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International Technology
The International Agricultural Research Centers

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Introduction

1. Tropical agricultural research, long the Cinderella of the agricultural support services, has been receiving well deserved, increased attention during the last two decades. This is not to say that it is a new phenomenon in tropical agriculture; research saved the cotton industry in the Gezira in the 1930s[1] and it laid the foundations for the competitiveness of the natural rubber industry with synthetics from the 1950s; it has brought about highly significant yield increases in such diverse crops as tea, oil palm and cacao. However, it had made relatively little impact on food crops though some discoveries like those of mosaic virus in cassava and streak virus in maize formed the basis of successful breeding programs by the international centers.

2. During the 50s and early 60s there was also a widely held view that the application of existing technology, either generated locally or imported from more developed countries would move agriculture forward and that extension rather than research should be strongly supported. However, yield increases were small and it was really towards the end of the 60s that the combination of high yielding varieties, fertilisers and irrigation and, of course, the right price to attract farmers started the so called "green revolution" in rice and wheat. The early international research centers thus set the pattern - and the expectations - of

the series of international research institutions that followed IRRI and CIMMYT. Since the Consultative Group for International Agriculture Research (CGIAR) was set up in 1971 to finance international centers, much has been written about the international agricultural research system, its origins, its achievements and its uniqueness. It has strong supporters, and equally strong critics somewhat unbalanced at times. In this paper I have not set out to defend or criticise the past but rather to try and look at the future of the system, based on what the international centers have achieved and their plans and that of the CGIAR itself for the future. In doing so, I think it essential to emphasise that the international center system is only a relatively small part of the total research system operating in the developing countries.

The Management of the CGIAR System

3. To many of you the system or at least major parts of it are well known, so I will do no more in this section than attempt to give sufficient background on which to base discussions of future developments. The philosophy behind the founding of the first center, IRRI, in 1960 is well expressed by the following quote from Hill.(2)

> "Experience to date strongly suggests that an organization of this kind (IRRI) can perform the following important functions: (1) by bringing together a competent staff on indefinite tenure, well balanced among the relevant disciplines, and by providing them with the facilities required for high quality research and experimentation, it is possible to increase materially the speed with which higher yielding varieties of crops and improved cultural practices are developed. (2) An important contribution can be made towards training professional personnel within the region in which they expect to work: the high level manpower required to staff agricultural colleges, experiment stations, extension services, and administrative posts in ministries of agriculture. (3) An institution such as the International Rice Research Institute can serve as catalyst and pace setter—an instrument for helping increase the

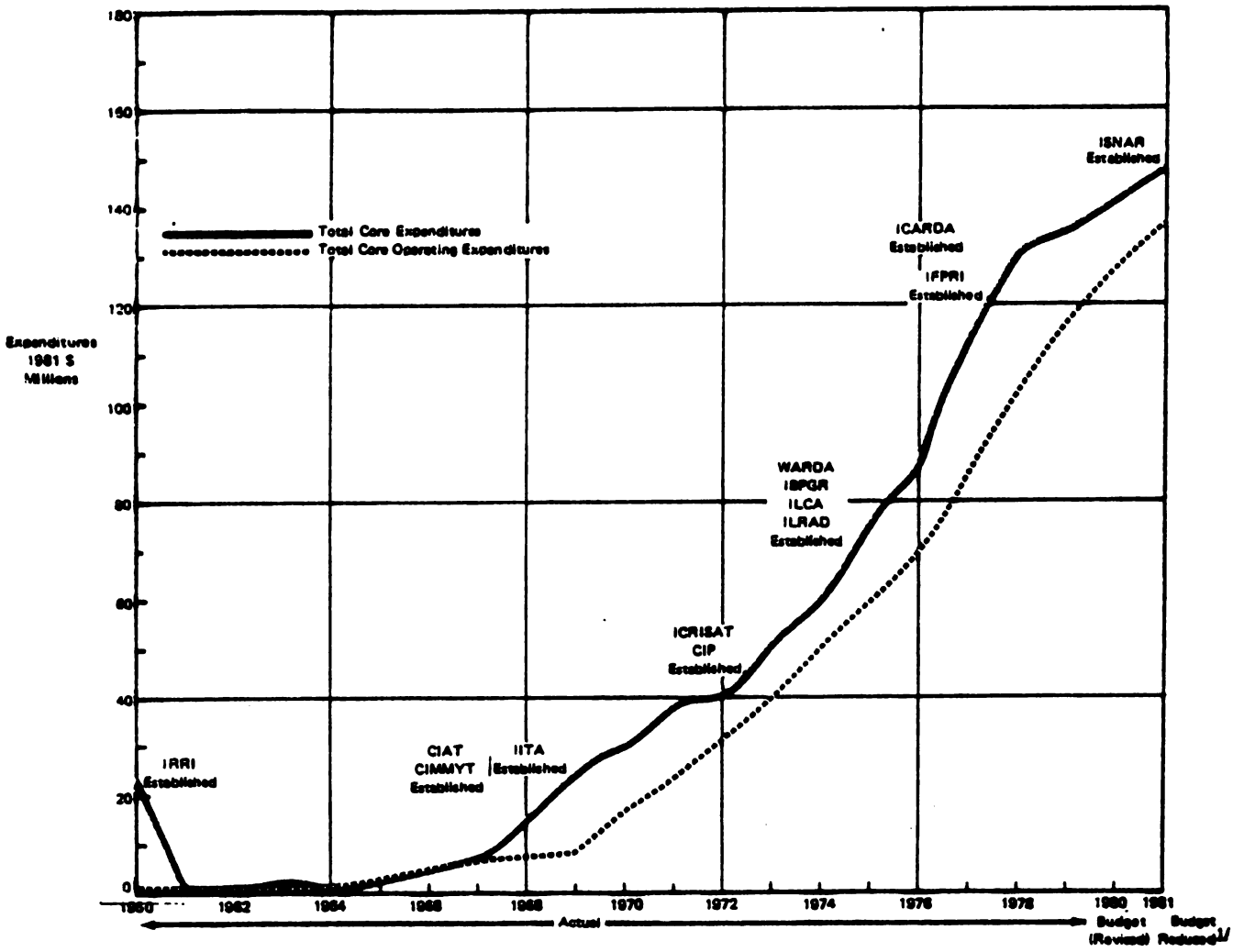
efficiency and effectiveness of other research, training and extension organisations in the region it servies. Through its library facilities, its germ plasm banks, its regional seminars and conferences at the working level, and its grants for research work of promise, and by other means, it can stimulate and help improve the quality of research within a large region. (4) Such an institution can demonstrate to visiting administrators and other laymen, in a manner that is not otherwise possible, the kind of balanced, sustained attack that is necessary if the foundations are to be laid for steady and reasonably rapid progress in increasing agricultural production. This can be important in countries where administrators and the public generally have little real understanding of what is involved in shifting a traditional agriculture to an agriculture based on the application of modern science and technology."

4. It will be noted that the center was thus intended to speed up the generation of new technology, to increase the numbers of well trained scientists and perhaps as important as anything else, to demonstrate the impact of good research on agricultural production to policy makers. This philosophy has been followed by each of the succeeding international centers though naturally there have been considerable changes in the concepts of what the centers should be doing and the ways in which they should do it. The founding of the Consultative Group in 1971 could be thought of as the start of the system in its present form though the evolution towards an integrated system, both conceptually and practically, has been slow and the process has revealed both advantages and problems.

5. The managements of the international centers have generally supported the strongly held belief that to be successful, research organisations must be allowed a great deal of freedom to organise their research programs. As independent centers with independent boards of management, each center has been free to follow this philosophy but the degree of freedom allowed to individual scientists shows considerable variation. On the other hand many research organisations exert a

fair degree of control over their individual research institutes and quite strong financial and program constraints are usually operated. Of course, the amount of freedom varies greatly with the cultural and historical background of research organisations but as a generalisation research institutions working on technology generation or applied research are more closely controlled than those involved in basic research. While the directors of the international centers have some justified fears of bureaucracy, particularly of the international kind, one of the unique features of the international agricultural research system is that the individual canters have been able to retain a great deal of freedom within the syetem. However, the independence of the centers has been eroded somewhat in the past two or three years because the donors are beginning to develop a collective sense of priorities; they are asking for an increasing degree of 'accountability' and perhaps most important to a decline in the rapid growth of funding that characterised the first seven or eight years of the CGIAR. Worldwide inflation, particularly severe in some of the host countries of the centers and rapid currency fluctuations, have added to the problems of financial management of the system. The question of 'accountability' is viewed with mixed feelings by research directors. Schultz[(3)] has said "those who provide the funds establish the accounting rules; they are rarely aware of the sharp diminishing returns to the burdensome accounting they demand". This could indeed impose a burden on the system that should be avoided if at all possible. The growth in financial resources as indicated by Fig. I could certainly be construed as denoting a strong faith in the system but the general consensus amongst donors at present appears to be that in the near term, at least, there will be relatively little growth in real resources. This would suggest that we must expect that any

FIGURE 1
International Agricultural Research Centers
Annual Core Expenditures and Core Operating Expenditures 1960–80
(in Terms of Constant 1981 Dollars)



1/ Level of Budget Expenditures to be Proposed to the CGIAR

CGIAR Secretariat 1980

major new activities, particularly in the existing centers will need to be financed by reordering priorities within the present resources of the centers and the system. This consideration will obviously have a very important impact on the centers' future programs and I will return to the topic when discussing their plans for the 1980s.

The Accomplishments of the International Centers

6. We all know that successful agricultural research has a high payoff but we also know that it operates within a relatively long time frame. Much has been written about the impact of the new varieties of wheat and rica. Some aspects of this have been summarised in the 1978 Integrative Report[4] and in the publications of Dalrymple.[5] Perhaps one of the more interesting aspects of these increases in yield is the rapidity with which they occurred. In some states in India for example, production growth rates in wheat reached nearly 10 per cent per annum. Annual increases of 5 per cent per annum occurred in many areas, a sustained rate seldom reached in developed countries. It is perhaps worth emphasising that these achievements illustrate the impact of good technology even where extension services are not especially strong.

7. Much of the discussion about the impact of the high yielding varieties has not been concerned about how it was achieved and the role of international and national research and extension programs but rather about the social and economic impacts, and particularly the influence on income distribution. Undoubtedly farmers with access to adequate land, irrigation and other inputs have benefitted very substantially. Those without these have not but tha technology itself is inherantly scale neutral. Some of tha factors e.g. improvement of irrigation

has generated additional employment; on the other hand double or triple cropping with rice has necessitated introduction of some machines e.g. threshers. The impacts of the "green revolution" have well summarized by Ruttan[6] in which he states that where the technology has been introduced in areas with a reasonable degree of equity in resources the effect has been favourable on both productivity and equity. Where there has been great inequity resources the pattern of inequity has been reinforced. The conclusion to be drawn from these experiences is that new technology cannot solve inequalities in resources and this points to the need not to do less research for the better endowed areas which after all form the breadbaskets of many countries, but rather to the need to increase and accelerate the research on the more difficult problems of the less well andowed areas.

8. In this connection it should be pointed out that the spectacular increases in production in irrigated rice and wheat have not been repeated and are unlikely to be so, in rainfed annual food crop production. There are many reasons for this. There had been rather little research on many of the major crops like sorghum, millet, tropical roots and tubers and legumes like cowpeas and beans. The international centers have been working on these at most 10 years so their technology is only now beginning to pass down through the national research programs. However, there are many other problems and World Bank experience with projects in rainfed crops leads us to believe that it is going to be difficult to make rapid improvements in the yields of these crops. A number of our projects draw attention to the lack of improved technology, to the problems of dealing with risk since a package with increased inputs also brings increased risks, to the problems of markets since crops like cassava and yams are difficult to

store and to the problems of replacing rather extensive systems in which land was not limiting with systems requiring more labour but where there is little or no animal or mechanical power.

9. In many of these rainfed areas it is probable that no one technology e.g. improved seeds, will have a major impact. Rather it will be a combination of several improved practices like better seeds, better timing of cultivation and weed control, better water and soil conservation, improved soil fertility, and perhaps improved mixtures of crops that the farmer will need to use if he is to obtain substantial improvements. Thus he will have to put into practice a fairly complex package of practices if he is to get substantial improvements. There are many problems in this not least the fact that we are dealing with the poorest, most risk prone and least educated farmers.

Research Output

10. While all of the IARCs would like to be able to measure their success in terms of the impact of their technologies on agricultural production they recognise that the outputs of a research organisation are new knowledge and new technology and that their clients are the national research and to some degree the national extension services of the developing countries. The contributions of the centers to technology development are published annually and were summarised in the 1979 Integrative Report of the CGIAR.(7) As more than 50% of the resources of tha system go into plant breeding and related activities, this area is the single most important activity in most of the crop-oriented centers. The general consensus, as demonstrated by statements of national agricultural researchers is that the collection, conservation and incorporation of useful genes in the

mandate crops of the centers is a major activity that will continue its value into the forseeable future.

11. The IARCs distribute their breeding materials at various stages, sometimes as a finished variety, often as segregating materials. As will be discussed later the centers expect a considerable change over time as the national programs develop strength, much of the material will be distributed at earlier stages in the breeding cycle. Nevertheless the international centers may have to come to the rescue when serious outbreaks of pests or diseases occur. This has happened in the case of rice in Indonesia when a new biotype of brown plant-hopper caused severe damage over large areas. Fortunately IRRI had a back up variety which was resistant and which could be multiplied quickly and distributed to replace the susceptible variety. However, this example demonstrates some of the problems that confront modern agriculture in the developing countries. It has been estimated, for example, that 25% of the 130 million hectares of the world's rice is in short strawed, photo-period insensitive cultivars. This area of about 30 million hectares is planted with about 100 cultivars which have replaced thousands of traditional varieties. Although many of these new varieties have resistance to several pests and diseases, this resistance is often based on a single major gene for each disease or pest. It would be desirable to have more of the so called horizontal or field type resistance but obtaining combinations of these presents quite different problems. The use of multilines in wheat is of course one way of approaching this problem. In conclusion it looks as if the international centers may do some of the defensive research needed to maintain the recent gains but it is likely that the burden will fall increasingly on the national programs as modern agriculture spreads.

12. Although plant breeding and genetic improvement have occupied a good deal of the attention of the international centers, it is worthwhile drawing attention to the work of the centers in developing systems of better land and water management. As indicated earlier much of the impact of the research work has been in irrigated agriculture but it is already very obvious that improvements in production in rainfed annual crops are much more difficult to achieve. I noted earlier the lack of suitable technical packages and the need for the farmer to combine a number of improved practices in order to obtain substantial increases in production. In this connection improved water conservation in the semi-arid areas and better control of excess water in the humid areas are obviously very important.

13. Land conservation is also of great importance. Increasing concern is being expressed about the ravages of soil erosion, not only in the destruction of agricultural land in the catchment areas but also in the rapid siltation of reservoirs and irrigation schemes in the lowland areas. Soil erosion has, of course, been an emotive topic for many decades and the crusades undertaken by people like Bennett in the USA are very well known. Soil conservation was also a major objective in many of the colonial agricultural systems, and was often done through coercion. It is significant that many of these projects have broken down since independence; this together with the spread of population into land which should never be farmed under annual crops and the intensification of cultivation on lands which formerly had a stable farming system under shifting cultivation have led to soil erosion becoming an extremely widespread phenomenon. Indeed the increasing wealth of countries like Nigeria and hence

the increased demand for food has intensified the pressure on the land very greatly. Mechanisation is becoming much more widespread and once this is introduced all stumps are removed so that there can be no regeneration of the trees.

14. There is no doubt, therefore that destruction of land, in some cases in a spectacular manner, in others in an insidious way, will be increasingly serious in the next decades. We may find ourselves in the paradoxical situation of having given a great deal of attantion and effort to the conservation of genetic resources and too little attention to the land resources on which these can be grown. However, the problem remains that while the destructive impacts of soil erosion are obvious, the benefits of soil conservation are difficult to demonstrate and are delayed well into the future. Thus they are not only intra-farm but are also inter-farm and inter-generational.

15. Obviously many developing countries are neither in the position to subsidise soil conservation works (for example to 80% in the United States) nor to enforce soil conservation by coercive practices. This makes it all the more important to develop farming systems that will be economically viable, socially acceptable and that will confer some immediate benefits on the farmer as well as conserving the soil. This emphasises the importance of such work as that being done at IITA whereby the combination of minimum tillage and conservation of crop residues is used to improve yields and conserve the soil. In this large scale experiment it has been shown that the construction of graded contour banks for conventional tillage costs about $430/ha. Even with these the blocks with conventional tillage had 250 mm of runoff (carrying 42 kg/ha. of plant nutrients) compared with 16 mm of runoff (carrying 13 kg of plant nutrients)

during a four month maize crop.(8)

16. My intention in convering this subject at some lengh is because I wanted to mention briefly the idea of transferability. The system has given much attention to this and to the subject of location specificity. It has tended to emphasise the wide adaptability and hence the transferability of some of the new varieties and thus has stressed that priority be given to such subjects. In this sense rasearch such as that on farming systems and land conservation is regarded as having little transferability. However, a product like new knowledge or new methodology crosses national and ecological boundaries easily and this is thus the kind of end product that is needed from this research though it is obviously completely dependent on national programs for the generation of location specific technology.

Training

17. Every country would give training a very high priority and the centers have recognised this by making training one of their major efforts. I think that everyone agrees that the formation of trained human capital is perhaps the most important single asset that could be created. Centers have approached this in different ways. The crop oriented centers have had production training courses which have concentrated on training developing country scientists in the conduct of a crop research program, usually lasting for the period of one crop. They have also had a variety of in-service training programs at the master, doctoral and post-doctoral levels though the numbers have obviously been limited and the capacity of the centers in relation to the needs is really quite small. There are many countries where the numbers of people with the required educational levels are small. In Africa for example, even the more advanced countries had

only about 10 per cent of the population of secondary school age enrolled in secondary schools compared with 56 per cent in the Philippines.(9) Regardless of the efforts of the international centers and other organisations involved in training agricultural scientists, these countries will need a very long time to reach a desirable broad educational base.

Work with National Programs

18. I mentioned earlier something of the changes in the strategy of the international agriculture research system. I think that one example of this is the attitude towards national research. The early international centers were thought of as substituting to some extent for the weaknesses in national programs and indeed there continue to be suggestions that the centers could disappear, by being absorbed by national or regional programs as the national programs become stronger. The centers have long since realised, however, that in the absence of strong national programs their impact would be very limited and so they have become involved to varying degrees in strengthening national programs. One obvious way has been in training but some of the centers have or had substantial technical assistance programs in which they were the implementing agency for a commodity based research project in a specific country. By and large this kind of activity, which is normally supported by special funding from a specific donor, has not had the universal support of the Consultative Group; partly because it was thought that the centers were being drawn into areas which could detract from their major concern of doing research of transnational importance and partly because it was considered that they had rather little comparative advantage in this area.

19. Nevertheless national program involvement demonstrates a dilemma for a worldwide system for there are vast differences in the capacity amongst national

programs and there are very big differences between regions. National programs in Africa are by and large much weaker than those in Asia or Latin America and indeed the centers operating in Africa face a very difficult problem. ILCA, for example, is concerned with livestock improvement in Africa where most national progrems are weak, but where livestock research is particularly weak. Yet by the very nature of the problems ILCA can only make substantial progress by working with national programs. Thus overall progress in producing better technologies in livestock husbandry are likely to be slow, even slower than is normal in livestock research.

20. Involvement in national programs is only one aspect of what has come to be called off-campus activities. There are many others, regional programs, off-campus core programs such as the research on deep water rice in Thailand where the center itself does not have a suitable environment on the campus, international testing programs and networks which have been described and summarised in the stripe review by the TAC.(10) Altogether the centers now have a major effort outside the main campuses, amounting to about 25% of the total resources of the system. Nevertheless strengthening national research institutions may indeed be one of the major accomplishments of the CGIAR system. Intangible benefits occur when administrators and governments are convinced that agricultural research is a worthwhile investment. They occur when the research systems of developing and developed countries are brought closer together and where their synergistic effect will be of incalculable value. Agricultural science does not recognise political or ecological boundaries and the international research system is one to which all may contribute and all may benefit.

Future Developments in the CGIAR System

21. At the moment the CGIAR is undergoing a review dealing with its future

management. I will not discuss this aspect but rather draw together some ideas on issues that the system will be faced with in the next decade or so. I would suggest that we consider this in the context of the system's role as a research organisation dealing mainly with food crops. The background against which it will carry out its work will be dominated by three main considerations:-

(1) population growth, particularly in the urban areas

(2) increased demand for food due to rising incomes

(3) increasing costs of energy

Population growth and the impact on food needs has been widely discussed and is illustrated by the fact that Latin America will have a population of about 600 million by the year 2000 compared with 350 million in 1980. I will give a little more attention to the impact of increasing incomes in the developing countries on food consumption. Eight of the major oil exporting Third World countries with approximately 360 million people have had an average increase in food imports of 19 per cent per annum.[11] Indeed food imports into the developing countries doubled in real terms between 1970 and 1977. Furthermore, the demand for poultry and pork livestock products, which consume grain, has been growing at a rate of 4.5% per annum. Major increases are expected in the centrally planned economies. The Peoples Republic of China, for example is expected to import about 15 million tons of grain in 1980/81 compared with an average 4 - 5 million tons in the 1961 - 77 period. The combination of population growth rates and rapid increases in per capita income seems likely to provide an unprecedented growth in demand for food in the next few decades.

22. Increasing costs of energy and their impact on food production are also the subject of much discussion. Modern agriculture is often accused of being a profligate user of energy. Yet the facts seem to point the other way. For example, from 1945 to 1975 the primary energy input for the average ha. of US corn production increased from about three barrels of oil equivalent to about five. Of this the energy for fertilisers increased from near zero to about two barrels but yields increased from 2 to 5 tons/ha[12] so it took on average two and a half less barrels of oil to produce the five tons of corn. Similar kinds of calculations have been used to show that if agriculture in the Sahel was modernised (to include irrigation of 600,000 ha.), energy consumption would be of the order of one million tons of oil equivalent p.a. which would be only a small proportion of the Sahel's total energy equivalent. Dispassionate analyses of energy use related to food production, therefore, appears to suggest that the energy used in actual production of food is not likely to be so critical as is sometimes suggested. However, many people, including vast numbers of rural people, depend on renewable sources of energy for most of their other needs, particularly heating and cooking and agriculture supplies a considerable proportion of this in the form of crop residues and manure. The increasing emphasis on agro-forestry is a recognition that wood will supply an increasing amount of these energy needs.

23. Alcohol production is another aspect of the energy equation in agriculture. Brazil, for example, has a target of 4.8 billion litres of alcohol from 72 million tons of cane in 1980/81 rising to 10.7 million litres from 160 million tons of cane by 1985.[13] The country also has plans to build 11 plants for production of alcohol from cassava giving 345 million litres per annum. The development of plans such as this could, of course, have very serious impacts on other aspects of food crop development particularly on food for export.

The Determination of Priorities

24. One can thus look at the future research plans of the CGIAR system against this background of food, feed and fuel needs. To do this we can look at the priorities as determined both by the system itself and by the centers. We should do this too against a background that, as mentioned earlier, there is unlikely to be any substantial increase in resources in the near term. Indeed the older centers have virtually no opportunity for growth at present and in some cases have had to cut back a little on existing programs. This makes it all the more important to distinguish between short and long term plans. Recent program and budget documents show that the centers regard the present financial stringency as temporary so they have made cuts in such programs as training and germ plasm collection which can be easily accelerated once additional funding is available. Where there have been particularly severe shortages posts have been left unfilled. Obviously these solutions can only be of a short term nature.

25. If we accept the fact that there is not likely to be any substantial increases in real resources for the system, we see that the determination of priorities becomes a critical part of the whole operation both at the center and the system level. Ordering priorities for research is a process fraught with difficulties even at the national level. At the international level it is even more difficult since the international system has only a small part, perhaps less than 10%, of the total resources going into agricultural research in the developing countries. It exerts more influence than this proportion of the resources would indicate and it has a degree of stability of funding, resources per scientist and freedom that is the envy of most national programs. Neverthe-

less these advantages carry with them the obligation to show that the resources are well used.

26. The overall priorities of the system are determined by the Technical Advisory Committee (TAC) a committee comprised of 13 agricultural scientists from developed and developing countries that was set up at the time the Group was formed. The broad objectives of international support to agriculture are stated by the TAC as follows:

(a) increasing the amount, quality and stability of food supplies in the LDCs and meeting the total food needs

(b) meeting the nutritional requirements of the less advantaged groups in the LDCs.

27. Some of the quantitative parameters for use in priority assessment include planted areas, production, numbers of countries and people involved in the production, contribution to rural and urban diets, resources allocated to the commodity by national research programs. By taking these and other factors into account the TAC advised the Group that:

(i) Group resources be directed first towards assuring the continued support of the IARCs and other related activities already established by the Group.

(ii) When these requirements have been fulfilled, the TAC advised the Group that additional resources be directed to filling important gaps; the five subject areas in order of priority were: tropical vegetable research, water management research, plant pest and disease physiology and ecology research, food policy research and

aquaculture research.

28. Since this paper was agreed by the CGIAR in 1979, the International Food Policy Research Institute (IFPRI) has been accepted by the Group for funding. On the other hand the Group acted on TAC's advice that the International Centre for Insect Physiology and Ecology not be admitted. An acceptable mechanism for carrying out international research on water management is being sought at the moment. Using a matrix system the TAC[14] summarised its recommendations on priorities under commodities, production systems and production factors as illustrated in Tables, I, II and III. Table I for instance, shows that there are some areas of research in the 1st priority group on which no CGIAR supported research is at present taking place (tropical vegetables and aquaculture) and some second priority areas where there is research (barley, triticale, cowpea, sweet potato, broad beans). In terms of production systems (Table II), some work is under way in all of the 1st priority areas and in some of the 2nd priority areas. For production factors (Table III) a great proportion of the existing research at the IARCs is concerned with improved seeds, and pest and disease management. There is some work on plant nutrition, mainly nitrogen fixation, and on mechanisation but there is relatively little on post harvest technologies and soil and water management.

Priorities in the International Centers and National Programs

29. The above summarises the Group's views on priorities for international research and the extent to which these are being presently followed in the system. However, while the TAC can advise the Group on a broad strategy of priorities for

TABLE I

	1st Priority	2nd Priority	Observations
COMMODITIES			
Cereals	- Rice, wheat, maize, sorghum, and millet	- Barley, triticale	
Roots, tubers and others starchy foods	- Cassava, Potato	- Sweet potato, plantains, yams	
Pulses	- Dry beans	- Cow pea, chick pea, pigeon pea, broad beans, and lentils	Importance of 2nd priority crops is high in certain regions
Vegetables	- Selected tropical vegetables which, of highest priority, include amaranths, winged bean, peppers and okra	- Other tropical vegetables	Nine vegetables have been selected for consideration in the research programme of the proposed IVRIT (para 173).
Oilseeds	- Groundnut, soyabean	- Coconut, cotton, several annual oilseeds	Importance of 2nd priority crops is high in certain regions
Animal and animal products	- Nutrition & reproductive efficiency of ruminants - Trypanosomiasis - Theileriosis - Aquaculture (low-cost systems with plankton, herbivorous & omnivorous feeders)	- Non-ruminant livestock - African Swine Fever & other important animal diseases - Aquaculture (other systems)	

TABLE II

	1st Priority	2nd Priority	Observations
PRODUCTION SYSTEMS	- Rainfed and irrigated croplands of arid & semi-arid tropics and sub-tropics - Arid rangelands - Infertile lands of sub-humid and humid tropics	- High rainfall tropical lowlands - Tropical and sub-tropical highlands - Agroforestry	Including related aspects of socio-economic research at micro-level & macro-level and regional assessments of soil & climate conditions. Including also related animal production systems
	- Food policy research related to 1st priority commodities and production systems	- Broader aspects of food policy research	

TABLE III

	1st Priority	2nd Priority	Observations
PRODUCTION FACTORS			
Improved seeds and breeds	- Improved seeds of 1st priority crops	- Improved seeds of 2nd priority crops - Conservation, evaluation & use of special animal breeds	
Plant nutrition	- 1st priority crops	- 2nd priority crops and efficiency in fertilizer use	Including nitrogen fixation
Plant pest and disease management & control	- Genetic resistance to pests & disease of 1st priority crops and integrated pest management in 1st priority production systems	- Genetic resistance to pests & disease and integrated management in 2nd priority crops and production systems	Including basic research aspects of pest and disease physiology and ecology
Soil and water management	- 1st priority crops and production systems	- 2nd priority crops and production systems	Including related aspects of soil fertility management
	- Design parameters and low-cost technologies for irrigation and drainage	- Irrigation and drainage of special problem soils	Mainly at farm and village level
Post-harvest technologies	- 1st priority crops, especially roots and tubers	- 2nd priority crops	Mainly at farm and village level
Mechanization	- 1st priority crops & production system	- 2nd priority crops and production system	See qualifications in Chapter IV

the system as a whole, it is the international centers themselves which have to develop priorities in terms of resource allocations for the commodities included in their mandates. Even the single commodity centers have to make allocations; for example, IRRI has to decide how much of its resources should be devoted to irrigated and to upland rice and CIP has to decide how much of its work should go to potatoes in the highland areas of Latin America and the tropical and sub-tropical areas there and elsewhere. Although it has a global mandate for beans and cassava (excluding Africa) CIAT has devoted much of its resources to work in Latin America but again it has to make difficult decisions on how to allocate these resources to the different commodities.

30. Several of the international centers including CIP, CIAT and CIMMYT have published or are in the course of developing long range (5-10 year) plans which set out where the centers intend to put their emphasis over the next decade. By and large the centers have not suggested any radical changes in the programs that they have pursued since the centers started for there are no proposals, for example, to drop one mandate crop and adopt another. CIP has probably been the most adventurous in projecting its path through to the year 2000.(15) For example it expects to terminate its collection efforts for both cultivated and wild potato species by 1982. It expects to have populations with good resistance to late blight, nematodes and viruses by 1990. Beyond that it expects to focus increasingly on long term needs such as maintenance, exploitation and utilization of the world germ plasm collection, global communication networks for the transfer of potato information and training in new techniques. Direct help to national programs is expected to decrease but regional programs will become increasingly important.

31. Although the centers do not, by and large, envisage radical changes in what they will be doing in the 80s, one aspect which receives commonly recurring emphasis is the work with national programs. This is demonstrated by the stated intentions to put less emphasis on production of varieties for testing and release by national agencies and more on the production of elite germ plasm for use in national breeding programs. Furthermore, several of the centers have consulted the leaders of national programs on their long range plans. It is also of interest to note that several of the centers, especialy those working on the lesser known crops, (lesser known in the sense that there had been rather little research on them prior to the formation of the IARCs) expect to have solved the major disease problems and to be able to switch more of their resources to work in increasing yield potential. This has important implications for the future when it is recalled that even in crops, like rice and wheat, there has been little increase in yield ceilings in the last decade. Indeed even in these crops more and more attention has had to be given to fighting the pest and disease "tread mill" whereby minor pests and diseases become major ones through changes in cultural practices or varieties or new strains of the pest or disease. In some instances completely new pests (16) e.g. green spider mite and mealy bug on cassava in Africa have appeared. Thus while IITA has managed to greatly reduce the threat of the two major diseases, cassava mosaic and bacterial blight, it has now to cope with two new pests. Downy mildew, a serious disease of maize in India has now appeared in Africa. It is situations like these that may prevent the centers moving away from research on pests and diseases into other areas and while we may expect some shifts in program emphasis we must be cautious about expecting too much.

32. To summarise therefore I would suggest that we shall see gradual changes in the emphasis rather than in the kinds of research or changes in commodities over the next decade unless there are fairly major additions in funding. A greater involvement of the national programs in breeding work and a greater involvement of the IARCs in back-up research, particularly in pest and disease control, drought tolerance and some aspects of more basic research e.g. tissue culture would describe the picture as I see it.

Some Challenges of the 80s

33. In this seminar we have been discussing the prospects for technological progress in agriculture in Latin America in the 1980s. As I have indicated above the international centers expect the national programs to take over an increasing share of the work that they have been doing in the 60s and 70s. This can only if the national programs grow in strength and stability; this, of course, is going to be a very uneven process both intra- and inter-continentally. I have pointed out the particular problems of Africa but even in Latin America different countries are starting from very different bases. Unfortunately the information on the quantitative and even more the qualitative research resources of many countries is very meagre. Furthermore, the instability of funding and of government support for research is well documented. Another factor of concern is that many countries lack well thought out strategies for agricultural development on which a properly planned research and development strategy can be based. A good illustration of this is the case of the "resource poor" farmers. Donors to the CGIAR have stressed time and again that they wish the work of the centers to have a major emphasis on increasing the prosperity of these farmers. This is illustrated by the fact that the centers are involved in a major effort on the crops of poor

farmers and poor areas, millets, sorghums, cassava; on the development of technologies that will require low amounts of purchased inputs for these crops and on the development of crops e.g. grain legumes that will improve the quality of nutrition of poor people. However, these strategies are not always congruent with national strategies where priority may be given to more productive areas, because the pay off is quicker and better and to cash crops because of the need for foreign exchange. This situation may be exacerbated by the fact that the richer farmers and landowners often have a far stronger influence at the policy making levels of governments and thus exert a strong influence on how resources are used.

34. Historical aspects would suggest that many national programs will continue to develop in an irregular fashion with periods of strength followed by periods of weakness but that the overall trend will be one of continuing improvement. It is also likely that once a national program reaches a certain "take off" point, it will not be so subject to fluctuations in support and quality. Indeed there are indications that several countries have reached this stage.

35. By and large, therefore, I think that we can expect that the transfer of some of the present activities of the centers to the national programs will proceed at an uneven pace. It will certainly be facilitated by improved planning and stability of funding in the national programs, by enhanced training programs by both the international centers and the many other institutions involved in training and by a better knowledge of the capacities and capabilities of the national programs at both the center and the international system level.

36. If things go roughly according to plan, will there still be major gaps? My impression is that there may be four areas at least where these could occur.

The first is in the non-food or cash crop area. In many countries most of the poorer farmers derive the major part of their cash income from non-food or industrial crops. Examples are coconuts and cotton. Cotton has had a good deal of research but even now much defensive research, especially against pests, is necessary to maintain higher yields. Coconuts on the whole have had very sporadic research and progress in combatting serious diseases and improving yields has been very slow. Without some cash income farmers in these poor areas will be unable to purchase even the modest inputs that will enable them to increase food supply. Of course, there is the possibility that some national programs, recognising the attention being given to food crops by the international centers will divert a larger proportion of their scarce research resources to these crops.

37. The second area is in the management of difficult lands (steep lands, shallow soils, deeply flooded areas for example). I have mentioned earlier the problems of soil conservation on sloping lands and water control in these and in the drier areas. The international centers can supply better building blocks in the shape of improved varieties of mandate crops for these areas. The work on farming systems can supply ideas on better ways of conserving soil and water. Work on agro-forestry could help in the development of more productive species for fuel and energy production but one of the question remarks is over the "transferability" of such technology. Perhaps this is the area where the transfer of ideas, of methodology and of demonstration of success will be most useful.

38. A third area is that of increasing the efficiency of inputs like fertilisers and water. Of course, much is already being done on this. Better varieties make more efficient use of these inputs. International institutes outside the CGIAR e.g. the International Fertiliser Development Center (IFDC) are

researching better fertilisers and better and cheaper ways of using materials such as local phosphate rocks. However, methods of advising small farmers on the use of fertilisers are too often based on techniques from the developing countries. How to maximise the benefits of fertilisers in mixed cropping systems, in areas where two or three crops a year are grown, in areas where climatic risk is high are challenges which seem to be receiving rather little attention from either national or international programs.

39. Irrigation is a great stabilising factor in agriculture production in many countries yet there seems to be universal agreement that water is used very inefficiently. There is also agreement that social factors play a major role in this inefficiency but there seems little agreement on whether there are major researchable problems and if there are, how they could best be tackled. Once again the major constraint seems to hinge on the question of "transferability" of results since it is often suggested that most of the problems are location specific; nevertheless this is an area where ideas and methodology would be transferable.

40. A fourth area concerns the transfer of technology to small farmers. We have many examples of success where small farmers have improved their production significantly; in some cases this has taken place in spite of weak extension services. Several of the international centers, for example the IRRI rice constraints program, have made a major contribution to understanding why small farmers behave as they do. The training and visit system in India has shown that a well organised, single purpose system, well armed with suitable technology can contact large numbers of small farmers and persuade them to take up new technologies. Nevertheless millions of small farmers remain untouched by improved technology. Perhaps greater efforts in the social science field

directed to these questions could lead to new ideas in communcation and novel ways of increasing the rate of spread of improved agriculture.

41. This is not, of course, an all inclusive list; there are many many areas where additional efforts are needed but we have, in the last analysis, to consider these in the context of the resources, international and national, that will be available. We all recognise that spending an agricultural research in well below the figure of say 1% to 2% of the value of agriculture production that many consider the optimum range and we must also recognise that many countries will have extreme difficulty approaching this range in the next decade.

42. However, I would conclude on a reassuring note for I do think that in spite of all the problems and problem areas, agriculture production has made quite remarkable progress in the last two decades. There seems to be increasing recognition at every political level that good agricultural research has had and will continue to have an important role in improving production.

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