individual programme details based on the best possible guidance from the global professional community and to link these programmes to the individual donor interest and capabilities of executing agencies and institutions. There is also rapid progress being made to establish ongoing regional and sub-regional capability in developing country areas to assist them in detailing their needs, determine their own resources and bring them together with donors to provide the supplemental assistance required.

This gives a brief picture of what FAO has done in the past, the new initiatives that are developing out of current events, and the general areas of anticipated programme interest in the future. It might be appropriate to close by indicating that based on current trends, the future international activities in the areas dealing with international pesticide schemes will not be limited so much by available financial resources as by the ability to mobilize the right people to develop and carry out the necessary activities and to effect the required coordination.

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# BRITAIN'S ROLE IN INTERNATIONAL PEST CONTROL

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Summary After a short introduction on the history and present day organisation of British government, academic and industrial research and development contributions to international pest control, the paper highlights special contributions in the research, development and extension, information and advisory and education and training spheres.

Present international problems in the areas of pesticides, integrated control and environmental consideration are then reviewed, and finally some major future problems in international pest control are discussed.

## INTRODUCTION

Because of its former colonial possessions, Britain has been involved in the development of overseas agriculture and hence crop protection for over a century. From 1841 the Royal Botanic Gardens at Kew were the centre of what was in effect a technical assistance network in agriculture for the colonies. In 1898 the Imperial Department of Agriculture for the West Indies was formed and this led to the development of the Imperial College of Tropical Agriculture, which has played a unique role in the training and development of generations of British tropical agricultural research and development scientists. In 1919 the Colonial office set up a Colonial Research Committee and in 1940 the Colonial Development and Welfare Act - "the C.D. & W" - was passed, and inaugurated an area of expansion in agricultural and medical research and development, including pest control. By the middle of 1947 over £1 million had been spent on colonial research, the biggest slice of this going on pest control, and a large network of organisations in the UK and overseas were collaborating in this work. Finally in 1949 the Colonial Research Service was formed, thus providing both continuity of work and of expert manpower.

This British colonial enterprise did not, of course, go forward in isolation; it had close links with government departments such as the Ministry of Agriculture and the Department of Scientific and Industrial Research, with bodies such as the Medical Research Council, the Agricultural Research Council, research stations like Rothamsted and with several universities, all of which carried out research and training in pest control and contributed to the growing information service. Above all, the climate was such as to encourage research and development in problems of overseas agriculture and to produce several generations of scientists knowledgeable and interested in these areas. All this has had a profound and long lasting influence on the policy and operations of a host of government, academic and commercial organisations connected with overseas agriculture and pest control.

Britain has inputs into international pest control in the UN agency area mainly via WHO, FAO, UNESCO, UNIDO and UNEP with ODM, MAFF and DHSS as the lead departments,

in the Commonwealth area through the CAB, in Europe through the various EEC institutes through MAFF, to the developing countries through ODM, through the Universities both directly and via the Inter-University Council and through the commercial area both directly and through several government departments. The Consultative Group for International Agricultural Research - the CGIAR - is a fairly recent arrival on the scene but an important one, and I want to say a few words about it.

The CGIAR is a consortium of donor organisations and countries organised by the World Bank to carry on the initiative taken by the Ford and Rockefeller Foundations in developing world centres of international agricultural research. There are now many CG institutes in being such as for example CYMMIT, IRRI, IITA, ICRISAT, and since their programmes are concerned with crop and livestock development, the problems of pest control are important. Britain, through the ODM, has made considerable inputs to these institutes, not only financial but in manpower, consultancies and special projects. These Centres and their programmes are set up to deal with specific problems of world agriculture and are particularly aimed at helping the developing countries.

## BRITISH CONTRIBUTIONS TO INTERNATIONAL PEST CONTROL

It is clearly neither possible nor desirable to mention all aspects of our contribution and instead I have chosen a few examples to highlight British inputs which illustrate the breadth and depth of our national research effort.

It is convenient to consider these under four headings:-

(a) Research
(b) Development and extension
(c) Information and advisory services
(d) Education and training

(a) Research achievements cover a wide field but must include high on the list new types of chemicals for control purposes. I stress the word "new type" because I have used the criterion of an entirely new lead in chemistry or use to merit inclusion.

Thus the work in the early 1940's at Jealotts Hill and Rothamsted on the phenoxy-acetic acid esters was a discovery of prime importance in the production of the first ever specific herbicides (MCPA; 2, 4-D; and 2,4,5-T). Similarly the work on the bipyridyls, also at Jealotts Hill, (paraquat and diquat) opened up new fields of application - the famous "ploughless cultivation" - while recent developments like benzoylprop-ethyl set a new level of selectivity in herbicides.

In the field of insecticides BHC was discovered as an insecticide simultaneously both here and in France and it would hardly do at this conference, at which one of the first public communications about them was made, to omit the work at Rothamsted on the synthetic pyrethroids, now beginning to be developed commercially. I mention this not only because it is an important British input to pest control but because it is an example of a development process in which discoveries made in a state-supported research institute are made available for development by commercial firms; I shall return to this point later.

Moving on to another area of research, you cannot nowadays go to any conference on pest control without hearing "n" papers, where "n" is often a large whole number - on Ultra Low Volume techniques - and ULV is a British invention. It arose from the development of chemical control of the Desert Locust in the 1950's, was first applied practically in ground spraying by the Sayer Exhaust Nozzle Sprayer, was further developed by a group of British scientists in collaboration with a commercial firm to produce the Micronair device for aerial spraying and has seen /its

its latest expression in hand held sprayers such as the Micron ULVA. These practical expressions of the philosophy of small droplet application of concentrated solutions of pesticide are of particular importance today in reducing both cost and environmental damage. The technique is capable of many other uses and one of these, perhaps the most up-to-date, the application of micro-encapsulated pheromones to crop plants for control by the confusion approach, has been discussed by one of my colleagues in a previous session of this conference. Finally, in the research sphere, a contribution in quite another field - the development in a laboratory set up and financed by ODM of the first breeding colony of tsetse flies. This work made tsetse flies available as a laboratory animal and opened up the way for intensification of work on insecticides, tsetse fly biology and physiology, and work on the trypanosomes themselves, all of great importance in the campaign against animal and human trypanosomiasis.

(b) I now move on to discuss the development and extension field - and by this phrase I mean the incorporation of basic research findings into practical control methods through the intermediary stage of operational research, both in the laboratory and the field. I have only time to mention two areas here but they are major British contributions to international pest control - stored products control and swarming locust control.

Stored products research and control is of course directly relevant to UK agriculture and the work of the MAFF Pest Infestation Control Laboratory has been central to this effort. Internationally, and in the colonial era, stored products pest control was early recognised as of great importance and this led to the formation of a Tropical Section at Slough which in the course of time has evolved into the TPI Tropical Stored Products Centre.

The work of these laboratories married the use of the latest insecticides and research on the biology and ecology of stored products pests to developments in agricultural engineering in relation to the physical handling of produce and its drying and storage in a series of devices ranging from steel bins to air warehouses. Allied to this basic development was - and is - a large extension effort of teams of scientists in countries such as Nigeria and Kenya which carry out operational research on new techniques, train local scientists, help local Ministries of Agriculture to formulate legislation on produce handling, publish extension literature, arrange demonstrations and develop information services. FAO has also been involved in this effort for many years and the British input to its work, particularly in the training field, has always been a large one.

As regards the British role in the development of control methods for swarming locusts I have to exercise caution, because as Director of the former Anti-Locust Research Centre I was among those responsible for part of this work, and also because there are several people in this hall with more expertise and experience than myself in this sphere - and this includes our Chairman, Mr Yeo, for several years Director of the OICMA Locust Control Organisation in West Africa, and Mr R.J.V. Joyce, a former Director of the Desert Locust Control Organisation for Eastern Africa.

But both of them would, I'm sure, support my claim that it was largely due to British research, development and financial support, masterfully deployed by Sir Boris Uvarov, that brought international locust research and control into being. Uvarov insisted from the first that the British effort on locust control, although originally set up to aid the colonies, must be deployed beyond these on the basis of the ecology and distribution of locusts; thus from the outset the work was international and co-operation with all countries involved actively sought. The logic of this approach was soon appreciated and so groupings of several governments, including the British, French, Belgian, Portugese and South African were able to agree to set up and finance several international locust control organisations to

deal with the three most damaging African species of Acridid - the Desert, Migratory and Red Locusts - organisations still in existence today, financed by the African countries at risk from these pests.

The scientific basis of Uvarov's approach was biogeographical work on the distribution and movement of these species and this was married to operational research on the use of new insecticides and the development of new application techniques like ULV from both ground and air. The nature of the problem made it mandatory to develop some sort of international forum for discussion and decision and in the 1950's FAO became involved and since then has been the international co-ordinator for this work. This locust research and development is also important because the resulting scientific and operational techniques can be and have been applied to other migrant pest species such as armyworms and cotton boll worms. With these and similar pests the essential background is one of international co-operation and research and the exchange of information.

(c) Mention of information brings me naturally to the third of the British inputs to international pest control - information and advisory services. The research and development effort I have outlined above produced a vast amount of data which clearly needed to be re-distributed so that other countries and organisations could benefit. The Commonwealth Agricultural Bureaux system, developed originally to provide information and technical assistance to the Commonwealth, was one response to this demand. It has developed into one of the largest agricultural information systems in the world, producing, inter alia, a number of internationally renowned abstract and scientific journals in the pest control field such as the "Review of Applied Entomology" and the "Bulletin of Entomological Research".

(d) The provision of information merges into training, which is simply a formalised information exchange procedure. Programmes of research and overseas projects require expert manpower, and this consequently evokes a demand for the training of scientists and technicians in new techniques and a requirement for university courses in such areas as applied entomology, plant pathology and crop protection. I have already mentioned before the number of universities which have developed overseas interests and links - and indeed some university schools such as, for example, the London School of Hygiene and Tropical Medicine, were set up as a direct response to the requirements of overseas agriculture and public health.

This thumbnail sketch of British involvement in international pest control has given some idea of our past contribution - I think I may say without undue exaggeration our large contribution - to international pest control in several fields. I want now to consider some of the problems in this field and how I see - and clearly this can only be a personal opinion - British science helping to solve them.

You have heard from the previous two speakers about some of the major global problems with which the UN agencies are dealing and I have explained that Britain is making a direct contribution to most of these with manpower, money, research and sometimes all three. We are, for example, participants with WHO in the programmes on onchocerciasis, schistosomiasis, trypanosomiasis, Chaggas disease, and rodent disease control and with FAO on locust control, stored products pest control, integrated pest control, animal trypanosomiasis, tick control, field rodent problems and others. We are also involved in the MAB programmes of UNESCO and the environmental projects of UNEP.

I feel however that simply to list our inputs in all these areas would be less than interesting, so for the remainder of my time this morning I want to look briefly at what I see as the outstanding present and future problems of international pest control, and see what contribution Britain is making now and might make in the future.

## PRESENT INTERNATIONAL PROBLEMS

### (a) Pesticides

The global public concern over the environment and the accompanying debate produced an initial heavy reaction against pesticides, particularly the organochlorines, but the demonstrable fact that banning them would produce a drop in world food production, variously estimated at between 10-30%, caused a revision of that demand. A variety of national reactions to the pesticide/environment problem has however ensured a notable degree of international chaos in such spheres as pesticide registration and the law regarding introduction and sales. Internationally agreed registration procedures and rules for safety in use are long overdue and it is somewhat heartening to know that there is now a more co-ordinated approach by Government and industry on this. The British voluntary notification scheme may appear too simple or too subtle, depending on where you stand, but it has much in it to commend in the international scene. Another big problem of international pest control work is getting adequate trials done overseas, because of difficulties of cost, logistics, permission and so on. Here is an area where a real advance could be made if FAO and WHO, for example, could work out a co-operative system to regularise trials of new products and their evaluation.

One special aspect of international pest control is the actual supply, demand and cost position of biocides. Estimates of supply and demand on an international scale would be of great benefit to all and here FAO, with the active co-operation of industry, has taken the lead in trying to set up an information system. It is significant that the FAO conference where this idea was discussed was attended officially by representatives of industry and such meetings afford an opportunity for co-operation and co-ordination which can only be of mutual benefit and should be expanded.

### (b) Integrated control

It is now widely accepted that to economise on the use of expensive pesticides, to obviate dangers like the appearance of resistance and secondary pests, and to minimise the risk of environmental degradation, integrated control systems, combining cultural, environmental, biological and chemical control must be developed.

Government, university and commercial organisation scientists in Britain have all played a part in developing this approach, and the work of Hussey at Glasshouse Crops Research Institute on integrated control in the greenhouse, and the work of Way at Imperial College on pest and disease forecasting may be given as examples of particularly relevant UK research. The principles developed in this and related work have been passed into the international scene through UK membership of the FAO Panel of Experts on Integrated Control, which is now developing a global programme in cotton, rice, maize and other major crops in which British expertise will certainly be involved.

It is as encouraging as it is important that government and university research institutes and British pesticide companies are becoming more interested in this area, and are developing research programmes dealing with the necessary marriage of chemical and non-chemical techniques. Integrated control is not new but its application in modern agriculture demands a far more tightly knit programme combining all possible inputs against a background of detailed knowledge of the pest/host interaction in particular eco-systems. This approach requires time and expertise and involves detailed surveys, crop-loss assessment to determine economic injury levels, the availability of pesticides with limited activity spectra and their more precise application, and, once these have been developed, selling the system to farmers by training and extension work. Integrated control schemes take time to develop, but one of the first steps towards them must always be better regulation of

pesticide usage through reduced dosage and more selective formulation and application. This work is going on now both in government and commercial research laboratories and it needs to be expanded and accelerated. It is precisely in developing countries, where pesticide application is still far below the average of developed countries, and hence where environmental problems are not generally so severe - although there are exceptions to this - that integrated control can be of great value.

I have mentioned above the FAO/UNEP Global Programme for Integrated Pest Control and British inputs to the planning and development of this have already been significant and in several areas. I want however to select one for particular mention and this is the development of viruses for insect control. Luckily this has already been the subject of a paper in a previous session of this Conference (Session 6A, by Dr Tinsley, the Director of the NERC Unit of Invertebrate Virology) so I need not go into detail, but I want to emphasise the salient points which demonstrate the advantages of a co-operative research programme both nationally and internationally.

First, the basis of effort in the UK is a co-operative and cost-shared project between NERC and ODM, involving Dr Tinsley's unit and my own. The objectives of this are to identify and characterise the viruses of certain insect pests, species of Spodoptera and Heliothis, test their pathogenicity and develop methods of application and strategies of use. Since, under the Stockholm agreement, viruses are now to be treated as pesticides, extensive toxicological and safety testing is mandatory and NERC/ODM have arranged with the Microbiological Research Establishment at Porton to carry this out. If these tests show, as we are confident they will, that these viruses are highly species specific and not pathogenic to non-target organisms, we can move to the field testing stage, where effectiveness and economics can be determined and operational research on methods of formulation and application pursued. The NERC/ODM group has of course no interest in developing this method on a commercial scale and here we would hope and expect industry to take over the problems of production and marketing.

It is a story analogous to that of the development of the synthetic pyrethroids - and it surely emphasises the value of closer co-operation between government research organisations and industry - an approach urged at the 1973 meeting of this Conference by Dr Rudd-Jones. I will return to this theme of co-operation later on, but meanwhile, in the context of integrated control, I must point out that most of us concerned to develop this field acknowledge that chemical control must remain the mainstay of pest control for some further 10-15 years. This being so, it is necessary for all concerned to spend money and effort in developing safer, more economic techniques of pesticide application. Here much remains to be done, ranging from the direct and simple approach of better labelling, packing and instructions for use of pesticides, to the development of techniques like the use of granular or encapsulated materials. Further refinements in ULV application - the concept of "controlled droplet application" and the machinery to produce this, have been described in a previous session of this conference - show what can be done in this sphere, and Dr Graham-Bryce, in his excellent review paper yesterday, produced a number of stimulating suggestions on which programmes for improvement of pesticides and their use could be based.

(c) Environmental considerations

Environmental considerations must now have high priority in pest control and one often sees a demand for the production of "cheap, efficient and environmentally safe pesticides". Here there are many problems to overcome, the two most important being that of the economics of production and the elucidation of the long term effects of pesticides. It is ridiculous to expect industry, which has to live by the profit motive, to devote millions of pounds to the production of compounds which

may not have a viable market. Farmers anywhere in the world can only spend limited sums on pesticides and if any product, however environmentally desirable, is too expensive, they cannot buy it. This is particularly so in developing countries, where the economic facts of life dictate the continued use for the moment of proven, cheap, effective insecticides, despite their potential environmental risks. In the environment game, as elsewhere, you only get what you pay for and governments insisting on higher standards will have to pay for them. The commonsense approach that it is not sensible to insist on environmental standards which cannot apply or be met in developing countries has been a useful official British injection at international conferences dealing with this subject.

However, abundant evidence attests to both the overuse and misuse of pesticides, especially wide spectrum pesticides, particularly in tropical situations, and a more far-seeing attitude is necessary in which available insecticides are formulated and applied in a more target specific manner.

The second problem concerning the environmental effects of pesticides is the elucidation of their long term environmental effects. Here, both scientific and lay sensationalism has created the "Doomsday syndrome" out of a minimum of fact and evidence, because we really know very little about this crucial area. However, Britain is one of the few countries which have devoted a research effort, both national and international, to investigate such effects and this research will be of increasing importance in the next few years, during which the world food situation will demand increased use of pesticides in developing countries in particular.

Two British research projects may be mentioned here, the first concerning the long term effects of chlorinated hydrocarbon insecticides in tropical agro-ecosystems. This research is being carried out over a five year period in co-operation with the International Institute for Tropical Agriculture in Nigeria and has as objectives both the investigation of the effects of pesticides on crops and soil and of processes like litter decomposition which are of prime importance in soil fertility, and also the development of a methodology of approach which could be used as a model for investigations in other eco-systems with other pesticides.

The second project is a co-operative one in which Britain is supplying the scientific co-ordination and programme development side of work in Botswana to determine the effects of aerial spraying of endosulfan for tsetse fly control on non-target organisms in the operational area, the Okavanga Delta. This project brings together Botswana inputs from the Departments of Agriculture and of Game and Wild Life, inputs from UNDP on hydrology and from FAO in the fields of entomology and fisheries. This international project will provide basic data on the environmental effects of endosulfan which will be directly relevant to the choice of pesticide and methodology in the proposed large scale tsetse control schemes of FAO and WHO in Africa, mentioned by the two previous speakers.

## INTERNATIONAL REQUIREMENTS - THE FUTURE

When we consider the future it must give us cause for sombre reflection. World food production is not keeping up with world population growth - and I am reminded of Winston Churchill's aphorism about dictators - "Dictators ride to and fro upon tigers which they dare not dismount. And the tigers are getting hungrier". The governments of the world ride their national tigers, some of which are pretty hungry now. Let us make no mistake - if one of them gets too hungry and unseats his rider in search of food we are all in trouble. As both Dr Metzger and Dr Goring emphasised yesterday, the main problems are to be found in the developing countries, both as regards population growth and agricultural development. But I have always thought it the height of arrogance and stupidity to tell developing countries that they should reduce their population growth unless we are at the

same time helping them to develop their agriculture.

This is not the time or the place to talk about the politics of aid programmes, but it is the time to say clearly that there are technologies available now which will increase world food production - and quite quickly. High yielding varieties, fertilizers and plant protection systems are three front runners in the field. It is significant that the World Food Council includes plant protection in its "priority" areas.

We cannot yet produce figures for world food losses to pests and diseases which are more than controlled guesses, but the best guesstimates suggest a total loss of 20-30%. Nor can we be absolutely certain of what percentage of this can be saved by adequate plant protection - it may be 15% it may be less. But a 10% saving is a highly realistic and realisable figure which could go a very long way in terms of saving some hundreds of thousands from starvation and probably millions from malnutrition. And this is, let me emphasise, by the application of presently available technology, with presently available chemicals. This would then give the world a breathing space of perhaps 10 years in which to concentrate on the basic population problem.

The world food situation demands concentrated attention to the development of pest control in major food crops - rice, maize, sorghum, and grain legumes. Cotton must also be included because it provides small farmers with money to subsidise the essential specialised inputs of fertilizer and pesticides to such food crops. Outstanding livestock pests such as trypanosomiasis, diseases spread by ticks, and the special case of diseases such as schistosomiasis, malaria and onchocerciasis which reduce the output of the agricultural work force, must also be tackled.

There is thus a requirement now for cheap, efficient and environmentally acceptable systems for pest control in all these areas. But time is against us and we cannot afford to wait to perfect systems for the future. However, there are available now the rudiments of integrated control systems applicable to many of these problems, and in particular in many cases chemicals and application technologies of proven worth. Therefore I would put as top priority the development of international training, demonstration and extension projects to get this available knowledge used by farmers, particularly in the developing countries but this is something which can only be done by integrating the knowledge, expertise and facilities available in the government, academic and commercial spheres. The recent ODM White Paper on overseas aid now places emphasis on rural development and the improvement of small farmer practice and thus provides a channel and the possibility of financial support for this sort of approach. It is not so glamorous as research and it requires an informed socio/economic approach of great difficulty, but it is an absolute essential if we are to make some real movement towards higher food production in the near future. One of the ways that this could be done - an approach mentioned by several speakers at this conference - would be the provision by commercial firms of a complete "plant protection service" package.

The second priority, in my opinion, concerns the utilisation of traditional multi-cropping systems - and its modern development - and pest control in these. Because these systems are familiar to peasant farmers and because they have been adapted over many years to the local ecosystems they often offer a sound basis for high yields. But they pose special problems of pest control which will require a concentrated research effort for solution. It is most likely that this will be found in some form of integrated control and I would put as a priority development of the various component techniques for integrated control - the refinement of pesticide application, the employment of pesticides in relation to more precisely defined economic injury levels, the development of control by environmental manipulation, the use of pheromones for survey and control and particularly the development of resistant varieties of plant and animal stocks.

Looking much further into the future, a startling fact to emerge from recent work on traditional cultivation methods is the damage done to the land by mechanical disturbance such as ploughing and the unacceptable soil erosion that follows, particularly in high rainfall areas. If present estimates are correct then there is little apparent alternative to the development of a new system of agriculture in which chemical and biological agents must be perfected to allow crops to be grown while minimising soil disturbance.

These are all challenging problems, but they are, I firmly believe, capable of solution. But they are not capable of solution by the unaided efforts of any particular section of the scientific community or by any one nation alone. If there has been any recurrent lesson in this brief sketch of Britain's role in international pest control it has been that of the importance of bringing to bear on all our problems a multi-disciplinary approach supported by government, academic and industrial expertise. The organisation, and also the motivation, of these three major components of the scientific plant protection community has hitherto kept them essentially apart from one another, both in the national and the international sphere. If we are indeed to increase world food production at the pace necessary to avert a catastrophe then it is essential to break down the barriers and develop a real co-operative approach.

I think the British record in international pest control is second to none, but I am convinced that we shall not be able to continue to utilise our experience and skill in expanding this further unless we are ready to develop closer links in the national effort between all the relevant organisations and to make the resulting contribution available on a co-operative basis in the international sphere.