SB
123
.3
H39

Consultative Group on International Agricultural Research

CGIAR

Study Paper Number 3

Plant Genetic Resources

The Impact of the International Agricultural Research Centers

J. G. Hawkes

CIAT
BIBLIOTECA
17 FEB. 1986
60381

The World Bank
Washington, D.C.

Copyright © 1985
The International Bank for Reconstruction
and Development / THE WORLD BANK
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

First printing October 1985
All rights reserved
Manufactured in the United States of America

At its annual meeting in November 1983 the Consultative Group on International Agricultural Research (CGIAR) commissioned a wide-ranging impact study of the results of the activities of the international agricultural research oganizations under its sponsorship. An Advisory Committee was appointed to oversee the study and to present the principal findings at the annual meeetings of the CGIAR in October 1985. The impact study director was given responsibility for preparing the main report and commissioning a series of papers on particular research issues and on the work of the centers in selected countries. This paper is one of that series.

The judgments expressed herein are those of the author(s). They do not necessarily reflect the views of the World Bank, of affiliated organizations, including the CGIAR Secretariat, of the international agricultural research centers supported by the CGIAR, of the donors to the CGIAR, or of any individual acting on their behalf. Staff of many national and international organizations provided valued information, but neither they nor their institutions are responsible for the views expressed in this paper. Neither are the views necessarily consistent with those expressed in the main and summary reports, and they should not be attributed to the Advisory Committee or the study director.

This paper has been prepared and published informally in order to share the information with the least possible delay.

J. G. Hawkes recently retired from the University of Birmingham, England, where he was Mason Professor of Botany and head of the Department of Plant Biology.

Library of Congress Cataloging-in-Publication Data

Hawkes, J. G. (John Gregory), 1915-
Plant genetic resources.

(CGIAR study paper, ISSN 0257-3148 ; no. 3)
Bibliography: p.
1. Germplasm resources, Plant. 2. Germplasm resources, Plant--International cooperation.
3. Agriculture--Research--International cooperation.
I. Title. II. Series.
SB123.3.H39 1985 631.5'3 85-20405
ISBN 0-8213-0639-1

ABSTRACT

This genetic resources impact study was commissioned as part of a general impact study on all aspects of agricultural research and development within the CGIAR organization.

Since the term genetic resources often means different things to different people, the first part of this report gives a discussion on the subject and attempts to define the terminology in general use. It also describes the chain of activities into which genetic resources work can be divided.

The second part of the report describes the genetic resources activities of the international centres and of the International Board of Plant Genetic Resources (IBPGR). It also attempts to evaluate the impacts of each stage in the genetic resources chain.

The third part sums up the work, assesses its strengths and weaknesses, and makes suggestions for future development. The writer concludes that genetic resources are being made freely available to those who request them. The International Board of Plant Genetic Resources is promoting and developing the use of genetic resources materials, and IARC breeders are taking full advantage of the germplasm available to them, passing breeding lines and selections to national programmes for further trials and, where appropriate, releasing new varieties with better yields, adaptation and resistances than those previously available.

PREFACE

The information given in this report was obtained partly from visits to the centres concerned, partly from publications and partly by correspondence.

Visits were made to IBPGR and those centres least well-known to me, namely, CIMMYT, ICARDA, ICRISAT and ILCA. Reports were obtained from CIAT, CIP, IITA and IRRI, all of which centres I know relatively well and have visited recently.

Information on the IBPPR regionally-coordinated programmes was obtained personally through visits to Thailand and Indonesia (Southeast Asian region), Kenya (East African region) and Syria (Southwest Asian and North African region). The centres' outreach programmes and their impacts on national breeding programmes were studied in all countries visited.

ACKNOWLEDGEMENTS

I would like to express my grateful thanks to the directors and scientific and administrative staff of the international agricultural research centres (including IBPGR) for facilities provided during my visits and in response to my letters. Without such friendly and enthusiastic response this report could never have been written.

I also wish to pay tribute to the help received from scientists in national programmes as well as the IBPGR regional coordinators. I am grateful to Professor Jock Anderson, Project Director, for his help and advice and to Robert Herdt and Donald Plucknett of the CGIAR Secretariat for their friendly advice and comments.

My very grateful thanks go also to Dorothy Marschak for editing the manuscript for publication.

CONTENTS

SECTION I GENERAL

1. Introduction

Genetic resources work consists of a series of distinct activities or stages which follow each other in a logical sequence. Therefore, an assessment of impact must be made by identifying these as the end-products of each stage in terms of their influence on the one following it. At the end of the sequence or chain the final, and most important, impact will be the use to which genetic resources materials have been put in the breeding of better yielding, better adapted and more resistant varieties in third world countries. A very important part of this final impact is the improvement of the standard of living of the small farmers, though it is obvious that genetic resources work is only one of the ways in which this goal may be attained.

Before discussing the stages in the chain of genetic resources work mentioned above, it may be useful to define again the term "genetic resources". In the broad sense they are the total genetic diversity of any biological entity. In the narrower, more usual sense they comprise the genetic diversity of plants or animals useful to man, and in the context of the present study, they are confined to a limited range of the major crop species and the wild species genetically related to them. To go into further details they can be subdivided as follows (Hawkes, 1983).

(1) Currently grown commercial varieties (cultivars). (2) Obsolete commercial varieties. (3) Breeding lines and stocks. (4) Induced or natural mutants. (5) Old land races, which are normally populations that have not been scientifically bred or selected. (6) Primitive forms of crop plants of great genetical diversity. Some workers do not distinguish these from land races. (7) Weed races, of various types and modes of origin, related both to the crops and to the wild species from which they are derived or to which they are related. (8) Related wild species, including both the presumed ancestors of the crops and wild species not so closely related. These materials can be considered as a potential source of valuable genetic diversity for use by plant breeders.

Category 1 materials (currently grown commercial varieties) would not normally be stored in genebanks, since these can be usually obtained from other sources. The lines and selections currently used by breeders, and generally termed Breeders' Working Collections, have sometimes also been included as one of the genetic resources categories. However, these are normally excluded since they are constantly changing and do not need to be conserved apart from special lines thought to be of more permanent value, mentioned under (3) above. A partial exception to this rule is the "active" or, really, "working" collection of wheat conserved at CIMMYT. Category 4 materials (induced or natural mutants) should not be stored in genebanks unless they are considered to possess known genes of combinations of present or future value to breeders.

So far as genebanks are concerned, categories (5) to (8) are of greatest importance for collecting and conservation.

Exploration and conservation objectives are based on one or both of the following reasons:

(i) The most important reason for collection and conservation of genetic resources is the threat or actual loss of genetic diversity in the field. This may take the form of loss or diminution of land races and primitive forms of crop species through their replacement by high yielding varieties (HYVs) by the farmers. It may also be due to the loss of wild species or weed races through changes in land use resulting from human population pressures and other factors.

(ii) The second reason for conservation is based on plant breeders' needs. Genetic resources materials, particularly of wild species, weed races, primitive forms and land races, may be needed urgently by breeders because they know or hope that characters of resistance or adaptation urgently needed in plant breeding programmes exist in these materials. Such collections of conserved material may also be under threat of genetic erosion or they may not. The important factor here is that they are urgently needed by breeders.

Finally, we must recognize that there is a third category of material (though generally only wild species or semi-cultivated forms) where no genetic erosion is in progress and which is of no immediate interest to breeders. Whilst keeping a careful watch from time to time on such materials it is as well to leave them alone, since when they are collected and deposited in a genebank all natural evolutionary change will cease (see also, below - <u>in situ</u> conservation).

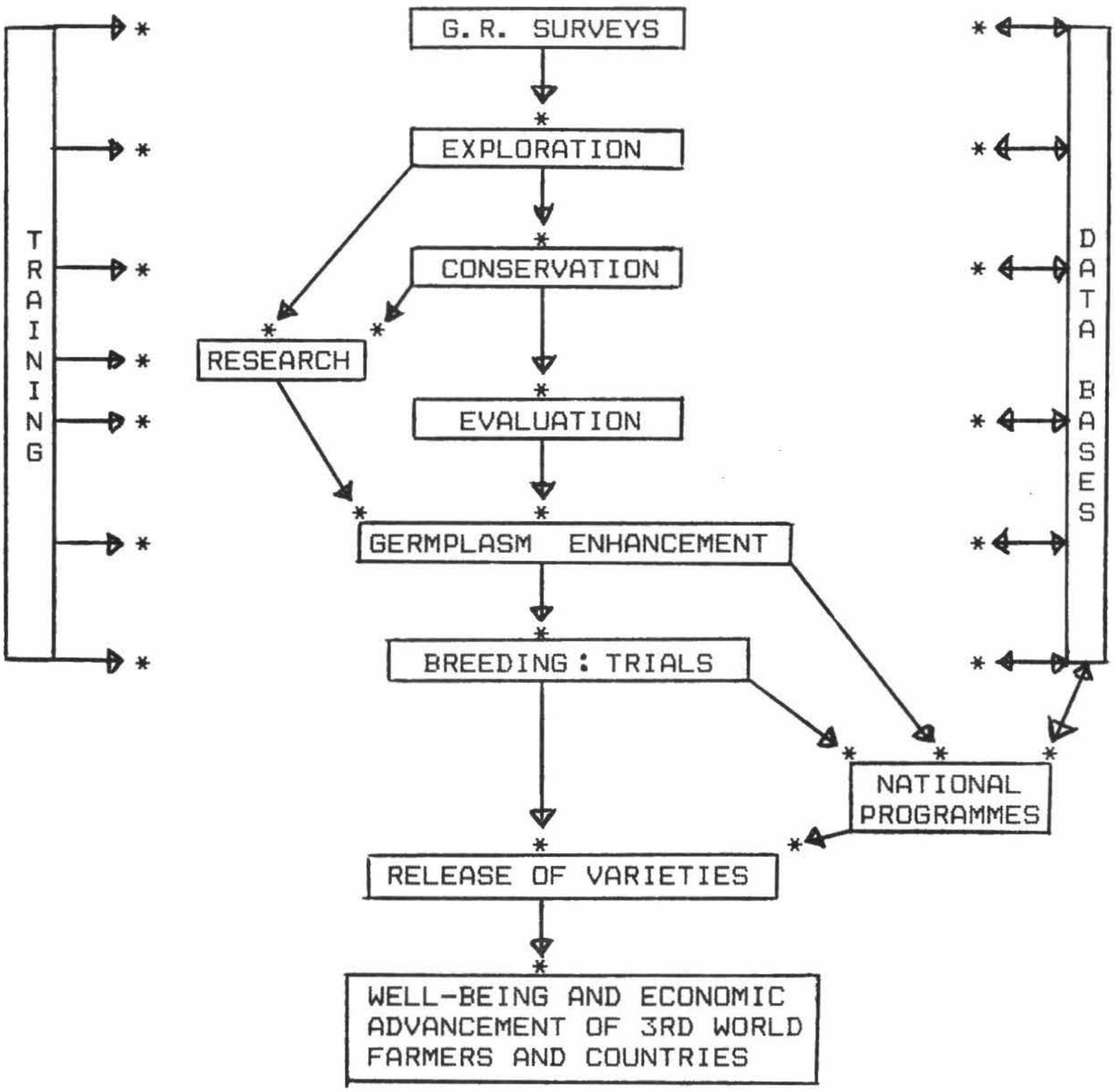
2. The Genetic Resources Impact Chain

The chain of genetic resources activities is set out in Figure 1, with the corresponding impacts shown as a series of asterisks (*). The central chain forms the core of genetic resources work, with three lateral items which exert impacts on nearly all the other stages. Feedback also occurs in most cases. Let us now examine each stage in detail:

i. <u>Genetic resources surveys</u>

These involve for each crop an assessment of materials already existing in genebanks and what is likely to be still available in the field. A study of the patterns of variation in the crop and its wild relatives should also be undertaken. For many of our major crops the information is still fragmentary or incomplete. The ideal situation is that found in a single centre or institute which has global responsibility for a crop, knows exactly the areas from which collections have been made, where they are stored and exactly the

GENETIC RESOURCES IMPACT [*] CHAIN



areas from which more material is still needed. Studies of the numbers of accessions already in genebanks for a particular crop are not so useful, since there is nearly always much duplication of materials between banks; furthermore there may be too many samples collected from easily accessible places and none or only a few from others. Ideally, computer-generated distribution maps using provenance data from existing collections (latitude and longitude coordinates) would show at a glance where more collections need to be made. All information obtained from surveys is to be welcomed, either in the form of area surveys, or more usefully, crop surveys[1] (Frankel, 1973) and (Piedrabuena and Esquinas-Alcazar, 1983). These will be mentioned, when they exist, under individual crops. Unfortunately, the need for this important prerequisite has not been generally recognized. In consequence, this has resulted in much duplication of effort on the one hand, and under-collected areas on the other.

A feed-back in the other direction, or lack of it, as the case may be, results from imperfectly recorded locality data (passport data) during exploration missions. If no clearly defined localities are noted, the surveys of where material has been collected will be incomplete and this will result in unnecessary duplication of collecting efforts. Thus the impact of genetic resources surveys, when good, can prevent unnecessary duplication of collections and can indicate where the time and money should be spent to advantage in "filling the gaps".

On the whole, IBPGR has been well aware of the need for surveys, whilst the other concerned centres have to some extent lagged behind in this respect.

ii. Exploration and collection

Efficient collecting method, using the appropriate internationally agreed sampling techniques (Hawkes 1980, IBPGR 1983), are essential for all genetic resources work. The areas of distribution of the cultigen and its wild relatives must be sampled evenly so that a high probability of capturing rare or locally endemic alleles, as well as the common ones, is achieved.

The main outlines of the agreed seed sampling techniques were laid down at the FAO 1973 Technical Conference on Genetic Resources, and have been refined where necessary by further research and discussion.

Although seeds and vegetative storage organs are the materials generally collected, with emphasis on seeds particularly, certain groups of plants with "recalcitrant" seeds cannot be collected easily because of their very short

1 IBPGR crop surveys have been issued for a range of crops and crop groups. So far, nineteen publications have been issued, and others are underway. They will be referred to later when the particular crops are being discussed.

seed viability. A possible way of collecting in vitro samples in the field has recently come under discussion and are being tested for cacao and cassava (IBPGR, 1984). IBPGR has had a major impact here by supporting or sponsoring exploration missions (Lawrence, 1984). The IARCs have also played a most useful role in collection missions for the crops for which they possess a global mandate. There have been many examples of joint IARC/IBPGR missions, especially for major CGIAR mandate crops, which have added materially to the crop centre collections.

Thus the impact of exploration activities may be judged by the nature and quality of the material put into genebanks, having particular regard to correct sampling methods and the even coverage of the distribution area of the crops concerned, together with their wild relatives. An assessment based on numbers of samples only is of little use, and can at times be positively misleading.

iii. Conservation

The primary purpose is to conserve genetic resources materials both for long-term storage (base collections) and for short to medium-term storage (active collections)[2]. These latter collections are used for evaluation and for the distribution of samples to breeders and others who need materials for evaluation purposes. A good genetic resources collection will possess a wide and satisfactory range of material of the species with which it is concerned, dependent of course on the impact of exploration activities, and through them of the surveys. The responsibility of conservation workers is to preserve materials under optimum conditions so as to prevent genetic erosion within the seed bank and thus to preserve the genetic integrity of each sample. To this end, conditions of temperature and moisture must agree with internationally agreed procedures, germination tests must be made at regular intervals, and regeneration, when carried out, must also be effected with a full understanding of the hazards involved. The work of IBPGR and its several advisory committees has helped to strengthen the impact of conservation work in the IARCs and in national conservation programmes very considerably, both for seed and for tissue culture storage.

Directories of germplasm collections for a limited number of crops have been issued by IBPGR. These will be referred to later. A list of institutes which conserve germplasm to the required standards has also be published (Hanson et. al., 1983).

2 Another important conservation method is the preservation of genetic resources in their natural environment, which is thus termed in situ. It has not yet come under consideration by IBPGR or the IARCs. Its potential impact is considerable for wild species, but it is perhaps of little or no importance for the cultigens.

Drawing these points together, we can identify the following impacts of genetic conservation work:

(a) A good range of accessions in the genebank from all parts of the distribution area of the crops, and those of their wild relatives, ensures that breeders possess a broad genetic base to aid in solving problems of yield, pest and disease resistance and adaptation to extreme environments.

(b) An adequate range of obsolete cultivars, mutant lines and important breeding lines serves the same end.

(c) Good storage facilities must be available to ensure that the genetic integrity of each sample is preserved and that it remains, as far as possible, of the same genetic constitution as when it first entered the bank.

(d) Adequate germination testing and regeneration of samples are required for the same reasons. The regeneration of cross-pollinated crops needs particular care, and adequate numbers of plants kept under some form of isolation to prevent contamination from pollen of other samples is essential (Porceddu and Jenkins, 1982).

(e) The genebank manager and/or conservation officer should act as a "catalyst" in making sure that information (see Section x) and materials are sent to breeders and other scientists for evaluation of materials. This is an essential impact of conservation work, linking it on to the next stage in the genetic resources chain.

(f) The genebank manager should also keep in close contact with others holding similar materials, with a view to avoiding duplication.

iv. Evaluation

This term encompasses the various activities designated earlier as "scoring", "testing", "screening", "measuring" and so on. It involves a study of each genebank accession to understand and note down its morphological, agronomic and other features such as disease and pest resistance; features, in other words, that may be of interest to breeders. Without this sort of work breeders will be largely unaware of the material in genebanks which they might need but would be prevented from using for lack of information.

Since evaluation is such an all-embracing activity, IBPGR has attempted to break it down into four sections, namely, (a) passport information, (b) characterization, (c) preliminary evaluation and (d) full (or secondary) evaluation (Erskine and Williams, 1980).

(a) Passport information has been mentioned before, under genetic resources surveys.

(b) Characterization concerns those characters that are highly heritable, can be easily seen by the eye and are expressed in all environments. This work is normally carried out at the genetic resources centre during an initial multiplication of stocks before they are put into long-term storage.

(c) Preliminary evaluation is concerned with other characters of interest to breeders, which can be scored in the field but which are of a less highly heritable nature.

(d) Full (in-depth) evaluation is to some extent open-ended and is largely concerned with laboratory or glasshouse screening for pest and disease resistance and for adaptation to extreme environments, though much of this last-named work will generally need to be carried out under appropriate field conditions.

Whereas characterization and preliminary evaluation should be carried out in genebanks, the full (or in-depth) evaluation will need to be undertaken by breeders and other scientists interested in the crops concerned and in their pests and pathogens, etc. In the IARCs there are no problems in undertaking such work since breeders and other scientists all work in the same institutes and are able to collaborate freely. Until recently IBPGR has taken responsibility for only the first three activities. It is currently planning selective work for the fourth. One can therefore readily see that, on a world scale, in-depth evaluation of a crop and its related wild species will not take place unless (a) the crop comes within the mandate of one of the IARCs, or (b) it is of interest to scientists in developed countries (e.g. wheat, maize, barley, rice, potatoes, etc. - but all these come within IARC mandates in any case). Should the genetic resources centre in developing countries possess the stability of funding and well-trained personnel to accomplish these tasks - well and good - but normally they do not, or do so only to a limited degree. Thus, although the objective of this report is to look for impacts within the CGIAR-funded centres and institutes, and between these and third world countries, one must emphasize that there is likely to be a grave loss of impact in the field of in-depth evaluation of certain crops in developing countries. This continues also into the area of germplasm enhancement as will be discussed below.

In order to standardize the scoring of evaluation data, IBPGR has convened committees of breeders for various crops, whose task has been to standardize sets of descriptors and descriptor states for the crops concerned.[3] Thus the data can be entered into data banks in a standard form and as such the information should then be available to breeders. One has to admit that this work has rather lagged behind in national genebanks, and is really not too well advanced in certain IARCs either.

3 Over thirty of these descriptor booklets have been published by IBPGR at the time of writing. Another fifteen are available or in press.

On the whole, then, the impacts of evaluation have not been as strongly or as uniformly developed as those of exploration and conservation. Some breeders for some crops, such as potatoes, are interested almost exclusively in in-depth evaluation, and others are following this trend. Yet IBPGR has no mandate for in-depth evaluation. It would seem that further discussion and decision-making are needed here on a very wide basis to see how evaluation impacts could be coordinated and strengthened on a global scale.

v. Germplasm enhancement

This is a recently coined term which overlaps in its meaning with "pre-breeding" and "parental line breeding". It is defined as the production of breeding lines into which are incorporated/(or introgressed) the useful genetic characters of wild species and primitive forms. This activity often needs some basic research (see Section 11 - Research) on the taxonomy, crossability and genetic compatibility of wild and cultivated species. It involves creating early generations of crossing and selection between advanced and primitive materials which some breeders regard as part of their work in any case but in which others breeders hesitate to become involved. The direct introduction of alien germplasm into their highly-bred elite lines may retard their breeding programmes by several years, and they are thus understandably reluctant to use such material in the raw state. This is in fact one of the serious barriers militating against the proper use of genetic resources materials. Germplasm enhancement is an essential activity, therefore, which serves to remove such barriers. Its impact is felt very strongly in crops such as potatoes, wheat, barley and some grain legumes, whilst its lack is equally seen in certain other crops such as maize, whose breeders have in the past been reluctant to make use of the wealth of genetic diversity present in the genebanks. Again, IBPGR has no mandate to promote germplasm enhancement (or pre-breeding) work, and this is to be regretted. A recent EUCARPIA Workshop has highlighted some of the problems[4], but further thought and impacts are needed here.

vi. Breeding and trials

Little needs to be said about these activities in general, since they require the more detailed examination that will be given for each crop. By and large, one of the strengths of the IARCs lies in their excellent breeding programmes and in their close collaboration with national programmes. Most of the materials sent to national programmes are nursery trial selections, but enhanced germplasm and even "raw" materials straight out of the genebank are also passed to national breeders on request.

---

4 EUCARPIA Workshop on pre-breeding in relation to genebanks (1983). Genetica (Acta Biological Iugoslavic, Series F), 15, (2&3), 145-422

The impact of this work is clear. Promising accessions, breeding lines or advanced materials are sent by the IARCs to national breeders so that they can release new varieties selected from them. Hence when such materials are promising, possessing good yield potential, disease and pest resistance and tolerance to stress, their impacts will be high, exerting a useful influence on stages seven and eight.

vii. National programmes and release of varieties

The release of varieties has been briefly touched on above. This topic and attempts at the formation of estimates of economic advancement and well-being will be discussed in the crop sections.

viii. Well-being and economic advancement of Third World farmers and countries

This section is included to see whether some preliminary assessment can be made of the effect of the newer varieties introduced as a result of the breeding work of the centres, using the genetic resources materials, as outlined above. It is understood, of course, that the adoption of higher yielding, more resistant and better adapted varieties is only one factor in a complex situation and the remarks made by the author for the various crops are value judgements based on the often scanty information available.

ix. Training

Training forms a most valuable part of genetic resources work, since it has impact on every stage in the genetic resources chain. Although training in general has been assessed very recently by Professor Hugh Bunting, it will be useful to mention here the Masters course in genetic resources given at Birmingham. This is a specialist vocational course of one year's duration that has been in existence since 1969. Several former Birmingham students are in positions of authority in the IARCs (CIMMYT, CIP, IITA) and many are in charge of national genetic resources programmes in third world countries. Several, also, are working as consultants for IBPGR, and one is in post as an IBPGR regional coordinator. Some 200 scientists, chiefly from developing countries, have received training and the course continues, with an intake of about 12 to 18 students each year: IBPGR has also recently established a training course in French at Gembloux, Belgium on a trial basis.

x. Data bases

These form an extremely important part of genetic resources work. When well-organized they provide abundant information on the reevaluation results of materials in the genebanks. In fact, their impact on all stages of the genetic resources chain is, or can be, very great indeed. The lack of well-organized data storage and retrieval work is very counter-productive to the use of genetic resources in breeding, thus exerting a negative effect on the production of new varieties. More details follow in the crop sections.

xi. Research

Research is needed in genetic resources work at all levels. It helps to improve exploration sampling methods (Brown, 1978), and is helped through the use of material obtained from expeditions to elucidate further the taxonomic and genetic systems of wild species and cultigens, and especially the genetic compatibility of the species concerned.[5] Research on seed storage methods obviously has a considerable impact on genetic resources conservation. It is particularly urgently required concerning the storage of recalcitrant seeds (Withers and Williams, 1982), where no satisfactory method has been yet established. Much tissue culture research is being carried out at some IARCs but more is needed, particularly with tuberous materials (see under crops: CIP, CIAT, IITA). The emphasis put on research by the external review of IBPGR is to be welcomed.

Research on evaluation methods is carried out at the IARCs and/or under contract, using non-core funding, with laboratories in developed countries. In this way, the benefits of more basic, less applied, research can accrue to the IARCs and the third world countries with whom they liaise. This is an area of importance from the impact point of view, which should be strengthened considerably in the near future.

5 See, for example, Simpson (1983), Witcombe and Erksine (1984) and Chang, Adair, and Johnston (1982).

SECTION II CROP PROGRAMMES

Instead of dealing with the genetic resources work under each of the International Agricultural Research Centres and Institutes in turn it was considered better to arrange the information on a crop basis. It was not possible in the time available to deal with several minor crops, but all those falling within the IARC mandates have been included. Other crops, particularly vegetables, fruits, spices, stimulants, sugars, timbers, included since these are dealt with through national programmes and special organizations. However, it should be emphasized that IBPGR's mandate covers many of these, especially in so far as exploitation, conservation and evaluation are concerned (see IBPGR section, pp. 83-95)

The crops are arranged in the sequences used by IBPGR In its Bibliography of Crop Genetic Resources (Hawkes et al., 1983).

1. Wheat (bread, durum): CIMMYT, ICARDA

i. Surveys

Wheat and wheat relatives have been collected by expeditions from many different countries and are stored in genebanks in various parts of the world. No surveys of materials in banks and what still should be collected have been made by CIMMYT. An IBPGR Advisory Committee met in 1976, 1978 and 1981, co-sponsored by CIMMYT, but the reports were subjective, with no summary of data. A survey by IBPGR appeared in 1981. This was the first published attempt to study what materials were to be found in national and regional genebanks and where collections should still be made. This has now been followed by an article on wheat collecting by C.G.D. Chapman (1984) and an unpublished report refining the data and making some assessment of the duplication of accessions in the various banks. A report on proposals for the collection of ICARDA crops has recently appeared (Toll, J. IBPGR, unpublished), as well as a description of wheat genetic resources in China (Yue Dhaua, 1984).

From the reports it would seem that some further collecting still needs to be done, particularly in Northern Africa, Southern Europe and Southern USSR. Strong emphasis is placed on the need to collect durum land races in stress-environments as well as primitive diploid and hexaploid wheats and wild relatives. Priority areas are the Atlas mountains, Oman, Saudi Arabia, Iraq, Lebanon and Yemen P.D.R. cases and wadis should receive particular attention.

Clearly, the impact here has come from IBPGR, since it was not provided by CIMMYT and only to a limited extent by ICARDA.

ii. Exploration

Collecting expeditions have previously been financed and organized by industrial countries in North America, Europe and East Asia, but IBPGR has played an important role since 1974, not only in the provision of finance but in establishing priorities and arranging expeditions.

CIMMYT has made no impact here, but ICARDA has collected durum wheat and barley in 1984 in Morocco with IBPGR and has generally collected these crops on its multi-purpose exploration trips (see also Rifai et al., 1981 and Perrino et al., 1984).

iii. Conservation

Ayad, Toll and Williams (1980) report that wheat collections are held in 40 different countries, 24 of them developing ones. Major base and active collections (see definitions in the first section of this report) are stored in 16 different countries (Croston and Williams, 1981). The total number of wheat accessions has been estimated at over 157,000, but because of duplication a realistic estimate might be one third of this or even less.

The CIMMYT wheat collection in 1981 contained 70,000 accessions but was reduced through the elimination of duplicates to about half that figure. The collection is largely a breeders' working collection, its purpose being "to maintain useful bread wheat, durum wheat, triticale and barley germplasm developed and used as progenitors by the CIMMYT Wheat Improvement Programmes" (Sencer, paper presented in Japan, December 1983). The current holdings are:

Bread wheat	9,411	entries
Durum wheat	3,883	entries
Triticale	4,267	entries
Barley	4,630	entries
Interspecific crosses	463	entries
New introductions	19,087	entries
Total wheat	37,111	entries

Amongst these are said to be over 1,600 primitive and wild wheats, Aegilops etc. A duplicate of each line will be sent to the National Seed Storage Laboratory, Fort Collins. Storage and regeneration are satisfactory and the bank is in charge of a senior scientist. The head of the wheat programme, Dr. Curtis, estimates the composition of the bank as follows;

Materials derived from land races	10-15%
National programme varieties (third world)	50%
Developed country varieties	30-40%
Wild species	3-4%

This is therefore not a germplasm bank in the usual sense, and the very small proportion of land races and wild species militates against a proper use of these resources in the plant breeding programmes. The genetic base is very narrow even though most effective for short-term advances. Thus in a wider long-term sense CIMMYT's impact must be very poor in the effective use of the total world wheat genetic diversity.

The ICARDA position with respect to durum wheat is little better. It possesses 16,412 accessions of durum wheat, mostly from the USDA and BARI collections as well as material from national programmes. The majority consists of land races, a large proportion being from high elevation sites. Since some 82% of the world durum wheats are grown in North Africa and the Middle East, ICARDA is in a unique position to collect these, and it has carried out this work conscientiously, though more samples need to be banked. Good storage conditions for base collections are being built and at present the material is in deep freeze chests. Most are in active collection storage or will be put into it shortly. Progress is slow here and needs to be sped up. The genetic base is a satisfactorily broad one and when storage facilities are complete and material is moved in the impacts should be very positive.

iv. Evaluation

At CIMMYT this is excellent, with sixty agreed descriptors recording passport data, morpho-agronomic characters, disease resistance and quality. The work is undertaken cooperatively between the GRU and other appropriate sections. Aluminium tolerance is now included. Multilocation testing for disease resistance under "heavy pressure" conditions is effected, with the genebank material put into the regional breeding trials.

ICARDA has documented (= described) most of the durum collection for morpho-agronomic features but using only 9 descriptors, which is clearly insufficient. More work is needed. On the other hand, screening for drought, salt and cold tolerance as well as for Septoria resistance has progressed satisfactorily. Passport data are so far lacking for the BARI material. More evaluation is needed on wild wheat progenitors.

For both CIMMYT and ICARDA evaluation is on the right lines, but for ICARDA it is still rather slow, with a consequently low impact level.

v. Germplasm enhancement

At CIMMYT a wide-crossing programme started in 1959, and some US $650,000 was spent on this activity in the 1980-84 period. The work was targeted towards resistance to Helminthosporium sativum, Fusarium gramineum and stress tolerance to salt, drought, heat, aluminum and copper. Eighty inter-generic hybrids using Aegilops, Agroypyrum, Elymus, Haynaldia and Secale are maintained, but crossing success has been low, with too much autosyndetic pairing in the F_1s. Some 27,000 lines from these crosses have been evaluated however, and some promise is shown. Fourteen additional lines of wheat with one chromosome of Elymus giganteus are maintained. A wide range of D-genome Aegilops squarrosa is being requested from several sources.

Little use has yet been made of bread wheat land races, and this should be remedied as soon as convenient.

At ICARDA the cereal breeders have begun a wide crossing programmes using durums, Triticum dicoccoides and T. aestivum. This work needs to be planned and developed on a much wider basis.

vi. Breeding trials

In this area lies the strength of all the centres. Bread wheat breeding at CIMMYT has had tremendous and well-deserved success in the past and continues to do so. The impact here has clearly been immense (seen next section). Relatively new impacts have been the breeding of high-yielding aluminum tolerant strains by crossing disease-resistant aluminum tolerant but low-yielding Brazilian varieties with high-yielding CIMMYT strains. Other objectives are resistance to Septoria, rusts, insects and other diseases and pests, as well as tolerance to heat and drought, and early maturity. There is a joint CIMMYT/ICARDA project on bread and durum wheat for rainfed areas.

The standard international nurseries and on-farm trials are carried out by both centres. Triticale work is progressing satisfactorily at CIMMYT.

It should be noted that at CIMMYT and ICARDA up to half the total scientific staff is involved in regional programmes (seven in CIMMYT) in wheat-producing developing countries.

ICARDA's durum breeding work has the same structure as that of CIMMYT, but with a fundamental difference. With durum breeding, land races are found to be of fundamental importance in tailoring lines adapted to a wide range of agro-ecological conditions. The land races are thus used very actively - the impact from the germplasm bank in this respect being most valuable, an area where CIMMYT, on the contrary, does not generate much impact.

vii. National programmes; release of varieties

From 1962 to 1984, 319 named bread-wheat cultivars were bred from CIMMYT materials or CIMMYT-related materials through national programmes. From 1962 to 1984 some 250 named durum and 137 triticale cultivars were released in a similar way. It has been estimated that CIMMYT-related wheats are now grown on some 40 million hectares in developing and 10 million hectares in industrial countries. A conservative estimate indicates that these wheats add about 200 kg/ha to the yields, which leads to US$ 1.2 billion/year of added output, assuming that the same area of wheat as before is under cultivation. In fact, improved CIMMYT varieties have expanded from 29 million hectares to 45 million hectares In Bangladesh there has been a 12-fold increase, from 89,000 tons of wheat in 1973 to over 1 million tons in 1983; these were grown on 600,000 hectares of which 97% were used for improved CIMMYT-derived varieties. Finally, it is estimated that developing countries grow a total of 45 million hectares of CIMMYT-derived varieties and industrial countries about 10 million hectares Thus 55 million ha out of a total of 240 million hectares are sown to CIMMYT-derived varieties, which is some 23% of the total. This is a spectacular figure which demonstrates the major impact of CIMMYT, particularly amongst developing countries.

ICARDA has released, generally through national programmes, new durum varieties giving more than double the usual yield in 250-300 mm rainfall areas. These varieties have more than average disease resistance. Recent releases of durum ICARDA-derived varieties are registered in Syria, Tunisia and Egypt, with two bread-wheats in Pakistan, Syria and Sudan.

viii. Economic advancement

There is no doubt that CIMMYT has had a very large impact here, and that ICARDA's impact is beginning to be felt, bearing in mind that its work started comparatively recently.

CIAT
BIBLIOTECA

ix. Training

Neither CIMMYT nor ICARDA has provided training in genetic resources as such, but on the other hand, training in evaluation, breeding and trials work has been intensive and has provided major impacts in the development of national programmes and the correct utilization of CIMMYT and ICARDA breeding lines.

x. Data bases

Satisfactory systems have been developed for ICARDA, but the CIMMYT data base system started very late and inventories are not yet available.

xi. Research

This is dealt with under various heads above. It has on the whole been successful, but more effort should be devoted to investigations linked to germplasm enhancement.

xii. Conclusions

CIMMYT can be criticized for its lack of interest in surveys and exploration activities, for its unwillingness to accept global responsibility for bread-wheat germplasm, and the narrow genetic base of its gene-bank material. This latter results in a narrow genetic base for the breeding programmes. Nevertheless, CIMMYT's record for the breeding and release of varieties in cooperation with national programmes is spectacular. However, it may well be difficult to maintain this much longer if the genetic base of the CIMMYT collections is not considerably broadened.

CIMMYT's genebank should be "active" and not confined almost entirely to "working"; it should possess a broad genetic base of land races and wild species of wheat, Aegilops and related genera.

ICARDA's record in this respect is better, but the genebank activities need to be speeded up greatly. For this, more scientific staff are needed - and in particular a cereals liaison officer to interface between breeders and the genebanks. The rest of the activities both at CIMMYT and ICARDA, are excellent, and apart from the inherent weakness of a rather narrow genetic base, have provided satisfactory impact on the well-being of those developing countries where wheat is a major crop.

2. Barley: CIMMYT, ICARDA

i. Surveys

Neither CIMMYT nor ICARDA has undertaken a survey of materials in the field and in the genebanks, but Witcombe (1983), working for IBPGR at ICARDA, assembled data on world barley expeditions. He concludes that Ethiopia and Turkey were well-collected, whereas other countries were either poorly collected or there was little information on the collections, e.g. China. Only 12,000 land race and wild species collections have been made, of which more than one third are from Ethiopia and more than 10% from a single expedition carried out in Greece, Turkey and Iran. He further considered that a figure of 20,000 accessions of land races and wild species might be an approximate target to aim for.

Jane Toll's report (unpublished) also emphasized the need for further barley collections to be made in the ICARDA mandate area of North Africa and the Middle East, and accords high priority to Algeria, Morocco, Iraq and Lebanon; medium priority for Tunisia, Yemen P.D.R., Saudi Arabia and Oman; and lower priority to Iran, Jordan, Syria and Turkey. Special areas to search are the Atlas mountains and other mountainous areas, desert oases and wadis.

The important impact here has clearly been provided by IBPGR.

ii. Exploration

As mentioned above, good collections have been made in Ethiopia, Greece, Turkey and Iran. In the 1984-85 season, ICARDA collaborated with IBPGR in a collecting mission to Morocco where 89 samples of barley were collected as well as other crops. An important recent expedition to collect wheat and barley in Libya was described by Perrino et al. (1984), and another in Syria and Jordan by Weltzien (1982).

It is quite clear that ICARDA should make itself responsible, either alone or with IBPGR, for a crash programme of barley land races and wild species collections, since otherwise not only will much genetic diversity be lost, but even if it is not, it will be unavailable to breeders.

Thus, the impacts for barley are weak and should be greatly strengthened.

iii. Conservation

CIMMYT lists 4,630 barley accessions, reduced from 9,735 in 1981 by the elimination of duplicates. These are, as with wheat, a breeders' working collection.

ICARDA possesses 14,215 accessions, mainly obtained from the USDA small grains collection. More land race and wild species collections are needed, as mentioned above.

Storage is medium-term at present, with 4°C and 15% R.H. Some long term storage in chests is available, but new facilities are planned at -18°C and 5% seed moisture content.

The situation is thus reasonably satisfactory but progress seems slow.

iv. Evaluation

Some 8,000 accessions have been characterized at ICARDA using twenty-five descriptors, all but two being morpho-agronomic and the rest dealing with protein and lysine content. IBPGR has also provided funds to ICARDA for some of this work.

A cereal liaison officer in the GRU is needed to coordinate ICARDA screening work by breeders, phytopathologists and entomologists. At present most screening is done in the field, though laboratory accessions for resistance to Rhynchosporium, Puccinia striiformis and Erisyphe has been affected. Drought resistance is extremely important and land races from China, Tibet and Korea have been evaluated for this character as well as some from the Middle East and 780 accessions of H. spontaneum. Salt tolerance is also of great importance and sixty barley lines have shown promise for salt-drought tolerance, with six lines showing the greatest value in the field. A preliminary catalog for 5,000 accessions has been produced.

This work is interesting but coordination is needed to provide better directives and hence better impacts.

v. Germplasm enhancement

Little is done here, although perhaps with barley it is unnecessary when using H. spontaneum and land races for problems of barley production in the Middle East.

vi. Breeding

Conventional barley breeding using European and American breeding lines and cultivars is not very useful in solving problems of drought and salt tolerance in the ICARDA mandate areas. Varieties are needed that are able to increase yield in regions of low rainfall (180 to 35 mm/yr) or where green-stage grazing by sheep is possible. Testing at seven sites and with the usual type of nurseries (including key location disease nurseries) in Lebanon, Syria, Tunisia and Cyprus has shown that a number of land races and selections from them show considerable promise. Materials have been distributed to national programmes, also.

viii. Varietal releases

The variety ER/Apam is being multiplied for distribution to farmers in Tunisia, whilst the selections Rihane, Harmal, Badia, Roho and W12269 have done well in many countries. Lines have also been identified that, except in

(viii,ix and x already dealt with or will be discussed under IBPGR).

xii. Conclusions

In view of the fact that the ICARDA GRU was formally constituted only in 1983 to replace and coordinate the previously somewhat haphazard accumulation of germplasm within the crop programmes, it has not done to badly with respect of barley germplasm. Nevertheless the impacts are disappointingly small at present. They should be improved after a cereals liaison officer is appointed and the genetic base is broadened. It should be noted that CIMMYT's barley genetic resources programme has been entirely passed over to ICARDA.

3. Rice: IRRI, IITA, CIAT

The global mandate for rice genetic resources lies with IRRI. West African rice (both O. sativa and O. glaberrima) comes within IITA's mandate but is also encompassed within that of IRRI. The basic mandate of the rice programme at CIAT covers the western hemisphere, but only in terms of production and intermediate outputs. However, it is concerned with the impact of high-yielding varieties in Latin America and as such is germane to the present study.

IITA has been designated as a rice regional base centre for Africa. It stores collections made by other African organizations such as WARDA, ORSTOM, IRAT, etc (Ng et al., 1983) and coordinates exploration on missions, in which it often takes part.

i. Surveys

Two workshops were convened jointly by IRRI and IBPGR to review the needs and priorities for rice exploration and conservation (IBPGR/IRRI, 1978; IRRI/IBPGR, 1983). The IBPGR/IRRI rice advisory committee reported on Asian wild rices in 1982, setting out priorities for exploration, conservation and characterization (IBPGR/IRRI, 1982). Plans are also underway for a similar study in West Africa, though a special section on West Africa appears in the IRRI/IBPGR 1983 report (co-authored by Ng et al.). The survey by Ng of Plant Genetic Resources in Africa also contains much useful information.

From these reports and from personal inquiries it is clear that maximum impacts have been made for rice surveys.

ii. Exploration

Rice exploration activities have been well coordinated and documented. Manuals for field collectors have been published (Chang et al., 1972; Change, 1976).

A coordinated exploration scheme involving fourteen countries in South and Southeast Asia has been established by IRRI (Chang, 1984, unpublished report), with direct and indirect participation. An IBPGR exploration officer has recently been seconded to IRRI with a view to collecting in various regions from where inadequate numbers have so far been received. He is also adding more collections of wild species to the bank since these were under-represented in the past. More than 9,000 samples have been assembled from "stress" environments.

From 1971-84 some 39,200 samples were collected in Asian countries, a little less than one third of which were obtained by IRRI expeditions. IBPGR grants enabled nearly over 14,000 samples to be assembled from seven Asian coun-tries and Madagascar. In Africa, coordinated efforts between IITA, ORSTROM, WARDA, IRAT etc. provided nearly 9,000 samples of which 872 were of O. glaberrima and seventy-seven were of wild species. Plans for IRRI and IITA to continue collecting in 1985-86 have been formulated.

The collection and documentation methods are of high standard in IRRI and IITA expeditions, but are of varied quality in other cases. Nevertheless, all organizations concerned have clearly developed very satisfactory impact in this field, apart from IRRI's initial failure to search for and collect wild species.

iii. Conservation

Major collections (in terms of sample numbers) are recorded by Toll et al., (1980), including Argentina, Bangladesh, China, France, India, Indonesia, Japan, Liberia, Madagascar, Malaysia, IITA, IRRI, Sri Lanka, Thailand, USSR and United States. Not all these collections are kept under optimum conditions however. Hanson et al. (1984) record long-term base collections only at IRRI (global) and IITA and United States (regional).

An excellent programme for rice storage and regeneration is in operation at IRRI (see IRRI/IBPGR, 1983), and there are now some 74,000 entries, including 1,100 wild species accessions.

The IITA collections of nearly 9,000 entries are under medium-term storage, but only one half of the collections can be accommodated in long-term base storage conditions established with IBPGR support. A grant received from the Italian government in 1984 of US $1.5 million will provide the correct conditions and capacity for base storage of rice and other crops.

Some 2,000 collections of Oryza glabberima and 5,800 of O. sativa are stored, besides over 300 collections of wild rice. All collections are duplicated at IRRI. From 1976 to 1983, IITA has sent 7,549 samples to over fifty countries, including some 2,700 to African and 2,500 to Asian countries. Since 1962 IRRI has supplied more than 530,000 samples in response to 5,000 requests.

Thus IRRI's and IITA's conservation work are of maximum impacts.

iv. Evaluation

IRRI's evaluation programme includes not only characterization for fifty morpho-agronomic features but also for a range of thirty-eight resistance and adaptation characters (Chang et al., 1982; unpublished report, 1984). Particularly interesting are those for diseases (viruses, fungi, bacteria) and insects, and for adaptation to drought, adverse soil conditions, deep water and flood tolerance and adverse temperature tolerance.

Over 4,000 accesssions have been characterized at IITA for fourty-four agrobotanical characters and the data entered into the computerized data base. IITA was allocated responsibility for coordinating all characterization, evaluation and documentation of rice in Africa.

Screening at IITA of many thousands of accessions has been undertaken for rice yellow mottle virus, which is indigenous to Africa. Most of the O. glaberrima accessions showed resistance, but few of the Africans or Asian O. sativa lines were resistant. Horizontal resistance to rice blast and high resistance to Diopsis (stalk-eyed fly) have also been identified. In the latter case good levels of resistance were found in fifty-seven out of 1,000 cultivars tested. Tolerances to iron toxicity, cold and drought have been found, particularly in land races.

At both IRRI and IITA there is close collaboration between the GRU and scientists from the appropriate sections (phytopathology, entomology, physiology). In this way evaluation is very satisfactory and of high impact.

v. Germplasm enhancement

The input of disease and pest-resistance and stress tolerant germplasm into rice gene pools, using a team approach, is progressing actively (Chang et al., 1982). Useful degrees of drought resistances have been identified (Chang et al., 1973; and Chang et al. undated). Anther culture techniques to obtain haploids and somaclonal variation work have not been very successful up to now, though the introgression of useful genes from wild species into cultivated races has been extremely valuable (Khush, 1984). Particularly spectacular has been the use of one grassy stunt-resistant collection of O. nivara in the production of resistant breeding lines (see next section). Chang (1985) reports that green leafhopper resistance has been transferred from O. glaberrima to O. sativa through hybridization, through desirable progenies have not yet been produced. The transference of aluminum tolerance from Brazilian to Asian rices and of iron toxicity resistance from African to Asian rices has also been noteworthy.

This activity at IRRI has also provided useful impacts. No information has yet been received on this subject from IITA.

vi. Breeding; trials

During 1966-67 at IRRI, some 303 entries, largely drawn from the germplasm bank and the IRRI breeding nurseries, were widely distributed to rice breeders in twelve countries in Asia and the Americas. Accessions distributed by the International Rice Testing Program (IRTP) began in 1975 and those from the germplasm bank constituted about 10-15% of the sources of high resistance/tolerance. International nursery material (1,277 sets) were sent out to fifty-four countries in 1984. These comprised materials of interest for upland rice yield, rain-fed shallow water yield, adaptation to arid regions, and to deepwater, floating and tide-prone conditions. They also included resistance or tolerance to cold, salinity and alkalinity, acid lowland soils, acid upland soils, rice blast, bacterial blight, tungro virus, brown planthopper, whitebacked planthopper, stem-borer and thrips. Resistance to grassy stunt virus has already been mentioned; it has been incorporated into useful breeding lines and varieties. Drought resistance is important, since about 50% of the world's 141 million hectares of rice are grown on rain-fed areas (see Chang et al., 1974).

IITA cooperated with IRAT, IRRI and WARDA in four rice testing programmes for yield and adaptation, Breeding for blast resistance is underway as well as for yellow mottle virus resistance. Promising lines have been identified. Breeding for resistance to three stem boreres, including Biopsis is an important part of this work. A total of 6,810 accessions were screened for seven insect pests and led to the identification of sixty-eight reisistant or moderately resistant lines. IITA 121 is recommended for lowland irrigated conditions with moderate Diopsis resistance. Excellent impacts are developing in this phase of the work.

vii. National programmes and variety release

IRRI has scored spectacular successes in the release or recommendation of varieties and breeding lines for national programmes. Sometimes the IRRI lines are adopted directly by third world countries; alternatively they are used as breeding materials.

Some ten IRRI varieties and nineteen breeding lines have been recommended for various African countries; twenty-nine varieties and lines for the Americas; and over 130 for Asian countries (Khush, 1984). Similar lists are provided by Chang (unpublished report).

Personal inquiries to Thailand elicited the information that they have twenty-one recently released varieties formed by crossing Thai traditional varieties and land races with IR8. New varieties and selections are in the pipeline. These always possess one Thai parent, which contributes to the traditional high quality that IRRI varieties are said to lack, with the yield, semi-dwarf stature and resistances provided by the IRRI varieties. At present IR36, IR50 and IR841 are used as sources of resistance genes. IR50 is of particular interest since it resists three biotypes of brown planthopper. F_1

hybrid rices are being bred also, using the WA type from China and restorer lines from IRRI.

A similar situation can be described for Indonesia. Dr Siwi (personal communication) reports that since 1970 some fifty varieties have been released, thirty-six produced by the national rice breeding programme and fourteen introduced directly from IRRI. All these thirty-six varieties contained germplasm from local landraces or varieties crossed with IRRI varieties or lines. The reasons for this are as for Thailand.

This is a very valuable instance of the use of IRRI varieties and national germplasm in the production of national programme varieties, but it would seem that this does not always happen. Some countries adopt IRRI varieties or advanced lines without incorporating their own germplasm, which, it seems likely, might have contributed useful genes for adaptation and quality.

The adoption of IRRI or IRRI-related varieties has, according to Siwi and Kartowinoto (1984), increased Indonesian rice yelds due to breeding from 1.74 to 2.62 t/ha between 1973 to 1983. In spite of population increase this has meant a 29% per capita yield increase, though there has also been an increase due to a greater area planted and improved technology. Because of these factors Indonesia has changed from being the world's biggest rice importer to complete self-sufficiency.

In this connection the publication by Herdt and Capule (1983) is also most illuminating.

IITA varieties have been released with tolerance to iron toxicity, aluminum toxicity and with promise for irrigated lowlands and upland regions. Two varieties were released in Sierra Leone with high yield and blast resistance, suited to swamp and irrigated conditions. Three other adapted varieties were also released. Four superior varieties were released in Liberia, one with tolerance to iron toxicity. Three releases were accomplished in Tanzania, one blast-resistant line in Togo, and a drought and blast-resistant line in Zaire. Introductions into Cameroon, Ghana, Central African Republic and Zambia have also shown great promise in their adaptation to local conditions and disease resistance. Excellent impacts, with continuing promise for the future, can be identified here.

viii. Well-being and economic advancement

From the evidence available to me I would judge that IRRI's impact has been of the very highest order in most rice-growing countries.

Although numerical data are not available from IITA, statistics on the areas in which the newly released varieties are grown give good indication of economic advancement, especially in Sierra Leone where the new varieties yielded 30% more than the local variety and have lead towards self-sufficiency of rice in that country. The impacts seem to be very promising.

ix. Training

Both at IRRI and IITA, training in genetic resources work and related disciplines has been good. At IITA two courses have been organized, financed by IBPGR. At IRRI the genebank has provided 2-6 month in-service training for staff of national centres on genebank management, and thirty trainees have attended since 1970, about the same numbers as at IITA. Further courses are planned.

Impacts here are good, but the courses should be continued and, where necesary, extended.

x. Data bases

Both institutes have good programmes of data storage and retrieval. Catalogs have been developed and requests for special information can be supplied. IRRI's unpublished research data and computerized information program are available on request.

xi. Research

This has been dealt with under the head of Germplasm enhancement.

xii. Conclusion

The record of IRRI Is first class, with major impacts all down the genetic resources chain. A former lack of capacity to handle wild species has now been rectified. The IITA work is also of very high calibre, and collaboration with WARDA, ORSTROM, IRAT and IRRI is excellent, with good prospects for the future.

4. Maize: CIMMYT

i. Surveys

Since maize is now grown in nearly all tropical, subtropical and warm temperate countries of the world, the problem of conserving its diversity is rendered more complex than that of a crop restricted to a smaller and more uniform area. The centres of diversity lie in Latin America, and publications on the races of maize, based on collections made in the 1940s and 1950s, have appeared during the 1950s and 1960s. These show where maize has been collected, but say little about where it has not. Hernandez (1973) attempted to do this but with insufficient detail, and no recent survey has appeared. This is mainly due to the fact that the CIMMYT maize bank, which contains most but not all the Latin American germplasm, has no computerized data storage and retrieval system from which inventories or computer-generated maps could be constructed. Such a data base should also incorporate information from the more important national maize collections in Latin America and, if possible, in other parts of the world.

The lamentable lack of impact here is due to the low priority set by CIMMYT in the past for this type of work, including the proper management of the maize genebank itself.

In late November of 1984 CIMMYT agreed to accept global responsibility for maize germplasm from 1985 onwards, with extra funding provided by TAC for three years, and thereafter taking this work into its core budget. This implies that a senior scientist will be appointed to take charge and long term storage and other facilities will be provided.

Although other centres store two or more crops in the same genetic resources unit, CIMMYT seems to feel that the wheat/maize duality should reach right down to germplasm work, thus duplicating perhaps unnecessarily many of its facilities. The present writer has some reservations about this, but the basic CIMMYT attitude to its two crops is not likely to change.

ii. Exploration

CIMMYT has not been involved in exploration work, but IBPGR has sponsored maize collecting expeditions in various parts of the world. Much work has been done by Hernandez (Mexico), Brieger (Brazil), Sevilla and Brogman (Peru), Avila (Bolivia), the Pergamino group (Argentina), Torregoza and Lopez (Colombia) and many others, though the relevant date on their collections are difficult to obtain in the literature. Again coordination is urgently needed. Reports from Europe are easier to find (see, for instance, Mota et al. 1981, 1982; Bettancourt and Gusmao 1981; Radovic and Zivkoric 1983; and many reports from multi-crop collecting trips).

Although IBPGR believes that world maize collections are adequate, apart from the Himalayas and a few other small areas, we shall not really be certain of this until the computerized surveys are completed. Hence the poor impacts of surveys throws a shadow over exploration, though it must be said in all fairness that a very great range of land race material has been collected in the past. It is be hoped that this still exists in a viable condition in the banks and that every effort will be made to fill any existing gaps.

iii. Conservation

At present CIMMYT has a rather poor medium-term storage facility for 15,000 samples running at 0-3°C with a relative humidity of about 32% and a seed moisture content of about 11%. A grant of $80,000 from IBPGR in 1984 will make it possible to expand and improve the medium-term capacity and add rooms controlled at -15°C with seed humidity reduced to about 5%. Better seed drying and preparation facilities are also planned. This should improve the storage life from 20-25 years to 40-50 years.

After regeneration, subsamples will be sent to Fort Collins for duplicate storage, and whilst undergoing this regeneration they will be characterized, if this has not been done already.

The present composition of the collections is as follows:

Land races, wild species and varieties	94%
Groups composed of several original similar collections	5%
Composites	1%

There are 10,117 maize lines, three accessions of Zea perennis, two of Z. mexicana, one of Z. luxurians and eighty-six of unclassified teocintles. Clearly there should be far more of these wild materials in the bank, including, of course, a range of Tripsacum materials. It is not known how much duplication exists between the CIMMYT collection and others in Latin America.

A survey of world maize banks was published by Ayad et al. (1980). Those holding major collections are in Argentina, Bolivia, Canada, Colombia, Japan, Mexico (national collection), Peru, Romania, USSR, United States and Yugoslavia. A survey of duplications needs to be carried out, as for wheat.

To sum up, it seems clear that the CIMMYT collection is basically a very valuable one (see below). It should certainly be better stored and coordinated to give it greater impact. However, the impact of wild maize relatives is less strong, and this aspect needs considerable improvement.

iv. Evaluation

Characterization is progressing steadily as material is regenerated. Apart from this, a great deal of evaluation has been in progress. Material has been assessed at different sites and when found useful has been taken into the enhancement programme. Techniques of simple mass inoculation have been evolved that can be used easily in developing countries. Yield is not considered to be of such importance, since it already exists in advanced breeding lines.

v. Germplasm enhancement

CIMMYT breeders are developing broad-based gene pools into which promising germplasm material is continually being inserted.

The wide-cross unit is attempting to transfer desirable traits to maize that are found in other genera, in a programme started in 1974. There seems little point in trying by conventional crossing methods to hybridize maize and sorghum, since thousands of crosses have already been tried with no success whatsoever.

Some 130 F_1 hybrids between maize and Tripsacum have been made, but the sterility barriers do not allow much germplasm transfer to take place. Nevertheless sequential backcrosses have been obtained. Such hybrids have been put into tissue culture to ascertain whether somaclonal variation will provide the genotypes required. DNA transfer techniques in collaboration with the University of Illinois show some promise.

It seems a pity that CIMMYT does not try the much simpler techniques of maize x teocintle crosses, evaluating the very large gene pool existing in Euchlaena that is available in many laboratories in the United States and elsewhere.

Thus, the wide-cross programme is not providing much of an impact at present, though some aspects could be valuable in the future.

vi. Breeding; and trials

Maize breeding at CIMMYT is based on population improvement. Germplasm material, when found to be promising, is constantly being introduced into the 38 CIMMYT Gene Pools as the first stage in the breeding process. These pools are developed for types of grain, and their color and texture, as well as for climatic adaptation and maturity type. From these, promising materials are passed to the seventy populations that are included in the international testing programme. Much emphasis is placed on the introduction of characters of resistance and adaptation to stress environments. The pipeline materials might then be "siphoned" directly into the gene pools, rather than at a later stage into national programmes. The international nurseries are five in number: (a) tropical - 0 to 1,000 m. alt.; (b) subtropical - 1,000 to 2,500 m. alt.; (c) temperate - more than 30°N. or S. latitude, and (d) tropical highlands - more than 2,500m. alt. Thus a great deal of germplasm from the genebank is constantly going into the breeding pools and right through towards final selections.

So-called pipeline material is being developed on a longer term basis. This contains disease and pest resistance and is scheduled for introduction into national programmes in any year, according to circumstances, from 1985 to 1995. CIMMYT has been involved in hybrid corn work in certain countries, though not in Mexico or South America. After national programme needs have been satisfied there has been a sharing of materials with private seed companies.

vii. National programmes and varietal releases

CIMMYT works almost entirely through national programmes and has outreach programmes in many different countries, as well as in centres such as IITA and ICRISAT. It was not possible to find out whether, near the final stages before varietal release, crosses were made between CIMMYT lines and adapted local varieties. In any case the system in force should insure that releases are tailored to local agro-ecological conditions and consumer preferences.

As of September 1984 the following number of releases are recorded:

(a) South and Central America and the Caribbean	81 releases
(b) Africa..	24 releases
(c) Asia..	17 releases
Total	122 releases

Thus CIMMYT believes that it is returning improved germplasm to third world farmers, and by and large this seems to be true.

viii. Well-being and economic advancement

Some 3.5 million hectares of improved maizes from the international system are currently planted. Thus impacts are at a very high level in this respect.

ix. Training

Whilst CIMMYT does not provide training in germplasm exploration and conservation it does train in enhancement and improvement. Techniques developed at CIMMYT are widely used by national programmes.

x. Data base

Because of the hold-up in the initial stages (i to iii) already mentioned, the passport and evaluation data are not yet into a computerized information and retrieval system. No catalogues are available but these should, it is hoped, be available by 1985-86. The impact here is not yet visible, therefore.

xi. Research

This has already been touched on in the section on germplasm enhancement.

xii. Conclusions

Because of CIMMYT's present mandate, impacts are lacking or very weak in (i) surveys (ii) exploration and (iii) storage. More wild material ought to be stored and evaluated, particularly a broad base of Euchlaena germplasm. Less effort should be devoted to very long-term activities, such as attempts at maize-sorghum crosses.

Impacts are very strong on breeding, working with national programmes and varietal releases.

Finally, the recent decision by CIMMYT to accept the global mandate for maize genetic resources should make it possible for an even broader maize genetic base to be evaluated and utilized within the next quinquennium.

5. Sorghum and Millets: ICRISAT

i. Surveys

Sorghum and millet surveys were carried out by the IBPGR Advisory Committee on Sorghum and Millets Germplasm in 1976 and 1981. On the basis of their priorities and recommendations a world survey was published later (Achemampong et al. 1984), which forms the basis of material given below. (See also Hrinarayana 1979).

Sorghum. Good collections of cultivated materials exist, even though urgent work is needed in the Central African Republic and Chad. ICRISAT lists other countries needing attention. There is extremely poor representation of wild and weedy forms in the genebanks, and in 1982 only 167 collections belonging to ten taxa were in the ICRISAT collections (Mengesha et al. 1982). Much more collecting is needed, especially in Ethiopia, Eastern Sudan, Uganda, Burundi, Rwanda, Kenya and Tanzania.

Pearl Millet (*Pennisteum americanum*) is also under-represented with respect to wild and weedy materials, which are needed from Niger, Sudan and Burkina Faso. Cultivated and wild materials are needed from the Central African Republic, Chad, Mauritania, Namibia and Sierre Leone. The oases of North Africa and certain areas of Ethiopia also need to be explored, as well as Eastern and Southern Africa, parts of West Africa, Burma, PDR Yemen, Spain, Pakistan and India. From this it seems that most areas of pearl millet cultivation and of wild species distribution should be collected.

Finger millet (*Eleusine corocana*) both the cultivated species and progenitor materials need to be collected as well as other wild species in the secondary gene pool, or even the tertiary one. No action has yet been taken to collect in the priority areas established in 1981, namely, Somalia, Sudan and Uganda. More collections are needed from China, Ethiopia, Nepal and Sri Lanka.

Foxtail millet (*Setaria italica*) needs further collections, particularly of wild and weedy materials, though an analysis of the provenances of existing collections does not seem to have been made. Only eight collections of weedy forms and seventeen 17 of wild species were made in the 1975-82 period.

Proso millet (*Panicum milaceum*). Small collections exist, chiefly in India, but no IBPGR field work has yet been carried out on this crop or its wild relatives.

Little millet (*Panicum sumatrense*). No surveys have been made.

Barnyard millets (*Echinochloa spp.*). No surveys have been made of this or of Kodo (*Paspalum scrobiculatum*) and Forio millets (*Digitaria exilis*). Teff (*Eragrotstis teff*) is confined to Ethiopia and no doubt there is knowledge at the Ethiopian genebank as to what still needs to be collected.

Impacts are reasonably good so far as sorghum and the more important millets are concerned. From foxtail millets onwards (see above list) no surveys seem to have been made.

ii. Exploration

Extensive cultivated sorghum collections have been made in the past but insufficient wild ones (see above section). The same can be said for pearl millet and finger millet, where large gaps exist and should be filled as soon as possible. The situation is even worse with the other millets, where hardly any recent collections or plans for future collections have been made. With Digitaria IBPGR has collected D. exilis in Mali, Togo and Burkina Faso, and with teff a joint IBPGR/Ethiopia collecting trip in 1980/81 provided twenty-three samples.

The general conclusions here are that the impacts with millets are low or non-existent, and even for sorghum greater impacts with wild and weedy forms would be desirable.

iii. Conservation.

A total of 24,604 sorghum collections are held at ICRISAT under medium-term conditions, and a new long-term storage facility at -18°C with capacity for 100,000 samples is almost completed. About half of the collection was taken over from the Rockefeller Foundation collection. A wide range of genetic stocks is stored. Over 210,000 germplasm samples have been distributed. Large collections are stored also in Argentina, Australia, China, Ethiopia, ORSTOM (France), India, Mexico, Romania, Thailand, USSR, United States. and Yemen A.R. (see Anishetty et al. 1981). Sorghum long-term security base collections agreed by IBPGR Hanson et al. 1984) are at ICRISAT and Fort Collins, United States. Similar collections for Pennisetuum are at Ottowa, ICRISAT and Fort Collins; for Eleusine at Addis Ababa; for Panicum miliaceum at ICRISAT: and for Setaria italica at Beijing, China and ICRISAT.

Thus cultivated sorghum possesses a broad genetic base in storage with consequent strong impact. However, the impact for wild sorghum is slight.

ICRISAT stores 16,985 samples of pearl millet, again half coming from the old Rockefeller collection. A range of genetic stocks is available, and over 41,000 germplasm samples have been distributed. Smaller collections exist at ORSTOM, Canada and Malawi.

ICRISAT stores 1,863 samples of finger millet, whilst the Indian national collection numbers about 6,000.

There are 1,260 accessions of foxtail millet at ICRISAT and nearly 10,000 samples in China and India (possibly including duplicates). ICRISAT should store a duplicate collection of these.

For proso millet ICRISAT stores 753 samples, whilst there are nearly 2,000 samples in India and others in Japan, Hungary, Nepal and United States. A duplicate set should be available.

ICRISAT holds 291 samples of little millet and India over 400.

Barnyard millet is represented by 517 ICRISAT collections, 782 in the Indian national genebank and fifty in Japan.

Kodo millet is represented by over 2,200 samples in India, and 300 at ICRISAT, where a back-up collection should also be held.

Fonio millets are held by ORSTOM (215 samples) and sixty-two in Togo. There are none at ICRISAT. ICRISAT has no teff materials, and an unspecified number is held at PGRC/Ethiopia.

The conclusion is that for cultivated sorghum and pearl millet ICRISAT does well, and the impacts are satisfactory. The ICRISAT impacts for the minor millets are very low or non-existent, and wild materials of sorghum and pearl millet show a rather low impact.

iv. Evaluation

ICRISAT's evaluation work is confined to sorghum and pearl millets. The other millets are stored only, but IBPGR has provided funds for their characterization.

For sorghum, 20,355 lines have been evaluated using morpho-agronomic characters. Disease, pest and drought resistance has been recorded but merely on the basis of no attack or apparent adaptation. Screening against grain mold, downy mildew, *Striga* and midge has been carried out also. Summaries are given below. See IBPGR/ICRISAT (1980, 1984).

Insect resistance	15,724 screened	323 promising
Disease resistance	16,209 screened	133 promising
Drought resistance	1,752 screened	246 promising
Striga resistance (in laboratory)	15,504 screened	641 promising

Large-scale pearl millet characterization and screening for resistance to downy mildew, ergot and smut has been undertaken, and 16,022 lines have undergone morpho-agronomic evaluation. See IBPGR/ICRISAT 91981). Summaries are as follows:

Insect resistance	1,512 screened	234 promising
Disease resistance	5,909 screened	1,794 promising
Protein content	3,523 screened	100 promising
Dwarf stature	14,852 screened	6 promising

A preliminary evaluation of the minor millets is in progress. See IBPGR (1983a, 1983b).

v. Germplasm enhancement

Attempts have been made to introgress genes from agronomically poor or wild material into a high yielding short stature and daylight insensitive background - the so-called conversion process. This has been accomplished both in sorghum and pearl millet. Since there is not a wide range of wild and weedy materials of either crop in the genebank there has not been too much scope for such work. Some Parasorghums, in another section of the genus, have been shown to possess shoot-fly resistance. These cannot be crossed with the Eu-sorghum species (which include the cultivated species) and a cytogenetical study will be needed to see whether the crossability barriers could be overcome.

A not very inspiring set of impacts can be identified here.

vi. Breeding and trials

Sorghum breeding priorities include high yield, good grain quality, resistance to diseases, tolerance to pests and to drought, and nutrient and heat stress. Screening is carried out in West Africa (Niger), Mexico (at CIMMYT), India (also at Indian national centres) and Zimbabwe. The customary disease and insect nurseries are provided for national programme breeders, and there are wide-adaptation trials in Africa, India and Latin America.

The pearl millet breeding priorities include yield, grain quality, resistance to pests and diseases, and adaptation to stress conditions. At a lower level of priority, grain protein quality and rust resistance is looked for. In Africa high priority is accorded to resistance to Striga, stem-borer and head caterpillar.

Population breeding methods are being used for pearl millet (see Singh et al., unpublished) in the improvement of composites subjected to recurrent selection (see also Andrews et al. unpublished, for a discussion of breeding for disease resistance).

The impacts of this work would appear to be quite satisfactory.

vii. National programmes; release of varieties

For India all ICRISAT varieties are released through national programmes, but in many other countries where there are no national programmes, the ICRISAT varieties are released directly on to the market.

Fifteen new sorghum varieties were released in India during the years 1980-83. Releases also took place in Ethiopia, Zambia, China, Venezuela, El Salvador, Mexico and Sudan. There are many other useful lines in the national breeding programmes and in ICRISAT trials. The sorghum variety SPV 351 was recently released for rainy season cultivation. Hybrid ICRISAT sorghums are already grown in 60 to 70% of the States of Maharashtra and Karnataka (see Mahapatra et al. 1984). SAR 1 and 2, Striga-resistant lines, are doing better than the local varieties. No financial estimates are given in the above mentioned report, but it seems clear that the yield increase from 9.3 to 11.2 million tons in India, despite an area decrease, can be at any rate partially attributed to ICRISAT activities.

Sixteen varieties of pearl millet were released in the period 1980-83 in India. Two were released in Senegal and the variety Ugandi was released in Sudan in 1982. the variety ICM-1 (WC-C75) was released in India recently, which has good resistance to downy mildew and is less resistant to ergot than any other currently grown variety. Also ICMS 7703, with the same kind of resistances was released recently. MSL 814 (o sterile) is used in several places in India.

The impacts for India with respect to sorghum and millets is very high. Less impact seems to have been developed elsewhere relative to India, it seems, but this may be due, in part at least, to my lack of information on other countries.

viii. Well-being and economic advancement

From the Mahapatra et al. 2984 report, already referred to, ICRISAT's impact in this sphere seems to be satisfactorily high.

ix. Training

None accomplished in GRU as such.

x. Data base

Existing data are being put onto the new computer (8,000 records by 1984), and printouts will be available later. Impacts here are potential, but will certainly be valuable.

xi. Research

This has been covered in previous sections.

xii. Conclusions

ICRISAT's impact with cultivated sorghums and pearl millet is satisfactorily high for cultivated materials apart from surveys and germplasm enhancement. For wild materials the impacts are weak through lack of collections.

Impacts for the other millets are medium to weak, or in some, practically non-existent. IBPGR has take the initiative with surveys and has helped with exploration.

A coordinated global policy for the minor millets is urgently required.

6. Potato and Sweet Potato: CIP, IITA, AVRDC

CIP accepted the global mandate for potato genetic resources when it was first founded. It does not conserve the cultivars of North America, Europe, Asia and Africa, however.

CIP has also recently approved a program of research for sweet potato in specific aspects where CIP pereives that it has a comparative advantage, whilst IITA previously accepted the total global mandate for this crop, but in practice confines its activities to Africa. AVRCC has been allocated the mandate for sweet potato germplasm in Asia by its governing board.

i. Surveys

CIP has undoubtedly made a major impact in this field and has moved much further than any of the other centres. Planning conferences attended by experts from various countries were convened at 3-yearly intervals (see CIP 1973; 1976; 1979) to establish priorities for countries and for cultivated and wild potato species.

An IBPGR survey of sweet potato germplasm was published in 1981, and CIP has commenced a sweet potato survey for the Americas. IITA and AVRDC surveys for Africa and Asia, respectively, have apparently not been made, since these centres presumably rely on the IBPGR one. In general, the IBPGR 1981 publication recommends that collecting should be concentrated in Guatemala, Ecuador, Colombia and Peru in the primary gene centre of diversity, and in China, Southeast Asia and East Africa in the secondary centres. Wild species should be collected in the Americas particularly, since these are considered to be genetically closer to the cultigen. This seems short-sighted, since wild species in other parts of the world (Africa and Southeast Asia, especially) ought surely to be included so as to provide as broad a genetic base as possible.

It seems that the impact for sweet potato surveys lies completely with IBPGR.

ii. Exploration

By 1980, over 90% of the total cultivated potato germplasm had been collected, due to a crash programme funded from the CIP core budget. This is unique amongst the CGIAR network. Wild species have also been systematically collected, particularly in Ecuador, Peru and Bolivia, following the recommendations of the planning conferences. Collections in Argentina, Colombia and Chile were made with national funding, helped also by CIP and IBPGR. In Mexico, joint Mexican/United States/Canadian expeditions have added materially in recent years to the wild potato germplasm already present in several genebanks in the United States and Europe. Funding from West Germany and Holland has recently been provided, together with CIP support, to collect in Bolivia and Argentina. Some 1,500 samples of wild potato germplasm have now been collected from Peru, and even more from Bolivia and Argentina together. Most of the Bolivian, Argentinian and Mexican collections were made by collectors not employed by CIP, but with full coordination with it. This is an excellent CIP record which provides strong impacts on activities further down the genetic resources chain.

IITA has collected about 140 lines of sweet potato since 1976 in expeditions to eighteen African countries. AVRDC, with help from IBPGR, has established a very large collection (some 1,200 samples) but it is unclear whether these were collected by AVRDC or were received from other institutes. Collaborative exploration work has been effected in Indonesia, Malaysia, the Philippines, Thailand and Papua-New Guinea. Collecting is also in progress in the Solomon Islands.

iii. Conservation

The cultivated potato collection at CIP consists of 5,000 samples (reduced from about 12,000 by the elimination of duplicates). These are grown annually at high altitudes in the experimental fields and are stored in controlled conservation facilities nearby. Duplicates of all lines are stored at Tibaitata, Bogota, Colombia, and replaced by a new CIP harvest in each succeeding year. Duplicates were eliminated with the help of a computer and checked biochemically in Germany (BRD). In vitro storage has been developed, and currently 250 clones are being stored in this way. A new wing has recently been constructed to conserve pathogen-free in vitro materials, and in five years the whole collections will be stored. Seeds from open pollinations and controlled matings are also obtained and stored.

The wild species collection consists of ninety species and 1,500 samples, stored as true seed, together with seeds of the cultigens, in a medium-term store of 66.7 cu.m. capacity. The temperature is 0°C and there are long-term storage freezers at -15°C. Some 60,000 packages of 50 gr. each are already in store. Duplicates of wild species are sent to Sturgeon Bay, Wisconsin. Distribution of raw germplasm has been effected, but only 600 wild species collections are available as true seed and only 375 have been sent to Sturegon Bay. It is difficult to tell how much cultivated "raw" germplasm has been sent to national programmes, since the figures given include all the breeding lines and selections (see (vii) below).

The limitations in this work are the disappointingly slow progress in producing enough true seed of wild species for storage and the lack of response to requests for samples from outside bodies. This results in very low impact for wild species storage and distribution. The difficulties with clonal distribution are that pathogen free material can be dispatched virtually only in vitro, and as mentioned above only 250 (=5%) have yet been converted to this form of storage. Impacts here are disappointingly low also, with respect to "raw" genetic resources.

At IITA, so far as can be seen from the reports, some 100 entries of sweet potato have been put into meristem culture, of which about 80% were found to be fee from sweet potato virus disease, which is said to be the only one reported for Africa. IITA holds 800 clones of vegetatively propagated material.

The AVRDC sweet potato collection consists of 1,200 entries, in the form of tubers and cuttings. It was agreed by IBPGR that AVRDC should be a clonal repository for sweet potato germplasm. At the same time Damania and Williams (1980) report that there are also seed and/or clonal repositories in the United States, Indonesia, Japan and the Philippines. AVRDC is about to install a quarantine house for the introduction of vegetative material and it is obtaining true seed by means of polycross methods. Some 736 collections are maintained in Papua-New Guinea in a vegetative state.

Clearly the AVRDC impacts are small but promising. Those of IITA are also rather small, probably by reason of low level financial support for the genetic resource unit in the recent past - a story which is repeated for some other crops also.

iv. Evaluation

All the entries of cultivated potato at CIP have been characterized according to the agreed IBPGR descriptor list (Huaman et al. 1977). There are fifty-six morphological descriptors, ten agronomic ones, five for frost, drought and heat, sixteen for diseases and pests (but no pathotypes or races distinguished and thus not very useful), and four chemical descriptors. Wild materials have been identified and described, and new species published.

Secondary evaluation data are as follows:

Fungal pathogens	9,193 samples screened
Bacterial pathogens	254 samples screened
Virus pathogens	2,410 samples screened
Cyst nematodes	6,156 samples screened
Root knot nematodes	3,938 samples screened
Frost and hail resistance	4,275 samples screened
Insects (tuber moth)	2,871 samples screened
Nutritive quality	840 samples screened

No mention of other insects or of distinct pathotypes is given in this survey, but these are clearly taken into account by the appropriate scientists. In the publication "Potatoes for the developing world" (CIP 1984), the data are broken down according to the various pathogens. It would have been interesting to see what resistances or levels of tolerance were found as a result of this screening work, but we are only told that the frequency of resistant genotypes ranges from 2% to 10% and that some lines show multiple resistances. This may well be the case for cultigens, but for wild materials the percentage of resistant genotypes is certainly much higher. Interesting resistances are known amongst wild species to the potato leaf roll virus, potato spindle tuber viroid, and different pathotypes or races of bacterial wilt, the two cyst nematodes, and viruses X and Y. So far as published results are concerned, screening of the wild materials is more advanced in the United States and West Germany than it has been at CIP up to now. Furthermore, the results of screening do not seem to be yet available in the form of inventories or print-outs. Thus although the impact of CIP is commendably high for the cultigens, information is not at all evident for wild materials, even though it certainly exists, as seen in papers contributed to learned journals. Thus in this respect the impact is considerably weakened through the lack to date of coordinated published information.

Evaluation at IITA for resistance to the sweet potato virus disease complex and weevil (IITA 1983) has shown some promise. Furthermore, fifty-five lines out of 414 tested in the glasshouse showed a high degree of resistance to Meloidogyne incognita and M. javenica. A descriptor list was published in 1981 by IBPGR and 31 morpho-agronomic characters were defined, as well as eight others for chemical content, fourteen for insect reaction, twenty-nine to fungi, bacteria and viruses and nine to nematodes. It is not clear as to how much of this characterization and evaluation has been carried out at IITA, but some work in this area has been accomplished at AVRDC and elsewhere in Southeast Asia. Unfortunately, judging by the admittedly incomplete information to hand, impacts here seem to be rather low.

v. Germplasm enhancement

At CIP this work is very promising. At that centre it is called "the creation of 'back-up' populations", and it aims to "overcome the genetic distance between primitive cultivars and advanced clones" (CIP 1984). Much work at CIP and in many institutes in North America, Europe and elsewhere involved the breaking of crossability barriers by means of conventional methods using bridging species and through the use of modern in vitro techniques such as protoplast fusion and embryo culture. Recurrent selection at CIP to increase the frequency of desirable characters is of particular interest and will be touched upon in the next section. Thus CIP, in common with several institutes in industrial countries, is making very satisfactory impacts indeed in this work.

No information on germplasm enhancement of sweet potatoes has been received from IITA or AVRDC.

vi. Breeding; trials

At CIP a strategy of potato population breeding and recurrent selection is used to increase the frequency of resistance genes in gene pools. Thus, good yield qualities are combined with resistance to diseases and pests and adaptation to stress conditions. For tuber moth resistance breeding, twenty-two primitive cultivated forms and twenty-one wild accessions with resistance genes are now included in the breeding programmes. However, in the first ten years of CIP's work, clones from developed country programmes were mostly used to contribute good agronomic characters so as to make good materials quickly available for developing countries. Now, however, the genetic resources collection is used as an essential source of resistance, especially to cyst nematodes, frost and viruses, and adaptation to the lowland tropics. Wild materials, particularly, are being used for resistance to Phytophthora, bacterial wilt, root knot and cyst nematodes, potato spindle tuber viroid and leaf roll and X viruses.

As a result, seventy countries have already received CIP germplasm. This consists of 1,057 clones, 244 in vitro samples, 950 tuber families (42,000 genotypes), 257 true seed samples (42,000 genotypes) for selection of potential cultivars and 68 true seed progenies (379,000 genotypes) for agronomic and adaptation studies. CIP impacts in breeding and in country-wide trials in different parts of the world are thus extremely strong.

In its 1983 report, IITA states that it is developing sweet potato lines with resistance to the sweet potato virus disease complex (SPVDC) and to weevils. Promising lines are TIS 2498 and TIS 9265 with SPVDC resistance. TIS 2498 is widely adapted and is grown in several African countries. Lines are also being developed with resistance to root knot nematodes.

AVRDC has developed high-yielding sweet potato selections adapted to the low input cropping systems of tropical Asia. These are rich in Vitamin A and are early maturing. There is not enough evidence available from IITA or AVRDC to be able to identify clearly the impacts from these programmes.

vii. National programmes and varietal releases

Based on CIP material the following potato varietal releases have been made:

Latin America	- 10 releases;
Africa	- 32 releases, including 6 in Kenya, 6 in Rwanda and 5 in Zaire
Asia	- 12 releases, including 4 in Nepal and 3 in Vietnam

More than thirty countries have identified promising clones and the released varieties have principally contained Phytophthora resistance, bacterial wilt resistance, earliness and adaptation to warm climates. Thus on the whole good impacts are sustained here, especially in Peru, Turkey, Rwanda, Zaire and

Kenya. CIP divides its extramural work into seven regions in different parts of the world and five country networks. By means of this double infrastructure, the selection and breeding lines produced at headquarters can be further bred and selected in close collaboration with national programmes.

AVRDC selections of sweet potatoes have been released in the Philippines, and disease-resistant lines have found their way into other national programmes. Virus indexing and meristem culture are needed to expedite the flow of breeding lines and selections into other countries. No information from IITA is available apart from the statement that TIS 2498 is grown in several African countries. Some impacts are resulting from this work but the evidence available at present is insufficient for more certain conclusions to be drawn.

viii. Economic advancement

No financial details are available.

ix. Training

CIP has contributed to several genetic resources training programmes held at the National Agrarian University at La Molina, Lima. IITA has collaborated with IBPGR in running two training courses in genetic resources in which some thirty students received training in exploration and conservation work. CIP, in common with other centres, has provided training in various countries on germplasm utilization, and has developed an effective germplasm management training manual that is being used by their national collaborators

x. Data bases

At CIP, all potato evaluation results are deposited in a computerized data storage system and are available on demand. This is now being upgraded, but unfortunately no inventories have been published and no detailed information on wild species can be obtained. Computerized record systems are available at IITA. At AVRDC, computer-generated inventories are urgently needed. The impacts here leave a great deal to be desired for all three centers, since no computer-generated inventories have been published, so far as I know, apart from a short list from CIP some years ago.

xi. Research

CIP is undertaking a considerable amount of research, often in collaboration with universities and institutes in North America, Europe and Japan. Thus, for example, cryo-preservation research is in progress, linked with the University of Bath, inheritance studies with the Universities of Wisconsin and Wageningen, protein and isoenzyme in Japan, to name but a few. CIP is undertaking studies on the use of 2n gametes in breeding, on virus detection methods and on the identification of new viruses, on the production of true seed varieties (with Wisconsin and also with Birmingham) and on the genetic stability during in vitro storage and under cryo-preservation. Research is also in progress on the biosystematics of wild potatoes and on the origins of cultivated species (with the University of Birmingham). Overcoming crossability barriers has been shown to be successful both by means of traditional and in vitro methods. Thus the impacts here are very impressive indeed.

No information is available from IITA or AVRDC.

xii. Conclusion

CIP's work in most of the links of the genetic resources chain is very impressive and with important impacts for the developing world. The lack of a properly working data base and certain difficulties in obtaining materials slightly mars an otherwise perfect series of impacts in every aspect of its work.

Insufficient data are available for IITA for impacts to be assessed properly. AVRDC data are not available in some areas (my fault probably, rather than theirs). However, the general conclusion here is that the work is developing quickly and that good impacts are in the pipeline.

7. Cassava and Yams: CIAT, IITA

CIAT has accepted the global mandate for cassava germplasm; substantial collections are also kept at IITA. Yams are not a mandate crop in either centre, but some activities are in progress at IITA.

i. Surveys

An analysis of the germplasm situation at CIAT was made in 1980, including priority areas for exploration work and collecting strategies for the 1980-83 period. Priorities were again established in 1984, and further trips were planned to Colombia, Brazil and the Orinoco basin of Venezuela. According to Gulick et al. (1983) about 25% of the existing cultivars have already been collected and 50% more are still needed. The figure of 75% is thought to be sufficient for capturing most of the alleles in this cultigen, but of course this would only be true if the samples were collected evenly throughout the whole area of its distribution. More wild species collections are still needed from the centres of diversity in Southwest Mexico and North-Brazil. Of an estimated total of ninety-eight wild species, all but nineteen are found in South America. CIAT has thirty-one wild species but the number of samples of some may be very small. Nassar (1981) reports living collections of six wild species held at two institutes in Brazil and it is to be supposed that most, if not all of these have been sent to CIAT. The sample numbers for each species number as few as six or seven in some instances, though in others many more have been collected. There is no doubt, however, that much more wild germplasm needs to be collected, under a carefully coordinated plan. Wild cassava species are of potential interest to breeders for possible presence of characters conveying low hydrocyanic acid content, disease and pest resistance, high starch and drought resistance. Even though for the present all useful genes are found in the cultigen, the situation may require a much broader genetic base in the near future.

Yams (Diosorea spp.) are reviewed briefly by Coursey in the IBPGR descriptor booklet (IBPGR 1980). However, this work does not, unfortunately, include a survey of yam genetic resources in the field or any kind of proposed active programme.

ii. Exploration

Materials have been collected by CIAT in collaboration with IBPGR and national programmes in all the major distribution areas from Mexico to Paraguay. In the last six years 1452 varieties have been sent to CIAT as in vitro cultures to comply with quarantine regulations.

In 1969-71, CIAT expeditions collected 2000 accessions from Mexico, Panama, Venezuela, Colombia and Peru. Several hundred new collections were made between 1972 and 1980. In 1980 IBPGR declared cassava a priority crop, and subsequent IBPGR expeditions collected 1000 samples from Brazil, 150 from Paraguay and 200 from Peru. A second expedition to Paraguay took place in March, 1984. A Central American collection is expected from CATIE, Costa Rica, and a further collection from Panama is needed to replace material lost through bacterial blight attack. Thus the pace and impact of cultivated cassava exploration work is very good. For wild species, since only thirty-one of the ninety-eight species have been collected in the living state, the impacts are rather poor, and much more effort needs to be put into wild species collecting work.

In Africa IITA had collected 163 samples of cassava and 443 of Dioscorea species by 1984.

iii. Conservation

At CIAT there are three distinct strategies for cassava conservation: the trial fields, seed collections and meristem collections. The field collection can only be considered as a temporary measure, though plants in this form are needed for characterization studies. Seeds are kept in active stores at 5° to 8°C and base store at -15° to -20°C. Satisfactory facilities for seed management are available. Some 30 to 50 seeds are held of each accession of thirty-one wild species and seeds have been obtained from 640 clones by open pollination.

The total cassava holdings are 3,600 entries and over 2,000 of these have been successfully put into in vitro storage. This process started in 1979 and will take more than two years to complete. In vitro facilities for 6,000 accessions are available, and could be extended to accommodate 7,500 entries when more field collections have been made and assuming that duplicates will have been eliminated. The materials are kept under minimal growth conditions and some 750 lines have been freed from viral, bacterial and fungal diseases by thermotherapy. In addition, a set of fourty to fifty elite lines are kept in vitro for distribution to institutes requesting them.

Because of quarantine restrictions all intercontinental exchanges and most international ones in Latin America can only be made in the form of in vitro materials. The in vitro laboratory, therefore, plays a key role not only in storage but in transfer of material to and from national programmes as well as in the elimination of diseases. Transfer of germplasm from 1973-1984 took place as follows:

	Countries	Stakes	In vitro	Seeds
South American (Andean)	5	116	39	13,472
South American (non-Andean)	3	39	54	21,421
Central American	7	134	110	7,100
Caribbean	10	125	336	21,584
Middle East	2	2	4	-
Rest of Asia	11	79	147	151,850
Africa	6	42	46	77,665
South Pacific	5	39	8	1,864
North America	2	84	75	17,875
Europe	5	39	13	8,380
Total	50	699	832	321,611

This table shows that, despite the genuine successes of the tissue culture programme, by far the largest amount of material is sent in the form of seeds. There is no designated duplicate storage collection as yet.

The in vitro programme of cassava storage shows excellent impact. However more seed storage research needs to be carried out to improve impacts in this area.

At IITA the cassava collection is small but is being added to from time to time. Some in vitro work is in progress.

The yam germplasm collection contains 558 entries, included in six cultivated species, as well as 61 entries of wild relatives and seventy-six unidentified collections. Some meristem culture work has been undertaken with these materials, also. Other fairly large collections exist in Fiji, Indonesia, Ivory Coast, Philippines and Solomon Islands. There is no designated base collection. To conclude, there seems to be rather small impacts for cassava and yam storage at IITA, which may be due mainly to budgetary restrictions.

iv. Evaluation

Cassava characterization is based on the IBPGR descriptor list, though only thirty-seven out of the seventy-four IBPGR morpho-agronomic descriptors are used. Some thirty passports and entry data are used, but only ten for adaptation and resistance characters, which is clearly inadequate.

Preliminary evaluations include yield, root quality and disease and insect resistance. Most lines are evaluated at four sites, namely north coast, mid-altitude zone, eastern plains and highlands. No resistance has yet been found in the cultigen to the African mosaic virus but this is found in the wild species, Manihot glaziovii. There is an urgent need to extend the evaluation of the wild species.

In 1982 some 700 clones were evaluated in six different ecological zones and some 8-15 clones were selected as potentially promising for each zone. Even so, only a small number of germplasm accessions is said to combine the requisite traits for a given zone, and they must therefore be used in a crossing programme. This is only to be expected.

On the whole this work has progressed fairly well with the cultigen, and large-scale multiple-type screening for pest and disease resistance under field conditions is a regular feature of the trials system. Promising levels of resistance have been found to thrips, mites, whiteflies, mealybugs and lacebugs. Tolerance to low soil fertility has also been found. The impacts of this work are satisfactory, but attention needs to be directed to the wild species, where at present the impacts are virtually non-existent.

v. Germplasm enhancement

Some work on bridge hybrids has been in progress to broaden the genetic base and concentrate useful characters in advanced breeding lines. No work has been attempted to introgress useful characters from wild Manihot species into the cultigen. Impacts here are very low, chiefly because basic research on wild species and their genetic compatibility with the cultigen is needed (see xi) and has not yet been carried out in any sort of integrated scheme.

vi. Breeding; trials

Promising lines from the evaluation work go into variety trials in five regions of Colombia:

(a) Eastern llanos	(very acid soils)
(b) North coast	(very dry conditions)
(c) Popayan	(low temperature tolerance)
(d) CIAT - Palmira	(medium altitude)
(e) Caqueta	(lowland humid tropics)

Clones are also sent to national programmes (as meristems, where necessary) for screening. The characters looked for are good adaptation, high yield potential, moderate pest and disease resistance, high starch content and high yield stability. There are no international cassava trials, and all selections go to national programmes. Thus in 1982 some 63,000 F_1 seeds were obtained, of which 20,000 were used in the selection programme and nearly 40,000 were distributed to Brazil, China, Malaysia, Mexico, Philippines and Thailand. Impacts here seem to be satisfactory.

At IITA, improved families and lines of Dioscorea rotundata have been bred. It now seems possible to breed virus and nematode resistance into selections with high yield and minimum inputs, together with good storage quality and uniform tubers. Work with D. alata is still in its early stages (IITA 1983). Impacts are not very impressive so far.

vii. National programmes; release of varieties

The CIAT cassava variety CMC40 introduced into Cuba in the mid-1970s is now grown on 250 hectares and will probably occupy 15% of the total cassava area in 1985. The Cuban national programme has developed its own clones, CEMSA 5-28 and 74-725, using CIAT material. Promising selections such as MMex59 and MPan51 have already been released in Mexico. In Haiti a CIAT clone CMC40, introduced in 1976 has been released as the variety "Madame Jaques". In Thailand two CIAT lines are being tested, Huey Pong 4 and 5; one of these is likely to be released shortly. Similar reports come from Thailand. In summary, the number of varieties produced or distributed by CIAT and grown commercially in various countries amounts to about twenty-five - a reasonably good impact which no doubt will be increased considerably in the near future.

At IITA 5 improved cassava varieties (TMS 30572, 30555 30337, 30001 and 30211) have been multiplied rapidly and distributed to thousands of farmers through national channels. They are reported to be grown on over 80,000 hectares and this is likely to increase to 3 million hectares by 1990. They are said to give high yield (50 to 300% more), stable production, resistances, and better processing qualities. New promising lines such as TMS 4(2), 1425 and 50395 are now being multiplied on a large scale. Good success in the release of varieties or selections are recorded also for Sierre Leone, Zaire, Gabon, Tanzania, Seychelles, Rwanda, Liberia and Cameroon. Here also, impacts are developing in a very satisfactory way.

viii. Well-being and economic advancement

From the increased yields mentioned in section (vii) it seem highly probable that those new releases of cassava from CIAT and from IITA have played an important role in higher crop yields and a higher standard of living. Unfortunately no figures to illustrate this statement are available.

ix. Training

CIAT has organized, in collaboration with IBPGR, a training course on the exploration and conservation of genetic resources in 1983. This was a Spanish language course given to fifteen trainees from seven countries. Four in vitro storage training courses have been given to a total of thirty-six participants, and seventeen internships for tissue culture work were arranged.

Two courses took place at IITA in collaboration with IBPGR, with a total of thirty participants from about ten countries. Some of these students later went to Birmingham to continue their studies at M.Sc. level. Thus good impacts arise from this area.

x. Data base

Cassava passport data at CIAT are in process of computerization, and evaluation data are now on magnetic tape. Print-outs are available for distribution. The work is slowed down to some extent by the lack of on-line facilities to the main frame computer. A microcomputer is needed in the GRU for day-to-day inventories.

A computerized documentation system exists at IITA for rice and cowpea germplasm, but it is unclear as to whether cassava and yam data are also included as yet. However, the system seems to be working effectively, with satisfactory impacts for the major crops at least (Ng, 1982).

xi. Research

At CIAT a collaborative research project on long term cryogenic storage of cassava meristems in liquid nitrogen is underway with the Prairie Regional Laboratory at Saskatoon, Canada. The results so far seem promising. Studies on the phenotypic stability of in vitro stored material have been initiated and it is hoped to investigate genetic diversity by means of enzyme electrophoresis.

This work will undoubtedly provide a useful impact. However, research is urgently needed on genetic compatibility between wild and cultivated cassava species, the extent of inbreeding depression, and seed physiology and dormancy. There is a large gap in our knowledge of the wild cassava species and only about one third have been studied in the living state. A research fellowship in the cyto-genetics and reproductive biology of wild and cultivated cassavas is urgently needed at CIAT and probably a similar one for Dioscorea at IITA. In this respect there seems to be a short-sighted approach, since it is now well-known that in crop after crop breeders are being forced into using characters of pests and disease resistance from related wild species.

xii. Conclusions

Not enough emphasis at CIAT or at IITA is placed on investigations with related wild species; in other words, although the genetic base for the cultigen is moderately satisfactory, that for related wild species is very narrow, and this is a situation of potential danger for the future. Whilst not in any way wishing to belittle the achievements and impact of meristem work at CIAT, the balance between this and cyto-genetical studies with the crops and its wild relatives is very one-sided. Collaborative funding along the lines of the work with Canada needs to be sought and implemented as soon as possible for cyto-genetical and related studies.

Apart from this criticism and the lack of certain information from IITA the impacts are promising, though work goes too slowly in both centres because of insufficient funding and personnel. Finally, lest it should be thought that IITA's record in this section is not as advanced as that of CIAT, we must remember that neither cassava or yams are mandate crops at IITA and are thus unlikely to attract much funding.

8. Faba Bean and Lentils: ICARDA

ICARDA has accepted the world mandate for these two crops.

i. Surveys

General discussions on grain legumes, including faba beans and lentils, are provided by Witcombe and Erskine (1984) and Cubero (1984a).

A survey of the taxonomy, species distribution and the occurrence of races in different areas for faba beans is given by Cubero (1984b). Witcombe (1984) points out that collections of faba beans are sill seriously under-represented from countries such as China, Iran and India. However, a proper survey based on the distribution of actual collecting sites is still needed. Witcombe's first priority countries are China, Morocco, USSR and parts of India and Pakistan. Toll (unpublished) would add Algeria, Libya and Tunisia as first priority, Iraq as second priority, and Afghanistan, Lebanon, Turkey and Iran as third. Clearly more collecting is needed, but the surveys provide good impacts to indicate the correct priorities.

For lentils, there are good surveys by Cubero (1984c) and Erskine and Hawtin (1983). Solh and Erskine (1984) review genetic diversity in this crop and set out priorities for collecting in Algeria, North Morocco, Bangladesh, Burma, India (Bihar and Madhya Pradesh), North and Northeast Iraq, Pakistan and Chile. Most of these countries are also included in Toll's list (unpublished). The collections of wild lentils urgently need more material, and are very under-represented. Toll recommends emphasis be placed on Afghanistan, Cyprus, Iraq, Jordan, Lebanon and Turkey.

As with faba beans, a great deal more collecting is needed, but a proper survey of passport data in the existing collections is required. By and large, the impacts here are reasonably good but need improving.

ii. Exploration

For faba beans, ICARDA is attempting to stimulate collecting efforts, aided by IBPGR. It inherited the ALAD bean collection, and has also received material from Cyprus (Della 1980), Egypt (IITA collections and personal ones - Abdulla) and Afghanistan. The Germplasm Institute at Bari has sent collections from Algeria, Greece, Spain and Tunisia, and Ethiopian materials have been received from the national genebank. Since a great deal more collecting is needed, it would seem appropriate for ICARDA to take a more positive attitude and make its own collections wherever possible.

More lentil collections are needed also, and ICARDA and IBPGR are jointly attempting to stimulate this work. Recent collections are reported from Syria (Sidhu et al. 1983) and from Pakistan (Ahmad et al. 1982), but more efforts are needed, as discussed above. ICARDA should play a more active role here also, since the impacts are now rather weak.

iii. Conservation

ICARDA at present possesses a medium-term cold store of 252 cubic meters at 5°C and 14% R.H. for all its mandate crops, which can accommodate 60,000 entries. A low temperature base collection store is under construction, with funding provided by the Italian government. Major collections of faba beans are held at ICARDA (2791), Leningrad (2525), Bari (1469), Gatersleben (786), Wageningen (700), Braunschweig (500) and some other places (Witcombe 1984). No doubt many of these are duplicates. ICARDA has been invited by IBPGR to participate in the international base collection network when its long-term storage facilities become available. Since faba beans are outcrossing, regeneration provides problems, but these seem to be solved by interposing 5 meters wide swathes of brassicas between the sample plots.

ICARDA possesses 5838 accessions of lentil, collected in (or obtained from) sixty-two countries. Somarod (unpublished) states that ICARDA has received large collections from USDA-Pullman, Iran and India (see also Ayad and Anishetty 1980). All these 5835 accessions are now being placed in the active collection.

Much material from the bean and lentil collections is made available to ICARDA breeders and to national programmes when requested. A lentil germplasm catalog was published recently (Erskine and Witcombe 1984).

The conservation impacts are reasonably good, therefore, in so far as materials are being made available and stored well, even though base storage is needed. The genetic base is not as broad as it should be, for reasons discussed in (i) and (ii) above.

iv. Evaluation

It is stated that evaluation is carried out by the GRU in collaboration with the breeders. There is no IBPGR descriptor list for faba beans and ICARDA has therefore developed one (see Witcombe 1984, Apppendix 10). Since Witcombe was at that time an IBPGR employee one should say, however, that IBPGR has certainly complied with its commitments in this respect. The descriptor list contains thirty-one morpho-agronomic characters, six stress descriptors and twenty pests and disease descriptors. The method adopted for screening the landrace samples of faba bean, when each sample is highly variable within itself, is to screen the pure lines extracted from each, whilst still retaining the original population sample (Hawtin 1984). According to Elsayed (1984) the genebank materials are of major use in providing sources of genes for traits such as high yield, yield stability, wide adaptation, disease and insect resistance, improved plant type and useful physiologicl characters. Good sources of Botrytis and Asochyta resistance have been identified and promising selections, able to grow in low rainfall areas (300-350 mm p.a.), have emerged. Nematode and Orobanche resistance has also been found in the genetic resources materials, and nine lines high in protein (30-35%) have been found. In DDR (East Germany), one line out of 600 showed high resistance to fourteen isolates of bean yellow mosaic virus. This work with faba beans shows commendably high impacts. No work has been done on wild relatives, however, since these are not geneticlly compatible with the cultigen (see (v) below), which for the present seems to possess all the useful characters needed.

Wild lentils have not yet been properly evaluated (Erskine and Hawtin, 1983), but the very wide diversity of both small-seeded and large-seeded forms has been well studied. The descriptors shown by Solh and Erskine (1984) comprise twenty-four morpho-agronomic characters, five for stress conditions, and 14 for resistance, drought resistance and Orobanche resistance. As a result, features useful to breeders were identified; these included cold tolerance, height (over 35 cm,. and pods more than 15 cm above the ground surface, for mechanical harvesting), lodging resistance, and rust (Uromyces) and Asochyta resistance. In general the land races showed good adaptation to the local conditions where they were collected. Useful characters were also found in certain wild lentil species.

The impacts of the activities described in this section are excellent, and no doubt further useful genes or gene combinations will be discovered during the next few years.

v. Germplasm enhancement

As mentioned above, the first step towards the improvement of faba beans is to create inbred lines from the landrace populations so that they can be properly evaluated; the inbreeding process is also likely to reveal useful genetic variation that was hitherto obscured (Witcombe 1984).. In fact, Hawtin (1984) goes so far as to state that Vicia faba should be developed as a fully autogamous species, thus improving stability of yield and other characters. However, such a drastic step does not seem to have been considered necessary by maize breeders, and perhaps might not be required for faba beans either.

Other work on faba bean enhancement is discussed in section (xi) - Research.

More work on the use of wild lentil species is needed. However, crosses between Lens orientalis and L. culinaria at ICARDA were used to transfer drought tolerance from the former to the latter (Erskine and Hawtin 1983). More work is required and impacts are of medium importance for both these crops.

vi. Breeding; trials

Faba bean breeding is discussed by Elsayed (1984). From 1,000 pure lines sixteen traits were scored for various morphological and agronomic characters as well as resistance to diseases and pests such as Botrytis (chocolate spot), Asochyta, rust, root rots, aphids, leaf miner, pod borer, Orobanche and stem nematodes. Collaboration with Egypt and Sudan for certain of these pests and diseases has also been arranged. After crossing and selection the materials go to yield-trials, followed by international yield trials and screening nurseries. One problem is that the pure lines do not possess as wide a range of adaptation as synthetics might provide. High-yielding cultivars for low rainfall zones are also being produced. Other objectives, in addition to high yield, resistances and drought tolerance are protein content and the elimination of favism factors.

With lentils, Erskine (1984) reports that the breeding programmes start with landraces and select better lines from them, which are then crossed together. The objectives are to produce cultivars with high and stable yields, good quality, cold tolerance for higher altitudes, Orobanche tolerance, weevil (Sitona) resistance, and resistance to the root-rot complex and to drought. Many promising lines resistant to cold have been identified and two lines from India (ILL 3047 and 3112) were most tolerant to Orobanche. Eleven downy mildew resistant lines from Lebanon were found. The Argentinian macrosperam variety "Precoz" is adapted to Indian day length conditions and is being used to improve seed size in the Indian lentil germplasm.

National yield trials for 1-3 years are followed by on-farm trials.

So far as breeding is concerned, the impacts are good, but it surely might be useful for faba bean breeders to try, as a parallel development, the techniques of population breeding (see potatoes and pearl millet for example).

vii. National programmes; releases of varieties

Many useful selections of faba beans are being used in multi-location or on-farm trials for 1984 and 1985 in a wide range of countries. The results for yield, resistances, large and small-seeded lines and disease and pest resistance are promising. No releases or near-releases are mentioned in the 1983 reports (ICARDA, 1984a,b).

Lentil development has gone ahead more quickly than faba bean work. A line with high yield and rust resistance - ILL357 - is about to be released in Ethiopia. The selection ILL 4605 (originally from Argentina) has shown considerable promise in India and Pakistan. Five more selections have reached on-farm trials in Pakistan. In Syria the large and small-seeded varieties yielded between 15 and 28% more than the local checks (ICARDA, 1984b).

Impacts on the actual releases of faba bean varieties are zero, though much interesting material is in the pipeline. For lentils the impacts are already beginning to emerge, probably chiefly because many of the breeding lines have been developed directly from landraces without any need for a preliminary programme of pure line production, as was required for faba beans. Some of the lentil trial materials are landraces or landrace selections - sent directly to national programmes, and are already in advanced trials in various countries.

viii. Well-being and economic advancement

This stage has not been reached in the two crops under discussion. No impacts.

ix. Training

Many training courses in genetic resources work for Arab speaking participants have been organized at ICARDA and ACSAD (Arab Centre for Studies of Arid Zones and Dry Lands) in Damascus, with the help of the IBPGR regional coordinator for North Africa and the Middle East. The impacts here are good.

x. Data bases

ICARDA has excellent computer facilities, and since 1983, passport and other data have been going into computer storage. This is calculated to take five years and should be accelerated. A very useful "Lentil Germplasm Catalog" has just been published (Erskine and Witcombe, 1984). It includes information on accession number, donor and number, collector and number, collection date, country of origin, date received by ICARDA, time to flowering, time to maturity, plant weight, lowest pod height, yield (three types), harvest index, 100-seed weight, seeds per pod, year of evaluation, testa color and pattern, cotyledon color, protein content, cold susceptibility and susceptibility to *Orobanche crenata* in three successive years. Over 5,400 accessions are included. This is extremely useful to breeders and is of very high impact value.

xi. Research

Investigations on low favism-inducing substances in faba beans and its mode of inheritance are in progress with the University of Manitoba, Canada. The variety "tropical white" possesses very low levels. Research is also being conducted in collaboration with the University of Reading on the identification of factors which limit the transfer of useful traits from wild to cultivated faba beans, that is, lack of genetic compatibility between the species. Research on the faba bean ideotype is also underway.

Some work is in progress at ICARDA on the feasibility of transferring useful resistance and other characters from wild to cultivated lentils, but it is hampered to some extent by the narrow genetic base of wild materials.

On the whole, the impacts are promising but so far are potential rather than real.

xii. Conclusions

Collecting needs to be sped up for both crops and related to a careful survey of the collection localities of material already in the bank, in order to identify gaps. The progress of accessing materials into medium and long-term storage started only in 1983, but this work should be sped up if possible. A shortage of technical staff can be identified here. Faba bean breeding progresses more slowly than lentil breeding but this may be due largely to differences between these two crops. A faba bean inventory is urgently needed. The over-all conclusion is that impacts are good in view of the fact that the genetic resources programme has been in existance for a short period only.

9. Phaseolus Beans: CIAT

CIAT has accepted responsibility for the exploration, storage and characterization of all four cultivated *Phaseolus* species, together with their wild relatives. The breeding and improvement programme is confined to one species only, *P. vulgaris*.

i. Surveys

No far-reaching surveys have been made of materials in the various *Phaseolus* collections in different parts of the world with a view to looking for gaps in species and countries where collecting should be undertaken. From a study of the numbers of samples of each species in the CIAT and other collections (see section section (iii) below) it seems clear that more efforts are needed to collect *P. coccineus*, *P. lunatus* and *P.acutifolius*, even allowing for the fact that their areas of cultivation are not so extensive as that of *P. vulgaris*. Wild and weedy forms also need more exploration work, especially *P. vulgaris*, subsp. *aborigineus* and the wild relatives of the other cultigens (Vanderborght, 1983). Since the species identity of some of the genebank materials is questionable, IBPGR and USDA are jointly funding a project for the proper taxonomic identification of these materials.

Impacts here are still rather diffuse and more efforts need to be put into planning conferences which would include taxonomists, collectors and specialists in Phaseolus evolution, cyto-genetics and reproductive biology. From these conferences detailed surveys and priorities for exploration should emerge. The production of computer-generated maps based on the location data of gene bank materials would also be most valuable.

ii. Exploration

CIAT has made or encouraged expeditions, generally with IBPGR funding, to the Phaseolus regions of primary diversity and origin, particularly Mexico, Central America, Colombia, Venezuela, Ecuador, Peru, Bolivia, Argentina and Brazil. Collections have been made by national scientists and by USDA and IITA teams in Africa, Asia, the Iberian peninsula and elsewhere. IITA has collected 1,382 samples of P. vulgaris and P. lunatus in African countries since 1976.

More collecting is needed, as noted above; special efforts should be devoted to the collection of wild species, since at present CIAT possesses only 337 entries of wild and weedy P. vulgaris (Vanderborght 1983) and a few of the other three species. Thus impacts are good in terms of total numbers, but poor as regards P. lunatus, P. coccineus and P. acutifolius, as well as wild species.

iii. Conservation

Storage conditions are of good quality on the whole. Active collections are stored at +5 to +8°C at 12-14% moisture and an estimated seed life of 4-5 years. Base collections are stored at -2 to -6°C, with an understanding that this will be later reduced to -15°C; the moisture content is 5-8% and the estimated seed life is 30-50 years.

The most recent storage numbers are as follows:

Species		Numbers in store	Increased
P. vulgaris		29,552	16,799
P. lunatus		2,410	700
P. coccineus		1,083	220
P. acutifolius		166	166
Non-cultivated		84*	30
	Total	33,295	17,915

* But 337 samples of P. vulgaris weedy and wild forms according to Vanderborght (1983).

Increased material is also characterized at this stage and put into proper storage conditions. At present only 17,000 samples are in the active collection and 3,000 in the base collection.

About 60% of the sample are from the Americas. Other collections are held in Brazil (designated base duplicate collection), North America and Europe. Samples have been received from national collections in fifty-four countries, mostly of P. vulgaris. Some 20% of these possess no passport information.

Lyman et al. (1983) consider that most of the P. lunatus CIAT collections are of the Sieva type (1468 numbers), whilst the pallar type totals 325 numbers, the potato type 107 numbers and wild forms only fifty-three. Most are from the Americas.

There are quarantine problems concerned with the introduction of materials from Africa, Asia, Eastern Europe and Brazil. Six thousand samples of this type lie untouched in the active store, since the Colombian authorities require each sample to be grown for a season in a quarantine house and the national facilities for this are inadequate. CIAT should take action here, either to send the material abroad for third country quarantine or provide the necessary quarantine houses themselves, since otherwise these collections will lose viability and have to be discarded. This is a real bottleneck, since the CIAT breeders cannot use any of these 6,000 lines at present.

Transfer of raw germplasm to other countries is as follows:

Region	Countries	Seed samples
Andean South America	6	1,735
Non-Andean South America	3	1,264
Central America	6	15,238
Caribbean	6	1,048
Africa	14	1,673
Asia-Oceania	12	1,162
North America	2	1,087
Europe	15	1,267

In addition 74,900 samples were passed to the CIAT bean breeding programme. It should be noted that most requests are for specific characters and come from national programme breeders, entomologists and pathologists. A few requests for wild materials are received, also.

The IITA collections are stored under satisfactory conditions. Some 1,770 samples have been distributed to Africa, Asia, Europe and the Americas.

The impacts here are mixed. Material is stored well, but the quarantine bottleneck is most unfortunate, with consequent negative impacts. More genebank material other than P. vulgaris is needed, as well as wild species. This is of course a "knock-on" effect of the shortcomings in sections (i) and (ii). Transfer of materials into the base collections, after multiplication, is very slow, due primarily to low staffing levels.

iv. Evaluation

IBPGR descriptor lists have been published for P. vulgaris, P, lunatus and P. coccineus (IBPGR, 1982a, 1982b, 1983c, respectively), but not for P. acutifolius. Most of the screening at CIAT has been done on the P. vulgaris materials in connection with the breeding programme. Only about 700 lines of P. lunatus have been characterized, the P. acutifolius work is underway and that for P. coccineus has just started. The references given by Lyman et al. (1983) for evaluation of P. lunatus are all published in the USA, where there is considerable interest in this species, and also at Gembloux, Belgium.

To return to P. vulgaris, the materials are characterized using twenty-eight out of the fifty-nine IBPGR morpho-agronomic characters. Some 12,000 accessions have been processed in this way and the information passed into computer storage. Material is replicated at four sites: (a) CIAT (1,000 m), (b) Popayan (1,800 m), (c) La Selva (2,200 m), and (d) Obonuco (2,700 m). The higher altitude plots include accessions which are mostly climbers and do not adapt well to the CIAT altitude. In all the plots the accessions are evaluated for growth, adaptation and yield as well as field resistance to diseases and pests. This is followed by more careful evaluation for resistance to bean golden mosaic virus, common bacterial blight, Ascochyta leaf spot, leafhopper, Zabrotes and Acanthoscelides. It has been shown that wild P. vulgaris forms are particularly interesting for stored grain insect resistance. However, they possess low level of resistance to bean golden mosaic virus, common bacterial blight, Ascochyta leaf spot and leafhopper.

The impacts for P. vulgaris characterization and screening are most satisfactory. The position of the other species needs to be decided, but for the present it would seem that CIAT accepts responsibility for their conservation and characterization only.

v. Germplasm enhancement

(see xi, Research)

vi. Breeding; trials

This and the following sections refer to P. vulgaris unless otherwise stated. CIAT breeders are making selections of elite stocks from the gene bank (EP nursery) at a rate of 350 per year. Promising progenies are deposited in the gene bank. The breeding consists of three phases: (a) identification of breeding problems, (b) breeding for the problems identified, using promising parents from the germplasm evaluation programme, (c) obtaining multiple factor combinations in acceptable cultivars.

In addition to adaptation and quality, breeders are looking for resistance to angular leaf spot, Anthracnose, common and golden mosaic viruses, chlorotic mottle virus, rust, storage insects and drought. They are also looking for suitable plant architecture for various conditions.

A 3-stage nursery evaluation is used:

1. Bean team nursery - looking at agro-ecological adaptation and disease resistance;
2. Preliminary yield trial, where disease resistance is confirmed or otherwise, and where yield potential and seed quality are evaluated;
3. International bean yield and adaptation nursery in various agro-ecological zones. National programme leaders collaborate at this stage, and all nurseries are freely available to them. There are also special series of disease and insect resistance nurseries to sort out pathogen race complexes, and nurseries for drought, rhizobium nitrogen fixation and insects not occurring in Colombia.

Collaborative links are developed with national programmes so as to ensure that good selections are available for their conditions and needs.

Some reports on lima bean breeding at IITA were given in the Tropical Grain Legume Bulletins but there was no newsletter. Lima bean research was discontinued at IITA IN 1979.

vii. National programmes; release of varieties

For the last two years resistance to bean common mosaic virus has been incorporated into all lines leaving CIAT. The following successes are recorded (CIAT 1983):

Angular leaf spot. Three lines are resistant in Colombia but susceptible in Brazil; the reverse holds true for two others; and a further two lines are resistant in both countries.

Anthracnose. Over 15,500 lines have been evaluated and eight are resistant in Latin America, where more races of the disease occur than in the USA or Europe. These eight lines are also resistant to angular leaf spot.

Bean common mosaic virus. Good lines are being developed with BCMV resistance and red seed color.

Bean golden mosaic virus. High level resistance was selected in collaboration with the Institute of Science and Technology in Guatemala. Selected lines gave rise to several outstanding varieties in Guatemala which have been passed on to producers in other countries. Negro Huasteco 81 is a Mexican variety of this type.

Bean chlorotic mottle virus. Argentina lost over 50,000 hectares of beans due to this virus in 1981. Now line DOR 41, released as ICTA-Quetzal, was registered in Argentina in 1982 and is rapidly replacing the local variety Negro Comun.

Rust. The International Bean Rust Nursery has identified a series of seven national cultivars and nine CIAT-bred ones with considerable rust resistance stability. Durable resistance is still under investigation.

Storage insects. Good levels of resistance to storage pests have been confirmed and the resistant line G12949 is outstanding.

Drought. Three CIAT Lines tolerant to drought have been identified but no selections capable of being released by national programmes are yet ready.

Nitrogen fixation. Seventeen breeding lines with good ability to fix N_2 were identified.

Plant architecture. Eleven lines show promise for various qualities. Table 4 in the CIAT 1983 report lists twenty-four promising lines and fourteen varieties in seed multiplication that have been distributed to various countries. It also lists thirteen established commercial varieties based on CIAT materials.

CIAT's impact in the production of promising selections, some of which have already been released through national programmes, is most encouraging, and much more is clearly in the pipeline. Particular successes are recorded for releases resistant to golden mosaic virus, bean chlorotic mottle virus, rust and storage insects.

viii. Well-being and economic advancement

No figures are available, but in light of the loss of over 50,000 hectares of beans in Argentina before the cultivar ICA Quetzal, resistant to bean chlorotic mottle virus, was introduced there is likely to be a very large impact in this area.

ix. Training

The training course in collaboration with IBPGR held at CIAT in 1983 has already been mentioned. In this course thirteen trainees from seven countries participated. Six bean germplasm internships for trainees from five countries have also been awarded. Good impacts have resulted from this work but more training courses will be needed.

x. Data bases

Passport and screening results from the germplasm bank are stored in the main frame computer, but the lack of a direct link from this to the GRU slows down the work considerably. A microcomputer is also needed for "housekeeping" operations. A print-out inventory for P. vulgaris was published in 1980, and an updated version is now required. This contains twenty-five morpho-agronomic descriptors, five fungal/insect resistance descriptors and three that record adaptation to stress conditions. A useful feature at the end of this inventory is lists of accessions grouped under each particular pest, pathogen etc.

Criticism of the inventory has been expressed by the breeders since it gives no data on races and pathotypes to which the bean accessions show resistance. Although this criticism is valid up to a point, it would be impossible to include more detail in a generalized inventory of this sort. Separate race/pathotype inventories for each pest and disease are the obvious answer to this problem.

Impacts are good here.

xi. Research

Vanderborght (1983) looked for discriminant characters to enable him to identify duplicates in the wild species collections at CIAT, and the same methods could be used for cultivated beans in the collection. Certainly some kind of study to see how best to identify and eliminate duplicates is needed. Protein and enzyme electophoretic work is planned (with IDRC funding) to study genetic diversity in the collections. A project proposal has been accepted by USAID in the use of in vitro culture to rescue embryos from wide crosses between species where endosperm/embryo incompatibility occurs.

Collaborative research is also in progress with the University of Gembloux to obtain wide crosses and germplasm transfer through the development of amphidiploid interspecific hybrids.

These research programmes seem to promise useful impacts for the future.

xii. Conclusions

The impacts with regard to surveys are still rather weak. Much more collecting efforts should be concentrated on wild and weedy forms of all species, and particularly on the cultivated forms of P. lunatus, P. coccineus and P. acutifolius, which are severely under-represented in the genebanks. Storage conditions are good but the pace of entering materials into the bank is too slow. A quarantine problem constitutes a bad bottleneck to progress and should be solved quickly.

Evaluation of P. vulgaris accessions is proceeding satisfactorily but needs speeding up with the other three species.

Breeding is confined entirely to P. vulgaris and thought should be given to the other three species. There is a strong need at least to develop a P.

lunatus breeding programme for tropical countries, and it is to be much regretted that IITA discontinued their work with this species in 1979. For the rest, P. vulgaris breeding and release of varieties through national programmes is progressing well, and with satisfactory use of the germplasm resources at CIAT.

10. Chickpea and Pigeonpea: ICRISAT, ICARDA

i. Surveys

The distribution of cultivated and wild chickpea is well-known, thanks to the taxonomic studies and field and herbarium surveys of van der Maesen (1972; 1973a, b; 1984). The cultivated chickpea extends mainly through the Mediterranean basin, the Middle East, central Asia, India and Ethiopia, but is grown in many other countries besides. The distribution of the wild species is known also. Collections had been made previously by various institutes and it is likely that whatever remains of these is deposited in the genebanks at ICARDA and ICRISAT, whilst gaps in collections have been identified. Of the two types, "desi" and "kabuli", ICRISAT takes responsibility for desi, whilst joint responsibility for kabuli is shared by ICARDA and ICRISAT (Singh and Malhotra 1984). Thus, impacts here are good, largely due to the efforts of Dr. van der Maesen rather than to IBPGR or the CGIAR centres, directly. Van der Maesen and Pundir (1984), however, point out that much more wild chickpea material needs to be collected.

The distribution, ancient history, taxonomy and origin of pigeonpea is covered briefly but adequately by De (1974). It is also picked up again by van der Maesen et al. (1981), Remanandan (1981) and Thothothri and Jain (1981) as well as van der Maesen (1979). The 1981 papers were published from a pigeonpea workshop organized by ICRISAT.

So far as can be seen, the crop has been reasonably well surveyed, though wild collections are still needed in greater quantity. Thus, as with nearly every crop in this present review, the wild species are rather inadequately covered, an no computer-generated distribution maps of the collection localities are available. Nevertheless, on the whole, survey impacts are reasonably good.

ii. Exploration

ICRISAT holds over 13,000 chickpea entries from fourty countries, though certainly many of these will be duplicates. It is considered that further collecting trips should be made to Burma, NorthEast India, Pakistan, Tanzania, North and South Ethiopia and Turkey.

ICARDA inherited 1,798 kabuli chickpea accessions in 1977 from the Ford Foundation ALAP programme and has added a further 2627 accessions of which most are said to be landraces. The total of some 5000 samples undoubtedly contains many duplicates (Toll, undated) since most come from other institutes. In fact, it seems to be ICARDA's policy to rely mainly on these sources rather than to carry out its own collecting trips. Its own priority areas for further collecting do not coincide with those set out by ICRISAT, but this may be due to the fact that ICRISAT is chiefly concerned with the desi type and ICARDA the kabuli type. The countries listed are Iraq, Syria, Algeria, Morocco, Bulgaria and USSR (first priority); Afghanistan, Pakistan, Southern Europe and Mexico (second priority); Lebanon (third priority).

Wild chickpea germplasm is mentioned by van der Maesen and Pundir (1984) who deplore the fact that only fifty-four accessions belonging to fourteen wild species are to be found in collections. ICARDA has thirty samples of seven wild species. The problems here relate to the difficulties of seed regeneration in conditions at ICRISAT and ICARDA, as well as in Israel, where a sizeable collection of wild Cicer is to be found. Research inputs are needed here.

Impacts for chickpea germplasm exploration are thus reasonably good but could be improved, whilst for the wild relatives they are rather bad at present.

Pigeonpea materials at ICRISAT number 10,000 samples from thirty-six countries, including 467 samples of related wild species. More exploration of cultivated materials is needed from the Philippines, Southrast China, Southrast Asia, Australia, parts of India, Burma, Zaire, Malawi, Uganda and the Caribbean Islands. Considerable exploration is needed for wild species in the genera Cajanus and Atylosia.

Impacts for pigeonpea could be much improved, with a carefully formulated exploration plan as first priority.

iii. Conservation

The ICRISAT genetic resources unit was established in 1979 (Mengesha et al. 1984). Short-term storage is at 15°C whilst medium-term storage is at 4°C. The materials are sun-dried to 7-8% moisture, but this method is unsatisfactory, in the opinion of the present writer, since it gives no control of temperature, which at times might rise too high, with consequent damage to the seed. There is as yet no long-term storage, but the facilities are nearly completed. The seeds in these will be sealed in cans. The laboratories and cold store facilities were built with funds provided by the Japanese government and the Asian Development Bank.

At ICRISAT there are now 13,819 accessions of chickpea from fourty different countries and 10,104 accessions of pigeonpea from thirty-six different countries. All these are cultivated materials. The shortage of wild collections has already been mentioned.

ICRISAT materials distributed up to 1984 to evaluators and breeders are as follows:

	Internal	India	Elsewhere	Countries
Chickpea	75,092	24,121	34,779	56
Pigeonpea	44,280	15,106	6,613	71

[ICARDA storage facilities mentioned under: Barley, p. 11]

At ICARDA the number of chickpea samples received between 1980 and 1984 totals 1736 from twenty-eight countries, especially Syria (916), Jordan (85), Morocco (65), Mexico (52), Chile (205), Turkey (43) and India (33). It is stated that national programmes are being encouraged to make future collections, but ICARDA itself has carried out much collecting in Syria.

ICARDA has distributed 6330 samples of chickpea to forty-three developing and sixteen developed countries between 1979 and 1984. This includes 1833 samples given to ICARDA evaluators and breeders.

On the whole, the impacts here are good, apart from the small amount of wild materials in the banks of both centres.

iv. Evaluation

ICRISAT's chickpea evaluation programme is very extensive. All germplasm has been screened for Fusarium wilt and 58 resisters were found. Dry rot (Macrophomina) screening has revealed forty-eight resisters. Some medium resistant lines to Ascochyta blight were found from screening work in North India (see also ICARDA). For grey mould (Botrytis), 6000 lines were evaluated and some resistance has been found. Screening for chickpea stunt (pea leafroll virus) has not been carried out systematically. If no symptoms are noted after three years the material is considered to be promising but will be rechecked in the laboratory. Some work has been carried out also on nematodes, iron deficiency and soil moisture stress. Several sources of additive resistance have been noted for Heliothis resistance, and pod-borer resistance has been found in twenty-two accessions.

Some promising lines of chickpea have shown increased capacity for nitrogen fixation, and there are indications of resistance to drought and salinity here and there, though very small numbers have so far been screened.

Apart from the evaluation for disease and insect resistance and stress tolerance, general morpho-agronomic evaluation has also been carried out in the genetic resources unit.

At ICRISAT pigeonpea has also received much attention from the evaluation viewpoint. A descriptor list was published jointly with IBPGR (IBPGR/ICRISAT

1981b) and over 9,000 lines have been characterized. Almost the entire collection (10,000 lines) has been screened for Fusarium wilt resistance, and thirty lines with good resistance were identified . Some 300 lines with good resistance to sterility mosaic virus have been identified and these show no symptoms, even after rattooning. Phytophthora stem and leaf blight has received attention, but with less promising results. There are two strains of the pathogen known; only one accession has been found resistant to strain 1 and none at all to strain 2.

The entire collection of chickpea and pigeonpea has been screened for Heliothis resistance and a few promising accessions have been identified. Screening for nitrogen fixation and salinity tolerance has revealed some promising lines, and screening for waterlogging tolerance is underway.

At ICARDA, 3,300 kabuli chickpea accessions were evaluated for morpho-agronomic characters, as well as Ascochyta blight, cold tolerance, iron deficiencies and photoperiod insensitivity; many useful lines were identified. Ascochyta blight resistance has been found in accessions from Afghanistan and the USSR: tall erect plants for more efficient mechanical harvesting have also been identified from the USSR. Cold tolerance has been identified in lines from India and Pakistan, better yields from Spain and Mexico, larger seeded forms from Tunisia and Spain and high protein from Chile and Argentina (Singh et al. 1983).

Reddy and Singh (1984) report evaluations of 9574 desi and 3836 kabuli accessions for Ascochyta blight resistance (the desi lines having been received from ICRISAT). The results showed eleven kabuli and six desi types tolerant. Other work showed ten useful lines possessing useful cold tolerance.

The amount of screening at both centres for resistance to fungal, viral and insect attack, as well as tolerance to environmental stress and other valuable characters, is most praiseworthy. This results in very high impacts indeed.

v. Germplasm enhancement

At ICRISAT all eight wild Cicer species were once assembled, but it was found that they were almost impossible to maintain. Cicer reticulatum has been introgressed with the cultivated chickpea and the material is now at F_7 to F_8 stage. Clearly more work is needed (see xi, Research).

With pigeonpea, Atylosia latisepala was crossed successfully with the cultigen, Cajanus cajan, and the cultivar NP (WR) - 15 has resulted from this material. All attempts with other species of Atylosia have so far failed. (see xi, Research).

Clearly, the small amount of work in this field results from the knock-on effects of little interest in wild species. Impacts are therefore not far from zero, but there could be much interesting research in the future.

vi. Breeding; trials

At ICRISAT the chickpea breeding work is well advanced. The Fusarium wilt resistant materials are reaching national programmes and some resistance is incorporated into double-podded forms. Ascochyta blight resisters are now in advanced generation and are being shared with India and Pakistan, with some fifteen to twenty crosses each year, helping to combat this very serious problem. Chickpea stunt breeding materials are now available in stunt nurseries

Fusarium wilt and Macrophomina root rot resistant materials are also incorporated into international nurseries. Breeding for Heliothis resistance has produced promising lines which are also put into field trials in Northern India, where the ranking remains the same. These are wilt susceptible, but some lines which are resistant to Heliothis and wilt have been sent to national programmes. A total of 6-7,000 lines go out to national programmes each year.

There is no systematic breeding programme for drought tolerance, but it is always looked for in the general breeding programme.

Attempts are being made to adapt the genotype to September sowings for January harvesting.

In all, it is estimated that, on a world scale, some 50% of the research stations in developing countries possess 80% of ICRISAT materials. Much material is also picked up for breeding and selection by industrial countries.

Pigeonpea breeding at ICRISAT is providing many resistant lines selected from adapted landraces. Most of these were late-maturing, but the newer lines are early-maturing, thus showing the useful impact of breeding work. If three crops per year are grown the total yield is greater, even though individual crop yields are less than these from later maturers with fewer crops per year and larger individual crop yields.

In the breeding work, wild species have not yet been used, but general breeding work is concerned with introducing pest and disease resistance into various adapted types. In Africa and the West Indies large green-seeded types are preferred for cattle feed. Large-seeded types are also preferred in East Africa, but these do badly at ICRISAT. Some cyst and root-knot nematode resistance is also available for combating these rather serious pests.

At ICARDA, kabuli chickpea breeding is being undertaken in collaboration with ICRISAT. Several useful high-yielding lines have been produced, which also possess resistance to Ascochyta blight, cold tolerance, large seeds and tall habit; these are less photoperiod-sensitive. They are used in improving the local land races, whilst maintaining good nutritional and cooking quality. Breeding trials in Syria and elsewhere in Mediterranean-climate countries are being conducted with considerable success.

By and large, the breeding impacts for chickpea at ICRISAT and ICARDA, and for pigeonpea at ICRISAT have been very impressive.

vii. National programmes; release of varieties

With chickpea, the ICRISAT line ICCC4 has been released in Gujarat State and has done well in central India. The early variety P1329 has done well in all-India yield trials (the original material coming from Iraq, it is thought), but has not actually been released. Also the kabuli type ICCC32 has been identified for release in central India. ICCC37 is also a very good performer. At present three ICRISAT varieties have been released through the national programme in India and one each is under consideration for Australia, Bangladesh and Ethiopia. Two are at the same stage for Nepal.

Pigeonpea varieties have been released by Indian scientists based on selected ICRISAT landraces, as well as one useful early variety. Some crosses were also sent to Australia where they were selected and released, and then transferred to developing countries such as Indonesia and Thailand. The variety ICPL 92, which was released in Himachal Pradesh is one of the ICRISAT lines, and ICPH 2 is in pre-release far trials. The variety Hunt is released in Australia. Both ICPL 87 and ICPL 270 are recommended for release in India. ICPL 227 has resistance to wilt and ICPL 345 possesses sterility mosaic resistance. The Heliothus tolerant lines ICPL 84060 is of interest, and the Alternaria blight resister, ICPL 365 is promising in Bihar State.

There are a number of useful chickpea lines developed by ICARDA which are in multi-location or on-farm trials by national programmes. ILC 482 is a very high yielder, recently released in Syria as a new cultivar. It is estimated that yields could increase by 100% as a result. Disease-resistant lines considered for release in the following countries are: Morocco (ILC 482, 484, 195), Cyprus (ILC 3279), Jordan (ILC 484, 202), Lebanon (ILC 482), Egypt (ILC 195, 482, 484), Oman (ILC 3279, FLIP 80-5), Spain (ILC 72,200), Turkey (ILC 482), Syria (ILC 620, 629 and several others). These were all selected directly from ICARDA germplasm without hybridization. The line ILC 3279 is tall, easily mechanically harvested, with good cold tolerance and resistance to five of the six known races of Ascochyta blight. This was selected from a land race in Uzbekistan.

Impacts for varietal releases at both ICRISAT and ICARDA are very high and most praiseworthy.

viii. Well-being and economic advancement

As usual, it has proved very difficult to obtain figures here but the record number of releases mentioned in section (vii) provides a clear indication of the value of genetic resources of chickpea and pigeonpea to those developing countries that grow them. The estimation that chickpea yields could increase by 100% in Syria as a result of the introduction of ILC 482 is very satisfactory evidence.

It seems clear that impacts are very high for both these crops.

ix. Training

At ICRISAT several trainees per year have been involved in evaluating and characterization, as has also been the case with ICARDA. Courses specifically arranged for genetic resources trainees have been arranged at ICARDA recently, in collaboration with IBPGR.

Apart from the ICARDA courses specifically referred to, which should provide good impacts, it is hard to assess the impacts from general training as applied to genetic resources. Training in this specific area would be valuable at ICRISAT.

x. Data bases

These have already been mentioned in general for crops dealt with earlier in this report. Evaluation data for kabuli chickpea were published in a useful catalogue (Singh et al., 1983). This contains passport data for 33000 accessions as well as details of evaluation methods. Good impacts result from this, and it is to be hoped that other crop catalogues will follow on quickly.

xi. Research

Little has been done with chickpea and pigeonpea in relation to wild species hybridization and introgression with the cultigens. There are evident problems of wild species seed production at ICRISAT, ICARDA and elsewhere (Van der Maesen and Pundir, 1984), and more research on gene transfer from wild to cultivated species is urgently needed.

xii. Conclusions

ICRISAT and ICARDA possess broad genetic bases for the cultivated chickpea and pigeon pea; the material is well conserved, evaluated and used in breeding, with a good flow of material into national programmes and release of new varieties. All this work provides excellent impacts and is well worth the money invested. Spin-off into industrial countries such as Australia and the USA is also evident.

Surveys of chickpea and pigeonpea are good, and there is a useful literature on the subject. More collecting of the cultigens is needed in certain areas, and the wild species are not properly explored, researched or utilized. This is a pity, since breeders may well need wild germplasm in the near future, judging by experience with other crops. However, apart from this and one or two other minor criticisms, the impacts from chickpea and pigeonpea germplasm work are of a satisfactorily high quality, and breeders have made commendable use of the large germplasm collections at their disposal.

11. Groundnuts: ICRISAT, IITA

The major part of this section deals with the common groundnut, *Arachis hypogaea*, which is an ICRISAT mandate crop. The other two groundnuts, *Vigna (Voandzeia) subterranea* (Bambarra groundnut) and *Kerstingiella geocarpa* (Kersting's groundnut) are grown to a limited extent in Africa and have been collected by IITA, even though they are not mandate crops. They will therefore be mentioned only in passing.

i. Surveys

Arachis is native to South America, where all the related wild species in the genus are to be found. There have been many surveys of both cultivated and wild materials, chiefly by Gregory (see Gregory and Gregory 1976), Krapovickas (1969) and Simpson (1980, 1982a, 1982b, 1984, etc.). V.R. Rao (1980) has dealt with the materials now stored at ICRISAT. IBPGR has funded the entire collection activity in Latin America since 1976. Although the cultigen is fairly well-explored there are many areas that need attention, whilst collection trips into the hinterland of Brazil and adjacent regions (Valls 1983), as well as to Asian and African countries, are still needed. More collections of the African groundnuts are needed (Ng 1982 and unpublished) also.

Impacts here are commendably high.

ii. Exploration

Much work has been carried out already, particularly for the wild species, in South America (see above, Surveys), but more collecting is needed in Brazil, Ecuador, Venezuela, Peru, Uruguay and Paraguay. An ICRISAT scientist normally takes part in such trips. IITA has helped collect *Arachis* for ICRISAT, particularly in West Africa. According to ICRISAT scientists more collections are needed from Egypt, Sudan, Ghana, Chad, Mali, Niger, Ivory Coast, Madagascar, Malawi, Zambia, Ethiopia, Burma, Thailand, Indonesia, India and China. Even so, impacts here are good.

iii. Conservation

ICRISAT stores 11,448 accessions of cultivated material from eighty-four countries; this is considered to be incomplete but a good representation of the total genetic diversity. Much has come from other gene banks and collections, and the rest from collecting missions. The gene bank stores 19 wild species (plus five unidentified ones), the total accessions being 206. Although this number seems low, it must be remembered that many other collections of wild germplasm exist, particularly the Stephenville one in the U.S.A. (Simpson 1984).

At IITA there are 1,100 accessions of Bambarra groundnut, of which a duplicate set will be sent for safekeeping to Braunmschweig, West Germany. Only forty-seven accessions of Kersing's groundnut are held. Large collections of Bambarra groundnuts have been sent to Burkina Faso, Zambia and Japan for testing and breeding. Worldwide interest is now growing in this crop.

Samples of Arachis distributed from the ICRISAT genebank to breeders and others, up to the end of 1984, are as follows:

To ICRISAT breeders	To India	Abroad*	Total
32,482	12,930	8,147	53,559

*To 62 countries

The Conservation impacts of ICRISAT for groundnut are satisfactorily high.

iv. Evaluation

At IITA a grant has been received from GTZ (West Germany) to regenerate and characterize the Bambarra groundnut collection.

The evaluation work undertaken on groundnuts at ICRISAT has been developed to a very high level, and in this report it is possible only to touch on some of the highlights.

Groundnut descriptors were developed in 1981, in collaboration with IBPGR (IBPGR/ICRISAT 1981c), and include passport, morpho-agronomic, disease, pest and stress descriptors. Some 9,000 accessions have been characterized. The rest can best be summarized in a table reproduced from an ICRISAT project report (see Table 1).

Apart from this table there are data on pod rot resistance, testa resistance to Aspergillus and the production of aflatoxins, rosette virus

Table 1: Groundnut Germplasm Evaluation/Screening Results

	Screening for	Number of Accessions	Number of promising accessions	Identified by
I.	Disease Resistance			
	Late leafspot (Cercospora)	9400	127	Groundnut Pathology
	Rust (Puccinia)	10000	97	Groundnut Pathology
	Late leafspot + rust	9400	86	Groundnut Pathology
	Bud necrosis	7400	21	Groundnut Pathology
	Peanut mottle virus	1800	5	Groundnut Pathology
	Peanut clump virus	2650	3	Groundnut Pathology
	Yellow mold	1850	8	Groundnut Pathology
	Pod rot	3222	24	Groundnut Pathology
II.	Insect Resistance			
	Thrips	3400	17	Groundnut Entomology
	Jassids	3100	17	Groundnut Entomology
	Termites	526	9	Groundnut Entomology
	Multiple resistance	3400	7	Groundnut Entomology
	Aphids	300	2	Groundnut Entomology
	Leaf miner	930	15	Groundnut Entomology
	Spodoptera	120	4	Groundnut Entomology
	Heliothis	145	3	Groundnut Entomology
III.	Drought Tolerance	378	12	Groundnut Physiology
IV.	Biological Nitrogen Fixation	342	6	Groundnut Microbiology
V.	Oil Content	319	1	Biochemistry

resistance (in land races from Burkina Faso) and some other promising results. Useful resistances have also been found in wild species (see V.R. Rao, 1980).

For evaluation in general, therefore, the impacts are very high.

v. Germplasm enhancement

Most useful genes are found in the cultivated groundnut. Others are found in wild species of *Arachis* and in other wild species. There are difficulties in obtaining germplasm transfer from wild to cultivated materials. These will be dealt with later in the section on research.

vi. Breeding; trials

Breeding is carried out not only at ICRISAT headquarters but also at the Regional Groundnut Improvement Program for Southern Africa at Lilongwe, Malawi, established in 1982.

Breeding is being undertaken to combine disease and pest resistance, etc. with high yield and good adaptation to local conditions. Breeding lines showing promise are released to national programmes. Thus, fourteen rust-resistant breeding lines were jointly released by ICRISAT and USDA (Hammons 1982). *Aspergillus flavus* resistant lines are bred with high-yielding varieties. The line Robut 33-1 has been bred for lower field incidence to bud necrosis, and NCAC 343 with good resistance to thrips, jassids and termites. Multiple insect resistance breeding is also under way as well as drought resistance breeding.

The results of all this work are promising and of very positive impact.

vii. Release of varieties

In India new high-yielding lines are in mini-kit (on-farm) trials. One is to be released and eight more are in national evaluation trials. Indian breeders have developed lines based on ICRISAT materials suitable for their own conditions. The line IGSC1 developed for drought resistance was in mini-kit trials in 1983. Late leaf spot and rust-resistant lines provided by ICRISAT have aided greatly the Indian national groundnut research programme.

It would seem from the various reports issued by ICRISAT (see also TAC, 1984) that no actual release of groundnut varieties has yet been accomplished.

Thus the impacts here are certainly very good potentially, but not in actuality.

viii. Well-being and economic advancement

See last paragraph of section vii.

ix. Training

IITA's training record has already been mentioned (see under cassava). ICRISAT has trained 150 people during the last six years in various aspects of genebank management, evaluation and breeding. Some impacts here.

x. Data bases

Good data bases are being developed, though answers to requests are slow. Some inventories are being produced. Impacts here are potential rather than actual, but since the breeders are responsible for evaluation, the data are no doubt available to them.

xi. Research

A sizeable programme of research is under way to explore the methods by which germplasm from the wild species can be transferred to the cultigen. For this, a basic knowledge of the genome constitution is needed. Since the wild species are diploid, whilst the cultivated is tetraploid, it was hoped to make triploid hybrids, extract hexaploids from them and then backcross to the tetraploid cultivated parent. Unfortunately an unacceptable range of plant types resulted (Singh and Moss 1984a,b), and it was found better to double the diploid species first, and then cross with the tetraploid. In this way some disease resistance has been transferred. In wider crosses the problem could be that, because of the lack of chromosome pairing between different genomes, it would be impossible to eliminate undesirable characters. A good radiation source is needed but is not yet available.

Growth hormones to help with seed set and tissue culture of young ovules and embryos have also been investigated (Sastri et al. 1981, 1982).

Collaborative research with laboratories in Europe and North America is being developed to help some problems of disease attack and various physiological problems.

This basic and applied research at ICRISAT is good and could well be copied by some of the other centres. However, the impacts seem perhaps to be just around the corner. Even so, this is not a criticism of a programme that is full of interest and with excellent potential.

xii. Conclusions

Impacts are excellent in surveys, exploration, research, conservation, evaluation and breeding. Unfortunately there is little evidence to the writer for this crop on varietal releases and economic development. No information was forthcoming on impacts, actual or potential on countries other than India. There seems to be a situation here where further discussions might be valuable.

12. Vigna and Soya: IITA

IITA is responsible for the storage of a global base collection of cowpea (Vigna unguiculata), as well as for its collection and improvement. It also holds the mandate for the storage and improvement of soybean (Glycine max), (but see IBPGR report mentioned below).

i. Surveys

Cowpea is indigenous to Africa with its centre of diversity in West Africa. Closely related wild species occur in Southeast Africa (Ng and Marechal 1984). A survey conducted last year (IITA 1984) identified gaps in existing collections and recommended that exploration be carried out with the following priorities: first, Sahel countries; second, Angola, Ethiopia, Lesotho, Madagascar, Mozambique, Namibia, Somalia, Sudan and Swaziland. High priority was also accorded to the collection of wild cowpea relatives throughout Africa (see also IBPGR, 1982c).

Soybean was domesticated in Northeast China and there is little diversity in Africa. IITA has not conducted a survey on this crop so far as I am aware. However, IBPGR convened an ad hoc working group on the genetic resources of Glycine at Urbana, Illinois in 1982 (see IBPGR 1983d). Material was stored at six institutes in China, with about 50,000 samples, but clearly many of these were duplicates. Some 6000 samples will be put into long-term storage at Peking. In Japan there are some 3,500 samples at Tsukuba, of which an estimated 670 are duplicates. In the USA some 9,300 samples from Asia, Australia, Africa and the Americas are stored. In the USSR some 3,000 samples of G. max are held, Korea has 2,833 samples which have been scored for twenty-four characters, and AVRDC holds 10,2000 samples. Five hundred collections of the wild perennial species are conserved in Australia, India has 4,000 cultivated samples, and smaller numbers are available in some European countries, Indonesia, Nigeria and Brazil. It was recommended that base collections be designated in China, USA, Australia and Japan, but no mention was made of IITA. Priorities for collecting wild and cultivated species were suggested, in Asia and Australia mainly. Again, Africa was not mentioned.

Impacts are good so far as cowpea surveys are concerned, and for soybean in relation to areas other than Africa.

ii. Exploration

From 1976 to 1980 the IITA genetic resources unit collected cowpea germplasm in eighteen African countries. Plans have been made to explore cowpea and rice germplasm in Central African Republic, Chad, Niger, Guinea, Senegal, Gabon, Congo, Zaire, Ethiopia, Somalia, Mozambique and Zimbabwe in 1985-1987. The Italian government has promised special funding for this work, and collaborative exploration will take place with the Germplasm Institute at

Bari and IBPGR. IITA has also established connections with Asian countries for exploration in 1985-87. Impacts for cultivated cowpea exploration are excellent. They are not very impressive for wild cowpeas or soybean.

Planned soybean exploration is not undertaken by IITA, but materials are collected when they are found during exploration missions. Much exploration takes place in Eastern Asia and Australia (see IBPGR report).

ii. Conservation

A long-term storage facility is now available at IITA with a temperature of -20°C, for cowpea and rice. All other necessary equipment is available.

The cultivated cowpea collection now stands at 11,800 accessions, obtained from thirty different countries. Only 210 accessions of wild Vigna species are stored at present. Some 20% of the collection is under duplicate storage at NSSL, Fort Collins, Colorado, but the whole collection will be deposited in due course.

From 1978-83 10,651 samples of cowpea germplasm were distributed to over fifty different countries, half of these to African ones, and almost as many to Asia. These do not include breeding lines. Over 40,600 samples were issued within IITA itself.

Most soybean germplasm at IITA was obtained from collections made by IITA's soybean scientists at other institutes, and from AVRDC, USDA and the International soybean programme. Some tropical collections were sent from Indonesia. A total of 13559 soybean germplasm accessions are stored. No figures for distribution are available.

Impacts for cultivated cowpea storage and distribution are excellent. The soybean storage impacts are not very good yet,and no distribution figures for wild cowpea and soybean are available; thus impacts cannot be assessed in this respect.

iv. Evaluation

A cowpea descriptor list was published by IBPGR (1983i). It includes descriptors for passport data, morpho-agronomic characters and disease, pest and stress data. The genetic resources unit has characterized about 9,000 accessions for agro-botanical features, and in collaboration with the crop improvement programmes has evaluated materials for disease, pest and stress resistance.

Some 7,000 lines were screened for Striga resistance and one resister was found. Sources of resistance to bruchids (Callosbruchus maculatus), thrips (Megalurothrips sjotedti), aphids (Aphis craccivora), leafhopper (Empoasca), mosaic virus, and cowpea mosaic virus were found. Some useful drought resistance, earliness and better plant type characters were also identified.

A soybean descriptor list was published by IBPGR (1984f). A useful review of the literature on the screening of wild Glycine species was published by Vaughan and Hymowitz (1983). Various species are noted with resistance to rust (Phakopsora), powdery mildew (Microsphaera) and yellow mosaic virus; studies on izoenzyme patterns, trypsin inhibitors, seed oil content, fatty acid composition and other characters are also referred to. This work does not appear to be linked with that of IITA.

At IITA, screening for good seed storability and "seed weathering" is in progress. The latter term refers to seed deterioration prior to harvest when warm humid conditions prevail during the time of maturation. Screening for "seed weathering" resistance has revealed twelve accessions with consistently high resistance levels (TGM 1171, 46, 106, 112, 693, 685, 737P, 737w, 618, 94, 730 and 122). General screening for agronomic characters is also under way, and lines with good seed storability have been found in Indonesian germplasm. Good root-nodulating lines have also been identified, and because of their tendency to associate indiscriminantly with local rhizobia races, have been called "promiscuous" nodulators. Under trials with various soil types, certain lines were identified with high yield and good yield stability under varying conditions.

On the whole, the screening programmes have been very satisfactory for both crops, and in this respect have shown high impact. Little or nothing has been done with related wild species.

v. Germplasm enhancement

It is stated by Ng (draft report, 1984), that cowpea pre-breeding will be carried out in the future by combining useful resistance and tolerance characters with high yielding features. In fact it seems from the IITA that this work is already in progress.

No soybean pre-breeding, in the usual sense, has yet taken place at IITA. Vaughan and Hymowitz (1983) report on considerable success attained in crossing wild perennial Glycine species with the cultigen. If not already contemplated, IITA would do well to link itself closely with these studies. Impacts on germplasm enhancement at IITA must be considered as very low at present.

vi. Breeding; trials

Cowpea breeding research at IITA began in 1970, and already many advanced breeding lines of superior yield, plant type, earliness and resistance to pests and diseases are in the pipeline. IITA breeders send advanced breeding lines and families to over 200 cooperators in more than fifty countries. Since conditions vary from the dry Sahel zone on the one hand to the humid tropics on the other, the range of adaptation must be very wide, and this range has indeed been accomplished by IITA breeders.

Singh (1984) mentions useful sources of resistance to anthracnose, Cerospora, bacterial pustule, yellow mosaic virus, aphid-borne mosaic, Septoria and brown blotch diseases. Eight high-yielding advanced lines with multiple resistances to these pathogens have been produced. Similarly sources of resistance to the insect pests, leafhopper, aphids, thrips, pod borer and bruchids, have been identified, and five improved multiple insect-resistant lines have been developed.

Promising early maturing liens (17 82E-18, IT 82E-60 and IT 82E-77) have been developed, and their erect plant height and upright podding facilitate mechanical harvesting. The fact that the pods are held above the plant canopy on long peduncles has the added benefit that infection with pod borer is prevented, since this takes place when the pods in shorter varieties touch the ground. These early maturing lines are also particularly valuable in the savanna areas with very short rainy periods or for growing with residual moisture, following paddy.

The development of bush-type vegetable cowpea lines obviates the need for a supporting trellis, which is usually needed for the normally climbing vegetable cowpea group. Promising lines here are IT 81D-1228-13 and IT 81D 1228-14.

Soybean breeding objectives at IITA focus on increased seed longevity, natural nodulation and high yields (see discussion under (v) - Evaluation). A local African cultivar "Malayan", collected in Nigeria but possibly originally from Malaysia, is a useful breeding parent. It nodulates well and the seed longevity is good. Since it is a poor yielder it has been crossed with lines having good yield, and progenies with the desired characters have been selected.

Several useful superior lines are now in the pipeline and will be released shortly.

The general conclusions to be drawn from IITA cowpea and soybean breeding work is that it is going ahead rapidly on a broad front and that the impacts are very satisfactory indeed.

vii. Release of varieties and national programmes

Several varieties were previously selected from the cowpea germplasm accessions and released to farmers in various countries as VITA 1,3,4 and TVu 1502. Singh (1984) reports, furthermore, that twenty-one other improved varieties have already been released to farmers by national agricultural workers or scientists in many parts of the world. Several cowpea varieties, ranging from early (less than 60 days) to medium (75-80 days) maturity, with superior disease resistance and good seed quality have been developed, tested internationally, and released by national programmes. Thus, some thirty-two cowpea lines developed by IITA have been released in about thirty-one countries.

To take some concrete examples, the extra-early maturing of "Ezorowo", named in Nigeria for the IITA lines TVx 3236 is generally released and especially useful for paddy fallow and mixed cropping. Its yield is far superior to that of traditional varieties.

The variety Manaus, released in Brazil from IITA 4R-0267-01F, completely resolved cowpea shortage in Amazonas State from 1981 onwards. In 1982 two more IITA Lines VITA-6 and VITA-3 were released in Brazil as MEAPA 821 and 822. These all doubled the traditional yields. Four additional varieties were released in Venezuela, Nicaragua and Guatemala in 1982; these had good leafhopper and drought resistance. In summary, Singh (1984 table 6) lists fourty-three varieties released or multiplied in sixteen African, eight South and Central American and seven Asian countries.

This success rate of cowpea is excellent, and provides extremely high impacts.

The impacts in soybean work are not as yet so spectacular, probably because of the shorter time in which breeding has been in progress. Nevertheless, large numbers of lines are currently being multiplied in Nigeria by national or regional programmes and similarly large numbers are featured in international nurseries in Africa, Asia and Latin America. Thus, impacts are beginning to be felt and will no doubt be greater in the near future.

viii. Well-being and economic advancement

No figures are at present available but prospects seem most promising.

ix. Training

This has already been discussed in section (7.), Cassava.

x. Data bases

Some 9,000 cowpea lines are documented and the data put into the computer. Soybean characterization will be undertaken shortly. There is no information on whether "in-depth" evaluation data are also in computer storage and no inventories have been prepared.

This work seems to have lagged behind, undoubtedly through shortage of staff at IITA with time available to carry out these tasks.

Impacts here are low at present.

xi. Research

Germplasm research at IITA on cowpea and soybean would appear to be entirely lacking, no doubt, again, through lack of staff. Research outside IITA on wild species has already been mentioned (Vaughan and Hymowitz 1983).

Impacts here are lacking at IITA.

xii. Conclusions

Impacts for cowpea are high for surveys, exploration, conservation, evaluation, breeding and varietal release; they are not so impressive for wild species, enhancement data bases and research.

Impacts at IITA for soybean surveys, exploration and conservation are low, for evaluation and breeding quite high, and for releases potentially high. For data bases, enhancement and research, they are low to zero rating. Whilst accepting that soybean is a comparatively new crop for Africa and that its centre of diversity is far away in Eastern Asia, one cannot help feeling that it is treated at IITA somewhat like a poor relation. Some positive thinking and decision-making is needed if soybean impacts are to be raised in the future. More coordination with China, Japan, Korea, etc. might be valuable here.

13. Forage grasses and legumes: ICARDA, CIAT, ILCA

The mandate for exploration and conservation of temperate to warm temperate forages from the drier regions of North Africa and the Middle East has been accepted by ICARDA.

CIAT has accepted responsibility for tropical forage germplasm, with special emphasis on Latin America.

ILCA is responsible for graze and browse forages (chiefly legumes) from Africa and especially the Trifolium species from the African highlands.

Some amount of overlap might be presupposed but cooperation and exchange of information between centres prevents any excessive duplication of effort.

IBPGR's input into forage collecting and the designation of base collections is of considerable importance.

i. Surveys

Most of ICARDA's efforts are directed towards Medicago and Trifolium. Limited attention is given to grasses such as Avena, Dactylis, Festuca and Lolium, whilst the collection of Vicia and Lathyrus has been more or less incidental. Toll (undated) mentions that good collections have been made by Australian missions. However, there is a general lack of information on species distribution. An IBPGR intern, recently appointed, is carrying out an eco-geographical survey of annual legumes at 95 sites and has already identified seventy-five species, with another fifteen or so far unidentified. Impacts here are poor, and much more effort is needed to survey materials in the field and already existing in collection.

CIAT has made some attempts at surveys, but because the whole problem of tropical forages is so open-ended in terms of species, genera and countries to be included in its remit, CIAT can well be forgiven for not producing any more definitive schemes. Much useful information is contained in the work edited by Mott and Jimenez (1979), which will be referred to later, from time to time. In general, there are twenty-four grass genera of interest, and of these, eight are are considered to be of greatest importance (Andropogon, Hyparrhenia, Panicum, Setaria, Paspalum, Brachiaria, Hermarhria and Melinus; twenty-five legume genera are listed in the programme, of which five are rated of highest importance (Stylosanthes, Zornia, Centrosema, Pueraria and Desmodium). A further fifty-one genera of legumes are also listed. (Schultze-Kraft, personal communication). Neglected areas of Latin America where much more collecting is needed are the Brazilian Matto Grosso, parts of Argentina, Paraguay, Bolivia, Peru, Ecuador, Mexico, the Caribbean and much of Africa and Asia. This seems far too ambitious, and a more feasible collecting plan is needed, with funding and collaboration from different organizations linked into it. Particularly in Africa and Asia, other organizations could collaborate, as ILCA is already doing. Impacts here are beginning to show, but far more should be given to this aspect of forage genetic resources work.

ILCA commenced its forage program in 1980, so has not been able to progress too far. Very detailed collection plans have been worked out, concentrating on the indigenous Trifolium species of the East African highlands. A useful plan is to take data from dried specimens of the relevant genera in the major African herbaria, and others, related to their distribution, ecology and pathology. These would be entered into computer store and used to plan future collecting activities. Later, computer-generated maps of distribution in relation to environmental data would be produced. These are valuable potential impacts for the future.

ii. Exploration

ICARDA received 9,476 samples in the 1979-84 period from thirty-five countries, including some from existing collections (Holland - 3,731, United States - 1,320, United Kingdom -1,078) and others received through national programmes and by various collectors (Mexico -359, Morocco - 312, Syria - 947, Lebanon - 220, Ethiopia - 110, etc.). (See also Gintzburger et al. 1983). In 1984 ICARDA collections were made in Syria (1,254), Cyprus (123) and in Morocco. The Moroccan forage germplasm was collected at ninety-four sites in areas ranging from 200 to 650 mm rainfall and should therefore contain a very wide range of adaptation. Some 390 populations were sampled.

IBPGR believes that much more material needs to be collected and ICARDA is also interested in Pisum as a forage crop.

Impacts at ICARDA are reasonably good, but could be better organized if an adequate survey were available.

CIAT has made extensive collections in Latin America since 1979, particularly of legumes. The collecting trips outside Colombia are generally made in collaboration with national institutes. The Latin American grasses are not so useful as those of Africa, and even Asia, so collections are received through exchange to some extent. The CIAT team is also collecting in Africa. Neglected areas have already been mentioned under Surveys. Much thought has been given to correct methods of collecting (see Mott and Hutton 1979; Leon et al. 1979; Reid 1982; Schultze-Kraft 1979; Schultze-Kraft and Alvarez 1984; Schultze-Kraft et al. 1984). On the whole, the impacts are good, particularly since collections are made systematically, country by country, from year to year. However, the rate is too slow, and more staff are needed.

ILCA has worked out detailed collection methods (Lazier undated; Reid and Lazier 1979) for African forages. Work started in 1980 in the highlands of Ethiopia, concentrating on native *Trifolium* species. In 1982 this extended to the lowlands of Ethiopia, including such legume genera as *Alsicarpus*, *Desmodium*, *Dolichos*, *Lablab*, *Neonotonia*, *Stylosanthes*, *Vigna* and *Zornia*, of potential forage importance. In 1984 collecting missions extended to Kenya (in collaboration with CIAT) and Niger (with IBPGR support). In 1985 collecting activities will be extended to Rwanda, Burundi, Zimbabwe and Tanzania (also with CIAT). In future years it is hoped to sample in West and Southern Africa also. For the Ethiopian *Trifolium* collecting and the Kenya trip IBPGR funding has been allocated.

Attention has also been turned to the browse species in the genera *Erythrina* and *Aeschynomene*, as worthy of investigation.

With each collection comprehensive ecological data are obtained, so that the materials can later be matched with user's requirements.

Impacts from ILCA exploration work are very good, and hold good future promise.

iii. Conservation

ICARDA's collection is 90% legumes and consists of some 16,800 samples. Of these, there are 3,149 *Medicago* samples, 2,732 forage *Vicias*, 3,221 *Pisum* and some 3,000 forage cereals. There are only 622 grasses, however. There are thirty species of annual *Medicago* in the collection, but of six species there are very low numbers. High number of *M. aculeata*, *M.lacinata*, *M. orbicularis*, *M. polymorpha*, *M. rigidula*, *M. tornata* and *M. truncatula* have been assembled. Storage conditions were discussed in earlier sections.

There is a good range of collections, but more exploration work should add greater numbers of *Trifolium* and other genera to the germplasm bank.

From 1979 to 1984 3,636 samples were distributed, mostly to developing countries (3,024 samples), with and only 612 to industrial countries. A total of thirty-three countries have received germplasm, very large numbers going to Ethiopia (1,159), and a fewer to Tunisia (593), Morocco (288), Jordan (239) etc.

Impacts for conservation and distribution of materials are most satisfactory (given the fact that the long-term storage facility is not yet operative).

CIAT has no formal mandate to conserve forage germplasm but clearly should and does deposit materials in the genebank. The important grass and legume genera which it conserves have been mentioned under Surveys. The collection amounts to more than 13,000 accessions, of which 11,900 are legume and 1,140 grasses. Over 90% are non-domesticated.

The whole collection is under short to medium-term storage at 5 to 8°C and 60% relative humidity. This is clearly not at all satisfactory. There is no designated genebank for duplicate samples and this is needed, just as the CIAT mandate needs clarification.

Distribution of samples in the period 1980-84 was good, with 7,318 samples going to national programmes in Latin America, Africa, Asia and Oceania - nearly all "raw germplasm". Over 6,3000 samples were passed to the CIAT tropical pastures programme evaluators and breeders (see Luse 1979a,b).

ILCA, also, lacks suitable storage facilities, with materials currently stored on open shelves at about 20°C and 50% relative humidity. This has resulted in much loss of viability. Some deep-freeze -20°C facilities are available, but only 408 samples have yet been stored in this way. IBPGR will provide better facilities later, and the Italian government has also shown interest.

Present holdings from all sources are as follows: African tropical legumes 1,278; non-African tropical legumes 2,043; African tropical grasses eighty-six; non-African tropical grasses seventy-seven; browse and cereal materials also available. Total holdings are 5,231 samples.

The requests for material come in at about 80 to 100 per year, and these numbers will be increased when a catalog becomes available.

Apart from the small amount of proper storage facilities, the ILCA conservation impacts are promising.

iv. Evaluation

Most of the ICARDA evaluation work is carried out at the headquarters field at Tel Hadya. Seven hundred medic collections have been characterized, using 18 morpho-agronomic descriptors, but no others seem to have been so evaluated. In collaboration with the crop sections, more than 1,800 genotypes of vetches, peas and medics have been screened for disease resistance and for producing self-generating pastures. M. rigidula is most promising from this latter point of view. Also, at all sites in Syria M. rigidula produces more herbage and seed than the commercial medic cultivars originating in Australia; it also has a certain proportion of impermeable seeds during the first season, thus retaining a capacity to germinate after more than one year. The disease resistance screening was done not only at Tel Hadya but at disease "hot spots" on the Syrian coast.

This evaluation work is promising and shows satisfactory impacts of "in depth" evaluation, though the progress in characterization seems rather slow.

Evaluation at CIAT is moving ahead rapidly. Some 95% of accessions possess passport data (see data bases section). Initial evaluation has been carried out on growth, flowering and seed production for 80% of the legume and 86% of the grass materials. The screening process undertaken by the forage improvement section is divided into five stages, lines which are successful in a lower one passing into the next higher. Stage I screening is carried out at Palmira (CIAT) and Quilichao for individual plants. Category II takes place at Carmagua (Eastern plains, or llanos) and Brasilia (campo cerrado). At this stage 10-25 plants are scored for agronomic characters. Category III subjects promising lines to heavy or intermittent grazing. Category IV assesses yields, grazing preferences, nutritive value, etc. Category V is the final stage, growing under commercial conditions. Some 78 regional trials took place in 1983.

A range of nine promising "key" legume species was identified - three of Stylosanthes, three of Centrosema, Damodium ovalifolium, Pueraria phaseoloides and Zornia sp. (CIAT 7847). The two grasses Andrpogon gayanus and Brachiaria spp were also included. This does not include any of the traditional agronomically well-known species and is considered to be a step forward with much potential impact.

Screening trials of disease and pest resistant lines have been conducted. Thus spittlebug resistance trials have been conducted in 15 locations in seven different Latin American countries, and three species appear to offer some tolerance. Stylosanthes macroephala lines have shown anthracnose resistance across ecosystems, whilst S. guianesis shows excellent results in forest ecosystems. (Explanations are discussed for this - CIAT 1984, p.32). Among grasses, Andropogon gayanus and Brachiaria decumbens were found to be broadly adapted to both plains (llanos) and forest ecosystems (Kretschmer 1979).

All this work of CIAT Is innovative and of great importance, with very high impacts.

At ILCA, the initial characterization sites were chosen in the Ethiopian highlands and the lowlands (rift valley). The data will be completed in 1985-87 and the agronomic data will be computerized. At present, some 10-15%

of all lines are evaluated, which consists of noting data on morphology, flowering, seed set, seedling regeneration, disease and insect attack, and competitive ability. National programmes are encouraged to cooperate, and ILCA participates in a newly formed pasture and legume network for East and Southern Africa. Trifolium species yields in Ethiopia have been evaluated by Kahurananga and Tsehay (1984). Twenty-two accessions were used and showed considerable promise for this character as well as good genetic diversity, responsiveness to phosphorus application and rhizobium requirements. Priority taxa for breeding have been identified; this includes twenty-three legumes and eight grasses for Africa and for more genera from outside Africa.

ILCA's evaluation trials and progressing well, even though the programme is a comparatively young one. The impacts are small at present but of good promise.

v. Enhancement

None, so far.

vi. Breeding; trials

It will be understood that with forages in general the plan is to find satisfactory lines or eco-types amongst collected materials without undertaking any breeding as such (but see CIAT report below). Thus, what is included for these plants under "evaluation" would for domesticated materials be to a large extent included under "breeding and trials".

So far as the present writer is aware, no actual breeding work on forage legumes and grasses is being undertaken at ICARDA or ILCA.

At CIAT, however, an active breeding programme is underway. The most important part seems to be the breeding for anthracnose resistance in Stylosanthese guianensis, combining the anthracnose resistance and high yield traits which occur separately in "tardio" and "common" types. A continuing flow of breeding material is assured by an active crossing programme. The previous breeding projects with Centrosema, Leucaena and S. capitata have been terminated but several advanced breeding lines are still in the regional trials.

Spittlebug resistance breeding focuses on the selection of suitable lines from 70 Brachiaria species tested in fifteen locations in seven different countries, from which breeding work will be undertaken.

The impacts from the CIAT forage breeding programme have not yet developed, but there is certainly much potential here.

vii. Releases; national programmes

At ICARDA highly productive pasture lines are being developed directly from the GRU accessions of indigenous annual Medicago species. Accessions 79, 7 and 3 are particularly promising. Forage barley and triticale lines that can be grazed early in the season are IFB 250, 249, 264, 251 and 248) (see ICARDA 1983). Impacts are slow but of considerable future potential.

The release of lines at CIAT is going ahead satisfactorily. Selections of the African grass, Andropogon gayanus, released by ICA in Colombia under the name "Carimagua I" and by EMBRAPA, Brazil as "Planaltina" show excellent adaptation to low-fertility acid soils with high aluminum content, as well as tolerance to pests and diseases, high drought and fire tolerance, high productivity etc.

CIAT 621 was released in Peru in 1982 as "San Martin", in Venezuela in 1983 as "Sabanereo', and in Central America as "Veranero;" this is another selection of Andropogon gayanus, and has a good dry season performance, good growth on very poor soils and spittlebug resistance. In Colombia Carimagua I has now spread widely, even out of the area for which it was originally developed. In the Cerados of Brazil it does better than Brachiaria decumbens because of its spittlebug resistance.

Stylosanthese capitata, CIAT 10280, has also done well. A blend of five entities collected in Brazil between 1975 and 1977 has been released in Colombia as "Capica" - a legume adapted to the well-drained acid Eastern savannas.

S. guianensia "tardio" type CIAT 2243 from the central Cerrados, has been shown to be quite anthracnose resistant, tolerant to drought and producing a large amount of dry matter. This is being released by EMBRAPA/CPAC under the name "Bandeirante".

S. macrocephala CIAT 1281 with similar useful characteristics is also being released shortly in Brazil.

S. guianensis CIAT 136 will be released in the near future for the Peruvian Amazon region.

Thus the CIAT impacts for many areas of Latin America for new releases are extremely good.

The ILCA programmes are not sufficiently advanced yet for varietal releases to have been accomplished.

viii. Well-being and economic advancement

From the data given above on CIAT releases it would seem reasonably certain that considerable impacts are now being made in beef production, which is thus having a beneficial effect on the economies of the countries concerned. Live-weight animal gains with grazing evaluation tests showed more than 2-fold gains per animal and 15-fold gains per hectare are achieved in the best-managed savanna areas (CIAT 1984). Unfortunately, no statistics on economic progress are available.

ix. Training

Various genetic resources training workshops have been mentioned previously for ICARDA and CIAT. Interns are also being trained at ICARDA and CIAT, whilst ILCA is planning to train an intern in 1985. Training impacts are satisfactory.

x. Data bases

ICARDA has entered passport information from 1,600 Medicago lines into its data base as well as evaluation data. A Medicago catalogue is due to appear shortly.

A CIAT catalog of over 10,500 entries was printed two years ago (Schultze-Kraft et al. 1983). The data are arranged by family, genus and species, and include information on source or collector, date and approximate locality. Unfortunately, no collector's numbers are given. A key list in order of accession numbers is also included. Morpho-agronomic characterization data are fully computerized and the system is explained by Song and Rawal (1979). Appendices to Mott and Jimenez (1979) list the descriptors used.

A comprehensive data base with 120 descriptors has been developed on the ILCA HP 3000 computer. A first edition of the catalog is in preparation and will include detailed collection and ecological data. All seed inventories will be computerized by mid-1985. Meanwhile, printouts are available.

Impacts for all three programmes are reasonably good or will be when the ICARDA and ILCA catalogs are available. Printouts and/or catalogs of useful disease and pest resisters, as well as stress tolerators, are also needed.

xi. Research

Minimal growth techniques have been devised for the micro-propagation of Andropogon, Pennistum and Brachiaria germplasm at CIAT. Anther cultures are being used to produced homozygous diploid lines. Research on the reproductive biology of Stylosanthese guianensis is being undertaken, so as to clarify breeding objectives. Impacts here are promising.

No genetic resources research programmes have been identified at ICARDA or ILCA.

xii. Conclusions

The exploration and collection of tropical pasture species progresses far too slowly, and since CIAT estimates that ten years will be needed, it would be prudent to speed it up by the allocation of more staff and resources. The same would apply to ILCA, and to a lesser degree ICARDA, whose remit is somewhat more limited.

CIAT's programmes of evaluation, breeding and varietal releases have progressed much further than those of ICARDA and ILCA, which have had much less time available in which to accomplish them. However, it seems very likely that useful impacts are in the pipeline. Little breeding work has so far been accomplished, but this will undoubtedly be needed in the future.

On the whole, given the open-ended aspects of forage work, the impacts are remarkably good but might be further improved if more staff were made available. The lack of good storage facilities is unfortunate.

14. The International Board for Plant Genetic Resources: IBPGR

The work of IBPGR must be considered in a different way from that of other centres. For the latter it has been possible to describe their genetic resources work on a crop basis (see section 1 to 13), but for IBPGR the only possible way is to divide it on a discipline basis. A quote from its mandate makes this clear: "The basic function of the IBPGR is to promote and coordinate an international network of genetic resources centres, to further the collection, conservation, documentation, evaluation and use of plant germplasm and thereby contribute to raising the standard of living and welfare of people throughout the world". In fact, its mandate related particularly to the developing world, since it comes under the aegis of the Consultative Group on International Agricultural Research (CGIAR) whose purpose is: "to bring the resources of modern biological and socio-economic research to bear on the long-neglected possibilities of agricultural progress in the tropics and subtropics, where nearly all the less-developed countries lie" (CGIAR, 1980).

It will be convenient to divide IBPGR's work into three heads, as follows:

(a) Promotion and diffusion of genetic resources information.
(b) Theoretical and practical support under the sub-headings previously used in this report, namely: (i) surveys, (ii) exploration, (iii) conservation, (iv) characterization and preliminary evaluation, (ix) training, (x) data bases, including documentation and (xi) research funding.
(c) The promotion and coordination of national programmes and committees and an international network of genetic resources centres.

It will be noted that IBPGR is not mandated to cover "full evaluation", under section (iv), nor does it concenrn itself with (v) germplasm enhancement, (vi) breeding and trials, or (vii) release of varieties. Its concern with (viii) "well-being and economic advancement", is a real one, even though its mandate does not imply the type of impact that we have been examining for the crops in previous sections. These comments are not intended as criticisms. It would be very unwise of IBPGR to try to convert itself into a crop-breeding organization, even though in its mandate it does in fact mention the "use of plant germplasm...". In this respect, it is no doubt assumed that national programmes will utilize the germplasm assembled with the help of IBPGR - an assumption that we shall examine later, under the final section.

(a) Promotion and diffusion of genetic resources information. One of the best methods used by IBPGR to keep the scientific community informed about genetic resources work is the Genetic Resources newsletter, published quarterly. This was started by FAO as the Plant Introduction Newsletter (1957-1970; Nos. 1-024) and continued by them under the present title (1971-1976; Nos. 25-32). It appeared at irregular intervals until IBPGR took it over in 1978. The news and views, especially about collecting trips and new developments in the work of IBPGR, are most valuable; germplasm information is also published that has no direct connection with IBPGR, but which is of considerable value.

Other useful publications have been the Bibliographies of Plant Genetic Resources Literature (Hawkes et al., 1976, 1983; Williams, 1976) and the English/Arabic glossary of plant genetic resources terms (Ayad, 1980). Glossaries of terms in Chinese and perhaps some other languages would also be useful. In all these publications, including the Newsletter, IBPGR's impacts have been most valuable.

IBPGR has continued FAO's promotional work in the organization of international technical conferences at FAO headquarters. The FAO conferences took place in 1961, 1967 and 1973, and these were followed by a joint FAO/UNEP/IBPGR conference in 1981. The last three of these conferences helped to develop the theoretical and practical basis of genetic resources work, and books based on them have been published. Impacts here are of very high quality.

Another very useful project that has helped to spread information about genetic resources has been the production of a slide pack and booklet (IBPGR, 1983f) with text available in twelve languages. This replaced an earlier FAO slide pack. It is to be hoped that IBPGR will also produce a film or video of its crop genetic resources work.

Finally, IBPGR has published a series of promotional booklets emphasizing the value of its work on a global basis in the exploration of conservation of plant germplasm. These are mostly not dated, unfortunately, but the titles speak for themselves: Facts about the IBPGR (also in French and Spanish); The Conservation of Crop Genetic Resources; Los Recursos Fitogeneticos

(Esquinas-Acazar, 1981, 1983); Crop Genetic Resources; A Global Network of Genebanks; Priorities Among Crops and Regions (1976, revised 1981 - see also IBPGR 1981 Annual Report). These various publications do not provide sufficiently clear promotional impacts, since they are confusing both in titles and dates. A revised policy is needed here.

All the publications so far mentioned are clearly aimed at the scientific community and possibly to some extent at the general public. Various authors and editors of books and popular scientific journals have from time to time mentioned IBPGR's work but have often got their facts wrong. A serious gap here, with consequent lack of impact, is a policy for really well-written pamphlets, magazine and newspaper articles and books appealing to the general reader, such as appear in great quantities on nature conservation but, it seems, hardly ever on genetic conservation. Thus, IBPGR should promote a greater awareness amongst governments and individuals of the importance of genetic resources. To help in this task, IBPGR could be well-advised to arrange contracts with a number of well-known science writers to promote its image and to inform the public of the vital role of genetic resources in the world today. To sum up, IBPGR's promotional impacts at the scientific level are adequate but could be expanded. Awareness at the governmental and political levels needs to be improved considerably, and in this, IBPGR's impacts are rather low.

(b) Theorectical and practical support

(i) Surveys

We have already mentioned IBPGR's work in the establishment of crop and regional priorities for germplasm exploration and conservation. These normally appear in the IBPGR annual reports but should be more widely diffused so that a greater range of people become aware of them.

Surveys of crop genetic resources carried out by IBPGR have been mentioned in the crop sections. Their purpose is to try and estimate the materials which still need to be collected in the field and those which are already stored in the genebanks. Twenty-eight surveys have been published by IBPGR (see 1983 Annual Report), which do not, of course, cover all crops but are useful contributions to this end. In theory, the centres ought to be responsible for surveys of their mandate crops, but in practice only CIP has done so independently, and IRRI, CIAT and ICARDA cooperatively with IBPGR (but not with all their crops in the last two centres mentioned).

Five crop advisory committees with the CGIAR centres have been established (wheat, rice, maize, sorghum and millets, and Phaseolus). There are also five working groups (cotton, Hevea, cacao, barley, Allium, Prunus).

Although the IBPGR impacts here are satisfactory, more are needed, although the definitive studies of what still should be collected must wait until computer map printouts based on collection passport data can be constructed.

IBPGR will in future be concerned with field surveys based on eco-geographical analysis of vegetation, where possible by aerial photography.

ii. Exploration

The work of IBPGR includes consideration of technique as well as financial assistance to expeditions.

A manual was published on collecting techniques, in collaboration with EUCARPIA (Hawkes, 1980), and also a more recent report on practical constraints in collecting (IBPGR, 1983g). A particularly interesting development in the collection of "difficult" materials, using in vitro techniques for materials such as root and tuber species, bananas, coconut and cocoa, comes from the in vitro committee (IBPGR, 1984c). These publications are the results of discussions of leading scientists in these fields, promoted by IBPGR, and are of considerable impact.

Another important aspect of IBPGR's work has been to promote the adoption of a minimal descriptor list for "passport" (accessions and collection) data. This list appeared in the manual (Hawkes, 1980) but probably needs some updating. The passport data mentioned in the various crop descriptor lists designed by crop committees vary quite considerably and badly need standardization by a suitable committee. Unfortunately, the opportunity was lost when the "practical constraints" (IBPGR, 183g) report was put together. Impacts for this work are good but there is need for improvement, therefore.

IBPGR's work in sponsoring or financially helping collecting missions has been extremely good. In the ten years of its existence it has directly or indirectly organized and funded some 500 missions in eighty-eight countries throughout the world, and particularly in the tropics and subtropics (Lawrence, 1984). As a result, over 100,000 samples have been deposited in genebanks. Thus, IBPGR, more than any other single agency, or group of agencies, has salvaged the major part of the world's crop germplasm - a work of very high impact indeed.

More work is now urgently needed with respect to wild species related to the crops themselves. These are still seriously under-represented in nearly all collections.

By and large, IBPGR has assumed the initiative as well as much of the financial responsibility for collecting the mandate crops of the CGIAR centres. With all its other responsibilities, it might be questioned as to whether IBPGR should assume the additional ones which many would regard as responsibilities of the centres. However, since, with some exceptions, the centres do not seem to budget for exploration work, IBPGR is forced to take this one to its own shoulders and thus allocate funding which perhaps ought to be spent on non-mandate crops. This point is worth discussion but cannot be resolved in the present report.

During the period from 1975 to 1984, inclusive, IBPGR allocated over 5.6 million dollars to exploration missions. Relating this to the information given above on the number of missions fielded and the amount of material collected, the operation has not only been very cost-effective but has been of the greatest possible impact for the salvage of world crop genetic resources.

iii. Conservation

Ex situ conservation of materials in seed and tissue culture banks was under discussion before the establishment of IBPGR, when the general guidelines were laid down at the FAO Technical Conferences of 1967 and 1973. Nevertheless, IBPGR has carried the work forward by means of a advisory committees and conferences.

The problems of seed storage under conditions favorable to long-term conservation and minimal loss of the genetic integrity of the original samples have been addressed. A working group was established in 1976 (IBPGR, 1976b) to report on design and cost aspects of long-term seed storage, and this was followed by the establishment of an advisory committee which first met in 1981 (IBPGR, 1981f) and again in 1984 (IBPGR, 1984b). It also published reports on deep-freeze chests (Ellis and Roberts, 1982) and the design of seed storage facilities (Cromarty et al., 1982). In addition, the proceedings of a conference sponsored by EUCARPIA, IBPGR and UNDP on genebank seed management techniques were published by IBPGR (Dickie et al., 1984). This scientific promotion for the storage of orthodox seeds is excellent and of high impact value.

IBPGR has also turned its attention to recalcitrant seeds; these are seeds that cannot be stored by techniques in which temperatures and humidity are reduced. A literature survey was commissioned on achievements and possible approaches (King and Roberts, 1979), and the proceedings of a workshop, co-sponsored with IUBS and the International Genetic Foundation in 1980, were published two years later (Withers and Williams, 1982. There is no doubt that in the very difficult field of recalcitrant seed storage, IBPGR has done what it could and has arrived at the conclusions with which most scientists would agree, namely, that the solution lies in the field of in vitro storage of meristems rather than in storage of the seeds themselves. The impacts are thus good, in pointing the way towards how the problem might be solved.

Correct methods of orthodox seed regeneration when viability begins to decrease under storage have been discussed in a seminar in which IBPGR took part (Porceddu and Jenkins, 1982), and in several chapters in the book edited by Holden and Williams (1984), based on the 1981 technical conference in Rome. Several papers on this subject have also appeared in the newsletter. Thus, satisfactory impacts on seed regeneration are developing, but more international discussion and decision-making are still needed, especially for cross-pollinated crops. Impacts could thus be improved in this area.

The organization of international efforts in the field of in vitro conservation has followed a similar path to that of orthodox seeds. It has, of course, been chiefly concerned with the conservation of clonally propagated materials and species where seed storage is either difficult or impossible.

The work began with commissioned reviews of the literature (Withers, 1981, 1982) and of the problem of genetic variability under in vitro conservation (Scowcroft, 1984). An advisory committee was established and the first meeting took place in 1982 (IBPGR, 1983h); the report of the second meeting in 1984 has not yet been published. The report of the sub-committee on in vitro techniques for germplasm collection has already been mentioned (IBPGR, 1984c). This work progresses well, with a lively and well-informed international committee taking useful decisions. Impacts here are, therefore, most satisfactory.

We now turn to the administrative and organizational aspects of IBPGR's work on genetic conservation.

IBPGR has provided cold store facilities in the form of deep freeze chests or walk-in storage facilities, and has also helped to upgrade existing installation. Four of the CGIAR centres (CIAT, IITA, ICARDA CIMMYT) and AVRDC have received funding from IBPGR, generally to help with upgrading of existing cold stores. During the years 1976 to 1984, no less than 37 countries have received considerable sums to provide storage and drying equipment, some of them receiving funds more than once for special purposes or where storage facilities were located in different places. Funding has also been allocated to the establishment and maintenance of vegetative collections. In total, from 1975 to 1984, inclusive, IBPGR has allocated nearly 2.5 million dollars to genetic resources conservation. This is an extremely good figure, which on any standard must be accounted as a very high impact indeed, since without this, the major part of world crop germplasm would have become irretrievably lost.

Finally, we must look at the publications that draw together information on germplasm collections. From time to time, individual directories of germplasm collections have been published by IBPGR and eleven have now appeared. Most of these were mentioned earlier in the crop reports but three were not (Williams and Damania, 1981; Toll and van Sloten, 1982; Gulick and van Sloten, 1984).

A general report on seed stores for genetic conservation, published by Ng and Williams (1978), outlined the situation at that time, when only twenty-five centres for long-term storage were identified, thirteen of them in the industrial countries. There were twenty-eight centres with medium-term storage only, sixteen of them in the industrial countries. This contrasts strongly with the report six years later by Hanson et al. (1984), where designated security base collections, as well as other significant collections of a wide range of crops, are listed. The data cannot be compared in detail with the 1978 report, but it appears that there are now 133 centres conserving crops in medium and long-term storage units, of which fifty-one centres store materials at -5°C or less. About twenty-two of these are in developing countries and several are listed at CGIAR centres. In a further publication (IBPGR, 1984d), a list is given of forty-one centres participating in the IBPGR global network of base collections, of which twenty-two are situated in developing countries (including CGIAR centres) and less than half in developed ones. It is thought that, for the future, about fifty base collections will be sufficient for world needs, though facilities and management policies in these collections will need to be improved materially; IBPGR is already working towards this objective. A publication entitled "Seed Technology for Genebanks" will be referred to in more detail under (ix) Training (IBPGR, 1979).

iv. Characterization and preliminary evaluation

IBPGR is well aware of the need to standardize the systems by which gene-bank samples are described in a way that data may be easily stored and exchanged for each crop. There is a need to arrive at a more standard series of descriptors and descriptor states for passport data, which include the basic collection data together with gene bank accessions data. Thereafter, the descriptors will vary from crop to crop, but should be standardized within each. Some fourty-four descriptor booklets (including several revisions) have been published by IBPGR at the time of writing.

IBPGR has divided evaluation data into three main categories (Erskine and Williams, 1980).

1. Characterization. This includes:

(1a) Morphological/botanical characters
(1b) Agronomic characters of high heritability, visible in whatever conditions the materials are grown.

2. Preliminary evaluation.

This includes a limited number of additional agronomic traits thought desirable by a consensus of users of the particular crop.

3. Full evaluation.

This involves the scoring of characters conferring tolerance, resistance or immunity to pests and diseases, and adaptation to particular agro-ecosystems. More importantly, it includes tolerance or resistance to stress conditions such as cold, frost, drought, heat and various soil conditions such as high salinity, aluminum, etc. IBPGR does not concern itself with full evaluation.

To begin with, the IBPGR crop committees set out long lists of morpho-botanical characters. Thus the first wheat and Aegilops descriptor list included twenty-six of this type and twenty-nine agronomic ones. The revised list, published three years later, reduced these to six in each case, thus reducing the time spent in lengthy characterization, which might have been more usefully employed in other work.

The present writer is strongly of the opinion that only a few characterization and preliminary evaluation descriptors should be used for each crop, and that the genebank manager should as soon as possible see that his material is evaluated for resistances to pests and diseases as well as to adaptation to "stress" environments. If this work cannot be undertaken in his own institute, arrangements should be made for them to be carried out elsewhere. IBPGR should identify a series of institutes in different parts of the world where, within carefully prescribed conditions, such tests could be carried out.

Thus, in the opinion of the present writer, IBPGR's impacts in evaluation have been not only largely negative but have been positively misdirected, to the detriment of other more important activities. IBPGR is now beginning to reassess its policy in this respect (see IBPGR, 1984d, P. 21).

ix. Training

IBPGR has played an extremely important role in the training of young scientists in various aspects of genetic resources work. It has supported, since 1975, the Masters course at Birmingham, United Kingdom, on Conservation and utilisation of plant genetic resources, and will continue to do so, at least for the next few years. Including certain modules available for shorter periods, the Birmingham course has trained some 200 students, of whom nearly 75% have come from a very wide spread of developing countries. Students from industrial countries are funded separately.

IBPGR has supported, or completely funded, a large range of short training courses in many parts of the world, intended to provide in-depth training on specific parts of IBPGR's work (see also IBPGR, 1984e). Thus, 886 participants from ninety-eight countries have been trained, since 1975, on funds received from IBPGR.

Publications on training are available (Mehra et al., 1981; Kumar, 1983; IBPGR, 1979, etc.).

In the whole field of training, IBPGR's impacts have been commendably high. Arrangements to provide training in French and Spanish are also under discussion.

x. Data bases

IBPGR has placed considerable emphasis on the proper documentation and computer storage of information on existing germplasm collections. Assistance with the purchase of "hardware" has been provided for twenty-two countries, mostly in the form of microcomputers (Apple II, chiefly) as well as monitors and printers. Equipment has also been given to ICARDA and WARDA, and to EUCARPIA to set up the Malu data base. More than a quarter of a million dollars has been spent in this way. Considerable assistance has been given towards the establishment of international data bases so that inventories could be published. Thirty-seven grants have been made in this way, some of them to developed countries, because in these cases the proper expertise and facilities were only available in them.

Although much effort and financial support has been provided in this area by IBPGR, the results are not as promising as could have been hoped. A steady flow of data into the data base systems, and out again when requests for information are received, is still not attained in most countries, even in many developed ones. A model was set up in connection with the Nordic genebank (Blixt and Williams, 1982), but this was not very useful in practice. Quick visits by consultants have taken place, but again, these are not sufficient, by themselves, without considerable back-up. There is no doubt that carefully designed data base learning programmes, which proceed stepwise in easily understandable stages, are urgently required. They should also be provided in a range of languages.

Although IBPGR impacts in this field are good, many more are still needed.

xi. Research

The Board has funded research in various areas, particularly as concerns seed and in vitro storage (IBPGR, 1984d, p. 39). It now realizes that a more coordinated approach is needed, particularly "in the understanding of breeding systems in many clonally propagated species and their wild relatives; the genetic basis of regeneration, particularly in cross-pollinated species; sampling techniques other than for annual seed crops; and better techniques for measuring variability" (IBPGR, 1984d, p. 44). The present writer is very much in agreement with this approach and would add another research area, namely the experimental taxonomic study of a number of tropical crops and their wild relatives, e.g. cassava, jute, yams, certain millets, etc. A working group to consider these should be established.

IBPGR's intentions are to stimulate research and to put some funding into it, but not to outlay very large amounts.

Impacts from IBPGR's past research initiatives and support are good, and prospects for the future impacts are promising.

(c) The promotion and coordination of national programmes and committees and an international network of genetic resources centres

National genetic resources programmes have been established in eighty-three countries, of which fifty were assisted or stimulated by IBPGR. National committees have been created in about twenty-five countries, and IBPGR has thus provided widespread impact at national levels. The problem here, as IBPGR is aware, is to maintain the impetus, and ensure that adequate funding continues to be provided from national or outside sources.

A very important factor here is the development of regional groupings - a suggestion put forward in the "blue-print", arising from the Beltsville 1972 committee, as a result of which IBPGR was created.

Regional committees have now been established for Southeast Asia and for Europe (the latter with UNDP involvement). IBPGR influence has also been strong in Africa, East Asia, and the Pacific, Latin America, North Africa and the Middle East, the Mediterranean and South Asia. IBPGR's work is chiefly concerned with coordination of country activities, exploration, conservation and training.

Regional coordinators have been appointed for Europe, Latin America, West Africa, East Africa, Southeast Asia and North Africa and the Middle East. Their task is to liaise with national and international organizations, to help to build up activities, promote and help with training, and promote the formation of national committees where these do not already exist.

Some regions are much more advanced than others, and the tasks of some of the regional coordinators are consequently much more difficult, particularly as some of the regions are composed of a large number of countries, many of which do not have any tradition of cooperating regionally.

This is an area of IBPGR's activities where impacts are rather uneven, chiefly because of differences in level of awareness and willingness to cooperate between groups of countries. Southeast Asia and Europe are examples of good cooperation, whilst Southwest Asia is an area where many difficulties have been encountered. A newsletter is published by the regional committee for Southeast Asia, with 3-4 numbers each year, starting in June 1977. This is well-edited and provides good impacts. None of the other regions have yet published newsletters, though special booklets on crops are issued from time to time by the UNDP/IBPGR European Programme (see UNDP/IBPGR 1983, 1984). Various reports of the Southeast Asia and Mediterranean programmes have also been published by IBPGR. In addition, a useful report on Andean germplasm was published two years ago (Piedrabuena and Esquinas Alcazar, 1983) as well as a report based on the first Andean regional meeting (IBPGR, 1982f).

It will already have been noted that impacts in this work are very uneven. They are good in Southeast Asia, though some countries rather lag behind. Europe is moving ahead, but should do so much more quickly with the level of expertise available. Given the interest and expertise present in South Asia, impacts are lamentably small. So far, Latin America, West Africa and East Africa are just in the initial stages, and IBPGR should put more personnel into these regions. The Southwest Asian organization has virtually collapsed, but through no fault of IBPGR. Thus impacts are very uneven, but given the magnitude of the tasks, IBPGR has acquitted itself quite well up to now. Much more effort is needed, however, and perhaps some totally different approach might be contemplated for the future.

Conclusion. During the ten years of IBPGR's existence, the general impacts have been extraordinarily good, and IBPGR has unquestionably rescued the major part of the world's germplasm resources, which would otherwise have disappeared completely. In present day jargon it has prevented an almost total genetic "wipe-out".

Clearly, much remains to be done, and this can be summarized here in a list designed to indicate where impacts are not as high as could have been wished.

(a) Promotion and diffusion of genetic resources information

This has been good within the community of scientists working with genetic resources, but one correspondent states that letters of inquiry about training, internships, expeditions, new genebanks, project funding, etc. remain largely unanswered, and information only diffuses by word of mouth or "grapevine" methods. The information is only reported in the newsletter several years later. There is a clear need for a good information office in Rome, headed by a responsible person, with authority to answer questions by telephone, letter, telex or cable.

Another very important area is the diffusion of knowledge about genetic resources, and IBPGR's work in this area, to the general scientist and biologist, as well as the educated public. There is a great need for the employment of a first class science writer to develop and maintain public knowledge and awareness of IBPGR's work, through articles in journals such as Science, Nature, Scientific American, New Scientist, etc., as well as the quality press, in a range of countries. Good translation services would be needed here. So many of the articles in the quality press at present are written by journalists and others who do not possess real knowledge and understanding of IBPGR's work. In consequence impacts in this area are often rather low, or even decidedly negative.

(b) Theoretical and practical support

1. Surveys

In this area IBPGR has done well and has taken over responsibilities and developed impacts that the centres have been unable to assume. However much needs to be accomplished, particularly with non-mandate crops. Research on the evolution and relationships of crops to their wild prototypes and relatives is urgently needed (see later, under Research) so as to understand and make maximum use of the genetic resources still available.

ii. Exploration

Here, too, IBPGR has developed maximum impacts providing funding and expertise both for mandate and non-mandate crops. Much still needs to be done, however, with wild species related to the crops themselves.

iii. Conservation

Major impacts have been developed in this area also, not only through helping to develop the theoretical and practical bases for conservation, but in providing funding support to the centres and national programmes, as well as data lists of global storage facilities. Connections with developed countries have been important in conservation and the planning and execution of expeditions where the appropriate expertise was to be found.

iv. Evaluation

IBPGR has dealt, up to now, only with characterization and preliminary evaluation. Impacts have been good, though the present writer has, for some years, not been in agreement with the emphasis placed on this work, to the detriment of "full" or "in depth" evaluation (i.e. the screening for resistance to pests and diseases, and tolerance to stress conditions). As a consequence of IBPGR's policy, although in the centres useful resistance and/or tolerance characters have been identified, passed into the breeding programmes and have often been incorporated in newly-released cultivars in the non-mandate crops, very little or nothing at all has happened in the all-important area of utilization. There has thus been a most unwelcome "block", with consequently complete lack of impacts. Whilst agreeing that "in depth" evaluation is not easy to accomplish in developing countries, I feel strongly that IBPGR should now address itself to this organizational task. In fact, in the publication IBPGR in its Second Decade (IBPGR, 1984d, pp. 23-24) this matter is now mentioned.

v. Germplasm enhancement is also not included in IBPGR's mandate. Again, it is an important step in the efficient utilization of germplasm and should be at least reviewed by the Board at an early data.

(vi-vii) These activities are clearly outside the scope of IBPGR.

ix. Training

Major impacts are made by IBPGR in a very satisfactory way. The provision of internships - clearly a form of vocational "training by doing" - is most valuable and should be extended.

x. Data bases, documentation, etc.

IBPGR has made reasonably good impacts here, but its policy should be subjected to scrutiny with a view to improving progress in an area of work which needs very close understanding and cooperation between information scientists, on the one hand, and agricultural and biological scientists on the other.

xi. Research

IBPGR has developed good impacts in research-support grants to scientists in developed and developing countries. More ad hoc committees of biological scientists and breeders should be set up to identify problems and suggest how they might be solved. This is particularly needed in the area of crop evolution studies linked to surveys of genetic resources in the field and in the genebank. Major and minor crops should be reviewed in this way. The conservation (seed and in vitro) committees have set a very useful pattern for this type of work.

SECTION III SUMMARY AND CONCLUSIONS

1. The Work of the IARCs

It is not easy to summarize the genetic resources work of the centres network. Crops differ widely and the local conditions and policies of the centres and the scientists working in them differ to some extent from centre to centre.

Although there have been several criticisms and low impact assessments in section II of this report, the over-all conclusions are that all the centres have evaluated and utilized the genetic resources of their mandate crops in an efficient and innovative manner. Of this there can be little doubt, when considering the genetic resources of the crops themselves. Where most of the centres do less well, and in some cases do nothing at all, is with the wild species related to their mandate crops. It is often argued that all the genetic diversity needed at present can be found within the crop itself. This attitude is short-sighted, and although some centres do not take this position, most still pay little regard to wild species.

It is interesting to note that even concerning the cultigen, breeders' attitudes can vary considerably. Many still rely on the techniques of breeding with elite stocks, particularly with the old world temperate cereals. It is often found, however, that interesting results are obtained from the use of landraces when breeding for tolerance to stress conditions and sometimes also for resistance to diseases and pests. These land races have become adapted to local conditions over periods of thousands of years, and although their yields are not high, very promising selections can be obtained from them or from crosses between them and high-yielding varieties or breeding lines. This seems to me to be one of the major impacts of the breeders' use of genetic resources materials in the centres programs. However, a number of other strong impacts also emerge, and to summarize these properly, it will be necessary to treat them under the eleven headings used in Section II of this report.

i. Surveys

Without doubt these are the weakest parts of the centres genetic resources work. Surveys of genetic resources in the field require a good basic knowledge of the taxonomy, geographical distribution, ecology, and evolutionary development of the crop and its related wild species. Very few centres possess this kind of expertise and few have considered it necessary to look for collaborative links with experts in this field from overseas institutes and universities. This lack of understanding of the taxonomic, cytological and genetical background to the evolution of the crops, and its wild prototypes, has been the reason why the importance of related wild species has not been sufficiently understood. The low impacts for wild species exploration, conservation, evaluation, enhancement and use is undoubtedly due to the lack of interest in them or a realization of their potential importance for future plant breeding work.

Many centres have been helped by IBPGR with their survey work, both of materials in the field and in gene banks. Impacts are variable, however; although they are excellent for CIP, which carried out its own surveys with the aid of expert committees, and for IRRI, and a number of other centres for particular crops (ICARDA - chickpeas; ICRISAT - groundnuts; IITA - cowpea; and others), in many instances the problems have been rather put to one side, or have been dealt with in a somewhat ad hoc manner.

IBPGR's impacts on surveys have been high, where these have been carried out, but many crops have not yet been surveyed. Computer-generated maps based on collection passport data are still totally lacking.

ii. Exploration

Again, some centres such as IRRI, CIP, IITA (for cowpea), CIAT (for cassava), ICARDA (for chickpea) and CIAT and ILCA (for forage grasses and legumes), have made great impacts with their exploration work, whilst others have waited for IBPGR to take the initiative (and even provide the finance in some cases) in arranging or supporting collecting missions. Again, apart from a very few centres, wild species have not been properly attended to. Some centres have not taken any initiative at all, or very little. This may be due to lack of funding, but if all centres are to comply with their commitments to conserve the genetic resources of their mandate crops, they must make funding available where necessary. In this respect, also, a clarification of their mandates is urgently necessary. We shall deal with this point later.

IBPGR's work on exploration has provided very high impacts indeed, as can be seen from Section II, subsectioon 14.

iii. Conservation

On the whole this is carried out by all centres fairly well, and by some very well indeed, given the fact that proper storage facilities are only just becoming available for base collection, and duplicate base collections have not always been designated. Seed drying facilities are not always up to the required standard, and some centres still believe that seed drying in the sun is sufficient. More consideration should be given to the identification and elimination of duplicates, and more technical staff should be available for seed viability testing and regeneration.

It would also be valuable for the centres to work towards a greater standardization of the terms used for various activities, as for instance;

(1) Base collections	(For long-term storage)
(2) Active collections	(not "working collection"; for short to medium storage)
(3) Breeder's working collections	(for breeding and selection; not generally for storage at all)
(4) Regeneration or rejuvenation	(not "maintenance", as used in ICRISAT reports; for renewing base collection stocks when they begin to lose viability)
(5) Multiplication	(for active collection seed increase when more material is needed for evaluation, etc.)

IBPGR's work on conservation has been satisfactorily high. Manuals for genebank managers, when published, should also provide useful impacts.

iv. Evaluation

Most of the centres carry out evaluation to a high level, particularly the part called by IBPGR "full" or "in-depth" evaluation, or what the present writer has termed "secondary" evaluation. This is the screening of material for resistance to pests and diseases and for tolerance to environmental stresses.

The scoring of morphological and agronomic characters has generally been carried out by the Genetic Resources Units and on the whole has been accomplished well and speedily. Some crops such as *Phaseolus coccineus*, *P. lunatus*, minor millets, yams and certain groundnuts have not yet been adequately evaluated.

By and large, therefore, the centres have provided high impacts in evaluation.

IBPGR has developed fairly good impacts in the scoring of morphological and agronomic characters (characterization and preliminary evaluation), though it has tended to over-stress their importance in the past and has thus involved genebank personnel in lengthy and not too important activities to the detriment of others of greater value. This situation is now being revised however.

IBPGR has not involved itself in the full or in-depth type of evaluation, mentioned above. Thus the impacts here have been largely negative (see IBPGR section, p. 89). This means that a whole range of non-mandate crops grown and stored in developing countries, and ones in which industrial countries have no interest, are not receiving adequate attention for scoring for disease and pest resistance or for tolerance to stress conditions in any coordinated way. Hence there is a danger that the genetic resources potential of these crops will not be understood, and that sooner or later the governments of countries holding such collections will withdraw funding for their conservation (see also p.7 of this report). Crops that might suffer in this way are amaranths, Chenopodium, aroids, minor roots and tubers, lupins, peas, winged-bean, safflower, various palms, tropical vegetables, bananas, many other tropical fruits, fiber plants such as jute, sisal, etc. and tropical flavoring, stimulants and medicinal plants.

v. Germplasm enhancement

Impacts tend to be very poor in this area because centres are not collecting and storing wild species, or if they do so, are generally not attempting to transfer the useful characters into elite breeding lines. Exceptions can be seen with rice, potato and groundnuts, and to some extent also with wheat, barley, maize, faba bean, lentil and phaseolus bean. Much more work is needed, based on a better understanding of the wild species, as mentioned above.

IBPGR is not involved with enhancement.

vi. Breeding; trials

As we mentioned in the first part of this section, all the centres have developed high to very high impacts in this aspect of genetic resources work. IBPGR is not involved in this type of work.

vii. Release of varieties and national programmes

Good to excellent impacts have been developed by most centres in the transfer of materials to national programs from which new varieties have been released. Lower impacts have resulted in certain crops, generally because of the shorter periods during which breeding has been in progress. There is no IBPGR involvement here.

viii. Well-being and economic advancement

It has been almost impossible to assemble hard data for this aspect of the survey, but there is strong evidence that good to excellent impacts have resulted for wheat, barley rice, maize, sorghum, pearl millet, potato, chickpea, pigeonpea and cowpea, and possibly also in certain forages, lentils, faba beans, phaseolus beans, etc. More information is needed here, but pipeline evidence indicated high percential impacts for the near future. There is no IBPGR involvement here.

ix. Training

Most centres have developed very good impacts in the training of third-world scientists in matters of crop breeding, trials, diseases, pests, etc., all of which has great relevance to the use of germplasm resources. A number of centres have also collaborated with IBPGR on specific training in genetic resources exploration and conservation, particularly CIAT, CIP, ICARDA, IITA and IRRI. Short training courses have been organized by IBPGR regional officers very successfully in Southeast Asia, Latin America, West Africa and the Mediterranean/Middle East regions. IBPGR has supported the Birminghamtraining course since 1975 and ad hoc courses in various other industrial countries. Impacts from IBPGR and most centres are excellent, therefore.

x. Data bases

The entry of scoring and screening data into computer store and their retrieval as print-outs and inventories are extremely important, as we have seen. CIAT, ICARDA ICRISAT, and IRRI are in the forefront of this activity, with high to excellent impacts. IBPGR is also developing data bases and promoting their use in national programme genebanks, with resulting impacts that unfortunately vary considerably from country to country.

xi. Research

Research impacts in the genetic resources field vary greatly between crops. Thus there is good research on tissue-culture conservation methods at CIP (potatoes), CIAT (cassava), and IITA (yams, etc.). Research on specific relationship and genetic compatibility is under way in a range of crops (wheat, rice, maize, potato, lentils, phaseolus beans and groundnuts), but certainly much more is needed, and this could be inexpensively carried out through research contracts with laboratories in industrial countries. IBPGR has also funded research in genetic resources methods and techniques. The conclusion are that some useful impacts have resulted but many more need to be developed.

2. The Work of IBPGR

IBPGR's work has extended far beyond the eleven heads mentioned above, as will be seen in sub-head 14 of Section II of this report. Impacts are very good indeed in most aspect of IBPGR's work.

In the promotion and diffusion of genetic resources information, IBPGR has made good impacts within the genetic resources community but has not done so well within the broader scientific community and amongst the informed world public. It is suggested that awareness at the governmental and political level needs to be improved considerably. For this a public relations officer needs to be appointed.

IBPGR's impacts in surveys, exploration and conservation have been satisfactorily high. The shortcomings of IBPGR's policy with evaluation have already been mentioned. This policy may well be revised in the near future with a view to the promotion of in-depth evaluation amongst national genebanks, where it is most urgently needed.

As we mentioned before, IBPGR has not involved itself in the past with germplasm enhancement or breeding. Although plant breeding would seem indeed to be outside the field of IBPGR's activities, the same might not be said for germplasm enhancement. This latter activity, often termed pre-breeding or parental line breeding, is an essential step in the proper utilization of the germplasm of wild species and primitive forms. Without pre-breeding, many breeders will not use genetic resources at all, a cause of the poor agronomic characters introduced along with disease and pest resistant characters from the wild species into elite breeding lines. In the view of the present writer IBPGR ought to extend its mandate to include the promotion of germplasm enhancement or pre-breeding, in order to ensure that genetic resources materials are used by breeders.

In the aspects of training, data bases and research IBPGR's impacts have been excellent and are continuing to be so, though more thought needs to be put into improving progress in data base work. Research promotion is good.

National programmes and regional coordination are uneven, depending on countries and regions, but IBPGR is certainly doing well, given the difficulties encountered.

It is clear from this review that there is insufficient coordination amongst the centres and IBPGR of genetic resources work. It is therefore strongly suggested that a coordinating or consultative committee should be established. This should be composed of one or two representatives for each centre and from IBPGR. Its task would be to clarify the genetic resources crop mandates and try to standardize the approaches of the centers and of IBPGR. In this way a greater uniformity of work level and of responsibilities would be attained. Such a committee would not need to meet more than once a year but, in doing so, the flow of information and ideas from centre to centre and from those to IBPGR and back again would be immensely helpful and should strengthen impacts in those areas considered at present to be weak or poorly developed.

3. Conclusion

To conclude this impact study on plant genetic resources, I am satisfied that the work of the centres and of IBPGR is, by and large, proceeding along the right lines. More financial support for germplasm work is needed at some of the centres, and there is a tendency to underplay the importance of wild species, related to the crops themselves, in providing a source of genetic diversity for present and future needs. More exchange of genetic resources information and coordinated planning within the CGIAR network would also prove extremely valuable. For the future also, TAC, the centres and IBPGR should consider the problem of the non-mandate crops that are of value to developing countries. The in-depth evaluation, germplasm enhancement and breeding aspects of those crops, that at present are not the concern of either the centres or of IBPGR, should receive attention in order to see how their genetic resources could be utilized adequately. If this is not done, one can foresee the danger of a loss both of interest and future financial support for germplasm conservation on the part of the governments of the countries concerned. This is a serious gap in promotion and funding which needs to receive some thought and discussion in the immediate future.

Apart form these criticisms, the general record of the CGIAR in genetic resources work is very impressive indeed. Germplasm materials are being evaluated and utilized on a massive scale, and the results in terms of newly released varieties are outstandingly good.

Finally, this study of the CGIAR system shows very clearly indeed that the genetic resources of the whole world are being made freely available to first, second and third world countries on a scale that none of us had believed possible some fifteen to twenty years ago. Such a record gives the lie to those who criticize the system by stating that genetic resources are wholly or partially restricted to industrial countries only. I have found no evidence whatever for such criticisms, but on the contrary, have been very much impressed by the generous way in which the germplasm used within the CGIAR system is being made freely available to all those developing countries that are interested in it. Furthermore, this availability is not confined to the "raw" germplasm but includes all types of materials improved and selected by breeders.

In my view this is a very impressive record indeed, which fully justifies the financial inputs expended on this work.

BIBLIOGRAPHY

ACHEAMPONG, E., ANISHETTY, N. M. and WILLIAMS, J. T. (1984). A World Survey of Sorghum and Millets Germplasm. IBPGR, Rome.

AHMAD, Z., MOHMAND, A. S., HAQANI, A.M., HASHMI, N. I., MALIK, B. A. and BHATTI, M. S. (1982). Collecting chickpea and lentil in Pakistan. Plant Genetic Resources Newsletter, 52, 2-3.

ANDREWS, D. J., KING, S. B., WITCOMBE, J. R., SINGH, S. D., RAI, K. N., THAKUR, R. P., TALUKDAR, B. S., CHAVAN, S. B. and SING, P. (unpubl.). Breeding for disease resistance and yield in pearl millet. Submitted as ICRISAT Journal Article No. 457.

ANISHETTY, N. M., AYAD, W. G. and TOLL, J. (1981). Directory of Germplasm Collections. 3. Cereals IV Sorghum and Millets. IBPGR, Rome.

ANISHETTY, N. M., TOLL, J., AYAD, W. G. and WITCOMBE, J. R. (1982). Directory of Germplasm Collections. 3. Cereals IV. Barley. IBPGR, Rome.

(ANON - IBPGR) (1982). Conservation of the wild rices of tropical Asia. Plant Genetic Resources Newsletter, 49, 13-18.

ASTLEY, D., INNES, N. L. and van der MEER, Q. P. (1982). Genetic Resources of Allium Species. IBPGR, Rome.

AYAD, W. G. (1980). A Bibliography of Plant Genetic Resources Terms (in English and Arabic). IBPGR, Rome.

AYAD, G. and ANISHETTY, N. M. (1980). Directory of Germplasm Collections I. Food Legumes. IBPGR, Rome.

AYAD, G., TOLL, J. and ESQUINAS-ALCÁZAR, J. T. (1980). Directory of Germplasm Collections. III. Cereals. 2. Maize. IBPGR, Rome.

AYAD, G., TOLL, J. and WILLIAMS, J. T. (1980). Directory of Germplasm Collections III. Cereals 1. Wheat. IBPGR, Rome.

BARULINA, H. (1930). Lentils of the USSR and of other countries. Suppl. 40, Bull. Appl. Bot., Genet. and Pl. Breed., 1-319.

BETTENCOURT, E. and GUSMÃO, L. (1981). Maize collecting in the Azores. Plant Genetic Resources Newsletter, 46, 15-17.

BRIEGER, F. C. (1963). Collection and evaluation of indigenous races of maize. Genetica Agraria, 17, 256-264.

CGIAR (1980). Consultative Group on International Agricultural Research. CGIAR, Washington, D.C.

CHANDEL, K. P. S. (1981). Wild Vigna species in the Himalayas. Plant Genetic Resources Newsletter, 45 17-19.

CHANG, T. T. (1976). Manual on Genetic Conservation of Rice

Germplasm for Evaluation and Utilization. IRRI, Los Baños, Phillipines.

CHANG, T. T. (1984). Exploration and collection of the threatened genetic resources and the system of documentation of the rice genetic resources at IRRI. From: Jain, S. K. and Mehra, K L. (eds.) Conservation of Tropical Plant Resources, 48-54. Bot. Survey, India.

CHANG, T. T. (1985). Germplasm Enhancement and Utilization. (Unpublished mimeographed report).

CHANG, T. T., ADAIR, C. R. and JOHNSTON, T. H. (1982). The conservation and use of rice genetic resources. Advances in Agronomy, 35, 37-91.

CHANG, T. T., LORESTO, G. C. and TAGUMPAY, O. (1973). Screening rice germplasm for drought resistance. Sabrao Journal, 6 (1) 9-16.

CHANG, T. T., LORESTO, G. C., O'TOOLE, J. C. and ARMENTA-SOTO, J. L. (Undated). Strategy and methodology of breeding rice for drought-prone areas. In: Drought Resistance in Crops with Emphasis on rice.

CHANG, T. T., SHARMA, S. D., ADAIR, C. R. and PEREZ, A. T. (1975). Manual for Field Collectors. IRRI, Los Baños, Philippines.

CHAPMAN, C. G. D. (1984). Wheat collecting: an inventory. 1981-1983. Plant Genetic Resources Newsletter 58, 1-4.

CHAPMAN, C. G. D. (Unpublished). Wheat Genetic Resources. A Review and Proposals for Future Action. IBPGR, Rome.

CHARRIER, A. (1983). Étude des Ressources Génétiques du Genre *Abelmoschus* Med. (Gombo). IBPGR, Rome.

CIAT (1980). Catálogo Descriptivo del Germoplasma de Frijol Comun. Unedad de Recursos Geneticos. CIAT, Cali, Colombia.

CIAT (1983). CIAT Report for 1983. CIAT, Cali, Colombia.

CIAT (1984). External Program Review. Tropical Pastures Program Report. (Revised Version, 30 January, 1984). CIAT, Cali, Colombia.

CIP (1973). Workshop on Germ-Plasm Exploration and Taxonomy of Potatoes. I. International Potato Centre, Lima, Peru.

CIP (1976). Report on the Planning Conference on the Exploration and Maintenance of Germ Plasm Resources. II. International Potato Centre, Lima, Peru.

CIP (1979). Report on the Planning Conference on the Exploration, Taxonomy and Maintenance of Potato Germ Plasm III. International Potato Centre, Lima, Peru.

CIP (1984). Potatoes for the Developing World. A Collaborative Experience. International Potato Centre, Lima, Peru.

CROMARTY, A.S., ELLIS, R. H. and ROBERTS, E. H. (1982). The Design of Seed Storage Facilities for Genetic Conservation. IBPGR, Rome.

CROSTON, R. P. and WILLIAMS, J. T. (1981). A World Survey of Wheat Genetic Resources. IBPGR, Rome.

CUBERO, J. I. (1984a). Utilization of wild relatives and primitive forms of food legumes. In: Witcombe, J. R. and Erskine, W. (eds.) Op.cit. pp. 73-84.

CUBERTO, J. I. (1984b). Taxonomy, distribution and evolution of the faba bean and its wild relative. In: Witcombe, J. R. and Erskine, W. (eds.) Op.cit. pp. 131-143.

CUBERO, J. I. (1984c). Taxonomy, distribution and evolution of the lentil and its wild relatives. In: Witcombe, J. R. and Erskine, W. (eds.) Op.cit. pp. 187-203.

DAHUA, YUE (1984). Wheat genetic resources in China. Plant Genetic Resources Newsletter, 57, 2-7.

DAMANIA, A. B. and WILLIAMS, J. T. (1980). Directory of Germplasm Collections. II Root Crops. IBPGR, Rome.

DE, D. N. (1974). Pigeon pea. In: Hutchinson, J. B. (ed.) Evolutionary studies in World Crops: Diversity and Change in the Indian Subcontinent. C.U.P., Cambridge.

DELLA, A. (1980). Broad bean collecting in Cyprus. Genetic Resources Newsletter, 44, 17-19.

DICKIE, J. B., LININGTON, S. and WILLIAMS, J. T. (eds.) (1984). Seed Management Techniques for Gene Banks. IBPGR, Rome.

ELLIS, R. H. and ROBERTS, E. H. (1982). Use of Deep-Freeze Chests for Medium and Long-Term Storage of Small Seed Collections. IBPGR, Rome.

ELLIS DAVIES, W. (1984). A Plan of Action for Forage Genetic Resources. IBPGR, Rome.

ELLIS DAVIES, W. and McLEAN, B. T. (1984). Directory of Germplasm Resoures. Forages (Grasses, Legumes, etc.). IBPGR, Rome.

ELSAYED, F. A. (1984). Evaluation and utilization of faba bean germplasm in an international breeding program. In: Witcombe, J. R. and Erskine, W. (eds.) Op.cit. pp. 173-186.

ERSKINE, W. (1984). Evaluation and utilization of lentil germplasm in an international breeding program. In: Witcombe, J. R. and Erskine, W. (eds.) Op.cit. pp. 225-237.

ERSKINE, W. and HAWTIN, G. C. (1983). Pre-breeding in faba beans and lentils. Genetica, Beograd, 15 (3), 287-294.

ERSKINE, W. and WILLIAMS, J. T. (1980). The principles, problems and responsibilities of the preliminary evaluation of genetic resoures samples of seed-propagated crops. Plant Genetic Resources Newsletter, 41, 19-33.

ERSKINE, W, and WITCOMBE, J. R. (1984). Lentil Germplasm Catalog. ICARDA, Syria.

ESQUINAS-ALCÁZAR, J. T. (1981). Genetic Resources of Tomatoes and Wild Relatives. IBPGR, Rome.

ESQUINAS-ALCÁZAR, J. T. (1981, revised 1983). Los Recursos Fitogenéticos - Una Inversión para el Futuro. IBPGR/INIA, Rome and Madrid.

ESQUINAS -ALCÁZAR, J. T. and GULICK, P. J. (1983). Genetic Resources of Cucurbitaceae. IBPGR, Rome.

EUCARPIA (1983). Eucarpia workshop on pre-breeding in relation to gene banks. Genetica (Acta Biologica Iugoslavica, Series F), 15 (2 & 3), 145-422. Belgrade-Zemun.

FISCHBECK, G. (1983). Unpublished report on IBPGR mission to ICARDA Genetic Resources program. AGPG: IBPGR/83/17.

FRANKEL, O. H. (1973). Survey of Crop Genetic Resources in their Centres of Diversity. First Report. FAO, Rome.

GINTZBURGER, G., SHETA, A., RAHMAN, M., FITURI, M. and FRANCIS, C. M. (1983). Libyan forages collected. Plant Genetic Resources Newsletter, 56, 23-29.

GREGORY, W. C. and GREGORY, M. P. (1976). Groundnut. In: Simonds, N. W. (ed.) Evolution of Crop Plants. Longman, London.

GRUBBEN, G. J. H. (1977). (Edited by Tindall, H. D. and Williams, T. J.) Tropical Vegetables and their Genetic Resources. IBPGR, Rome.

GRUBBEN, G. J. H. and VAN SLOTEN, D. H. (1981). Genetic Resources of Amaranthus - A Global Plan of Action. IBPGR, Rome.

GULICK, P., HERSHEY, C. and ESQUINAS ALCÁZAR, J. (1983). Genetic Resources of Cassava and Wild Relatives [includes descriptor list]. IBPGR, Rome.

GULICK, P. and VAN SLOTEN, D. H. (1984). Directory of Germplasm Collections. 6.I. Tropical and Subtropical Fruits and Tree Nuts. IBPGR, Rome.

HADDAD, N. (1984). Utilization of genetic resources in a national food program. In: Witcombe, J. R. and Erskine, W. (eds.) Op.cit. pp. 85-94.

HAMMONDS, R. O. (1982). Disease resistant groundnut released. Plant Genetic Resources Newsletter, 51, 12-14.

HANSON, J., WILLIAMS, J. T. and FREUND, R. (1984). Institutes Conserving Crop Germplasm. The IBPGR Global Network of Genebanks. First Decade of Service. 1974-1984. IBPGR, Rome.

HARINARAYANA, G. (1979). Millet genetic resources in India. Plant Genetic Resources Newsletter, 40, 27-30.

HAWKES, J. G. (1980). Crop Genetic Resources Field Collection Manual. IBPGR/European Association for Research on Plant Breeding (EUCARPIA), Wageningen, Holland.

HAWKES, J. C. (1983). The Diversity of Crop Plants. Harvard University Press, Cambridge, Mass.

HAWKES, J. C. (1984). Consultancy Report to CIAT on Germplasm Activities. Manuscript.

HAWKES, J. G., WILLIAMS, J. T. and HANSON, J. (1976). A Bibliography of Plant Genetic Resources. IBPGR, Rome.

HAWKES, J. G., WILLIAMS, J. T. and CROSTON, R. P. (1983). A Bibliography of Crop Genetic Resources. IBPGR, Rome.

HAWTIN, G. C. (1984). Strategies for exploiting the faba bean gene pool. In: Witcombe, J. R. and Erskine, W. (eds.) Op.cit. pp. 163-171.

HERDT, R. W. and CAPULE, C. (1983). Adoption, Spread and Production Impact of Modern Rice Varieties in Asia. IRRI, Los Banos, Philippines.

HERNANDEZ X, E. (1973). Genetic resources of primitive varieties of Mesoamerica. In: Frankel, O. (ed.) Crop Genetic Resources in their Centres of Diversity. FAO/IBP, Rome.

HUAMAN, Z., WILLIAMS, J. T., SALHUANA, W. and VINCENT, L. (1977). Descriptors for the Cultivated Potato. IBPGR, Rome.

IBPGR (1976a). Report of IBPGR Advisory Committee on Sorghum and Millets Germplasm: First Meeting. 3-7 Oct. 1976. IBPGR, Rome.

IBPGR (1976b). Report of IBPGR Working Group on Engineering Design and Cost Aspects of Long-Term Seed Storage Facilities. IBPGR, Rome.

IBPGR (1978a). Genetic Resources of Bananas and Plantains. (IBPGR Working Group). IBPGR, Rome.

IBPGR (1978b) Coconut Genetic Resources. (IBPGR Consultation), IBPGR, Rome.

IBPGR (1979). Seed Technology for Genebanks. Lectures Given on a Short Training Course. Edinburgh. IBPGR, Rome.

IBPGR (1980a). Descriptors for Yams (Dioscorea spp.) [with an Introductory Note by D. G. Coursey]. IBPGR, Rome.

IBPGR (1980b). Coffee Genetic Resources. (IBPGR Working Group). IBPGR, Rome.

IBPGR (1981a). Report of IBPGR Advisory Committee on Sorghum and Millets Germplasm: Fourth Meeting. 5-9 September 1981, Dakar, Senegal. IBPGR, Rome.

IBPGR (1981b). Report of IBPGR Working Group on the Genetic Resources of Sweet Potato. IBPGR, Rome.

IBPGR (1981c). Genetic Resources of Sweet Potato (IBPGR Working Group on Genetic Resources of Sweet Potato). IBPGR, Rome.

IBPGR (1981d). Genetic Resources of Cruciferous Crops. IBPGR Secretariat Consultation. IBPGR, Rome.

IBPGR (1981e). Genetic Resources of Cocoa (IBPGR Working Group). IBPGR, Rome.

IBPGR (1981f). IBPGR Ad Hoc Advisory Committee on Seed Storage. First Meeting. IBPGR, Rome.

IBPGR (1982a). Descriptors for Phaseolus vulgaris. IBPGR, Rome.

IBPGR (1982b). Lima bean descriptors. IBPGR, Rome.

IBPGR (1982c). Genetic Resources of Vigna Species. (IBPGR Ad Hoc Working Group on Vigna Species). IBPGR, Rome.

IBPGR (1982d). Genetic Resources of Citrus. (IBPGR Working Group). IBPGR, Rome.

IBPGR (1982e). Genetic Resources of Vitis species (IBPGR Working Group). IBPGR, Rome.

IBPGR (1982f). Plant Genetic Resources in the Andean Region. Report of the First Regional Meeting. (Also in Spanish). IBPGR, Rome.

IBPGR (1983a). Echinochloa Millet Descriptors. IBPGR, Rome.

IBPGR (1983b). Kodo Millet Descriptors. IBPGR, Rome.

IBPGR (1983c). Descriptors for Phaseolus coccineus. IBPGR, Rome.

IBPGR (1983d). Genetic Resources of Soyabean. (IBPGR Working Group on the Genetic Resources of Glycine Species). IBPGR, Rome.

IBPGR (1983e). Genetic Resources of Capsicum. (IBPGR expert consultation). IBPGR, Rome.

IBPGR (1983f). Crop Genetic Resources Booklet with Slide Pack Photos and Text. IBPGR, Rome.

IBPGR (1983g). Practical Constraints Affecting the Collection and Exchange of Samples of Wild Species and Primitive Cultivars.

IBPGR, Rome.

IBPGR (1983h). IBPGR Advisory Committee on In Vitro Storage. IBPGR, Rome.

IBPGR (1983i). Cowpea Descriptors. IBPGR, Rome.

IBPGR (1984a). Report of a Second Meeting of the Cocoa Working Group. IBPGR, Rome.

IBPGR (1984b). IBPGR Advisory Committee on Seed Storage. Second Meeting. IBPGR, Rome.

IBPGR (1984c). The Potential for Using In Vitro Techniques for Collecting Germplasm. IBPGR, Rome.

IBPGR (1984d). The IBPGR in its Second Decade. An Updated Strategy and Planning Report. IBPGR, Rome.

IBPGR (1984e). IBPGR Annual Report for 1983. IBPGR, Rome.

IBPGR (1984f). Descriptors for Soyabean. (In Chinese and English). IBPGR, Rome.

IBPGR/ICRISAT (1980). Sorghum Descriptors. IBPGR, Rome.

IBPGR/ICRISAT (1981a). Pearl Millet Descriptors. IBPGR, Rome.

IBPGR/ICRISAT (1981b). Descriptors for Pigeonpea. IBPGR, Rome.

IBPGR/ICRISAT (1981c). Groundnut Descriptors. IBPGR, Rome.

IBPGR/ICRISAT (1984). Revised Sorghum Descriptors. IBPGR, Rome.

IBPGR/IRRI (1978). Proceedings of the Workshop on the Genetic Conservation of Rice. IRRI, Los Baños, Philippines.

ICARDA (1983). ICARDA Research Highlights, 1982. ICARDA, Aleppo.

ICARDA (1984a). Food Legume Improvement. Research Highlights 1982-83. ICARDA, Syria.

ICARDA (1984b). ICARDA Program of Work and Budget: 1985. ICARDA, Syria.

ICRISAT (1981). Pigeonpea genetic resources. Proc. Int. Workshop on Pigeonpeas. Vols. I and II. ICRISAT, Patancheru, India.

IITA (1983). IITA Research Highlights for 1982. IITA, Ibadan, Nigeria.

IITA (1984). World Cowpea Research Conference, 4-9 Nov. 1984. IITA, Ibadan.

IRRI/IBPGR (1983). Rice Germplasm Conservation Workshop. IRRI, Los Banos, Philippines.

JANA, S (1982). Canada-ICARDA collaboration for cereal germplasm conservation. Plant Genetic Resources Newsletter, 49, 5-10.

KAHURANANGA, J. and TSEHAY, A. (1984). The potential yield of some annual Ethiopian Trifolium species. Tropical Grasslands (exact reference not available).

KING, M. W. and ROBERTS, E. H. (1979). The Storage of Recalcitrant Seeds - Achievements and Possible Approaches. IBPGR, Rome.

KRAPOVICKAS, A. (1969). The origin, variability and spread of the groundnut, Arachis hypogaea. In: Ucko, P. J. and Dimbleby, G. W. (eds.). The Domestication and Exploitation of Plants and Animals. Duckworth, London.

KRETSCHMER, A. E Jr. (1979). VII. Characterization and preliminary evaluation. In: Mott, G. O. and Jimenez, A. (eds.) Op.cit. CIAT, Cali, Colombia.

KUMAR, H. (1983). see MEHRA et al., 1981. Translation into Hindi. IBPGR/ICAR, new Delhi.

KUSH, G. S. (1984) - mimeographed). IRRI breeding program and its worldwide impact on increasing rice production. Presented at Stadler Genetics Symposium on "Gene Manipulation in Plant Improvement". March 19-21, 1984, Univ. Missouri, Colombia MO.

LAWRENCE, T. (ed.) (1984). Collection of Crop Germplasm. The First Ten Years, 1974-84. IBPGR, Rome.

LAZIER, J. (1984). Forage genetic resources at ILCA. IBPGR Working Group Meeting Sta. Lucia, June 1984 (unpublished).

LAZIER, J. (undated). Theory and Practice in Forage Germplasm Collection. ILCA, Addis Ababa.

LUSE, R. A. (1979a). VIII. Transfer of forage germplasm. In Mott, G. O. and Jiménez, A. (eds) Op. cit. CIAT, Cali, Colombia.

LUSE, R. A. (1979b). IX. Preservation of forage germplasm. In: Mott, G. O. and Jiménez, A. (eds.) Op.cit. CIAT, Cali, Colombia.

LYMAN, J. M., BAUDOIN, J.-P. and HIDALGO, R. (1983). Unpublished manuscript chapter for a book on legumes to be edited by R. J. Summerfield and published by Granada Publishing Company.

VAN DER MAESEN, L. J. G. (1972) Cicer L., A monograph of the genus with special reference to the chickpea (Cicer arietinum L), its ecology and cultivation. Mededelingen Landouwhoge-school Wageningen. Veenman and Zonen, Wageningen.

VAN DER MAESEN, L. J. G. (1973a). Chickpea: distribution of variability. In: Frankel, O. H (ed.). Survey of Crop Genetic Resources in their Centres of Diversity. FAO/IBP, Rome.

VAN DER MAESEN, L. J. G. (1973b). Genetic resources of chickpea.

Plant Genetic Resources Newsletter 30, 17-24. IBPGR, Rome.

VAN DER MAESEN, L. J. G. (1979). Wild pigeon peas in Africa. Plant Genetic Resources Newsletter, 40, 8-10.

VAN DER MAESEN, L. J. G. (1984). Taxonomy, distribution and evolution of the chickpea and its wild relatives. In: WITCOMBE, J. R. and ERSKINE, W. (eds.)Op.cit. pp. 95-101.

VAN DER MAESEN, L. J. G., REMANANDAN, P. and MURTHI, A. N. (1981). Pigeon pea genetic resources. In: Proc. Int. Workshop on Pigeonpea Vol. 1. p. 385-392.

VAN DER MAESEN, L. J. G. and PUNDIR, R. P. S. (1984). Availability and use of wild Cicer germplasm. Plant Genetic Resources Newsletter, 57, 19-24.

MAHAPATRA, I. C., BHUMBLA, D. R. and BOKIL, S. D. (1984). Final report on the case study relating to the impact of ICRISAT on National Agricultural Research System and farmers of semi-arid tropics of India. ICRISAT (Mimeographed).

MEHRA, K. L., ARORA, R. K. and WADHI, S. R (1981). Plant Exploration and Collection: South Asian Training Course Lectures. IBPGR/ICAR, New Delhi.

MENGESHA, M. H., PRASADA RAO, P. K. E. and APPA RAO, S. (1982). Sorghum and Millets germplasm at ICRISAT. Plant Genetic Resources Newsletter, 51, 21-26.

MENGESHA, M. H. et al. (1984). Genetic Resources Unit - Status Report. ICRISAT, Patancheru (Mimeographed).

MOTA, M., FARIAS, R., TEIXEIRA, M. and BETTENCOURT, E. (1981). Report on a Mission to Collect Zea Mays and Phaseolus Germplasm (Southwest and Central Northeast of Portugal), September 1981. POR 81B. Genetics Department, Estação Agronómica Nacional, Oeiras, Portugal.

MOTA, M., FARIAS, R., TEIXERA, M. and BETTANCOURT, E. (1982). Zea and Phaseolus collecting in Portugal. Plant Genetic Resources Newsletter, 50, 20-21.

MOTT, G. O. and HUTTON, E. M. (1979). Strategies for the collection and improvement of tropical forages. In: Mott, G. O. and Jiménez, A. (eds.) Op.cit. CIAT, Cali, Colombia.

MOTT, G. O. and JIMENEZ, A. (eds.) (1979). Handbook for the Collection, Preservation and Characterization of Tropical Forage Germplasm Resources, (Workshop at CIAT, 1978). CIAT, Cali, Colombia.

MURATOVA, Y. (1931). Common beans - Vicia faba L. Suppl. 50, Bull. Appl. Bot. Genet. and Plant Breed. 1-298.

NASSAR, N. M. A. (1981). Collecting wild cassava in Brazil. Plant Genetic Resources Newsletter, 47, 14-23.

NG, N. Q. (1982). Genetic resources programme of IITA. Genetic Resources Newsletter, 49, 26-31.

NG, N. Q. (Unpublished). Survey of Plant Genetic Resources in Africa. IBPGR/IITA.

NG, N. Q., JAQUOT, M., ABIFARIN, A., GOLI, K., GHESQUIERE, A. and MIEZAN, K. (1983). Rice Germplasm Genetic Conservation Workshop. IRRI/IBPGR, Los Banos.

NG, N. Q. and WILLIAMS, J. T. (1978). Seed Stores for Crop Genetic Conservation. FAO/IBPGR, Rome.

NG, N. Q. and MARECHAL. R. (1984). Cowpea origin, diversity, taxonomy and germplasm. World Cowpea Research Conference 4-9 Nov., 1984. IITA, Ibadan.

PERRINO, P., POLIGNANO, G. B., HAMMER, K. and LEHMANN, C. O. (1984). Wheat and barley collected in Libya. Plant Genetic Resources Newsletter, 58. 39-48.

PIEDRABUENA, M. B. and ESQUINAS-ALCÁZAR, J. T. (1983). El Germoplasma Vegetal en los Paises Andinas. IBPGR (CIRF), Rome.

PORCEDDU, E. and JENKINS, G. (1982). Seed Regeneration in Cross-Pollinated Species. Proc. C.E.C./Eucarpia Seminar. Balkema, Rotterdam.

RADOVIC, G. and ZIVKOVIC, V. (1983). Collecting local maize in southern Yugoslavia. Plant Genetic Resources Newsletter, 53, 15-16.

RAO, V. R (1980). Groundnut genetic resources at ICRISAT. Proceedings of the International Workshop on Groundnuts, 13-17 October 1980. ICRISAT, Patancheru.

REDDY, M. V. and SINGH, K. B. (1984). Evaluation of a world collection of chickpea germplasm accessions for resistance to Ascochyta blight. Plant Disease, 68 (10), 900-901.

REID, R. (1982). Browse and forage legume collecting in Mexico. Plant Genetic Resources Newsletter, 52, 7-9.

REID, R. and LAZIER, J. R. (1979). III. Description of the collection site In: Mott, G. O. and Jiménez, A. (eds.) Op. cit. CIAT, Cali, Colombia.

REMANANDAN, P. (1981). The wild gene pool of Cajanus at ICRISAT, present and future In: Proc. Int. Workshop on Pigeonpea Vol. 2. p. 29-38. ICRISAT, Patancheru, India.

RIFAIE, R., BOURGOIS, J.-J. and WITCOMBE, J. R. Aegilops and wild wheat in Syria. Plant Genetic Resources Newsletter, 45, 2-7.

SASTRI, D. C. and MOSS, J. P. (1982). Effects of growth regulators on incompatible crosses in the genus Arachis. J. Experimental Botany, 33, 1293-1301.

SASTRI, D. C., MOSS, J. P. and NALINI, M. (1982). The use of in vitro techniques in groundnut improvement In: Giles, K. L. and Sen, S. K. (eds.) Plant Cell Culture in Crop Improvement. Plenum, New York.

SCHULTZE-KRAFT, R. (1979). I. Preparation for collection trip. II. Germplasm collection in the field. In: Mott, G. O. and Jiménez, A. (eds.) Op.cit. CIAT, Cali, Colombia.

SCHULTZE-KRAFT, R., ÁLVAREZ, G., BELALCÁZAR, J., HENAO, M. del R., NÚÑEZ, R. and ORTIZ, J. (1983). Catálogo de Germoplasma de Especies Forrajeras Tropicales. (3rd edition). CIAT, Cali, Colombia.

SCHULTZE-KRAFT, R. and ÁLVAREZ, G. (1984). CIAT tropical forage collection: a status report. Plant Genetic Resources Newsletter, 57, 15-18.

SCHULTZE-KRAFT, R., HOUMING, J. and XUNWEN, H. (1984). Tropical forage legumes on Hainan Island, China. Plant Genetic Resources Newsletter, 59, 1-3.

SCOWCROFT, W. R. (1984). Genetic Variability in Tissue Culture: Impact on Germplasm Conservation and Utilization. IBPGR, Rome.

SENCER, A. (unpubl.) The CIMMYT Wheat Germplasm Bank. Paper presented to the 6th IWGS, 28th November 3rd December 1983, Japan.

SIMPSON, C. E. (1980). Collection of peanut germplasm. Plant Genetic Resources Newsletter, 44, 32-33.

SIMPSON, C. E. (1982a). Groundnut exploration in Peru and Brazil. Plant Genetic Resources Newsletter, 48, 7-8.

SIMPSON, C. E. (1982b). Collection of Arachis germplasm (1976-82). Plant Genetic Resources Newsletter, 52, 10-12.

SIMPSON, C. E. (1984). Plant exploration: planning, organization and implementation with special emphasis on Arachis. In: Conservation of Crop Germplasm - An International Perspective. Crop Science Society of America.

SINDHU, J. S. and SLINKARD, A. E. (1983). Collecting lentils in Syria. Plant Genetic Resources Newsletter, 55, 24-25.

SINGH, A. K., MOSS, J. P. and SASTRI, D. C. (1983). Utilization of wild relatives in genetic improvement of Arachis hypogaea L. I. Techniques. In: Current Approaches in Cytogenetics, 151-157. Spectrum, Patna.

SINGH, A. K. and MOSS, J. P. (1984a). Utilization of wild relatives in genetic improvement of Arachis hypogaea L. VI. Peanut Science, 11, 17-21.

SINGH, A. K. and MOSS, J. P. (1984b). Utilisation of wild relatives in the genetic improvement of Arachis hypogaea L.

Theor. Appl. Genet., 68, 355-364

SINGH, K. B., MALHOTRA, R. S. and WITCOMBE, J. R. (1983). Kabuli Chickpea Germplasm Catalog. ICARDA, Aleppo, Syria.

SINGH, K. B. and MALHOTRA, R. S. (1984). Collection and evaluation of chickpea genetic resources. In: Witcombe, J. R. and Erskine, W. (eds.) Op.cit. pp.105-122.

SING, P., RAI, K. N., WITCOMBE, J. R. and ANDREWS, D. J. (undated). Population breeding methods in Pearl Millet improvement (Unpublished - Mimeographed).

SINGH, S. R. (1984). Impact of IITA's Grain Legume Program. IITA, Ibadan.

SIWI, B. H. and KARTOWINOTO, S. (1984). Plasma Nutfah Padi (Rice Germ Plasm) (Rice breeding report, Sukumondi-mimeographed). [Makalah untuk Simposium Padi]. A paper for the Symposium on Rice.

SOLH, M. and ERSKINE, W. (1984). Genetic Resources of lentils. In: Witcombe, J. R. and Erskine, W. (eds.) Op.cit. pp. 205-224.

SOMAROO, B. H. (1984). The Genetic Resources Program [at ICARDA]. Unpublished report.

SONG, L. and RAWAL, K. (1979). X. Data management and forage germplasm. In: Mott, G. O. and Jimenez, A. (eds.) Op. cit. CIAT, Cali, Colombia.

TAC (1984). Report of the External Program Review of ICRISAT (Restricted). TAC Seretariat, FAO, Rome.

THOTHATHRI, K. and JAIN, S. K. (1981). Taxonomy of the genus Cajanus DC. In: Proc. Int. Workshop of Pigeonpea Vol. 2. p. 3-7. ICRISAT, Patancheru, India.

TOLL, J. (undated). Proposals for the Collection of Germplasm of ICARDA Crops in the ICARDA Region. A Short and Medium Term Plan of Action. IBPGR, Unpublished.

TOLL, J., AINISHETTY, N. M. and AYAD, W. G. (1980). Directory of Germplasm Collections. III. Cereals. 3. Rice. IBPGR, Rome.

TOLL, J. and VAN SLOTEN, D. H. (1982). Directory of Germplasm Collections. 4. Vegetables. IBPGR, Rome.

UNDP/IBPGR (1983). Report of Prunus Working Group. UNDP/IBPGR, Rome.

UNDP/IBPGR (1984). Report of Allium Working Group. UNDP/IBPGR, Rome.

VALLS, J. F. M. (1983). Collection of Arachis germplasm in Brazil. Plant Genetic Resources Newsletter, 53, 9-14.

VANDERBORGHT, T. (1983). Evaluation of Phaseolus vulgaris wild types and weedy forms. Plant Genetic Resources Newsletter, 54, 18-25.

VAUGHAN, D. A. and HYMOWITZ, T. (1983). Progress in wild perennial Soyabean characterization. Plant Genetic Resources Newsletter, 56, 7-12.

VIRMANI, S. S., CHAUDHARY, R. C. and KHUSH, G. S. (1981). Current outlook on hybrid rice. Oryza, 18, 67-84.

WILLIAMS, J. T. (1976). A Bibliography of Plant Genetic Resources - Supplement. IBPGR, Rome.

WILLIAMS, J. T. and DAMANIA, A. B. (1981). Directory of Germplasm Collections. 5. Industrial Crops. I. Cacao, Coconut, Pepper, Sugarcane and Tea. IBPGR, Rome.

WITCOMBE, J. R. (1983). A provisional world list of barley expeditions. Genetic Resources Newsletter, 53, 25-40.

WITCOMBE, J. R. (1984). Genetic resources of faba beans. In: Witcombe, J. R. and Erskine, W. (eds.). Op.cit. pp. 145-162.

WITCOMBE, J. R., BOURGOIS, J.-J. and RIFAIE, R. (1982). Germplasm collections from Syria and Jordan. Plant Genetic Resources Newsletter, 50, 2-8.

WITCOMBE, J. R. and ERSKINE, W. (Eds.) (1984). Genetic Resources and their Exploration - Chickpeas, Faba Beans and Lentils. Published for ICARDA and IBPGR by Martinus Nijhoff and Dr. W. Junk, The Hague, Netherlands.

WITHERS, L. A. (1980). Tissue Culture Storage for Genetic Conservation. IBPGR TEchnical Report, IBPGR, Rome.

WITHERS, L. A. (1981). Institutes Working on Tissue Culture for Genetic Conservation. IBPGR, Rome.

WITHERS, L. A. (1982). Institutes Working on Tissue Culture for Genetic Conservation. A Revised List. IBPGR, Rome.

WITHERS, L. A. and WILLIAMS, J. T. (eds.) (1982). Crop Genetic Resources. The Conservation of Difficult Material. IUBS, Serie B42.