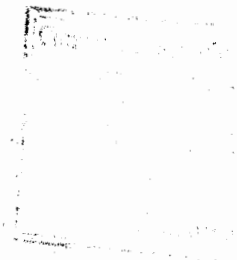
WORKSHOP ON GERM-PLASM EXPLORATION AND TAXONOMY OF POTATOES

Held at CIP, Lima, Jan. 1973



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At the request of Dr. Richard Sawyer, Director General of the Centro Internacional de la Papa, a workshop was set up to examine priorities and recommend an action programme for the next five years on potato germ-plasm exploration and taxonomic research.

The present document sets out a summary of the discussions and recommendations, pointing out priorities and indicating the individuals and organizations from whom co operation might be sought, in addition to the work envisaged at the Center itself.

The members of the workshop were as follows:

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I. Introduction

A wide genetic base for the breeding of new potatoes in all parts of the world needs no stressing. More and more, breeders are turning to the use of wild species and primitive cultivated forms to solve problems of disease resistance and adoptation to a wide range of environmental conditions.

Unfortunately, this reservoir of genetic variability, which until a few years ago had been taken so much for granted, is now diminishing at an alarming rate. The old highly complex pattern of diversity is, paradoxically, being replaced by the newly bred cultivars which are themselves derived from it. Such an erosion of genetic diversity is a process that must be halted, if breeders are to continue the production of new varieties and now in the near future.

The conservation of our rapidly diminishing germ-plasm resources in gene banks, either by means of seed or in various other ways is becoming a matter of increased urgency year by year.

As a basis for genetic conservation, a carefully coordinated plan of exploration and collection needs to be established. It was the purpose of this workshop to examine the situation carefully in order to ascertain how much material already existed in potato gene banks in various parts of the world and to make plans for collecting as much as possible of the genetic resources as yet unexplored.

At the same time the workshop recognized the need for taxonomic research in order to provide a basis for genetic and plant breeding studies and to help with the more efficient utilization of the gene-bank material.

II. Germ-Plasm Exploration

Potatoes occur indigenously either as cultivated species or wild species, or both, right through the American continent, from the USA southwards to southern Chile and Argentina. Many collecting expeditions have taken place in the past, but much living material has been lost. In many areas the evidence of dried herbarium collections

indicates the occurrence of a species where no living material has been gathered. Some species, which are known to widespread and variable, are represented in gene banks by one or two collections only. Others are well-collected from a certain region but totally unrepresented by living material from the rest of their distribution area. Very often, the cultivated species have been collected haphazardly, without a properly coordinated plan.

It was therefore agreed that the first task of the workshop should be to examine the priorities, country by country, for wild and cultivated species, for exploration work. Our task was greatly helped by the provision of a series of species distribution maps made by J.P. Hjerting, under the direction of P.R. Rowe; these gave details of living and non-living collections, species by species and country by country for the wild species held in the Sturgeon Bay gene bank. The data of non-living collections were mostly taken from the literature. Unfortunately there had not been time to make up similar maps for the cultivated species, but plans for these are under way and are noted in the list of recommendations made by this workshop.

A working document prepared for the workshop (see Appendix 1) formed an additional basis for discussion, as well as a report to F.A.O. on genetic erosion in potatoes (see Appendix 2).

Priorities were established under three heads:

1. Genetic erosion in progress or threatened.

2. Plant breeding needs, based on knowledge of the species and/or areas concerned.

3. Lack of living material in comparison with known distribution area, even though plant breeding needs are unknown. Taxonomic interest.

For each country or group of countries we have assigned A, B, or C priorities in descending order, A being most important. In some instances, the situation seemed of such importance or the threat of genetic erosion so great that an E category for emergency was assigned. This conforms to the classification used by F.A.O.

In a few cases the word none was assigned, where material was considered to be of no value or had already disappeared.

III. Priorities for Germ-Plasm Exploration (see pp. 10 - 11 for summary)

1. USA, Mexico, Guatemala

Little obvious genetic erosion is taking place with the wild species though they are of obvious interest to plant breeders because of their resistance to Phytophthora, viruses and insects. For many of the species, especially those of northern Mexico, and the USA, the living material in collections represents a very inadequate sample of the total geographical distribution. Although the main

outlines of their formal classification have been worked out there are many biosystematic problems of interest that await solution.

These are no indigenous cultivated potatoes in the USA but those of Mexico and Guatemala are so much threatened that the situation should be classed as "emergency".

2. Central America

The wild species are of low priority for collection so far as erosion or plant breeding interests are concerned, but of slightly higher interest taxonomically, since they form a linkage group between Mexico and South America. There are, however, so few species and of such limited distribution that very little effort would be needed to collect them.

There would seem to be no indigenous cultivated species in Central America and the varieties grown are recent cultivars of no interest for germ-plasm exploration.

3. Venezuela

We have some evidence of genetic erosion in the wild species and there is a complete lack of living collections in this group. We are not aware of any plant breeding needs in the wild species of Venezuela.

Erosion is also known in the cultivated species, and collections are apparently lacking in gene banks, though there may be some in the Bogotá collection, Colección Central Colombiana. No information on plant breeders' needs is available.

4. Colombia

Genetic erosion of the wild species is intense, because of habitat destruction (forest felling). No interest to plant breeders has yet been seen in this group, but more material is required in the living state.

Genetic erosion in the cultivated species is also intense, as a report from L. López indicates (see Appendix 2). One species (S. phureja) is of interest to breeders as a source of bacterial wilt resistance. Further collections are necessary but later assessment of the situation will be made when the cultivated species distribution maps have been completed.

5. Ecuador

The extent of genetic erosion of the wild species was not known to members of the workshop. Plant breeding needs were not yet apparent, but since practically nothing was available in living collections this group would rate high on that count.

For cultivated species, C. Ochoa reported to other members of the workshop that genetic erosion was threatened and that very little material existed in gene banks.

The cultivated material also seemed to be of considerable interest to breeders. Thus on two counts at least, this group of potatoes were rated at highest priority.

6. Perú

The wild species of Perú represent a particularly interesting part of the total number known, and from reports by C. Ochoa at the meeting and by Z. Huamán (see Appendix 2) they are threatened by erosion in a number of areas, both through the spread of urbanization and the destruction of forests. In Ancash Department some of the wild and the cultivated forms may have suffered genetic erosion by earthquake damage. Furthermore, a rather limited amount of the wild species exists in collections and very little has been evaluated for plant breeding needs. Even so, what has already been examined shows considerable promise.

Considerable genetic erosion amongst the cultivated species was reported by C. Ochoa (see also Z. Huamán's report in Appendix 2), throughout the whole country, with the northern part of the country (Ancash to Piura) showing particular stress. In the central departments (Huánuco, Pasco, Junín, Huancavelica) the threat is intense though not so much as in the north, where complete ranges of cultivars have disappeared in the last ten years. Even in the more traditional south the newly bred cultivars such as Renacimiento are beginning to be accepted but have not replaced the older ones as yet. However, it was felt that this situation would not last for long.

It was therefore agreed that an emergency classification should be assigned for genetic erosion, with A qualification both for plant breeding and taxonomic interests. Although much material had been collected by C. Ochoa, some of which was already in the CIP gene bank, it was hoped that Ochoa's collections now growing at Cuzco could also be added and a central documentation file built up. This should be done with the greatest possible speed so that gaps in the collections could be identified and filled without delay. From the discussions it also emerged that the diploid, triploid and pentaploid forms were even more threatened than the tetraploids; hence from this point of view, and especially in relation to di-haploid breeding programmes and a study of the relationships between ploidy levels, in addition to the reasons discussed above, the workshop emphatically placed an emergency rating on the Peruvian cultivated potatoes as a whole.

7. Bolivia

From the personal knowledge of C. Ochoa and J.G. Hawkes, the Bolivian wild species were not thought to be in great danger of genetic erosion, but were rated more highly on plant breeding interest and lack of living collections (see also Appendix 1).

The cultivated species are threatened by erosion as Ochoa and Hawkes pointed out during the discussion (see also reports by M. Cárdenas and M. Zavaleta in Appendix 2). The category "B" should be assigned to them in respect of plant breeders' interests and need for further collection.

8. Argentina

Wild species here have been well-collected in the past and are continuing to be explored by the Balcarce group (K.A. Okada). They are of great interest to breeders also for their Heterodera resistance, though the need for collections has been largely met. Therefore the priorities here are not so high, even though it is certain that adequate collecting can be relied on from the Argentine colleagues.

The cultivated indigenous materials from Argentina are gravely threatened with extinction (see Appendix 1) and would rate an emergency category. More knowledge of these from a taxonomic viewpoint is needed also.

9. Chile

Leaving aside the non-tuberiferous Etuberosa series there is only one wild species in Chile - S. maglia. It would merit a low rating for erosion or plant breeding interest, but more collections, especially of diploid cytotypes, are needed from its whole range.

The situation regarding the cultivated Chilean potatoes has long since passed the emergency level and has reached the point of total extinction, according to a verbal report made by C. Ochoa at the Workshop meeting, and a report to F.A.O. of which a copy was shown to the Chairman. All varieties now grown in Chile, with possibly one or two exceptions, are European or Chilean bred cultivars of recent origin.

Fortunately, C. Ochoa visited Chile in 1969 and made 270 samples, many of which are still kept in the University collection. There are also some 40 lines in the Sturgeon Bay gene bank made by D. Correll. Although some may be duplicates there must still be a reasonable range of Chilean material available here and there, the major part being the extremely valuable Ochoa collection.

Since practically nothing now exists in the natural distribution area of the Chilean cultivated material the Workshop could not assign priorities to this group, apart from the plant breeder' interest.

10. Uruguay, Paraguay, Brazil

A "B" priority was assigned to the wild species for collection needs. Little was known on genetic erosion or plant breeders' interest.

No indigenous cultivated potatoes exist in these countries.

IV. Taxonomy

The pattern of variability of potatoes, as with most other ancient cultigens, is a complex one. Species boundaries are often unclear and phenotypic plasticity renders taxonomic problems even greater. Thus the cultivated forms have been separated in to as many as 35 species or grouped together into a single one, S. tuberosum. In a similar way, the wild species, of which many are of great interest to breeders, are highly varied and can be grouped into about 150 species or split into more than 250.

From a practical point of view, and to be of maximum use to the breeders, a reasonably simple and workable taxonomic system will be of the greatest value. Forthis reason, a broad concept of species and grouping will provide a system in which fewer name changes are likely, even though it might not always fit in with current phylogenetic ideas.

The Workshop considered that for the purposes under discussion, first priorities should be given to the provision of a simple and clear system of classification, special attention being paid to the cultivated forms.

At a different taxonomic level it would be of value to look at biosystematic problems at the interface between taxonomy and cyto-genetics, so as to provide further information about the possible evolutionary relationships between and within species. In this way, results of value to breeders, helping with the evaluation and utilization of material, should be forthcoming. Again, this research should as far as possible be directed towards the cultivated species or wild species of interest and value in breeding research.

It was also suggested that numerical taxonomic projects might be carried out, using a programme already found to be valuable by D. Ugent for Mexican potato species.

The need for continuing to use chemotaxonomic methods when appropriate was also stressed.

V. Priorities for Taxonomic Research (see p. 12 for summary)

This section should be read in conjunction with the Taxonomy section of the working document provided for the workshop (Appendix 1).

The taxonomic series into which the tuber-bearing species of the genus Solanum have been divided were examined in sequence, and priorities from A to C assigned for taxonomic research.

Priorities

None 1. Juglandifolia These two series have been traditionally assigned to the
None 2. Etuberosa tuber-bearing group on their general morphology even though they are not tuber-bearing.

In view of the fact that no hybrids have been made between these and the tuber-bearing species, despite many attempts, no priorities for taxonomic research have been set on them, within the interests of CIP.

C 3. Morelliformia A satisfactory taxonomic system has been established
C 4. Bulbocastana for the species in these series. Some biosystematic work would be of interest.

C 5. Pinnatisecta (See notes in working document) There are still a few problems of species delimitation, through lack of living collections, but the main systematic outlines are clear.

C 6. Commersoniana (See notes in working document) The main taxonomic system in this series is reasonably clear.

A few problems need elucidation, however.

C 7. Circaeifolia No formal taxonomic problems exist in this series.

A 8. Conicibaccata Basic Taxonomic work, using living and dried collections, is urgently needed with this series. Biosystematic studies involving an analysis of the higher polyploids would also repay attention. Undoubtedly several species could be sunk into synonymity.

A 9. Piurana Much work is needed to define the limits of this series and to study the species in greater detail. More living collections are required.

B 10. Acaulia Further taxonomic work is needed at the biosystematic level to clarify the status of subsp. aemulans and subsp. albicans, as the higher polyploids within subsp. punae.

B 11. Demissa More biosystematic studies are needed on this economically important Mexican series. (See working document).

C 12. Longipedicellata The formal taxonomy of this group seems to be in fairly satisfactory state, though some biosystematic problems would repay further study.

C 13. Polyadenia (As for Longipedicellata).

C	14. Cuneolata	The relationship of the newly described species, S. anamatophilum, to S. infundibuliforme needs elucidation when living material of the former is obtained.
B	15. Megistacroloba	Studies on living material of certain species not as yet well known would be valuable.
C	16. Ingaefolia 16a Olmosiana	Biosystematic studies are needed here but the taxonomy is satisfactory.
	17a Tuberosa	Wild species (See working document).
C	Colombia	Few problems.
A	Ecuador	Much more research on this group is needed when living collections have been made.
A	Perú	(As for Ecuador)
A	Bolivia	(As for Ecuador)
C	Argentina	Few problems.
C	Chile	Few problems.
E	17b Tuberosa	Cultivated species.

Apart from biosystematic studies on the individual species as mentioned in the working document (Appendix 1), there is an outstanding need for a series of booklets, describing the main group of varieties country by country, in a manner similar to those published by the Rockefeller Foundation and associates for the races of maize in Latin America.

Such a series of booklets should be written in collaboration with specialists in the various countries and should be published as soon as possible. C. Ochoa informed the workshop that he had already been engaged on such a study for Perú, and it was therefore hoped that the Peruvian booklet would be the first in the series. Each treatment would set out the data on levels of ploidy and / or species as well as being based on tuber, leaf, and flower characters, etc. Some keys to the identification of varietal groups might be possible, based perhaps on tuber and / or leaf and flower characters.

It was stressed that this whole subject should be treated as of "emergency" priority.

D. Ugent mentioned a scheme of studying potato fields in three or four selected areas with a view to describing the agro-ecological and ethnobotanical aspects of "primitive" potato cultivation before it was swept away forever.

The Workshop thought that this plan although of great interest, might fall with in the area of the National Science Foundation for attracting support funds rather than CIP. Nevertheless, it was hoped that when a concrete plan was put forward, CIP would be given the opportunity of commenting on it with a view to providing certain on-the-spot facilities and general support.

VI. Summary of Priorities for Germ-Plasm Exploration

1. U.S.A., Mexico, Guatemala

Wild

1. C
2. A - B
3. A - B

Cultivated

1. E
2. C
3. C?

2. Central America

Wild

1. C
2. C
3. B

Cultivated

1. None
2. None
3. None

3. Venezuela

Wild

1. B
2. C
3. A

Cultivated

1. B
2. ?
3. A

4. Colombia

Wild

1. A
2. C
3. B

Cultivated

1. A
2. B
3. C?*

5. Ecuador

Wild

1. ?
2. C
3. A

Cultivated

1. A
2. B
3. A

6. Perú

Wild

1. B
2. B
3. A

Cultivated

1. E
2. A
3. A

* Needs later assessment

Key: On page 11.

7. Bolivia

Wild

1. C
2. B
3. B

Cultivated

1. A
2. B
3. B

8. Argentina

Wild

1. C
2. B
3. C

Cultivated

1. A - E
2. C
3. A

9. Chile

Wild

1. C
2. C
3. B

Cultivated

1. None **
2. C
3. None **

10. Uruguay, Paraguay, Brazil

Wild

1. C?
2. C?
3. B

Cultivated

None

** All gone; now only in collection.

Key:
1. Threat of genetic erosion.
2. Plant breeders' needs
3. Lack of living material, taxonomic interest.

A. High priority.
B. Medium priority.
C. Low priority.
E. Emergency.
None: No interest.

VII. Recommendations for Germ-Plasm Exploration

A. Cultivated Species

1. It is recommended that highest priority be given to exploration of cultivated potatoes in the following countries.

   Perú, Ecuador, Mexico, and Argentina

2. The next highest priorities should be given to the cultivated potatoes of Venezuela, Colombia and Bolivia.

   Notwithstanding the above, it is hoped that collecting activities will be carried out along a broad front in the next five-year period throughout the whole area under discussion.

B. Wild Species

1. The highest priority countries for wild species collections should be:

   Venezuela, Colombia, Ecuador, Perú

2. Next highest:

   Mexico, Bolivia

3. Lowest priority:

   Central America, Argentina, Chile, Paraguay, Uruguay, Brazil.

VIII. Recommendations for Taxonomic Research

It is recommended that the highest priority be given to taxonomic research on the following series:

Conicibaccata	
Piurana	
Tuberosa	From Ecuador, Perú and Bolivia (Wild Species).
Tuberosa	From all Andean countries (Cultivated Species). In view of their plant breeding importance, special emphasis should be placed on taxonomic research in this group.

IX. Collaboration suggested for various countries

1. U.S.A. Funds to be solicited to encompass wild species collections in 1973/1974; D. Ugent to make collections or report on other botanists willing to do so.

2. Mexico, Guatemala D. Ugent to be responsible for cultivated species collections.

3. Central America Local contacts to be established eg. Luis González at San José and Jorge Soria at Turrialba, Costa Rica.

   Contacts to be sought in Honduras with the Ministry of Agriculture at Tegucigalpa and with Antonio Molina at the Escuela Agrícola Panamericana nearby.

4. Venezuela Contacts to be sought with Alvaro Montaldo and other colleagues at Maracay concerned with potato research.

5. Colombia Luis López at I.C.A. to be contacted and asked to put forward a planned collecting programme.

6. Ecuador C. Ochoa to make contact with G. Albornoz, at Sta. Catalina (I.N.I.A. P.) and to arrange collaborative collecting expeditions.

7. Perú The problems of adequate germ-plasm collection are so large that it should be necessary if possible to have at least three collecting teams in the field at the same time, working to a coordinated network plan. This will need to be related to the material and documentation already existing in gene banks, details of which were not available to the Workshop. Help should be requested from Prof. C. Vargas of Cuzco.

8. Bolivia Further collecting work here will be made in collaboration with M. Zavaleta, M. Cárdenas and A. Vidaurre. Two Dutch expeditions will visit Perú and Bolivia in 1974 and 1975 respectively, and their routes and collecting programmes should be coordinated into the general master plan. Support funds for the Bolivian collectors would be needed.

9. Argentina The main collecting work here will be done by K.A. Okada (I.N.T.A.). Priorities for the rapid collection of cultivated potatoes should be conveyed to I.N.T.A. with suggestions for immediate action. The two Dutch expeditions will also be working in this country, and plans should be integrated accordingly.

10. Chile Contacts should be made with:

Andrés Contreras	Valdivia
Alberto Cubillas	(now in Comell)
Primo Accatino	(Santiago)

It should then be possible to decide whether any material still exists which is worth collecting. Support funds would probably be needed.

11. Uruguay It should be possible for K.A. Okada to collect here.

12. Paraguay "Miss E. Bordas" (Asunción) can be contracted and asked to send material from various parts of the country. Some modest support funds would probably be needed.

13. Brazil Contacts should be made with D. Mota da Costa, Raúl Ribera and O. Drummond.

Mota da Costa has already signified that he would be interested to make further collections in the southern states of Brazil.

X. Further Recommendations

The Workshop further recommends that:

1. A thorough survey should be made of all cultivated and wild material existing in gene banks.

2. Mapping of cultivated material should be made by hand, in a similar way to the maps already made at Sturgeon Bay for the wild species.

3. A programme should be put under way immediately in collaboration with Dr. David Rogers (Boulder, Colorado) to set all records into suitable form for computer storage and retrieval, using a system such as TAXIR*. Key data should include accession numbers, collector's name and number, country, Department, Province, nearest locality, latitude, longitude, date, altitute, species name, etc. All other relevant information should be added. On the basis of this scheme, which falls into the international system agreed by F.A.O., printouts of basic material and computer distribution maps may be provided on request, and other data files concerning morphology, resistance to disease, etc. etc. may be later added. A pilot project is now under way, using TAXIR, in which CIP, Sturgeon Bay and the Commonwealth Potato Collection (C.P.C.) are collaborating, the results of which will be reported at the Rome meeting on the Conservation of Crop Genetic Resources in March.

4. First priorities in germ-plasm collecting should be given to cultivated forms, having in mind the general programme already outlined.

5. Further help in germ-plasm exploration should be sought from competant person other than those mentioned in section IX such as J.P. Hjerting (Copenhagen).

6. Similarly, the first priorities in taxonomic research should be given to cultivated forms.

7. In relation to conservation work the workshop stressed that if the plan outlined in this paper come to fruition that adequate facilities be made for the expanded amount of

* "Taxonomic Information Retrieval System"

material which the gene bank will have to hold.

8. Further, it was stressed that the bank should possess as broad a base as possible of material in the form of true seed. Research on the techniques to be used to convert the cultivated forms to true seed should be conducted as soon as possible.

9. In addition it was recognized that a limited number of cultivars, breeding lines and genetic stocks should be maintained clonally for a number of years, for demonstration and research purposes. Certain odd-number polyploids may also need to be maintained clonally.

10. Finally the workshop suggested, although conceding that this was beyond its brief, that there was an urgent need to increase efforts in evaluation to facilitate the utilization of the material for the needs of developing countries.

XI. Suggested time Schedules for Germ-Plasm Collections and Related Activities

1973

1. Mapping of cultivated species (at Wisconsin or elsewhere)
2. Collecting expedition in:

Perú	(C. Ochoa, Jackson, etc.)
Mexico	(Ugent)
Argentina	(Okada)
Bolivia	(Zavaleta, etc.)
Ecuador	(Ochoa, et al.)
	(or in 1974)

Small funds to be set aside for collecting aid in areas of low priority.

1974

1. Collecting expeditions in:

Perú	(Ochoa, Jackson, Huamán)
Bolivia	(Zavaleta, etc.)
Colombia	(López, etc.)
Venezuela	(López, Montaldo)

First Dutch expedition to Perú, Bolivia, Argentina.

2. N.S.F. Programme in Perú (Ugent)
3. Continue data storage programme, computer mapping, etc. (Rowe, Rogers, Hawkes).

1975

1. Collecting expeditions in:

Perú	(CIP Staff)

Second Dutch expedition to Perú, Bolivia, Argentina.

Colombia	(López et al.)
Mexico	

2. N.S.F. Programme (continued) (Ugent)

3. Data storage programme (continued).
4. Junior fellowships (2) for germ-plasm and taxonomic studies.

1976
1. Collecting expeditions in:
   Perú
   Other countries as considered necessary.
2. Workshop on Germ-Plasm
   collection, classification, maintenance and utilization.

1977
1. More collecting efforts to be concentrated in areas not adequately covered in previous four years.
2. Further action to be taken on the basis of the 1976 Workshop on Germ - Plasm collection, classification, maintenance and utilization.

Members of the Workshop ended the meeting by expressing their thanks to Dr. Sawyer, Director General of CIP, for inviting them to take part in the meeting and for generously providing facilities and hospitality.

APPENDIX 1

Notes for the Workshop on Exploration and Taxonomy of Potato Species, at C.I.P., Lima, January 1973

A. EXPLORATION

The extent to which potato exploration work is needed will not be known exactly until the survey of material in the Sturgeon Bay gene bank is completed. We shall then be in a position to relate the material actually available to the total distribution area of each species and in this way identify gaps in the coverage. By January 1973 this information should be available, as well as data from C.I.P. itself, the C.P.C., C.C.C. and other collections.

At this stage, certain guidelines can be set out, as follows:

1. U.S.A., México and Guatemala

   a) Wild species An important center of variability occurs in Central México, with another center of lesser importance in Guatemala. North of the 26th parallel the species thin out and only two are to be found in the U.S.A. The approximate distribution of species in this area are known but living collections are almost certainly limited to a few easily accessible localities. Therefore, much collecting work in México and Guatemala is needed, related to what collections exist in Sturgeon Bay as well as the Rockefeller Foundation potato seed bank in Chapingo. The help of United States botanists should be enlisted to collect seeds of S. jamesii and S. fendleri from throughout their ranges in the south-western States.

   b) Cultivated species There was probably never very much variation amongst the cultivated potatoes of México and Guatemala, and no indigenous varieties are known from the U.S.A. The variation that once existed in the Mexican and Guatemalan cultivars has now probably been largely if not entirely replaced by bred cultivars of the type introduced by the Mexican Ministry of Agriculture, in association with the Rockefeller Foundation.

All types so far found in this region are 4 x S. tuberosum forms, many of them with characters of subsp. andigena. They undoubtedly sprang from post-Colombian introductions.

The present situation should be evaluated especially for the remoter higher altitude potato growing areas in México and Guatemala where recent cultivars might not yet have become established.

2. Central America (Honduras, Nicaragua, Costa Rica, Panamá)

a) Wild species The amount of diversity in these countries is slight, being confined to a few species in series Conicibaccata. Living collections are needed, however, since most former collections have died out, and what remains is possibly one or two lines only of S. longiconicum from Costa Rica.

b) Cultivated species In Central America it seems probably that all forms cultivated belong to S. tuberosum subsp. tuberosum, recently introduced or bred locally. They are probably of little interest for gene bank purposes.

Help in this area for wild and cultivated collections might be solicited from I.I.C.A. at Turrialba, Costa Rica.

3. Venezuela, Colombia, Ecuador

a) Wild species In these countries the wild species still need to be collected, since very little living material is available, apart from certain collections of S. colombianum, S. flahaultil, S. tuquerrense and S. moscopanum.

Several species have never been available for study in the living state (see taxonomy section) and co-ordinated collecting plan for the whole area should be set up, with headquarters in Bogotá.

b) Cultivated species Collections have been made in Colombia, Venezuela and Ecuador by the writer and Colombian collegues, and have been cultivated in Bogotá in the Colección Central Colombiana. This took place some 20 years ago, and new collections should be made of diploid and tetraploid forms to replace losses and complete the collection.

4. Perú

a) Wild species This is the most important country in South America with regard to variability in wild and cultivated species. Many wild species collections have been made and are stored in gene banks as living material. However, a vast amount of collecting still remains to be done in all parts of the

country, based on the distribution data already obtained by Ochoa and others. This would seem to be top priority so far as the conservation of wild plant genetic resources is concerned.

b) Cultivated species A well planned and co-ordinated scheme for the collection of cultivated species throughout the country is needed, related to the collections already present in C.I.P., Sturgeon Bay and elsewhere. Special attention should be paid to weed forms in southern Perú and varieties from the remoter areas where the new cultivars and selections have not yet penetrated. Attention should be paid also to the eastern slopes and valleys of the Andes to search for S. phureja cultivated material. The help of Professor C. Vargas and Ing. Agr. Fidel Flores in Southern Perú should be engaged.

5. Bolivia

a) Wild species These have been collected recently, in 1971, by the Birmingham University Expedition and it is hoped to augment these collections by the Dutch expeditions in 1974 and 1975. Special attention is bein paid to certain regions for the solution of taxonomic problems (see taxonomy section).

b) Cultivated species Much exploration work is still required, even though the 1971 material is now conserved at C.I.P. The continued help of Ings. Agrs. M. Zavaleta, H. Gandarillas and S. Alandia will be needed, as well as advice from Professor Cárdenas and further help from Sr. Vidaurre of Potosí. A co-ordinated plan should be elaborated, involving help in the collection of wild and cultivated material by the colleagues mentioned above.

6. Argentina

a) Wild species Much collecting work has been done by Hawkes and Hjerting, and is being ably continued by Okada. The taxonomic and genetic conservation problems are well understood on the whole, though certain areas in the east, west-central and north-east regions must still be explored.

b) Cultivated species The collections made by Hjerting and co-workers in the 50's have now been lost and may not now be replaceable. Material might be obtainable from Brucher, though this is doubtful in view of possible virus infections and poor documentation. A search should be made without delay for cultivated and weed forms, especially since Brucher has claimed that material of different ploidy level exists in Argentina. Help should be obtained from Okada and also Virsoo (Tucumán) if he is able to take part in this project. The assistance of Ruis Leal in Mendoza should also be enlisted for surveys in Mendoza, San Juan and the Nahual Huapi regions, where more collecting is certainly needed.

7. Chile

a) Wild species Very few tuber-bearing wild species occur in Chile. Collections of the non-tuber-bearing series Etuberosa would be valuable from the botanical point of view, since although no crosses with the Tuberosa gene pool have yet been accomplished there is no reason to suppose that this could not be accomplished in the future.

b) Cultivated species The very valuable Ochoa collection from southern Chile will be conserved and discussions should take place between Dr. Ochoa and Chilean agronomists to see whether there is any other material that ought still to be collected.

8. Brazil, Paraguay, Uruguay

No indigenous cultivated forms are known from these countries but living collections of S. commersonii, S. chacoense, subsp. muelleri and S. caldasii are needed, especially in the form of fertile diploids.

B. TAXONOMY

Suggestions for future taxonomic work are set out series by series.

1. Juglandifolia

Living collections and taxonomic work on species in this series are needed, but this hardly seems to fall within the interests of C.I.P. Discussions next August at the special interest group on Solanaceae during the Boulder meeting on Systematic and Evolutionary Biology might well provide decisions on future work in this series and its relationship to other genera (e.g. Lycopersicon, etc.)

2. Etuberosa

Taxonomic work, based on living collections, is needed for this series, though probably not at a very high level of priority in view of the so far insurmountable cross-ability barriers between it and the tuber-bearing species. It remains of interest, however, in view of the immunity to viruses of the species so far investigated. Hybrids may perhaps be obtained in the future through naked protoplant fusion, so the series should perhaps not be totally disregarded in C.I.P. progammes.

3 & 4. Morelliformia and Bulbocastana

The main outlines of the species in these series are clear so far as formal systematics is concerned. Experimental work on species relationships, however, may well provide information of value to breeders in the future.

5. Pinnatisecta (including Trifida)

The formal taxonomy of this group, also, remains reasonably clear, though S. hintonii and S. nayaritense have not yet been collected in the living state and are thus urgently in need of investigation. Natural and artificial hybrids between species in Pinnatisecta, Bulbocastana and Morelliformia need investigation also. The hybrid nature of S. x michoacanum as postulated by Correll, is now accepted, and S. trifidum is recognized as a genuine species of considerable interest. More collections and taxonomic studies are needed with S. stenophyllidium. The nature of S. nicaraguense has now been postulated and perhaps needs little further attention.

6. Commersoniana

The taxonomy of this series is fairly well-known in main outline. However, some investigations on the interface between the two subspecies of S. commersonii in Entre Ríos province are needed, as well as the forms of S. chacoense subsp. muelleri in southern Brazil. Much more knowledge of the taxonomic position and relationships of S. calvescens is required, and for this purpose more collections should be made in Minas Gerais, Paraná, Santa Catarina and Rio Grande do Sul States.

S. yungasense and S. tarijense are well-known, though the origin of the former would repay investigation.

7. Circaeifolia

Relationships between the two species in this series, S. capsicibaccatum and S. circaeifolium, should be investigated, as well as their position vis-a-vis other series.

8. Conicibaccata

Much taxonomic work is urgently needed on this series, since many species are unknown in the living state and others are not well studied. Some species boundaries need revision and cytological work on the nature of the polyploid series is required. An interesting chemotaxonomic study of this series is being carried out by L. López (Colombia).

9. Piurana

Since my 1963 'Revision' was published I have become less happy about this series. If it is retained some species will need to be removed from it and place in series Conicibaccata or Tuberosa. Much material needs to be assembled in the living state and biosystematic studies carried out. Polyploidy is also seen here and needs further cytological investigation.

10. Acaulia

Whilst the taxonomy of subsp. acaule and subsp. punae is clear, much still remains to be understood with regard to subsp. albicans and subsp. aemulans. Higher

polyploids of subsp. punae in northern Perú should be further studied as well as the origin of this apparently autotetraploid species S. acaule, as a whole.

11. Demissa

This is a rather heterogeneous group, mainly of hexaploids, but with two pentaploids and a diploid species, S. verrucosum. This latter should perhaps be restored to series Tuberosa where Rydberg first placed it. Of the two pentaploid species, the origin of S. edinense has been verified by Ugent, but that of S. semidemissum is unknown. One common ancestor for the hexaploids (S. verrucosum) has been postulated by Marks but the other parents for each are completely unknown.

The whole group would form the basis for an excellent cytotaxonomic study.

12. Longipedicellata

Species boundaries for the taxa in this series are satisfactory, though S. stoloniferum may need further subdivision. The nature of S. vallismexici has been established by Marks, and species relationships among the tetraploids have been established by the writer. However, the parental diploids of these polyploids are not known, and cyto-genetical work is therefore needed to elucidate this problem.

13. Polyadenia

The biosystematic relationship of this series to others should be further investigated. More should be known about the distribution of S. lesteri through new collections in southern México (Oaxaca, etc.).

14. Cuneoalata

There seem to be no outstanding taxonomic problems in this series. (But a recently described Peruvian species may be placed here).

15. Megistacroloba

Several species in this series are imperfectly known, and some have never been studied in the living state.

16. Ingaefolia

The relationship of the species S. ingaefolium and S. rachialatum to each other to S. olmosense in series Olmosiana needs investigation, and their distribution areas should be defined more precisely.

16a. Olmosiana

See under 16, above.

17a Tuberosa

a) Wild species Because so many species are placed in this series it will be convenient to discuss them by countries.

Colombia Only two species are known for this country, one of which, S. labbianum, has never been studied in the living state.

Ecuador There are probably about four species in this country. None is well known experimentally, and more work on all of them is required.

Perú There is an extreme richness of Tuberosa species in Perú, greater than in any other part of the Andes, with some thirty species now recognized. Much work is needed on a wide range of species from this country, and it seems probable that greatest efforts should be concentrated on various systematic and evolutionary problems on the Peruvian taxa.

Bolivia Some fifteen species are now recognized from Bolivia, one or two of which spread into Perú. Investigations on several groups of Bolivian species are under way at Birmingham (especially the weed species group which also spreads into Perú), but work by other investigators would be welcomed.

Argentina The taxonomic problems of most Argentinian Tuberosa species are solved, but with some work still needed on certain taxa which spread into Bolivia.

Chile Only one species (S. maglia) is known, and little work is needed.

17b Cultivated species

(i) S. ajanhuiri. The nature and origin of this species is being studied by Z. Huamán.

(ii) S. stenotomum This species needs further taxonomic study with regard to infraspecific classification. Since it is generally assumed to be the most primitive of all the cultivated potato species, biosystematic studies are required to identify its wild prototype.

(iii) S. phureja The relationship of this diploid species to S. stenotomum should be further investigated, as well as the forms of this species from Perú, if they can be found.

(iv) S. x chaucha Cyto-taxonomic studies on this hybridogenic species are being carried out by M. Jackson to investigate the extent of gene flow from diploid to tetraploid cultivars and vice-versa. Artificial lines are being synthesize and compared with naturally-occurring lines.

(v) & (vi) S. x juzepczukii and S. x curtilobum The nature of these two hybridogenic species has already been established. (Hawkes, 1962).

(vii) S. tuberosum (including subsp. andigena). Good evidence has now been provided from recent studies (unpublished) by P. Cribb to substantiate the hypothesis (Hawkes, 1956) of its origin from natural crosses of S. stenotomum x S. sparsipilum. A paper by H.W. Howard also adds considerable weight to this hypothesis. Further work with subsp. andigena dihaploids is under way at Birmingham.

Classification of groups of varieties of subsp. andigena in the Andes would probably be worthwhile. Such a classification (following the lead of the excellent work of the maize geneticists) should include dichotomous keys and should be based on leaf, flower and tuber characters.

Final Conclusions

The preceding notes are set out as a basis for discussion in an attempt to show very approximately the areas where further efforts should be concentrated.

In the writer's view, emphasis should be placed on experimental studies linked to morpho-geographical data wherever possible. Cytology, genetics, chemo-and sero- taxonomy should be brought in, and numerical- taxonomic studies should be considered wherever possible.

From the results of the taxonomic studies it should then be possible to make the material more available for potato breeding and general utilization.

J.G. Hawkes,
Birmingham.
January, 1973

APPENDIX 2

Potato Genetic Erosion Survey - Preliminary Report

January, 1973

J.G. Hawkes

1. Introduction

The F.A.O. Unit for Crop Ecology and Genetic Resources asked me to carry out a survey, through correspondents, of the extent to which genetic erosion is or may be taking place in the centers of variability of the cultivated potato and its wild relatives.

Until 1971 I had assumed that very little erosion was taking place in the main gene centers of the South American Andes, though much evidence was available to show that in Chile the old land races had been disappearing rapidly from about 1950 onwards, because of the bad Phytophthora epidemics which occurred at that time.

However, whilst taking part in a collecting expedition to Perú and Bolivia in 1971 I became aware that the richness of varietal diversity had diminished very startlingly, as compared with the situation in 1939 when I last visited those countries to collect cultivated potatoes. I had assumed that the Andean potatoes would be protected from genetic erosion by the fact that standard European and North American varieties cannot be grown at the high altitudes to which the Andean potatoes are adapted. Nevertheless, the Andean potatoes themselves had changed. In fact, during this 30-year period the local breeders some of whom I myself had helped to train, had begun the processes of breeding and selection which are now causing the replacement of much of the old richness of primitive forms and species by better yielding standard varieties.

Furthermore, agronomists and extension officers had promoted the cultivation of a limited number of selected variants or land races, even when new cultivars were not available. These also, were replacing the old richness of varietal diversity.

Fields were much tidier in 1971 as contrasted with 1939. There was an almost total absence of wild and weeds forms in the furrows and around the field borders, in marked contrast to their relatives abundance in 1939. This indicated an apparent end to the process of co-evolution of crop and weeds by hybridization and gene flow from one to the other - a process which had probably been continuing for several thousand years, ever since potatoes were first domesticated.

Most expeditions to a gene centre, our 1971 one included, tend to keep chiefly to the main roads, so that the desired areas may be explored in the time available. Hence the situation may be less alarming than appears at first sight. It is possible that in the more remote regions where the communications are poor, where the plant

explorers or extension officers fail to penetrate, or where the stronger forces of tradition militate against the adoption of newer varieties, then the original genetic diversity may still remain intact. However, we can have little cause for complacency, since experience with other crops and in other parts of the world has shown that new high yielding cultivators can extend rapidly in a few years into extremely remote regions, thus displacing the old land races entirely.

So far as wild species of potato are concerned, the situation is somewhat better. The greatest threat is to the potato weed species, which, strangely enough, seem often to "take refuge" in maize or other fields at the lower altitudes, but cannot do so at levels where maize is not grown. The main threat to the truly wild species is the usual one of habitat destruction, particularly in the vicinity of the ever-expanding capital cities and in the natural forests, which themselves are threatened with complete destruction in many regions.

In view of what has been said above it seemed to be a matter of urgent necessity to attempt a more careful survey of genetic erosion in potatoes.

I discussed the matter with Sir Otto Frankel of C.S.I.R.O., Canberra, Australia, and Dr. Jorge León, Chief of the Crop Ecology and Genetic Resources Unit at F.A.O., Rome. They advised me to carry out a survey by correspondence with colleagues in those countries where the potato is cultivated or occurs wild, within the general area of its "natural" distribution, so as to obtain further information on the problem. It was further hoped that the information would be of value to Dr. Richard Sawyer, Director of the International Potato Center at Lima, Perú, in helping him to plan a strategy for the exploration and conservation of potato materials in the gene bank that is now being established in his Institute. The matter has also been discussed with Dr. Roger Rowe, Director of the Inter-regional Potato Introduction Station at Sturgeon Bay, Wisconsin, U.S.A., who has on my suggestion instituted a careful study of the genetic range of living material, species by species, in the Sturgeon Bay gene bank.

It must be emphasized that the present account is no more than a preliminary survey, which it is hoped will act as a basis and a stimulus for a more exact report at a later date. Enquires were made from sixteen colleagues in México, Venezuela, Colombia, Ecuador, Perú, Bolivia, Argentina and Chile. Replies were received from five colleagues only, though fortunately these were from the main potato-growing countries of Venezuela, Colombia, Perú, and Bolivia. This account, then, represents the views and experience of these colleagues, as well as my own, and is thus incomplete. When the exploration work which will be planned and co-ordinate with the International Potato Center begins to take shape the picture will undoubtedly become clearer.

2. Genetic erosion in the U.S.A., México, and Guatemala

a) Wild species An important center of variability occurs in central México, with another one of lesser importance in Guatemala. North of the 26th parallel

the species thin out, and only two are to be found in the U.S.A. So far as I am aware, there is no serious threat to the wild species in this area, though I should point out that I have received no information from correspondents and my last major expedition there took place in 1958.

b) Cultivated species There was probably never very much variation amongst the cultivated potatoes of México and Guatemala, and no indigenous varieties are known from the U.S.A. The variation that once existed in the Mexican and Guatemalan land races has now probably been largely if not entirely replaced by bred cultivars of the type introduced by the Mexican Ministry of Agriculture, in association with the Rockefeller Foundation. A survey of the present situation is urgently needed.

3. Genetic erosion in Central America (Honduras, Nicaragua, Costa Rica, Panamá)

a) Wild species The amount of diversity in these countries is slight, being confined to a few species in series Conicibaccata. I suspect that habitat destruction in the high mountain forests constitutes a threat to the species growing in them, but I am not at present in a position to make a clear statement in this respect, since I have no potato-scientist contacts there and have not made a recent visit.

b) Cultivated species In Central America it seems probable that all forms cultivated belong to S. tuberosum subsp. tuberosum, recently introduced or bred locally. They are probably of little interest for gene bank purposes.

4. Genetic erosion in Venezuela

a) Wild species I have no knowledge of the threat to wild potato species in this Country.

b) Cultivated species Dr. Alvaro Montaldo writes:

"Venezuela cultivates 14,000 hectares of potatoes. Of these, 10,000 hectares are localized in the lower zone (450-1000 m) and the intermediate zone (1000-2000 m), where new varieties such as Sebago, Red Pontiac and Alpha are grown. The Andean States of Mérida, Táchira and Trujillo at heights of between 2000 and 3500 m some 4000 hectares of potatoes are grown. About half of this area is occupied by old varieties such as 'Arbolona negra' (s. andigena) and a very small part by S. rybinii (=S.phureja)".

Only the S. tuberosum subsp. andigena and the S. phureja forms need concern us here, and unfortunately the information is not detailed enough to indicate whether genetic erosion is taking place or not. Further information has been requested.

5. Genetic erosion in Colombia

a) Wild species I have no recent information but I suspect that the destruction of the forests which was taking place in 1948-51 when I worked in Colombia is still continuing, with the consequent diminution of the distribution areas of the wild species growing in them.

b) Cultivated species Sr. Luis López writes:

"It is difficult for me or for any of my countrymen to give good information on the extent of the erosion of genetic variability in cultivated potatoes in my country due to the lack of recent collections to compare with those that you yourself made in the years 1948-1951.

It is not difficult to imagine the loss of many cultivated varieties which are highly susceptible to diseases, bad shape and poor commercial quality since several highly selected hybrids have been distributed to the potato areas with good acceptance by growers and in the markets. Those newly bred cultivars such as 'Ica Purace', 'Ica Guantiva', 'Ica Tolima', Cumanday', etc. which are high yielding are replacing most of the old varieties in the whole country. The "Instituto Colombiano Agropecuario" through the Extension Service and the "Programa Nacional de Tuberosas" is encouraging the farmers to grow bred cultivars which have good yield, and resistance to certain diseases.

The demonstration to farmers of the advantages of growing bred cultivars in their own lands is convincing them that they should replace their old varieties with newly bred ones because they can achieve higher incomes. The highly selected hybrid 'Ica Purace' is actually cultivated in all the potato areas and more or less 30 per cent of the whole production of potato in the country is 'Ica Purace'. Nevertheless, consumers are very conservative and they are asking for the old commercial varieties such as 'Tuquerreña' in the departments of Boyacá, Cundinamarca and Nariño; 'Tocana Blanca', 'Tocana Rosada', 'Pamba Blanca', 'Pana Azul' in the department of Nariño; 'Yema de Huevo' (Solanum phureja) in most of the country; 'Salentuna' in Caldas and Antioquia departments. The extent of this requirement stimulates the farmers to grow them, despite their low yield.

Old varieties such as 'Lisarza and 'Salentuna' in Caldas are imposible to replace because of their very good adaptation to high altitudes and resistance to transport damage on mules or car and so far no bred cultivar can compete with them in that respect.

It seems quite clear from this account that genetic erosion has taken place to a very large extent in Colombia; nevertheless, the situation would seem to be by no means hopeless, especially since the will and the means to make new collections are present.

6. Genetic erosion in Ecuador

No information has so far been forthcoming from that country. The situation would probably be rather similar to that in Colombia.

7. Genetic erosion in Perú

a) Wild species Sr. Zósimo Huamán writes:

"In April 1971, during the Birmingham University Potato Collecting Expedition to Bolivia and Perú, we collected wild potato species in the Dept. of Puno, Cuzco, Apurimac and Junín, in the same places as I collected them in 1970 or in the type localities of Hawkes, Vargas and Ochoa's species. For example, S. canasense, S. soukupii, S. multidissectum, S. raphanifolium, S. lignicaule, S. marinasense, S. calcense, S. ochoae, S. pumilu, S. bukasovii, S. pampasense, S. abbotianum, etc.

Some species such as S. hawkesii (Machu Picchu, Cuzco) S. longimucronatum (Curahuasi, Abancay, Apurímac), etc. are not found any more in their type localities.

The situation of wild species from the Lomas along the Pacific Coast is seriously threatened by the grazing of goats and use of desert land for building new towns. Thus, S. wittmackii in the Lomas de Amancaes, near Lima: S. neoweberbauri, in the Lomas del Cerro Morro Solar, Chorrillos, Lima, etc.

So far, I have not made collections of wild or cultivated potatoes in the Northern Region of Perú."

My own observation coincide with those of Sr. Huamán; in addition, my experience in Northern Perú indicates that certain species inhabitating medium altitude forests on the eastern slopes are threatened because of the threat to these forests themselves.

b) Cultivated species Sr. Zósimo Huamán writes:

"The Peruvian Ministry of Agriculture through its National Potato Project has established Agencies for an Agricultural Extension Service all over the potato growing areas of Perú. This organization has at least one agency in each Distrito and its role is to encourage the growing of newly bred varieties, use of fertilizers, weeding practices, etc., by the Andean farmers in order to raise the national average yield of potatoes. Moreover, the recent Law of Land Reform and Law of Agricultural Co-operatives are giving more backing to crop improvement of potatoes, maize, etc.

All these organizations have already shown their effectiveness in the attempt to raise the standard of living of the Andean people. In this way the cultivated area with bred varieties such as 'Renacimiento', 'Mantaro', 'Mariva', etc. is increasing every year. Furthermore, there is a trend to grow some old cultivars which have a great acceptance in the market because of their quality, flavour, etc. for example, Ccompis in Cuzco; 'Yurac sisa' in Apurímac; 'Chata Blanca' in Junín, etc.

The Peruvian Potato Programme has devoted great attention to its branches in Cuzco and Puno because here the level of education of the people retards the process of changing patterns of communal life and customs. Therefore, the replacement of old cultivars and primitive forms of potatoes is taking place very quickly in the center of diversity of potatoes. This is so not only in farms near the main roads, but also in small villages, through the activities of the Agricultural Schools or primary schools. It is quite common for teachers to introduce newly bred varieties and cultivate them in small patches near the school to demonstrate to the people their resistance to diseases, better yield, etc., compared to native varieties.

In the Central and North Regions of Perú the depletion in variability of potatoes is even greater than in the South because the level of education has made the introduction of newly bred varieties easier.

In 1969 an earthquake of great intensity was concentrated in the Callejón de Huaylas, Ancash Department; consequently a large number of old cultivars of potatoes were lost because great extensions of cultivated land were covered by earth. Although a fortnight before the earthquake, Srs. Fermín de la Puente and Luis López collected almost 100 clones in markets and fields near the main road, it is highly likely that a great deal of variability was lost. Therefore, it would be advisable to initiate collections on a large scale in those regions threatened by natural disasters.

In 1970 López and I took part in a collecting expedition around Cuzco, Apurímac, Ayacucho, Huancavelica, Junín, Pasco and Huánuco. We were able to appreciate that many varieties were not found in local markets because either they could not be sold easily or they were cultivated in small areas for family consumption. We made good collections in fields during harvesting and in the temporary heaps set out in the fields before storage.

Unfortunately, I have not made collections of cultivated potatoes in these Departments again and therefore I cannot give a precise report on the genetic erosion in potato germ-plasm which is taking place in those regions.

Some varieties of Solanum x curtilobum and S. x juzepczukii, which are cultivated around 4,000 m are highly susceptible to Spongospora subterranea, Synchitrium endobioticum, etc. In Huancavelica, Ayacucho and Puno I saw these heavily infected varieties being harvested and learned that the farmers were willing to change to the newer bred varieties grown by more prosperous local farmers which do not show a marked degree of infection.

One of the most threatened species is S. stenotomum subsp. goniocalyx in the North of Perú. Varieties such as 'Amarilla', 'Yema de Huevo', etc. are practically disappearing because they are highly susceptible to virus diseases and have a low yield despite their good quality."

The account given by Sr. Huamán speaks for itself. Genetic erosion is clearly taking place in Perú, and to an extent as great as that in Colombia. More details are required, though the general outline is clear. A well-planned and co-ordinated scheme for the collection of cultivated potato species throughout the country is needed, paying special attention to weed forms in southern Perú and to areas where the new cultivars and selections have not yet penetrated.

8. Genetic erosion in Bolivia

a) Wild species Sr. Moisés Zavaleta writes:

"In weed and wild potatoes collected in different places in Bolivia and at different times, we observed strong genetic erosion. Thus, in Mocomoco, Prov. Muñecas, Dept. La Paz, we found in 1958 five different kinds of 'taihua' a weed potato that grows like 'lelekoyo', in maize fields; the tuber shape was either rounded or long and the skin colour was black, white, red or yellow. The tubers were about 120 grams each and some clones showed short dormancy. Recently we went to make a new collection of this material but could find only the red round-tubered form.

In Killumblaya, near Puerto Acosta, Prov. Camacho, Dept. La Paz we found another weed potato with same name, 'taihua', but this sample was different from that found in Mocomoco, and is very similar to one in Santiago de Huata, Prov. Omasuyos, Dept. La Paz.

In Culpina, Prov. Sud Cinti, Dept. Chuquisaca, we saw in 1964 many weed potatoes in potato fields, but when we returned in 1967 we observed few weed plants in the potato fields.

Our first collection of the wild species S. achacachense was made from plants growing between stones by the road from Achacachi to Sorata in 1958. Today they can only be found on rocky slopes in places where they are inacessible to grazing animals.

In 1963, going by road from Aiquile to Sucre, we collected many samples in the field between stones and scrub. In our 1969 trip we looked for the same samples but could not find any wild potatoes. However, far from the road amongst cactus and spiny scrub, we found some, because in these places they were protected from goats.

Thus erosion of genetic variability in weed and wild potatoes seems to be due principally to the elimination of weeds from fields of potato and to the grazing of animals such as goats which eat all wild potatoes, unless they are specially protected."

b) Cultivated species Professor Martín Cárdenas writes:

"The task to be undertaken is of course very immense since we do not possess enough information from surveys some 30 to 40 years ago to tell what species have become extinct. A unique factor which menaced wild, weed and cultivated potatoes was the Reforma Agraria, a political law which has given all the available agricultural land to the Indians. Before this Reforma, landlords or patrones, having a special knowledge of certain fine potato varieties, had as many of these cultivated as possible. I still remember when visiting the high - altitude estancias a very fine assortment of 'Papa huaycus' belonging to several varieties of S. andigena and S. stenotomum. Now these are not to be found. I believe that it will be necessary to collect again as much as possible of the potato species and varieties, wild, weed and cultivated, and to keep it in a gene bank before it disappears completely, through the destructive action of civilization."

Sr. Moisés Zavaleta writes on the cultivated potatoes, as follows:

"During the last ten years I have made many trips around Bolivia, collecting cultivated potatoes in many parts of the country.

In S. phureja it seems that most cultivars are infected with virus diseases, and for this reason farmers prefer to grow them on the upper parts of the mountains where sometimes there is a danger of frost.

In Millipaya, Prov. Larecaja Dept. La Paz, I found in 1962 great variability in S. phureja cultivars. The most important cultivars were 'Kellu phureja' and 'Chiar phureja'. In 1967 I returned to collect samples but could find none, even though I made enquiries of many farmers and walked to many farms to try and get samples of these two cultivars. During this collecting session I found a large field of 'Alka phureja' which is the most commonly grown cultivar of S. phureja.

Between Sorata and Tacacoma, 10 years ago I found many field of 'Janko Phureja'; today it is difficult to find samples of this cultivars.

Ten years ago during my first trip to Tacacoma I collected many samples of potatoes, most of them S. andigena. This material was cultivated in glasshouses at the Belen Experimental Station and was also planted in the field. All samples showed good healthy plants, comparatively free from virus. In material collected subsequently in the same place most of the cultivars were seriously infected with virus diseases. I also found different varieties to those collected during the first visit, two of the most interesting being 'Pichuya' and 'Pala'.

In 1962 the S. ajanhuiri cultivars 'Janko ajahuiri'and 'Yari'were found in many parts of the Prov. Pacajes, Dept. La Paz. However, in my 1968 trip I found few samples, most of them with very small tubers.

Many cultivars of S. stenotomum and S. goniocalyx are used to prepare special dishes by the farmers and are eaten at home. They are grown in small plots and for this reason many cultivars are some times not found in the markets. The most important cultivars are 'Culi', 'Pina', 'Kunurana', and 'Zapallo'.

The S. andigena cultivar 'Sicha' was mentioned by many collectors during early explorations. I looked for this cultivar in many places but could not find it. Particularly characteristic is that it has an 8 month growing period, black skin, yellow flesh and rounded tubers. Today some tubers with similar characteristics and falsely called 'Sicha'. However, I made a special trip to Takesi, near Mount Murarata in Dept. La Paz, on the old road from Palca to Chulumani and there I did find many fields of 'Sicha'.

In Potosi many people talk about 'Janka papa' cultivars. Their production is mentioned for Tinkipaya, Prov. Frías, Dept. Potosi. The interesting feature of this tuber is that it must be roasted, not boiled. It has small rounded tubers with black skin. I could find no samples of this cultivar.

Cultivars of S. juzepczukii are more susceptible to virus infection than those of other species. All material of S. juzepczukii when grown at the Belen Experimental Station was seriously infected with virus.

After the introduction of 'Sani imilla', which is a selected cultivar, I observed that the most primitive forms had disappeared in many places. Although it has good yield its quality is bad. At first it commanded the same price as the good cultivar 'Chiar imilla' but last year the price was lower than that of 'Chiar imilla' because of the inferior watery tubers.

Another important species that was mentioned in many early collections is S. chaucha. Today it is difficult to find samples of it in cultivation.

In Achaccachi, Prov. Omasuyos, Dept. La Paz, before 'Sani Imilla' was introduced we saw mixtures of species, but today most of the fields are cultivated with 'Sani imilla' and there are few plots with a mixture of primitive species and forms.

We conclude that in many parts of Bolivia the erosion of genetic variability is due to the introduction of selected cultivars, and many primitive forms are diminishing or have disappeared altogether."

The conclusion is inescapable that in Bolivia, even more than in Perú genetic erosion in potatoes has been progressing at an alarming rate. Indeed, it would seem that this has now arrived at a point which could be classified as an emergency, on the genetic erosion scale.

9. Genetic erosion in Argentina

a) Wild species From my experience on my 1967 expedition I do not think that genetic erosion amongst wild species has yet reached a dangerous level. No recent report has been received.

b) Cultivated species The collections made by Hjerting and co-workers in the 50's have now been lost. Our experience in 1967 indicated that there had been a drastic diminution in the range of cultivars during the intervening period. It should be understood that I am here referring primarily to the north-western provinces where the indigenous or semi-indigenous land races were cultivated. A search should be made without delay now to salvage the last remnants of this apparantly fast disappearing material.

10. Genetic erosion in Chile

a) Wild species Very few tuber-bearing wild species of Solanum occur in Chile. I have no information as to how far these are threatened. The escaped or weedy forms of S. tuberosum may be disappearing, but again, I have no information on this.

b) Cultivated species Genetic erosion in Chile has been particularly intense not only because the native land races succumbed to Phytophthora in the early 1950's when this disease first made its appearance there, having apparantly no inherited resistance to it, but many European and North American varieties have also been introduced into that Country in the last few decades. Luckily, the valuable Ochoa collection from

southern Chile is being conserved in the Lima gene bank. Further information from Dr. Ochoa and from knowledgeable Chilean potato specialists is required to see whether there is any indigenous material still existing in Chile which still needs collection and preservation.

11. Genetic erosion in Brazil, Paraguay and Uruguay

The amount of genetic erosion with wild species is entirely unkown to me.

No indigenous cultivated forms occur in these countries.

J.G. Hawkes
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