AGD/TAC:IAR/82/5
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THE CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

Twenty-Seventh Meeting, Los Baños (Philippines), 9-17 March, 1982

CROP PROTECTION

PROPOSALS FOR A POLICY FOR CROP PROTECTION IN THE CGIAR SYSTEM

(Agenda Item 5)

<u>*Proposed objectives of the discussion*</u>

The discussion of this topic at the 26th TAC Meeting is summarised in paras. 42-43 and 290-302 of the Draft Report of that meeting (AGD/TAC:IAR/81/29).

This document incorporates those Ibadan discussions and subsequent correspondence with Centres involved in crop protection. It also seeks to identify issues that TAC may wish to discuss before finalising its recommendation to the CGIAR.

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

February 1982

PROPOSALS FOR A POLICY FOR CROP PROTECTION IN THE C.G.I.A.R. SYSTEM

INTRODUCTION

1. 'Crop protection' is a useful collective term to embrace the variety of measures that producers may adopt to ensure the continued, cost-effective growth of healthy crops. It therefore comprises crop husbandry (agronomic methods), through suppressive techniques such as varietal resistance, chemical and biological control, to the sophisticated biochemical and genetical research needed to understand and control resistance to pests or insensitivity to chemicals. Within the CGIAR system all approaches are relevant to activities within the international research centres, but recommendations for use in developing countries must be tailored to fit the economics and practicalities of their national agricultural systems.

2. The history of discussion on this subject within TAC and the CGIAR is summarised in Appendix A. This document seeks to confirm the views recently expressed by TAC and the Centre Directors, and therefrom to distil a policy acceptable to the CGIAR as a whole.

ECONOMIC IMPORTANCE OF CROP PROTECTION

3. While exceptionally serious damage may attract most attention, these effects are probably smaller than the aggregate of average losses. The complexity and variability of damage to crops, and the lack or inaccuracy of many statistics on production and loss, make it difficult to express them in terms of monetary values, let alone of human welfare.

4. One of the most comprehensive estimates remains that made by Cramer ('Plant Protection and World Crop Production', M.H. Cramer, 1967, Bayer). Table 1 illustrates conclusions (U.S.$ equivalents based on 1965 values updated to ?). It must be recognised both that the estimates are now old and have been criticized as exaggerated by some commentators.

Table 1 **Extent and value of losses**

	As % of potential production				Total expressed as US $ (billions)
Caused by	Insects	Diseases	Weeds	Total	
Wheat	5.0	9.1	9.8	23.9	5.8
Rice*	26.7	8.9	10.8	46.4	16.9
All cereals	14.7	8.9	11.2	34.8	34.0
All crops	12.2	11.8	9.7	33.7	71.0
All crops	with polyphagous pests (rodents, locusts, termites, birds)				
	13.8	11.6	9.5	34.9	75.0

5. The order of magnitude of these estimated costs of pests, diseases or weeds has been confirmed by some more recent and specialised assessments. The decrease of crop yields worldwide due to weed infestation was estimated at 11% by Parker and Fryer (FAO Plant Protection Bulletin 23, 83-95, 1975). CIMMYT now quotes most recent losses of wheat and maize, from diseases alone, of 33 million tons for each crop, representing monetary costs (1976 $) of $4.4 billion for wheat and $3.2 billion for maize.

6. Even allowing for the fact that these figures include data for all countries, not just those of primary concern to the CGIAR, it is plain that losses are many times the cost of the investment to improve food supplies. Before discussing how best to spend the limited resources available, it is necessary to clarify certain terms that may be confusing to non-specialists.

TERMINOLOGY

7. 'Crop protection' in the wide sense used here comprises all the means available to avoid or limit damage to crops. It therefore includes the effects of weeds, polyphagous pests (rodent, locusts, termites, birds, etc.), with those of the pests and diseases of growing crops and of their products after harvest.

8. 'Pest': When used here in quotes 'pest' is meant in the traditional sense of any organism (or virus, etc.) that damages others and especially crop plants. 'Pests' therefore include vertebrates, insects, mites, nematodes, parasitic plants, weeds, fungi, bacteria, viruses, etc.

Excluded are the excesses or deficiencies of chemicals in soil, water or air that damage plants naturally or as a result of pollution.

Pest (without quotes) is used as a collective term for damaging animal infestations as distinct from diseases resulting from infections by microbial pathogens.

9. Integrated crop-protection (ICP) and Integrated 'pest' management (IPM): These two terms express concepts introduced first as 'integrated pest control' that recognise that 'pests' may best be suppressed to less than economically damaging proportion by utilizing all suitable techniques (chemical, cultural and biological) compatible with cost, ecological and toxicological requirements. IPM is a term in common use (and some abuse), which was first proposed by entomologists; ICP is preferred because it stresses the involvement not only of the target crop, but also of adjacent or succeeding crops; however, IPM is in more common use.

CROP PROTECTION SCIENCES

10. Integrated crop protection and integrated 'pest' management are much respected philosophies for attempting to protect crops and their products to the benefit of human welfare. However, neither includes all the scientific and agricultural endeavours on which their success depends. It is well, therefore, to summarise the scope of the scientific requirements:

(a) Scales of research:

Cellular and sub-cellular studies of the cytology, physiology and biochemistry of 'pests' and, where applicable, of their host plants and of the interactions between host and 'pest'.

Studies of whole organisms to reveal the biology of pests, pathogens and weeds, and of their natural enemies, with a view to control. The studies involved will differ with the class of 'pest', but will include taxonomy, life history and etiology, structure and function and mechanisms of resistance to 'pests' or sensitivity to pesticides.

Studies of populations of both 'pests' and crop plants, for example, epidemiology, competition, population dynamics and population genetics.

(b) Research on control agents and practices:

Conventional crop-protection chemicals - chemical structure/activity relationships; modes of action; methods of formulation and application; persistence and degradation; effectiveness, selectivity and side-effects.

Novel methods or materials for control - new target systems or active compounds (e.g. pheromones, phytoalexins), etc.

Natural enemies - the provision and maintenance of beneficial organisms; competitors, antagonists, predators, parasites, etc.

Plant breeding for resistance - the cytogenetics of resistance factors, breeding and selection methods, the mechanisms and durability of resistance.

Cultural controls - crop rotations, tillage practices and nutrition, provision and preservation of healthy seeds or planting material (including quarantine precautions, certification schemes, etc.).

(c) Development of crop-protection strategies:

The prediction of damage and the timing of treatments; surveys of incidence and damage; increasing the durability of resistance to 'pests' or sensitivity to chemicals such as may be achieved by mixed cropping or rotation of crops or treatments.

The integration of crop production and protection to maximize yield most cost-effectively and practically to satisfy farmers, their food needs or markets.

SOME STRENGTHS AND WEAKNESSES OF MAJOR CROP PROTECTION TECHNIQUES

11. Breeding for resistance: Although usually a major factor in breeding programmes, 'pest' resistance is far from being the sole objective of plant breeders. Early experience showed that air-dispersed fungi and some insects can quickly evolve to circumvent single, 'specific', resistance genes, so that previously resistant varieties were attacked afresh. Now most breeding programmes seek more durable, non-specific, resistance. Although the mechanisms are still often very poorly understood, it is plain that resistance breeding can often almost keep pace with evolution or, if 'durable' even outpace it. It is evident that resistant varieties, of proved suitability to local environments and farming practices, constitute one of the easiest and most effective routes to agricultural improvement in developing countries.

12. The great emphasis on plant breeding in many of the international centres has been important in the contributions they have made, and has greatly increased national capabilities to continue the work. An awareness

exists that to achieve the potential of some new varieties needs concurrent change in tillage, nutrition, weed control, etc . The emphasis on new agronomy to match new varieties or the synthesis of new farming systems should stimulate consideration of the balance between varietal and cultural improvement that is correct for individual international agricultural research centres during the next one or two decades. Where training has created a national competence in the simpler means of plant improvement, IARCs should perhaps divert more effort to agronomy, agrometeorology, 'pest' forecasting, pesticide residue analysis, and to improving understanding of 'pest' population dynamics and genetics? There would be little purpose in IARCs duplicating breeding programmes that developing countries could do for themselves, but much merit to be gained from changing emphasis to develop competitive advantages in different scientific aspects that national programmes will need help with as their competence increases.

13. Plant breeders have been prominent among those who have fostered the preservation of the world's plant genetic resources. In many important crops perhaps enough has been done to ensure that there are preserved at least small collections of most species, including wild progenitors and many local cultivars. In terms of the time scale of plant history, the need was urgent and the response was fast. However, we may not be entitled to be satisfied with current efforts, and should question what their inadequacies may be. Two questions may illustrate the point:-

- The era of much increased genetic resource collection has been concurrent with an era of unrivalled genetic resource exploitation through the advent of scientific plant breeding and not least from within the CGIAR system. The period of short-lived 'boom and bust' cycles of varieties with hypersensitive resistance led breeders in developed countries to consider, and even to try to implement, strategies for the deployment of resistance factors. Few if any succeeded, but should we not study the use and deployment of the genetic resources that we have collected even more intensively than we encouraged the amassing of a new, perhaps irreplaceable, resource?

- Natural populations are usually diverse, what size of sample (or better number of collections) is required of each adequately to represent the full capability of the genome? How effectively do our existing collections equip us to preserve and extract characters that confer uncommon biochemical properties or resistance factors?

14. <u>Chemical control</u>: Since the 1940s there have been revolutionary changes in pesticides; natural products and simple inorganic chemicals have given place to more specific synthetic organic compounds. Many of these have proved enormously successful biocides, but some have properly led to serious environmental concern. Perhaps the most difficult have been the insecticides that persist in air, soil or water, and are concentrated in natural food chains. Serious problems persist, for example, in the treatment of stored grain with organo-chlorine insecticides, where the amount consumed may be a very much larger proportion of that applied than in the case of a seed-dressing or a herbicidal application.

15. Recent developments may solve some problems but create new ones. For example, the enormous activity of some of the latest pesticides means that only 10g/ha of active ingredient may be required, compared with 10kg/ha for the first synthetic insecticides. But applying uniformly materials of such activity will require full development of all the exciting advances in application techniques now appearing.

16. The agrochemical industry is estimated (Fig.1) to have had world sales of almost $12 billion in 1980. Nevertheless, the current requirements for efficacy, toxicity, environmental safety and economic constraints are such that about 15,000 compounds may have to be examined for each one marketed at a research and development cost of perhaps $20-25 million. Therefore the launch of a new pesticide requires the prospect of worldwide sales on such major crops as cotton, maize, wheat, rice, vines, fruit and tropical plantation crops.

17. With such costs it is understandable that the agrochemical industry seeks to recoup its investment by pricing them so that their effect is profitable rather than necessarily reflecting the actual manufacturing cost. Nevertheless, as Fig.1 implies, large amounts are used in the tropics and this can be expected to increase. Nevertheless, costs of the materials and their application will remain out of reach of most 'small farmers' until their incomes are greatly increased. This respite must be used to develop the means of educating farmers and the public in developing countries about the dangers of pesticide misuse and the precautions that must be taken to ensure safety.

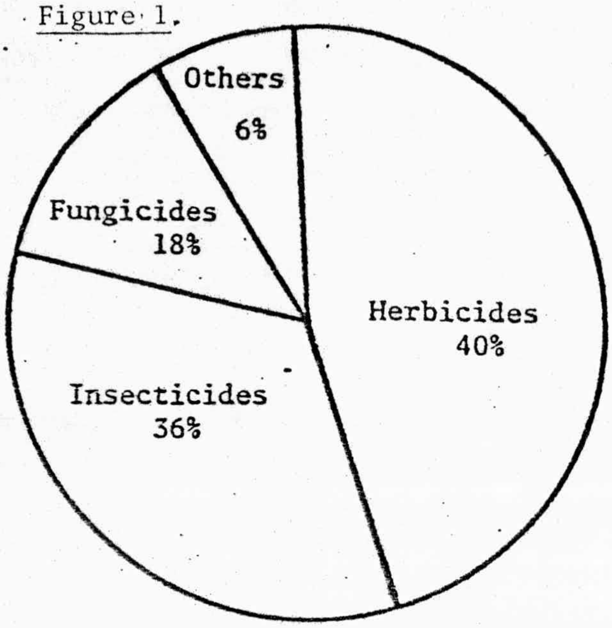
18. Biological control: The possibility of setting unobjectionable organisms to suppress 'pests' is one of great attraction, considerable difficulty and some success. The rather small number of indisputable successes have deserved and gained a 'classic' status which has tended to obscure the difficulties. They have disproportionally concerned insect introductions and particularly into protected environments or perennial crops. Efforts are certainly worth continuing because the chances of success seem greater on the scale of the small farmer, where a higher labour input is possible than in the large land clearances of mechanised arable cropping.

19. Information from visitors to the People's Republic of China suggests that they may have made important developments in biological control during their recent years of isolation. The facts would certainly merit examination on behalf of the developing countries that the CGIAR serves.

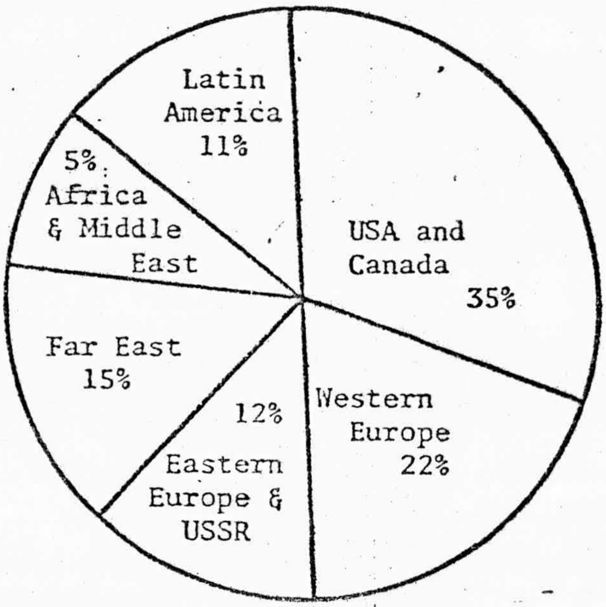
20. Cultural practices: Before the recent advances of breeding, biological control and pesticides, agricultural practices such as crop rotation, cultivation, adjustment of sowing date, plant nutrition, harvesting procedures and storage conditions formed the basis of efforts to protect crops. They remain important and effective methods and, although perhaps temporarily eclipsed by the attractions of new and labour-saving materials and techniques, they remain major pest control resources within the capabilities of poor farmers. Most are capable of considerable improvement through modest changes to equipment and careful education through collaborative improvement of farming systems.

21. The integration of crop protection practices: Although ICP and IPM are new terms, they embody the very old concepts of good husbandry which aimed to incorporate any practice that would maximize healthy yield with least cost or harm to the land and its inhabitants. The word 'integration' implies an acceptance of the judicious use of plant resistance, biological, chemical and cultural practices to keep 'pest' incidence below amounts that cause serious loss. It therefore accepts a tolerable amount of damage in order to avoid the imbalance that can lead to catastrophic epidemics.

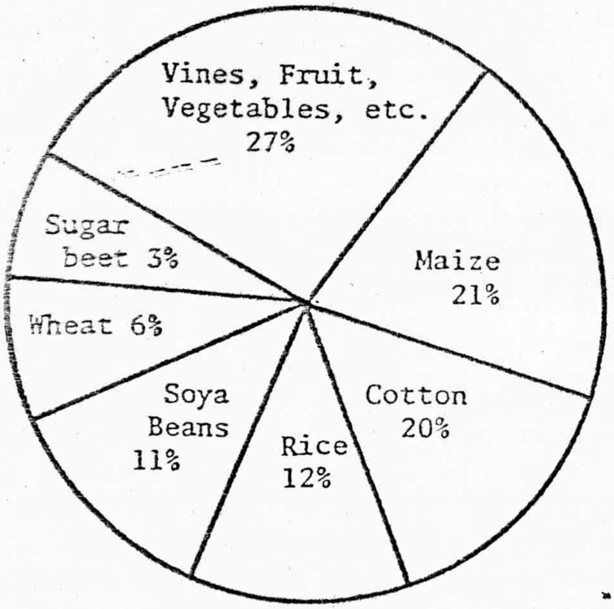
Figure 1.



1980
World Agrochemical Usage Groups
(Total $11,600 - 11,800 million)



1980
Agrochemical Usage by World Areas



1980
Usage of Agrochemicals by Crop

Source: British Agrochemical Association, 1981.

22. It is essential to remember that plagues, pestilences and famines were much more a feature of traditional agriculture than they are of science-based agriculture. Many diseases of crops and livestock are completely eradicable, others (e.g. many virus diseases of perennial plants) can be reduced to insignificance with little more than knowledge and care. Yet the new materials and techniques do require collaborative study between research scientists, national specialists and farmers to decide and explain which should be introduced to local practices and how this may best be done. Perhaps not infrequently such discussions may need to offer advice to developing countries on unaccustomed pressures from the seed, fertiliser, machinery and pesticide salesmen, who may each have vital contributions to offer if properly fitted into a schedule of education and development.

23. Three areas of crop protection seem at this time to merit particular mention and effort to integrate them into successful crop production, namely weed control, post-harvest damage and the often related development of mycotoxins.

24. Weed control: Weeds may exceptionally cause almost complete crop failures, but even more important is the fact that they form one of the usual dictates of farming practice. In a recent report the FAO Committee of Experts on Pest Control (Draft 2nd Report, October 1981) have estimated that weed control occupies about 40% of the time and effort of many resource-poor farmers in developing c ountries. Parker and Fryer (1975, FAO, Plant Protection Bulletin 23, 83-95) estimated that crop losses from weeds averaged 11.5% of total production and, perhaps even more significantly, stated that with the application of existing knowledge only, this could be decreased to 8% within ten years.

25. The effects of weeds may often be greater in countries where water and nutrients are scarce than where large inputs are feasible. Not uncommonly the most productive new crop varieties have shorter stature which makes them less effective competitors with weeds. Even though weeds such as wild oats may be important worldwide, and so benefit from effort among the world's 45 world science societies (12 in developing countries), they may behave differently in temperate and tropical zones. Others such as *Phalaris arundinacea*, *Striga* spp. and *Orobanche* spp. flourish most in warmer climates. The investigation of minimum tillage husbandry which may prove particularly suitable to some tropical crops, soils and climates, implies some weed control by herbicides. For reasons such as these there is a widespread opinion that more effort should now be devoted to the science and practice of weed control in the tropics, ensuring its relevance to local practice through establishing and co-operating with national specialists.

26. Post-harvest losses: Much of crop protection concerns attempts to realise the potential yield of crops in particular environments. By contract, post-harvest damage levies the full loss of a proportion of the yield already harvested and hence also of the effort and investment involved in gaining it.

27. Estimates range from insignificant in good storage (which may often be of traditional type), to over half destroyed or spoiled. The variety of products affected and of the damage and spoilage, make accurant assessment particularly difficult, but most estimates fall between averages of 5 and 15%. Deuse and Pointel(1) are quoted as estimating the post-harvest losses in Africa (the continent of greatest need) as the annual food equivalent of 55 million people. Post-harvest damage takes many forms: physical damage by machinery; spillage from damaged containers; increased water loss; spoilage through

(1) *Deuse and Pointel 1974. Proc.1st Intl.Conference of Stored Product Entomologists, Savannah, 85-93.*

ingestion, faeces, loss of seed viability or nutritive quality. Further damage may result from the production in the foodstuff of potent mycotoxins or allergens, which may make it dangerous to feed to humans or livestock.

28. In many countries there has been an unfortunate division in scientific and agricultural administration 'at the farm gate'; this separated those who grew crops from those who stored food. Although of less effect to the subsistence farmer, this interruption tended to obscure the fact that many spoilage fungi contaminate or cause latent infections on crops during growth. These develop fast if favourable conditions occur during storage. Most are suppressed by dry storage of dry products, except where metabolism by insect infestations releases water, which condenses locally, permitting mycelial growth causing spoilage and caking. Most insects infesting stored products are small and fast breeding, so damage is related to population increase. Breeding rate is controlled by the rates of egg laying, the speed of development and the presence or absence of various resistance factors and as mechanical barriers to entry and oviposition or nutritive or toxic constituents in the stored product.

29. Experience in developing countries and research (e.g. by P. Dobie at the Tropical Products Institute, London) has shown that some of the worst recent problems have occurred in large stores of improved varieties. This is not surprising because local native cultivars arose from long unconscious selection for storage capability, as well as for yield and 'pest' resistance of the growing crop. Breeders in some IARCs are already aware of the problem and are instituting procedures to reject breeding lines subject to serious post-harvest loss. Plainly such co-operation should occur actively with all crops and be linked to education concerning the correct means of storage.

30. Mycotoxins: With few exceptions (e.g. mushrooms), fungi on foodstuffs have traditionally been regarded with suspicion. Russian workers were pre-eminent for many years, but interest widened greatly after the discovery in 1960 that the death of many young turkeys in U.K. was due to the presence of potent 'aflatoxins' in groundnuts infected with *Aspergillus flavus*. Subsequently some aflatoxins have been shown to be potent hepatocarcinogens, and other important toxic products have been associated with *Aspergillus* spp., *Penicillium* spp., *Fusarium* spp. and other microfungi. In common with thermophilic actinomycetes that grow fast in heating stored forages, these fungi can also cause important and debilitating respiratory allergies in humans and farm animals. Although much remains to be learnt about these organisms, the variety of the physiological effects of their product or means for their suppression, it is plain that they are often both unsuspected and particularly serious in warm, wet countries.

31. Although many IARC scientists are aware of these problems, few give them attention, probably because there is little evidence of variability within breeding material. However, the importance of these problems in some areas merits active co-operation with national scientists, and especially with post-harvest biologists.

PRESENT SOURCES OF INFORMATION AND ACTION

32. The purpose of this paper is to develop a strategy for investment and effort in crop protection with the CGIAR system. It would be impractical and beyond this purpose to attempt to list the world activities, but equally difficult to justify a policy for the CGIAR without first giving some account of the activities of other agencies.

General:

33. The International Agricultural Development Service published a listing of 'Agricultural Assistance Sources' (New York, 1980); although it lacks any indexing of interests, it lists 13 multilateral and regional organisations, 5 private foundations and institutions and 16 national bi-lateral assistance organisations. All are relevant to the CGIAR System, and most are known to have supported crop protection projects. The International Society of Plant Pathologists, and comparable bodies for other disciplines, bring together the scientists involved in crop protection research.

34. National crop protection services vary enormously in extent and competence, and their improvement must be a priority objective. Although help can be given to encourage development through teaching and demonstration, there are many roles that can only properly be discharged as national responsibilities, for example, plant health and quarantine services, pesticide residue analysis, seed certification schemes and many regulatory provisions. The few advanced institutions in developing countries (e.g. ICIPE) perhaps have a special role in research training. FAO has taken a conspicuous role in organising international collaboration in support of crop protection, e.g.:

- 'FAO/UNEP Co-operative Global Programme for the Development and Application of Integrated Pest Control in Agriculture'. (Concerns efforts in Africa, Latin America, Middle East and S.E. Asia, on cotton, rice, maize, sorghum, millet, etc.)

- 'FAO Plant Protection Programme'. (Concerns post-harvest loss, control and assessment of plant disease, plant quarantine, pesticides, WHO/FAO Annual Meeting on pesticides, weed management.)

- 'FAO/International Agency for Atomic Energy'. (Techniques for use in breeding for 'pest' resistance, pesticide residue analysis and environmental consequences.)

- The most recent and perhaps the most relevant effort is sponsored by both FAO and UNDP as an 'Action Programme for Improved Plant Protection'. It is the responsibility of the FAO Committee of Experts on Pest Control, which met first in 1980 (Rome) and again in 1981 (Eschborn, F.R.G.). This group has the important intention of defining the needs for strong national crop protection services to survey the capabilities and needs of individual national programmes. It hopes to collect data on crop loss, but because of the great cost of widespread surveys, has decided to try to acquire data from experiments, small surveys, etc. It has also begun preliminary surveys of plant protection services in twelve African countries. The Committee inherited past interests in the Desert Locust, so it is understandable, if tantalizing, that it decided to give this problem some priority. When it has opportunity, and perhaps has strengthened the representation of experts in diseases to match those in animal pests, it will attend more to plant diseases; to weeds, where it recognizes a need for much more work and the training of more specialists (perhaps by establishing a weed science department in an African University); to birds, rodents, plant quarantine, the registration of pesticides and decreasing the incidence of post-harvest losses.

  It is much to be hoped that this group can continue and extend their valuable work which has realistic aims. It recognizes the need to strengthen its resources, and it is necessary that this be supported.

CROP PROTECTION WITHIN THE I.A.R.C.s

35. Centre Directors are thanked for supplying information here and elsewhere in this section. If there are inaccuracies or misinterpretations, the TAC Secretariat will be grateful for corrections.

Table 1 summarises the scientific effort involved in crop protection research. The total is quite impressive, but even so may not be adequate to the task.

Table 2 Crop Protection* Personnel of I.A.R.C.s

	CIMMYT	IRRI	IITA	CIAT	CIP	ICRISAT	ICARDA	WARDA	TOTAL
Pathology:									
Specialists	11	3	9	17(1)	7	15(1)	6(1)	3	
Others †	7	34	-	?	14	-	6	-	
(Total)	18	37		17	21	15	12	12	
Entomology/Nematology:									
Specialists	4	7	11	10	6(1)	12(2)	-	4	
Others †	-	37	?	-	4	-	4	-	
(Total)	4	44		10	10	12	4	4	
Weed Control:									
Specialists	-	-	3	-	-	-	-	2	
Others †	10	-	?	-	-	-	6	-	
(Total)	10	-	-	-	-	-	6	-	
IPM Specialist	-	-	-	-	1	-	-	-	
(Total)	32	81	23	27	32	27	22	18	

* Includes only staff in post. Excludes any staff engaged full-time in plant breeding, but includes 7 breeder/pathologists (CIMMYT).

† Includes part-time crop protection workers, e.g. breeder/pathologists and weed control/agronomists (CIMMYT), also research fellows, associate specialists and technicians. IITA has in addition 17 breeders much concerned with crop protection.

Figures in brackets indicate staff included in total, but out-posted from Centre.

It has proved difficult to find a common basis for tabulating breeder/pathologists, junior staff, scholars, etc.: the help of IARCs would be much appreciated.

CIMMYT

36. 'Pest' management in wheat. About 75% of CIMMYT's wheat programme is devoted directly or indirectly to plant protection, mostly against diseases. The effort has three main approaches: breeding for resistance, fungicidal control, herbicidal control of weeds.

(a) Breeding for resistance has concentrated particularly on major rust (stem, leaf and stripe) diseases, and provided wheat cultivars resistant world-wide to stem rust (*Puccinia graminis*). Limited effort is devoted to *Septoria* spp, *Fusarium* spp, *Helminthosporium* spp, smuts and barley yellow dwarf virus.

The search for and incorporation of resistance depends on:

(1) The traditional genetical and pathological analysis of particular gene action and their incorporation by conventional pedigree breeding.

(2) Partly on growing very numerous acquisitions in areas where particular diseases are regularly severe, and selecting those showing the lowest average coefficients of infection (ACI), which usually prove to be those containing many resistance genes.

(3) Selecting for 'dilatory resistance' (slow-rusting, etc.), which may result from inefficient infection, limited growth, poor or delayed sporulation.

(4) Production of 'multiline varieties' comprising phenotypically similar plants which, because they contain different resistance genes, should produce more stable resistance. Collaborative work with Indian institutions in developing the exceptionally adaptable cross 8156, is the most advanced example.

(5) The results of ten years' study of results from intercontinental 'trap nurseries' for the three major rust fungi have indicated large areas where uniform wheat genotypes place crops at special risk from pandemics of such air dispersed pathogens. Such information should help CIMMYT develop a strategy for introducing varieties likely to avoid disastrous attacks.

(b) Chemical protection of wheat. While CIMMYT continues to believe that fungicides should only complement genetic protection, it does recognize that they could become more important where wheat cultivation may approach the present intensity in N.W. Europe. Currently its work aims:

(1) To evaluate new materials so that it can, from HQ or regional programmes, advise farmers on methods of controlling particularly serious attacks of diseases not yet effectively controlled by resistance. Currently this mostly concerns leaf rust, with head scab (*Fusarium* spp) as another contender.

(2) At HQ, seed treatments aimed to eliminate seed-borne diseases (mostly smuts and bunts) are evaluated and applied to all samples issued; experimenters also use specific fungicides to eliminate diseases that might otherwise complicate or invalidate experiments.

(3) There is limited work on methods of fungicide applications (e.g. in irrigation water, granular side dressing, seed dressing and foliar sprays).

(c) Weed control investigations. Interest began through the need to control weeds in breeders' plots. Now that this is achieved by using herbicides, efforts have been extended as part of the crop's agronomy, to fields in Mexico and the regions. Emphasis was placed on wild oats (*Avana fatua*) and canary grass (*Phalaris minor*). While evaluation of new herbicides continues further work has shown that, by cultural methods alone, devastating infestations can be rendered unimportant in two years. Interestingly the effective methods differ from those attempted in temperate latitudes where a cold winter follows harvest. Different national practices may explain why weed control is a major factor limiting wheat yields in Pakistan, India and N. Africa, but not in Bangladesh, Nepal and the S. American Southern Cone Region.

37. 'Pest' management in maize.

(a) Breeding for disease resistance. Diseases are comparatively of less economic importance to the maize crop than to wheat. Polygenic resistance is uniformly used, and adequate field tolerance to *Helminthosporium* spp and rusts exists other than in the highlands of equatorial Africa. Nevertheless, further improvement is proceeding, for example, against *Helminthosporium maydis* which is potentially serious in hot countries. The major needs are to improve resistance to:

(1) Streak virus, at present limited to lowland Africa, where a programme has been established to extend recent IITA successes.

(2) Corn stunt, where cooperation with Central American countries is making good progress, which could be extended should the disease occur in Asia or Africa.

(3) Downy mildew, in co-operation with regional staff in Thailand.

Other diseases receiving attention are tar spot (*Phyllachora* sp), increasing in Central America, fungicidal controls are now known and genetic resistance is in prospect; stalk rots (*Fusarium* spp) in Egypt; and ear roots, particularly in the Andean Highlands.

(b) Breeding for resistance to insects appears to take longer than to diseases, and now involves the mass culture in Mexico of larvae of fall army worm, sugarcane borer, Southwestern corn borer and ear worm. Thought is being given to how to develop methods for studying other damaging insects that do not occur in Mexico.

Collaborative programmes exist for measuring susceptibility of germplasm and new varieties to stored grain pests (with Tropical Products Institute, U.K.), and to aflatoxins in relation to genotype and climate (with USAID/USDA/University of Missouri). There is continuing selection for better and tighter husk cover, which decreases bird damage and entry of weevils into stored grain.

(c) Weed control. Weeds constitute one of the major limitations to maize production, but their control is usually specific to local environments and soils. Therefore trainees and regional staff are made award of the problems and principles in traditional and limited tillage crops. They also have access to information from HQ and experiment station staff, who regularly conduct herbicide trials to ensure protection of experimental materials at CIMMYT experiment stations.

(d) Chemical control. Materials are tested regularly against pathogens and pests to attempt to ensure the reliability of the experiments it conducts or of the seeds it plants or exports.

(e) Stability of varieties. CIMMYT believes that its international testing programme is an extremely effective way to improve tolerance to the various stresses new varieties may meet. It is based upon the multilocation testing of many segregates, and subsequently recombining and retesting those that do best. It is thought that this progressive concentration of tolerance factors has shown measurable progress in a wide range of genetic material. CIMMYT considers its central effort is adequate, but recognizes a need for more regional investment against 'pests' that do not occur in Mexico.

IRRI

38. Rice diseases. Breeding for resistance has been given much priority through studies of etiology and screening methods to identify sources of resistance. As a result, resistance has been identified to all thirteen diseases studied. Some resistance genes have been characterized and incorporated into newly developed varieties. The outstanding success was through incorporating a resistance gene from *Oryza nivara*, which greatly reduced the incidence of rice grassy stunt in the Philippines and elsewhere since 1974. Adequate resistance to sheath blight has not yet been found, and continued work is required where pathogenicity changes have occurred.

Chemical control is studied and applied where economically feasible. There have also been encouraging results from epidemiological studies of rice tungro disease, which have resulted in the Philippines in co-operative work leading to the ability to identify 'low risk crop seasons'.

39. Rice pests. Screening the germplasm collection (50,000) for resistance to eight major pests revealed 2,600 varieties with single or multiple resistance. National programmes have provided co-operation enabling screening for insects (e.g. gall midge) not occurring in the Philippines. Insect resistant varieties are now important in integrated control schemes in Asian countries. This is especially true of action against the brown plant hopper, where moderately resistant rice varieties have been shown useful in increasing the effectiveness of bio-control agents and insecticides. The mechanisms of resistance are also being identified.

40. Insecticides against rice pests are studied more at IRRI than anywhere else in the world. The programme embraces both application methods; the role of bio-control agents (including fungal pathogens) in suppressing pest populations; sex pheromones; insect migration; biologically active plant constituents and the biochemical bases of resistance. This work is done largely in conjunction with the world's foremost specialist laboratories and agrochemical companies.

The Department of Entomology annually up-dates (to 2,000 scientists) a literature survey (600 articles) concerned in the management of insects in rice-based cropping systems. Besides contributing to scientific journals, IRRI distributes newsletters and results to over 16,000 rice scientists throughout the world, and produces tape-slide programmes for use in training at IRRI or elsewhere.

IITA

41. Although the mandate covers cassava, sweet potato, yam, cocoyam, rice, maize, cowpeas and soybeans, IITA restricts attention to African problems on those crops where the global mandate lies elsewhere. Weeds are seen as a major production threat, but they cannot be considered in isolation from land management any more than can research on pests and diseases be divorced from the locations where they occur or from the breeding programmes, which must acknowledge marked consumer preferences.

42. Weed research therefore emphasizes weed ecology, effects of tillage, smothering cover crops and the screening of herbicides for use in single or mixed species crops, or for the persistence of their residues in soils and water. Virus research has included studies of etiology, purification and serology to assist virus indexing and to understand the mechanisms of virus transmission (especially through seeds). It is recognised that few farmers can afford agrochemicals, so pest management studies aim especially to integrate pest, disease and weed control with resistant varieties and agronomic practices.

43. Legumes. Insect damage is most serious on cowpeas, which succumb to leaf hoppers, aphids, thrips, pod-borers and pod-sucking bugs against which breeding is directed as well as aginst fungal, bacterial and virus diseases. Stink-bugs and viruses cause major problems in soy beans, where breeders seek to find resistance or to limit seed transmission. The use of trap crops is also being investigated.

44. Cereals. Of three important African virus diseases of maize, the most serious is maize streak. Sources of resistance have been found by using mass infestations with the leaf-hopper vectors and serological virus detection. The elite resistant selections of the TZSR series are now extensively used in Africa. Less, but increasing attention is devoted to resistance to downy mildew, stem borers and cob rots. In rice, the other mandate cereal crop, attention has to be given to blast which is serious on upland varieties (the most important in Africa) against which varieties with durable resistance are in prospect. Otherwise research has been concentrated on African problems, particularly rice yellow mottle virus, stalk-eyed fly and *Maliarpha* borer. Sensitive serological identification of rice yellow mottle virus has aided the identification of very resistant rice collections that are now used in the breeding programme.

45. Root and tuber crops. Cassava germplasm with marked resistance to bacterial blight and cassava mosaic is now in wide use in Africa, so attention has been turned to two pests spreading quickly after introduction from East Africa. Introducing hairy plant characters and biological control offer quick improvement. Recently sweet potato germplasm resistant to weevil and viruses has been identified and distributed to many African and Asian countries. Preferred varieties of cocoyam (*Colocasia* sp.) are being displaced because they are susceptible to cocoyam blight (thought to be caused by *Pythium* spp.). It is hoped that they can be preserved by incorporating recently identified sources of resistance.

CIAT (no revision received)

46. The importance of viruses, bacterial blight, rusts and anthracnose, leaf hoppers and pod weevils, to the *Phaseolus* bean programme, were recognised and described in 'Bean production problems' published in 1980. Similarly, an earlier publication 'Cassava pests and their control' (1978) reviewed work on resistance to mites, bacterial blight, and the *Sphaceloma* sp. causing super-elongation. Blast (*Pyricularia* sp.) and weeds dominate the pest control programme on rice.

CIP

47. Maintaining the health of vegetatively propagated crops is both unusually difficult and important. CIP continues to evaluate 'pest' resistance in the glasshouse and field, and to incorporate promising characters into its breeding programmes. Depending on the 'pest', both monogenic and polygenic sources are used, together with biological control (of root-knot nematode), pheromone confusion techniques (for tuber moth), agronomic and some chemical control.

ICRISAT

48. Screening germplasm for major 'pests' is a priority objective on all the mandate crops (Sorghum, pearl millet, pigeon pea, chickpea and groundnut). There is also work on other elements of pest management, including natural (?) and biological control, cultural practices and the use of pesticides.

There is a concern for the total 'pest' complex of the crops which involves biological and ecological studies of insect pests (especially *Heliothis* sp., pigeonpea podfly, sorghum shootfly, stem borers, and on ground nut, thrips, jassids and leaf miner), and among diseases (wilt complexes or pigeonpea and chickpea, viruses and leaf spots on groundnuts, head moulds and charcoal rot on Sorghum, ergot and downy mildew on millet. Mycotoxins, particularly aflatoxin, are of prime importance to the groundnut pathologists. *Striga* spp. are the weeds receiving particular attention, both in India and in Africa.

ICARDA

49. Disease problems.

(a) The cereals programme aims to identify and use durable resistance to the diseases most important in the ICARDA region. This is done by identifying regions where particular pathogens occur in annual epidemics, to analyse the occurrence and role of various resistance genes, to incorporate the best into breeding programmes and to distribute them to national programmes.

(b) Non-cereal forage pathology is everywhere notoriously difficult and neglected, and only began in ICARDA in 1980-81. Therefore it has not passed the survey stage, but initial attention is directed to *Ascochyta* sp., powdery mildew, downy mildew and common leaf spot (*Pseudopeziza* spp.).

(c) Among food legumes the major problems are: in faba bean (*Vicia faba*), rust, chocolate spot and *Ascochyta* sp.; in lentils, wilt and root rots; in chickpeas, *Ascochyta* blight.

Work has begun on the biology and epidemiology of *Aschochyta* spp. and *Botrytis* spp. (chocolate spot). Resistance screening procedures have been developed for laboratory and field use. At present ICARDA staff are unable to tackle virus and bacterial diseases or the root rot complex, so there is a temporary reliance on help from research in developed countries in the temperate zone.

50. Insect problems. Sources of resistance or natural enemies are being identified; among cereals, to stem sawfly (*Cephus* spp.) and aphids; among food legumes to aphids, stem borers, *Sitona* weevils and storage insects.

51. Weed control. Although there is a general awareness of the value of agrochemicals in integrated crop protection, most work has so far been devoted to herbicides. In cereals and forages this involves identifying best compounds and dosages for different agro-ecological zones, crop vigour and to match cultivar susceptibility. For weed control among food legumes attention has been given to both selective and broad-spectrum herbicides, and international trials have been established for faba bean, chickpeas and lentils.

The parasitic flowering plants receive special attention both to discover tolerance to *Orobanche* sp. among food legume genotypes and, in Syria, the possibility of controlling *Cuscuta* sp. with alfalfa seeds.

WARDA

52. Most of the crop protection staff work in the special projects in mangrove swamp rice (Sierra Leone), irrigated rice (Senegal), floating and deep-flooded rice (Mali) and upland rice (Ivory Coast). Besides screening for resistance to pests, the WARDA specialists have included insecticides and herbicides in coordinated variety trials.

53. The Centre has recently agreed to extend its work on rice stem-borer in conjunction with ICIPE. It recognises the need to begin a regional programme for integrated 'pest' management in rice, also involving training, applied research and demonstration, but at present lacks the funds to begin.

NEEDS FOR TROPICAL CROP PROTECTION RESEARCH

54. The record of the 26th Meeting of TAC (AGD/TAC : IAR/81/29, p.85, para.302) specifically requested IARCs to answer the questions posed in para.50 of AGD/TAC : IAR/81/6 Rev.1. For convenience the questions are repeated below, with a summary of the replies.

(a) *At present the cellular physiology and biochemistry of 'pests' is mostly studied in developed countries. Is there a need for increased effort by IARCs?*

Several centres recognised a need and dependence on this type of work, but with only occasional mention of exceptions, e.g. ILRAD, ICIPE, thought it best left to collaboration or contract with specialist laboratories in developed countries.

(b) *Most study of 'pests', natural enemies, etc., is presently located with study of the commodity affected. Do the crop and location specificities make it unwise to attempt centralisation?*

A strong and unanimous opinion against centralisation of crop protection research. Supported by the need to decentralise some work from individual centres to their regional or national programmes. Also stress placed upon the necessity to preserve multi-disciplinary teams devoted to all aspects of crop improvement at mandated Centres.

(c) *Taxonomy and culture collections are essential facilities that are best centralised, but often poorly funded. Should the CGIAR System have more formal links with such institutions (USNCC; Commonwealth Mycological Institute, Kew; Bureau voor schimmelculture, Baarn, Netherlands; etc.)?*

Almost without exception IARCs recognized their continual dependence on such institutions. Five of eight Centres questioned wanted more formal links, several commented on present generosity, none complained of unwillingness to help. Few seemed to realise the threats to continuation of such facilities in their home countries.

(d) *Quarantine is a national responsibility, but important to IARCs for seed health and dispersal of vegetative propagating material. Is there any possibility of improvement or economy by centralisation?*

There was a recognition of national responsibilities, and most Centres were opposed to centralisation. Comments included the need for individual Centres to improve standards and to assist in identifying unrecognised causal agents; the need for central agreement on standards (with FAO assistance); the success of some regional centralisation (WARDA); no central station could handle the necessary diversity; third country quarantine was often valuable.

(e) *The certification of healthy propagating material seems well suited to tropical agriculture, but relatively little practised. Should certification schemes be encouraged?*

Almost complete unanimity in favour of developing certification schemes (CIMMYT felt it could benefit more by improved seed storage). Comments included: the need to develop schemes in relation to the development of national programmes and a fear that schemes might succeed only where dispersal or vectors are rare. (There is much evidence that such fears are exaggerated where infection rates are slow, or replenishment with fresh certified material is frequent and affects much of the crop.)

(f) *Are facilities adequate for studying or seeking help with: natural enemies, epidemiology, loss assessment, increasing the durability of plant resistance and/or 'pest' sensitivity to pesticides?*

Most Centres recognised inadequacies in these capabilities, but in general considered present spending was right within financial limitations. Several agreed they relied for such special needs on contract or special assistance. IITA recognised that need differed much with different 'pests', but thought any apparent over-commitment to resistance breeding was not an element of faith, but a recognition of the reality that it was the least expensive, widespread way of controlling pests for tropical farmers (and simultaneously increasing yields).

(g) *Accepting that integrated pest management is a desirable objective, are the IARCs adequately staffed and equipped to study the component of chemical control that it implies?*

A majority of Centres thought they were adequately prepared for the need for agrochemicals. Several recognised a role for chemicals (most often herbicides) where other methods had not succeeded. Two admitted to having no competence at present; others would add more if funds permitted, or were prepared to leave it as a national responsibility.

(h) *Is the present effort on weed science adequate? Must it be crop and location specific?*

Unanimous agreement with both questions; plainly a reply to which CGIAR should listen and respond. Comments included: recognition that often the ecosystem/water regime was more specific than location or crop species; that weed control was a major labour demand on tropical farmers; that those trained weed specialists were urgently needed (an opportunity for a university?); recognition of dependence on the Tropical Weeds Programme of Weed Research Organisation U.K., which has recently been closed, but supplied unbiased evaluation of herbicides.

(i) *Should the IARCs devote more effort to pest-harvest losses and/or mycotoxins? If so, how should it be increased?*

One centre considered increasing yield more important than preventing loss or toxicity. Most recognised a general need for more awareness and action, but thought that, in general, adequate help was obtainable from laboratories in developed countries (Tropical Products Institute, U.K., American Universities, etc.). Several recognised a need to incorporate screens into breeding programmes to exclude very susceptible products. ICRISAT acknowledged a major concern with aflatoxins in relation to groundnut breeding, but no Centre offered to develop this as a specialist or training responsibility.

(j) *Are the other damaging agents as thoroughly studied as we can at present afford? If not, what change of priority is proposed?*

Acknowledged to be not a plainly worded first question. Possibly because of this, few Centres acknowledged great need to change priorities. In any event, it was thought changes would seldom be common to all Centres. ICRISAT did see needs to emphasize work on birds, nematodes and parasitic weeds. IITA noted that changing crop practices could affect pest, disease or weed problems.

(k) *Do IARCs have sufficient capability in or access to agrometeorological research concerned with the effects of weather and climate on crop protection?*

The majority of Centres thought there should be more work done. Only ICRISAT had a specific programme. IRRI had received WMO and special fund assistance, but wanted it to be a core activity. One Centre had difficulty in obtaining national/regional data, but this seemed unusual.

(l) *The CGIAR has supported work most likely to bring quick improvement to crops and food in tropical countries. As national research develops, should the IARCs prepare to exercise their competitive advantage to assist national programmes with more fundamental studies, for which they now rely on developed countries?*

Most Centres agreed, but thought the needs must be studied case by case; could be met by the longterm planning exercises; must await considerable development of national programme competence; would be a long time before it became urgent.

Additional question - ICRISAT thought the following should have been asked:

> *Is the breeding/selection work in the IARC geared to the farmers' current and short-term future needs, particularly with regard to insect pest threats? This question has to be asked, for in general much of the breeding, selection and testing in the IARCs and in most national programmes appears to be conducted under insecticide umbrellas. ICRISAT has set aside two unsprayed areas, 86 ha on the black soil and 29 ha on the red soil, for testing and research. Plant breeders are starting to conduct projects in these areas.*

ISSUES THAT TAC SHOULD CONSIDER BEFORE SUBMITTING POLICY PROPOSALS TO CGIAR DONORS

55. TAC and CGIAR donors will be as conscious of present financial difficulties as are the Centre Directors. Although all would recognise many needs, there will, therefore, be few that can be met other than in the most economical ways. Nevertheless, there is evidence of subjects which require preservation or priority assistance.

56. At the 26th Meeting (IITA June 1981), TAC agreed with Centre Directors that there was a need to increase co-operation between IARCs on crop protection matters, and that this was to be linked with better dissemination of information. There seem to have been no mechanisms proposed for achieving these aims.

57. TAC should not, without discussion, endorse the confidence that Directors General express in their present allocation of funding. Some topics are stated provocatively below, to ensure such discussion.

58. TAC may well agree that IARCs are correct in recognising the need for understanding of biochemical and cellular processes in pathogenicity and resistance, but deciding that they should not yet emphasize such research. Or, would TAC recommend further international support for such specialised institutions, or the training of occasional IARC staff in the most modern technologies (in laboratories in developed countries) to aid the recognition and future realisation of opportunities for tropical crops (by staff secondment, etc.)?

59. The Centre Directors firmly endorse the dispersion of most crop protection work within the IARCs, where multi-disciplinary teams are concentrated on mandate crops. If TAC still shares this view it should state it firmly as a policy for the C.G. System.

60. The present discussions have stressed the importance of national crop protection programmes to the application of research findings; the individual role that each nation must play in plant quarantine and in training, and public education to ensure that misuse of agrochemicals does not damage plants, animals, humans or the environment.

TAC has not defined any policies to the Group for internal action or as recommendations to other agencies. For example, would it leave initiatives to IARCs and their regional programmes; should it endeavour to offer more training in, for example, residue analysis, or should it limit its response to assisting FAO or other agencies as they may request?

61. Centres readily acknowledge their willingness to rely on specialist expertise from developed countries. At present they detect little danger of losing such services. However, the closure of the Tropical Weeds Unit at the Weed Research Organisation, Oxford, and threats to the finances of other research and taxonomic institutions in U.K., may reflect potential losses in other countries during recession.

Should TAC recommend to CGIAR that they act to prevent the loss of organisations with tropical interests, unique accumulated knowledge where survival could be ensured for a fraction of the cost of re-creation?

62. These discussions and the replies to questions have emphasized several possible needs to strengthen the capabilities of the IARCs, for example:

- Losses of stored products, storage conditions and treatments do receive valuable attention, but there is a need for more, e.g. in the recognition and prevention of mycotoxins, the particular dangers of pesticide use on stored products and active selection to ensure that new cultivars are not more susceptible to storage problems than their predecessors.

- Pesticide chemistry, where despite opinions expresssed, capabilities seem restricted compared with other institutions comparable in quality to IARCs.

- Basic approaches to population dynamics, epidemiology, 'forecasting', loss assessment.

- Agrometeorology, both as a basis for the investigations above and as a means of assessing the frequency of 'crisis weather', the proper management of soils and crops.

TAC may wish to discuss these needs and others, and to consider whether they could not partly be met by recognising existing treams in IARCs as worthy of further support to enable them to offer training and advisory roles to other Centres and national programmes.

63. Weed control seems to constitute a rather special case. A first requirement is perhaps the need to train more weed specialists, and there may be reason to encourage the establishment of relevant courses in national educational establishments.

If tropical countries follow the pattern of agrochemical use in temperate lattitudes, then herbicides may be the first to become widespread. In view of the heavy demand that weed control makes on the time and effort of subsistence farmers, this may well be so, but current work also demonstrates that there is much to be gained from changing cultivation practices in relation to knowledge of weed ecology in the wide variety of tropical climates and soils.

64. Many IARCs developed with a strong emphasis on plant breeding, and there would be much support for the view expressed by IITA in answering Question f (p.17). However, TAC must devote no less attention to long-term planning than it expects of the IARCs. It should therefore consider:-

- Whether the success of plant breeding in producing heavier yielding cultivars may not itself create needs for changed cultivations, thereby altering the optimum balance of effort in breeding or providing other requirements for success.

- When the training in plant breeding given in IARCs will have established sufficient competence in national programmes to permit decreased effort in the centre of global mandate.

- Whether there may be a need to conserve the deployment of naturally occurring resistance sources rather than the present practices of encouraging maximum exposure of all possible genotypes to pathogens, single or in natural ecological groupings.

65. It is surely a prime duty of TAC to discover any tendencies to conservatism or complacency that might occur in Centres, and to seek and agree changes of balance that may be more profitable.

1. At its 5th Meeting TAC in 1973 considered papers from UNDP/FAO and FAO/International Agency for Atomic Energy Division, seeking better identification of gaps in pesticides residue research. Another paper by FAO introduced the subject of integrated pest control, and proposed a network of cooperative multi-country research projects. At the 6th TAC Meeting, FAO papers proposed worldwide coordination of research on *Fusarium* spp, and a worldwide coordinated programme of research on horizontal resistance to wheat diseases. TAC did not support these proposals, considering that 'pest' control should be an integral part of the research programmes of the primary commodity research centres.

2. The question of pest and disease management and control was mentioned at the 21st meeting in the TAC Review of Priorities for International Support to Agricultural Research (AGD/TAC : IAR/79/1 Rev.1). TAC recognised the problems that the development of pathogen biotypes created for plant breeders. They identified both the hazards of dispersing new biotypes and the delays that strict quarantines would cause to breeding programmes. The Committee supported the continued search for durable resistance and for more study of epidemiology and physiology to assist the development of effective integrated control practices.

3. In reviewing factor-oriented research ('Factor-Oriented Research under the CGIAR', AGD/TAC : IAR/80/5), TAC concluded that it had identified water management and plant pest and disease physiology, ecology, management and control, as high priority areas for consideration of possible new institutional arrangements under CGIAR auspices.

4. At intervals TAC has considered the contributions that could be made to pest management by ICIPE, especially if it were to be admitted to the CGIAR system (see Chapter III of the TAC mission report to ICIPE - Review of TAC and CGIAR discussions on ICIPE. At its 24th Meeting, TAC recommended against the admission of ICIPE chiefly on the ground of its place among the relative priorities of the CGIAR system and factor-oriented research, as well as of its possible complementarity with the commodity programmes of the IARCs. [Report of the 24th TAC Meeting (AGD/TAC : IAR/80/28) paras. 171-182, pp.51-54].

5. In Manila in November 1980, the CGIAR accepted TAC's recommendation concerning the non-admission of ICIPE; it also asked the World Bank to act as secretariat and fiscal agent to a consortium of donors for ICIPE. The CGIAR also asked TAC to review the priority to be given by the CGIAR to pest management, a task that was begun at the 25th Meeting of TAC (Addis Ababa, Feb/March 1981). The secretariat produced a valuable introductory paper (AGD/TAC : IAR/81/6), which stimulated much discussion and a decision to request a committee member to revise the document (AGD/TAC : IAR/81/6 Rev.1), to serve as the basis for a discussion with the Centre Directors at the 26th TAC Meeting. This is summarised in the Report of the 26th Meeting (Ibadan, Nigeria, June 1981, paras.42-43 and 290-302: Ref: AGD/TAC : IAR/81/29).

The present document seeks to incorporate the Ibadan discussions and subsequent correspondence with Centres involved in crop protection towards a policy for crop protection which TAC may wish to recommend to the CGIAR in November 1982.

JMH/MHS
24.2.82