BIBLIOGRAPHIC DATA SHEET

1. CONTROL NUMBER: PN-AAJ-487

2. SUBJECT CLASSIFICATION (695): AF30-0210-G530

3. TITLE AND SUBTITLE (240)

Exploration, taxonomy and maintenance of potato germ plasm III; report of the Planning Conference, Lima, Peru, 1979

4. PERSONAL AUTHORS (100)

5. CORPORATE AUTHORS (101)

CIP

6. DOCUMENT DATE (110): 1981

7. NUMBER OF PAGES (120): 197p.

8. ARC NUMBER (170): 633.491.I61f

9. REFERENCE ORGANIZATION (130): CIP

10. SUPPLEMENTARY NOTES (500)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Potatoes
Germplasm
Taxonomy
Seeds
Storage

13. PROJECT NUMBER (150): 931097300

14. CONTRACT NO.(140): AID/DSAN-G-0079

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

PN-AAJ-487
633.491
I61f

Report of the Planning Conference on the Exploration, Taxonomy and Maintenance of Potato Germ Plasm III

Held at CIP, Lima, Peru
October 15-19, 1979

THE INTERNATIONAL POTATO CENTER (CIP)

INTERNATIONAL POTATO CENTER

REPORT OF THE PLANNING CONFERENCE ON THE EXPLORATION, TAXONOMY AND MAINTENANCE OF POTATO GERM PLASM III

Held at CIP - Lima, Perú

October 15-19, 1979

Left to right: L. Lopez, Z. Huaman, R. Hanneman, C. Ochoa, J. Hawkes, K. Okada, O. Page, L. Snilde, J. van Soest, H. Mendoza, P. Grun.

F O R E W O R D

This is the Twentieth Planning Conference sponsored by the International Potato Center to develop guidelines for the Center's Research.

The first Planning Conference on "Germ Plasm Exploration and Taxonomy of Potatoes" held in January, 1973, was followed by a second Conference in March, 1976. During this second Conference progress achieved during the preceding years in the collection of cultivated species, their taxonomy and maintenance was reviewed. Plans were also formulated to collect wild species.

This triennial systematic review and development of research recommendations has contributed directly to the successful establishment of an outstanding Solanum germ plasm bank. In this endeavour special commendation must be given to Ing. Carlos Ochoa for the hardships endured and the competence with which he has assembled the very large CIP collection.

The specific purpose of this third Planning Conference is to review progress since 1976, to determine the most efficient method of maintaining the germ plasm collection, and to formulate recommendations for future explorations and taxonomic research, particularly of the wild species.

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International Potato Center

PLANNING CONFERENCE ON EXPLORATION, TAXONOMY AND MAINTENANCE OF POTATO GERM PLASM III

A G E N D A

Monday, October 15

	Chairman, morning session. O.T. Page, Director of Research
09:00	Welcome and Opening Remarks. Dr. P.R. Rowe, Deputy Director General
09:30	Tour of CIP research facilities. C. Ochoa
10:15	Coffee

REVIEW OF CIP EXPLORATION AND TAXONOMY PROGRAM

10:30	"Review of Recommendations of March, 1976 Conference: Status of Solanum Expeditions, Collections, and Classifications" C. Ochoa
11:15	"Review of Planning Conference on the Utilization of Genetic Resources: Status of Germ Plasm Maintenance and Computerization" Z. Huamán
12:00	Lunch

Monday afternoon

Chairman, afternoon session.
H. Mendoza, Head,
Department of Breeding & Genetics

13:30 "Collections of Primitive Cultivars"

a) Andean - C. Ochoa

b) Colombian - L. López

14:30 Coffee

WILD SPECIES COLLECTIONS

14:45 "Wild Tuber-bearing Solanums of North America"
J.G. Hawkes

15:15 "Collection and Taxonomy of Argentina Wild Species"
K.A. Okada

Tuesday, October 16

Chairman, morning session.
N. Estrada
Department of Breeding & Genetics

WILD SPECIES COLLECTIONS - Cont'd

08:30 "Collection and Taxonomy of Andean Wild Potatoes (Peru and Bolivia).
C. Ochoa

EVOLUTION

09:15	"Recent Concepts in the Evolution of Tuber-bearing Solanums" J.G. Hawkes
10:00	Coffee
10:15	"Evolution of Tetraploid Cultigens from the View of Cytoplasmic Inheritance" P. Grun

STRATEGY FOR GERM PLASM MAINTENANCE IN COLLECTIONS

11:00	"Computerized Data Management on the Primitive Cultivated Collection Maintained at CIP" Z. Huamán
11:30	"Strategy of the IR-1 Collection" R.E. Hanneman
12:00	Lunch

Tuesday afternoon

	Chairman, afternoon session. Z. Huamán
13:30	"Progress of the German-Netherlands Potato Department of the Genebank in the FAL" L.V.M. van Soest

14:00	Discussion: Interrelationships of CIP with Other Collections. Leader: P.R. Rowe
15:00	Coffee
15:15	Discussion continued

Wednesday, October 17

Chairman, morning session.
K. Brown
Director of Regional Research

QUARANTINE AND UTILIZATION

08:30	"The Role of the IBPGR in Organizing Conservation Networks of Vegetative and Seed Material" J.T. Williams
09:15	"In vitro Maintenance of Valuable Solanum Resources at CIP" L. Schilde
09:45	"Present Use and Future Needs for Wild Solanum Species in Breeding at the International Potato Center" H. Mendoza
10:15	Coffee
10:30	Discussion

Thursday, October 18

A Committee of three will formulate recommendations arising from presentations and discussions during the preceding sessions.

The Committee will fly to Huancayo at 08:00 Thursday morning.

All participants will return by air Thursday afternoon.

Friday, October 19

Chairman, morning session.
O.T. Page

09:00	Summation of Recommendations and Establishment of Research Priorities.
	I Explorations
10:30	Coffee
10:45	II Taxonomy
12:00	Lunch
13:30	III Maintenance

***

I. Recommendations for Potato Germ Plasm Exploration

A. Cultivated Species

The Planning Conference noted with pleasure that most of the objectives for the exploration and collection of cultivated materials, as noted in the 1976 report, had now been fulfilled. However, further work was considered to be necessary in the following countries:

1. Mexico (no progress since 1976)
2. Colombia (more samplings needed in the departments of Huila, Boyacá, Santander and Bolívar (Sierra Nevada de Santa Martha)).
3. Chile (more sampling required in the Island of Chiloé, the nearby mainland and the Chonos Archipiélagos).

B. Wild Species

1. The criteria for wild species in assessing collecting that were used in the 1976 report were applied here, as follows:

    1. Absence from germ plasm collections.
    2. Potential usefulness for potato research and improvement.
    3. Threats to habitat and consequent genetic erosion.

    In addition, when planning an expedition, collectors should pay special attention to species that have known resistance or other traits of interest for potato improvement.

For each country or region the same priorities were used as in 1976, namely:

E	:	Emergency
A	:	High priority
B	:	Medium priority
C	:	Low priority

This conforms with the FAO classification.

The AGREED PRIORITIES and criteria for countries, regions or sections of countries were as follows:

Country	Priority	Chief Criteria
U.S.A.	B	2,3
Mexico	A	1,2
Guatemala	B	1,3
Central America	A-B	1,3
Venezuela	B	1,3
Colombia	A	1,3
Ecuador	B-C	1,3
Perú (North)	E-A	1,3
Perú (Central)	B	1,2
Perú (South)	A-B	1,2
Bolivia	A-B	1,2
Chile	B-C	1,2,3
Argentina	B-C	1,2
Uruguay	C	1
Paraguay	B	1
Brazil	B*	1,2

* "A" for *S. calvescens*

2. Further work on the wild potato species is needed as follows:

PRIORITY 1. It is gratifying to note that of the species listed in 1976 report that did not exist in gene banks, some 16 species have now been collected in the living state. A further few species were described between 1976 and 1979, of which none are deposited in gene banks. The CONFERENCE URGES collectors as a matter of high priority to pay particular attention to species unknown in banks as well as those known on the basis of a very few collections. A new list of material not available in living collections is included in Annex I.

PRIORITY 2. Even those species deposited in the banks in more satisfactorily high numbers may still be providing only a fraction of their total range of diversity. The CONFERENCE therefore, RECOMMENDS that provenance data for all materials in gene banks be thoroughly scrutinized in order to identify areas within the total distribution of wild species where further collections would be justified. In this respect the newly developed data management systems may be of very considerable help, and where grid coordinates are given for collections computerized map printouts for living accessions should be contemplated.

3. Collectors should be ENCOURAGED to use population sampling methods and to take more samples throughout the species range than has hitherto been the general practice. They should also document their collections on standardized data sheets in accordance with the recommendations provided by FAO and IBPGR.

4. A subsample of all material collected must be offered to the country of origin. Collectors should also be encouraged to send sub-samples to one or more of the gene banks at CIP, Sturgeon Bay and Braunschweig.

II. RECOMMENDATIONS FOR TAXONOMIC STUDIES

A. Cultivated Species

The Planning Conference was gratified to note that the taxonomic and biosystematic studies on cultivated potatoes recommended in the 1973 and the 1976 Planning Conference reports have now been completed.

The identification of duplicate accessions in the CIP collections has progressed rapidly since 1976 and some 30% of the accessions studied have been eliminated.

Further work on the cultivated potatoes is needed, as follows:

PRIORITY 1. It is RECOMMENDED that the identification of duplicates in the CIP collection be continued as rapidly as possible. Electrophoretic verification of morphologic duplicates should be carried out.

PRIORITY 2. It is RECOMMENDED that the taxonomic status of the cultivated potatoes of Mexico and Chile be studied. In this respect, the IBPGR-sponsored work at Valdivia, Chile, should be encouraged.

PRIORITY 3. It is FURTHER URGED that an investigation be carried out on the possible wild ancestors of the cultivated species.

PRIORITY 4. The Conference RECOMMENDS that descriptions and classifications of the primitive cultivar groups within each species and level of ploidy be carried out. These should be published in parts as completed and distribution maps should also be included.

B. Wild Species

Taxonomic research on the wild species SHOULD BE CONDUCTED with a view to understanding species relationships and thus to facilitate their use in plant breeding.

PRIORITY 1. It is RECOMMENDED that taxonomic monographs of the wild species be prepared.

PRIORITY 2. It is RECOMMENDED that emphasis should be given to biosystematic studies in the following series and species:

(a) Series Etuberosa in relation to Series Tuberosa.

(b) Series Acaulia.

(c) Series Tuberosa, particularly *S. gourlayi* and *S. oplocense*, the *S. bukasovii* complex and *S. sparsipilum*.

(d) Series Pinnatisecta, Bulbocastana, and Polyadenia in relation to Series Tuberosa.

(e) Series Longipedicellata.

(f) Series Demissa.

PRIORITY 3. It is RECOMMENDED that an Atlas of the wild species and their breeding potential be prepared.

III. RECOMMENDATIONS FOR DOCUMENTATION AND DATA MANAGEMENT

1. The Planning Conference noted with pleasure that the recommendations of the 1976 Planning Conference on standardized descriptors and descriptor states* as well as the self-sufficiency in computer assisted data management have all been satisfactorily achieved.

2. Since knowledge of the availability of genetic resources is crucial to their evaluation and eventual utilization in potato improvement the CONFERENCE RECOMMENDS that those in charge of gene banks should be encouraged to

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* See Report of the Planning Conference on "The Utilization of the Genetic Resources of the Potato II" Annex I - A list of descriptors for the cultivated potato. October,1977.

publish up-to-date inventories of their holdings. These should always include the collectors' numbers as well as the gene bank accession number.

3. In connection with 2 above, IT IS RECOMMENDED that CIP should promote the early preparation of world indexes and inventories of potato genetic resources based on information held by CIP and other gene banks. These should include, inter alia:

   (a) Indexes of species, collector's name and number, with the equivalent accession numbers for the various gene banks.

   (b) Inventories of species, collector's name and numbers, and evaluation data.

   (c) Inventories of species, collector's name and number with the appropriate provenance data (e.g. country, department, province, locality), altitude, etc. ("passport data").

4. The Conference ALSO RECOMMENDS that gene banks should be encouraged to develop appropriate data systems for seed storage germination tests and regeneration management. Inventory control systems are already available.

5. It is further RECOMMENDED that all collectors be strongly urged to submit full information on their collections to gene bank managers for inclusion in the appropriate data banks.

6. In this connection it is also RECOMMENDED that evaluation of cultivated and wild materials at CIP and elsewhere continue to be carried out and that the results of such evaluation be submitted as soon as possible to data banks. Evaluation data obtained at CIP should be exchanged internally and with other institutions or gene banks.

IV. RECOMMENDATIONS FOR GERM PLASM MAINTENANCE

1. It is RECOMMENDED that CIP continue to be responsible for the maintenance, regeneration and distribution of the cultivated species. True seed should be obtained for all duplicate clones before they are discarded.

2. When converting duplicate material into true seed, it is RECOMMENDED that crosses should be made among different accessions of similar geographic origin, both for diploids and tetraploids. Tetraploid clones should not be selfed or sib-mated for maintenance purposes because of the real danger of inbreeding depression. However, this process may be of value in revealing the presence of recessive characters which could be useful in plant breeding.

3. Duplicates of odd-numbered polyploids would be discarded, with the knowledge that true seed at the same ploidy level cannot be obtained. (See page 8, # 9).

4. Where many duplicates of a clone are identified it is RECOMMENDED THAT up to three accessions should be retained, representative of different parts of its geographical distribution, or when conflicting evaluation data have been obtained.

5. It is RECOMMENDED that in addition to CIP, duplicate long-term base storage of potato germ plasm seed collections be arranged in laboratories situated in two different continents. Long term base storage has already been established at the National Seed Storage Laboratory in Fort Collins, U.S.A. It is suggested that this facility might also be established at an appropriate institute in Europe.

6. The CONFERENCE ENDORSES the 1976 recommendation that a cooperative exchange scheme should be developed by CIP with IR-1 at Sturgeon Bay, the BGRC at Braunschweig, and if possible with other centers, for the regeneration and exchange of true seed of the cultivated and wild species. Duplicate samples should be deposited in one or more of the cooperating centers for safe storage (see also 5, above).

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7. The CONFERENCE RECOMMENDS that seed regeneration be conducted when germination has fallen to 10-15% below the level at which it was first put into store. Ideally, seed regeneration should involve at least 20 plants bulk pollinated, assuring that each plant has an equal opportunity of contributing to the next generation. It is RECOMMENDED that research be conducted on the effects of seed storage and regeneration methods on the genetic composition of the material.

8. The CONFERENCE RECOMMENDS that research on the long-term storage of *in vitro* plants and their distribution be actively pursued. In particular, more experience should be obtained on *in vitro* storage at 25°C under minimal conditions. The work on liquid nitrogen storage of meristems for very long-term conservation should also be continued. It is also RECOMMENDED that research be carried out on problems of long-term tuber storage.

9. The CONFERENCE URGES CIP to re-examine its priorities on the conservation of germ plasm and breeding materials. In this connection it is suggested that certain cultivated clonal materials now at risk (particularly diploids and odd-number polyploids) be put into *in vitro* culture as an emergency precaution against total loss.

10. In order to cover the danger of meristem collection losses through natural and other disasters IT IS RECOMMENDED that duplicate collections be stored at some other appropriate institute.

V. PLANT HEALTH AND QUARANTINE

1. The CONFERENCE STRONGLY RECOMMENDS that studies be continued on the adaptation of tissue culture techniques to problems of freeing clones in the germ plasm collection from pathogens. In particular, the use of chemotherapy for virus elimination and methods of PSTV eradication in seeds and clonal material should be pursued.

2. IT IS RECOMMENDED that quarantine facilities be reviewed at CIP. IT IS ALSO SUGGESTED that new breeding stocks should be segregated at a safe distance from the CIP collections.

VI. FINAL COMMENTS

In conclusion, the Planning Conference was most impressed with the rapid and efficient way in which CIP has carried out the major part of the recommendations of the 1973 and 1976 conferences and offers its congratulations and thanks for the hospitality and facilities provided.

Material not Available in Living State in Gene Banks or Research Institutes

Series	Species	Country
Commersoniana	S. calvescens	Brazil
Conicibaccata	S. ayacuhoense	Perú
	S. buesii	Perú
	S. burkartii	Perú
	S. garcia-barrigae	Perú
	S. jaenense	Perú
	S. multiflorum	Perú
	S. neovargasii	Perú
	S. pillahuatense	Perú
	S. tundalomense	Ecuador
	S. villuspetalum	Perú
	S. woodsonii	Costa Rica-Panamá
Cuneoalata	S. anamatophilum	Perú
Etuberosa	S. palustre	Chile
	S. subandinum	Chile
Megistacroloba	S. x brucheri	Argentina
	S. chavinense	Perú
	S. hawkesii	Perú
Olmosiana	S. olmosense	Perú
Pinnatisecta	S. hintonii	Mexico
	S. nayaritense	Mexico
	S. stenophyllidium*	Mexico
Tuberosa	S. amabile	Perú
	S. colominense	Bolivia
	S. contumazaense	Perú
	S. cyanophyllum	Ecuador
	S. mollepujroense	Bolivia
	S. orophilum	Perú
	S. pascoense	Perú
	S. pumilum	Perú
	S. regularifolium	Ecuador
	S. scabrifolium	Perú
	S. suffrutescens	Ecuador
	S. torrecillasense	Bolivia
	S. trinitense	Perú
	S. virgultorum	Bolivia

* Material so named in certain collections may be incorrectly identified.

The International Potato Center

Dr. Roger Rowe

It is a pleasure for me to have the opportunity to welcome you to CIP and to give the opening remarks at this Planning Conference on the EXPLORATION, TAXONOMY AND MAINTENANCE OF POTATO GERM PLASM. First, in the name of the Director General and the CIP staff I welcome you to the INTERNATIONAL POTATO CENTER and to PERU. We want your stay here to be pleasant as well as productive. Each of you has left other responsibilities to come here to help us in our work. We appreciate this and we want to do everything possible to see that at the conclusion of this Conference you feel that your time has been used well.

I would like to review briefly what we expect to gain from this Conference. We would like an assessment of how our work stands now in relation to what was planned 3 years ago and in relation to the current situation in the field as a whole. Our program should be reviewed and evaluated not only within the context of CIP but also in relation to the recent developments at other institutions. In the work on germ plasm I believe that institutional cooperation has special significance.

Once you have established the current situation the next step is to develop recommendations for future work. It is important that you be aware of the philosophy and policies of CIP as they impact on decisions that you may make. In this context I wish to mention the CIP PROFILE 1970-1995 which has been distributed and which you should read. This document was developed to define the long-range goals and objectives of CIP. You will see that CIP intends over the next 10-15 years to concentrate on research to solve specific production problems, to help in the development of certain key national programs, and then phase out certain research areas in order to concentrate on work where CIP has a long-term comparative advantage here in PERU.

Specifically, in the next 2 years, CIP plans to solve the problems of the use of true seed for commercial potato production, and at the same time resolve the problems of growing potatoes in the low tropics. This technology must be in farmer's fields by the end of 1982. These research efforts will receive emphasis, not thru a larger CIP budget but from reductions in other efforts. CIP is at its maximum level of staff and facilities and no substantial real growth in budget is anticipated during the next few years.

Certain other key research areas have been defined and a time table for accomplishing certain goals has been set in the PROFILE. Specifically of concern to this Conference, the PROFILE indicates that by 1982 all collections of wild and cultivated species will be terminated and taxonomic work will focus on the effective and efficient utilization of the collection.

By 1990 CIP will be concentrating on the research for which it has a comparative advantage. These include: MAINTENANCE AND UTILIZATION OF THE WORLD COLLECTION AND THE DISTRIBUTION OF MATERIAL RESULTING FROM RESEARCH WITH THE COLLECTION.

Senior staff at headquarters will be reduced by one half by the year 2000. These will be replaced by visiting scientists who will use the germ plasm collection as a base for their research.

I don't believe that I have to go into detail on these points or to re-emphasize them. The significance of the statements are apparent. The overall view is that CIP expects to conclude in the next 2 years work on exploration and to concentrate on that work required to maintain and to utilize the materials. This Planning Conference should direct itself to developing recommendations for short-term and long-range work that will meet these objectives.

We wish to have available as a base for future work at CIP a complete, well-documented, healthy, and well-organized collection of potato germ plasm. This germ plasm should be available to all potato scientists in the world.

You should be aware of a change which influences your work. The location of Region I Headquarters has been changed from Lima to Bogota. One of the primary reasons for doing this was to give added security to the maintenance of the

lection. We hope to have a complete set of germ plasm in Colombia under the supervision of the Regional Scientist. This applies to the cultivated collection since it has to be grown each year in the field and this is subject to national catastrophics. This is a matter you may want to consider this development in view of maintenance needs.

This is your charge. Each of you has a particular set of interests and a particular knowledge. We ask you to join that knowledge together at this point for what you do during this Conference will have a great impact on the genetic resources that are to be available to your scientific colleagues now and in the future.

Review of Recommendations of March 1976 Conference: Status of Solanum Expeditions, Collections and Classifications

Eng. Carlos Ochoa

During the Taxonomy Planning Conference II in March 1976, I reported progress in our work of exploration, collection and classification of potatoes. This work covered the period 1973-1975. Results from 1976 to the present are included in this Report.

Following in a North-South direction of the American sub-continent I shall discuss principally the field work performed in collection of wild species and native cultivars during this period of 1976 to the present.

The strategic location of the International Potato Center, near the area of origin of the potato, has enormously facilitated these expeditions. The areas of exploration and collection of the material were chosen in accordance with the urgency recommended in Taxonomy Planning Conference II of 1976. We placed greater emphasis on those regions of greater genetic erosion. Some were considered emergency areas (= E) and others as priority areas designated high (A), medium (M) and low (B), in accordance with classifications used by FAO. Thus, the most important areas indicated were specified by countries under the following criteria of priorities:

I. For Cultivated Species

1. Genetic erosion in progress or threat or extinction.

2. Needs regarding potato improvement based on knowledge of the species and/or areas involved.

3. Lack of living material in comparison with the areas of distribution, even though their breeding needs are not known.

II. For Wild Species

1. Availability in the germ plasm collections.
2. Their potential use for research.
3. Erosion of habitat.

The following Table sums up the priorities for the collection of cultivated and wild species by country, and the work done until now:

COUNTRY	PRIORITIES			
	Cultivated	Exploration	Wild	Exploration
Venezuela	A	+, CIP	B	CIP
Colombia	B	+	B	-
Ecuador	B	CIP	A	CIP
Peru	B	CIP	E-A	CIP
Bolivia	B	CIP	A	CIP
Argentina	A	+	A-B	+
Chile	C	+, CIP	C	+,CIP
Paraguay	-	-	B	-
Uruguay-Brazil	-	-	A*-C	-
Mexico	E	-	A	-
Guatemala	B	CIP	B	-
Central America	-	-	C	-
U. S.	-	-	C	-

E = Emergency, A = High priority, M = Medium, B = Low.

CIP = Explorations made by CIP.

\+ = Explorations made by the same country.

* = For *S. calvescens*.

Venezuela

Priority A was given to the collection of indigenous cultivated potatoes in Venezuela, due to its strong genetic erosion. In September 1976, we made an extensive trip in the whole Andean region of the states of Trujillo, Mérida and Tachira, and gathered more than 140 samples of "papas antiguas" or "criollas." This number represents a record if the peripheral North Andean zone and collections gathered previously by other institutions or authors are considered.

The major part of the indigenous potatoes were collected on high wilderness areas of the states of Mérida and Trujillo. A few collections were also obtained in "conucos" or small plots of cleared land and, finally, in the local markets. It is possible that together with native materials, hybrid origin clones may have been collected. These may have resulted from the selections of hybrid origin made years before at the Estación Experimental de Mucuchíes and distributed in a potato improvement program. Most of these native collections were classified as *Solanum tuberosum* ssp. *andigena*, except for few samples of *S. phureja* Juz. et Buk. and *S. goniocalyx* Juz. et Buk. The samples belonging to hybrid cultivars of European origin such as "Alpha," or of Mexican origin such as "Atzimba," were discarded.

The work of collecting potatoes in Venezuela was performed with the help of the Fondo Nacional de Investigaciones Agropecuarias (FONAIAP) of the Ministry of Agriculture, through the Director, Dr. Alfredo Bustamante, and their potato expert, Dr. Raúl León Palencia, whom I thank.

Regarding the collection of wild species in Venezuela, which was done in 1977, it is of great interest to point out the re-discovery of *S. paramoense* Bitt., of which there was no live material at any germ plasm bank. It is also worth mentioning, for the first time, that this is a tetraploid species (2n=4x=48). Likewise, live material of *S. colombianum* Dun. was re-found in its type location, Tovar, where Moritz gathered it for the first time more than 130 years ago. In addition, the discovery of a new Venezuelan wild species *S. subpanduratum* Ochoa, of tetraploid (2n=4x=48) condition is of the greatest importance. It was painted in colors by Dr. Franz Frey of Kansem, Germany, and appears on the cover of the agenda of this Conference and on CIP's Annual Report 1978.

Colombia

Almost all the Colombian cultivars in CIP's Germ Plasm Bank are from collections made by the Programa de Papa del Instituto Colombiano Agropecuario (ICA). Duplicates of these collections were donated to CIP and represent more than 700 clones, the majority of them being S. phureja, followed in number by representatives of S. tuberosum ssp. andigena. The major part of these collections come from Nariño, Boyacá and Cauca, with a smaller number from Cundinamarca and from Santander. A few samples were collected by us in Nariño, as a complement to the collections we made in northern Ecuador.

We did not gather live collections of wild potatoes in Colombia, nor do we have information about them. CIP does not have this type of material. However, we are interested in obtaining seed of the Colombian wild species, especially of S. andreanum Baker, S. flahaultii Bitt. and S. lobbianum Bitt.

Ecuador

We explored Ecuador very recently to collect wild material in most of its Andean region. This was made possible through the administrative transactions and official permits obtained thanks to the assistance of Dr. Enrique Ampuero, Director of INIAP, whom I thank.

During the 1976 Conference, there was doubt on the category of priorities that should be assigned to Ecuador regarding wild potatoes. I am convinced, after the exploration that it should have been priority "E."

Although rainy season conditions were not favorable, because 1979 was a "dry year," we did locate sites for which no reference was available and collected live material including seed, tubers and even cuttings and seedlings. We are now able to say that some species have been saved from extinction and incorporated for the first time in a live collection. Included in these, for example, are S. paucijugum Bitt. and S. minutifoliolum Correll. Also a wild species with a 2n=6x=72 chromosome content, found in Ecuador, is extremely important from both the taxonomic and genetic point of view and from the implications for breeding programs. This species is now being studied and may become a valuable

source of breeding material in the fight against important problems and permanent dangers such as Phytophthora infestans and diseases caused by viruses.

Likewise, of great significance was finding very rare live material of the Ecuadorian species S. solisii Hawkes. This species was considered almost extinct and was not represented in any germ plasm bank. In this opportunity I report for the first time that S. solisii is a tetraploid species of 2n=4x=48 chromosome content. It is the second species of the Piurana series with these characteristics. The morphology of this species may be appreciated in part through its reproduction on the back cover of the agenda of this Conference.

Summing up, in Ecuador we have explored, among others, the mountain spurs of Célica in the province of Loja; the Cordillera of Chilla in the province of El Oro; the highlands of Sayausí and the wildernesses of Matanga in the province of Azuay; Cañar, Biblian, Azogues and Ingapirca in the province of Cañar; Chimborazo, Chunchi, Alausí in the province of Chimborazo; the region of Guaranda, Magdalena, Tundaloma, approaching the Balzapampa in the province of Bolívar; Baños, Tungurahua, Pelileo, Patate and Carihuayrazo in the province of Tungurahua; Latacunga, Pilaló, Machachi and Cotopaxi in the province of Cotopaxi; Volcán Pichincha, Lloa, Rumiñahui and Papallacta in the province of Pichincha.

The elevation above sea level of the places visited vary between 1,500 and 4,400 meters. The number of samples collected was more than 80, including plantlets and cuttings. Unfortunately, the plantlets and many cuttings did not survive during the time of the expedition and long crossing of the desert of Tumbes and Sechura.

The material collected in the form of tubers and seed was more secure and we now have live collections of S. paucijugum, S. solisii, S. minutifoliolum, S. colombianum and other species.

Although Ecuador is surely the richest country in South American flora in proportion to its size, it is also one of the regions where an extreme and rapid erosion of its natural vegetation is occurring. This is especially true in its Andean region.

According to Alwyn Gentry, Ecuador is likewise surely the least studied country, from the view point of flora. For an idea of the distressing situation of plant erosion in Ecuador, see the communication of Putney, published by UNDP-FAO in 1976 and the accompanying map. In my opinion, a few sporadic trips to Ecuador should be made as soon as possible to collect wild potatoes which have been detected in specific places and of which no live material has been collected previously. These places are threatened by imminent plant erosion and extinction of wild potatoes species. We likewise recommend a more exhaustive exploration for the near future in the regions of the volcanoes Carihuayrazo and Tungurahua in the province of Tungurahua and the highlands near volcanoes Cotopaxi, Antisana and Cayambe in the province of Pichincha, as well as some places we did not visit in the provinces of Imbabura and Carchi.

Peru

During the last 3 years numerous long trips were made in Peru. Field work was undertaken preferentially in the north, because of zones rich in wild potatoes which have not yet been incorporated into live collections. At the same time, we believe that in this region a rapid destruction of natural vegetation is occurring and with this the disappearance of many species of the native flora. Some 15 years ago, we collected wild species in relatively accessible areas in the north. Lately, we returned to these places and it was impossible to find some interesting material. This is the case, for example, of *S. olmosense*, *S. rachialatum*, *S. contumazaense*, *S. trinitense* and *S. scabrifolium*, all of them discovered and proposed by me some time ago. Some of these northern Peruvian species seem to have very restricted areas of dispersion, yet we still hope to relocate and save these materials from extinction. However, finding them does not only depend on the degree of erosion which might occur in its place of origin, but also on the favorable conditions of the rainy season and the time of the visit. It could happen that the rains have been scant or perhaps so excessive that they have produced floods or landslides or that protective vegetation has been eliminated. Occasional frosts could also occur or the fields could have been overgrazed or even the plants eaten by deer, the tubers by foxes, rodents or insects and the fruits by birds. For these reasons, when gathering wild potatoes it should be kept in mind that often it is not enough to make a single visit to the site or sites where a certain species had been found. This is, for example, the case of *S. humectophilum*,

another species of northern Peru which we found only after several trips and intensive search in the still virgin forests of the Amazonic basin. Now we have live material of this species in our collections. Something else which might occur, is the case which currently concerns some extremely rare and therefore valuable material such as S. ingaefolium, in almost extinct species and, therefore, difficult to find. The only collection available to us is found solely in tuber form. As it is diploid and self-sterile, and we have only a single clone, up to now we have been unable to obtain seed.

For the above reasons, we believe that whenever possible in the near future that special attention be given to specific searches for species that are definitely in danger of being lost. These would be specific searches rather than massive collecting expeditions as we have made in the past. Keep in mind that extinction is forever, there is no going back. At another opportunity during this Conference, I shall deal in greater detail with the progress we have made regarding the collection and classification of wild potatoes in Peru and other regions of the South American Andes. Nevertheless, here we wish to stress that one of the unknown regions as far as explorations are concerned has until recently been the Department of Ancash. Nowadays it constitutes one of the most explored areas of Peru, following our field work in April and May 1978. It took us almost 2 months to cover this enormous and difficult area. The employment of such a long time for restricted areas always seems to have been a problem to similar expeditions coming from Europe or the USA that tend to cover large distances and several countries and concentrate in places that are near highways.

Regarding intensive explorations and collections of wild potatoes in Peru, the work in the southern region remains to be done. Although the south has in the past been a zone of almost permanent interest to plant collectors, the available live collections of this vast region seem very limited. At CIP we have a relatively small quantity of samples which were obtained on an occasional basis when time and circumstances allowed during our collections of cultivated potatoes. I believe that it would be advisible to do wild potato collections in southern Peru in the future in order to have more complete living material from that region.

Bolivia

For this country priority A was assigned regarding the collection of wild potatoes. Therefore, we made an extensive exploration of nearly 6 weeks, ending at the beginning of

April 1978. During this time we covered an extensive zone in the Andean region of Bolivia. The whole trip was made using a specially equipped CIP vehicle, and with the assisttance of a driver. The area covered is from the northwestern region, in the vicinity of Lake Titicaca which borders Peru and southeast Bolivia, near Bermejo and Tarija at the border of the Argentine province of Salta. We covered from 15° to 22° latitude South, with areas comprised between 60° and 64° longitude West. During our work, preference was given to the collection of live material. On this occasion more than 120 samples of wild potatoes were gathered. It is interesting to note among our findings in Bolivia, the fact that we obtained live collections of S. circaefolium Bitt., a rare species which, according to the previous list (CIP, 1976), appears as a species which does not exist in any live collection. I must likewise draw attention to the finding of live material of a most rare species, S. alandiae Card. This species is a diploid (2n=2x=24), being the first information on it. It is likewise important to have explored and collected in the locality type of S. acaule Bitt. and S. megistacrolobum Bitt., which is Puna Patanca, where Fiebrig, at the beginning of the century collected the original material employed by Bitter for his original diagnosis. Thus, after 70 years live material of these species have been collected for the first time in their place of origin. During this time, Bolivia was visited by numerous potato collecting expeditions.

Chile

An expedition was made to Chile between the middle of December 1978 and January 6 of this year. The intention was to collect mainly in the region of Valparaíso and Concón, the Island of Juan Fernández, Island La Mocha, the Archipiélago de Los Chonos and the North of the Desert of Atacama.

It was likewise of interest to see the live collections of Chilean Potato germ plasm bank of the Instituto de Producción Vegetal de la Facultad de Ciencias Agrarias, Universidad Austral de Chile in Valdivia. With the exception of the region of Antofagasta and Calama, in northern Chile, the rest of the field work was done with the cooperation of Professor Andrés Contreras, from the Universidad Austral de Chile. He is also in charge of the Chilean germ plasm bank.

In the Central region of Chile, between Valparaíso and Concón, tubers of S. maglia were collected. On the Island

of Juan Fernández the only native species of the island, S. fernandezianum, is almost extinct. We had the good fortune of finding abundant berries which we shared, incorporating part of this material into the Chilean live collection which did not have it. On the Island La Mocha no wild species were found.

It was not possible to visit La Guayteca of the Archipiélago de Los Chonos. On the other hand, we made a short stop in Castro, capital of the Island of Chiloé, where 10 years before, also in company of Prof. Contreras, we collected a semi-wild or wild species at the Cemetery of Castro, which we again collected. This material remained in its entirely in Chilean collection.

In the north, I explored the highlands of Calama and Chuquicamata, in the province of Antofagasta, finding live material of S. rickii Correll, after 2 days of extensive search in this extremely dry region. This is a species which did not exist in any live collection and is almost extinct. In addition, before returning from our expedition to Chile, we made an agreement with the Instituto de Producción Vegetal of the Universidad Austral de Chile, so that Contreras may continue his collections of chilotan and wild potatoes, in agreement with a previously specified plan where the areas and places of greatest interest are indicated. It goes without saying that among others the Archipiélago of Los Chonos was included. In fact, furing part of January and February of this year the plan for collecting was continued and implemented by Mr. Contreras. During this time he collected some wild material, mainly S. brevidens Phil. and a few other samples of old and native cultivated potatoes, such as "Michuñes," in localities of the continent where no collections had been made before. Among these localities are included Lago Ranco, and the vicinity of Curiñanco and Puerto Bonifacio in the province of Valdivia; also Volcano Villarrica, Cabisañi, Maichín and Lake Caburgua in the South of the province of Cautín; and, finally in the province of Llanquihue, sites were visited on the western side of Lake Llanquihue such as Ensenada and Ralún. Unfortunately, the trip planned for Los Chonos could not be completed, as the only available vehicle, an old motor boat, broke down. Anyway, the collections made by Contreras partially were sent to CIP with separate duplicates for the Chilean collection. The year was dry in Chile and unfavorable conditions prevailed during the time of the collecting.

Finally, in connection with my visit to the living collection of the Chilean germ plasm bank at Valdivia, I would

like to make some brief comments. At the moment of my visit, the end of December of 1978, the primitive cultivars were in full floration and have about 280 accessions, among them several duplicates are present. A great number of these accessions are male sterile, while some others produce good pollen and set berries with variable number of well formed seeds. It was also possible to observe the presence of some mixtures of European cultivars mainly Grata, Maritta, Pimpernell and Ackersegen. I pressume that this collection does not have more than 60 different clones in total, the majority of them belong to Solanum tuberosum L. subspecies tuberosum (Juz. et Buk.) Hawkes, which the Russian authors call S. tuberosum L. (sp. coll.) subspecies chilotanum Buk. et Lechn.

I also wish to avail myself of the opportunity to clear once more and in definite way on the presence of the "native" Chilean cultivar called "Mantequilla", a diploid. The clone appears in this live collection where I had the opportunity to examine it in full bloom. It is nothing else but the classic "Yellow Potato" of white flower, native to the Central Peruvian Andes. I was able to confirm a cytological examination which indeed gave 2n=2x=24 chromosomes. The morphological examination of its counterpart of Central Peru, turned out to be identical, as well as the electrophoretic analysis of both clones turned out with identical spectrums.

The live collection of the wild Chilean potatoes is rather small, I have mainly observed the presence of S. brevidens and S. etuberosum.

Thus, during the last 3 years, intense explorations and collecting activities have been made to obtain mainly live material of wild potatoes in the South American Andes. In the following Tables are summarized by countries the total number of collected accessions and species, as well as the recuperated material in living state for the first time.

Wild Species from Bolivia, Chile, Ecuador, Peru and Venezuela - CIP GP. Bank - 1979

(Summary of Classified Species and Accessions Collected)

Country	Total N° of Accessions			N° Species
		Det.	Undet.	
Bolivia	130	80	50	16
Chile	49	15	34	4
Ecuador	45	28	17	7
Peru	401	200	201	34
Venezuela	11	6	5	3
	636	329	307	64

Recuperated Material in Living State for the First Time

CIP GP. Bank - 1979

Series	Species	Country
Juglandifolia	S. rickii	Chile
Circaefolia	S. circaefolium	Bolivia
Conicibaccata	S. albornozii	Ecuador
Piurana	S. paucissectum	Perú
	S. solisii	Ecuador
Megistacrolobum	S. dolichocremastrum	Perú
	S. hastiforme	Perú
Tuberosa	S. abancayense	Perú
	S. alandiae	Bolivia
	S. humectophilum	Perú
	S. minutifoliolum	Perú
	S. neoweberbaueri	Perú
	S. orophilum	Perú
	S. paramoense	Venezuela
	S. rhomboideilanceolatum	Perú
	S. velardeii	Péru

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Review of Planning Conference on the Utilization of Genetic Resources: Status of Germ Plasm Maintenance and Computerization

Dr. Zósimo Huamán

Concerning the preservation of cultivated potato germ plasm at CIP, the current strategy includes the clonal propagation of genotypes representing primitive cultivars of the Andean region as well as the maintenance of true botanical seed obtained from them. Some of the advantages of this strategy are that clones retain those gene combinations selected by native farmers through numerous years of primitive cultivation, they also might represent some genotypes which could be difficult to resynthesize; and which could facilitate a thorough assessment of the breeding potential of the Andean gene pool in a short period of time.

At present, a total of 12,427 samples of Andean cultivars has been assembled by systematic collections throughout the area where they still are being cultivated.

Elimination of Duplicates

The collection of many duplicate samples of the same cultivars has been inevitable because of some obvious facts: (1) those geographic areas with greatest diversity needed to be sampled repeatedly, (2) in each site the collector needed to get as many morphotypes as he could in order to collect most of the existing diversity, and (3) most cultivars are grown over a more or less extensive geographical area which could not be covered by the same collector or during the same harvest season. Therefore, once the collecting phase is nearly finished, the identification and elimination of most duplicated accessions is essential for an efficient and rational management of the germ plasm collection.

From 1973 to 1979, a total of 3,464 accessions have been eliminated as duplicates of 723 cultivars of morphotypes. However, within the collection there still remains to be a large number of duplicates.

All duplicated accessions are converted into botanical seed and then eliminated from clonal propagation. Following the recommendations of the 1976 Planning Conference on the Exploration and Maintenance of Germ Plasm Resources, controlled pollinations are made using bulk pollen of the same species from the same department or state of origin or from an area of about 20,000 km2 around the collection site when the accessions come from neighboring localities but belong to different departments or states. This practice is fully adopted for the diploid materials. However, at the tetraploid level it appears that it is more convenient to preserve selfed seed over hybrid seed. "If a desirable character is due to a single dominant gene, then there is little advantage for selfed over hybrid seed. On the other hand, if the desirable character is due to a number of polygenes, selfed seed has a big advantage over hybrids for finding the desirable character again in the progeny" (Page 78, Report on the Planning Conference on the Utilization of the Genetic Resources of the Potato, held at CIP in 1974). Therefore, in the case of tetraploid duplicates true seed is obtained using bulk pollen of all accessions of the same synonym group. This means that if the duplicate accessions are genetically identical they are in fact self-pollinations. However, with accessions showing severe virus infection this procedure is difficult to follow. In such cases all available open-pollinated seed is obtained.

The 1976 Planning Conference recommended also that the duplicates of odd numbered polyploids should just be discarded because no true seed of the same ploidy level could be obtained. Even though the potato species involved in the origin of these potatoes are known and the triploids are considered dead ends in breeding programs, there are some possibilities to preserve and utilize that gene pool. First, the pentaploids normally set numerous viable seed when crossed with 4x and their progenies stand close to the 4x level. Second, a few stable hybrids are produced when triploids are crossed with bulk diploid pollen. However, a better approach might be to double their chromosome number to the hexaploid level and then cross with 2x or 4x.

Accessions are considered duplicates when under the same environment they are morphologically identical for all visible characters, have the same electrophoretic patterns of their soluble tuber proteins and enzymes, and all available data on their disease and pest reactions are similar. However, there might be some cases where minor differences escape the preci-

sion of our evaluations. Therefore, the following practices have been adopted to reduce the risk that some variation might be lost in the process of duplicate elimination:

1) Whenever a group of duplicate accessions or "synonym" group shows some conflicting results on disease and pest reactions, enough accessions are retained so that every resistance found within the group is represented at least once. They will be discarded once they are re-evaluated and show similar results.

2) The resulting true seed of eliminated accessions maintain their identification number and they are kept separately for long term storage.

Maintenance of Stocks

The clonal collection is currently grown once a year at Huancayo. However, those accessions which do not yield enough tubers for their maintenance are planted again at La Molina.

The major threats to the collection when growing in the field are the presence of several pathogens in the soil. The soil fumigation now being implemented before planting will prevent losses of some clones due to extreme susceptibility to one or more of these diseases. Furthermore, genetic losses due to hail storms, frost, excess rain, etc., will also be prevented by planting the collection in Bogotá, Colombia under a cooperative agreement between ICA and CIP.

The tuber stocks for annual propagation are stored at Huancayo in a new storage facility. The use of artificial light during the period of sprouting prevents virus spread by contact of etiolated sprouts of neighboring accessions as well as by eliminating the previous practice of de-sprouting of tubers before planting. Furthermore, two tuber sets of the entire collection are maintained in cold storages at La Molina and Bogotá as an insurance against crop failure.

The stocks of true seed of the non-sterile entries in the collection are stored at La Molina in accordance with the standards set out by FAO and IBPGR. As a safeguard to avoid losses of germ plasm, lots of 1,000 seeds of most accessions in the collection are in the process of being sent to the National Seed Storage Laboratory at Fort Collins, Colorado.

CIP has proposed a cooperative exchange system for the regeneration and interchange of true seed of potato genetic resources. The gene banks at Sturgeon Bay, U.S.A. and Braunschweig, West Germany, have agreed in principle to the proposal. However, more progress beyond that point has not been made because of reasons other than technical or of scientific disagreements.

Data Management

With the collaboration of the Information Sciences Genetic Resources (IS/GR) program (formerly Taximetrics Laboratory) of the University of Colorado, the data bank of the entire cultivated germ plasm collection has been completed. It includes all available data on collecting localities, common names, taxonomic identifications and reactions to pests and diseases. Morphological data on 19 of the most useful descriptors have been recorded for about 6,000 accessions. More recently, data on 9 tuber characters were recorded from another 2,000 accessions. The data bank also includes information on the status of each accession, electrophoretic analyses and duplicate identification.

A provisional inventory of accessions in the collection with some resistance to pests and/or diseases has been generated from the data bank and made available to breeders. Furthermore, the morphological and taxonomic data have been used to sort out all accessions with identical data in an effort to find more duplicates in the collection.

During the Planning Conference on "Utilization of the Genetic Resources of the Potato II" held at CIP in 1977, a list of descriptors and descriptor states for the cultivated potato was presented for discussion. The final list of descriptors included helpful comments from C. Ochoa (CIP), J.G. Hawkes (University of Birmingham, England), L. Seidewits (Genebank, Braunschweig, F.R. of Germany) D.R. Glendinning (Genebank, Pentlandfield, Scotland), and R. Ross (Genebank, Sturgeon Bay, U.S.A.), and was agreed to by the breeders and scientists present at the Conference. Some descriptors were emphasized as being of greatest interest to breeding programs through international communication of data. Although, the list of descriptors was primarily made for use in the data management of the CIP germ plasm collection, the Conference recommended it to IBPGR for international use and it is available internationally for comment.

Collection of Primitive Potato Cultivars

Eng. C. Ochoa

The first collections of primitive potato cultivars were begun by CIP in 1973. Subsequent collecting trips were made in priority areas where greater genetic erosion is occurring. Field work in Peru has mainly been carried out in the North, where erosion is a more serious problem. More than 700 accessions of primitive cultivars have been collected in the mountain regions of Piura, Cajamarca, Ancash and La Libertad. Collections were also extended to the departments of Amazonas, Lambayeque, Huánuco and additional areas in Ancash and La Libertad. Accessions collected in Northern Peru add up to 2,500.

More than 2,600 accessions were also collected in priority regions of Central Peru, mainly in the departments of Pasco, Junin, Huancavelica and Ayacucho. Collections were also made by CIP in the department of Lima which was neglected by former expeditions. More than 300 accessions of interesting primitive cultivars were collected in the mountainous regions of this Department. Among them, some clones of *Solanum phureja* Juz. et Buk. were found.

The rich area of Southern Peru has long been a classical region for potato collectors. We have made extensive trips in the departments of Apurimac, Cuzco, Puno and Arequipa, where about 4,500 accessions have been collected.

CIP has also received donations of cultivated collections from Peruvian institutions, including the University of Puno, the Agricultural Experimental Station of Cuzco, the National Potato Program of the Ministry of Agriculture, and others.

Additional CIP collecting trips were made to other Andean countries. In Bolivia work was carried out in collaboration with Prof. Arturo Vidaurre and in Ecuador with the valuable help of Eng. Luis Cruz Albornoz, from the Ministry of Agriculture. Eng. Raúl León Palencia, from the Fondo Nacional de Investigaciones Agropecuarias in Venezuela, and Eng. Andrés Contreras, from the Universidad Austral de Valdivia in Chile collaborated in the collections of their countries.

In addition, CIP has received substantial donations of cultivated potatoes from Dr. Luis López, of the Instituto Colombiano Agropecuario (ICA) in Colombia, and from Dr. Armando Okada, of the Instituto Nacional de Tecnología Agropecuaria (INTA) in Argentina.

In summary, the primitive potato cultivars collected by CIP in the South American Andes add up to more than 13,000 accessions. These represent the greatest and most complete living potato collection in the world. These field collections have been terminated 2 years prior to the schedule recommended by our First Taxonomy Planning Conference of 1973.

Up to the present, more than 95% of the collection has been classified. The classification was made on the basis of species proposed by the Soviet researchers Juzepczuk and Bukasov in 1929, and the modifications introduced by Hawkes in 1963, with the exception of S. geniocalyx. In my opinion, this species should be maintained within the original scheme of Juzepczuk and Bukasov. Thus, the collections of live primitive cultivars in CIP's collection have been classified in 8 species, as follows:

Solanum ajanhuiri Juz. et Buk. of diploid condition (2n=2x=24). According to Huamán, it may have originated from a natural cross between S. stenotomum with the wild species S. megistacrolobum; it bears a great resemblance to S. stenotomum, it differs from this species mainly by the insertion of hairs in the regions of the leaf, with which it forms a very acute angle, by a smaller calyx of regular form and by the articulation of the pedicel which is very short and very close to the base of the calyx. It has resistance to frosts and its tubers are not bitter; they taste good. It has a very narrow range of variability. I only know the forms of those tubers that are white, purple and red of "ajanhuiri" dark blue flowers, those of white and purple of "yari" white flowers, and the yellowish white of "sisu" purple flowers. Distribution: Southern Peru in the vicinity of Lake Titicaca, as far as Oruro and Potosí in Bolivia, above 3,600 meters, up to an elevation of 4,200 m.

Solanum goniocalyx Juz. et Buk. With 2n=2x=24 chromosomes. It has a varied range, regarding the color of the flower, going from white to intense red, likewise a great variability of forms in tubers, leaves and plants. The tubers are usually of intense yellow pulp. Distribution: Highlands of Central Peru to northeastern Bolivia, between 3,200 and 4,000 m.

Solanum phureja Juz. et Buk. With 2n=2x=24. Plants are of rather low stature of variously dissectionated leaves, opaque or brilliant sparsily pilous of round to long conical berries. Vegetative period of early type 3-4 months, tubers without rest period. It is a species of great variability and the diploid species occupying the greatest geographical distribution in the South American Andes. Notwithstanding, its discovery in Peru goes back to a relatively recent time. It is preferentially cultivated in the eastern region of the Andes, between 1,600 and 2,800 m. It is also to be found, although less frequently in some high regions such as the basin of Lake Titicaca, between 3,600-3,800 m. Distribution: along the Andes between the Northeast of Bolivia to the States of Tachira and Merida in Venezuela.

Solanum stenotomum Juz.et Buk. Also diploid (2n=2x=24), it is considered the most primitive cultivated species. Considering the classical characteristics of differentiation, such as form and dissection of the leaves, of the calyx color, size and shape, anthers, style, etc, the variability presented by Solanum stenotomum is very large. To this must be added the natural hybrids produced with other cultivated diploid species, principally with S. goniocalyx or with hybrid of same and S. phureja which greatly increases the difficulty of classification of morphotypes within the same species. These three diploid species are immensely polimorphic and in order to make a classification that is as natural as possible, it is necessary to take into account and work with a great number of taxonomic characters. This task is underway, as well as those pertaining to electrophoretic studies of large quantities of morphotypes, as well as the respective analysis in the segregations of intra and inter specific crosses in order to examine the segregation patterns. This research is being developed at the level of a Ph.D. thesis on the part of Mr. Tay Chong Seng, of the University of Birmingham, under the guidance of Dr. Hawkes, and the author of this paper.

Solanum stenotomum is characterized for its medium to tall plants, 0.60-1.0 m in height, leaves of diverse degree of pubescence and opaque folioles. Its calyx is almost always irregular with lanceolated and long lobules. The vegetative period is of 4-7 months, with tubers of different colors and shapes and with a well defined rest period. It has played an important role in the formation of other cultivated species such as S. ajanhuiri, S. x juzepczukii and S. x curtilobum. Without doubt it has intervened in the formation of many morphotypes of S. chaucha in natural crosses with ssp. andigena. The forms resistant to frost and possibly formed by

crosses with some wild species and the subsequent natural selection in the course of time, as is the case with S. stenotomum x S. bukasovii, as has been artificially reproduced by the author. Distribution: Solanum stenotomum is found from the North of Peru (Huánuco) to central Bolivia (Oruro and Potosí), preferentially at heights between 3,000 and 3,800 m.

Solanum x juzepczukii Buk. This species has a 2n=3x=36 chromosomes and is frost resistant. It is of small plants of long and narrow leaves with small folioles; slender and short (2-5 cm in length) and indistinguishable and very short articulation near the calyx. Small rotated corolla (2.0-2.5cm in diameter) dark blue or light purple of very short lobules.

It has been proved that it is a species where S. acaule and S. stenotumum have intervened producing morphotypes in an equal member with different clones of S. stenotomum intervening. The species itself is not of great variability. In CIP's collection up to now we have not detected more than 18 morphotypes. Distribution: From central Peru (Junín) to the Northwest of Argentina, between 3,700 and 4,200 m. altitude.

Solanum x chaucha Juz. et Buk. This is another triploid species (2n=3x=36) of diverse hybrid origin and, therefore, it represents morphotypes springing from genetic segregations of a hybrid population or notomorphic shapes.

These shapes must have originated many times in nature through natural crosses between ssp. andigenum with cultivated diploid species such as S. stenotomum, S. goniocalyx or S. phureja. This does not exclude the possibility of the formation of natural triploids by other means. In spite of the enormous amounts of morphotypes belonging to ssp. andigena (4x) and the cultivated diploid species (2x) living alongside, the amount of morphotypes which are different from S. x chaucha found in nature is relatively small. In nearly 600 clones identified within this species, only 34 different shapes have been found. There is an enormous morphological variety among these morphotypes, some of which constitute commercial "varieties" of great demand with a vegetative period of from 5-6 months. The tubers usually have a rest period, although there are a few early forms (3-4 months) which have no rest period. Distribution: Along the Cordillera of the Andes, from Colombia through northwest Argentina, between 2,500 m to 4,000 m altitude.

Solanum tuberosum L. (2n=4x=48). Species characterized by the articulation of the pedicel placed in the middle third,

for a short calyx usually symmetrical, small leaves slightly arched with folioles ovate to ovate lanceolate about two times as long as broad, never very narrow lanceolate. Corolla of various colors with the lobes near half as long as broad. Tubers of various forms and colors nearly always with a strong dormancy period.

According to Hawkes, two subspecies are recognized:

Subspecies tuberosum Hawkes: Characterized by leaves less dissected, forming more open angles with the stem and with more wider folioles. Pedicels thickened towards the calyx. Corolla frequently white or slightly pigmented. Tuber formation under long days and also under short days in the tropics but only at low altitudes (from sea level to 2,500 m). Distribution: Originally only from the south-central region of Chile, mainly from the Archipielago of Chiloe and the adjacent Continental region. Now its distribution is worldwide.

According to Prof. Hawkes this subspecies was derived from the ssp. andigena on two different occasions. The first, in Chile, where ssp. andigena had been initially carried from the Andes of Bolivia by Indian tribes that emigrated to the coast of the Pacific, and secondly, in Europe, where ssp. andigena had been carried after the Spanish conquest and where similar climatic and daylength conditions to those of southern Chile, as well as a result of the artificial selection, formed again the typical ssp. tuberosum.

In classifying and grouping the potatoes of Chiloe and adjacent regions, one must be very careful. To the presence of the native cultivars called "chilotas", one must add the presence of European commercial varieties that have been introduced frequently since the past century and also of the native cultivars of the Andes that occasionally could have been introduced in more recent times. This is the case, for example, of "Mantequilla" which undoubtedly corresponds to Solanum goniocalyx. Thus, keep in mind the possibility that natural hybrids derived from this conglomeration of mixtures may be present.

Subspecies andigena Hawkes: It is distinguished by more numerous but narrower folioles in the leaves which generally are more dissected and form a sharp angle with the stem. The pedicles are not thickened toward the basis of the calyx. This is considered as the ancestral subspecies of S. tuberosum

and possibly originated from crosses of S. stenotomum and S. sparsipilum. Distribution: From the Andes of Venezuela in the northeast to the northwest of Argentina. It has been also found in Guatemala and Mexico.

The variability of the subspecies andigena is very large compared with the "chilotan potatoes" represented by subspecies tuberosum. While in the first subspecies we can differentiate some thousands of different morphotypes, in the native cultivars of Chiloe surely we cannot find even one hundred different clones.

Solanum x curtilobum Juz. et Buk. (2n=5x=60). Easy to distinghish by its semi-rosette or rosette habit, straight stiff leaves, rugose folioles, articulation of the pedicel very near to the calyx, very rotate and purple corolla up to 35 mm. in diameter with very short lobules and acumens.

It is a hybridogenic species derived by natural crosses between S. juzepczukii (non reduced gametes) with subspecies andigena (normally reduced gametes). It does not have a great variability. In the determinations made in near 200 accessions from our germ plasm bank, we have identified only two different morphotypes of S. x curtilobum. They are differentiated only by the color of the tuber skin, which could be white or purple and also for the presence or absence of pigmentation in the plant. Tubers are in both cases flattened oval in shape, superficial eyes with long eyebrows, white flesh and sprouts, purple at the base and tip.

Li' in some clones of S. x juzepczukii, some morphotypes were not easy to differentiate electrophoretically, the slab electrophoresis results were also not easy to distinguish.

After classification of the collections, a very important task is the identification of duplicate accessions. In this sense, after identifying the basic morphological groups of synonyms, we have send duplicate sets of samples to Prof. H. Stegemann of the Institute für Biochemie Biologische Bundesanstalt, in Braunchweig, Germany, for slab electrophoretic analysis. This means that each sample considered as a duplicate from the morphology point of view, has also been examined by chemical analysis. Most of Prof. Stegemann's results agree with our morphological determinations. In some cases, the clones identified by us as duplicates have shown different electrophoretic patterns and, therefore,

have been kept in the collection until further verification. On the other hand, some groups showing obviously different morphology, such as in the case of Solanum x curtilobum, have shown identical electrophoretic patterns.

At present, nearly 3,000 samples have been identified as duplicates, both morphologically and electrophoretically.

With the assistance of Eng. Alberto Salas we have prepared the following Tables, which show the reduction of identical clones or synonyms in the South American primitive potato species, morphologically and electrophoretically analyzed up to the present.

Reduction of Identical Clones or Synonymous by Countries

1. Native cultivars from ARGENTINA : 133 accessions reduced to 17 clones, as follows :

Coll. Number	Name (Group)	Species	Number of Duplicates
OKA-6292	Allo	ADG	3
6297	Colorada	ADG	14
6424	Collajera	ADG	16
6198	Condorilla	ADG	5
6407	Negra Ojosa	ADG	15
6244	Oca	ADG	3
6477	Rosada Redonda	ADG	2
6471	Runa Amarilla-I	ADG	3
6387	Runa Amarilla-II	ADG	16
6402	Runa Blanca	ADG	6
6275	Runa Bola Amarilla	ADG	5
6332	Tuni	ADG	17
6389	Abajeña	TUB	5
6440	Corazón Rosado	TUB	2
6361	Largo Achatado	JUZ	3
6370	Ccoe Sullu	CHA	5
6397	Abreña	CHA	13

II. Solanum tuberosum ssp. andigena from COLOMBIA : 41 accessions have been reduced to only 13 clones, as follows:

Coll. Number	Name (Group)	Number of Duplicates
CCC-4472	Argentina	2
4345	Guaqueña	3
4467	Guata Algodona	2
4570	Guata Roja	2
4375	Mampuera	3
4506	Ploma o Común	2
4217	Quincha Alargada	3
4449	Rubí	3
4634	Suripamba	3
4237	Tocana Parda	2
4319	Tocana Rosada	11
4426	Puquerreña	3
4576	S/N	2

III. Solanum tuberosum ssp. tuberosum from CHILE : 102 accessions reduced to 36 clones.

Coll. Number	Name (Group)	Number of Duplicates
CH-161	S/N	2
134	S/N	2
224	S/N	4
147	S/N	2
119	S/N	9
191	S/N	2
UA-309	S/N	4
311	S/N	2
313	S/N	2
CH-131	S/N	3
UA-306	S/N	2
CH-164	S/N	2
242	S/N	2
176	S/N	2
179	S/N	2

Cont'd

Coll. Number	Name (Group)	Number of Duplicates
UA-204	S/N	2
CH-149	S/N	2
251	S/N	3
113	S/N	3
225	S/N	2
185	S/N	3
128	S/N	2
125	S/N	5
169	S/N	3
177	S/N	2
UA-104	S/N	2
CH-152	S/N	2
132	S/N	2
143	S/N	2
120	S/N	2
UA-315	S/N	3
CH-69-274	Clavela	7
69-205	Magallanes	3
69-330	Michuña	2
69-265	Natalina	3
69-147	Tres Semanas	5

IV. A. *Solanum stenotomum* from PERU : 95 accessions reduced to 20 clones.

Coll. Number	Name (Group)	Number of Duplicates
OCH-8370	Comino	2
8913	Durazno	4
CIP-700146	Huacar Cóndor	4
OCH-8885	Michiaca	2
8530	Marmanillo	3
CIP-702142	Moro Pitiquiña	3
OCH-8034	Paucar Pitiquiña	3
8567	Pitiquiña Carne Blanca	4
10793	Pitiquiña Morada	2
8511	Poccoya	10

Cont'd

Coll. Number	Name (Group)	Number of Duplicates
8658	Puca Kicehuillo	5
9756	Puca Kicehuillo-1	3
7821	Puca Pitiquiña-I	21
HJT-5450	Puccya	11
OCH-9892	Sanqui huayta	3
8027	Ttomira	7
8868	Yana Ckanchillo	2
8911	Yuracc Pitiquiña-A	2
CIP-700670	S/N	2
CUS-241	S/N	2

B. *Solanum juzepczukii* from PERU : 100 accessions reduced to 14 clones.

Coll. Number	Name (Group)	Number of Duplicates
OCH-8495	Azul C'kanchali	4
8842	Huali Rickana C'kanchali	12
8632	Yurac Malcu-I	27
8557	S/N	2
8597	S/N	3
8655	S/N	3
8593	S/N	5
8563	S/N	6
9222	S/N	2
5266	S/N	15
5273	S/N	6
HUA-1042	S/N	4
CIP-700944	S/N	6
OCH-5271	S/N	5

C. Solanum curtilobum from PERU and BOLIVIA : 194 accessions reduced to 2 clones.

Coll. Number	Name (Group)	Number of Duplicates
OCH-7956	Azul Huaña	55
7636	Yuracc Huaña	139

D. Solanum tuberosum ssp. andigena from PERU : 2298 accessions reduced to 551 clones. In this list are included only 1306 accessions with Group name which represents 1080 duplicates or identicals and 226 clones. The rest, 992 accessions, which do not have yet Group name, represent 667 duplicates and only 325 different clones. The numbers with asteriscs are also distributed in Bolivia.

Coll. Number	Name (Group)	Number of Duplicates
HAW-6132	Abajeña	2
OCH-6411	Acero Juitu	4
7502	Allcca Ccompis	40
2786*	Allcca Ccompis Flor Blanca	70
5324	Allcca Tarma	4
7472	Allcca Tarma Rojo	15
8280	Allcca Sole-I	3
7668	Allcca Sole-II	8
9704	Allccai Huarmi	10
HAW-5595	Alka Imilla	2
OCH-10775	Amarilla Condo	2
5934	Ambacina	4
5461	Andarita-I	8
5896	Anahuata	2
7679	Aracca	3
6398	Auquin Juitu	3
HJT-5921	Azul Callhuan-I	8
CIP-701931	Azucarera	2
702188	Blanco Grueso Sub-cilíndrico	4
OCH-5605	Blanco Redondo	8

Cont'd

Coll. Number	Name (Group)	Number of Duplicates
6073	Blanco Redondo-II	3
CIP-701981	Blanco Redondo-IV	6
700573	Blanco Redondo-V	2
OCH-5396*	Bola	10
4690	Cachito Blanco	6
H/J-370	Cachona	2
OCH-5192	Canteña-I	7
8145	Carlos Ccolota	4
HUA-926	Casa Blanca	9
OCH-7447	Casa Blanca Ojo Morado	25
7879	Ccehuillo Overo Negro	28
7542	Ccolla	9
8227	Ccolla-I	3
8183	Ccolla-II	4
8970	Ccala Potas	2
OCH-7759	Ccala Juitu	3
HUA-873*	Ccoyo Largo Chata Ojos Rojos	2
905	Cerrenacshu	2
OCH-8860	Ckanchillo	3
8930	Ckarhua Suytu	2
7860	Ckari Huaccachi	5
8922	Ckauchillo	2
7577	Ckayma Marcela	24
7832	Ckecko Morado, Carne Blanca	9
7457	Ckellu Huaccoto	21
H/J-450	Coleto	2
OCH-4852	Condor Huarmi	2
8122	Cuchi Aca-2	2
HJT-5465	Cuchillo Raccqui	2
HAW-5457	Cusi	9
OCH-8168	Chacahualla-I	4
8589	Chacahualla-II	2
HJT-5625	Chajcha	3
OCH-7596	Chojlla Huahua	2
8286	Chaquillo-I	2
8354	Chaquillo-II	2
7550	Charcahuaylla	2
CIP-700719	Chata Blanca de Huasahuasi	6
HJT-5728*	Chata Negra de Huasahuasi	4
5898	Chata Rosada	3

Cont'd

Coll. Number	Name (Group)	Number of Duplicates
JAK-174	Chaucha Blanca	3
HJT-5676	Chaulina	2
HAW-5696	Chía papa	2
OCH-5976	Chingos	4
5509	Chingosina	3
CIP-701685	Chipsa Blanca	3
OCH-5921	Chujchuquiño Bicolor	2
CIP-700856	Chujchuquiño Carne Amarilla	3
OCH-7758	Chungui o Yana Palta	5
CIP-701224	Chunta Huarmay	3
OCH-7531	Chuti	10
7526	Falso Allcca Ccompis-I	4
7446	Falso Allcca Ccompis-II	2
CIP-700057	Flor Lila Clara	2
OCH-7855	Huaca Ccallu	2
CIP-700693	Huagalina	12
OCH-6048	Hualash	4
5671	Hualash Blanco	
H/J-436	Huallaca	2
OCH-8280	Hueracco	3
HAW-5554	Huila pala	2
HUA-939	Huitrona	2
OCH-5899	Higos	3
5320	Huayruro	5
8826	Imilla Huaman Huma	6
CIP-700594	Imilla Negra	4
702810	Imilla Roja	2
OCH-9060	Incalo	2
OCH-5844	Juata Paro	5
5304	Jaracca	4
7832	Kecko	4
9707	Kecko	2
5294	Kosela	3
CIP-701403	Largo Angosto, Corazón Negro-III	2
HJT-5526	Largo Rojizo	3
JAK-28	Largo Rojizo-IV	2
OCH-8486	Lecke Chaqui	2
8742	Linlina Carne Amarilla	3

Cont'd

Coll. Number	Name (Group)	Number of Duplicates
8118	Linlina Carne Blanca	2
7534	Linlina Carne Marfil	7
6504	Llamellina	17
CIP-700263	Llamellina-I	4
OCH-6099	Lleque	3
8434	Maceta	2
HAW-5430	Majtillo	4
OCH-10015	Marlo Blanco	3
7029*	Marlo Negro	40
6383	Manca Ñahui Rojo-I	3
3468	Milagro	18
JAK-73	Mishunga	3
HJT-5803	Misha Callhuay	3
OCH-4707	Muñicash juitu	5
8288	Muru Berundus	2
8518	Muru Hualta	2
8716	Muru Huaña	2
9303	Muru Lomo	10
8236	Muru Rumpus	2
8372	Muru Ttalaco-I	3
7675	Muru Ttalaco-II	3
8870	Pacus	11
CIP-702121	Pacus-I	8
OCH-9882	Pacus-II	2
CIP-700650	Pacusa-II	3
701122	Pacusa-III	2
OCH-4792	Paloma Blanca	3
6434	Pan de Lima	4
H/J-362	Papa Antigua	3
OCH-7510	Ppaspa Sunchu	11
5255	Parco	2
CIP-700141*	Parecido a Sakampaya	3
701023	Piña Blanca	2
OCH-9308	Platillo	3
9075	Ptalta Maku	2
CIP-700293	Pishgopa Chaquin	3
OCH-9005	Puca Bola Chato	18
8501	Puca Bola Típico	34
HJT-6043	Puca Conchucano	2
OCH-7792	Puca Chaquillo	2
7907	Puca Ckolla Huancucho	46
7569	Puca Ckolla Huancucho-II	7

Cont'd

Coll. Number	Name (Group)	Number of Duplicates
8123	Puca Imilla or Allcca Ccompis	10
4818	Puca Juitu	4
8861	Puca Ñahui	2
9905	Puca Pepino	2
9164	Puca Palta	3
9305	Puca Qawiña	2
8891	Puca Risco	2
7556	Puca Sole	8
8036	Puca Suayllu	2
CIP-700184	Puca Surimana	3
OCH-7539	Puca Suso	45
5097	Puca Taella	5
5863	Pulu	3
5556	Obrajilla	3
9954	Oca Negro-I	2
9870	Occe Chocllo	2
6460	Occe Juitu	3
5562	Ollan	3
9748	Oyolino	4
4994	Redondo Rojo	5
4896	Redondo Rojo-I	4
6205	Redondo Rojo-II	5
CIP-702122	Redondo Rojo-III	2
703183	Redondo Rojo-VI	2
OCH-5798	Redondo Negro	2
7497	Risco	6
CIP-701015	Rojo Cortamente Alargado	4
OCH-4923	Rojo Cortamente Alargado-I	2
CIP-700815	Rojo ovalado	2
HAW-5732	Runa Papa	3
CIP-701916	Sacma, Puma Maqui	3
HUA-805*	Sakampaya	3
CIP-702885	Sambo Kusi	3
OCH-8192	Sonso Lomo	2
OCH-6587	Sopa Negra	5
HAW-5554	Soles	2
OCH-8428	Soli	3
7621	Shaccolu	3
7467	Simuco o Paciencia	4
HUA-927	Sinchada	3
OCH-6490	Socco Palta	3

Cont'd

Coll. Number	Name (Group)	Number of Duplicates
JAK-86	Suela Colorada	5
OCH-10067	Suitu-III	6
CIP-700753	Suytu Poccoya	4
OCH-3092	Tabanillo	3
CIP-700188	Tabla Blanca	3
OCH-7482	Tabla Ojo Morado	15
CIP-702438	Tulpina	3
OCH-7746	Tumiri	2
10013	Tuyros	2
8278	Ttalaco-I	6
8690	Ttalaco-II	2
9943	Ttocyali Rojo-I	3
9002	Ttocyali-II	2
CIP-700682	Ulan Pantalón	3
HUA-830	Wila Coyllo	2
OCH-9301	Yana Alcca	5
7448	Yana Bola Carne Amarilla	6
9728	Yana Chipa o Warmi	2
7941	Yuracc Ckusi	17
7450	Yana Ckusi	4
7817-A	Yana Ckusi-I	11
8003	Yana Ckusi-II	12
CIP-703073	Yana Gaspar	8
OCH-7476*	Yana Imilla	31
CIP-700788	Yana Lomo	2
OCH-4707	Yana Mactillo	2
7504	Yana Mactta-I	4
8531	Yana Mactta-III	2
8608	Yana Mactta Piel Morada	18
8187	Yana Rurum	2
7739	Yana Shuito-II	3
7520	Yana Suito	3
7469	Yana Ttalaco	3
5393	Yuguima	5
8706	Yuracc Huajrita	4
8408	Yurac Mactillo	3
CIP-700595	Yurac Quehuillo	3
OCH-7730	Yurac Pepino	3
CIP-700594	Yurac rumpus	2

Cont'd

Coll. Number	Name (Group)	Number of Duplicates
OCH-9618	Yurac Sacco	2
5540	Yurac Suitu	3
7883	Yurac Taba	3
9843	Yuracc Toccyali	3
9257	Yuraj Ckusi	3
8362	Yutu Runtu	7

V. Native cultivars from VENEZUELA (including some T x A Hybrids) : 59 accessions reduced to 14 clones.

Coll. Number	Name (Group)	Species	Number of Duplicates
OCH-11172	Cucuba Gris Malvácea	ADG	4
11108	Cucuba Negra	ADG	3
11173	Cucuba Negra-I	ADG	5
11175	Cucuba Negra-II	ADG	5
11231	Cundinga-II	ADG	3
11217	Monserrate	ADG	5
11082	Negra Achatada	ADG	2
11086	Roja de Cristalina	ADG	7
11119	S/N	ADG	3
11069	Tuberosum-I	TUB	4
11072	Merideña	AxT	12
11131	S/N	AxT	2
11219	Puracé	TxA	2
11110	S/N	TxA	2

Reduction of Duplicate Accessions by Morphological and Electrophoretical Analysis
(Summarized results by countries)

Country	Total Accessions Analysed	Duplicates Identified	Different Unic Clones	Species
Argentina	7	5	2	TUB
Argentina	105	93	12	ADG
Argentina	3	2	1	JUZ
Argentina	18	16	2	CHA
Colombia	41	28	13	ADG
Chile	102	66	36	TUB
Peru	95	75	20	STN
Peru	100	86	14	JUZ
Peru & Bolivia	194	192	2	CUR
Peru	2298	1747	551	AND
Venezuela	37	28	9	ADG
Venezuela	4	3	1	TUB
Venezuela	14	12	2	AxT
Venezuela	4	2	2	TxA
	3022	2355	667	

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Collection of Primitive Colombian Cultivars

Dr. Luis E. López

Introduction

The Potato Program of the Colombian Agropecuarian Institute (ICA) was established in 1948. Its goal was to generate technology for potato growers in the country, to produce new varieties with high yield, earliness, better adaptation to the environment and with resistance or tolerance to diseases or pests. To accomplish the purposes the Program started collecting potato germ plasm of the country and introducing valuable stocks on which the breeding projects could be based.

The present paper deals with the so called Central Colombian Collection of Potato (CCC).

History

Several trips of exploration and germ plasm collection were accomplished in Colombia before 1948 by national and international comissions including Russians, Germans, and British. Literature shows that a great amount of potato germ plasm was gathered. However, not one duplicate of those collected accessions was left in Colombia.

The first data of collection of cultivated potato in the country was registered by Antonio Miranda (1934), who stated that in 1930 an agropecuarian exposition took place in the experimental station "La Picota," south of Bogotá. Thirteen potato clones were exhibited there and they were of great interest to observers.

About the same time Barbosa (1934) mentioned that 15 American varieties were introduced into the country but the results were negative because of *Phytophthora infestans* susceptibility, therefore the collection was eliminated. The same author registered the enthusiasm for collecting the national potato germ plasm, starting the project of collection in 1932.

Names of accessions received by the Station "La Picota" up to 1934 are:

From Department of Caldas:

Arrayana	Colorada	Almidona	Ojona
Pico de Aguila	Pepina*	Blanca	Yema de Huevo*
Alemana	Rosada larga	Colorada careta*	Colorada manzana*
Negra de Año	Alemana rosada	Alemana blanca larga	

From Department of Cauca:

Guata blanca *	Silviana*	Imperial francesa
Guata N° 1	Guata N° 2	Plancheta blanca
Colorada mambera	Redonda colorada	Pintada del Cauca

From Department of Nariño:

Guata buitrona*	Bareja o algodona	Guata leona*
Chaucha pastusa*	Chaucha de Ipiales	Guate blanca de Ipiales*
Tuquerreña de Túquerres*	Rosquilla	Gigante
Papa batata	Papa hibia	Tocanquilla pamba*
Pamba morada	Ojo de buey*	Pamba blanca

From Department of Boyacá:

Choconteña

Five years later Martínez (1939) pointed out that the country had a collection with more than 200 accessions of national,

* Still alive.

Ecuatorian and Peruvian origin, which was increased by the Ecuatorian Manuel J. Bastidas. He was contracted by the Colombian Government to be in charge of the breeding program. Pino (1944) indicated that in 1942 the collection registered 1,200 accessions between natives and hybrids, but this number was then reduced to 211 due to a rigorous selection procedure attempting to get material with good characters in order to offer it to the farmers.

Between the species of the collection they were registered Solanum tuberosum L. ssp. andigena (Juz et Buk) Hawkes, S. tuberosum L. ssp. tuberosum Hawkes, S. x curtilobum Juz et Buk., S. x juzepczukii Buk.

Up to 1948 there was no marked progress with the Colombian germ plasm because accessions were eliminated by selection if they did not show convenient characters to keep them growing. By the middle of 1948 the national government got the services of J.G. Hawkes who started and organized the Potato Program. This Program has been working without interruption since.

During 3 years of activity in the country Hawkes fixed aims and established research projects. Hawkes was practically the first explorer to collect and conserve potato germ plasm in Colombia. When he left the country in 1951, he left a record of: 421 cultivated and native accessions, 360 exotic accessions and 2 new species, all of them duly registered under the prefix CCC (Colección Central Colombiana). Fortunately, Hawkes was succeeded by N. Estrada R. who was aware of the germ plasm collection value and increased it to 1,540 registrations in 1967. Of course, not all of them were alive because nearly 50% had disappeared due to disease attacks.

Exploration and Collection of Potato Germ plasm

A. Out of Colombia

In 1969 the opportunity was available to explore part of Bolivia and Perú collecting potatoes, especially cultivated samples. Thanks to the Rockefeller Foundation economic support, the technical guidance and other facilities given by the Agricultural Ministry of Bolivia and Perú, our Potato Germ plasm Bank was enriched with 1,500 new accessions belonging to all the cultivated

species and a few wild ones. Again, in 1970, I went to Bolivia and Perú to explore some areas which were not touched in the previous trip. On this opportunity, Salta and Jujuy, the Northest Departments of Argentina were included. A total of 850 new registrations were added to the CCC with the help of the Rockefeller Foundation; Humberto Gandarillas, Moisés Zabaleta and some other of the Bolivian Agricultural Ministry; Doctor Sawyer of the Carolina Mission and some other members of the Peruvian Agricultural Ministry.

B. In Colombia

The collecting project of potato germ plasm was continued in 1973, under the cooperation of the International Potato Center. The collection, conservation, evaluation and utilization of the germ plasm was aimed to determine the genetic erosion and the distribution of the varieties in the country.

During the different exploring and collecting trips in nearly all the potato growing areas of the country, about 840 accessions, most of them cultivated, were recorded.

The potato germ plasm bank is increasing not only with the accessions obtained through the collecting trips but also with promissing hybrids selected in the breeding projects.

In 1976 the CCC had a record of 5,045 registrations from which 3,187 were alive, belonging to the cultivated species as follows:

Solanum tuberosum ssp. *andigena*	2,446
S. tuberosum ssp. *tuberosum*	145
S. phureja	260
S. stenotomum	189
S. goniocalyx	16
S. ajanhuiri	46
S. juzepczukii	17
S. curtilobum	68

There were also true seeds of 25 wild species, received from the Sturgeon Bay (Wisconsin) gene bank, from the University of Birmingham and Scotland, to be utilized in different research projects.

Storing and Growing Facilities

For the conservation of the germ plasm collection, the Potato Program has a wide refrigerated store (14 x 10 x 4 m). The collection is kept in that store at 2°C for the dormancy period which is nearly 5 months, although it depends on the accession.

Although the main research station of ICA (Tibaitatá) is 20 km west of Bogotá at an altitude of 2,600 m and has more than 400 hectares available to grow potatoes, this is not the optimum area for growing the potato germ plasm because of the incidence of virus transmitting insects. Therefore it is preferred to grow it at another research station (San Jorge) 45 kms. southeast of Bogotá, at 3,000 m where the incidence of insects is lower. The collection is usually planted the first week of February and harvested in August or September each year.

Actual State of the CCC

As mentioned above, in 1976 the CCC had 3,187 accessions, of which approximately 1,200 were from Colombia. This number has been greatly diminished because most of the material collected in Perú, Bolivia and northest Argentina was discarded in 1977. Some numbers of the CCC were also discarded because they were duplicated so they were replaced by healthy accessions.

ICA made the decision of discarding the exotic material (from Perú, Bolivia and Argentina) considering that efforts and expenses were being duplicated because that collection was also in CIP. The strategies was that CIP would be responsible of the world collection while other countries would look after the national material. Therefore ICA decided to keep only the Colombian accessions and a few selected ones of the exotic collection.

Before discarding the collection in the tuber-bearing Program, it was offered to CIP but it was not accepted because of the possibility of introducing more diseases with a material which was already available. It was then suggested to offer that material to other countries and it was done. The Vavilov

Institute accepted it. The Program sent nearly 1,500 accessions, each represented in 3 tubers.

Before discarding the collection, berries of 1,161 accessions were collected in the field (free pollination) and extracted seeds are kept in refrigerators.

Actually the CCC has 1,009 accessions (Gómez, C., 1978) which are being harvested from the field in the present week. They are represented by the following species and number of accessions:

Solanum tuberosum ssp. *andigena*	723
Solanum tuberosum ssp. *tuberosum*	158
Solanum phureja	127
Solanum curtilobum	1
Total	1009

The phytosanitary state of the CCC is not good, so a high percent of the accessions are infected by virus X, Y, XY, leaf roll and Latente Andino. So far, nothing has been done to clean the collection of present diseases, therefore some accessions are still being lost each year because of the infestation.

Genetic Erosion of Potato in Colombia

After exploring most of the growing areas of potato in the country, collecting the native germ plasm and comparing the list of gathered accessions with that registered by Hawkes in 1948-1951, preliminary data of the genetic erosion over a period of 25 years was obtained. This could be considered as 20%. On the contrary, it could be said that genetic erosion has not taken place in the wild species in which new distribution areas have been registered, despite the fact that no effort has been made to collect them.

In 1974 it was considered that the genetic erosion of potato was 22%. One year later, that percent came down because some accessions not found in 1973 were obtained in 1975 in a new collection trip to the growing areas of the Departments of Tolima, Caldas, Valle, Cauca and Nariño.

Considering the genetic erosion in the cultivated species, it is estimated that the most affected one is S. tuberosum ssp. andigena which has been 15%. In S. phureja it has been 5%.

The Department with highest genetic erosion was Nariño, followed by Cauca and Boyacá. They are the richest Departments in potato germ plasm.

In other Departments such as Tolima, genetic erosion was not registered, instead immigration of varieties was observed.

It is possible that even more reduction in genetic erosion data could be noted if a new collecting trip could be accomplished throughout the potato growing areas of the country.

Among the genetic erosion causes of the cultivated potato in Colombia are:

a) Diseases.

Every day the native potato germ plasm is getting infected especially by virus, thus reducing the yield of the crop.

b) Breeding.

The National Potato Program is producing new hybrids of good characters for cultivation and consumption such as high yield, good shape, color and taste. It is estimated that those hybrids are being cultivated in nearly 60% of the growing area of the country therefore replacing the native varieties in that percent.

Areas to be Explored

Some Departments have not been explored after the collection by Hawkes in 1948/51. Other Departments were explored in 1973 but for a very short time. Consequently it is recommended that collection trips be made to Huila, Antioquia, Boyacá, Santander and Sierra Nevada de Santa Marta.

The wild species deserve special care because they have not been carefully collected. It is necessary to pay attention to the population, variability, possible introgression and other important aspects of the Colombian wild species. With the description of a new Colombian wild species "Solanum

garcia barriga" by Professor Carlos Ochoa, it is demonstrated that possibly there are still wild species for discovery in Colombia.

Summary

1. It is necessary to clean the collection of diseases.

2. Evaluation of the collection agronomically and botanically.

3. To store the information in the computer using the potato descriptors established by Huamán et al (1977). The information is being completed for the CCC in order to put it into the computer and produce the first catalogue as soon as possible.

4. To get new seeds of controlled pollination of the collection.

5. To achieve collecting trips of cultivated varieties to the Departments of Huila, Boyacá, Santander y Sierra Nevada de Santa Marta.

6. Finally, to collect wild species in the country keeping in mind the population, genetic variability and possible introgression between species.

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The Wild Tuber-Bearing Solanums of North America

Prof. Jack G. Hawkes

Introduction

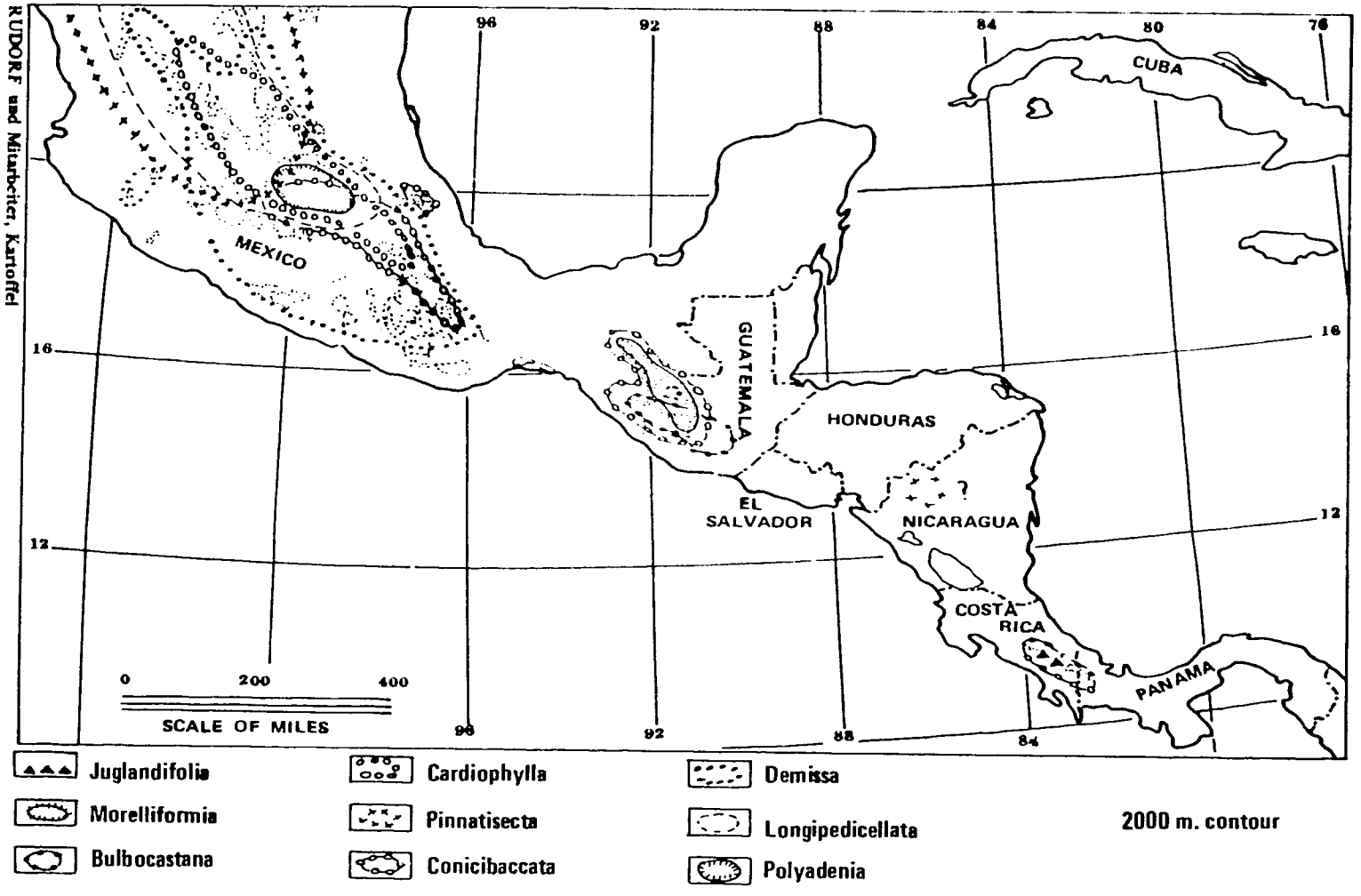
The wild tuber-bearing species of Solanum constitute a particularly rich gene pool most of which is accessible to the breeders in terms of inter-specific compatibility but much of which still needs collecting and evaluating. Of particular interest for plant breeders are the species which occur in the North American continent (including Mexico and Central America), since qualities of resistance to improtant diseases such as late blight (Phytophthora infestans) and insect transmitted viruses have been discovered in several species. Insect resistance is also known, so that it is likely that this group of species will become of very great importance as they are studied in greater detail and as breeders have greater recourse to wild species in the production of more pest and pathogen resistant strains with a wider range of adaptation to environmental conditions.

Patterns of Diversity

When the wild potatoes of both the northern and southern hemispheres are considered as a whole, it becomes clear that there are two fairly distinct centres of diversity. One of these lies in central to southern Mexico; the other is situated in the Andes of Perú, Bolivia and northwestern Argentina. The present paper will deal exclusively with the former group of species, which spreads northwards into the southwestern states of the USA and southwards into Guatemala, Honduras, Nicaragua, Costa Rica and Panamá.

The North American tuber-bearing species have been classified into eight series, as follows (Hawkes, 1978): Morelliformia, Bulbocastana, Pinnatisecta, Conicibaccata, Demissa, Longipedicellata, Polyadenia and Tuberosa*. (See Fig. 1). Polyploidy

* The non-tuberiferous series Juglandifolia has been excluded from this paper.



Distribution of Series of Wild Potato Species in Mexico and Central America

is to be found in most of these series, (see Table 1) and in two of them - Conicibaccata and Demissa - even hexaploid species have been found, though for Conicibaccata such hexaploids seem confined to South America. Most of the series are confined to one or other of the subcontinents, though Tuberosa and Conicibaccata are known in both.

Gene Pool Concepts

To be of maximum value to the breeder wild potato species should belong to the same gene pool or at least a closely allied one. Unfortunately, the North American species are not so easily manipulated as the South American ones in this respect. They in fact form some four crossability groups (Hawkes, 1958b, 1960) as follows (Fig. 2 and Table 2):

I Tuberosa, Conicibaccata, Demissa, Longipedicellata

II Pinnatisecta, Bulbocastana

III Polyadenia

IV Morelliformia

These groups correlate fairly well with the results of the immunological studies of Gel *et al*. (1960) who demonstrated three serological groupings, each with a distinct spectrum of arcs on double diffusion plates (Fig. 3).

The incompatibility or incongruity between the four different groups mentioned above is of perhaps less significance than appears at first sight. Thus, the cultivated potatoes, *S. tuberosum* and others from South America, belong to series Tuberosa and will cross readily with species in the same compatibility group, and even with hexaploid species such as *S. demissum* and diploids such as *S. verrucosum*.

Crosses between group I and the others are more difficult, though Dionne (1963) and Hermsen (1966) have demonstrated that with the use of *S. acaule* as a bridging species, gene transfer can be effected from group II (*S. bulbocastanum*, etc.) to group I.

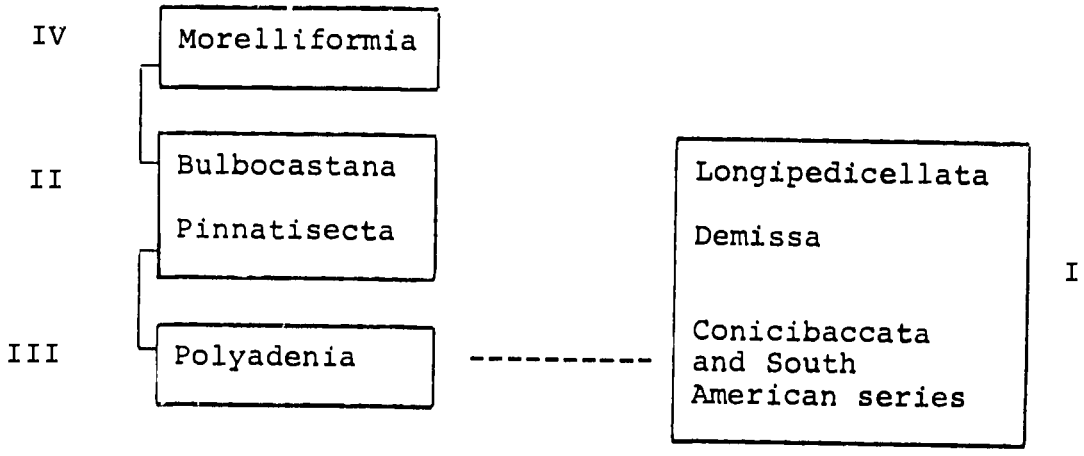
Many attempts have been made to introduce *S. polyadenium* genes into *S. tuberosum* and several hybrids have been reported (Stelzner, 1949; Swaminathan, 1951, etc.). However, the seedlings may not have been very vigorous, for no follow-up of the hybrid performances has been described.

Table 1. Wild potato species of Mexico and adjacent countries

Series	Mexico	U.S.A.	Guatemala	Honduras	Costa Rica	Panama
JUGLANDIFOLIA					S.jugandifolium (24)	
1. MORELLIFORMIA	S.morelliforme (24)		S.morelliforme (24)			
2. BULBOCASTANA	S.bulbocastanum (24, 36)		S.bulbocastanum (24) S.clarum (24)			
3. PINNATISECTA	S.brachistotrichum (24) S.cardiophyllum (24, 36) S.hintonii S.jamesii (24) S.michoacanum (24) S.nayaritense S.pinnatisectum (24) S.sambucinum (24) S.stenophyllidium S.trifidum (24)	S.jamesii (24, 36)				
4. CONICIBACCATA	S.agrimonifolium (48) S.oxycarpum (48)		S.agrimonifolium (48)	S.oxycarpum?	S.longiconicum (48) S.woodsonii	S.longiconicum S.woodsonii
5. LONGIPEDICELLATA	S.fendleri (48) S.hjertingii (48) S.papita (48) S.polytrichon (48) S.stoloniferum (48) S.vallis-mexici (36)	S. fendleri (48)				
6. DEMISSA	S. brachycarpum (72) S. demissum (72) S. edinense (60) S. guerreroense (72) S. hougasii (72) S. iopetalum (72) S. schenckii S. semidemissum (60) S. verrucosum (24)		S. demissum (72)			
7. POLYADENIA	S. lesteri (24) S. polyadenium (24)					

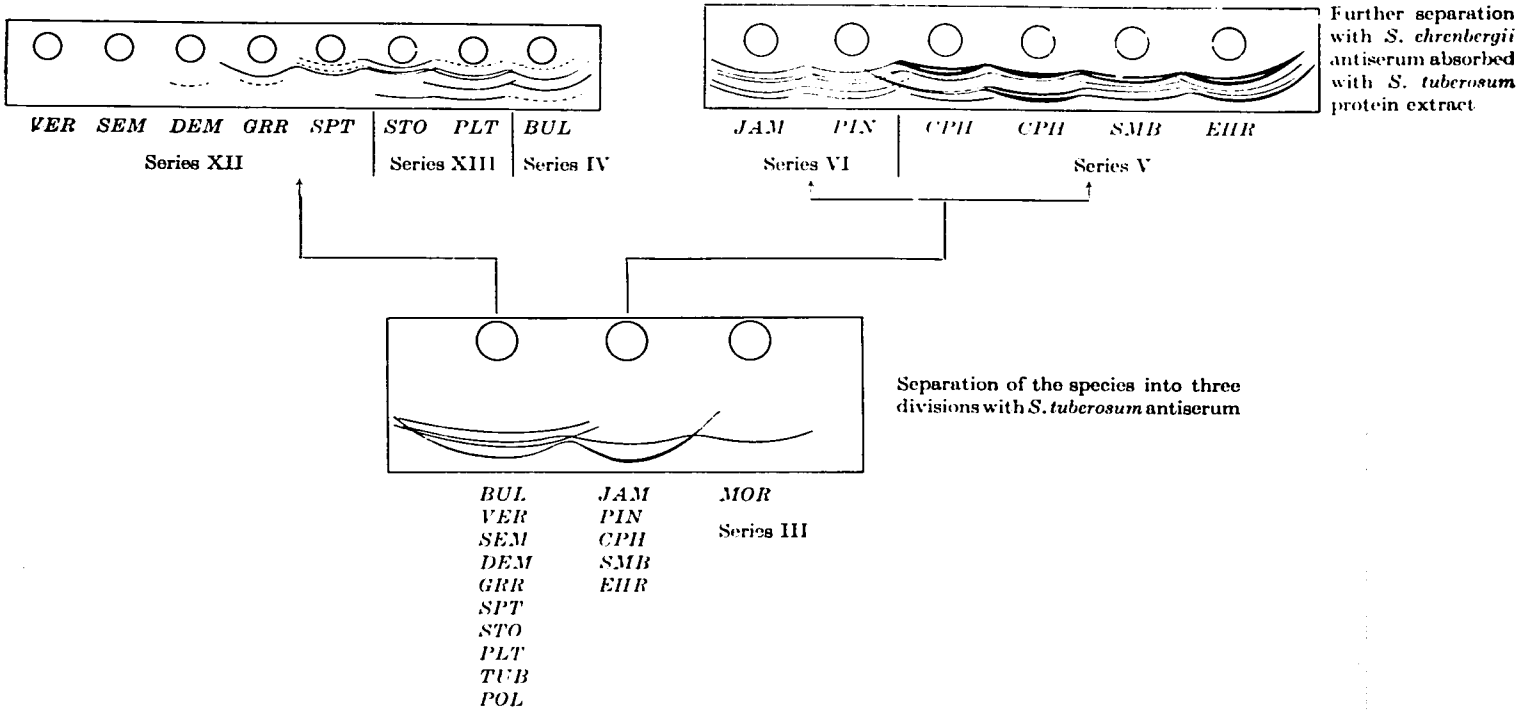
Fig. 2

Crossability Groups in Mexican Potato Series



Series	♀ \ ♂	S. tuberosum	S. verrucosum	S. demissum	S. guerreroense	S. hougasii	S. brachycarpum	S. stoloniferum	S. polytrichum	S. hjertingii	S. fendleri	S. lesteri	S. polyadenium	S. jamesii	S. pinnatisectum	S. cardiophyllum	subsp. ehrenbergii	S. brachistotrichum	S. clarum	S. bulbocastanum	S. morelliforme
Tuberosa	S. tuberosum	+	+	+				+					+	−		−					
	S. verrucosum	+	+	−		+		−						−			−				
Demissa	S. demissum	+	+	+		+	+	+			+			−	−	−	−			−	
	S. guerreroense			+	+	+	+														
	S. hougasii	−	−	+		+	+	−							−						
	S. brachycarpum					+	+														
Longipedicellata	S. stoloniferum	+	+	+				+								−					
	S. polytrichon			+				+	+												
	S. hjertingii									+											
	S. fendleri							+	+		+										
Polyadenia	S. lesteri											+									
	S. polyadenium	−	−										+	+							
Pinnatisecta	S. jamesii		−	−				−					+	+	+	−					
	S. pinnatisectum												+	+	+	+				+	
	S. cardiophyllum	−		−											+	+	+			+	
	subsp. ehrenbergii	−														+	+				
	S. brachistotrichum																	+			
Bulbocastana	S. clarum																		+		
	S. bulbocastanum	−														+			+	+	
Morelliformia	S. morelliforme																			−	+

Table 2. Crossability chart of North American species



code	species	code	species	code	species
BUL	*S. bulbocastanum*	*STO*	*S. stoloniferum*	*PIN*	*S. pinnatisectum*
VER	*S. verrucosum*	*PLT*	*S. polytrichon*	*CPH*	*S. cardiophyllum*
SEM	*S. semidemissum*	*TUB*	*S. tuberosum*	*SMB*	*S. sambucinum*
DEM	*S. demissum*	*JAM*	*S. jamesii*	*EHR*	*S. chrenbergii*
GRR	*S. guerreroense*	*POL*	*S. polyadenium*	*MOR*	*S. morelliforme*
SPT	*S. spectabile*				

FIGURE 3. The serological groupings of the Mexican potato species obtained with the two antisera.

The cross S. polyadenium x S. jamesii is apparently not too difficult, as well as S. polyadenium x S. cardiophyllum and S. polyadenium x S. pinnatisectum (Propach, 1940; Swaminathan, 1955; Graham and Dionne, 1961). However, this work merely transfers germ plasm from group III to group II and does not bring it closer to S. tuberosum. Similarly, no hybrids have been reported between S. morelliforme and S. tuberosum.

We can therefore postulate that groups II, III and IV belong to a secondary or even a tertiary gene pool in relation to S. tuberosum (see Harlan and de Wet, 1971), where special techniques are needed to make satisfactory transferals of germ plasm into the cultigen. It must be pointed out, however, that much of the work in this field with the North American species took place some 20 to 40 years ago; it is therefore highly likely that more modern techniques such as in vitro fertilization, protoplast fusion and the like might provide easier methods of gene transfer of germ plasm from Groups II, III and IV into the gene pool of S. tuberosum.

Species Taxonomy and Distribution

The taxonomy of the North American species has been treated in considerable detail by Bitter (1912, 1913), Rydberg (1924) and Correll (1952, 1962), as well as a number of other writers. Distribution maps (Figs. 4-13) are included here, taken from Hawkes (1966). A discussion of the taxonomy of these species is also included in Hawkes (1958a, 1963 and 1978), together with the South American species.

The distribution maps give the approximate boundaries of the species, but these will need to be verified after further study. Some species seem to be bitopic or even polytopic, but further collecting may fill in the gaps between the disjunct parts of their distribution. Rather striking in this respect are S. morelliforme (Fig.4), S. bulbocastanum (Fig. 5), S. demissum (Fig. 9), S. fendleri (Fig. 10), S. verrucosum (Fig. 11) and S. polyadenium (Fig. 13).

Although the main outlines of the taxonomy of wild potato species from the area in question seem reasonably clear, more work is still needed. The points were set out in the first Workshop report on germ plasm exploration and taxonomy of potatoes (see CIP, 1973, Appendix 1, pp. 4-8). In addition, it was noted that certain species such as S. hintonii and S. nayaritense were not known in the living state, and that

others, such as S. stenophyllidium and S. nicaraguense needed more attention. Amongst the recommendations of that Workshop it was stressed that "emphasis should be placed on experimental studies linked to morphogeographical data."

The 1976 Planning Conference on Exploration and Maintenance of Germ plasm Resources also dealt with the North American potatoes (Hawkes and Hjerting, 1976). One can only agree with the priorities for taxonomic research set out in that paper (pp. 43-48).

By and large, little work has been done since 1976 on this group of species, and the following notes summarise the recommendations, adding further comments in some places.

(a) Series Morelliformia and Bulbocastana. Low priority, but interest for breeding Phytophthora-resistant varieties. No taxonomic work has been carried out since the first Planning Conference.

(b) Series Pinnatisecta. More studies are needed here, particularly with S. hintonii, S. michoacanum, S. nayaritense, S. stenophyllidium, etc. This depends now on the collection of more material.

(c) Conicibaccata. Although it was mentioned in 1976 that much taxonomic work was needed on this series, a very useful study has now been completed by Dr. Luis López, and publications are being prepared. The inter-relationships of the North American species would merit further detailed study.

(d) Demissa and Longipedicellata. Biosystematic studies on these two groups are urgently required, particularly in relation to the origins of the tetraploid and hexaploid species and their diploid ancestors. As was mentioned in 1976, "the whole group (Demissa) would form the basis for an excellent cytotaxonomic and chemotaxonomic study," and this comment would apply also to Longipedicellata.

(e) Polyadenia. More work of a biosystematic nature is needed to elucidate the relationships of this series to Pinnatisecta on the one hand and Tuberosa on the other.

(f) Tuberosa. Only one species in this series, S. verru-

cosum, is known for Meso-America. Its distribution needs further study, as well as its relationships to series Demissa where it was formerly placed (see also Marks, 1955; Hawkes, 1956).

In the list of resolutions of the 1976 Planning Conference it was recommended that, amongst others, a biosystematic monograph of the wild potatoes of North and Central America be prepared and that high priority should be given to taxonomic studies in series Demissa, Longipedicellata and Conicibaccata, as well as some of the South American series and species groups.

Nothing has been done in the intervening 3 years to prepare the monograph, nor has work commenced on series Demissa and Longipedicellata. However, in view of the more urgent priorities concerned with the cultivated potatoes this is not surprising. If priorities for wild species are raised during the present conference it would probably be advisable to add series Pinnatisecta to the list.

Germ plasm Exploration Priorities

In the 1973 Workshop, priorities for exploration were graded on the following scale:

E	=	Emergency (Very urgent)
A	=	High priority
B	=	Medium priority
C	=	Low priority
None	=	No interest

These priorities were set out against three criteria, as follows:

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

For USA., Mexico and Guatemala the wild species priorities were:

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

This meant that for the first region plant breeders' needs and the lack of living material, as well as taxonomic interest were judged to be high (A-B), but less so for Central America. In neither area was the threat of genetic erosion considered to be very high.

In the 1976 Planning Conference the criteria were set out in a different manner, though the basic ideas were very similar:

1. Availability in germ plasm collections
2. Potential usefulness for potato research and improvement
3. Threats to habitat

Summing up the 1976 priorities for each country the list then read as follows:

United States	C
Mexico	A
Guatemala	B
Central America	C

This recommendation accords very well with that of the 1973 Workshop.

Material Available in Gene Banks

To assess the need for further collections it is necessary to calculate the amount of material already available in the gene banks. Since CIP possesses very little wild potato material from the North American continent the records of other banks must be studied. There are three banks which hold the major stocks of wild potatoes, namely:

(a) Sturgeon Bay, Wisconsin, U.S.A.
(b) Braunschweig-Völkenrode, West Germany (Dutch-German potato gene bank)
(c) The Scottish Plant Breeding Station, Edinburgh, U.K. (Commonwealth Potato Collection)

Assessments of the North American wild potatoes in these three banks is given in Tables 3 and 4, sorted by species and by collectors. It will be noted that the last Sturgeon Bay Inventory was published in 1969, but the data shown here

Table 3. Living North and Meso-American Potato Material at Sturgeon Bay*

Species	Correll	Rocke-feller Found.	Canada (Graham)	CPC Hawkes et al.	Ugent	Tarn	EBS and Ross	Miscell-aneous	Totals
S. agrimonifolium	-	-	5	2	-	-	-	-	7
S. brachistotrichum	1	-	-	4	-	-	-	-	5
S. brachycarpum	-	1	2	5	-	-	-	-	8
S. bulbocastanum	1	10	5	20	1	2	-	-	39
S. cardiophyllum	-	-	4	17	1	1	-	-	23
S. clarum	-	-	1	4	-	-	-	-	5
S. demissum	37	2	-	18	3	-	9	17	86
S. fendleri	-	-	3	15	-	1	-	-	19
S. guerreroense	2	-	-	-	-	-	-	-	2
S. hjertingii	-	-	-	7	-	-	-	-	7
S. hougasii	3	2	2	1	-	-	-	-	8
S. iopetalum	-	-	-	2	-	-	-	-	2
S. jamesii	-	-	5	6	-	1	-	3	15
S. lesteri	-	-	-	1	-	-	-	-	1
S. longiconicum	-	-	-	1	-	-	-	1	2
S. morelliforme	-	-	1	5	-	-	-	-	6
S. oxycarpum	-	-	1	3	-	-	-	-	4
S. papita	1	-	1	7	-	-	-	2	11
S. pinnatisectum	-	1	-	12	-	1	-	2	16
S. polyadenium	1	-	1	4	1	2	3	-	12
S. polytrichon	-	-	5	9	-	2	-	1	17
S. sambucinum	-	-	-	3	-	-	-	-	3
S. schenckii	-	1	-	-	-	-	-	-	1
S. stenophyllidium	-	-	4	-	-	-	-	-	4
S. stoloniferum	15	3	4	23	1	-	3	9	58
S. trifidum	-	1	8	1	-	-	-	-	10
S. verrucosum	2	-	2	12	2	1	1	1	21
Totals	63	21	54	182	9	11	16	36	392

* Based on 1969 Inventory (see Ross & Rowe, 1969) and personal observations of the author

Table 4. Living North and Meso-American Material at Braunschweig* (and Edinburgh)†

Species	Correll	Rocke-feller Found.	Canada (Graham)	CPC Hawkes et al.	Ugent	Tarn	EBS and Ross	Miscell-aneous	Totals
S. agrimonifolium	-	-	(3)	-	-	-	-	-	(3)
S. brachistotrichum	-	-	-	2 (2)	-	-	-	-	2 (2)
S. brachycarpum	-	-	-	-	-	-	-	-	-
S. bulbocastanum	-	2 (1)	1	11 (10)	-	-	-	-	14 (11)
S. cardiophyllum	-	-	(1)	1 (17)	-	-	-	1	2 (18)
S. clarum	-	-	-	-	-	-	-	-	-
S. demissum	36 (2)	2 (9)	-	17 (12)	-	-	11	14 (20)	80 (43)
S. fendleri	-	-	-	2 (18)	-	-	-	-	2 (18)
S. guerreroense	-	-	-	-	-	-	1	-	1
S. hjertingii	-	-	-	4 (7)	-	-	-	-	4
S. hougasii	(1)	-	-	(1)	-	-	1	-	1 (2)
S. iopetalum	-	-	-	5 (3)	-	-	1	-	6 (3)
S. jamesii	-	-	1	(8)	-	-	-	-	1 (5)
S. lesteri	-	-	-	(1)	-	-	-	-	(1)
S. longiconicum	-	-	-	-	-	-	-	-	-
S. morelliforme	-	-	-	2 (4)	-	-	-	-	2 (4)
S. oxycarpum	-	-	-	(2)	-	-	1	-	1 (2)
S. papita	-	-	-	(4)	-	-	3	-	3 (4)
S. pinnatisectum	-	1	-	13 (7)	-	-	-	-	14 (7)
S. polyadenium	1	-	-	4 (2)	1	-	2	(2)	8 (4)
S. polytrichon	-	-	1 (1)	4 (7)	-	-	-	(1)	5 (9)
S. sambucinum	-	-	-	(5)	-	-	-	-	(5)
S. schenckii	-	-	-	-	-	-	-	-	-
S. stenophyllidium	-	-	-	-	-	-	-	-	-
S. stoloniferum	-	-	-	(28)	-	-	1	(9)	1 (37)
S. trifidum	-	-	-	(2)	-	-	3	-	3 (2)
S. vallis-mexici	-	-	-	-	-	-	-	-	-
S. verrucosum	-	-	-	-	-	-	1	-	1
	3 (2)	-	-	12 (10)	1	-	-	4 (3)	20 (15)
Totals	40 (5)	5 (10)	3 (5)	77 (150)	2	-	25	19 (35)	171 (195)

* From Computer printouts 12 March 1979

† From the Commonwealth Potato Collection Inventory, 1969

include new accessions noted in my own personal files. Little has been accessed to the Commonwealth Potato Collection for the last decade, and the figures based on the 1969 inventory are reasonably accurate. The Braunschweig data are more recent (1979), largely due to the excellent computerised data management system devised by Dr. L. Seidewitz.

On studying these Tables one question will immediately spring to mind: are the collections in the three banks largely duplicates of each other? It seems that this may be so; yet each has a significant number of lines which do not valuable but has clearly been impossible to carry out with the data now available to me, since there are certain accessions noted in the inventories for which full information is lacking.

It will be seen that the existing Correll collections, made in 1947-48 consist chiefly of S. demissum and S. stoloniferum. The Rockefeller Foundation collections, made by Ing. Agr. R. Flores Crespo and others were assembled from 1960 onwards and seem to have been largely lost. The Graham collections were made in the mid-1950s and have been well preserved at Sturgeon Bay.

The CPC, Hawkes, etc. collections were made by E.K. Balls and W.B. Gourlay in 1938 and by J.G. Hawkes in 1949, forming the basis of the Commonwealth Potato Collection for this region. To these were added the more extensive material collected by J.G. Hawkes, J.P. Hjerting and R.N. Lester in 1958, which together form nearly half of the total of the Sturgeon Bay material.

In addition to these collections there are a few from Ugent and Tarn, and some collections by Reddick, Toxopeus and others which figure in the "Miscellaneous" column. The EBS collections are difficult to unravel, since although some were made by Professor H. Ross many were given EBS numbers that cannot at present be related to the original collections and the names and numbers of the collectors.

Reviewing the results of this survey several points seem worth stressing.

(a) The hybridogenic "species" such as S. x michoacanum (= S. pinnatisectum x S. bulbocastanum), S. x sambucinum (= S. pinnatisectum x S. cardiophyllum subsp. ehrenbergii), S. x vallis-mexici (= S. stoloniferum x S. verrucosum), S. x edinense subsp. salamanii (= S. demissum x S. tuberosum subsp. andigena) and

and S. semidemissum (= S. demissum x S. verrucosum probably) are absent or represented by a few clones only. This perhaps does not matter too much, since their germ plasm should be obtainable from collections of the original parents.

(b) Only two species, S. stoloniferum and S. demissum, are represented by over 50 collections and even these collections tend to have been made largely in the easily accessible regions around the Valley of Mexico, the Toluca valley and parts of Puebla and Michoacán States.

(c) Species represented by between 20 and 40 collections are the well-distributed S. bulbocastanum, S. cardiophyllum, and S. verrucosum. More material of these should be assembled.

(d) Those with 10-19 collections are S. fendleri, S. jamesii, S. papita, S. pinnatisectum, S. polyadenium, S. polytrichon and S. trifidum. Certainly, further collections of these species are needed.

(e) Some 15 species, more than half of the total number of about 35 species, are represented by from 1-9 collections only, whilst three species (S. nayaritense, S. hintonii and S. woodsonii - not listed on the Tables) have not been collected at all. All the species in this section should therefore receive high priority for exploration and collection.

Suggestions for Further Exploration Work

The results of the present survey clearly indicate the very narrow genetic base available in world germ plasm banks for the North American species. Even the moderate to well-collected species (see (b), (c) and (d), listed in the previous section) have almost certainly not been sampled throughout their range. Indeed, we still have no clear idea of their range in many instances. Although certain species may be narrow endemics, restricted to certain regions, further material should be sought. Clearly the species where only one or two accessions are available in the gene banks or where no collections have been made at all, deserve the greatest attention.

It will therefore be necessary to study carefully the exact locations where herbarium and living material has already been obtained for all these species and to plan further collection expeditions accordingly.

We have now built up a considerable range of expertise in the correct sampling techniques for plant genetic resources exploration (Allard, 1970; Jain, 1975; Marshall and Brown, 1975). Some knowledge has also been accumulated on the sampling of vegetatively propagated crops (Hawkes, 1975, 1980). These techniques should be applied to the sampling of wild as well as cultivated potatoes.

Further collections of wild materials have recently been made by Ugent and staff members from Sturgeon Bay in the American southwest (Hanneman, pers. comm.). It is understood that plans are being discussed for collecting throughout the appropriate regions of the United States and Meso-America over a 5-year period in a much more detailed way than has been accomplished before. Such collecting is urgently needed, and the present Planning Conference on potato germ plasm exploration would be well advised to give such work its unqualified support. Even though genetic erosion in the wild species is not so intense as with the cultigens, the resistance to pests and pathogens already known in this material would indicate that it may well be of the utmost interest to breeders in the near future.

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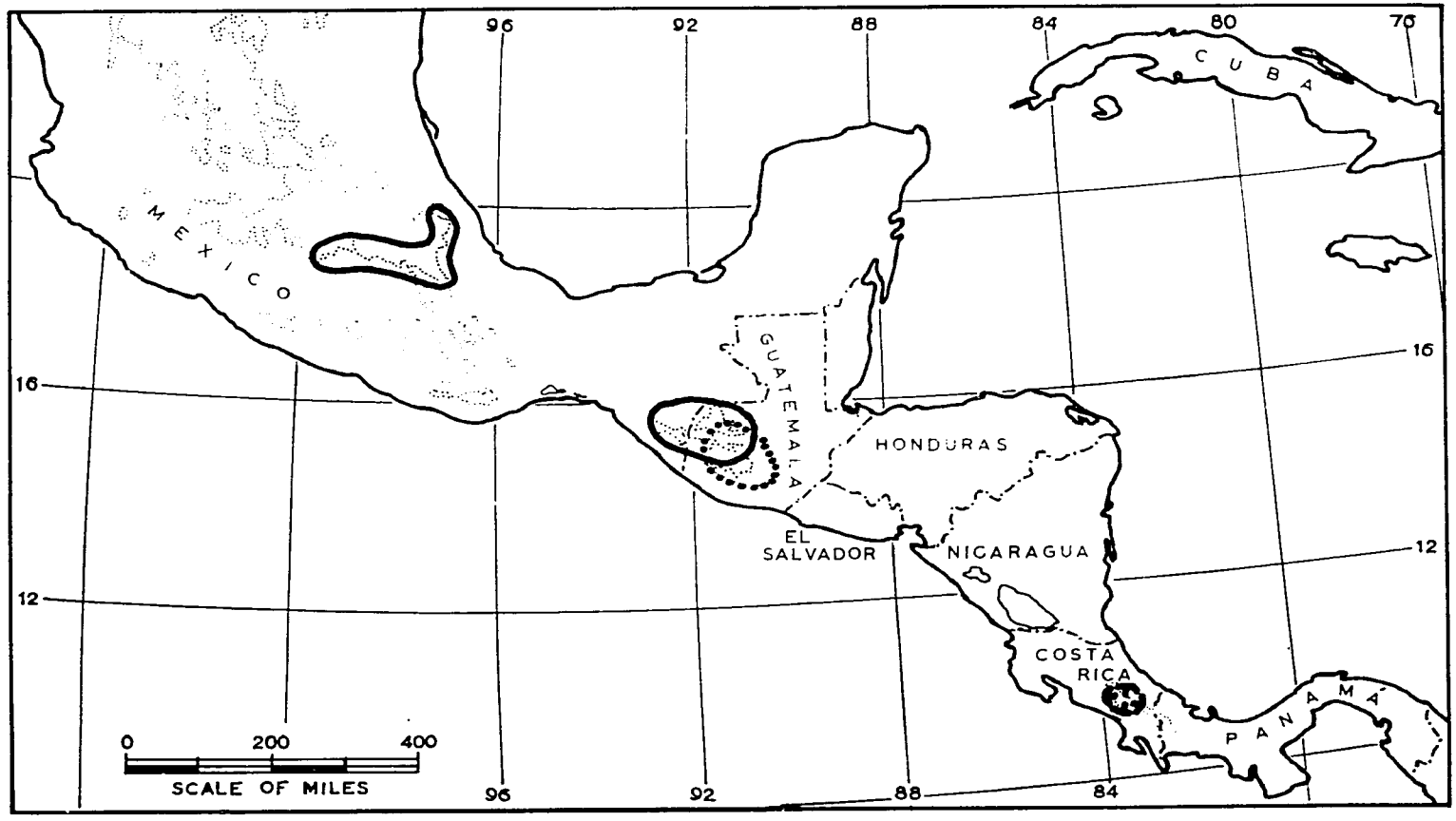
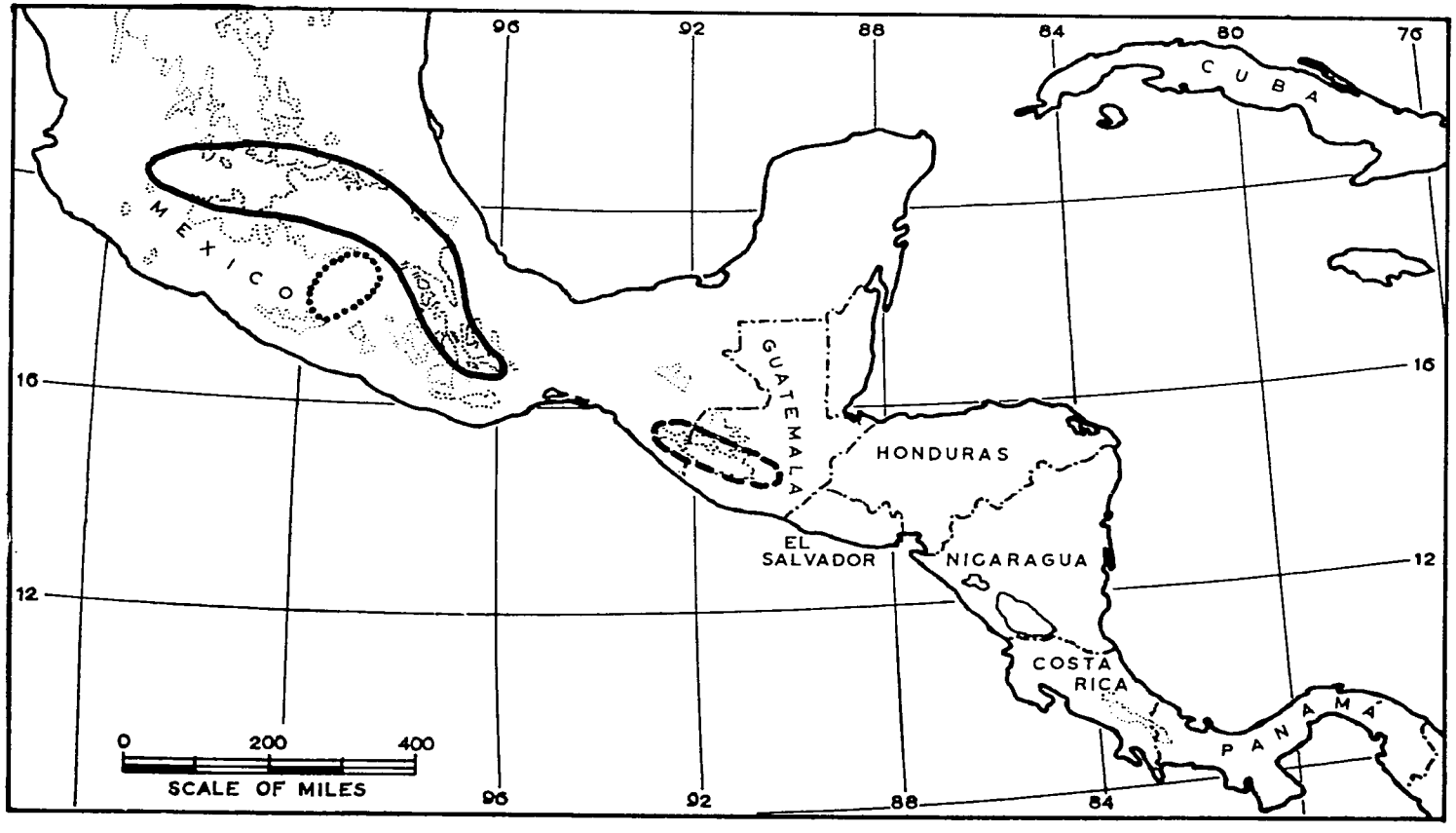
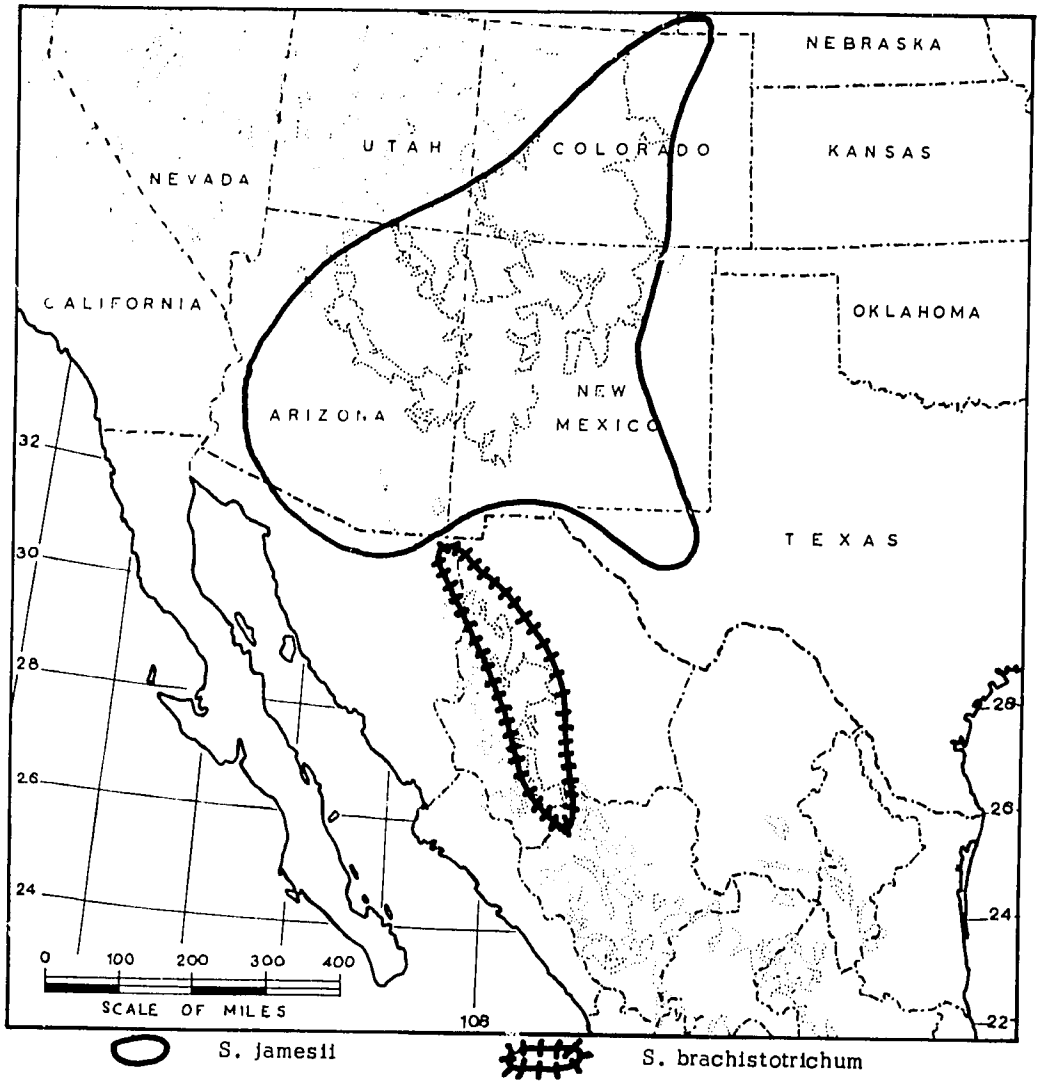

S. juglandifolium
S. morelliforme
S. clarum
96
92
88
84
80
76
16
12
CUBA
MEXICO
GUATEMALA
HONDURAS
EL SALVADOR
NICARAGUA
COSTA RICA
PANAMA
0
200
400
SCALE OF MILES

S. bulbocastanum

ssp. bulbocastanum ssp. dolichophyllum ssp. partitum




NEBRASKA
KANSAS
UTAH
COLORADO
NEVADA
CALIFORNIA
OKLAHOMA
ARIZONA
NEW MEXICO
TEXAS
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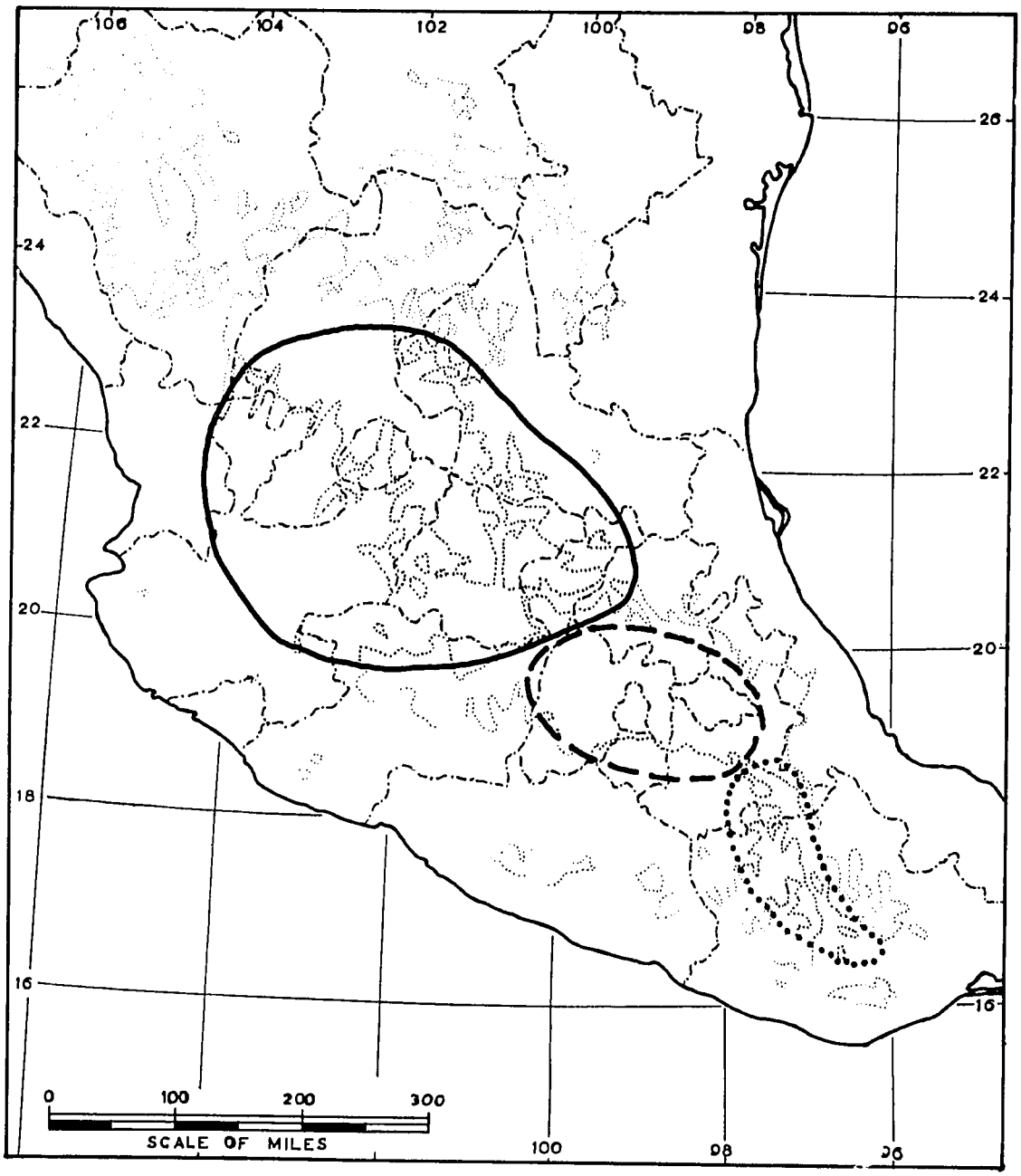
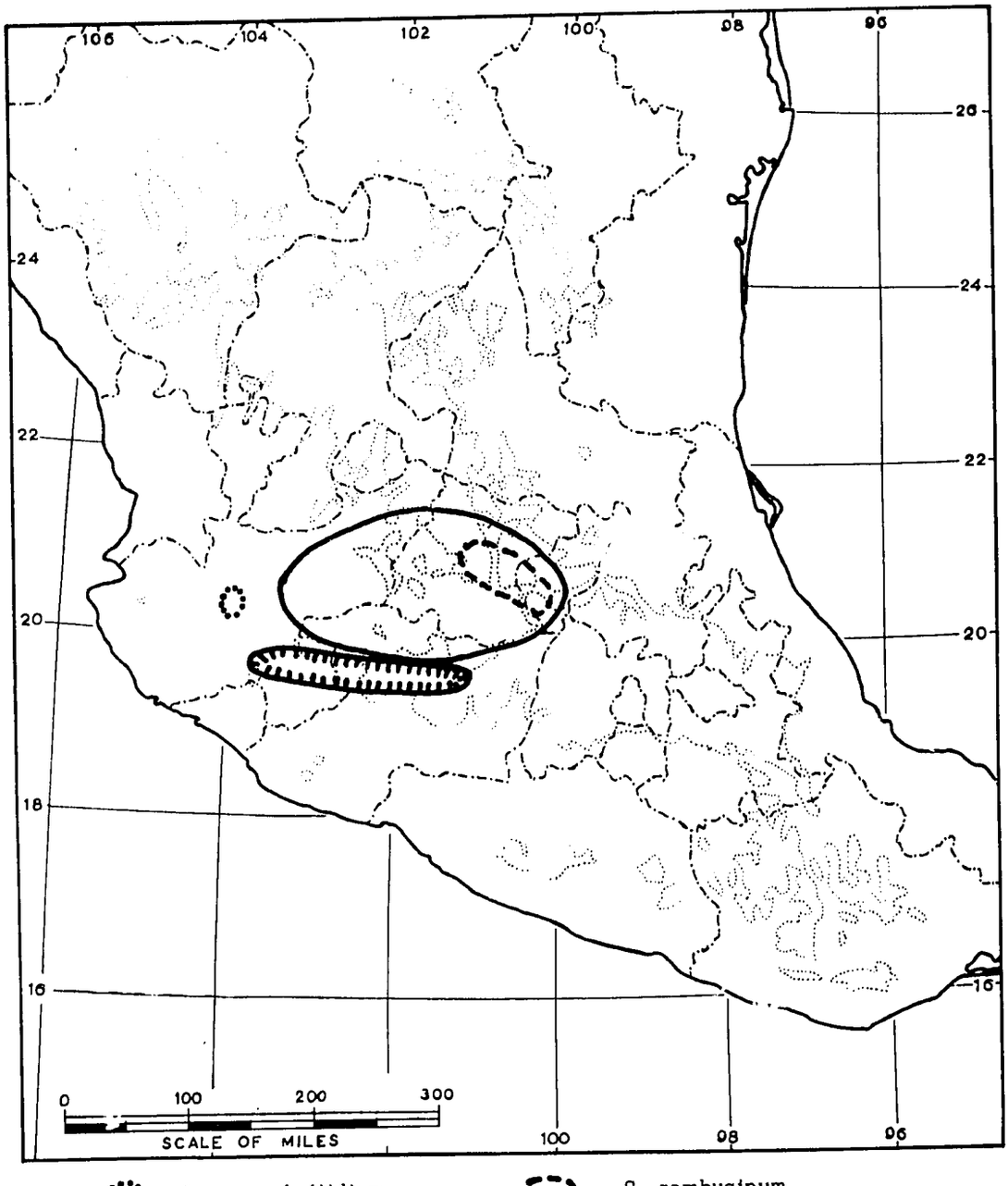
22
108
0 100 200 300 400
SCALE OF MILES
S. jamesii
S. brachistotrichum



S. cardiophyllum

ssp. cardiophyllum ssp. ehrenbergii ssp. lanceolatum

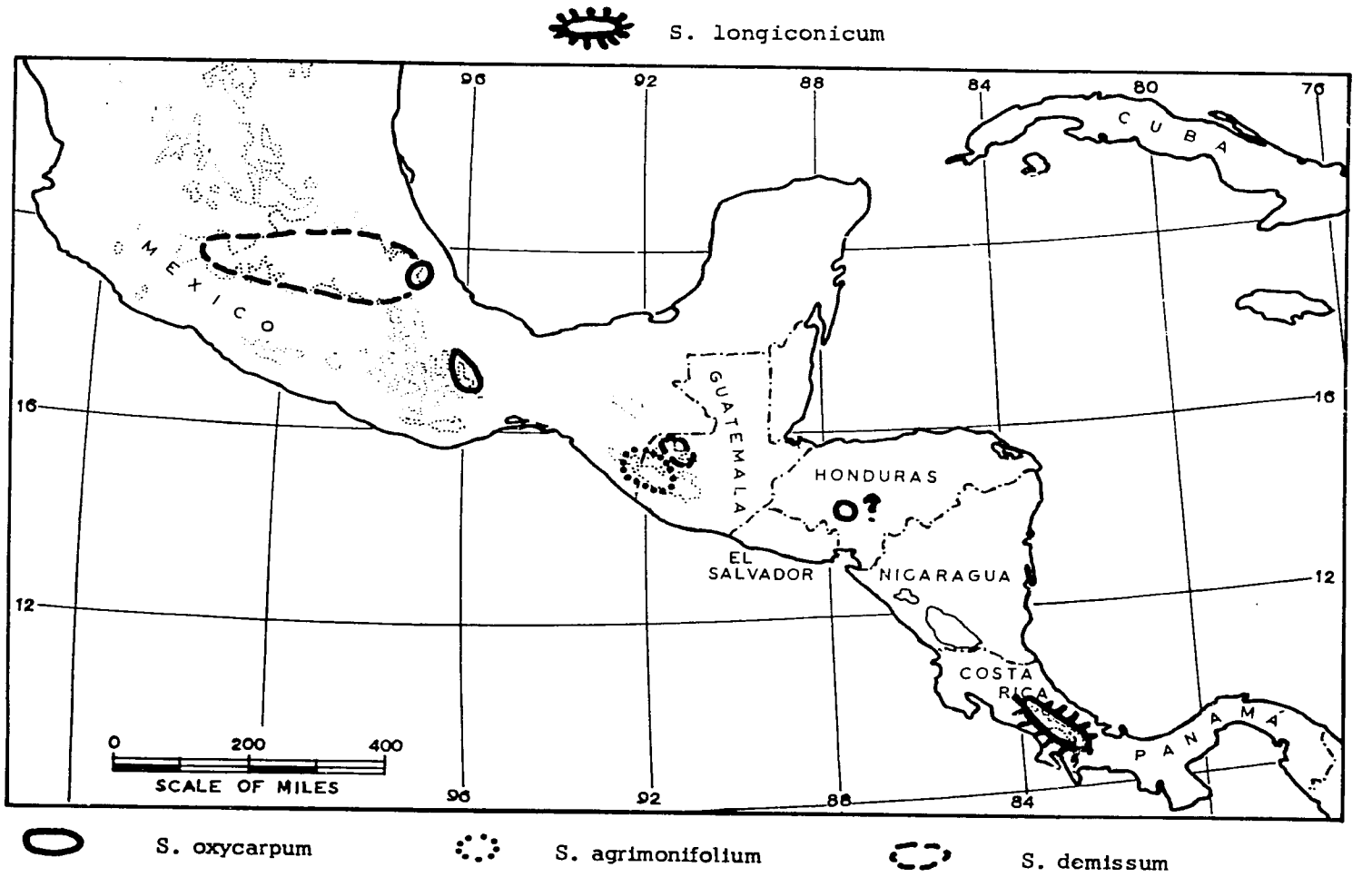


S. stenophyllidium

S. sambucinum

S. trifidum

S. pinnatisectum


S. longiconicum
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CUBA
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EL SALVADOR
NICARAGUA
COSTA RICA
PANAMA
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SCALE OF MILES
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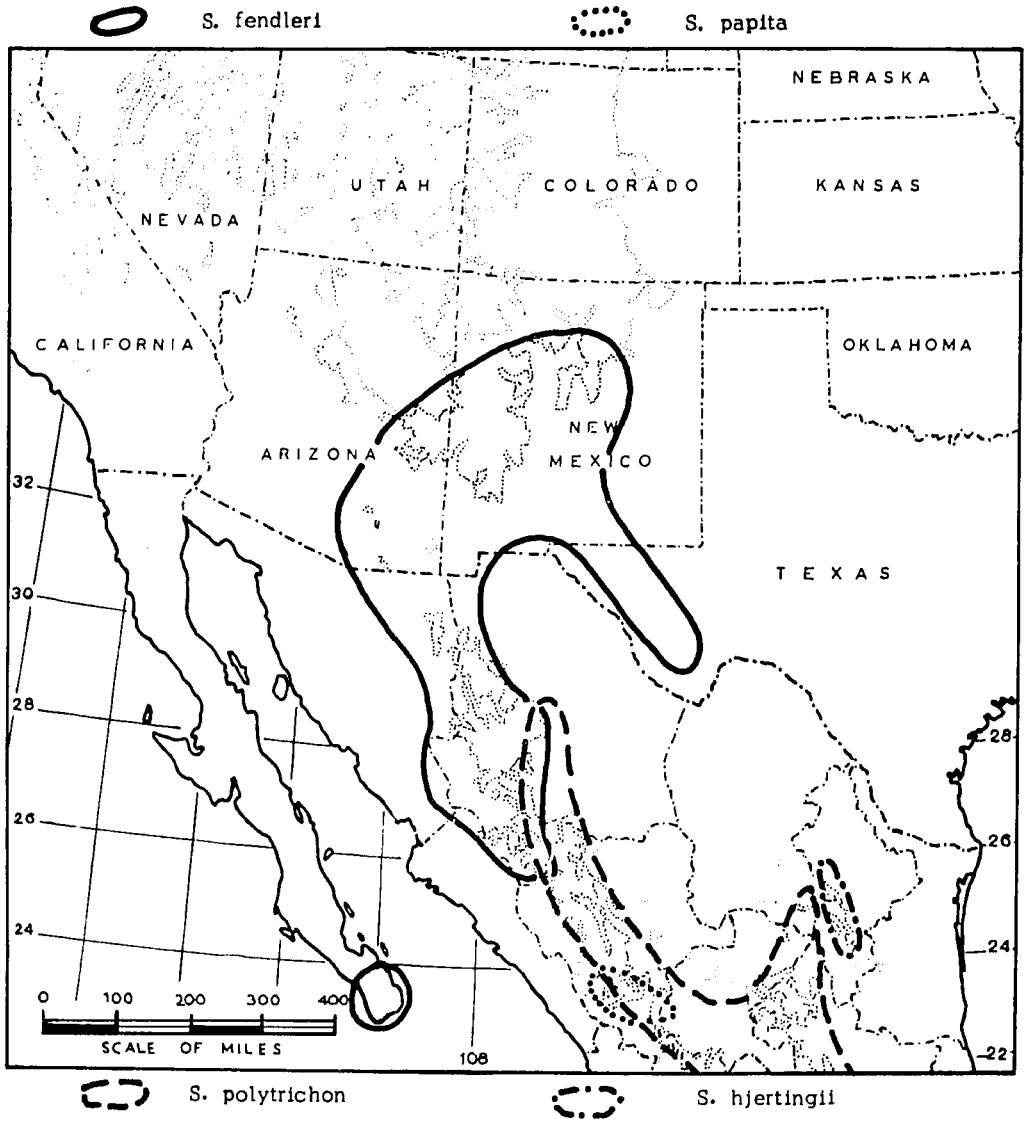
S. agrimonifolium
S. demissum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S. papita
NEBRASKA
KANSAS
UTAH
COLORADO
NEVADA
CALIFORNIA
OKLAHOMA
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NEW MEXICO
TEXAS
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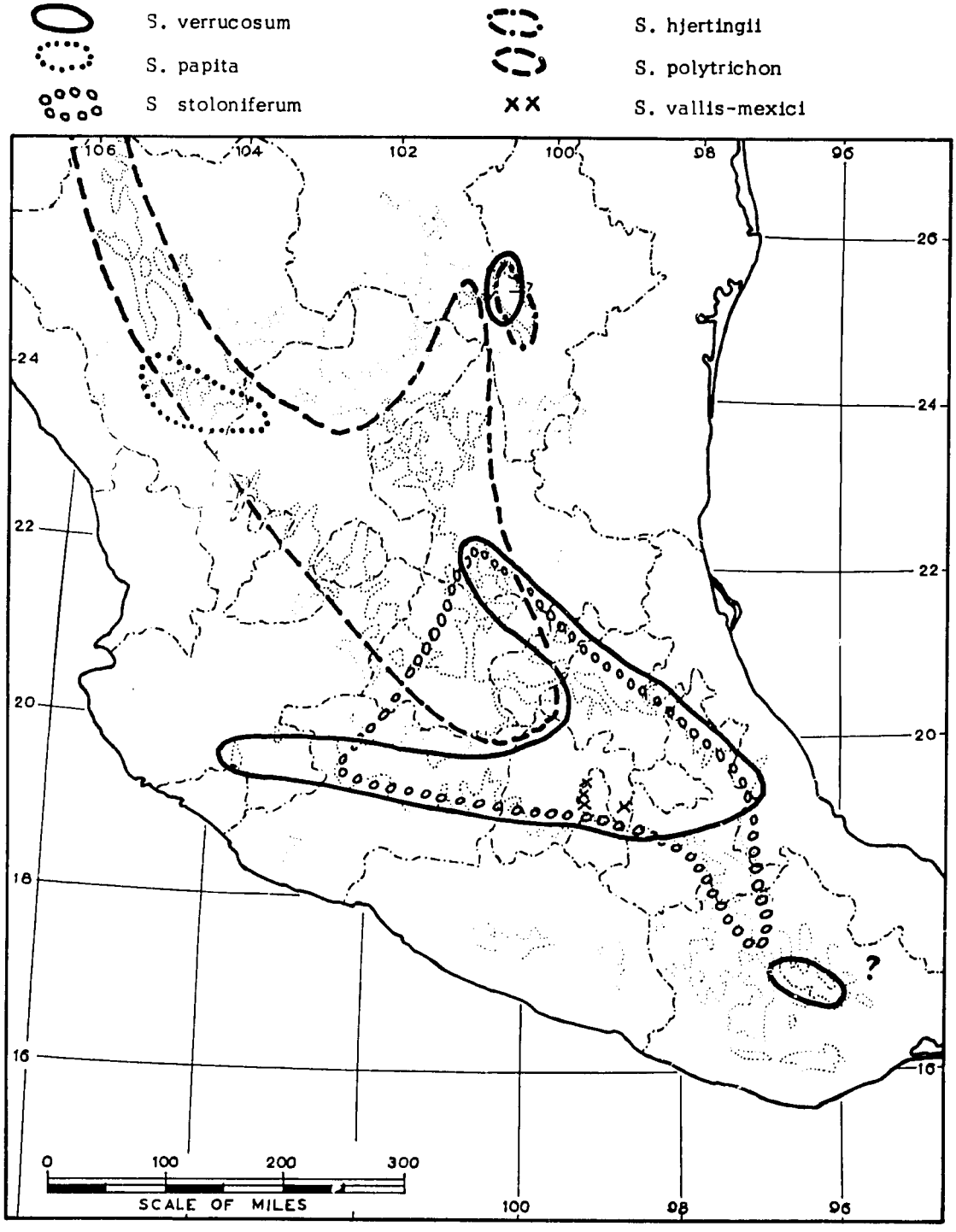
SCALE OF MILES
S. polytrichon
S. hjertingii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S. papita
S stoloniferum
S. hjertingii
S. polytrichon
S. vallis-mexici
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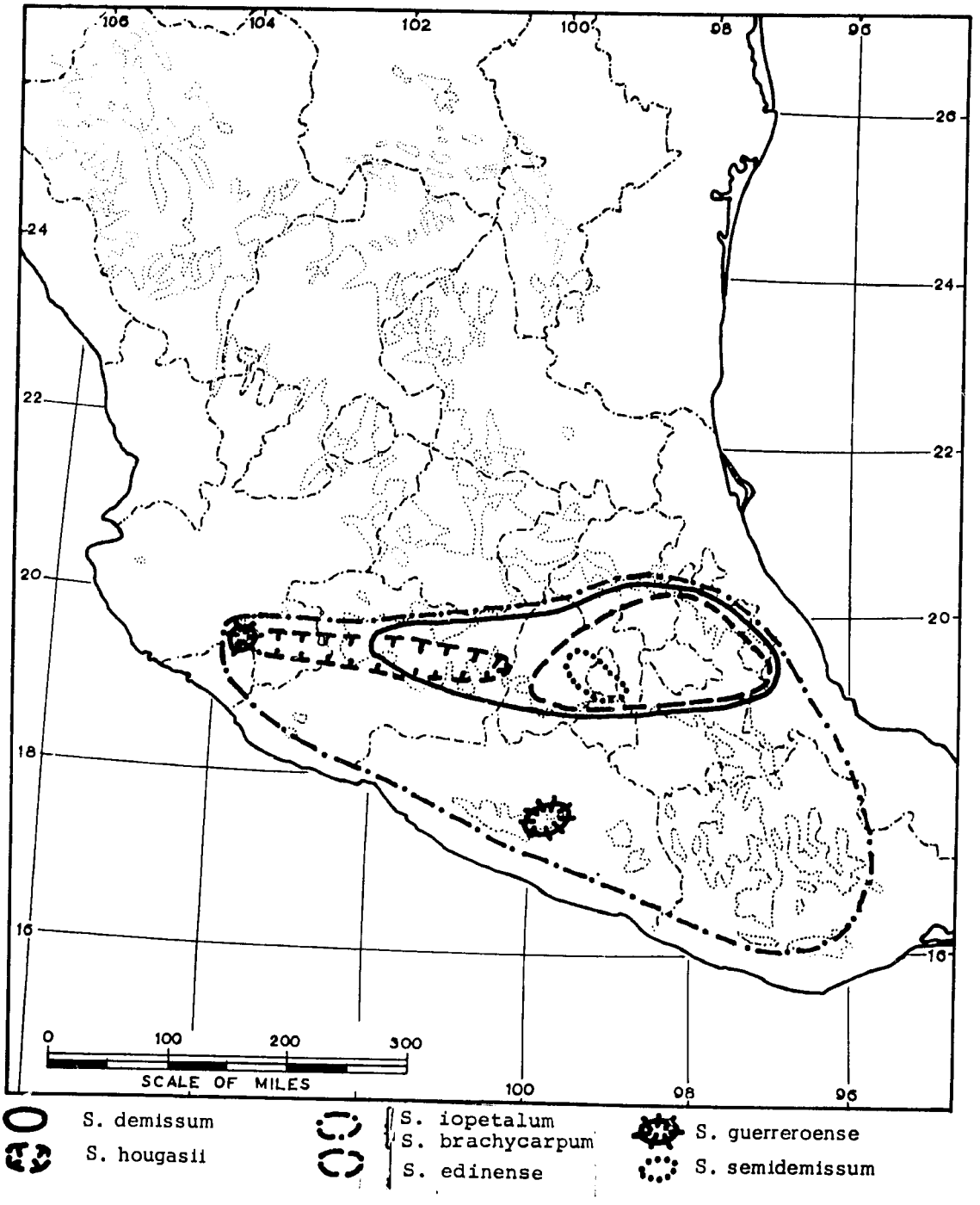
SCALE OF MILES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SCALE OF MILES
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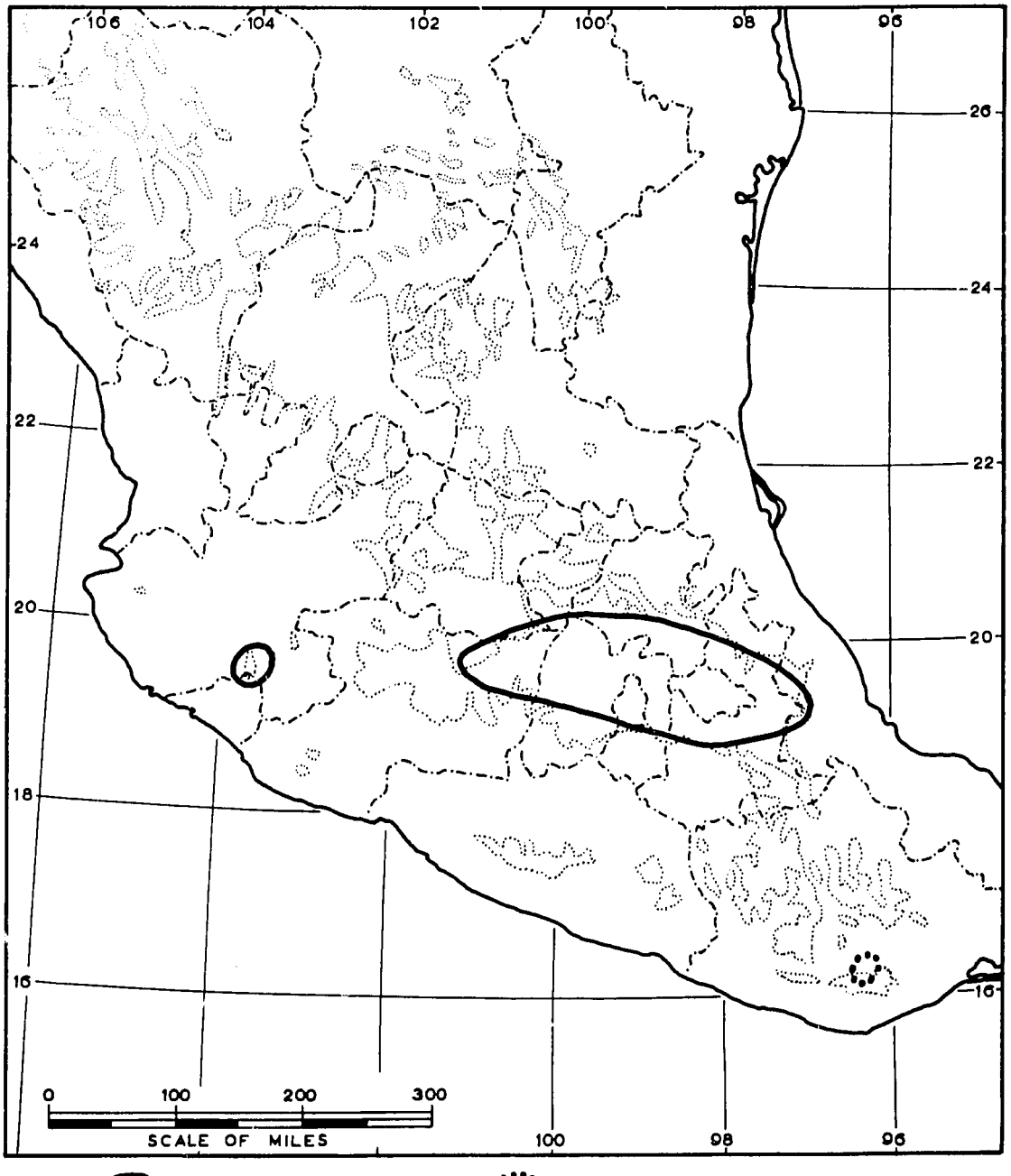
S. hougasii
S. iopetalum
S. brachycarpum
S. edinense
S. guerreroense
S. semidemissum



S. polyadenium S. lesteri

Collection and Taxonomy of the Argentine Tuber-Bearing Solanums

Dr. K.A. Okada

In this presentation I shall try to make a brief review of the situation of each species as well as some of the taxonomic problems which need to be studied in the light of my own experience.

Series Commersoniana

S. Commersonii

From an examination of some collections of subsp. malmeanum from province of Corrientes I gained the impression that the status of this subspecies would need to be reviewed. It is quite possible that subsp. malmeanum proves to be sufficiently differentiated from subsp. commersonii as to deserve recognition as a true species, that is, as S. malmeanum. In order to arrive at a conclusion more samples are needed from provinces of Entre Ríos, Corrientes, Misiones, as well as from the neighboring countries of Paraguay, Uruguay and Brazil.

S. Chacoense

This is a highly variable species with an extensive geographic distribution. Although only two subspecies have been recognized, I think that an intensive sampling from selected areas will make it possible to divide this species into a few more subspecies. Subspecies muelleri would require a special collecting effort since this taxon is scarcely known in the living state. Hybrids of S. chacoense with diploid S. microdontum are frequent; on the western ranges of Argentina hybrids of triploid S. microdontum x diploid S. chacoense were also found.

S. Tarijense

A large collection of S. tarijense from department of

Santa Victoria, Salta, was examined in Sturgeon Bay in 1977. It was noticed that in several collections there were, besides the normal white-flowered plants, plants with pale-violet flowers like S. x berthaultii. It seems, therefore, that this hybridogenic species is also present in northern Argentina though it may be possible that S. tarijense occurs in two color forms.

Serie Acaulia

Much more information is needed about the nature of subsp. aemulans. This subspecies has a disjunct distribution occurring in Tilcara (Jujuy) and then 600 km southwards in Sierra de Famatina (La Rioja). No collection of subsp. aemulans has been made between those two areas.

We have found that subsp. acaule hybridizes quite frequently with S. megistacrolobum and S. infundibuliforme, two common diploid species of the Argentine Puna (Okada and Clausen, 1979). We consider that the Tilcara population of S. acaule subsp. aemulans could have originated from a hybrid between S. acaule and S. megistacrolobum by the functioning of an unreduced gamete from S. megistacrolobum. Subspecies aemulans from the Sierra de Famatina has probably a different origin; triploid hybrids between subsp. aemulans and a diploid species related to S. spegazzinii were quite common in high altitude grassland of Sierra de Famatina. (Fig. 1).

Serie Cuneolata

S. Infundibuliforme

In my opinion this species plays a very important function in the transfer of variability to tetraploid S. gourlayi. In fact, I have found a high frequency of hybrids between these two species in several field populations in province of Jujuy. It seems that most of these hybrids are tetraploids; triploids have not yet been found. Mrs. Elsa Camadro has already found several clones of S. infundibuliforme able to produce 2n gametes, a fact that can help to explain the tetraploid nature of the hybrids found in the field.

A large number of tuber samples of S.gourlayi and hybrids of S. gourlayi x S. infundibuliforme that were collected last summer in the Quebrada de Incacuevas, Humahuaca, are now in cultivation at Balcarce.

Series Megistacroloba

S. Megistacrolobum

This species hybridizes very often with S. acaule. We have also found evidence indicating that S. acaule subsp. aemulans from Tilcara could be a hybrid between S. acaule subsp. acaule and S. megistacrolobum.

S. Boliviense

This species is morphologically very similar to S. megistacrolobum but it has a much more restricted geographic distribution. It is found only on the eastern, more humid slopes of the Sierra de Santa Victoria and Iruya.

S. Sanctae-Rosae

Many more living collections of this little species are required as well as biosystematic studies to evaluate the relation of S. sanctae-rosae with other species in the series Megistacroloba.

Series Tuberosa

Some of the most interesting biosystematic problems occurs in this group.

S. Microdontum Subsp. Gigantophyllum

We have found that triploid cytotypes of this species are quite common on the western mountains of La Rioja and Catamarca. The triploid cytotypes hybridize with S. kurtzianum (= S. x rechei) and S. chacoense, producing diploid hybrids. (Fig. 2).

S. Venturii

This is an endemic species to the Argentine republic not very well known in living collections. Its biosystematic relationships with other species should be worked out.

S. Vernei

Despite the importance of this species for nematode resistance breeding, we have only 17 living collections of

S. vernei. This is in part due to the fact that this species grows in areas of difficult accessibility in the upper belt of the Montano district.

S. Gourlayi

This species poses one of the most interesting albeit most difficult taxonomic problems. It occurs as diploid and tetraploid cytotypes which are not easy to differentiate (Fig. 3 and 4). Clausen (1979) in a comparative study of the diploid and tetraploid forms of S. gourlayi came to the conclusion that the pattern of variation of this species has been greatly increased by introgression from S. infundibuliforme. She also found that S. gourlayi is highly cross-compatible at both ploidy level with S. infundibuliforme. It seems that in the cross tetraploid S. gourlayi x diploid S. infundibuliforme the resulting hybrid is tetraploid rather than triploid suggesting the functioning of unreduced gametes in S. infundibuliforme. In fact, 2n pollen producing clones have been already found in S. infundibuliforme by E. Camadro (1979). She observed parallel spindles in several accessions of S. infundibuliforme which happened to be collected close to S. gourlayi (4x) plants. My own field data indicate extensive hybridization between these two species but so far no triploid hybrid has been found.

Tetraploid S. gourlayi can be easily crossed with S. tuberosum subsp. tuberosum, the F_1 being quite fertile and vigorous (Santini et al, 1976).

The tetraploid forms of S. gourlayi are confined to Quebrada de Humahuaca. Most of the diploid cytotypes on the other hand were found outside that area; diploid plants of S. gourlayi were found in a few localities of the Quebrada de Humahuaca although their true identity needs to be confirmed (Fig. 5).

S. Oplocense

In the course of my post-graduate studies at the University of Birmingham I found for the first time that S. oplocense occurs as an hexaploid (2n= 6x= 72). A similar situation was found later in all collections of this species from Argentina including a recent collecting of S. oplocense from the type locality (between Oploca and Oro Ingenio, Bolivia) made by C. Ochoa (Fig. 6).

There has been some confusion between S. oplocense and S. gourlayi; of the three collections of S. oplocense studied by Hawkes and Hjerting (1969), only one (Alandia and Ross 123) seems to belong to that species though its chromosome number was given as 48 rather than 72. Our collections of S. oplocense from the same area also proved to be hexaploids; we found, however, tetraploids which we consider preliminary to be hybrids of S. oplocense x S. tuberosum subsp. andigena. The other two collections determined as S. oplocense, Correll et al A666 and Petersen and Hjerting 962, both from the vicinity of Estación Azul Pampa, belong in all probability to S. gourlayi. Though we have collected intensively in that area on several occassions, no S. oplocense has ever been found; on the contrary tetraploid S. gourlayi was frequently collected. S. oplocense is known in Argentina from four localities in the province of Jujuy: Humahuaca, Yavi, Yavi Chico and El Angosto. This species has distinctive glaucous leaves with conspicuous hairy margins and purple veins, and purple-violet flowers with long exserted style (Fig. 7).

The plant has been found at the edge of cultivated fields and it seems to hybridize with S. infundibuliforme producing apparently tetraploid hybrids.

S. Vidaurrei

This is a south Bolivian species which occurs in Argentina in the northern departments of Santa Victoria and Iruya, province of Salta, being unknown in germ plasm banks. A number of diploid collections made recently in Iruya could be preliminary ascribed to this species (Fig.8).

S. Spegazzinii

An interesting "hairy" form of S. spegazzinii has been found to be common in the Valles Calchaquíes, province of Salta, in the northern range of its geographic distribution. The plants are characterized by long spreading hairs on stems and by the finely pubescent berries, a form described as S. puberulofructum by Correll which is a synonym of S. spegazzinii. This "hairy" form, however, would deserve recognition as a subspecies of S. spegazzinii.

A very narrow leaflet form related to S. spegazzinii has been collected in Cuesta del Obispo at 3,000 m alt.

More studies are needed with these collections to determine whether they should be recognized as a new taxon.

S. Kurtzianum

We have collected this species in the provinces of San Juan, La Rioja and Catamarca; in this last provinces we found large colonies of this species at the foot of the east facing slopes of Sierra de Zapata and Belén, particularly in the mountains between Belén and Andalgalá as well as along highway N° 40, between Belén and San Fernando, on the banks of occasional streams under shade of typical Monta trees and shrubs (Bulnesia, Prosopis, Larrea).

Brücher (1962) described S. improvidum on the basis of collections made near Belén stating that this species is a self-fertile diploid of white flowers. Our collections from the same area were self-sterile and it was frequently found in the same colony plants with pure white flowers and plants with white flowers bearing purple streaks externally on the petal centres, a character which is considered to be typical of S. kurtzianum.

We think therefore that S. improvidum is a synonym for S. kurtzianum, a similar conclusion to that arrived at by Hawkes and Hjerting (1969).

S. Maglia

So far S. maglia is only known in Argentina from one locality, Quebrada de Alvarado in department of San Carlos, Mendoza. It is then necessary to make a careful search of this species to establish its geographic distribution and to increase the number of samples available in germ plasm collections.

Cultivated Species

The most important areas for the cultivation of primitive varieties of potatoes are located in the departments of Santa Victoria and Iruya (province of Salta) between 3,000 and 4,000 m. Outside that region only scattered crops are found along the Quebrada de Humahuaca, the Puna region and the Valles Calchaquíes. There are five cultivated species in northern Argentina: S. tuberosum subsp. andigena, S. ajanhuiri, S. x chaucha, S. x juzepczukii and S. x curtilobum of which

the most common varieties belong to S. tuberosum subsp. andigena. The following varieties have been collected:

Name of Variety	N° of Collections
Alcona	12
Alcona negra	5
Allo	15
Azul	2
Blanca	8
Collareja	55
Colorada	29
Condorilla	6
Corazón Rosado	4
Cuarentona	3
Cuarentilla	1
Cuareña	1
Manzana	2
Monoabreña	1
Morada	16
Negra	28
Negra overa	1
Oca papa	23
Overa	4
Rosada	8
Runa bola	4
Runa blanca	33
Runa amarilla	17
Sacampeña	1
Santa María	1
Tuni	25

Several of these varieties are just different names for the same things as it has been found by Ochoa (see his paper for this Conference).

S. x juzepczukii and S. x curtilobum are two hybridogenic species found at about 4,000 m altitude where cultivation of other better varieties is no longer possible due to frost damage. They are rarely found in cultivation as they are not considered to produce good quality potatoes. S. ajanhuiri and S. x chaucha on the other hand are cultivated at lower altitudes but they too are not found very frequently.

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Fig. 1. Natural triploid hybrid of S. acaule x S. megistacrolobum (= S. x indunii Okada et Clausen) collected in dept. Rinconada, province of Jujuy.

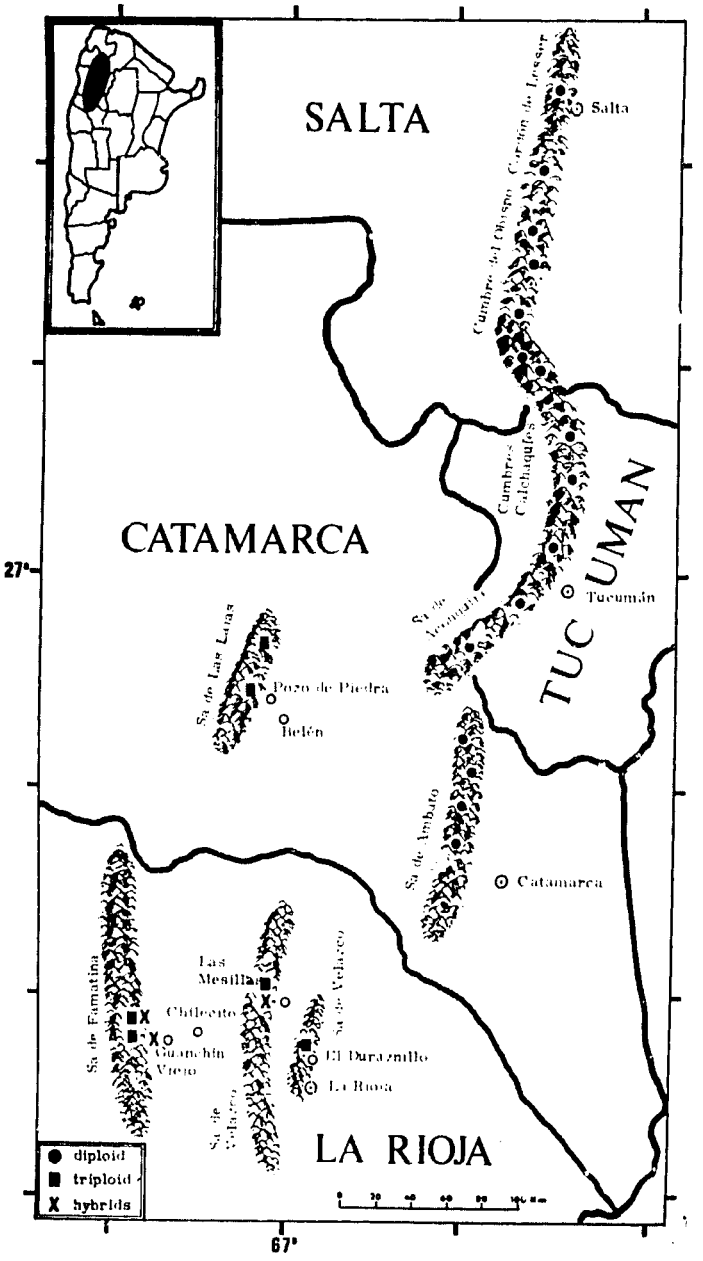

Fig. 2. Geographic distribution of triploid cytotypes of S. microdontum subsp. gigantophyllum and their hybrids.

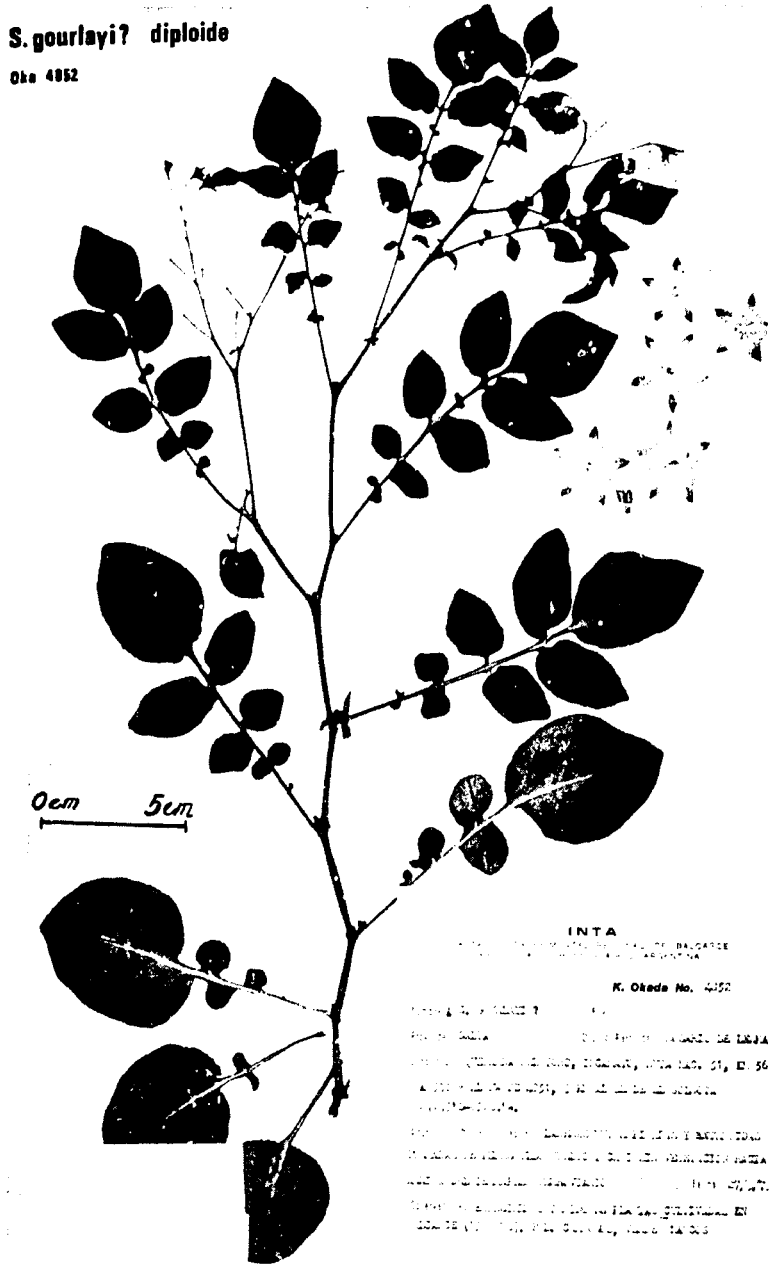

Fig. 3. Diploid plant of S. gourlayi from Quebrada del Toro, province of Salta.

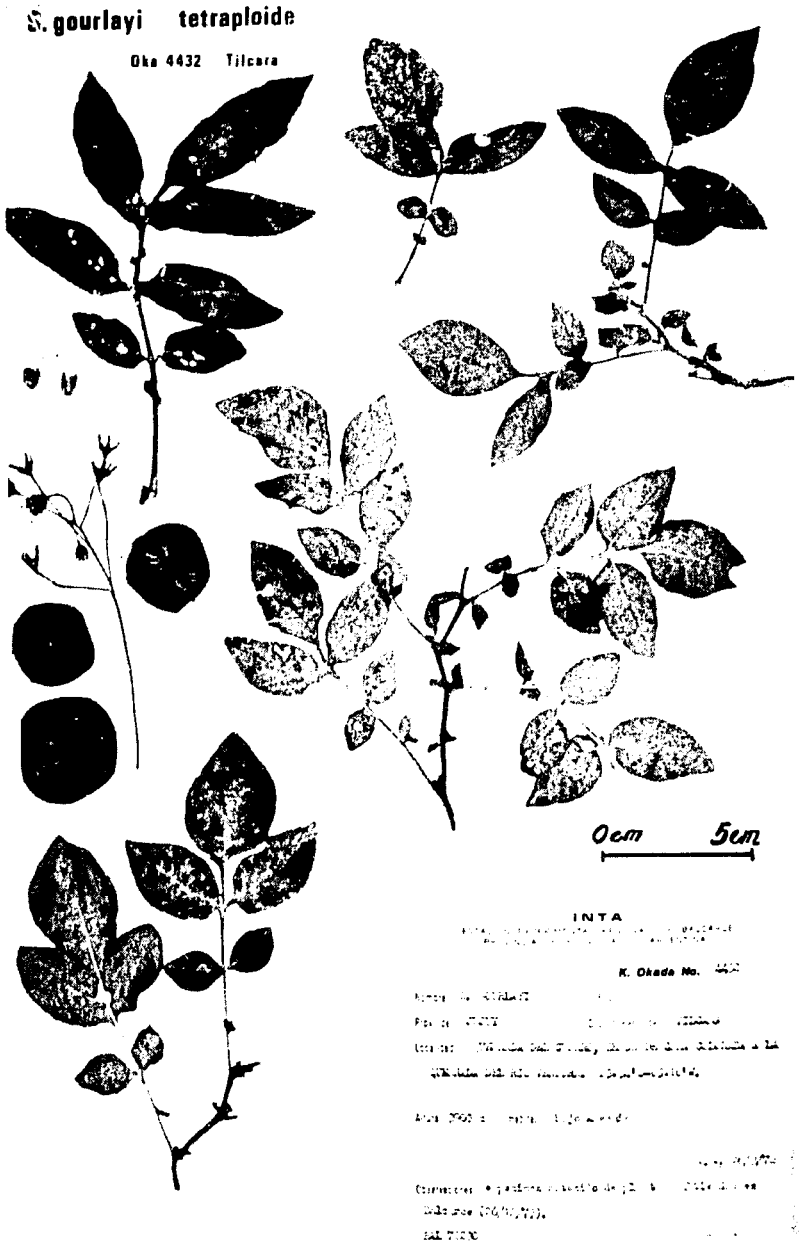

Fig. 4. Tetraploid plant of S. gourlayi from Quebrada del Chorro, province of Jujuy.

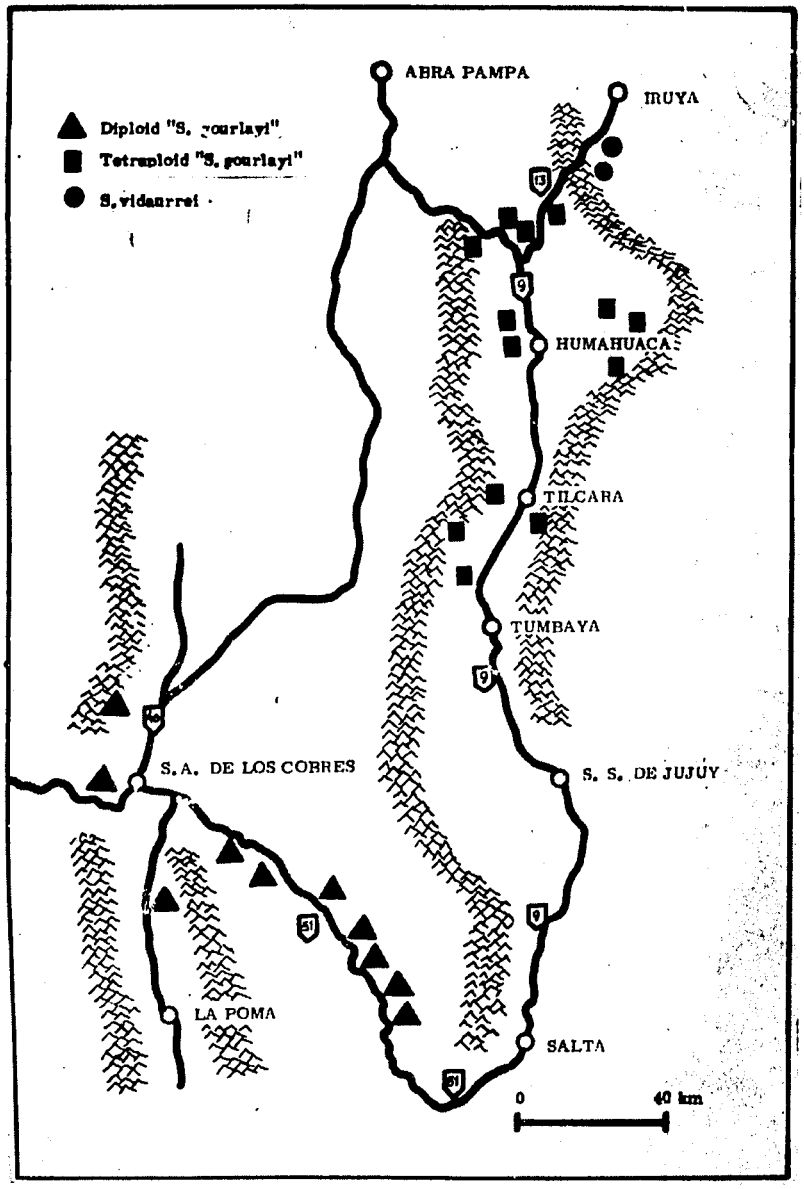

Fig. 5. Geographic distribution of diploid and tetraploid S. gourlayi in the provinces of Salta and Jujuy.

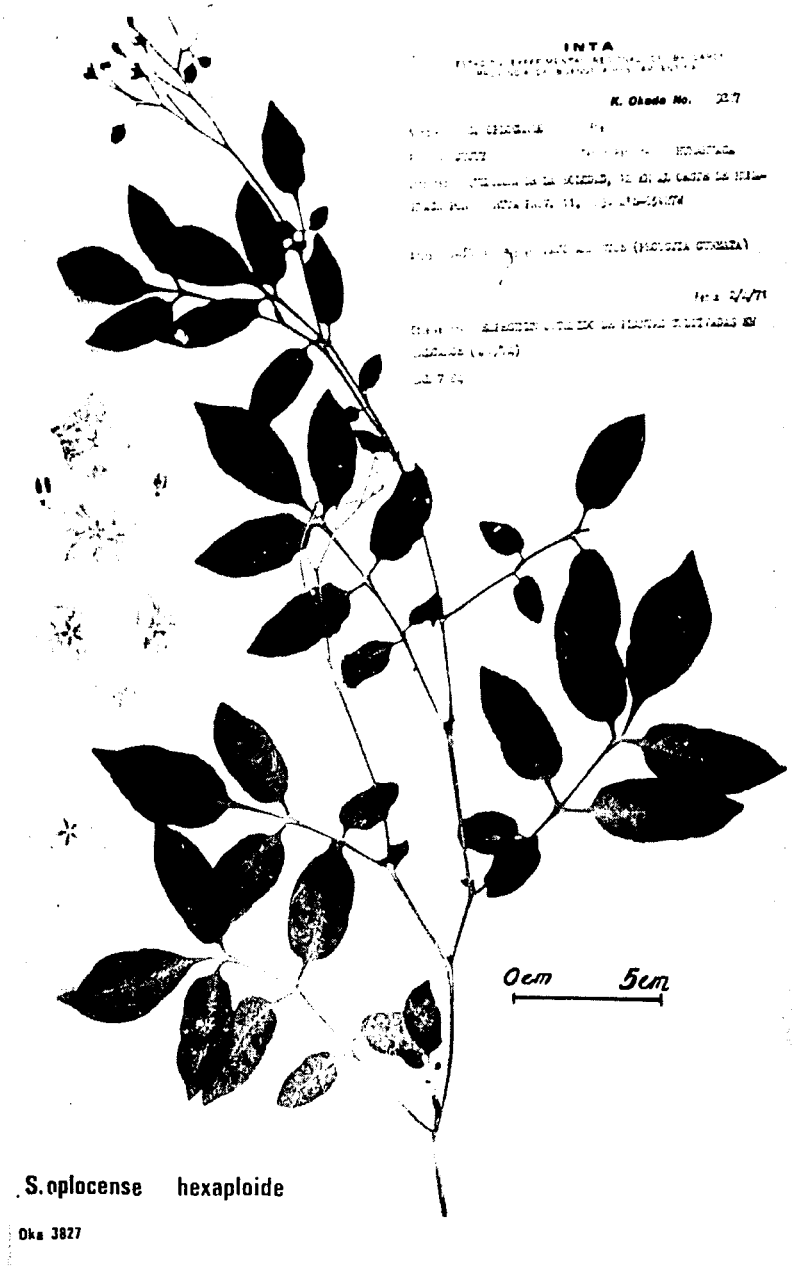

Fig. 6. Hexaploid plants of S. oplocense from Quebrada de la Soledad, Humahuaca.

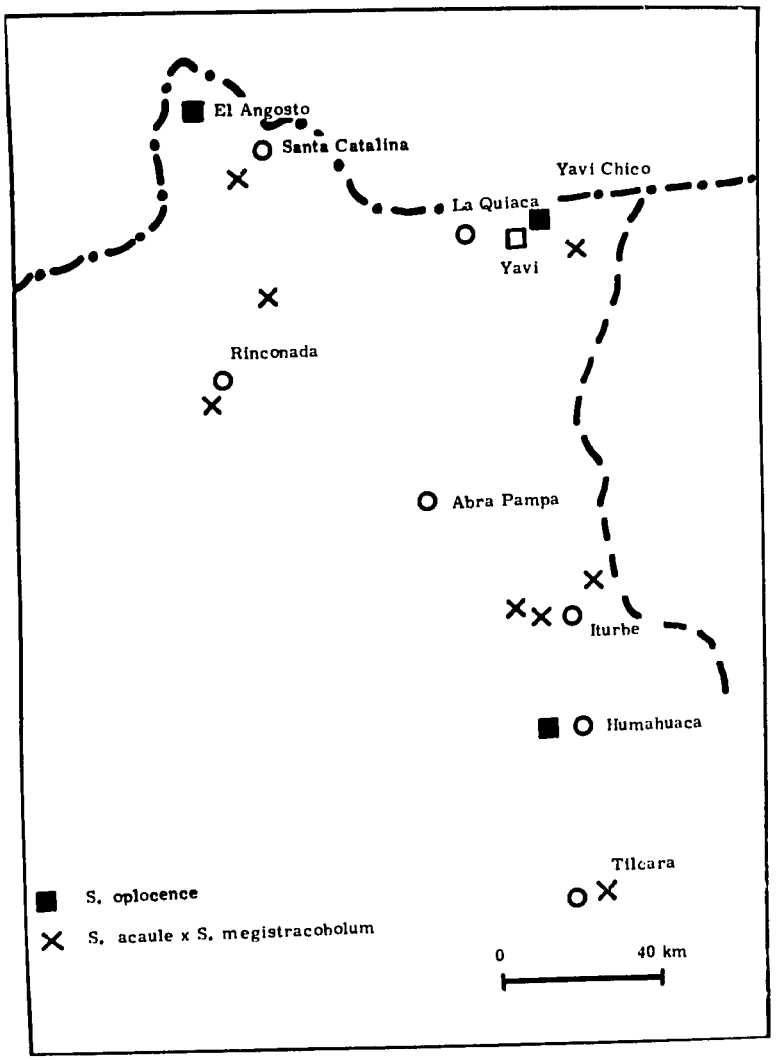

Fig. 7. Geographic distribution of S. oplocense and hybrids of S. acaule x S. megistacrolobum in the province of Jujuy.

Fig. 8. S. vidaurrei-like plant collected near Iruya, in the province of Salta.

Collection and Taxonomy of Andean Wild Potatoes

(Peru and Bolivia)

Eng. C. Ochoa

From the contributions of Dunal (1852), when only 17 species of tuber bearing Solanum were known, until the beginning of this century progress in the knowledge of this most useful group of plants was very slow. At the beginning of the century Berthault in France (1911) and above all Bitter in Germany (1912)-1914) gave a great and renewed impulse to the study of taxonomy in this difficult Genus. Bitter gave clear guidelines for the classification of the Tuberarium Section (= Sect. Petota). He made numerous comparative studies and determined a large number of synonyms, invalidating many species previously described or confirmed such as those which adjusted to his system. Bitter also contributed with the discovery of a large number of new tuberiferous species, nearly 50 of which still remain valid, with some exceptions.

Soviet potato expeditions to Mexico and South America, which began during the third decade of this century, marked a new epoch, not only regarding taxonomic knowledge of potatoes, but also showing the possibilities of their genetic improvement. During this period (1926-1933) the Russian researchers Juzepczuk and Bukasov discovered nearly 30 wild species and more than a dozen cultivated ones. Since that time other numerous expeditions have taken place and they apparently will continue. Periodically different countries organize expeditions to collect native potatoes in the mountainous areas of Mexico and South America. CIP, in the few years since it began operation, has conducted intensive exploratory and collecting activity in the South American Andes and is planning similar trips in the future.

However, even after more than two centuries since the first sporadic potato collections were made, the exploration phase and basic studies of these plants still have not yet been completed. Information is lacking for some unexplored or little explored regions of Mexico, Central and South América.

Although considerable progress has been achieved during the past 65 years, much remains to be done in potato taxonomy. Until now there is no unanimous opinion regarding the number of taxonomic groups and species. The best known contemporary researchers do not agree on these basic points. Dr. Correll considered a total of 174 species of potatoes distributed into 26 series in his 1962 comprehensive monograph on tuber bearing Solanum, including also the non-tuber bearing Basarthrum. Prof. Hawkes in his revision of 1963, considered only 156 species grouped into 17 series. In a more recent revision, this same author (G.P. Harris, 1978) recognizes 154 wild species and 8 cultivated, and 18 series. The Soviet researchers, Prof. Bukasov and Prof. Leknovitch, in their classification of wild and cultivated potatoes, published in 1971, present a total of 32 series in which a great number of species which are obviously synonymous are included.

At CIP we emphasize collection of live wild potatoes, giving preference to the Andean countries and regions offering the greatest interest in this sense. I now report at length regarding the collections and the classification from Venezuela, Ecuador, Chile, Bolivia and Peru.

Venezuela, Colombia and Ecuador, form a group of countries with a relatively small number of wild potato species, therefore, research is comparatively easy and fairly rapid provided sufficient live material is available.

In Venezuela the wild potatoes are represented by three series: Series Conicibaccata, which in my opinion is represented only for three species, S. colombianum Dun. (2n=4x=48), S. otites Dun. (2n=2x=24), and S. subpanduratum Ochoa (2n=4x=48); series Juglandifolia, represented by S. juglandifolium Dun and S. ochranthum Dun.; and series Tuberosa with S. paramoense Bitt. ex Pittier, which is of 2n=2x=48, tetraploid. The remaining species proposed in the past for this country, I consider invalidated. Among the valid species for Venezuela and which figure in the live collections of CIP, there are the following : S. colombianum, S. subpanduratum and S. paramoense.

We have not made intensive collections in Colombia. We understand that Doctor Luis López has been doing this work for some time. At CIP we would like to have live material, especially of S. andreanum, S. flahaultii and S. lobbianum.

The wild potatoes endemic to Colombia are not numerous. In my opinion only two are represented: S. lobbianum and S.

garcia-barrigae, the others which are mentioned for that country are likewise common to Venezuela and Ecuador. I believe that in their entirety the Colombian wild potatoes are represented by not more than 9 species distributed in 4 series, as follows:

Conicibaccata: S. colombianum Dun., S. chomatophilum Bitt., S. flahaultii Bitt., S. garcia-barrigae Ochoa and S. moscopanum Hawkes.

Juglandifolia: S. juglandifolium Dun. and S. ochranthum Dun.

Piurana : S. tuquerrense Hawkes.

Tuberosa : S. andreanum Bitt. and S. lobbianum Bitt.

Ecuadorian wild potatoes have remained in almost oblivion for a long time. In May of this year I made an expedition to Ecuador and even though the conditions of the year were not favorable, I collected good quantity of live samples which have been incorporated into CIP's germ plasm bank. These samples make up the most complete and only live collection of Ecuadorian wild potatoes. They come from practically all the Andean territory of that country. Nevertheless, it is necessary to keep in mind that it was impossible to obtain material of S. regularifolium Correll and S. cyanophyllum Correll. I cannot affirm that these species are already extinct, but much time and effort was made to search in their type localities as well as expanding the search into surrounding areas without being able to find them.

Up to the present, I have classified the wild Ecuadorian species as follows:

Series Juglandifolia : S. juglandifolium Dun., S. ochranthum Dun.

Conicibaccata : S. albornozii Correll*, S. paucijugum Bitt.*, S. tundalomense Ochoa*, S. colombianum Dun.

Piurana : S. tuquerrense Hawkes, S. solisii Hawkes*, and S. cyanophyllum Correll*

Tuberosa	S. minutifoliolum Correll*, S. regularifolium Correll*, S. suffrutescens Correll*.

The series marked with an asterisk (*) represent the Ecuadorian endemic species. Further and more complete information on wild potatoes from Venezuela, Colombia and Ecuador, will be presented by the writer in the near future.

In Chile, for many years, the Instituto de Producción Vegetal, Facultad de Ciencias Agronómicas de la Universidad Austral de Valdivia, Chile, has made special efforts to collect ancient cultivars or "chilota" potatoes. The leader of this project, which was backed by FAO, is Prof. Andrés Contreras. Recently a catalog was published on Chilean potato germ plasm, which contains information on the work of that group up to December 1978. Nevertheless, when examining the lists of materials, one can observe the absence of several native wild species. During our recent expedition to that country we made joint collection in places which had not been visited by Contreras. A large part of the material recently collected in the form of true seed has not been studied. We plan to do this once we can count on greater space and facilities.

In summary, the live wild potatoes collected in our expedition include S. maglia of series Tuberosa, S. brevidens and S. fernandezianum of series Etuberosa, and S. rickii of series Juglandifolia.

Regarding the native Chilean potatoes, they continue their seemingly inexorable process of extinction. In my opinion, the utmost efforts should be exerted to collect what few still remain in remote spots and conserve them in an adequate manner. The live collections we have seen in the experimental fields of Valdivia are suffering from a rapid deterioration due to viral infestations and as soon as possible meristem cultures should be used to save this material.

The list of classified live Chilean, Ecuadorian and Venezuelan species and material is found in BGP-CIP. The following is Table N° 1, presenting this material in summarized form:

Table I.

Wild Species from Chile, Ecuador and Venezuela

CIP GP. Bank - 1979

Series and Species	2n	Total N° Accessions	In Seeds	In Tubers
CHILE:				
TUBEROSA				
S. maglia	36	2	0	2
ETUBEROSA				
S. brevidens	24	1	1	0
S. fernandezianum	-	1	1	0
JUGLANDIFOLIA				
S. rickii	-	2	2	0
ECUADOR:				
CONICIBACCATA				
S. chomatophilum	-	3	1	1
S. colombianum	48	5	5	0
S. paucijugum	48	1	0	1
S. tundalomense	-	2	1	0
PIURANA				
S. solisii	48	1	1	0
TUBEROSA				
S. minutifoliolum	-	1	1	0
S. suffrutescens	-	1	1	0
VENEZUELA				
CONICIBACCATA				
S. colombianum	48	3	2	2
S. subpanduratum	48	1	1	1
TUBEROSA				
S. paramoense	48	1	0	1

In relation to Bolivian potatoes, I believe that the number of species in that country has been exaggerated. In fact, ever since the first description of Dunal's who proposed S. boliviense in 1852, up to the present, almost 50 species have been described. After extensive collection trips in Bolivia, and examination of material published by other authors, I am convinced that the Bolivian wild potatoes present a great number of synonyms. An appreciable number of species have already been invalidated by Correll and lately by Hawkes.

During the course of my expedition to Bolivia in 1978, under CIP auspices, special emphasis was made to visit type localities and collecting live material of wild species. All areas of greatest interest visited in Bolivia during this expedition were discussed by the author previously. Certain other places which should be visited were recommended for their special interest. The collection of live material found in those and other yet unexplored areas will afford additional data and perhaps species which are still unknown. Besides this, we recommend massive and exhaustive collection in the South and Southeast of Bolivia, where the greatest introgressive force of certain species will most certainly be encountered. This is especially true for S. chacoense, which has caused great taxonomic confusion in the past.

In the author's opinion, the wild endemic potatoes of Bolivia, at the present time, would be represented by 10 species (marked below with an asterisk*), two of them being hybrids. Including those species which furthermore are common in Argentina and Peru, and which are also found in Bolivia, the total number for this country would be 20 species grouped into seven series, as follows:

ACAULIA	: S. acaule Bitt.
CIRCAEFOLIA	: S. capsicibaccatum Card.* and S. circaefolium Bitt.*
COMMERSONIANA	: S. chacoense Bitt., S. tarijense Hawkes and S. yungasense Hawkes*.
CONICIBACCATA	: S. violaceimarmoratum Bitt.*
CUNEOALATA	: S. infundibuliforme Phil.
MEGISTACROLOBA	: S. megistacrolobum Bitt.

TUBEROSA : S. alandiae Card.*, S. x berthaultii Hawkes*, S. boliviense Dun., S. brevicaule Bitt.*, S. candolleanum Berth.*, S. gandarillasii Card.*, S. leptophyes Bitt., S. oplocense Hawkes, S. x dodsii Correll*, S. vidaurrei Card., S. sparsipilum (Bitt.) Juz. et Buk.

The names of Bolivian wild species published in the past not included in the above mentioned list, are considered by me invalidated or synonyms.

A large proportion of the live collections gathered during the expedition is already classified. The remainder we hope to finish studying soon. The results can be appreciated in Table 2.

In Peru collecting trips were made to the northern and central areas. Most of the south remains for future work. In the north the highlands of Piura, Cajamarca, Amazonas, La Libertad and Ancash were visited. In the central portion collections were made in the high areas of Lima, Pasco, Junín, Huancavelica and a small part of Ayacucho.

During these trips some 400 wild potato samples were collected. Half of these have already been classified. The criterion for classifying these has been done mainly on the basis already developed in my monograph published in 1962, and which I have been expounding for the last 10 or 15 years. For this reason, I do not go into detail at this time.

In short, the wild potatoes which are endemic to Peru, at present I consider to be more than 60 species which I have grouped into nine series, all of which fall within Section Petota (= Tuberarium) and subsection Potatoes (= Hyperbasarthrum).

With the exception of the Olmosiana series of northern Peru, of which no material has yet been found, and the Juglandifolia series, the representatives of which do not produce tubers, the other seven series are presented with material already classified and grouped in accordance with the above consignation, indicated in Table 3.

Table 2. WILD SPECIES FROM BOLIVIA[1]

CIP GP BANK - 1979

Series and Species	2n	Total N° Accessions	In Seeds	In Tubers
ACAULIA				
S. acaule	48	22	18	22
CIRCAEFOLIA				
S. capsicibaccatum	24	2	1	3
S. circaefolium	24	3	1	3
CONICIBACCATA				
S. violaceimarmoratum	24	2	1	2
COMMERSONIANA				
S. chacoense	24	1	1	1
S. tarijense	24	3	1	3
CUNEOALATA				
S. infudibuliforme	24	5	2	5
MEGISTACROLOBA				
S. megistacrolobum	24	7	6	7
TUBEROSA				
S. alandiae	24	2	0	2
S. x berthaultii	24	1	1	1
S. boliviense	24	6	4	6
S. candolleanum	24	6	3	6
S. gandarillassi	24	1	0	1
S. oplocense	72	2	2	2
S. sparsipilum	24-48	18	5	18
S. vidaurrei	48	1	1	1

(1) 16 species from a total or more than 130 accessions.

Table 3.

WILD SPECIES FROM PERU[1]
CIP GP BANK - 1979

Series and Species	2n	Total N° Accessions	In Seeds	In Tubers
ACAULIA				
S. acaule	48	46	37	41
CONICIBACCATA				
S. chomatophilum	24	9	6	3
S. laxissimum	24	1	1	0
CUNEOALATA				
S. blancogaldosii	24	2	2	1
INGAEFOLIA				
S. ingaefolium	24	1	0	1
MEGISTACROLOBA				
S. dolichocremastrum	-	5	4	5
S. hastiforme	-	1	1	1
S. magistacrolobum	24	3	3	1
S. raphanifolium	24	4	3	4
S. sogarandinum	24	3	1	1
PIURANA				
S. acroglossum	24	1	1	1
S. paucissectum	24	5	5	0
S. piurae	24	1	1	1
TUBEROSA				
S. abancayense	-	1	1	0
S. ambosinum	-	7	3	7
S. bukasovii	24	26	19	22
S. chiquidenum	24	1	1	1
S. hypacrarthrum	24	2	2	1
S. huancabambense	24	3	3	3
S. humectophilum	24	1	2	0
S. immite	24	2	1	1
S. lignicaule	24	3	1	2
S. marinasense	24	2	1	2
S. medians	24-36	28	2	28
S. multiinterruptum	24	13	7	10

TUBEROSA (Cont'd)	2n	Total N° Accessions	In Seeds	In Tubers
S. neoweberbaueri	36	4	0	3
S. orophilum	-	2	1	2
S. rhomboideilanceolatum	24	1	1	1
S. velardeii	24	4	3	4
S. weberbaueri	24	1	1	1
S. wittmackii	24	10	1	10

(1) 31 species determined up-to-date, from a total of 401 accessions.

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Recent Concepts in the Evolution of Tuber-bearing Solanums

Prof. J.G. Hawkes

Introduction

The wild and cultivated tuber-bearing Solanum species are generally considered to be a relatively "young" group of plants in geological and evolutionary terms. By the nature of the subject, good evidence is hard to come by, but because the species are all confined to one continent (though separated to some degree by the low-lying isthmus of Panamá) and because quite a large proportion hybridize with ease to form fertile F_1 progeny; and, finally, because the species boundaries are not too clear morphologically -- all these facts are used as evidence for the recent evolutionary development of the whole tuber-bearing group. Certainly, the different subgenera of the genus Solanum seem to be of great antiquity. They differ widely from each other and tend to be localised in the various continental fragments of what was, up to some 120 to 140 million years ago, the supercontinent of Gondwanaland (Hawkes and Smith, 1965). Thus, Lycopersicon* and Bassovia are confined to South America, Archaesolanum to Australia and New Zealand, and Lyciosolanum to Africa. The other two subgenera, Solanum and Stellatipilum are widespread, but 32 out of the 42 sections and subsections are monocontinental in their distribution. It is thus assumed that the subgenera and many of the sections are very ancient (some 120 to 140 million years old). This still leaves plenty of time for the species within these subgenera and sections to have evolved from their ancient ancestral stocks and does not conflict with the evidence for a fairly recent evolution of the tuber-bearing group.

Genome Analysis and Evolutionary History

The tuber-bearing section is variously assessed as possessing some 150 to 200 species out of the total of 2,000 belonging to the genus Solanum as a whole. Most potato species are diploid (74%), fewer are tetraploid (11.5%) and very few are hexaploid (5%). The rest consist of odd-numbered polyploids of a hybridogenic nature or those with a range of cytotypes.

* Sometimes included in Solanum.

Genome differentiation hardly seems to have taken place in the diploid species of South America; most of them hybridize easily and form fertile F_1s with regular bivalent pairing. However, the "F_2" progenies produced by F_1 sib-matings, indicate by the presence of weak and unthrifty plants that a cryptic structural differentiation has taken place between them. This would involve very small chromosome differences (inversions, translocations, etc.), too small to affect chromosome pairing in F_1 hybrids (Stebbins, 1945). This evidence has been interpreted as due to a difference of genetic architecture between the species, such that blocks of genes cannot substitute for each other in every type of F_2 segregant to provide healthy vigorous individuals. Taxa which on other evidence seem to be conspecific do not exhibit genetic breakdown of this type in their hybrids, whilst others which are markedly distinct show it rather clearly. The method is thus quite a useful criterion for judging taxonomic and, presumably, evolutionary relationships (Hawkes, 1958, 1978).

Analyses of F_2 progenies derived from crosses between the diploid Mexican potato species S. jamesii, S. pinnatisectum, S. brachistotrichum and S. cardiophyllum, all in series Pinnatisecta, also show very clear evidence of genetic breakdown (Hawkes, 1966) (Table 1). Thus both groups of diploids present evidence of fairly recent speciation, though it must be remembered that they belong to distinct crossability groups. This, and other evidence points towards the antiquity of the division of one diploid group from the other.

Somewhat different results have been obtained from F_2 progeny testing in the allotetraploid species in series Longipedicellata (S. stoloniferum, S. fendleri, S. polytrichon, and S. hjertingii). These gave no evidence whatever of genetic breakdown (Table 1), which may indicate that the species have only very recently diverged from a common stock after the process of amphidiploidy took place (Hawkes, 1966). Here we may have a group of very young species, which are morphologically dissimilar, and which have become differentiated through eco-geographical selection pressures, rather in the same way as the tetraploid wheats of the Triticum diccoccum and T. durum series have done. It is worth noting that the distribution areas of the Longipedicellata species do not overlap but, rather, seem to form a race-chain (Rassenkreis) in the manner of geographically differentiated subspecies. (See S. acaule, which is a classical example of a Rassenkreis, spread out along the Andes). The Longipedicellata tetraploids could thus have been derived from a single widespread ancestral species which had later become divide into separate isolated portions not very long ago.

Table 1. F_2 species hybrids in Mexican Solanums

Cross	F_1		F_2	
	Combination[1]	Family	Families	Observations
S.jamesii x S.pinnatisectum	1394 x 2300	58	172, 173	Genetic breakdown in both families
S.pinnatisectum x S.sambucinum	2300 x 2312	85, 86	145, 146, 183	Very wide leaf range, no breakdown
S.jamesii x S.brachistotrichum	H.289 x H.284	267	336	
S.brachistotrichum x S.card. spp. ehrenb.	H.284 x H.268	268	318, 319, 334	Only one small plant
S.cardiophyllum x ssp. ehrenbergii	40 x 2309	53	151, 152	Genetic breakdown in both families
" "	40 x 2297	52	149, 150	" " " " "
S.card. ssp. ehrenb. x ssp. lanceolatum	2299 x 2283	118	-	(F_1 did not flower; no F_2)
S.cardiophyllum x S.cardiophyllum	40 x 2258	51	147, 148	Genetic breakdown in both families
S.hjertingii x S.fendleri	H.371 x H.355	271	302, 303	Very uneven growth but no unthrifty plants
S.fendleri x S.hjertingii	H.355 x H.371	272	285, 300, 301	" " " " " " "
" x S.stoloniferum	H.363 x H.399	298	322, 323	" " " " " " "
S.stoloniferum x S.fendleri	H.399 x H.363	299	325, 326, 335	" " " " " " "
" x S.polytrichon	1212 x H.387	312	327, 328	" " " " " " "
S.polytrichon x S.stoloniferum	2330 x H.402	314	331	Poor germination. Breakdown
S.fendleri x S.polytrichon	H.363 x H.386	313	329, 330	Uneven growth but no unthrifty plants
S.hougasii x S.demissum	2433 x 2103	109	-	)
" x S.iopetalum	2433 x 2292	110	-	)
S.iopetalum x S.hougasii	2292 x 2433	111	-	) All F_1's sterile
S.guerreroense x "	2475 x 2433	112	-	) No F_2 generation possible
" x S.demissum	2475 x 1342	113	-	)
" x S.iopetalum	2475 x 2292	115	-	)

[1] Commonwealth Potato Collection, or Hawkes accession numbers.

Another example of two distinct species whose hybrids show no F_2 breakdown is that of S. microdontum and S. vernei (Hawkes and Hjerting, 1969, p. 344). None could possibly mistake one species for the other, and although they both bear genes for resistance to round cyst nematodes the actual loci seem to be different. The barriers between these two species which prevent gene flow have not been fully elucidated. Hawkes and Hjerting (1969) noted a scarcity of natural hybrids, possibly due to their adaptation to distinct habitats and rather more probably to differences of flowering time. However, other mechanisms for prevention of gene flow probably exist and should be looked for.

To sum up this section we can first see examples of diploid species which form fertile F_1 hybrids but show genome differentiation when submitted to the F_2 viability test, showing inability of blocks of genes to substitute for each other on F_2 segregation. Secondly, we have examples of species with distinct morphology and habitat adaptation which do not even show evidence of differences of genetical architecture in F_2 segregates. These, it would seem must be very "new" and must have only recently evolved as distinct gene pools.

A somewhat different but equally interesting situation is exhibited by the allotetraploid South American frost-resistant species, S. acaule. This shows regular bivalent pairing until it is crossed with diploid species in series Tuberosa. The triploids derived from such crosses then behave cytologically like typical autotriploids, with frequent trivalents at meiosis. To account for this it has been postulated that the Tuberosa diploids and S. acaule all possess the same basic genome "A". The former are designated A_1, whilst S. acaule all possess the same basic genome "A". The former are designated A_1, whilst S. acaule is designated as A_2 A_3. In S. acaule itself homologues are absent, as in the triploid A_1 A_2 A_3, the homoeologues then associate, giving trivalents, bivalents and univalents, as for a normal autotriploid (see Table 2).

Let us now look at the other well-known tetraploid, S. stoloniferum, which we have just been to be very similar genomically to its sister species, S. polytrichon, S. papita, etc. When this is crossed with S. chacoense the triploid hybrids behave quite differently from the S. acaule ones. In this case we obtain configurations approaching 12 bivalents and 12 univalents (Matsubayashi, 1955; Kawakami and Matsubayashi, 1956). This seems to indicate that the two species possess one genome in common (the A type) and a distinct one, present in S. stoloniferum (the B type), which is not found in S. chacoense. Hence

S. stoloniferum may be accorded the formula A_4 B (see Table 1). The results of Marks' work (Marks, 1965) point in the same direction, though it must be stated here that genome differentiation is not by any means clear cut, differing markedly from the type with strong genetic control as shown by Riley for tetraploid and hexaploid wheats.

An even more interesting situation can be seen in the Mexican hexaploids. Here, each species seems to possess two genomes in common, one of them possibly derived from S. verrucosum. The third is so distinct that no pairing takes place, resulting in completely sterile hexaploid hybrids (Table 2). The cytological analyses were carried out by Marks (1955), who obtained hybrid metaphase plates tending towards 24 univalents and 24 bivalents, though many other configurations occurred. One might therefore postulate that each hexaploid species possessed two genomes of the A type of one distinct one. Hence the genome formulae for these hexaploid species has been postulated as A_1 A_4 (B, C, D, etc.). We are here assuming that the A_1 genome is derived from S. verrucosum and the A_4 B from the series Longipedicellata. This is by no means certain for every hexaploid species, and we do not yet have any idea as to the origin of the C, D, etc. genomes. Thus more work is urgently needed to throw light on this interesting problem.

In addition to the suggestive evidence for genome differentiation in certain of the Mexican polyploids, as contrasted with the South American ones which seem to show little genome differentiation, there are also interesting crossability data to be considered.

The Mexican series Pinnatisecta and Bulbocastana form a crossability group distinct from that of series Demissa, Longipedicellata, Tuberosa and other South American series (Hawkes, this symposium). Series Polyadenia forms another and Morelliformia yet another again.

These crossability data also accord well with the main serological groupings (Hawkes, this symposium).

The evidence points towards an interpretation of greater age and complexity of the Mexican species groupings, contrasted with a greater simplicity and degree of uniformity of the South American ones.

We may thus postulate that the tuber-bearing group evolved first in Mexico from simple-leaved ancestral forms similar to S. morelliforme or dissected ones similar to S. pinnatisectum.

Table 2

Suggested Genome Formulae for Certain Potato Species and Series

Genome	Taxonomic Species or Series
A_1	Series *Tuberosa*, *Commersoniana*, *Cuneoalata*, *Megistacroloba*
A_2 A_3	Series Acaulia (*S. acaule*)
A_4 B	Series Longipedicellata (in part)
A_1 A_4 (B, C, D, etc.)	Series Demissa (hexaploid species *S. demissum*, *S. brachycarpum*, *S. guerreroense*, etc.)

Affinities with the yellow-flowered South American series Juglandifolia would be rather remote, since the latter seems closer to the genus Lycopersicon. Some faint affinity to the Chilean series Etuberosa must exist (see Hermsen, 1979) where a cross of S. etuberosum x S. pinnatisectum was brought about after many attempts.

It is therefore possible that the tuber-bearing species evolved in Mexico in late Cretaceous to early Tertiary times and that before mid-Eocene a group with the A genome migrated to South America where secondary centres of diversity were built up in the newly formed Andean Cordilleras.

Here they evolved in isolation from the Mexican species during the period when the land bridge between the two-sub-continents was severed. In Pliocene times the land bridge was restored and a return migration in two waves of species may have taken place. The first resulted in the formation of the series Longipedicellata tetraploids (A_4 B, etc.) and the second in the series Demissa hexaploids (A_1 A_4 B, etc.). It is significant that the common ancestral diploid component of all these, S. verrucosum, is still to be found in the areas where these hexaploids now occur (Hawkes, 1958 and this symposium).

Up until 1979 the fairly clear genome differentiation in Mexican potatoes was thought to have been unique. Now, however, some extremely fascinating evidence of genome evolution has been shown to exist in series Conicibaccata (López, 1979). It had been known for some time that polyploidy existed in that series and interesting preliminary studies had been reported by Marks (1965). Now, however, López has demonstrated the presence of a much more complex pattern of genome evolution than had previously been envisaged in South American species (see Table 3). This has yet to be integrated into the existing genome system and fully verified by further work. The results also indicate that series Conicibaccata may be much older than had hitherto been supposed.

Origins of polyploidy in the tuber-bearing species

It has been known for some time that many potato species possses the capacity to produce diploid pollen and embryo sacs along with the normal haploid ones. This phenomenon has been researched and discussed recently very thoroughly by Peloquin and co-workers (see, for example den Nijs and Peloquin (1977) for a definitive discussion and review of the literature).

Table 3

Postulated Genome Formulae for Certain Conicibaccata Species (López, 1979)

Diploids	
S. laxissimum and S. santolallae	X_1 X_1
S. urubambae and S. violaceimarmoratum	X_2 X_2
S. chomatophilum	X_3 X_3
S. ayacuchoense	X_4 X_4
Tetraploids	
S. agrimonifolium	X_1 X_1 X_5 X_5
S. colombianum	X_1 X_1 X_6 X_6
S. flahaultii	X_1 X_1 X_3 X_3
S. longiconicum	X_1 X_1 X_2 X_2
S. oxycarpum	X_1 X_1 X_7 X_7
S. paucijugum	X_2 X_2 X_3 X_3
Hexaploid	
S. moscopanum	X_1 X_1 X_6 X_6 M M

Whilst it is agreed that 2n gametes are a frequent phenomenon in potatoes it must be pointed out that the actual evidence for polyploidization in nature is hard to come by.

We know that triploid clones occur in a wide range of diploid species, and since there are no tetraploids with the right combinations of morphological characters to make it plausible for the triploids to be considered as 4x x 2x hybrids, we must assume that they are autotriploids. Such autotriploids are very common in the South American species S. commersonii, S. maglia and S. calvescens (Hawkes and Hjerting, 1969). They are also common in the Mexican S. cardiophyllum and S. bulbocastanum, and have been reported in some other species such as S. jamesii, S. venturii, S. medians, S. microdontum, etc. Yet in other species where unreduced gametes have been reported (e.g. S. infundibuliforme, S. chacoense) they have either never been reported or are extremely rare. (Again, I refer to the situation in nature, not in the experimental field). As den Nijs and Peloquin rightly point out, we might find more if we consistently collected tubers and made chromosome counts of every tuber collected, since seed collections are always derived from the highly fertile diploids.

What happens to these triploids? Are they evolutionary dead ends, or do they lead on towards the establishment of tetraploids? Unfortunately, much though one would like it to be so, the answer seems to be that they lead nowhere. In those species where autotriploids have been formed one never finds tetraploids. Conversely, where we find tetraploids, the only triploids we know about are 2x x 4x hybrids of known hybrid origin (S. vallis - mexici, S. bruecheri). The evidence for the origin of polyploids seems to point rather to interspecific hybridization, as the key process, though the case of S. juzepczukii (triploid) in providing a 2n gamete which then forms a pentaploid in the cross with andigena (n gamete) is reasonably well documented (Hawkes, 1962); Schmiediche, 1977), and seems to be an exception to the rule.

The work by López (1979), already referred to, indicates the probably hybrid nature of Conicabaccata tetraploids and hexaploid Here, indeed, there seems to be some good evidence for immediate polyploidization through the union of 2n gametes from each parent species. Thus 4x x 2x crosses have produced hexaploid progeny, whilst one case is reported of a 4x x 6x cross producing an immediate decaploid (2n = 120). Such results have not previously been reported in the literature so far as I am aware, but one must stress that they are obtained under experimental conditions only.

Origins of the cultivated polyploids

Much cooperative work between CIP and Birmingham on the origin of the cultivated species has been reported and will briefly be reviewed.

a) Diploids. The nature of S. x ajanhuiri was investigated by Huamán (1975) who found two series of cultivars, Yari and Ajanhuiri. Huamán established that the Yari cultivars were simple F_1 hybrids of S. stenotomum by the wild frost-resistant S. megistacrolobum, whilst the Ajanhuiri types were either backcrosses to S. stenotomum or F_2 segregants of the original cross selected for yield, palatability and frost resistance (Fig. 1 and Table 4).

The other diploid species, S. stenotomum, S. goniocalyx and S. phureja are currently under investigation by C.S. Tay, under the supervision of Eng. C. Ochoa and myself. It is assumed that they have all been derived by selection from wild diploid ancestors but it is not yet possible to say how many groups or "species" exist in this diploid complex.

b) Triploids. These are of two groups, the S. x chaucha group and the S. x juzepczukii group.

The S. x chaucha material was investigated by Jackson (see Jackson, Rowe and Hawkes, 1976, 1978; Jackson, Hawkes and Rowe, 1977). He established the nature of this triploid "species" as derived from S. tuberosum subsp. andigena x S. stenotomum crosses (Fig. 1). However, such crosses do not always give rise to triploids, and in some of them, depending on the clones used, significant numbers of tetraploids were observed, as well as parthenocarpic diploids. Thus, in the Huancayo 1974 season the numbers were 2x:5, 3x:69, 4x:401. In these tetraploid x diploid crosses the seed set was low, on average 3.2 seeds per berry. Diploid x tetraploid crosses gave no seeds whatsoever. Hence it was clear that there was a "crossability block" in crosses between tetraploids and diploids, rather than a "triploid block," as Marks (1966) had postulated.

The nature of S. x juzepczukii was investigated by Hawkes (1962) and Schmiediche (1977). Both studies quite clearly agreed that S. x juzepczukii was a natural hybrid of the wild frost-resistant S. acaule and the cultivated S. stenotomum (Fig. 1 and Table 4). Furthermore, Schmiediche's work indicated that parental selection for high frost resistance and low alkaloid content in S. acaule and good quality and combining ability in S. steno-

tomum could form the basis for a "neo-juzepczukii" breeding programme of better quality frost-resistant strains for the high Andes.

c) Tetraploids. The origin of S. tuberosum subsp. andigena was investigated by Cribb (1972) who concluded that it was an amphidiploid, primarily derived from S.stenotomum x S. sparsipilum crosses. At a later stage introgression with other wild species probably added to its diversity (Fig. 1 and Table 4); and, as we have seen, Jackson's studies, which showed that 4x hybrids could result from crosses of andigena with S. stenotomum, would provide a solution for the presence of similar patterns of diversity in S. stenotomum and andigena. Further evidence to support Cribb's work was provided by Woodcock and Howard (1975) who observed the typical calyx shapes of S. stenotomum and S. sparsipilum in S. tuberosum dihaploids.

Subspecies tuberosum is assumed to have evolved from subspecies andigena both in Chile and in Europe under selection for long day adaptation and other characters. However, Grun (1979) has proposed an interesting alternative hypothesis based on cytoplasmic evidence.

d) Pentaploid. There is only one pentaploid cultivated potato, S. curtilobum. It is considered to have evolved through crosses of S. x juzepczukii by andigena in which an unreduced gamete from the former parent was involved (Hawkes, 1962; Schmiedicne, 1977). Since the range of diversity in S. curtilobum is so narrow as to have possibly been derived from only one single genotype it is assumed that this cross must have been very rare, perhaps having taken place no more than once. Furthermore, it is not easy to make artificially.

Thus, the cultivated potatoes have been subjected to a fairly intensive study and they seem to have formed perhaps the most complex evolutionary patterns of any of our ancient cultivated plants.

Much work on the evolution of wild and cultivated species has been carried out and there has not been time to speak of studies on introgression, diploid species hybridization and other interesting work. It is hoped that further studies may solve outstanding problems in the future and facilitate the greater use of this interesting group by plant breeders.

Fig. 1 Evolutionary Relationships of Cultivated Potatoes

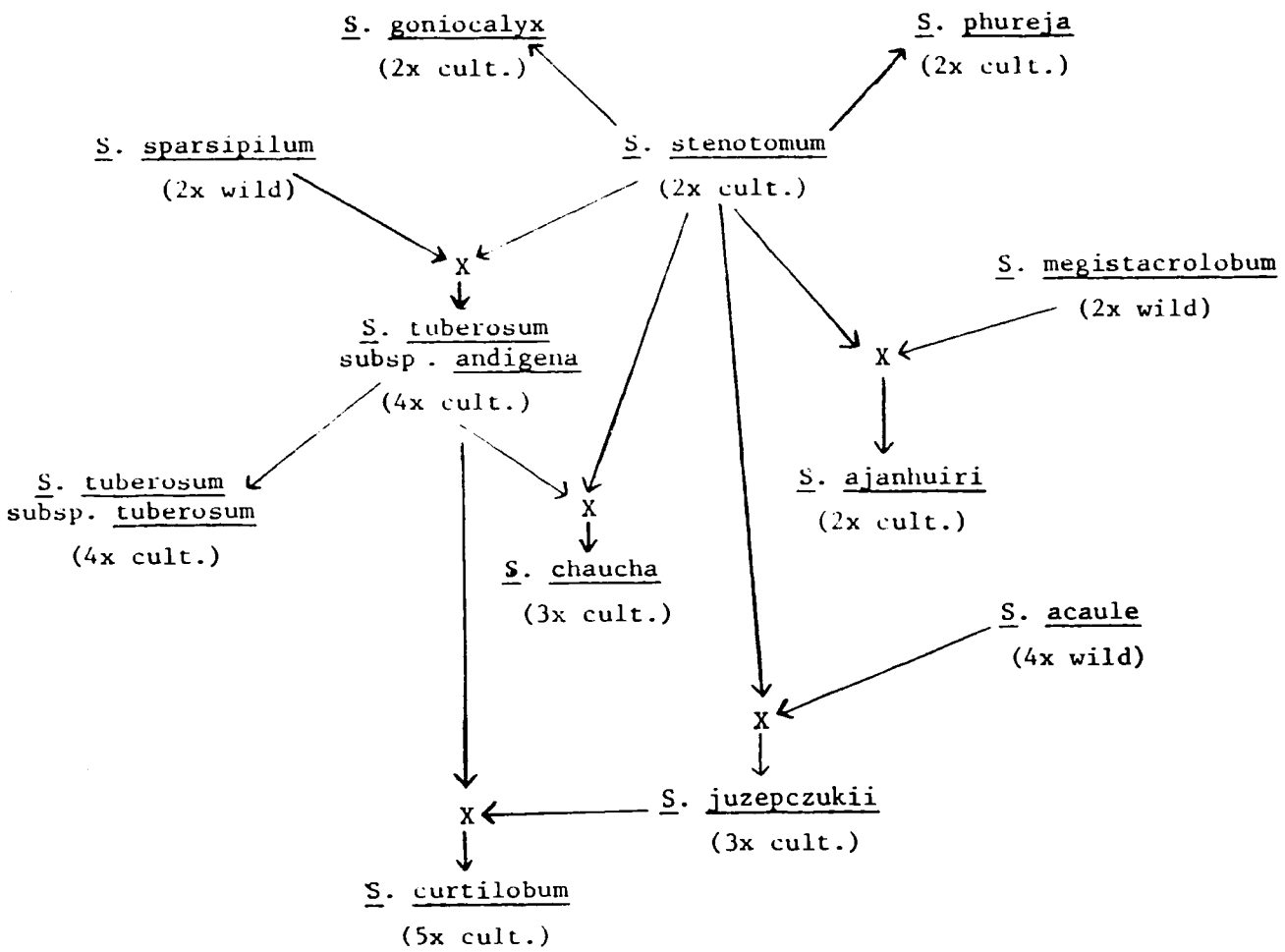

Table 4

Cultivated and Related Wild Potatoes

(*Solanum*) (x = 12)

	Cultivated	Wild prototypes
2x (2x = 24)	*S. stenotomum* *S. ajanhuiri* *S. phureja*	*S. canasense* X *S. megistacrolobum* _____
3x (2x = 36)	*S. chaucha* *S. juzepczukii*	_____ X *S. acaule*
4x (2n = 48)	*S. tuberosum* subsp. *tuberosum* subsp. *andigena*	_____ X *S. sparsipilum*
5x (2n = 60)	*S. curtilobum*	_____

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Evolution of Tetraploid Cultigens from the View of Cytoplasmic Inheritance

Drs. P. Grun and J. Staub

The commercial potatoes which we have inherited, including principally the ssp. tuberosum and ssp. andigena of S. tuberosum have evolved under the influence of prehistoric man. The plants were chosen based on their tuber characters, and sterilities, cytoplasmic or otherwise, were ignored. The events that lead to the evolution of ssp. tuberosum were rather different from those that lead to ssp. andigena, and the end result has been two potatoes with different cytoplasmic factors. The discussion today will bear upon certain practical results of these unconscious cytoplasmic selections by prehistoric man, particularly as they influenced ssp. tuberosum. One major point to be made will be that modern men who influence the future evolution of the potato should not also ignore the cytoplasmic factors, but should recognize their effects and take them into account in their efforts.

I. Many of the best clones of S. tuberosum ssp. tuberosum are male, and often female, sterile. They cannot, in their present form, be starting points for further improvement, and are closed to the avenue of propagation by true seed.

I recall the not entirely facetious description of potato breeding given by J.R. Livermore, potato breeder at Cornell University when I was a graduate student. It went something like this: "Nine times out of ten one of the two clones that you wish to cross will not flower, but if they both do flower, nine times out of ten they will both be male sterile. If one is male sterile, nine times out of ten the other one will be female sterile. If a berry is set, nine times there are very few seed will be set, and they will not germinate. If they do germinate, nine times out of ten the plants will be extremely weak, but if they are good strong plants that form good tubers, nine times out of ten they will be sterile."

This state of affairs is well recorded in the early literature, including papers by Stout and Clark (1924), Longley

Clark (1930), and Stuart (1921). Of 106 ssp. tuberosum clones surveyed by Stout and Clark (1924) only 9% were classified highly pollen fertile, and 79% formed no pollen at all. Of the 37 surveyed by Longley and Clark (1930), only 19% were even partially pollen fertile.

Another indication of the problem is reflected in the listing by Esch et al. in The Dutch Potato Atlas. Of 148 potato clones in the publication only 23% are described as forming more than "few" berries. Since the problem has existed for a long time and plant breeding must include conscious or unconscious selection for fertility, one might hope that modern clones are more free of the problem than those of earlier times. The Dutch Potato Atlas lists potatoes by year of release, so one can survey the percent from different periods of time that form more than "few" berries. The figures are not encouraging (Table 1), for the sterility has remained essentially constant during the past 50 years.

A demonstration plot of 19 important named clones and 8 lines that are among present day advanced breeding material was planted by Dr. Richard Cole in central Pennsylvania the summer of 1979. About half of the clones represented there were pollen sterile (Table 2) and approximately two-thirds formed no berries upon open pollination, or formed so few that one must search intensively to fine even one. It is clear that many of the best, most widely used potato clones of today can be bred with great difficulty, if at all, and are not easily subject to further improvement.

The total germ plasm of ssp. tuberosum clones is a narrow one, as demonstrated by relationship diagrams, such as that included in the report of the Committee on Genetic Vulnerability (Horsfall, 1972), and as shown by Mendoza and Haynes (1974). The narrow genetic base could account for the fact that progress in improving the subspecies has been slow, and some of the commonly used clones are 50-100 years old. One basis for this narrow germ base could be the sterilities expressed by so many clones for, as a result of this defect, many are excluded from further contribution to the germ pool. Breeders have been restricted to the relatively few that share the fertility necessary for further work.

There is a current trend towards commercial potato production by true seeds instead of propagation of tubers, as a means of reducing the expense of tuber handling as well as simplifying the virus control problem (Sawyer, 1978). If this method is to be developed for ssp. tuberosum, major changes in the subspecies will be required, for most genotypes of the subspecies are too sterile to be used for seed production.

Table 1. Percent of ssp. tuberosum potato clones listed in Dutch Potato Atlas that set given amounts of berries.

Berries Set	Years Clones Produced						
	Before 1911	1911-1920	1921-1930	1931-1940	1941-1950	1951-1960	Total
None to Few	80	44	82	86	78	74	77
Some to Many	20	66	28	14	22	26	23
Number of Clones	10	9	17	29	58	19	142

Table 2. Male and female fertility of important ssp. *tuberosum* clones in agricultural demonstration plots at The Pennsylvania State University during the summer, 1979.

	% Pollen Fertility			Berry Set[2]		
	n	≤20%	>20%	n	None-Few	Many
Commercial Clones[1]	18	45	55	18	73%	27%
Breeding Stock	10	60	40	6	50%	50%
Total	28	50	50	24	66%	34%

[1]Anoka, Atlantic, Belchip, Belrus, Buckskin, Butte, Chieftan, Croatan, Green Mountain, Katahdin, Kennebec, LaChipper, Michibonne, Monona, Oneida, Red Pontiac, Russet Burbank, and Superior.

[2]Based on plant rows showing a minimum of ten inflorescences.

II. The sterilities of these ssp. tuberosum clones are predominantly cytoplasmic in nature and result from events during the evolutionary history of the subspecies.

The constitution of the cytoplasm of ssp. tuberosum, including European, North American, and coastal Chilean forms has been subjected to analysis (Grun, 1970a, b, 1974, 1979, unpublished; Grun, Ochoa and Capage, 1977). Subspecies tuberosum clones from all three locations have cytoplasm that is sensitive to dominant genes that condition indehiscence of anthers, formation of sporads or of shrivelled microspores instead of normal pollen, formation of thin anthers, often greenish, that fail to mature, fusion of anthers to styles, formation of miniature styles on the ventral surface of anthers, and female sterility. These sterilities are consistently expressed when ssp. tuberosum plants are used as the female parent in crosses with any species that has such dominant genes in its genotype. Dominant genes which condition these sterilities have been identified in genotypes of S. tuberosum ssp. andigena, S. phureja, S. stenotomum, S. vernei, and S. kurtzianum. The reciprocal hybrids, having these other species as the female parent, are fertile, since the other taxa have cytoplasmic factors resistant to these dominant genes of their own genotypes.

Sterilities expressed within ssp. tuberosum are also cytoplasmic in nature. The evidence for this cannot be based on reciprocal crosses because all within ssp. tuberosum clones studied to date have the same sort of cytoplasm and because to test it directly would require reciprocal crosses between fertile and sterile plants, a process that is not possible.

The interpretation is inferred from the fact that the types of sterility that occur in clones of ssp. tuberosum are identical to those identified as cytoplasmic sterilities following reciprocal crosses involving ssp. tuberosum with the other species listed above. They include clear examples of sporads, shrivelled microspores, anther-style fusion, and ventral-styled anthers all found in clones that are apparently pure ssp. tuberosum.

How did so many plants of ssp. tuberosum come to contain genes that lead to their own sterility? Evidence has been accumulated (Grun, 1970a, b, 1974, unpublished; Grun, Ochoa

and Capage, 1977) for the interpretation that ssp. tuberosum was imported from coastal Chile to the Northern Hemisphere, probably in the 1800's following the late blight epiphytotics, and some even somewhat earlier. North American and European clones produced after the 1840's apparently all have the cytoplasmic sensitivities listed above. Two clones used before the 1840's have been studied to date. One, Myatt's Ashleaf, has the resistant cytoplasmic constitution typical of ssp. andigena, while the other, The Rocks, has the sensitive cytoplasm of ssp. tuberosum (Grun, unpublished). When ssp. tuberosum was introduced into the Northern Hemisphere it would have come into direct contact with S. tuberosum ssp. andigena, which was originally introduced to Europe in the 1500's, and was later introduced from Europe to North America (Salaman, 1949; Hawkes, 1956, 1967; Simmonds, 1964). The newly arrived ssp. tuberosum could have crossed with the well established ssp. andigena, which contains the dominant sterility genes. Selection forces in the Northern Hemisphere, including the climatological conditions as well as catastrophic selection by the late blight fungus during the epiphytotic in the 1840's removed most ssp. andigena genes, but ssp. tuberosum survived well there. The dominant sterility genes of ssp. andigena that remained would not have disturbed growers who were interested principally in the tubers.

III. The existence of sensitive cytoplasm in ssp. tuberosum constitutes a major limitation to the full potential use of germ plasm banks of wild species in potato breeding.

The facts discussed above must directly influence the degree to which plant breeders who improve ssp. tuberosum will make use of the valuable material accumulated and maintained in germ plasm banks. While much remains to be done in analyzing the distribution of genes that condition cytoplasmic sterilities when they are combined with ssp. tuberosum cytoplasm, it is clear that such genes are widespread particularly among Solanum species of the northern Andean regions. It is not being suggested here that ssp. tuberosum breeders could not, should not, or would not use such wild species in their breeding work. The importance of the wild species as sources of needed genes is such that they do and will use them, but when they do so it will be in spite of the substantial difficulties posed by the sterility genes that come with the crosses.

An obvious solution might be to make the interspecific crosses between wild species and ssp. tuberosum using ssp.

tuberosum as the male rather than the female parent, thereby taking advantage of the fact that most of the wild species concerned contain cytoplasmic factors resistant to such sterility genes. This is a potential solution, but it is a limiting one, and there are conditions that dictate that the breeder would often prefer to make the cross using ssp. tuberosum as the female parent: A breeder undertaking such interspecific crosses is committed to a program that involves many generations of backcrosses to ssp. tuberosum in order to regain the commercial qualities of this potato. At each step in the backcross process he would have systematically to use ssp. tuberosum only as the male parent. He would be limited to male fertile clones of ssp. tuberosum, thus eliminating some of the best material available, and tending to maintain the narrow gene base of the species.

Another aspect could well make him wish to use ssp. tuberosum as the female parent, and this involves recent studies of the cytogenetics of formation of unreduced gametes. Most of the species that house genes for disease resistance or for ecological or physiological characteristics which the breeder may wish to withdraw from germ plasm banks are diploid. These could be used directly in crosses with tetraploid ssp. tuberosum in 4x x 2x crosses or as 2x x 4x crosses both of which would produce 4x offspring through functioning of unreduced gametes of the 2x parent. Unreduced gametes are often formed by 2x parents by a mechanism involving formation of parallel spindles, causing first division restitution (Quinn et al., 1974). Such first division restitution 2x gametes are highly heterozygous, and the tetraploid hybrids produced by such gametes are often, therefore, very vigorous (Kidane-Mariam and Peloquin, 1974; Mendiburu and Peloquin, 1977). The classification of diploid wild species of the germ plasm bank as having first division restitution during pollen formation is fairly simple and therefore the breeder could plan to use 4x x 2x crosses using clones that he had already identified as forming the first division restitution type unreduced pollen. This would mean, however, using ssp. tuberosum as the female parent, and so retaining the sterility sensitivities.

The alternative course would be to make the cross 2x x 4x, using the diploid as the female parent. The techniques for evaluating the types of restitution that occur on the female side are not fully worked out and will of necessity be very much more difficult than those used on pollen mother cells. Therefore, the evaluation of clones of wild species to determine whether or not, they form first division restitu-

tion unreduced eggs would generally not be possible, at least at the present time. The breeder making the 2x x 4x cross would lose, consequently, the ability to predict the hybrid vigor that he might depend on if he made the 4x x 2x cross. What evidence there is available (Kidane-Mariam and Peloquin, 1974; Mendiburu and Peloquin, 1977) suggests, in fact, that first division restitution is not as common on the female side. The breeder using the 2x x 4x cross would, therefore, have avoided cytoplasmic sterilities at the price of losing hybrid vigor that would otherwise be available to him through first division restitution.

IV. Solutions to this problem consist of changing the cytoplasmic factors of ssp. tuberosum either by substitution backcrossing or by techniques of protoplast fusion.

One solution to the problem consists of genetic substitution - the insertion of as much of the diversity of genotypes of ssp. tuberosum as possible into the cytoplasmic background of several species of Solanum from the Northern Andean regions, including particularly S. tuberosum ssp. andigena, and probably S. phureja, S. stenotomum, S. vernei, and S. sparsipilum. The number of generations or recurrent backcrossing that would be needed to recreate ssp. tuberosum in a contrasting cytoplasm is not, at present, known, but the process could be monitored during the recurrent backcrosses to determine when the morphological and particularly the commercial properties of ssp. tuberosum had been sufficiently regained.

An incidental by-product of the process would be production of ssp. tuberosum clones with increased variability since some of the genotype of the wild species would inevitably remain in each backcrossed product. A second incidental by-product would be an increase in the cytoplasmic variation in the species, thus protecting it from the type of disaster that struck the corn industry of the United States in the 1970's when the predominant cytoplasm used, the Texas form, was found to condition unusual susceptibility to a new strain of southern leaf blight.

The process appears superficially simple, but it must be recognized that there may be problems involved that cannot at the start be recognized. While the two subspecies, ssp. tuberosum and ssp. andigena are generally classified in the same species at present, a substantial evolutionary distance separates them. They are morphologically distinct, occupy separate and markedly different native ranges, and when crossed in the direction ssp. tuberosum female x ssp. andigena male the hybrids are usually partially or fully sterile.

It will not be known until the process has been well tested whether the ssp. tuberosum genotype will be fully compatible with ssp. andigena cytoplasm, and what secondary effects the backcrossing may produce. One cannot even be sure, until it has been done, whether the cytoplasm of ssp. andigena will permit random gene substitution, or will continuously select for ssp. andigena genes, thus slowing the backcross substitution.

A start has been made towards carrying out this process of backcross substitution at The Pennsylvania State University. To determine the effects of cytoplasm on the plant phenotype in each generation the initial hybrids and as many backcross generations as practical are being produced in sterility-resistant cytoplasm, using that of ssp. andigena and of S. phureja, as well as in sensitive cytoplasm of ssp. tuberosum. The backcross process cannot involve repeated use of the same ssp. tuberosum clone within a line, since inbreeding depression is apt to weaken the progenies, but an attempt is being made to produce a number of distinct backcross lines, each involving relatively few ssp. tuberosum alternating in the generations.

Efforts to use ssp. andigena parent material directly from South America have generally been unsuccessful, but the northern-adapted ssp. andigena ("Neo-tuberosum") products of the programs of Drs. Simmonds and Plaisted have been much more readily useable. S. phureja parental material presented formidable problems because of its lack of adaptation to conditions in central Pennsylvania. Induced tetraploid hybrids of S. phureja x S. chacoense flower very well in the area, however, and supplied the wanted cytoplasm. It should be possible to practice selection for floriferousness and berry production during the backcross process, thus increasing the likelihood of obtaining a product amenable to reproduction by true seed.

Since the end product should have a sufficiently wide diversity of ssp. tuberosum genotypes in resistant cytoplasm that these forms could become the founder material for future breeding efforts, it obviously should involve as broad a sampling of ssp. tuberosum in the process as possible. Relatively limited reciprocal F_1 and first backcross progenies were under test in the field the summer of 1979, and some reciprocal backcross two seed has been produced. The morphological characteristics of the plants of each generation are being followed to monitor the rate of approach of the proge-

nies to ssp. tuberosum in order to obtain, at first approximation, information on the number of backcross generations that will be needed.

An alternative approach to cytoplasmic substitution could also be considered. This involves the combination of protoplasts of clones of ssp. tuberosum with irradiated or enucleated protoplasts of potential cytoplasm-donor species such as ssp. andigena. The successful efforts at such protoplast fusions in tobacco for transferring cytoplasmic sterility factors (Belliard et al., 1977) suggests that such a direct cytoplasmic transfer could be a practical possibility. Some of the requirements for Solanum protoplast production and manipulation have been worked out (Shephard and Totten, 1977; Butenko et al., 1977; Grun and Chu, 1978; Melchers et al., 1978), so a start has been made for using this technique as well. The advantage of the method, if fully developed, is that it might enable production of male and female fertile forms of clones that are at present fully sterile, and so open them to further genetic manipulation.

Summary

S. tuberosum ssp. tuberosum, as a result of its sensitive cytoplasmic factors, contains many sterile clones. The sterility factors restrict the usefulness of some of the best clones of the subspecies for further improvement and for propagation through true seed. They also complicate the use of wild species germ plasm in potato improvement. If ssp. tuberosum clones are used as female parents in crosses with many of the wild species, a process for which there are cogent arguments, the sterilities that result would seriously impede the subsequent necessary backcrosses. Effort should be directed towards replacing the ssp. tuberosum cytoplasm with resistant cytoplasmic forms such as occur in a number of Solanum species of the northern Andean regions.

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Computerized Data Management on the Primitive Cultivated Collection Maintained at CIP

Dr. A. Huamán

A large collection of germ plasm such as the one maintained at CIP requires of an appropriate system to record, store and retrieve massive amounts of data related to each entry in the collection. Data of such magnitude can be effectively handled with the application of modern computer technology.

A computerized data bank greatly facilitates a quick and efficient data retrieval according to the needs of the user. Such capabilities maximize the utilization of the accessions available in the germ plasm collection and their data from evaluations.

The CIP's germ plasm data bank has been developed through collaboration of the Information Sciences/Genetic Resources (IS/GR) program of the University of Colorado. It has grown both in number of items and number of descriptors per item according to the availability of data from collecting expeditions and evaluations. However, much work remains to be done to identify spelling errors or inconsistencies. These could have taken place at different stages of data transfer from the handwritten records of the collector to the transcription into machine readable forms. Consistent names across all the data bank are, for example, essential for all descriptors related to locality of collection. Routine up-dating of information is also required for those descriptors which are extremely dynamic such as status of the stocks, results from evaluations, etc.

Our data bank has been created using the computer facilities at IS/GR and the EXIR (Executive Information Retrieval) system. Although EXIR responds quite effectively to the need of storing and retrieving large amounts of data, it requires the use of computers with large memory and consequently, it is very expensive.

The development of powerful mini- and microcomputers during the last 3 years has made possible self-sufficiency in computer

assisted data management at CIP for our own applications. Recently a cooperative research agreement between the Division of Information Science Research (DISR) of the University of Colorado and CIP has been established. The immediate goal is the transference of our data base, presently at IS/GR, back to CIP by means of a hardware/software Germ plasm Data Management (GDM) microcomputer system. Although the GDM system is less sophisticated and slower than the EXIR system, it has been devised to handle large amounts of data. It includes software for data entry, report writing and sequential file interrogation.

At present the CIP data bank includes 12,427 entries or accessions and 44 descriptors per entry. They comprise 11 descriptors on collecting data, 7 on maintenance, 20 on taxonomic and morphological evaluations and 16 on disease and pest reactions.

Table 1.

Contents of CIP's Data Bank

Collection	N° Items	%	Country of Origin	N° Items	%
CIP	3,241	26.08	Peru	10,407	83.75
CCC	446	3.59	Bolivia	849	6.83
CUP	189	1.52	Chile	188	1.51
CUS	537	4.33	Colombia	464	3.74
HAW	251	2.02	Ecuador	184	1.48
HJT	799	6.43	Argentina	173	1.39
HUA	1,003	8.07	Venezuela	141	1.13
JAK	247	1.99	Guatemala	17	0.14
OCH	5,356	43.09	U.S.A.	4	0.03
OKA	170	1.37			
UA	188	1.51			
TOTAL	12,427	100.00	TOTAL	12,427	100.00

Table 1 shows the content of CIP's data bank by collector or donor name as well as by country of collection. It is remarkable that about 84% of the accessions in the collection come from Peru. Furthermore, Map 1 shows that within the Peruvian accessions 18% have unknown department of origin and that about 40% of them were collected in 3 out of 23 departments: Cuzco 24%, Huánuco 7.8%, and Junin 7.7%.

Finding duplicates in the collection will maximize the use of available funding, field space, and storage facilities, in the preservation of a more representative sample of the Andean germ plasm. It will also make feasible the use of other techniques such as invitro culture as a means to preserve genotypes. Consequently, the data bank has been utilized in as much as possible to assist and facilitate the identification of duplicate clones in the collection.

The usefulness of vernacular names of the accessions in duplicate identification has been explored. Thus, Table 2 shows examples of a large number of accessions which have the same native name in common with some variations in their adjectives. The likelihood that they could be duplicates is supported by available data on electrophretic analyses and synonym group numbers.

However, by printing out all vernacular names of a given synonym group and their locality of collection, it becomes apparent that samples of the same clone collected over a large area of cultivation have many different and unrelated names. They are only moe or less consistent for samples collected within a small geographical area.

In order to keep the identity of the collection and to use cluster analyses to find duplicates, data have been recorded on 19 of the most important tuber, stem and flower characters of about 6,000 accessions. A duplicate identification software developed at IS/GR sorted out a large number of accessions with identical or similar morphological data. By planting the collection according to those results, the chances of finding duplicates are substantially facilitated since groups of accessions with many characters in common grow next to each other.

Concerning electrophretic analyses of soluble tuber proteins and enzimes of duplicate accessions, Table 3 presents data on the groups sent to West Germany from 1976 to 1978. The data bank contains results for 4,978 accessions within 1,004 groups. Some 933 accessions comprising 343 groups have been recently sent for analyses.

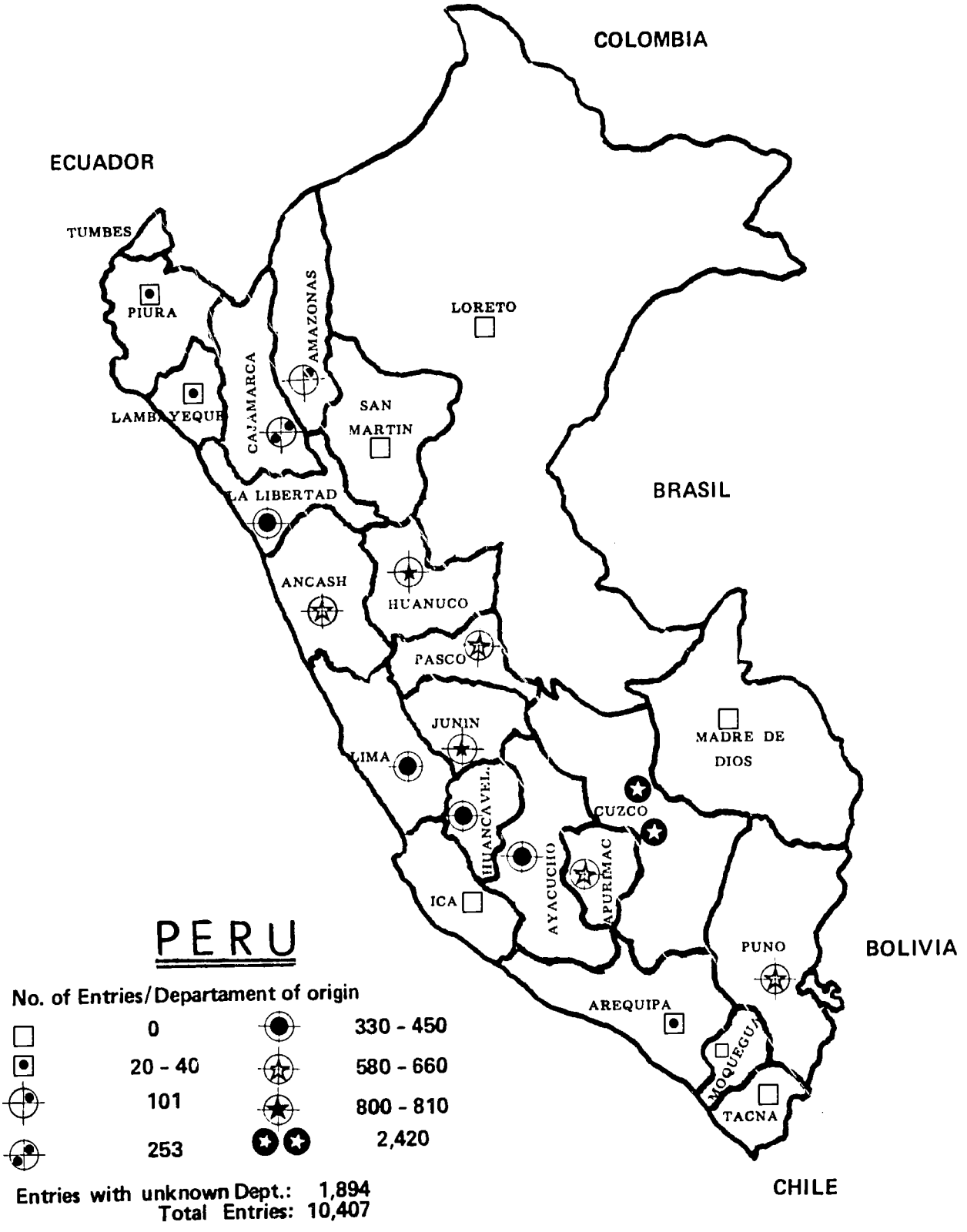
COLOMBIA
ECUADOR
TUMBES
PIURA
LAMBAYEQUE
CAJAMARCA
AMAZONAS
LORETO
SAN MARTIN
BRASIL
LA LIBERTAD
ANCASH
HUANUCO
PASCO
JUNIN
LIMA
HUANCAVEL.
AYACUCHO
APURIMAC
CUZCO
MADRE DE DIOS
ICA
PUNO
BOLIVIA
AREQUIPA
MOQUEGUA
TACNA
CHILE
PERU
No. of Entries/Departament of origin
0
20 - 40
101
253
330 - 450
580 - 660
800 - 810
2,420
Entries with unknown Dept.: 1,894
Total Entries: 10,407

Table 2.

Examples of Some Accessions with the Native Name "Imilla" (Young Girl) in Common

Vernacular Name	ID. No.	Syn.Gr.	Electrophoresis	
Alcca *Imilla*	CIP 702828	214		1054A
Alcca *Imilla*	HAW 5660	214		
Alcca *Imilla*	HAW 5704	227		
Alcca *Imilla*	OCH 5152	214		
Alka *Imilla*	OCH 5346	227	2103A	1054A
Ancco *Imilla*	OCH 5835	242		
Anco *Imilla*	OCH 5332	53	2103A	1054A
Imilla	CUS 134	53		1054A
Imilla Ccompis	CUS 219	53		
Imilla Rosada	HAW 6170	53	2103A	
Jancko *Imilla*	HAW 6192	214	2103A	
Jancko *Imilla*	OCH 5855	242		
Paco *Imilla*	HAW 5688	53	2103A	1054A
Puca *Imilla*	HAW 5532	53		1054A
Yuracc *Imilla*	CIP 702558	53	2103A	

Table 3.

Data on Groups with Similar Morphology sent for Electrophoretic Analyses

Shipment No.	Year	Total Groups	Number Clones/Group 2	3-5	6-10	10	Total No. Clones
1	1976	74	16	43	6	9	489
2	1976	94	27	19	20	28	964
3	1977	123	66	47	6	4	495
4	1977	144	37	59	22	26	969
5	1978	229	0	187	33	9	1,026
6	1978	340	200	118	16	6	1,035
TOTAL:		1,004	346	473	103	82	4,978
7	1979	343					933
		1,347					5,911

It should be pointed out that the number of samples to be sent each year for electrophoretic analysis is from 1,500 to 2,000. Generally, it requires more than a year to select out from the collection such a number of accessions and then grow them side by side to make very detailed morphological comparisons and determine their duplicate status. Consequently each shipment of material has to include some groups which are only similar in their tuber morphology. Those which show identical pherograms are verified morphologically once the biochemical data are made available.

A summary of the results obtained from electrophoretic analyses is presented in Table 4. Ideally there should be the same number of pherograms as duplicate groups sent. In practice, the number of pherograms obtained range from 1.5 to 3.0 times the number of groups. This is due to the prescense of accessions which are not duplicates and produce totally different pherograms. However, in most of the groups there are some accessions which, although producing basically the same pherogram, show some variations in presence or absence of faint bands in their protein and/or enzime pattern. In such cases all the accessions showing these minor variations are not eliminated.

Table 4.

Comparisons of Results Between Groups of Clones with Similar Morphology and their Electrophoretic Patterns

Shipment N°	Year	N°Groups Sent	N° of Pherograms	Percentage Agreement by Groups 0	1-49	50-74	75-99	100
1	1976	74	171	17.6	6.8	13.5	21.6	40.5
2	1976	94	275	24.5	11.7	7.5	26.6	29.7
3	1977	123	199	23.6	0.8	12.2	7.3	56.1
4	1977	144	268	8.3	3.5	15.3	16.0	56.9
5	1978	229	451	14.0	4.0	25.3	11.8	44.9
6	1979	340	651	37.4	3.2	13.8	3.2	42.4

Data on electrophoresis has also been used to enlarge the size of some synonym groups. One can sort out those accessions sent as references for the comparison of data from two or more shipments and then plant all the groups involved close to each other. The same is made with those groups that within the same shipment are found to be identical by electrophoretic comparisons of representative accessions.

Other data such as disease and pest reactions and collecting localities, are extensively used during the process of deciding which duplicate accessions should be eliminated.

Some information related to the number of accessions eliminated from the collection is shown in Table 5. About 30% of accessions in the collection has been discarded from clonal propagation as duplicates of 723 morphotypes or cultivars.

Table 5.

Number of Eliminated Accessions per Ploidy Level from 1973 to 1979

Ploidy	N° Accessions Eliminated						
	1973	1975	1976	1977	1978	1979	Total
Diploid	0	41	0	78	214	38	371
Triploid	0	41	0	270	307	55	673
Tetraploid	11	158	686	338	631	460	2,284
Pentaploid	0	0	0	0	115	21	136
TOTALS	11	240	686	686	1,267	574	3,464

No. of Synonym Groups = 723.

Total Number of Entries in the Collection = 12,427

In the future, the role of computerized data management is anticipated to be of greater importance in all the activities of the gene bank. This is particularly true in inventory and stock control, distribution, evaluation and, above all, utilization of the potato genetic resources available at CIP.

Strategy of the Inter-Regional Potato Introduction Project (IR-1)[1]

Dr. R.E. Hanneman, Jr.[2]

The Inter-Regional Potato Introduction Project (IR-1) has been in existence for over 30 years. Since its inception, it has been charged with the following objectives:

1. To introduce, preserve, classify, and preliminarily evaluate the wild and cultivated tuber-bearing *Solanum* species.

2. To distribute these introductions to potato breeders and to other scientists conducting research with the potato.

The ways in which the project meets these charges were outlined in the 1976 "Planning Conference Report - Exploration and Maintenance of Germ plasm Resources." A discussion of recent changes in the IR-1 program and an outlook to the future is presented here.

Since the 1967 CIP Planning Conference, a number of important changes have occurred at IR-1. These include the addition of a full-time person assigned to virus indexing and meristem culture to free clonal stocks from viruses. This program was established at the request of the IR-1 Technical Committee, which asked that the USDA plant physiologist attached to the cooperative USDA - University of Wisconsin research project associated with IR-1 explore the feasibility of using meristem culture to free clonal stocks in the collection from virus. He responded by identifying several

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[1]Cooperative investigation of the U.S. Department of Agriculture, Science and Education Administration, Agricultural Research, and Wisconsin Agricultural Experiment Station.

[2]Research Geneticist, USDA, Science and Education Administration, Agricultural Research, Department of Horticulture, University of Wisconsin, Madison, Wisconsin 53706.

media on which the meristems of most species and foreign cultivars grew satisfactorily. The commonly used media for meristems of most species and foreign cultivars grew satisfactorily. The commonly used media for meristem culture of cultivars were generally not satisfactory when used for the wild species, nor for all foreign cultivars. His work proved successful enough that it was decided to establish a full-time position devoted to meristem culture at IR-1.

IR-1 is cooperating in the development of a prototype for the computerization of inventory data and related reports. This is being done through a cooperative agreement between the National Germ plasm System of the USDA, Science and Education Administration, Agricultural Research and the Laboratory for Information Sciences (LISA) at Colorado State University, Fort Collins, Colorado. As a result of this effort, in cooperation with the University of Wisconsin, Madison Academic Computing Center, a computer program has been developed for all data listed in IR-1 inventories and also related maintenance information. The 1967 and 1972 inventories are now on tape and additional accessions will be added as Plant Introduction numbers are obtained. Two persons associated with IR-1 were sent to LISA for familiarization and training in computer techniques. This system should contribute greatly to the effectiveness and the efficiency of the IR-1 operation when fully implemented.

IR-1 sought and obtained support from the USDA, Science and Education Administration, Agricultural Research for an expedition to New Mexico and Arizona during the summer of 1978. Dr. Donald Ugent led this expedition and sent back 20 clones of Solanum fendleri and S. jamesii. He noted a considerable loss of species habitat due to forest harvesting. It appears that the last major undisturbed area for these species in the southwest United States is in the White Mountains of New Mexico.

IR-1 has a bright and healthy outlook to the future and has enjoyed excellent financial support for its operation. A considerable amount of renovating and updating of facilities have occurred, along with the construction of an additional greenhouse chamber. IR-1 is presently capable of handling 250 tuber families of 21 plants each along with maintenance of clonal stocks during its fall tuber increase, and 175 accessions of 20 plants each for seed increase during the spring. This places our true seed maintenance capability as presently done at 3-4000 accessions based on a maintenance cycle averaging 15-20 years for each accession. The true seed

increase capability could be nearly doubled if a fall increase were done in place of the tuber family offering. High-output fluorescent lighting has been added, making this possibility a reality when needed.

IR-1 continues to strive to meet the charge given it by maintaining and provinding a working collection, serving potato breeders and other scientists interested in the use and study of wild and cultivated species of the tuber-bearing Solanums.

Progress of the German-Netherlands Potato Department of the Gene Bank in the FAL

Dr. L.J.M. van Soest

Introduction

It is more than 5 years since the Ministers of Agriculture of the Federal Republic of Germany and the Kingdom of the Netherlands signed an agreement to establish a bilateral potato germ plasm programme in the Institute of Crop Science and Seed Research of the Federal Agricultural Research Centre (FAL) at Braunschweig. The project is bilaterally financed and the two participating institutes, the Foundation for Agricultural Plant Breeding (SVP) in the Netherlands (Director Dr. Ir. H. Lamberts) and the Institute of Crop Science and Seed Research in the Federal Republic of Germany (Director Prof. Dr. M. Dambroth) are working together in developing a potato gene bank. The bilateral agreement leaves room for participation by interested institutes of other countries, particularly in Europe.

A Programme Committee of eight members, scientists and ministerial advisers make recommendations on activities of the project.

The objectives of the project and details of the joint cooperation were outlined by Lange (1976) in a paper presented at the second Planning Conference. Furthermore, details concerning maintenance, storage, documentation, evaluation and distribution of our potato collection were discussed.

During the initial phase of this bilateral project the strategy of maintenance, particularly the establishment of the potato germ plasm collection, was the major concern of the department, whereas now the strategy of utilization is receiving more and more emphasis. Considerable progress has been made in the field of documentation and evaluation of the collection.

The first evaluation data of several screening tests carried out by specialists in both participating countries have been

published. An Index Seminum is at present in print and will be available at the end of this year.

The German-Netherlands potato collection now maintains 2,575 accessions of wild species, primitive cultivars, registered and old potato varieties.

In 1980 the department will organise a potato collecting expedition to Bolivia and some aspects of this expedition will be discussed.

The Potato Germ Plasm Collection

The collection includes botanical seed only and consists of 2,369 accessions of wild species and primitive cultivars. Furthermore a small collection of open pollinated seeds of registered and old potato varieties is maintained. This collection includes 206 accessions and is the first step towards the establishment of a gene pool of varieties in the form of botanical seed and an addition to the existing living collections in the Netherlands and the Federal Republic of Germany. Table 1 presents the number of accessions of wild and primitive Solanum species maintained in the German-Netherlands potato collection. Besides the complete collections from Wageningen (WAC, conservator Dr. Hermsen) and Cologne (EBS, conservator Prof. Ross) a great number of accessions were received from Dr. A. Okada of INTA (National Institute of Agricultural Technology) at Balcarce, Argentina.

Together with the cultivated species derived from the joint Dutch/British/CIP expedition in 1974, at present kept in Wageningen and the material to be collected during the planned expedition to Bolivia in 1980, the collection will increase to approximately 4,500 accessions.

Having established the collection from already existing collections it is obvious that duplicates exist. There are nearly 150 duplicates in the collection which, however, are kept under separate BGRC numbers due to the differences in regeneration methods in the past. Furthermore, a recently completed computer analysis revealed that we do have 525 accessions which are also maintained in the Interregional Potato Collection at Sturgeon Bay, USA.

Table 1.

Accessions of Wild and Cultivated Solanum Species Maintained in the German-Dutch Potato Collection at Braunschweig

Origin	Wild Species[x]	Primitive Cultivars[xx]
Wageningse Aardappel Collectie (WAC)	390 (50)	443 (3)
Erwin-Baur-Sortiment (EBS)[xx]	330 (64)	65 (4)
INTA-Balcarce	809 (17)	46 (1)
CIP-Lima	--	39 (1)
Other introductions	--	42 (1)
Dutch-English Andes Expedition 1974	205 (19)	--
Total	1734 (76)	635 (4)

[x] Numbers in parenthesis denote the number of different species.

[xx] Excluding some 200 accessions which have not been rejuvenated yet.

As shown in Table 1 the collection includes 76 different wild species and 4 primitive cultivars. This means that 80 from the 158 different species mentioned by Hawkes (1963) are maintained at Braunschweig. However, many species are represented by only one to five accessions thus giving a very low genetic diversity. The commonly found and often widespread species such as Solanum acaule, S. chacoense, S. gourlayi, S. infudibuliforme, S. tuberosum ssp. andigena and several species reported to have important properties for breeding purposes (S. demissum, S. phureja, S. spegazzinii, S. sucrense, S. tarijense and S. verrucosum) are somewhat over represented. Therefore, further extensions of the collection should be directed towards increasing the genetic diversity and it is expected that the planned expedition to Bolivia will contribute to this goal.

Lange (1976) discussed in detail our maintenance programme and the genetic consequences of the practised method.

Table 2 gives an indication of the operations involved in one year of maintenance.

Table 2.

Details Maintenance Programme by 100 Accessions per Annum

Average		Total	
No. of plants per accession:	20	No. of plants grown:	2,000
No. of pollination per accession:	100	No. of pollinations:	10,000
No. of berries per accession:	40	No. of berries produced:	4,000
No. of seeds per berry:	200	No. of seeds produced:	800,000

So far approximately 500 accessions have been multiplied but with the future extension in mind there is an urgent need to increase our multiplication capacity. With the present long-term storage facilities (-10°C to -20°C) and after drying to 5-6% seed moisture content the samples can be

stored for approximately 30 years. This means that with a collection of 6,000 accessions we need to rejuvenate 200 numbers a year. To increase our capacity we are considering the following alternatives in the maintenance programme:

1. A part of the collection will be grown initially in the field. Cuttings will be collected and placed in bottles filled with a solution of Potassium permanganate in a temperature-controlled greenhouse of 22°C. By this method, sometimes called the decapitation technique, the space needed in the greenhouse can be drastically reduced and the flowers be easily pollinated in comparison with the maintenance of plants grown in pots.

2. Growing of self incompatible species, in the field under isolation to stimulate a natural seed set.

Evaluation of the Potato Germ Plasm Collection

Just keeping a collection from dissappearing without evaluating it is of little value to potato breeding. From its initiation the German-Netherlands potato department has developed a system of co-operation with scientists in both participating countries. Specialists are screening our germ plasm for its properties particularly for resistance against the most important potato diseases in western Europe. However, there are possibilities for other potato workers to request stocks and to join our evaluation programme. For instance, some months ago we received data of 236 BGRC accessions screened for resistance to PVM by Dr. M. Dziewonska of the Potato Research Institute at Mlochów, Poland. Table 3 summarises the evaluations, the research institutes and the participating scientists of both countries. Our strategy is to screen all accessions during or directly after the maintenance. In the case of resistance testing to *Phytophthora infestans* leaves taken from the plants under multiplication are used whereas for screening of other properties we use tubers or seeds sent to the participating scientists directly after the rejuvenation. So far more than 2,000 data have been obtained and most of this information has been published in "Genbank Informationsdienst" (GID) No. 6 edited by Prof. W. Hondelmann. The publication of these data is facilitated by computer handling in close co-operation with our documentation specialist Mr. L. Seidewitz, Dipl. rer. hort.

Screening tests commonly adopted to evaluate potato cultivars for resistance against plant diseases are not always

Table 3.

Evaluation of the Potato Germ Plasm Collection

Character	Description	Institute/Researchworker
Nematodes		
Globodera rostochiensis	Ro_5	BBA (Dr. Rumpenhorst)
Globodera pallida	Pa_3	SVP (Dr. Huijsman)
Bacteria		
Erwinia carotovora	var. *atroseptica*	BLPB (Dr. Munzert and Dr. Hunnius)
Fungi		
Fusarium coeruleum		BBA (Dr. Langerfeld)
Phytophthora infestans	a. non-specific (field)	SVP (Mr. Tazelaar)
	b. non-specific (laboratory)	BBA (Dr. Schöber)
	c. specific (R-genes)	BBA (Dr. Schöber)
Synchytrium endobioticum	Pathotype 1	BBA (Dr. Langerfeld)
Viruses		
Potato Virus Y	PVY	SVP (Ir. Wiersema & Mr. Sypkes)
Potato Virus X	PVX	SVP (Ir. Wiersema & Mr. Sypkes)

BBA = Federal Biological Research Centre for Agriculture, Braunschweig and Müster, FRG.
BLPB = Bavarian Governmental Institute for Soil Cultivation and Plant Production, Freising, FRG.
SVP = Foundation for Agricultural Plant Breeding, Wageningen, The Netherlands.

suitable for screening wild or primitive species. Therefore it is sometimes necessary to first develop a screening method suitable for testing wild and primitive potato germ plasm. This was for instance necessary in the screening for Erwinia carotovora resistance and will be the case in testing for potato leaf roll virus (PLRV). Testing for PLRV resistance exposes several problems in connection with the spread of the infection and inadequate knowledge of disease symptoms in the different Solanum species. We hope to develop a modified field test as described by Wiersema (1972) where the tuber-bearing Solanum species will be planted between rows of PLRV infected tubers of potato cultivars. The recently developed ELISA may be used for routine testing of foliage of those species which do not show clear leaf-roll symptoms.

Breeding for resistance to the cyst nematode has been very important in Western Europe and our potato collection will be screened thoroughly for Globodera rostochiensis (Ro_5) and G. pallida (Pa_3).

In the screening for Phytophthora infestans we place more emphasis on non-specific (horizontal) than on R-gene resistance (vertical). Field resistance in Europe has been detected in some accessions of the following wild species Solanum berthaultii, S. microdontum, S. pinnatisectum, S. polyadenium and S. polytrichon (Tazelaar, personal communication). Laboratory tests, used by Dr. Schöber revealed that non-specific resistance can not only be found in S. stoloniferum, S. berthaultii and S. microdontum but also in the lesser known species S. hertingii and S. fendleri. Testing for resistance to the wart causing fungus Synchytrium endobioticum revealed that resistance can be found in several wild species (see GID No. 6). So far, screening for resistance to virus diseases has not received any attention. However, this year we started with seedling screening for PVX and PVY.

Finally, it must be mentioned that all our evaluations have been conducted with populations and need to be considered preliminary screening results.

Potato Collecting Expedition to Bolivia

The exploration of the genetic resources of our cultivated crops have been receiving increased interest in the past 10 years. Potato germ plasm of the geographical centres of genetic diversity have contributed various beneficial results towards breeding programmes, particularly in the field of resistances to diseases, pests and environmental stress factors. There are also indications that the use of wild species has contributed to yield increases of potato varieties (Hermsen, 1977).

The Programming Board of the German-Netherlands Potato Department stresses the significance of the exploration of potato germ plasm and supported unanimously the organisation of a potato collecting expedition to Bolivia. This country was selected as the exploration area after consulting several authorities with collecting experience in the centres of diversity of the potato.

The objectives of the expedition can be summarised as follows:

1. To increase the present collection with germ plasm from Bolivia. At present only 270 accessions of primitive cultivars and wild species are maintained in the collection.

2. To collect in areas where potato species almost certainly occur but few or no collections have been made ("white spots").

3. To attempt to collect some of the wild species which are at present unavailable or rarely available in gene banks.

4. To make germ plasm available to potato breeders of this important centre of diversity. The value of germ plasm from Bolivia, particularly the resistance to Globodera species and virus diseases, has been known for several years.

The expedition is scheduled for 17th February to 10th April, 1980. The project will be jointly financed by the Foundation for Agricultural Plant Breeding (SVP) of the Netherlands, the Ministry for Technical Co-operation of the Federal Republic of Germany and the International Potato Center, Lima, Peru.

The expedition will concentrate the collecting activities in the north-central (Dep. La Paz and Oruro) and the southern part (Dep. Potosi, Chuquisaca and Tarija) of Bolivia. It is planned to have two teams simultaneously in the field and each team will make the collections in the two above mentioned areas thus avoiding areas of overlap. At the same time a more taxonomically orientated potato collecting expedition led by Prof. J.G. Hawkes and Dr. P. Hjerting will collect in central Bolivia (Dep. Cochabamba and Santa Cruz). Both expeditions will co-ordinate their activities, particularly in the field of information and the exchange of material. In Bolivia there will be close co-operation with the Ministry of Agriculture (MACA) and the Consortium for International Development (CID).

The Present Status of Bolivian Potato Germ Plasm in Gene Banks

From the genetic conservation point of view the number of accessions actually maintained in gene banks is more important than the number of expeditions which have previously been organised. Rowe (1970) pointed out that the existing collections of living *Solanum* germ plasm may be more limited than might be expected, mainly because of the loss of early introductions. In the case of Bolivia some of the valuable collections of the late Prof. M. Cardenas have been lost. The number of accessions of cultivated and wild potato species from the three most important countries in the South American centre of diversity, maintained in the major collections of the world, are presented in Table 4.

The data illustrate that the potato germ plasm available from Argentina is adequate due to the intensive collections previously made. There is a broad spectrum of primitive cultivars from Peru available but the number of wild species are somewhat limited. However, the exploration activities of CIP in this country will guarantee the preservation of wild species from Peru. Table 4 clearly indicates the limited number of accessions from Bolivia, both wild and cultivated *Solanum* species which are maintained in existing collections. Considering the fact that there are several duplicates in the present collections it is significant to note that the germ plasm available from Bolivia is inadequate.

Analysis of the distribution of wild species from Bolivia maintained in four existing collections gives a good indication of the type of material at present available (Table 5).

Table 4 a.

Number of Primitive Cultivars from Argentina, Bolivia and Perú Maintained in Solanum Germ Plasm Collections

(Figures in Parenthesis Denote the Number of Different Species)

		Argentina	Bolivia	Perú
G.LKS	(1966)	696 (1)	233 (7)	391 (6)
CPC	(1968)	7 (2)	258 (4)	351 (3)
IR-1	(1979)x	146 (1)	158 (4)	187 (4)
BGRC	(1979)	150 (1)	92 (3)	240 (3)
CIP	(1979)x	173 (4)	849 (7)	10,407 (7)
INTA	(1976)xx	41 (1)	-	-

x personal communications Drs. Huamán and Hanneman Jr.
xx available for distribution (Okada, 1976).

Table 4 b.

Number of Wild Species from Argentina, Bolivia and Perú Maintained in Solanum Germ Plasm Collections

(Figures in Parenthesis Denote the Number of Different Species)

		Argentina	Bolivia	Perú
G.LKS	(1966)	176 (17)	56 (18)	103 (29)
CPC	(1968)	115 (16)	42 (10)	12 (9)
IR-1	(1979)x	1015 (18)	171 (22)	300 (44)
BGRC	(1979)	1176 (16)	178 (19)	141 (29)
INTA	(1976)xx	718 (16)	-	-
CIP	(1979)x		130 (16)	400 (36)

x personal communication Dr. Hanneman Jr., Prof. Ochoa.
xx available for distribution (Okada, 1976).

Table 5.

Presence of Wild Species from Bolivia in 4 Solanum Germ Plasm Collections

Not maintained	1 - 2 accessions	3 - 5 accessions
S. circaeifolium	*S. chacoense*	*S. tarijense*
S. ellipsifolium	*S. yungasense*	*S. boliviense*
S. ureyi	*S. capsicibaccatum*	*S. toralapanum*
S. alandiae	*S. violaceimarmoratum*	*S. gandarillasii*
S. candolleanum	*S. infundibuliforme*	*S. gourlayi* ?
S. colominense[1]	*S. canasense* ?	
S. liriunianum[1]	*S. doddsii*	**More than 5 accessions**
S. mollepujroense[2]	*S. leptophyes*	*S. acaule*
S. pachytrichum[3]	*S. microdontum*	*S. x berthaultii*
S. pumilum[4]	*S. torrecillasense*	*S. brevicaule*
S. vidaurrei		*S. oplocense*
S. virgultorum		*S. sparsipilum*
		S. sucrense

[1] possible synonyms *S. brevicaule*

[2] most probably *S. sparsipilum*

[3] synonym *S. leptophyes* (Hawkes, 1963)

[4] synonym *S. achacachense*

? distribution in Bolivia doubtful

The data are taken from the inventories of seed stocks of the following collections; Gross-Lüsewitz Sortiment (Rothacker, 1966), Commonwealth Potato Collection (Anonymous, 1968), US Potato Collection (Ross and Rowe, 1969) and the German - Netherlands Potato Collection (1979).

Hawkes (1963) recorded the occurrence of 33 wild species in Bolivia. However, there are a few synonyms and some may not be distinct species. There is, however, a group of at least 10 species which are at present not available in the existing collections. In fact, there are only 6 wild species of which more than 5 accessions are maintained in the world potato gene banks. In other words more than 80% of the wild species from Bolivia can be considered as having inadequate genetic representation in the existing Solanum collections. There is obviously a great need for broadening the collections of Solanum germ plasm with wild species of Bolivia and it is hoped that our expedition will contribute towards this end.

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The Role of the IBPGR in Organizing Conservation Networks of Vegetative and Seed Material

Dr. J.T. Williams

The International Board for Plant Genetic Resources (IBPGR) was established in 1974 as an autonomous, international scientific organization under the aegis of the Consultative Group on International Agricultural Research (CGIAR). Its basic function is to promote a global network of genetic resources centres which will ensure that crop genetic resources are collected, conserved, documented and evaluated. Through its work it acts as a service to breeders who can use the material and contribute to raising the standard of living and welfare of people throughout the world. During the five years since the founding of the Board we have witnessed a greatly accelerated awareness of the need to conserve variability in danger of irreplaceable loss -- whether this variability is in cultivated varieties, primitive land races or closely related wild or weedy forms.

Following this increase in awareness we have also witnessed the emergence of new national genetic resources programmes, many in developing countries of the world and also the strengthening or coordination of efforts in many developed countries in an attempt to "put their shops in order" to safeguard historic material held in germ plasm collections. In many of these programmes the Board has acted as a catalyst.

In its efforts the Board has received the support of the International Agricultural Research Centres of the CGIAR which deal with crops, a support which has helped greatly in the Board's attempt to build a dynamic global network; a network based on diverse types of institutions and one that has rapidly become a reality. Nevertheless there is still a long way to go as there are many uncollected parts of the world, many crops hardly collected and few really comprehensive collections except for a limited number of major crops. Examples of the latter are rice, maize and potatoes. From the outset the Board has relied on CIP which maintains more than 8,000 primitive cultivars as well as wild species. Even though the use of computer programs to identify duplicates (a method developed through the work of the IBPGR) is currently under way CIP's collection is

large and requires maintenance. This in an International Centre is closely linked with the need to grow material for evaluation and screening and increasing for distribution.

In its germ plasm work CIP has been guided by the Centre's Planning Conferences (e.g. 1973, 1976) and the IBPGR has not seen the need to duplicate such efforts by establishing any advisory committee for potatoes. The IBPGR thus views CIP as the centre to maintain a world collection and keep the world community of potato breeders informed about priorities and needs for germ plasm work. Nevertheless the IBPGR has helped, somewhat indirectly - but effectively, the efforts of CIP in its attempts for self-sufficiency in computer assisted data management and the development of standardized descriptors.

The success of such cooperation leads inevitably to better exchange of material since the material can be accompanied by basic information of great value to the recipient. Indeed the IBPGR views one of its measures of success as an increase in the exchange of material and its accompanying information. Sadly, for many centres this has just not taken place and the constraints are obvious: manpower for multiplication, retrieving information, packaging, despatching and keeping records.

In recent years, plant breeders have intensified the transfer of breeding materials and they and the Board are furthermore moving materials out of the centres of diversity of the crops. This inevitably raises a question of quarantine because many of these centres of diversity are centres of origin of many of the host pathogens. Despite these risks seed material has been moved at no great risk and the IBPGR has established a network of conservation centres for long-term storage.

In vegetatively propagated crops the risk of spreading plant diseases with the transfer of germ plasm may be acute but they have to be reduced to almost imperceptible levels to allow the gains in breeding. The IBPGR has not yet started to designate a network of germ plasm centres for vegetative material for various reasons which I shall outline below.

In the potato many exchanges have been made by using open-pollinated seed which has the advantage of relative freedom from virus, and can be easily despatched and stored. For wild species of potato this method is adequate but for cul-

tivars seed production poses heterogeneity problems which I have no need to repeat at a CIP Planning Conference. Nevertheless it is a rational way of maintenance which in general is acceptable for utilization. However, for a vegetatively propagated crop such as the potato, part of the genepool can only be maintained as a vegetative collection.

To overcome many difficulties in conserving and freely exchanging tubers, storage of meristems at extremely low temperatures seems to be a possibility although exchange of tubers grown under disease-free conditions with the testing of the plants by serological assays and/or indicated hosts is an alternative. Even though CIP has a disease-free scheme most centres are not equipped for such work. In addition, meristem culturing has to be performed when no disease-free plants are seen when clones are screened.

Work at CIP in recent years on the production of aseptic plantlet cultures, regenerated from shot tips of disease-free stocks have helped to overcome certain restricting quarantine regulations.

Problems of maintenance and exchange of material of vegetatively propagated crops have been widely recognized, and during the last decade when I have sat through many meetings dealing with genetic resources, the need to develop suitable methods of tissue culture have been stressed time and time again. In fact during 1979 when the IBPGR Regional Committee for Southeast Asia held its second meeting it recommended that the not inconsiderable expertise in many parts of the world should be encouraged whenever and however possible to produce practical solutions. At an IBPGR meeting on grapes in September 1979 a group of world experts went further and stated that any breakthrough would have repercussions the world over.

Worries are expressed about the genetic instability of certain types of tissue cultures and genetic changes can occur during the initiation of cultures or during their maintenance for long periods. Meristem cultures and the use of cryoprotectants and liquid nitrogen appear promising and some of the basic tissue culture procedures have been established for potatoes, bananas, sweet potatoes as examples. In this respect the CIP-ODA/UK University of Birmingham collaborative work is noteworthy.

The IBPGR has recognized the problems of conservation and exchange of vegetatively propagated crops and in 1974 asked its Secretariat to prepare a technical paper on plant health and quarantine problems in transfer of genetic resources. This resulted in the preparation of a treatise on the subject (Hewitt & Chiarappa, 1977) which in turn resulted in a task force making a series of recommendations addressed to FAO and the IBPGR. Both FAO and the IBPGR agreed that further discussion was necessary and the recommendations could not be implemented as such. Nevertheless the treatise has served a useful role in information.

More recently the IBPGR has reviewed its policies and activities and looked to the future (IBPGR 1979). In this review the Board noted that perforce its activities in the first instance had to be related to conservation of major staple crops and particularly seed crops but recognized that in the next 5 years more attention will be paid to conservation of vegetative collections. This topic is also likely to feature prominently in an FAO/IBPGR/UNEP Technical Conference planned for 1981.

The Board is not a research institution but will respond to advice and recommendations insofar as it is able and in addition will provide support in principle to accelerate much-needed research and try to help if necessary by mobilizing bilateral funding. The recommendations of this CIP Planning Conference will be of great interest to the IBPGR.

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In Vitro Maintenance of Valuable Solanum Resources at CIP

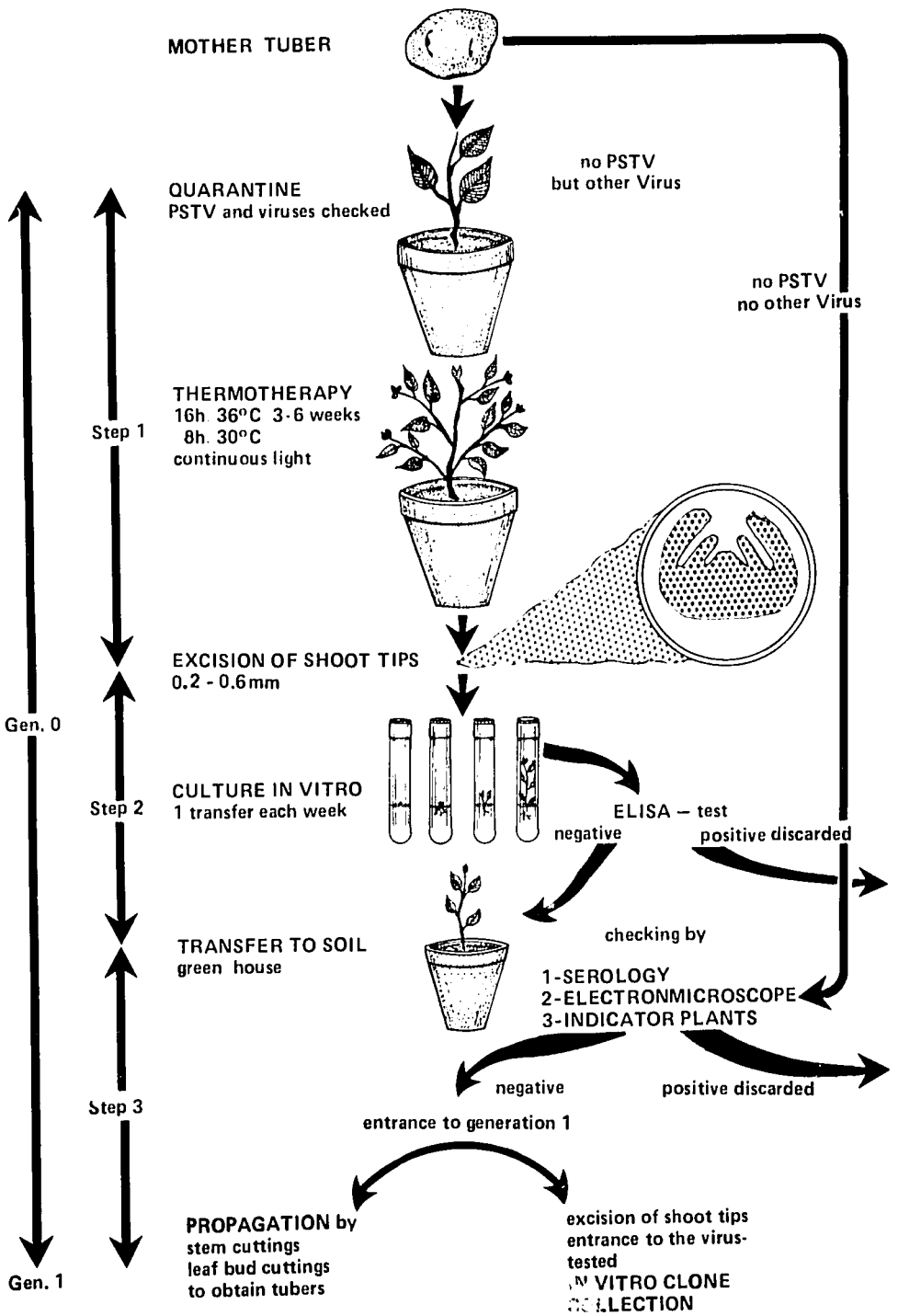
Dr. L. Schilde

The function of the *in vitro* collection is to preserve distinct genotypes pathogen free and to keep them available for further use in evaluation, breeding or basic research. Therefore, the techniques applied for maintenance and propagation of the collection have to fill the following requirements:

1. The genetic stability of the material should be preserved.
2. The maintenance of the collection should be economical without requiring high technological expenditure.
3. The techniques should be applicable to a wide range of genotypes.
4. It should be easy to propagate the material on a large scale.
5. A transfer of material to other countries should be practical but efficient.

Virus Eradication and Entrace of Clones to the Collection

Scheme 1 shows how material will be treated for virus eradication before entering the virus tested collection. The first step is a test for potato spindle tuber viroid (PSTV) of plants grown under high temperature which favors the propagation of PSTV. Only when this test is negative will the plant be indexed for other virus. Then the mother tuber will be planted and the resulting plants introduced to thermotherapy after decapitating the terminal bud. During this treatment at high temperature (16 hours 36°C; 8 hours 30°C) and continuous light the axillary buds of the main stem grow out rapidly. From the apical bud and axillary buds meristems with one or two leaf primordia are excised and cultivated as described by W. Roca et al (1978). In addition to the usual virus testing of the plants developed from the meristems, nodes of the same plants are propagated in shake culture at 25°C and another PSTV test of this material and potted plants is carried out. When all these tests are negative shoot tips of the same plants


MOTHER TUBER
QUARANTINE
PSTV and viruses checked
no PSTV
but other Virus
no PSTV
no other Virus
THERMOTHERAPY
16h. 36°C 3-6 weeks
8h. 30°C
continuous light
Step 1
EXCISION OF SHOOT TIPS
0.2 - 0.6mm
Gen. 0
CULTURE IN VITRO
1 transfer each week
Step 2
ELISA – test
negative
positive discarded
TRANSFER TO SOIL
green house
checking by
1-SEROLOGY
2-ELECTRONMICROSCOPE
3-INDICATOR PLANTS
negative
positive discarded
Step 3
entrance to generation 1
PROPAGATION by
stem cuttings
leaf bud cuttings
to obtain tubers
excision of shoot tips
entrance to the virus-tested
IN VITRO CLONE
COLLECTION
Gen. 1

are taken in culture and the resulting *in vitro* plantlet enters the virus tested collection.

Nodes with axillary buds are transferred to three media (Table 1). All three have the basic components of the medium of T. Murashige and F. Skoog (MS) (1962).

Table 1.

	MEDIUM		
	a Propagation	b Storage	c Storage
MS basal salts	+	+	+
Vitamins	+	+	+
G A ppm	(0.25)	(0.2)	-
A B A ppm		1.25	-
Saccharose %	3	6	0.5
Mannitol	-	-	4.0

On medium "a" the buds start to grow immediately and it takes about 2-4 weeks until a plantlet can be transferred to soil. For storage purposes this medium is, therefore, used for all clones which are frequently requested and for propagation purposes. Because of this fast growth at 25°C a transfer to fresh medium should be done about at 6-8 weeks. Whereas in "b" abscisinic acid is used as growth inhibitor in medium "c" osmotic stress reduces growth velocity. On medium "b" at 10°C the buds grow very slowly and a transfer is necessary only one a year. With medium "c" our experience until now shows that the plantlets can be kept in most cases at least 1/2 year at 25°C before the next transfer is necessary. The plantlets grown under these conditions show very small internodes and, therefore, many axillary buds are available for propagation. Plantlets from medium "b" and "c" are kept at 25°C as well as 10°C with a 18 hour light period.

The Table shows the intervals between transfers under these conditions as far as available:

Table 2.

Medium	Transfer Intervals in Months	
MS	12 - 17	2
MS + 4% mannitol	12 - 24	6
LAM + 4% mannitol	12 - 24	6

It shows two different stress media; we had found out the inhibition of growth under osmotic stress conditions with the LAM-medium (LAM 1975) while Dr. Henshaw at Birmingham obtained the same results with the mannitol - containing MS - medium.

The intervals on the Table are optimal values which indicate the time after which the plantlets have the correct conformation and have reached the top of the glass tube. We kept some material longer than indicated, and it was recovered completely.

Applicability of the Method to Different Genotypes

The described growth conditions have been applied to about 150 different clones. The genetic background of some clones is listed in Table 3.

Table 3. Genetic Background of Clones Taken Over in Vitro Collection

Genetic Background	No. of Clones
adg	22
tbr	47
juz	2
phu	1
spl	1
cha	1
tbr x adg	16
tbr x phu	9
phu x adg	1
neo tbr	2
tbr x neo-tbr	3

Without exception all clones could be grown and kept through these methods. Variation in the growth rates occurs but each clone can be recovered after the described storage periods.

Propagation of the Material

As was already shown at the last Planning Conference by W. Roca and G. Henshaw multiplication *in vitro* is quite successful. The basic MS-medium with some organic additional compounds but without hormones is used now.

The clones are usually propagated either by single nodes placed on MS-agar or, on a larger scale, in shake cultures, placing shoot parts with three nodes in liquid MS-medium. On most of the clones the axillary buds are growing into plantlets after 2-5 weeks and they can be cut into pieces again and introduced into the shake culture for further propagation or planted directly into soil. The few exceptions observed required longer time to develop into plantlets. With the cultures kept at 10°C we employ the same method but usually the growth of the first generation is retarded; therefore, to start propagation we have to produce an extra cycle under normal incubation temperature.

The requests for material during the present year are numerous as shown on the Table.

Table 4.

	Seed Production	Breeding	Others
No. potted plantlets	8,184	1,715	1,300

The Table shows that apart from our routine work we have obtained 11,000 plants of about 50 different clones.

Genetic Stability

Both the germ plasm collection in the field and the *in vitro* collection seek to maintain genetic stability. With true seed the case is different. This material is dormant for many years without the need of propagation. We are care-

ful not to accumulate mutations, as for instance through avoiding any non differentiated stage of the tissue. It was proved that in culture of callus mutations are accumulated to a much higher amount than in differentiated plant tissue. Therefore, our effort to shoot tip culture and propagation is directed to avoiding callus formation. We are at present developing one shoot tip with its meristem into one plant and we use pre-formed buds for propagation. This apparently produces a reduction in the propagation rate in comparison to multimeristem production. But as it is time consuming to obtain multimeristems it is practical to use the fast development through shake cultures. The results are equal as related to population with a higher guarantee of genetic stability of the latter method.

As W. Roca and co-workers (1978) already have shown for several clones, there was no difference in the protein pattern of the tuber proteins in electrophoresis after different storage conditions. At the moment we are comparing tubers which came from in vitro plants kept originally for up to 33 months at 10°C and up to 10 months in a medium which exerts osmotic stress. We have harvested tubers and we will plant them to compare them with tuber propagated plants. We have just obtained similar material from Dr. Henshaw from Birmingham and after propagation it will be also comparatively planted.

Transfer of Material

Presently many countries are requesting material from the in vitro collection. As we grow this material in a medium with high sugar contents, bacteria or fungi will show up and sooner or later overgrow the shoot tips or plantlets. Besides this an electronmicroscopical control is done at the beginning of the culture and as routine once per year. These cultures are also checked for the following virus and viroids: A, M, S, T, X, Y, PLRV, APLV, APM, tomato blackring, tobacco ring spot and PSTV.

This guarantees that at least "normal" bacteria and fungi and other known pathogens are not transferred to other countries when the material is exported. This year we have received requests from 10 different countries. We sent small plantlets which were grown from axillary buds in glass tubes. Each shipment has a leaflet added to it. This leaflet contains information prescribing the handling of the material. If it appears advisable we add a portion of dry medium,

therefore, if there is interest in propagating the material *in vitro* before planting in soil it could be done easily.

Table 5. Requests for in vitro Material from Other Countries

	1978	1979
Countries	7	10
Clones	25	37

The training of people from our different regions in how to receive the material, how to handle it and eventually how to propagate *in vitro* allows us the possibility of making our method of transfer more efficient. We expect that any of our trainees whichever the region will be able to further distribute pathogen tested material.

Economy of the Maintenance

We have tried to reduce the work involved by choosing conditions which are applicable to many different genotypes, which on one hand give a good propagation rate and on the other will allow greater transfer intervals without disturbing physiological or genetic characteristics of the plantlets. We have made an estimate for the time which is required for the collection at present.

Maintenance of the Clean Collection with 100 Clones

	Hours/Month
a) Normal growth 25°C	35
b) Reduced growth at 25°C	12
c) Reduced growth at 10°C	6

Storage in Liquid Nitrogen

In cooperation with CIP funded by the U.K. Ministry of Overseas Development Dr. Henshaw and his co-workers at the University of Birmingham (B.W.W. Grout et al.(78)) continued their work on freeze preservation of potato meristem tissue in liquid nitrogen. Most successful was the work with *Solanum goniocalyx*, which gave a survival rate of about 50%, for *S. andigenum* and *S. tuberosum* clones it was difficult to get shoot formation, often only callus was formed. This method is not yet developed enough for practical use and it could be very useful in the future for storage of germ plasm.

ACKNOWLEDGEMENT

I am thankful to Ing. D. Cunliffe for valuable help in the preparation of the English manuscript.

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Present Use and Future Needs for Wild Solanum Species in Breeding at the International Potato Center

Dr. H.A. Mendoza

It is considered that in the breeding of the potato cultivars used in most potato growing areas of the world only a small segment of the total genetic variability contained in the genus Solanum has been utilized. The main factors which have discouraged breeders from temperate countries to use more widely the wealth of genetic variability stored in primitive cultivated potatoes as well as in wild species has been basically:

a. The short day reaction of most of these materials which extends considerably the length of the vegetative cycle of the hybrids.

b. The undesirable agronomical characters which usually accompany the F_1 hybrids.

c. Crossability problems.

In view of these facts, breeders have tried to introgress the variability contained in primitive and wild potatoes by long back crossing programs oriented to "nobilize" the alien germ plasm. However, this "nobilization" process which consisted of a strong selection against the "wild" traits had minimized the contribution of those genetic stocks and only retained a very few genes controlling specific characters. Examples of this process are the utilization of species such as S. demissum, S. acaule and S. stoloniferum for their resistances to late blight, PVX and PVY, respectively. From the references up to nine backcrosses have been utilized to combine the desirable genes of these species with the necessary agronomic and quality characters.

The breeding philosophy at the International Potato Center is oriented to maximize the utilization of the genetic resources contained in the genus Solanum to produce potatoes better adapted to the growing conditions and stresses encountered in the developing world. This task is not easy given the complexities encountered in the use of various species of Solanum as well as the different hereditary patterns of the various traits to be combined. Therefore, it

was necessary to define a breeding philosophy as well as a methodology to achieve the goals.

The basic consideration is that the genetic maximization of potential yield can be achieved when a proper balance of genes is brought together. This can be expressed as the following linear function:

$$X = f\ (A + Y + R)$$

where X represents yield as the result of the action and interaction of genes for adaptation, yield *per se*, and pest and disease resistances. The A genes are considered regulatory units of major effects mainly concerned with the adaptive reaction to temperature and day length. These genes upon receiving the environmental influences would induce the developmental changes leading to the completion of the growing cycle. The Y genes or genes controlling yield per se would be mostly related to the potential capacity and efficiency of the plant to use light energy, transform it into chemical energy and store it in the form of plant material. These genes are thought to be polygenes whose interaction both within locus and between loci would be very important. The third group of genes of the yield functions are the genes R which control pest and disease resistances. Some of these genes are simply inherited, i.e. potato virus Y resistance or major gene for vertical resistance to late blight. Some others are polygenes of a more complex inheritance, i.e. resistance to leaf roll or horizontal resistance to late blight.

Most of these three types of genes, if not all, are scattered in that gigantic widely diverse and heterogeneous gene pool represented by the genus *Solanum* in both its cultivated species as well as in its wild tuberiferous and non tuberiferous relatives.

This gene pool is a sample space or universe in which the various attributes may be more or less isolated in sub-sets. It is also evident that the frequencies of the genes controlling these attributes are low. Therefore, the basic job is to merge two, three, or more sub-sets to generate populations which will have the desired attributes in the proper frequencies.

To improve this gene pool a population breeding approach with continuous cycle of recurrent phenotypic selection was

chosen instead of utilizing the traditional potato breeding approach. One of the main differences is that population breeding enhances the use of additive and non-additive gene effects while the traditional breeding depends most of all in non-additive gene effects, i.e. specific combining ability. Another difference is that in the incorporation of variability from wild species no backcross method is utilized.

The three main goals of the population improvement are:

a. Maintenance of a wide genetic variability and diversity.

b. Increase in gene frequencies of desirable alleles.

c. Stimulate recombination of characters.

Within this population scheme several wild species are being utilized. Among the most important the following can be cited:

S. acaule:	Frost resistance, immunity to virus X;
S. stoloniferum:	Immunity to viruses A and Y;
S. vernei:	Frost resistance, golden nematode resistance;
S. sparsipilum:	Immunity to root knot nematode, resistance to bacterial wilt, some indications of resistance to tuber moth.
S. chacoense:	Resistances to root knot nematode, bacterial wilt, some insects;
S. microdontum:	Resistance to root knot nematode;
S. bulbocastanum:	Resistance to late blight;
S. demissum:	Resistance to late blight;
S. berthaultii:	Insect resistance.

All these species are utilized by the various breeding programs at CIP in combination with Tuberosum and the primitive cultivated potatoes from the groups Andigena, Phureja, Stenotomum, S. curtilobum, S. ajanhuiri.

These wild species contribute genes for resistance to pests, diseases and some stresses as well as contribute genetic diversity. Also, they contribute many undesirable traits such as lateness, poor tuber characters, low yield. Therefore, one has to be very careful in the selection of the accessions or genotypes which will be integrated into the breeding populations.

This publication was processed and printed
by the Training and Communications Department
International Potato Center, Lima, Peru, March 1981.

Copies printed: 300

VII-G-E-19-0-300