GENETIC RESOURCES OF *CAPSICUM*

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INTERNATIONAL BOARD FOR PLANT GENETIC RESOURCES

GENETIC RESOURCES OF *CAPSICUM*

- a global plan of action -

IBPGR SECRETARIAT
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PREFACE

In 1976, the IBPGR commissioned the Royal Tropical Institute (RTI) of the Netherlands to produce a consultant's report on the genetic resources of vegetables with special reference to those grown in the tropics. The report (AGPE:IBPGR/77/23) was published in 1977. It included a summary of information available on genetic erosion and the priority requirements for collection and conservation of germplasm.

When the IBPGR discussed the report, it concluded that more information was required; thereafter an expert consultation was convened 24-25 January 1979 hosted by the National Vegetable Research Station (NVRS), Wellesbourne, UK. At this meeting *Capsicum* was proposed as a crop rating high global priority, especially because of its economic importance and the high degree of loss of natural variability. The IBPGR thereafter requested the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica, to formulate a global plan of action for *Capsicum* genetic resources.

Following preliminary studies undertaken at CATIE, an expert consultation on *Capsicum* genetic resources was held. The meeting was convened by the Unidad de Recursos Genéticos, CATIE, Turrialba, Costa Rica, 13-15 August 1980, on behalf of the IBPGR. A list of participants is appended to this report (Appendix I). The report of the meeting formed the basis of this IBPGR publication with the addition of further information compiled by the IBPGR Secretariat.

During the preparation of this report, the IBPGR Secretariat relied heavily on information provided by the above mentioned expert consultation and also of its members in their personal capacities. In addition, the IBPGR Secretariat wishes to acknowledge the assistance of the organizers and participants of the European Association for Research on Plant Breeding (EUCARPIA) *Capsicum* Working Group which met 14-16 October 1980 in Wageningen, the Netherlands as well as the assistance of several *Capsicum* experts throughout the world.

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1. ECONOMIC AND NUTRITIONAL IMPORTANCE

Capsicum peppers, native to the New World tropics, are now widely cultivated for use as spices or vegetables in the temperate zones as well as throughout the tropics. Chili powder, red and cayenne peppers, Tabasco, paprika, sweet or bell peppers and pimentos are all derived from the pod-like berry of various species of *Capsicum* (see Fig. 1). The pungency of peppers is due to capsaicin, the vanillyl amide of isodecylanic acid, contained in the placenta. A single dominant gene controls the presence of pungency. There are various degrees of pungency: apparently there are modifiers of the major gene and the environment has also been claimed to influence it (Heiser, 1976).

Hot pepper is one of the most important commercially grown vegetables in the tropics, and is probably the most important, after the tomato. It is exported to temperate countries in a dried form for use as a spice in flavouring sauces and canned products. However, the largest part is produced for home consumption. Sweet or bell pepper is more popular in temperate regions, but it is also grown in some tropical and subtropical areas such as Senegal, Kenya and North Africa during the winter months for export to Western Europe (Grubben, 1977). Some recent production figures are shown in Table 1.

The nutritional content of peppers is relatively high (see Table 2) and peppers are good sources of vitamins, particularly vitamin C, and in the dried pungent types, vitamin A. The intake of hot peppers per meal is generally low (1-4 g per capita), while bell peppers are usually consumed in much larger quantities, up to 20 g per meal, and therefore constitute a potentially important source for nutritional improvement. In addition to their use as food or condiment, peppers still have some use in medicine and some are valued as ornamentals (Grubben, 1977; Heiser, 1976).

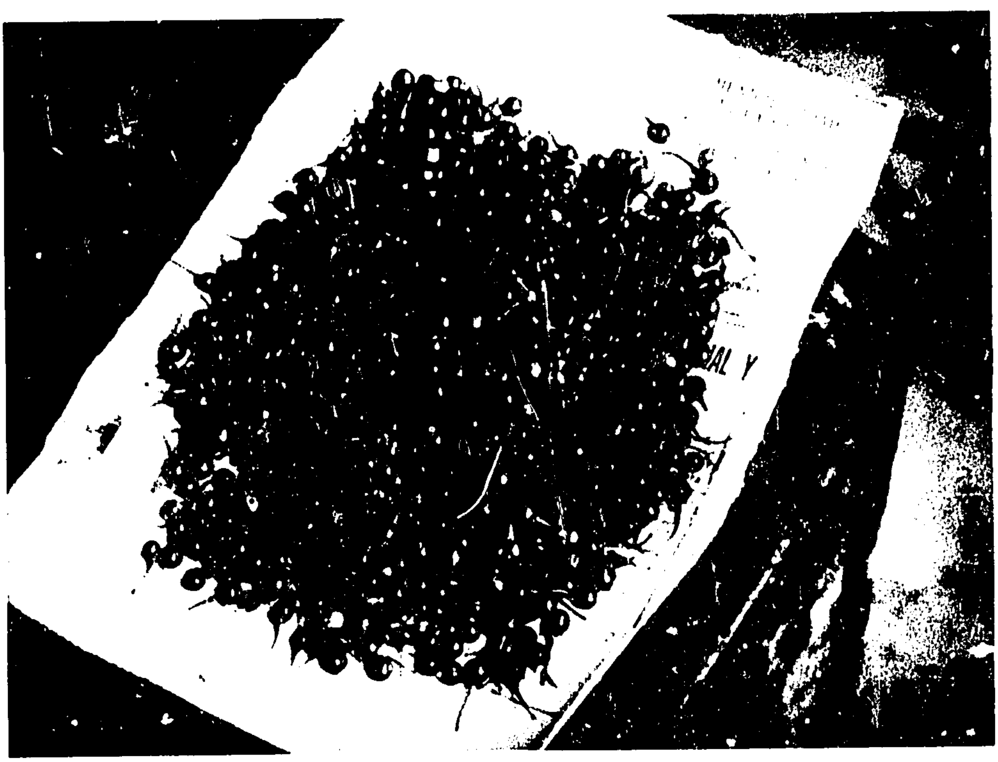

Figure 1. *Capsicum eximium* for sale, Tarija, Bolivia (photo by W.H. Eshbaugh)

Table 1. World *Capsicum* production (fresh)

	Average area harvested and fresh production per year			
	1969-1971		1979-1981	
	Area (1000 ha)	Production (1000 MT)	Area (1000 ha)	Production (1000 MT)
World total	685	5,027	957	7,055
Developed countries	104	1,474	128	2,011
Developing countries	403	1,955	610	2,892
Centrally planned countries	178	1,598	219	2,152

Source: FAO Production Yearbook 1981 (Vol. 35)

Table 2. Average nutritive value of sweet and hot peppers, per 100 grams edible product

	Sweet pepper	Hot pepper
Waste (%)	13	13
Dry matter (gram)	8.0	34.6
Energy (Kcal)	26	116
Protein (gram)	1.3	6.3
Fibre (gram)	1.4	15.0
Calcium (milligram)	12	86
Iron (milligram)	0.9	3.6
Carotene (milligram)	1.8	6.6
Thiamine (milligram)	0.07	0.37
Riboflavin (milligram)	0.08	0.51
Niacin (milligram)	0.8	2.5
Vitamin C (milligram)	103	96
Average nutritive value (ANV)	6.61	27.92
ANV per 100 per gram dry matter	82.6	80.7

Source: Grubben (1977), IBPGR

2. TAXONOMY

International communication on the collection and evaluation of *Capsicum* has been hampered by the lack of a stable taxonomy and a generally agreed nomenclature for the domesticated species. The same scientific name has often been used by different workers to refer to very different taxa. The IBPGR/CATIE meeting agreed that five different species of domesticated chili peppers should be recognized: *C. baccatum* and *C. pubescens* are easily identified, but *C. annuum*, *C. chinense* and *C. frutescens* are rather similar and can be distinguished only by a combination of flower and fruit characters. Diagnostic descriptions of the five domesticated species and keys for field identification were compiled at the meeting and are contained in Appendix II. It was recommended that these descriptions and taxonomic keys be distributed to *Capsicum* workers throughout the world, to promote uniform usage of the specific names.

The five domesticated *Capsicum* species all have close wild relatives with which they cross readily, producing viable and fertile hybrids. These wild relatives have not yet been fully evaluated, but they apparently contain useful sources of resistance to viral, bacterial and fungal diseases. The wild relatives should therefore be collected and conserved.

There are, in addition, about 20 other wild species of *Capsicum* which are less closely related to the domesticated peppers but of which at least some will cross with the domesticated species. Other wild taxa are known from herbarium specimens and from material collected recently in South America; more undescribed species probably exist. Many of the known wild species have very restricted distributions and some may contain genes for adaptation to unusual environmental conditions as well as disease resistance. For complete evaluation of the genepool of *Capsicum*, it is necessary that all of the wild species be available in collections so that their potential for plant breeding can be established.

A current list of all *Capsicum* species, mainly based on the work of Hunziker, is provided in Table 3 (after Pickersgill, 1983). At the request of the IBPGR Secretariat Drs. W.H. Eshbaugh, A.T. Hunziker and B. Pickersgill are developing a taxonomic key for all known species of *Capsicum*, which will be published at a later date.

Table 3. Species currently included in the genus *Capsicum* and their distribution

Wild species never utilized by man	Distribution
C. buforum A.T. Hunz.	Brazil (southern)
C. campylopodium Sendt.	Brazil (southern)
C. ciliatum (H.B.K.) O.K.	Colombia, Ecuador, Guatemala, Honduras, Mexico, Peru (northern), Venezuela
C. cornutum (Hiern) A.T. Hunz.	Brazil (southern)
C. dimorphum (Miers) O.K.	Colombia
C. dusenii Bitter	Brazil (southeast)
C. flexuosum Sendt.	Argentina, Brazil (southern), Paraguay
C. geminifolium (Dammer) A.T. Hunz.	Colombia, Ecuador
C. hookerianum (Miers) O.K.	Ecuador
C. lanceolatum (Greenm.) Morton & Standley	Guatemala, Honduras, Mexico

Table 3 (Continued)

Wild species never utilized by man		Distribution
C. mirabile Mart. ex Sendt.		Brazil (southern)
C. parvifolium Sendt.		Brazil (northeast), Colombia, Venezuela
C. schottianum Sendt.		Argentina (Misiones), Brazil (southern), Paraguay (southeast)
C. scolnikianum A.T. Hunz.		Peru
C. villosum Sendt.		Brazil (southern)
Species utilized by man		
(a) Purple-flowered species		
C. cardenasii Heiser & Smith		Bolivia
C. eximium A.T. Hunz.		Argentina (Salta, Tucumán), Bolivia
C. pubescens R. & P.	wild:	Not known in wild
	domesticated:	From Bolivia to Colombia, Costa Rica, Guatemala, Honduras, Mexico
C. 'tovari' nom. nud.		Peru
(b) White-flowered species		
C. annuum L.	wild:	From Colombia to southern USA
	domesticated:	Throughout Latin America
C. baccatum L.	wild:	Argentina, Bolivia, Brazil, Paraguay, Peru
	domesticated:	Argentina, Bolivia, Brazil, Colombia (southern), Ecuador, Paraguay, Peru
C. chacoense A.T. Hunz.		Argentina, Bolivia, Paraguay
C. chinense Jacq.	wild:	Brazil (Amazonia), Ecuador, Peru
	domesticated:	From Bolivia (southern) to Brazil (southern), Belize, Costa Rica, Mexico, Nicaragua, West Indies
C. coccineum (Rusby) A.T. Hunz.		Bolivia, Peru
C. frutescens L.	wild:	Throughout Latin America
	domesticated;	Colombia, Costa Rica, Guatemala, Mexico, Puerto Rico, Venezuela
C. galapagoense A.T. Hunz.		Galápagos Islands
C. praetermissum Heiser & Smith		Brazil (southern)

Source: Pickersgill (1983)

3. DISTRIBUTION, ORIGIN AND DIVERSITY

Capsicum is a New World genus. All five of the domesticated species and their wild relatives were confined to the Americas in pre-Columbian times (See Fig. 2). Early Spanish and Portuguese explorers, in their search for pepper, found the *Capsicum* peppers more pungent than those from the Caucasus (i.e. black pepper - *Piper nigrum*) and quickly introduced the species into Europe and Asia. Unlike related crops such as tomato and potato they found almost immediate acceptance, evidenced by the fact that there were already three races of *Capsicum* being cultivated in India by 1542 (Heiser, 1976; Purseglove, 1968).

Capsicum annuum is probably the most variable and extensively cultivated species in the genus. Its domestication first occurred in Central America: most likely in Mexico where archeological remains from about 7000 B.C. indicate that peppers were used by man even before the advent of agriculture (Pickersgill, 1969b). The *Capsicum* cultivars introduced into the Old World by the second voyage of Columbus in 1494 were probably *C. annuum*.

The centre of diversity for the cultivated forms of this species, *C. annuum* var. *annuum* includes Mexico and Central America; secondary centres exist in Southern and Central Europe, Africa, Asia and parts of Latin America. The area of distribution for the spontaneous forms of the species, *C. annuum* var. *glabriusculum*, extends from the southern USA through Mexico and Central America into northwest South America.

The centre of origin for *C. baccatum* is probably in Bolivia (Heiser, 1976). Archeological remains from Peru date the cultivation of *C. baccatum* var. *pendulum* by man as early as 2500 B.C. (Pickersgill 1969a). The wild and spontaneous forms (*C. baccatum* var. *baccatum*) have a narrow distribution from central Peru, through Bolivia, to northern Argentina and southern Brazil; its major centres of concentration are Bolivia and southern Brazil. The cultivated form of the species (*C. baccatum* var. *pendulum*) is grown throughout northwestern South America, including Colombia, Ecuador, Peru and Bolivia, and in southwestern Brazil (Eshbaugh, 1970). It has been introduced into Costa Rica, Hawaii, India and the southern USA.

The centre of origin of *Capsicum frutescens* is also in South America; its archeological remains in Peru date from 1200 B.C. (Pickersgill, 1969a). Apparently the only domesticated form of this species is the Tabasco pepper which is cultivated in the southern USA. In South America its wild and weedy forms are harvested for the market and home use. *C. frutescens* is distributed throughout lowland South America from southern Brazil to Central America and in the West Indies. It is also grown in Africa and in Southeast Asia (van Epenhuijsen, 1974; Heiser, 1976; Zeven and Zhukovsky, 1975).

Capsicum chinense is probably the most important pepper cultivated east of the Andes in South America. It is closely related to *C. frutescens* and its distribution in South America is similar to that species. Its area of greatest diversity is in the Amazon basin (Pickersgill, 1969b; Zeven and Zhukovsky, 1975). Some types of *C. chinense* grown in Africa are reportedly the most pungent of all peppers (Heiser, 1976).

Capsicum pubescens is notably a highland species that is relatively cold tolerant, but it also occurs at lower altitudes with *C. annuum*, *C. baccatum* and *C. chinense* (Eshbaugh, 1979; Pickersgill, 1971). It probably originated in Bolivia (Eshbaugh, 1980b) and is grown today in the Andes from Bolivia to Colombia. It is also cultivated in highland Mexico and Central America, but its introduction there may be post-Columbian (Heiser, 1969).

C. pubescens is only known in cultivation, but it is apparently closely related to *C. cardenasii* and *C. eximium*. These two species are gathered in the wild in Bolivia and are either used directly or sold in the market. Their area of maximum concentration and diversity is in Bolivia (Eshbaugh, 1980b and 1982), though their ecological affinities are different from those of *C. pubescens*. *C. cardenasii* normally occurs in warm dry areas.

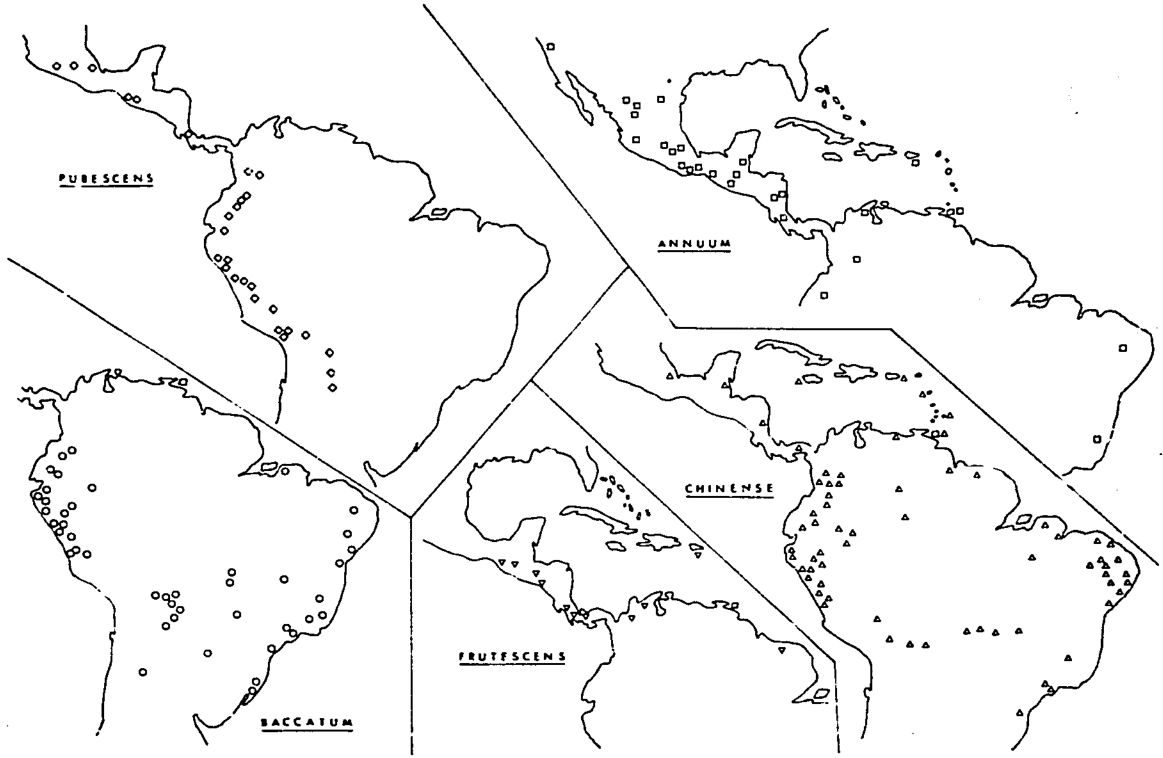

Figure 2. Distribution of the five domesticated *Capsicum* species in pre-Columbian times (prepared by Pickersgill, 1983)

4. GENETIC IMPROVEMENT

Much breeding work has been carried out on sweet peppers, mostly in the USA, but also in Brazil, Bulgaria, Czechoslovakia, France, Hungary, India, Italy, Japan, the Netherlands and the USSR. Important criteria for selection are high yield, resistance to virus disease (tobacco and cucumber mosaic), good fruit shape with a sweet, non-pungent taste, few seeds, and early production with a first harvest approximately 60 days after transplanting. Cultivars such as Allbig give good fruit setting in hot weather. Some cultivars of Hungarian paprika, with an elongated conical shape, have been selected for a high paprika-aroma content, thin skins facilitating drying, and for the production of a bright red powder on dehydration. More advanced techniques, such as the application of haploidy, tetraploidy, cytoplasmic male sterility and heterosis breeding are already being used by plant breeders. For mechanized cultivation, types with a compact habit, determinate growth and simultaneous ripening are required (Grubben, 1977).

The breeding of hot peppers is at a much less advanced state. In the USA cultivars such as Anaheim and Chili Cayenne (both *C. annuum*) and types of Tabasco (*C. frutescens*) are widespread. The cultivars of *C. annuum* have been selected for early yield, such as 120 days after transplanting to fruit harvest compared with 150 days for normal cultivars, a high capsaicin content, smooth shape for canning and thin-walled fruits for drying. Several horticultural stations in tropical countries such as Ethiopia, Ghana, India, Ivory Coast, Korea, Mexico, Nigeria and the Philippines have programmes directed towards the improvement of the local hot pepper cultivars, mostly by simple cultivar testing but also by hybridization. The improvement of disease resistance in the locally preferred types and of types suitable for export as dried hot peppers would appear to be the most important objectives (Grubben, 1977).

Donors for resistance to bacterial wilt (*Pseudomonas*), bacterial spot (*Xanthomonas vesicatoria*), virus diseases (tobacco etch, tobacco mosaic, tomato etch, cucumber mosaic) and *Cercospora* have been identified (Grubben, 1977; Sowell, 1981). The hot pepper cultivar College No. 9 Chili has been found to possess resistance to *Fusarium*. Local West African (thick-walled) hot peppers are not frequently attacked by fruit flies. There also exists an obvious resistance to *Sclerotium* (cv. World Beater) and *Phytophthora capsici*. Variation in susceptibility to nematodes and *Aphis* has also been noted in several cultivars (Grubben, 1977).

Until recently plant breeders concentrated on pepper improvement by hybridization and/or selection solely with *C. annuum*. Since the 1960s other species of *Capsicum* have become increasingly available. These have not yet been completely evaluated, but they seem likely to contain many useful characters, particularly disease resistance. *Phythophthora* resistance has been found in *C. baccatum* and *C. frutescens*, resistance to *Verticillium* wilt in *C. chinense* and *C. frutescens*, resistance to bacterial leaf spot in *C. chacoense*, resistance to cucumber mosaic virus and potato virus Y in *C. baccatum*. In addition, drought resistance has been reported in *C. cardenasii* (Pickersgill, 1980).

Interspecific hybridization in *Capsicum* has been studied, particularly at the University of Reading, UK (Pickersgill, 1967, 1971 and 1980). Pickersgill presented a paper on this extensive work at the 1980 meeting of the EUCARPIA *Capsicum* Working Group. The presentation covered an investigation of eleven species and concluded that: "None of the species of *Capsicum* included in our crossing programme has proved to be completely isolated from all the other species. It has even proved possible to cross white- and purple-flowered species,which have been considered distinct major groups on phytochemical criteria. It thus seems likely that genes from any one species could ultimately be transferred to any other, by the use of appropriate bridging species where necessary. This should give impetus to the screening and evaluation of species other than *C. annuum* for useful characters. It also reinforces the importance of collecting and conserving material of all species of *Capsicum* in genebanks for possible use by *Capsicum* breeders in the future."

A crossability polygon is provided in Figure 3. Because of genetic variation within species for interspecific compatibility and the application of advanced techniques for hybridization, it is likely that even more interspecific compatibility will be demonstrated as work in this area continues.

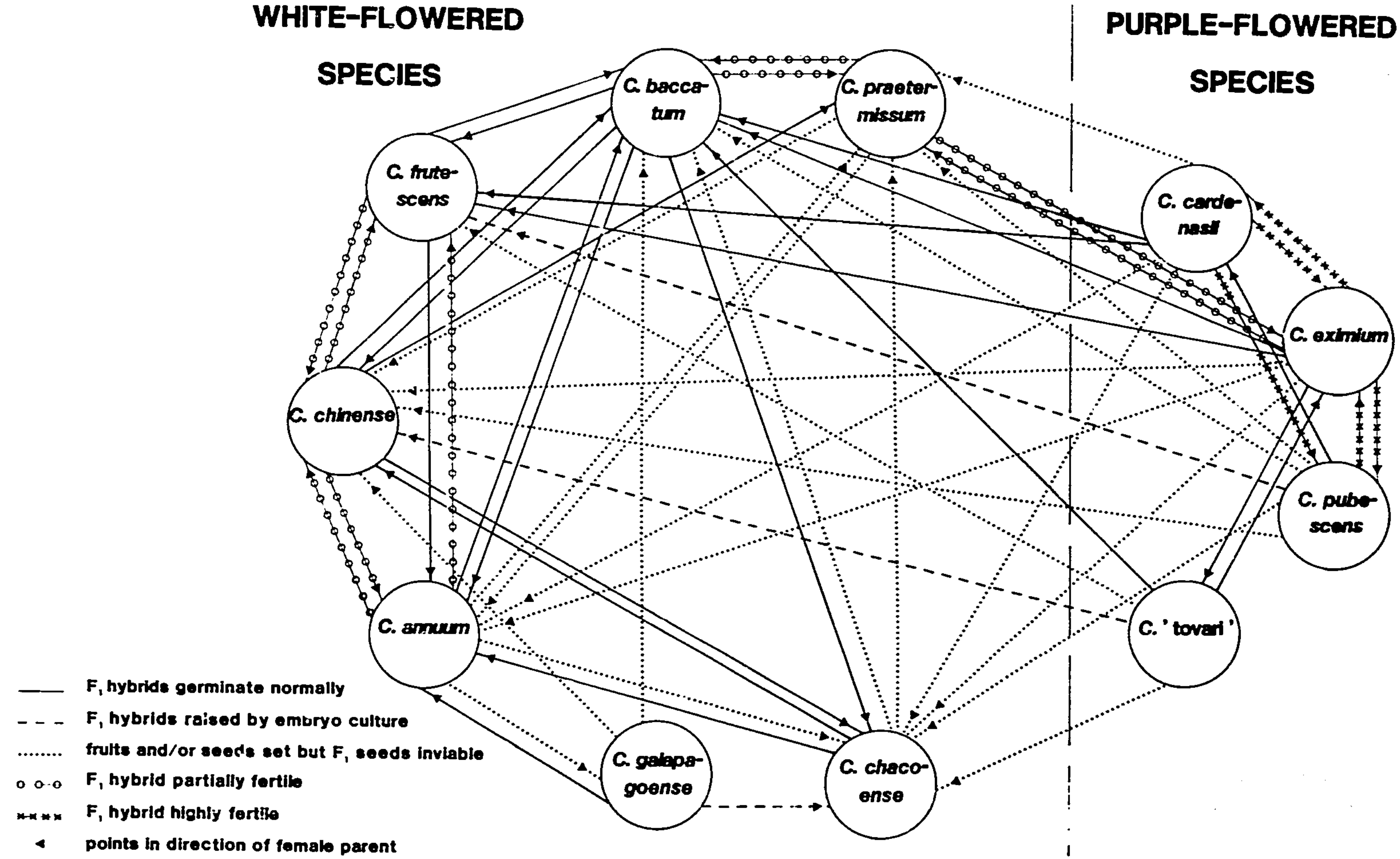

Figure 3. Crossability polygon for *Capsicum* species (after Pickersgill, 1980; modified with information from Lippert *et al.*, 1966 and Pickersgill, 1982, personal communication)

5. MAJOR COLLECTIONS

The importance of collecting and preserving *Capsicum* germplasm is already well recognized as evidenced by the number of large collections existing (see also Fig. 4). A summary of data relating to twenty-five major collections is presented in Appendix III. Further detailed information, including storage conditions, availability for exchange, the extent of phenotypic and agronomic evaluation of the collections and the methods of documentation is provided in the IBPGR Directory of Germplasm Collections. 4. Vegetables (Toll and van Sloten, 1982).

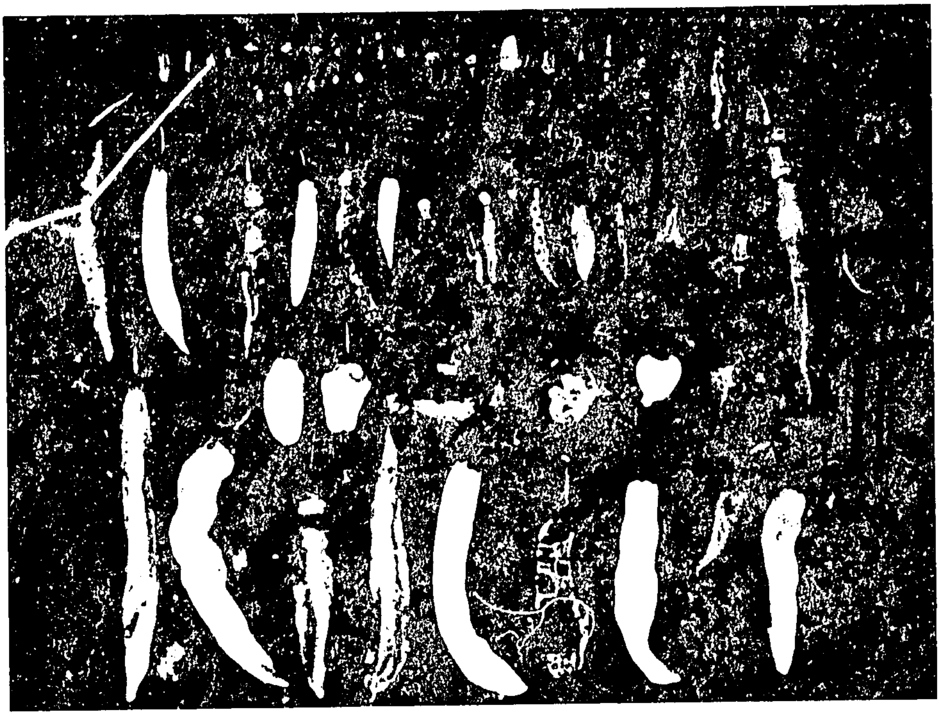

Figure 4. Variation in fruit characters in a *Capsicum baccatum* collection (photo by Barbara Pickersgill)

6. COLLECTING ACTIVITIES

The IBPGR/CATIE meeting discussed the taxonomic and geographic coverage of the existing collections of *Capsicum* (Appendix III) and agreed that these collections do not adequately cover the variability present in the domesticated species of *Capsicum*. The wild species are even more poorly represented, and several are not contained in any of the existing collections.

6.1 Priorities for collecting

The IBPGR/CATIE meeting discussed which areas need to be explored and collected, paying particular attention to Latin America, since this is where the crop is native and where wild species still occur. Collecting needs were reviewed on a country-by-country basis, though certain geographic areas (e.g. Amazonia) cut across political boundaries and should, if possible, be explored on a multinational basis. Full details of the recommendations, as endorsed by the IBPGR, are presented in Table 4. The IBPGR through its joint programme with FAO will follow-up at the country level to ascertain the agreement of and the inputs possible from national programmes in the regions mentioned in Table 4.

Table 4. Collecting priorities

PRIORITY 1 Latin America

Mexico: The states surrounding the Gulf of Mexico are of special interest for *C. annuum*. The state of Chiapas is important because it contains unique *C. frutescens* types as well as undetermined *Capsicum* species. The Unidad de Recursos Genéticos, Instituto Nacional de Investigaciones Agrícolas (INIA) is prepared to carry out several collection trips to these and other areas. 1/

Central America and Panama: The Guatemalan highlands (especially the Jalapa region), and some parts of Costa Rica are of importance, mainly for *C. annuum* and *C. frutescens*. The Unidad de Recursos Genéticos at CATIE, Costa Rica might logically operate this programme. 2/

Ecuador: More collections are needed from the coast, particularly in the north around Esmeraldas and in the south around Machala. The entire Oriente needs to be explored, in conjunction with other explorations in Amazonia. 3/

Peru: Most of the material currently available comes from the coastal valleys of the western slopes of the Andes. The eastern slopes, particularly in the departments of Ayacucho, Huancavelica, Junin, Pasco, Huanuco and San Martín, contain several poorly understood wild species and should also be explored for local cultivated types. The inter-Andean valleys, especially those of the Apurimac and Marañón, require thorough exploration. Peruvian Amazonia should be explored in conjunction with activities in Brazil, Colombia and Ecuador. The meeting recommended that the Universidad Nacional Agraria La Molina be involved in any collecting activities in Peru. 4/

1/ Based on the preliminary report of the IBPGR/CATIE meeting, the IBPGR funded collecting missions of *Capsicum* carried out by INIA, Mexico in the areas mentioned during 1980-1982. A summary is appended to this report (Appendix IV).

2/ The IBPGR is supporting a four-year multicrop collecting project (1982-1985), including *Capsicum*, carried out by the Universidad de San Carlos in cooperation with the Instituto de Ciencia y Tecnología Agrícola (ICTA) in Guatemala.

3/ The IBPGR is supporting a multicrop collecting project, including *Capsicum*, covering 10 provinces in Ecuador and the department of Nariño in southern Colombia during 1982/1983. The project is being carried out by the Instituto Nacional de Investigaciones Agropecuarias (INIAP) in cooperation with the Faculdad de Ciencias Agricolas of the Universidad Central.

4/ The IBPGR agreed to fund collecting missions for *Lycopersicon* and *Capsicum* in Peru, 1982-1983, organized by the Universidad Nacional Agraria La Molina.

PRIORITY 1 Latin America (Continued)

Bolivia: The Beni and Pando regions have never been adequately collected. *Capsicum baccatum, C. cardenasii* (see Fig. 5), *C. chacoense, C. eximium* and *C. pubescens* should be collected throughout their range in Bolivia. 1/

Brazil: Amazonia appears to be a major centre of diversity for *C. chinense* and should be thoroughly explored, ideally in conjunction with collecting missions in the Amazonian regions of Bolivia, Colombia, Ecuador, the Guyanas, Peru and Venezuela. *Capsicum baccatum* should be collected from southern Brazil and neighbouring Paraguay. A very important area which urgently needs to be explored for several wild *Capsicum* species is southern Brazil. The Centro Nacional de Recursos Genéticos (CENARGEN) should be requested to undertake the necessary exploration trips.

Argentina: Exploration is needed in the northern part of the country (provinces of Jujuy, Salta, Tucuman, Catamarca, La Rioja, Santiago del Estero, Formosa, Chaco, Corrientes, Misiones).

The meeting lacked information on previous collecting activities in Colombia,[2/] the Guyanas, Paraguay and Venezuela, but it seems likely that comprehensive collections should be made in these countries also, and that the Santa Marta region of Colombia in particular deserves attention.

PRIORITY 2 Central and South Asia and the Mediterranean[3/]

Central and South Asia: Some collecting has been carried out with IBPGR support e.g. in Pakistan and Bhutan. The National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India has also collected *Capsicum* germplasm during explorations in different areas of the country. Further collecting is required in the humid tropical tracts of the western and eastern ghats, from the northeastern region and the sub-Himalayan zone.

Mediterranean: Special emphasis should be given to collecting in Turkey

PRIORITY 3 Southeast Asia, China and Africa[3/]

Southeast Asia: High priority has been assigned to *Capsicum* collecting in this region by the IBPGR Regional Committee for Southeast Asia, especially in Indonesia and Thailand. 4/

Information on *Capsicum* collections in China and Africa is scarce or non-existent. It seems however likely that interesting types of *Capsicum* (mainly *C. annuum*) are being grown and these should be collected.

1/ The Centre for Phytoecogenetic Research of Pairumani is being supported by the IBPGR to carry out multicrop collecting missions during a three-year period starting in 1982. These missions will cover most of Bolivia and *Capsicum* will also be collected.

2/ The IBPGR is supporting a multicrop collecting project, including *Capsicum*, in the departments of Cauca, Valle, Quiclio, Risaralda, Caldas, Tolima and Antioquia, carried out by the Instituto Colombiano Agropecuario (ICA) during 1981/1982.

3/ Countries and regions mentioned under priorities 2 and 3 should be explored mainly for *Capsicum annuum*.

4/ The IBPGR is supporting a two-year project (1983/1984) to collect and evaluate *Capsicum* germplasm in Thailand, carried out by the Ramkhamhaeng University.

6.2 Sampling

Information to be recorded in the field is included in the section of passport descriptors in the descriptor list (see Appendix V). Four different field situations, requiring different sampling techniques are recognized:

i) commercial fields;
ii) markets;
iii) cultivated and weedy plants growing around dwellings; and
iv) wild species in undisturbed natural habitats.

In commercial fields, 50-100 plants should be sampled using random sampling techniques. Populations of wild species and backyard plants are often very small, so size and frequency of samples will be determined by availability of material.

The extent of cross-pollination in *Capsicum* in different parts of Latin America is still unknown. This information is important for understanding variability within and between populations and hence formulating an appropriate sampling strategy. For the present, to assist in obtaining data on cross-pollination, it is recommended that seeds from individual plants be packed separately and records taken of any segregation observed when the accession is grown out.

Seeds should be collected from fully-ripe fruits only. Dry fruits from markets generally contain viable seeds. Fresh fruits should be dried in the air or sun (not in an oven), or should have their seeds removed (gloves or other protective measures are recommended). Seeds remain viable for some years, so no special arrangements for shipment from the field to the base collections are necessary.

Figure 5. Collecting *Capsicum cardenasii* in La Paz, Bolivia, 1971 (photo by W.H. Eshbaugh)

7. CONSERVATION

The increasing commercial importance of *Capsicum*, both as a spice and a vegetable crop, and its cultivation on a larger scale in both tropical and temperate regions, has resulted in breeding programmes being established in many different countries, though sometimes on a rather narrow genetic base. Breeders need access to a geographically and taxonomically wide range of accessions, with adequate documentation on their origin and botanical and agronomic characteristics. These needs can be met by up-grading existing national collections in short- and medium-term storage facilities. In addition, to conserve genetic resources that are expensive to collect and/or in danger of disappearing, base collections in long-term storage are required. As an additional safeguard, these base collections should be held at more than one centre.

7.1 Seed storage and viability testing

Under normal laboratory conditions, *Capsicum* seeds remain viable for about 5-8 years, though there is considerable variation between and even within species. Optimum seed moisture content for storage is about 4-6%. Long-term storage at temperatures of -10°C to -20°C should retain adequate levels of viability for 40-150 years. Seeds to be deposited in long-term storage should not be treated with any chemicals (pesticides, fungicides, etc.).

Until more is known about the storage behaviour of *Capsicum* seeds, viability tests on stored samples should be carried out at regular intervals and stocks rejuvenated whenever viability declines significantly (see Ellis *et al.*, 1980). Seed dormancy, which is known in certain wild *Capsicum* species, may be overcome by germinating the seed on a substrate moistened with 0.2 M KNO_3, under white light (750 to 1250 lux) and in alternating temperatures (20/30°C or 15/30°C).

7.2 Rejuvenation and multiplication

Existing collections are rejuventated in different ways. In Europe, accessions are usually rejuvenated in insect-free glasshouses, but from very limited numbers of stock plants (often only 1-3) so that considerable variability may be lost at each rejuvenation cycle. In the Americas rejuvination takes place in field plots, usually with break rows of tomato or some other species, but levels of insect-mediated cross pollination may still be unacceptably high, though there is less risk of irrevocably losing diversity. INIA (Mexico) uses a combination of hand-selfing (followed by bagging) and open pollination to maintain stocks in its collections, but this is practicable only when ample reliable field labour is available. Photoperiodic requirements in some accessions may necessitate rejuvenation under controlled environment conditions or at different localities.

7.3 National collections

Much valuable material is held in national collections as indicated in section 5 and Appendix III. If breeders have not made full use of the existing national collections this is mainly due to lack of information since seed is available for exchange. Existing national collections should be encouraged to expand their holdings, particularly from their local regions, and to distribute information about the accessions they hold. The EUCARPIA triennial conferences on *Capsicum* which are now attended also by breeders from outside Europe, might be one forum.

7.4 Global collections

In addition to the working collections maintained at the various national centres, there is a need for a long-term base collection, containing material from the complete geographic range (native and introduced) of *Capsicum*. Duplicate base collections should be held at one or more additional centres.

On the basis of the recommendations of the *Capsicum* Working Group, the IBPGR has designated the following centres to maintain base collections of *Capsicum* genetic resources:

i) Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica

CATIE has agreed to hold a global base collection of *Capsicum* germplasm as part of the IBPGR global network;

ii) Institute for Horticultural Plant Breeding (IVT), Wageningen, Netherlands

The IVT has agreed to hold a global collection as part of the IBPGR global network; and

iii) The National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India

The NBPGR will be invited by the IBPGR to hold a base collection of Asian material as soon as long-term storage facilities are functional.

8. DOCUMENTATION

8.1 Descriptor list

A provisional list of descriptors was prepared by Ir. J. Engels, Unidad de Recursos Genéticos, CATIE (presently working in Ethiopia, see Appendix I). This list was discussed during the expert consultation at CATIE and during the meeting of the EUCARPIA *Capsicum* Working Group. The final agreed descriptor list in standard IBPGR format, provided in Appendix V, should be used in describing accessions in global and/or national collections.

8.2 Bibliography

The IBPGR/CATIE meeting agreed that the draft bibliography on genetic resources of *Capsicum* (Huertas, 1980) was a valuable tool. Members of the group have reviewed it for errors and omissions. The problem of keeping the bibliography up-to-date was discussed and it was suggested that centres holding base collections of *Capsicum* might also be responsible for maintaining the bibliography, using available services such as CAIN, BIOSIS or CAB.

9. REFERENCES

Listed below are references mentioned in the text and some of the papers presented during the IBPGR/CATIE meeting in Costa Rica.

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pepper, *Capsicum* sp. Bot. Rev., 32: 24-55.

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Interspecific isolating mechanisms in some South American chilli peppers. Amer. J. Bot., 54: 654.

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Some aspects of interspecific hybridization in *Capsicum*. Paper presented during the IVth Meeting of the EUCARPIA *Capsicum* Working Group, 14-16 October 1980, Wageningen, Netherlands.

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APPENDIX I

LIST OF PARTICIPANTS AT IBPGR/CATIE MEETING ON *CAPSICUM* GENETIC RESOURCES

Chairman:

Dr. J. León
c/o Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)
Apartado 74
Turrialba
Costa Rica

Members:

Ing. Francisco Delgado de la Flor B.
Programa de Investigación en Hortalizas
Universidad Nacional Agraria (UNA)
A.P. 456
La Molina, Lima
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Ir.Jan Engels
Plant Genetic Resources Center
P.O. Box 30726
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Dr. W. Hardy Eshbaugh
Department of Botany
Miami University
Oxford, Ohio 45056
United States of America

Dr. Heiner Goldbach
Plant Physiology
Technical University of Munich
8050 Freising-Weihenstephan
Federal Republic of Germany

Prof. Charles B. Heiser, Jr.
Department of Biology
Indiana University
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United States of America

Dr. Miguel Holle
IBPGR Regional Officer for Latin America
c/o Centro Internacional de Agricultura Tropical (CIAT)
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Dr. Armando T. Hunziker
Instituto Botánico
Universidad de Córdoba
C.C. 509
5000 Córdoba
Argentina

Dr. José A. Laborde Cancino
Unidad de Recursos Genéticos
Centro de Investigaciones Agrícolas de El Bajío (CIAB)
Instituto Nacional de Investigaciones Agrícolas (INIA)
A.P. 112
Celaya, Guanajuato
Mexico

Dr. W.R. Langford (retired)
United States Department of Agriculture
Rt. 1, Canta Line Rd.
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United States of America

Dr. Barbara Pickersgill
Department of Agricultural Botany
University of Reading
Whiteknights
Reading RG6 2AS
United Kingdom

APPENDIX II

DIAGNOSTIC DESCRIPTIONS OF THE FIVE DOMESTICATED SPECIES AND KEYS FOR FIELD IDENTIFICATION

A. DIAGNOSTIC DESCRIPTIONS OF THE FIVE DOMESTICATED SPECIES*

Domesticated *C. annuum* (C. *annuum* var. *annuum*)

Flowers solitary at each node (occasionally fasciculate). Pedicels usually declining at anthesis. Corolla milky white (occasionally purple), without diffuse spots at base of lobes; corolla lobes usually straight. Calyx of mature fruit without annular constriction at junction with pedicel (though sometimes irregularly wrinkled); veins often prolonged into short teeth. Fruit flesh usually firm (soft in certain cultivars). Seeds straw-coloured. Chromosome number 2n = 24, with two pairs of acrocentric chromosomes e.g. Hungarian Wax, commercial bell peppers.

Domesticated *C. frutescens*

Flowers solitary at each node (occasionaly fasciculate). Pedicels erect at anthesis but flowers nodding. Corolla greenish-white, without diffuse spots at base of lobes, corolla lobes often slighly revolute. Calyx of mature fruit without annular constriction at junction with pedicel, though often irregularly wringled; veins usually not prolonged into teeth. Fruit flesh often soft. Seeds straw-coloured. Chromosome number 2n = 24, with one pair of acrocentric chromosomes e.g. Tabasco pepper.

Domesticated *C. chinense*

Flowers 2 or more at each node (occasionally solitary). Pedicels erect or declining at anthesis. Corolla greenish-white (occasionally milky white or purple), without diffuse spots at base of lobes; corolla lobes usually straight. Calyx of mature fruit usually with annular constriction at junction with pedicel, veins not prolonged into teeth. Fruit flesh firm. Seeds straw-coloured. Chromosome number 2n = 24, with one pair of acrocentric chromosomes e.g. Habanero (Mexico); pimento de cheiro (Brazil).

Domesticated *C. baccatum* (*C. baccatum* var. *pendulum*)

Flowers solitary at each node. Pedicels erect or declining at anthesis. Corolla white or greenish-white, with diffuse yellow spots at base of corolla lobes on either side of mid-vein; corolla lobes usually slightly revolute. Calyx of mature fruit without annular constriction at junction with pedicel (though sometimes irregularly wrinkled), veins prolonged into prominent teeth. Fruit flesh firm. Seeds straw-coloured. Chromosome number 2n = 24, with one pair of acrocentric chromosomes e.g. Escabeche (Peru).

Domesticated *C. pubescens*

Flowers solitary at each node. Pedicels erect at anthesis but flowers nodding. Corolla purple (occasionally with white margins to lobes and/or white tube), without diffuse spots at base of lobes (though a drop of yellow nectar may accumulate in this position and simulate a corolla spot); corolla lobes usually straight. Calyx of mature fruit without annular constriction at junction with pedicel, veins prolonged into teeth. Fruit flesh firm. Seeds dark in colour. Chromosome number 2n = 24, with one pair of acrocentric chromosome e.g. Rocoto (Andes).

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* Wild relatives of the domesticated peppers may not conform precisely to these descriptions.

APPENDIX II
(Continued)

B. KEY TO DOMESTICATED SPECIES OF *CAPSICUM*

1. Seeds dark, corolla purple .... *C. pubescens*

1. Seeds straw-coloured, corolla white or greenish white 2
   (rarely purple)

   2. Corolla with diffuse yellow spots at bases of lobes ...... *C. baccatum*

   2. Corolla without diffuse yellow spots at bases of lobes ... 3

      3. Corolla purple 4

         4. Flowers solitary .... *C. annuum*

         4. Flowers 2-more at each node .... *C. chinense*

      3. Corolla white or greenish-white 5

         5. Calyx of mature fruit with annular constriction at junction with pedicel .... *C. chinense*

         5. Calyx of mature fruit without annular constriction at junction with pedicel 6

            6. Flowers solitary 7

               7. Corolla milky white,lobes usually straight, pedicels often declining at anthesis ..... *C. annuum*

               7. Corolla greenish white, lobes usually slightly revolute, pedicels erect at anthesis .... *C. frutescens*

            6. Flowers 2-more at each node 8

               8. Corolla milky white .... *C. annuum*

               8. Corolla greenish white 9

                  9. Pedicels erect at anthesis, corolla lobes usually slightly revolute ...... *C. frutescens*

                  9. Pedicels declining at anthesis, corolla lobes straight .... *C. chinense*

C. DIAGNOSES OF FORMS OF DOMESTICATED SPECIES OF *CAPSICUM*

	Form	Seeds		Corolla colours			Corolla spots		Calyx Constriction		Pedicels per node	
		Dark	Pale	Purple	White	Greenish	Present	Absent	Present	Absent	1	2-more
C. pubescens		*		*				*		*	*	
C. baccatum			*			*	*			*	*	
C. chinense	1		*	*				*	*			*
	2		*		*			*	*			*
	3		*			*		*	*			*
	4		*			*		*	*		*	
	5		*			*		*		*		* 1/
C. frutescens	1		*			*		*		*	*	
	2		*			*		*		*		* 1/
C. annuum	1		*		*			*		*	*	
	2		*		*			*		*		*
	3		*	*				*		*	*	

1/ These two forms of *C. chinense* and *C. frutescens* are not distinguished by this key; accessions of this form should be distinguished with the dichotomous key on page 20.

APPENDIX III

MAJOR COLLECTIONS OF *CAPSICUM*[1]

Institute	Number of Accessions: Domesticated species[2] — *C. annuum*	*C. baccatum*	*C. chinense*	*C. frutescens*	*C. pubescens*	Wild species	*Capsicum* spp. (not specified)	Observations
Departamento de Fitotecnica Universidade Federal de Viçosa 36.570 - Viçosa - M.G. BRAZIL Curator: V.W. Dias Casali	250		←— 250 —→			(*C. praetermissum*)		Active collection from Brazil (*C. annuum* also from Hungary and Mexico)
Institute of Plant Introduction and Genetic Resources 4122 Sadovo BULGARIA Curator: E. Vesselinov	125							Base and active collection Includes 73 Bulgarian landraces
Unidad de Recursos Genéticos Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) Apartado 74 Turrialba COSTA RICA Curator: H. Heinze	11	6	3	1	8	1 *C. galapagoense*	407	Base and active collection from Central America. Majority of non specified *Capsicum* spp. belong to *C. annuum*
Department of Genetic Resources Division of Genetics and Plant Breeding Methods Research Institute of Plant Production Ruzyně 507 161 06 Prague 6 CZECHOSLOVAKIA Curator: I. Bares	149							Worldwide active collection

1/ Only major collections (containing over 100 accessions of *Capsicum*) are detailed in this Appendix. Smaller collections are listed at end of Appendix.

2/ A large number of institutes have made no distinction between the domesticated species and their close wild relatives, the latter therefore are included under the domesticated species. For instance in *Capsicum baccatum* var. *pendulum*, the domesticated *C. baccatum* and its immediate wild relative *C. baccatum* var. *baccatum* are all listed under *Capsicum baccatum*.

APPENDIX III
(Continued)

Institute	Number of accessions: Domesticated species[2/] *C. annuum*	*C. baccatum*	*C. chinense*	*C. frutescens*	*C. pubescens*	Wild species	*Capsicum* spp. (not specified)	Observations
Station d'Amélioration des Plantes Maraîchères Institut National de la Recherche Agronomique (INRA) Domaine Saint-Maurice 84140 Montfavet-Avignon FRANCE Curator: E. Pochard	516	17	13	10	4	1 *C. chacoense* 1 *C. praetermissum*		Worldwide base and active collection, also includes 11 trisomics,3 haploid-producing lines, various tetraploid lines, 3 male-sterile lines,Peterson's cytoplasmic male sterility and various mutants
Zentralinstitut für Genetik und Kulturpflanzenforschung Corrensstrasse 3 4325 Gatersleben GERMAN DEMOCRATIC REPUBLIC Curator: Chr. Lehmann	709	16	9	47	13	4 *C. chacoense* 4 *C. eximium* 4 *C. praetermissum*		Worldwide base collection
Greek Gene Bank Cereals Institute North Greece Agricultural Research Centre Thessaloniki GREECE Curator: A. Zamanis	181							Base and active collection, 16 landraces from Greece, 124 selections of landraces from Greece and 41 commercial cultivars
Research Station Butatétény Vegetable Crops Research Institute Pf. 108, Park u.2 1775 Budapest HUNGARY Curator: G. Csilléry	60	20	15	8	4	2 *C. cardenasii* 4 *C. chacoense* 2 *C. eximium* 3 *C. praetermissum*		Active collection *C. annuum* mostly Hungarian landraces and cultivars
Research Centre for Agrobotany National Institute for Agricultural Variety Testing (NIAVT) 2766 Tápiószele HUNGARY Curator: A.L. Kiss	550							Worldwide base and active collection,includes 157 landraces, old and commercial cultivars from Hungary

Institute	Number of Accessions: Domesticated species[2/] *C. annuum*	*C. baccatum*	*C. chinense*	*C. frutescens*	*C. pubescens*	Wild species	*Capsicum* spp. (not specified)	Observations
National Bureau of Plant Genetic Resources (NBPGR) Indian Agricultural Research Institute (IARI) Campus New Delhi 110012 INDIA Curator: K.L. Mehra							130	Active collection. Includes ca. 80 landraces from India
Regional Agricultural Research Station Andra Pradesh Agricultural University Lam Guntur 522034 Andra Pradesh INDIA Curator: N. Sriramachandra Murthy	128	1	2	3				Worldwide active collection, includes Indian landraces
Plant Germplasm Institute Faculty of Agriculture Kyoto University Nakafo 1, Mozume, Mukoshi Kyoto 617 JAPAN Curator: M. Tanaka	59	136		370	77	1 *C. cardenasii* 7 *C. eximium*		Base and active collection. All landraces and wild types and species collected by the Kyoto University in Central and South America
Unidad de Recursos Genéticos Centro de Investigaciones Agrícolas de El Bajío (CIAB) Instituto Nacional de Investigaciones Agricolas (INIA) A.P. 112 Celaya, Guanajuato MEXICO Curator: J.A. Laborde Cancino	2577	139	240	91	56	1 *C. cardenasii* 19 *C. chacoense* 7 *C. eximium* 2 *C. galapagoense* 5 *C. praetermissum* 1 *C.* 'tovari'	46	This worldwide active collection includes duplicates of most of the accessions from P.G. Smith's collection, University of California, Davis, USA
Institute for Horticultural Plant Breeding (IVT) P.O. Box 16 6700 AA Wageningen NETHERLANDS Curator: H.J. Roelofsen	876	84	119	30	15	1 *C. cardenasii* 3 *C. chacoense* 3 *C. eximium* 1 *C. galapagoense* 3 *C. praetermissum* 1 *C.* 'tovari'	9	Worldwide base and active collection

APPENDIX III
(Continued)

Institute	Number of Accessions							Observations
	Domesticated species[2/]					Wild species		
	C. annuum	*C. baccatum*	*C. chinense*	*C. frutescens*	*C. pubescens*		*Capsicum* spp. (not specified)	
National Horticultural Research Institute (NIHORT) Idi-Ishin PMB 5432 Ibadan NIGERIA Curator: [illegible]. Badra/A.A.O. Edema	331			84				Base and active collection. Wild types, landraces and commercial cultivars from Nigeria
Programa de Investigación en Hortalizas Universidad Nacional Agraria A.P. 456 La Molina, Lima PERU Curator: F. Delgado de la Flor B.	19	160	58	9	56	1 *C. chacoense*	192	Active collection Wild types and landraces from Peru
Institute of Plant Breeding (IPB) University of the Philippines at Los Baños Laguna 3720 PHILIPPINES Curator: N.G. Mamicpic	66			102				Base and active collection, 24 *C. annuum* and 74 *C. frutescens* landraces from the Philippines
Centro Regional de Investigación y Desarollo Agrario (CRIDA 3) Instituto Nacional de Investigaciones Agrarias (INIA) A.P. 202 Carretera de Montañana 177 Zaragoza 16 SPAIN Curator: R. Gill	120	3	1	3			8	Worldwide active collection
N.I. Vavilov All-Union Institute of Plant Industry (VIR) Herzen Street 44 190 000 Leningrad UNION OF SOVIET SOCIALIST REPUBLICS Curator: V.F. Dorofeev							2125	Worldwide base and active collections, includes wild species, landraces and cultivars

APPENDIX III
(Continued)

Institute	Number of Accessions							Observations
	Domesticated species[2/]					Wild species	*Capsicum* spp. (not specified)	
	C. annuum	*C. baccatum*	*C. chinense*	*C. frutescens*	*C. pubescens*			
Department of Agricultural Botany University of Reading Whiteknights Reading RG6 2AS UNITED KINGDOM Curator: B. Pickersgill	90	110	200	40	15	1 *C. cardenasii* 5 *C. chacoense* 1 *C. ciliatum* 3 *C. eximium* 1 *C. galapagoense* 5 *C. praetermissum* 2 *C.* 'tovari'		Working collection with variable number of market and single plant accessions of wild types and landraces from Latin America
National Seed Storage Laboratory (NSSL) U.S. Department of Agriculture (USDA) Colorado State University Fort Collins, Colorado 80523 UNITED STATES OF AMERICA Curator: L.N. Bass	586	15	51	8	1	1 *C. chacoense*		Worldwide base collection held as active collection at Southern Regional Plant Introduction Station, Experiment, Georgia
Southern Regional Plant Introduction Station (S-9) U.S. Department of Agriculture (USDA) Experiment, Georgia 30212 UNITED STATES OF AMERICA Curator: G.R. Lovell	1981	287	312	163	10	12 *C. chacoense* 6 *C. praetermissum*	97	Worldwide active collection. *C. annuum* mainly from Turkey and Yugoslavia Partially duplicated as a base collection at NSSL, Fort Collins, Colorado
Northeast Regional Plant Introduction Station (NE-9) U.S. Department of Agriculture (USDA) New York State Agricultural Experiment Station Geneva, New York 14456 UNITED STATES OF AMERICA Curator: D. Dolan	731	106	127	70	41	1 *C. cardenasii* 9 *C. chacoense* 2 *C. eximium* 4 *C. praetermissum*	5	Worldwide active collection. The collection will be transferred to the Southern Regional Plant Introduction Station, Experiment, Georgia

APPENDIX III
(Continued)

Institute	Number of Accessions							Observations
	Domesticated species 2/					Wild species		
	C. annuum	*C. baccatum*	*C. chinense*	*C. frutescens*	*C. pubescens*		*Capsicum* spp. (not specified)	
Department of Vegetable Crops University of California Davis, California 95616 UNITED STATES OF AMERICA Curator: P.G. Smith	*	55	25	4	18	4 *C. cardenasii* 10 *C. chacoense* 11 *C. eximium*	12	Active collection. * *C. annuum* large collection,details not specified. Other species, wild types and landraces from Bolivia,Ecuador and Peru
Department of Botany Miami University Oxford, Ohio 45056 UNITED STATES OF AMERICA Curator: W.H. Eshbaugh	4	58	5		164	54 *C. cardenasii* 30 *C. chacoense* 145 *C. eximium*	9	Active collection. Wild types and landraces from Bolivia

SMALLER COLLECTIONS

Australia	Department of Primary Industries, Horticultural Research Station, P.O. Box 538, Bowen, Queensland 4805, curator: R.M. Wright
Austria	Institut für Pharmakognosie der Universität Wien, Währingerstrasse 25, 1090 Vienna, curator: J. Jurenitsch
Bulgaria	Maritsa Institute for Vegetable Crops, ul. Brezovsko shosse 32, 4003 Plovdiv, curator: E. Uzunova
	Institute of Genetics and Plant Breeding, Bulgarian Academy of Sciences, Sofia 1113, curator: M. Stoilov
Colombia	Centro Experimental Palmira, Instituto Colombiano Agropecuario (ICA), A.A. 233, Palmira Valle, curator: J. Jaramillo Vasquez
El Salvador	Centro Nacional de Tecnología Agropecuaria (CENTA), Km 33-1/2 carretera a Santa Ana, San Andrés, La Libertad, curator: M.A. Valencia F.
Ethiopia	Plant Genetic Resources Center (PGRC), P.O. Box 30726, Addis Ababa, curator: Melaku Worede
Italy	Istituto del Germoplasma, Via G. Amendola 165/A, 70126 Bari, curator: P. Perrino
	Istituto di Miglioramento Genetico e Produzione delle Sementi, Università degli Studi, Via Pietro Giuria 15, 10126 Torino, curator: L. Quagliotti
Japan	Seed Storage Laboratory, Division of Genetics, Department of Physiology and Genetics, National Institute of Agricultural Sciences (NIAS),Tsukuba, Ibaraki 305, curator: K. Kumagai
South Africa	Division of Plant and Seed Control, Pvt. Bag X 179, Pretoria 0001, curator: A.E. Swanepoel
Thailand	Division of Horticulture, Department of Agriculture, Bangkhen, Bangkok, curator: B. Chareonpanich
Tunisia	Institut National de la Recherche Agronomique de Tunisie, Avenue de l'Indépendance, Ariana, curator: N. Hamza
Turkey	Aegean Regional Agricultural Research Institute (ARARI), P.O. Box 9, Menemen, Izmir, curator: K. Temiz
United Kingdom	Department of Plant Biology, University of Birmingham, P.O. Box 363, Birmingham B15 2TT, curator: R.N. Lester

APPENDIX IV

CAPSICUM COLLECTING IN MEXICO[1]

Dates	Regions[2]	Species collected	Accession numbers[3]
27/08/80-30/08/80	Nayarit	*C. annuum* var. *annuum* *C. annuum* var. *glabriusculum*	BG 1610 - BG 1673
04/09/80, 05/09/80	Altos de Jalisco	*C. annuum* var. *annuum* *C. annuum* var. *glabriusculum*	BG 1674 - BG 1688
06/10/80, 15/10/80, 16/10/80	Nayarit	*C. annuum* var. *annuum* *C. annuum* var. *glabriusculum*	BG 2723, BG 2771 BG 2772 - BG 2793
16/10/80	Costa de Jalisco	*C. annuum* var. *annuum* *C. annuum* var. *glabriusculum*	BG 1689 - BG 1706
04/11/80-06/11/80	Península de Yucatán	*C. chinense* *C. annuum* var. *annuum* *C. annuum* var. *glabriusculum*	BG 1730 - BG 1748 BG 1713 - BG 1729
27/11/80, 28/11/80	Michoacán	*C. pubescens* *C. annuum* var. *annuum* *C. annuum* var. *glabriusculum*	BG 1751 - BG 1759 BG 2532 - BG 2534
01/12/80-05/12/80	Las Huastecas (Qro.,S.L.P., Tamaulipas, Nuevo León)	*C. pubescens* *C. annuum* var. *annuum* *C. annuum* var. *glabriusculum*	BG 1782 - BG 1855
08/04/81-10/04/81	Tabasco	*C. annuum* var. *annuum* *C. annuum* var. *glabriusculum*	BG 2801 - BG 2816
06/10/81-09/10/81	Sonora	*C. annuum* var. *glabriusculum*	BG 3205 - BG 3239
12/01/82-18/01/82	Michoacán Guerrero Oaxaca Chiapas	*C. pubescens* *C. annuum* var. *annuum* *C. annuum* var. *glabriusculum*	BG 3301 - BG 3324 BG 3328

1/ Full details on this IBPGR sponsored collecting project are described in: J.A. Laborde Cancino (1982). Informe Final de las Colectas de *Capsicum* Realizadas en 1980, 1981 y 1982. AGPG:IBPGR/82/92 (mimeographed). This document is available from the IBPGR Secretariat.

2/ A map showing the areas explored and the accession numbers obtained in different regions is shown in Figure 6.

3/ BG (= Banco de Germoplasma) accession numbers assigned by the Instituto Nacional de Investigaciones Agrícolas (INIA), Mexico.

APPENDIX IV
(Continued)

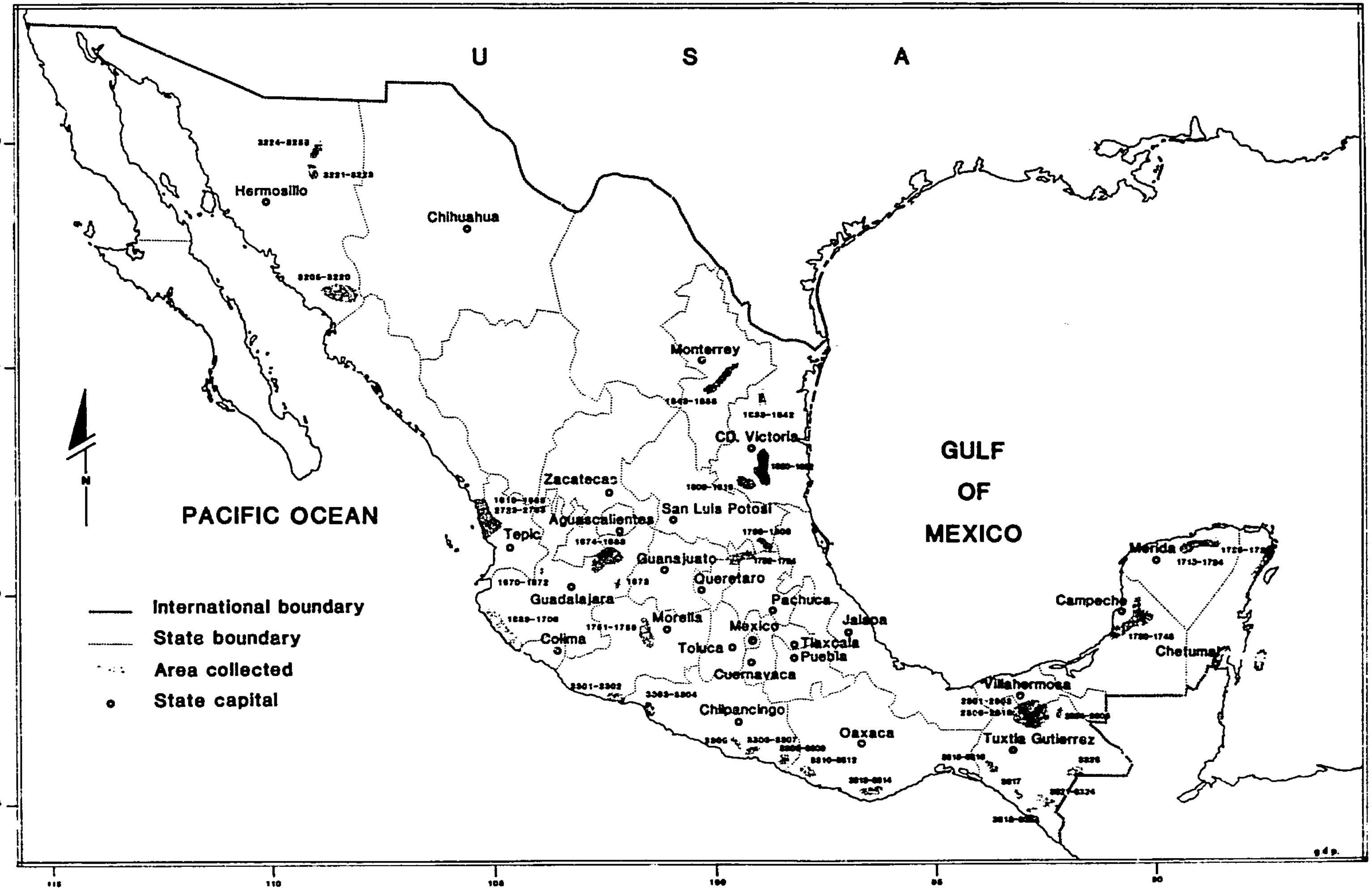

Figure 6. *Capsicum* collecting in Mexico

APPENDIX V

DESCRIPTOR LIST FOR *CAPSICUM*

PREFACE

This descriptor list has been prepared in an IBPGR standard format following advice on descriptors and descriptor states from the crop experts throughout the world. The IBPGR encourages the collection of data on the first four categories of this list; 1. Accession; 2. Collection; 3. and 4. Characterization and preliminary evaluation. The IBPGR endorses the information in categories 1-4 as the minimum that ideally should be available for any one accession. Other descriptors are given in categories 5 onwards that will enable the simple encoding of further characterization and evaluation data and which can serve as examples for the creation of additional descriptors in the IBPGR form by any user.

Although the suggested coding should not be regarded as the definitive scheme, this format has the full backing of the IBPGR and is promoted worldwide. The descriptor list given here provides an international format and thereby produces a universally understood 'language' for all plant genetic resource data. The adoption of this scheme for all data encoding, or at least the production of a transformation method to convert other schemes to the IBPGR format, will produce a rapid, reliable and efficient means for information storage, retrieval and communication. This will greatly assist the utilization of germplasm throughout the international plant genetic resources network. It is recommended, therefore, that information should be produced by closely following this descriptor list with regard to: ordering and numbering descriptors; using the descriptors specified; and using the descriptor states recommended.

Any suggestions for modifications will be welcomed by the IBPGR Secretariat, Rome.

APPENDIX V
(Continued)

The IBPGR now uses the following definitions in genetic resources documentation:

i) passport data (accession identifiers and information recorded by collectors);

ii) characterization (consists of recording those characters which are highly heritable, can be easily seen by the eye and are expressed in all environments);

iii) preliminary evaluation (consists of recording a limited number of additional traits thought desirable by a consensus of users of the particular crop).

Characterization and preliminary evaluation will be the responsibility of the curators, while further characterization and evaluation should be carried out by the plant breeder. The data from further evaluation should be fed back to the curator who will maintain a data file.

The following internationally accepted norms for the scoring or coding of descriptor states should be followed as indicated below:

a) measurements are made in metric units;

b) many descriptors which are continuously variable are recorded on a 1-9 scale. The authors of this list have sometimes described only a selection of the states, e.g. 3, 5 and 7 for such descriptors. Where this has occurred the full range of codes is available for use by extension of the codes given or by interpolation between them - e.g. in 8. (Pest and disease suceptibility) 1 = extremely low susceptibility and 8 = high to extremely high susceptibility;

c) presence/absence of characters are scored as + (present) and 0 (absent);

d) for descriptors which are not generally uniform throughout the accession (e.g. mixed collection, genetic segregation) mean and standard deviation could be reported where the descriptor is continuous or mean and 'x' where the descriptor is discontinuous;

e) when the descriptor is inapplicable, '0' is used as the descriptor value. E.g. if an accession does not form flowers, a '0' would be scored for the following descriptor:

Flower colour

1 White
2 Yellow
3 Red
4 Purple

f) blanks are used, for information not yet available;

g) standard colour charts e.g. Royal Horticultural Society Colour Charts, Methuen Handbook of Colour, Munsell Color Charts for Plant Tissues are strongly recommended for all ungraded colour characters (the precise chart used should be specified in the NOTES descriptor, 11).

APPENDIX V
(Continued)

PASSPORT

1. ACCESSION DATA

1.1 ACCESSION NUMBER

This number serves as a unique identifier for accessions and is assigned by the curator when an accession is entered into his collection. Once assigned this number should never be reassigned to another accession in the collection. Even if an accession is lost, its assigned number is still not available for re-use. Letters should occur before the number to identify the genebank or national system (e.g. MG indicates an accession comes from the genebank at Bari, Italy. PI indicates an accession within the USA system)

1.2 DONOR NAME

Name of institution or individual responsible for donating the germplasm

1.3 DONOR IDENTIFICATION NUMBER

Number assigned to accession by the donor

1.4 OTHER NUMBERS ASSOCIATED WITH THE ACCESSION (other numbers can be added as 1.4.3 etc.)

Any other identification number known to exist in other collections for this accession, e.g. USDA Plant Introduction number (not collection number, see 2.1)

1.4.1 Other number 1

1.4.2 Other number 2

1.5 SCIENTIFIC NAME

1.5.1 Genus

1.5.2 Species

1.5.3 Subspecies

1.5.4 Botanical variety

1.6 PEDIGREE/CULTIVAR/TYPE*/NAME

Nomenclature and designations assigned to breeder's material

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* The term "type" ("tipo" in Spanish) is widely used by workers in *Capsicum* breeding and horticulture. It designates a distinct group of cultivars, of common ancestry, such as Jalapeño, Escabeche, and others. The IBPGR/CATIE consultation felt that no other precisely equivalent term exists so the word "type" should be accepted, although in this content it has no taxonomic implications.

APPENDIX V
(Continued)

1.7 ACQUISITION DATE

The month and year in which the accession entered the collection, expressed numerically, e.g. June = 06, 1981 = 81

1.7.1 Month

1.7.2 Year

1.8 DATE OF LAST REGENERATION OR MULTIPLICATION

The month and year expressed numerically, e.g. October = 10, 1978 = 78

1.8.1 Month

1.8.2 Year

1.9 ACCESSION SIZE

Approximate number of seeds of accession in collection

1.10 NUMBER OF TIMES ACCESSION REGENERATED

Number of regenerations or multiplications since original collection

2. COLLECTION DATA

2.1 COLLECTOR'S NUMBER

Original number assigned by collector of the sample normally composed of the name or initials of the collector(s) followed by a number. This item is essential for identifying duplicates held in different collections and should always accompany sub-samples wherever they are sent

2.2 COLLECTING INSTITUTE

Institute or person collecting/sponsoring the original sample

2.3 DATE OF COLLECTION OF ORIGINAL SAMPLE

Expressed numerically, e.g. March = 03, 1980 = 80

2.3.1 Month

2.3.2 Year

2.4 COUNTRY OF COLLECTION OR COUNTRY WHERE CULTIVAR/VARIETY BRED

Use the three letter abbreviations supported by the Statistical Office of the United Nations. Copies of these abbreviations are available from the IBPGR Secretariat and have been published in the FAO/IBPGR Plant Genetic Resources Newsletter number 49

2.5 PROVINCE/STATE

Name of the administrative subdivision of the country in which the sample was collected

2.6 LOCATION OF COLLECTION SITE

Number of kilometres and direction from nearest town, village or map grid reference (e.g. TIMBUKTU7S means 7 km South of Timbuktu)

2.7 LATITUDE OF COLLECTION SITE

Degrees and minutes followed by N (north) or S (south), e.g. 1030S

2.8 LONGITUDE OF COLLECTION SITE

Degrees and minutes followed by E (east) or W (west), e.g. 7625W

2.9 ALTITUDE OF COLLECTION SITE

Elevation above sea level in metres

2.10 COLLECTION SOURCE

1 Wild
2 Farm land
3 Farm store
4 Backyard
5 Village market
6 Commercial market
7 Institute
8 Other (specify in the NOTES descriptor, 11)

2.11 STATUS OF SAMPLE

1 Wild
2 Weedy
3 Breeders line
4 Primitive cultivar (landrace)
5 Advanced cultivar (bred)
6 Other (specify in the NOTES descriptor, 11)

2.12 LOCAL/VERNACULAR NAME

Name given by farmer to cultivar/landrace/weed

2.13 NUMBER OF PLANTS SAMPLED

Approximate number of plants collected in the field to produce this accession

2.14 PHOTOGRAPH

Was a photograph taken of the accession or environment at collection?

0 No
\+ Yes

2.14.1 <u>Photograph number</u>

If photo has been taken provide any identification number/system in the NOTES descriptor, 11

2.15 HERBARIUM SPECIMEN

Was a herbarium specimen collected?

0 No
\+ Yes

APPENDIX V
(Continued)

2.16 OTHER NOTES FROM COLLECTOR

Collectors will record ecological information. For cultivated crops, cultivation practices such as irrigation, season of sowing, etc. will be recorded

CHARACTERIZATION AND PRELIMINARY EVALUATION DATA

3. SITE DATA

3.1 COUNTRY OF CHARACTERIZATION AND PRELIMINARY EVALUATION

3.2 SITE (RESEARCH INSTITUTE)

3.3 NAME OF PERSON IN CHARGE OF CHARACTERIZATION

3.4 SOWING DATE

3.4.1 Day

3.4.2 Month

3.4.3 Year

3.5 FIRST HARVEST DATE

3.5.1 Day

3.5.2 Month

3.5.3 Year

3.6 LAST HARVEST DATE

3.6.1 Day

3.6.2 Month

3.6.3 Year

4. PLANT DATA

4.1 VEGETATIVE

4.1.1 Plant growth habit

See Figure 7

3 Prostrate
5 Compact
7 Erect

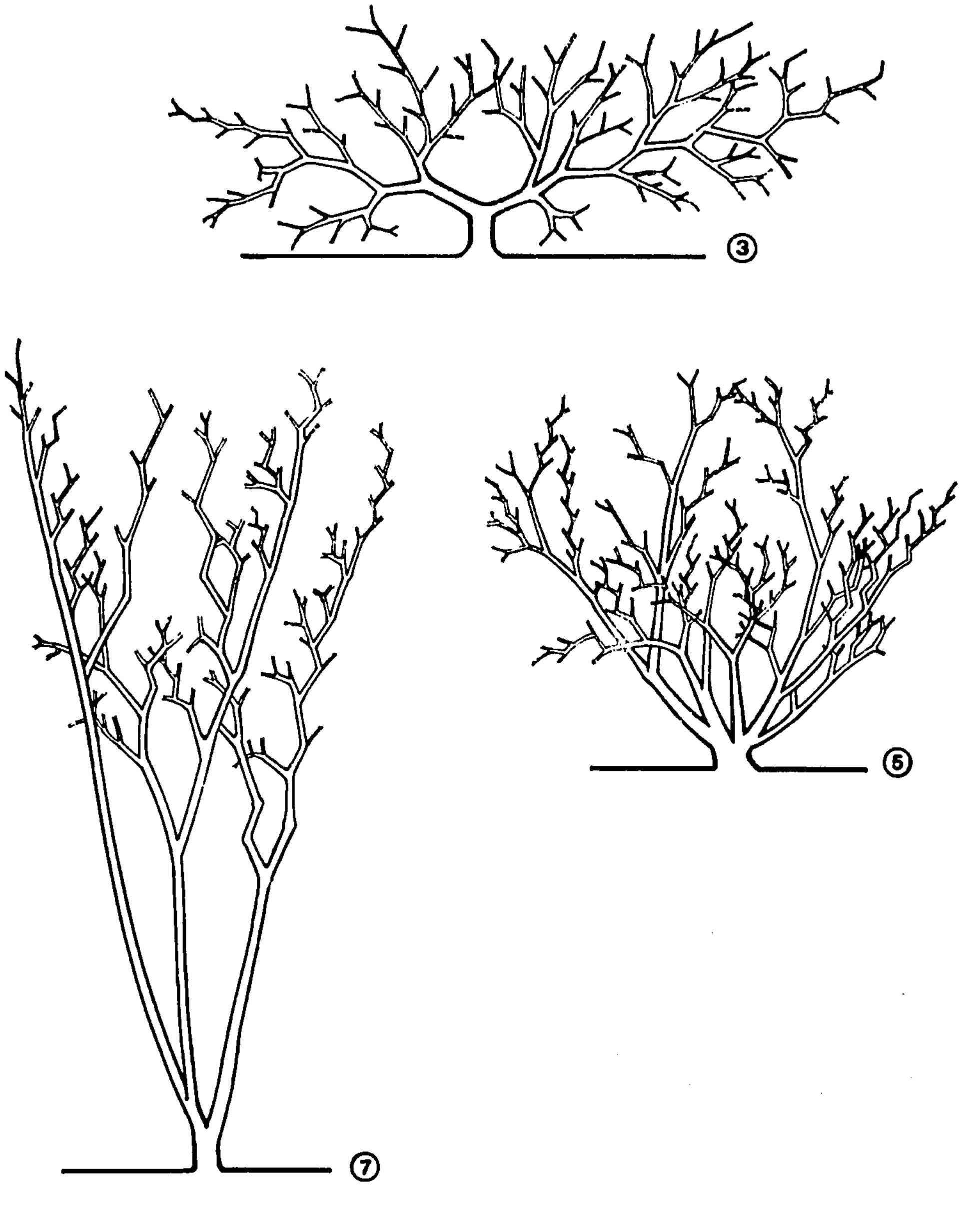

Figure 7. Plant growth habit

4.1.2 Stem pubescence

See Figure 8

0 Glabrous
3 Sparse
5 Intermediate
7 Abundant

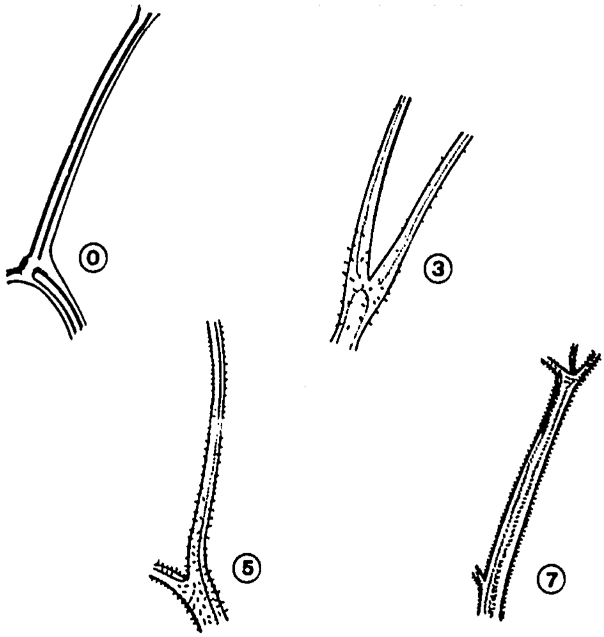

Figure 8. Stem pubescens

4.1.3 Stem colour

1 Green
2 Purple

4.1.4 Leaf pubescence

See Figure 9

0 Glabrous
3 Sparse
5 Intermediate
7 Abundant

APPENDIX V
(Continued)

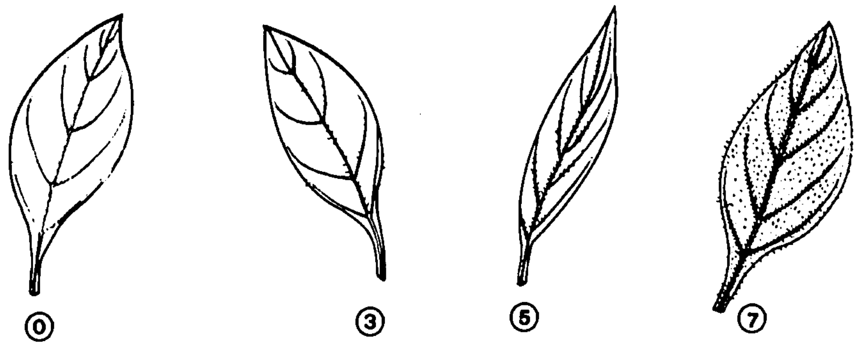

Figure 9. Leaf pubescence

4.2 INFLORESCENCE AND FRUIT

4.2.1 Number of pedicels per axil

4.2.2 Pedicel position at anthesis

See Figure 10

3 Pendant
5 Intermediate
7 Erect

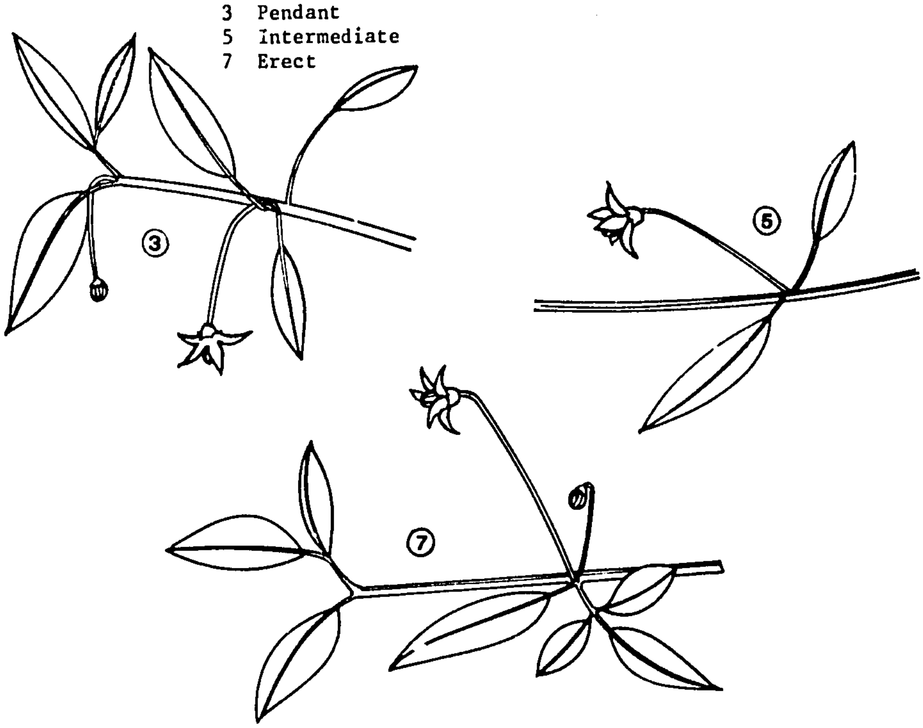

Figure 10. Pedicel position at anthesis

4.2.3 Corolla colour

1 White
2 Green-white
3 Lavender
4 Blue
5 Violet
6 Other (specify in the NOTES descriptor, 11)

4.2.4 Calyx margin shape

See Figure 11

3 Smooth
5 Intermediate
7 Dentate

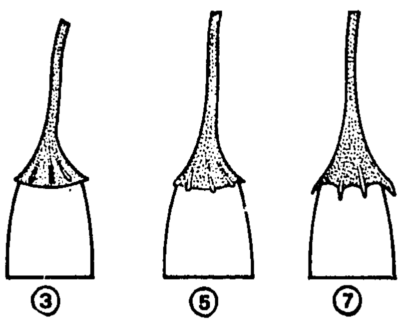

Figure 11. Calyx margin shape

4.2.5 Annular constriction at junction of calyx and peduncle

See Figure 12

0 Absent
+ Present

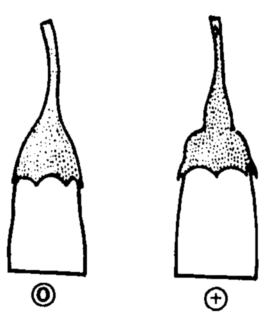

Figure 12. Annular constriction at junction of calyx and peduncle

4.2.6 Fruit position

3 Declining
5 Intermediate
7 Erect

4.2.7 Fruit colour in immature stage

1 Green
2 Yellow
3 Orange
4 Red
5 Purple
6 Brown
7 Black
8 Other (specify in the NOTES descriptor, 11)

4.2.8 Fruit colour in mature stage

1 Green
2 Yellow
3 Orange
4 Red
5 Purple
6 Brown
7 Black
8 Other (specify in the NOTES descriptor, 11)

4.2.9 Fruit length

1	Very short	(< 1 cm)
3	Short	(around 5 cm)
5	Medium	(around 10 cm)
7	Long	(around 15 cm)
9	Very long	(> 25 cm)

4.2.10 Fruit shape

See Figure 13

1 Elongate
2 Oblate
3 Round
4 Conical
5 Campanulate
6 Bell or blocky

4.2.11 Fruit shape at peduncle attachment

See Figure 14

1 Acute
3 Obtuse
5 Truncate
7 Cordate
9 Lobate

APPENDIX V
(Continued)

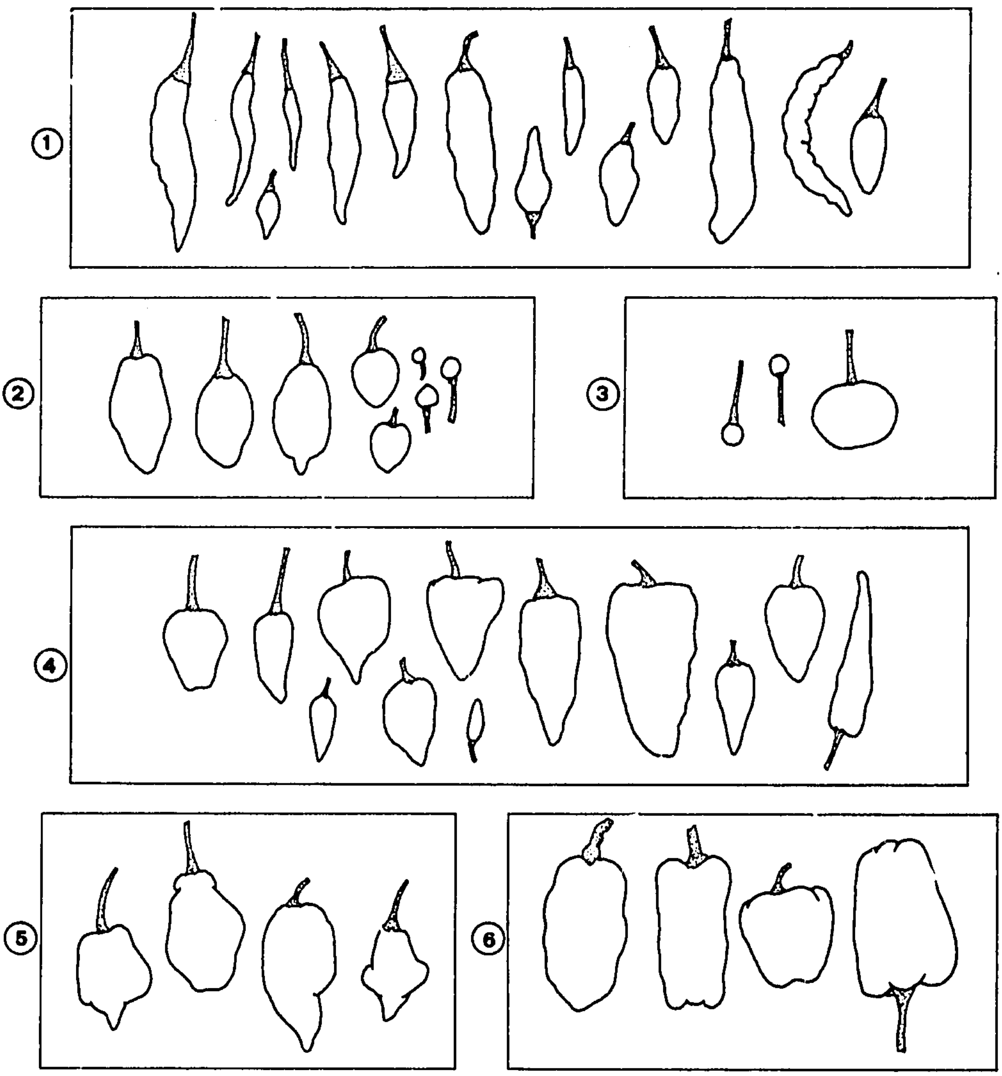

Figure 13. Fruit shape

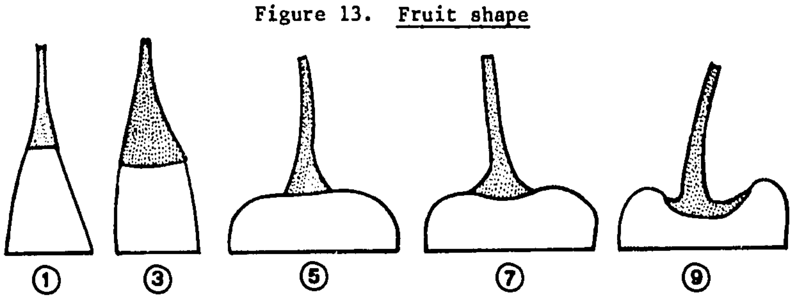

Figure 14. Fruit shape at peduncle attachment

4.2.12 <u>Neck at base of fruit</u>

See Figure 15

0 Absent
+ Present

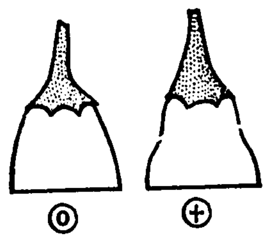

Figure 15. <u>Neck at base of fruit</u>

4.2.13 <u>Fruit shape at blossom end</u>

See Figure 16

3 Pointed
5 Blunt
7 Sunken

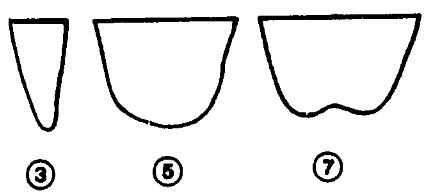

Figure 16. <u>Fruit shape at blossom end</u>

APPENDIX V
(Continued)

4.2.14 Fruit cross-sectional corrugation

See Figure 17

0 Smooth
3 Slightly corrugated
5 Intermediate
7 Very corrugated

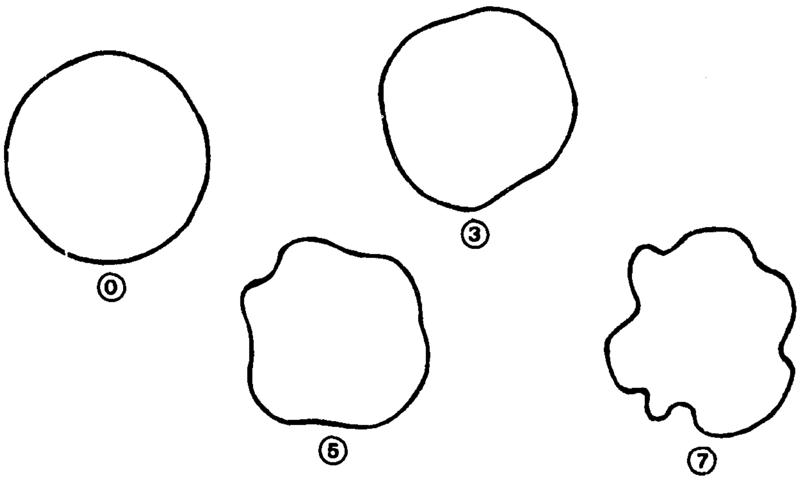

Figure 17. Fruit cross-sectional corrugation

4.2.15 Fruit persistence

0 Deciduous (only pedicel and calyx remain on plant)
+ Persistent

4.2.16 Fruit pungency

0 Not pungent (sweet)
3 Low
5 Intermediate
7 High

4.3 SEED

FURTHER CHARACTERIZATION AND EVALUATION

5. SITE DATA

5.1 COUNTRY OF FURTHER CHARACTERIZATION AND EVALUATION

5.2 SITE (RESEARCH INSTITUTE)

5.3 NAME OF PERSON IN CHARGE OF EVALUATION

5.4 SOWING DATE

5.4.1 Day

5.4.2 Month

5.4.3 Year

5.5 FIRST HARVEST DATE

5.5.1 Day

5.5.2 Month

5.5.3 Year

5.6 LAST HARVEST DATE

5.6.1 Day

5.6.2 Month

5.6.3 Year

6. PLANT DATA

6.1 VEGETATIVE

6.1.1 Plant height

Measured in centimetres from soil level to highest point

6.1.2 Plant width

Measured in centimetres at widest point

6.1.3 Node colour

1 Green
2 Purple

6.1.4 Leaf length/width ratio

6.2 INFLORESCENCE AND FRUIT

6.2.1 Days to flower

Number of days from sowing until 50% of plants have flowers

6.2.2 Corolla spot

0 Absent
1 White
2 Yellow
3 Green-yellow
4 Green
5 Other (specify in the NOTES descriptor, 11)

APPENDIX V
(Continued)

6.2.3 Anther colour

1 Yellow
2 Pale blue
3 Blue
4 Purple
5 Other (specify in the NOTES descriptor, 11)

6.2.4 Filament colour

1 White
2 Blue

6.2.5 Anther/Filament length ratio

6.2.6 Stigma position in relation to anthers at full anthesis

3 Included
5 Same level
7 Exserted

6.2.7 Self-compatibility

0 Absent
+ Present

6.2.8 Male sterility

0 Absent
+ Present

6.2.9 Days to fruiting

Number of days from sowing until 50% of the plants have mature fruits

6.2.10 Fruit set

3 Low
5 Intermediate
7 High

6.2.11 Fruit width

Maximum fruit width in centimetres

6.2.12 Fruit weight

Fruit weight in grams

6.2.13 Fruit wall thickness

Measured in millimetres at point of maximum width

6.2.14 Anthocyanin in unripe fruits

0 Absent
+ Present

6.2.15 Anthocyanin in ripe fruits

0 Absent
+ Present

6.3 SEED

6.3.1 Seed colour

1 Straw colour
2 Dark brown
3 Other (specify in the NOTES descriptor, 11)

6.3.2 Seed diameter

Measured at hilum in millimetres

6.3.3 1000 - seed weight

Measured in grams

7. STRESS SUSCEPTIBILITY

Based on a 1-9 scale, where

3 Low susceptibility
5 Medium susceptibility
7 High susceptibility

7.1 LOW TEMPERATURE

7.2 HIGH TEMPERATURE

7.3 DROUGHT

7.4 HIGH SOIL MOISTURE

7.5 HIGH HUMIDITY

8. PEST AND DISEASE SUSCEPTIBILITY

Based on a 1-9 scale, where

3 Low susceptibility
5 Medium susceptibility
7 High susceptibility

8.1 PESTS

8.1.1	*Anthonomus* spp.	Weevil
8.1.2	*Aphis* spp.	Aphids
8.1.3	*Gnorimoschema* spp.	Leaf miner
8.1.4	*Myzus persicae*	Aphid
8.1.5	*Scirtothrips dorsalis*	Thrip
8.1.6	*Spodoptera litura*	Fruit borer
8.1.7	*Hemitarsonemus latus*	Mite
8.1.8	*Meloidogyne* spp.	Root-knot nematode

8.1.9 Other (specify in the NOTES descriptor, 11)

APPENDIX V
(Continued)

8.2 FUNGI

8.2.1	*Alternaria solani*	
8.2.2	*A. tenuis*	
8.2.3	*Botrytis cinerea*	
8.2.4	*Cercospora capsici* (Head and Wolf)	
8.2.5	*Colletotrichum* spp.	Leaf spot
8.2.6	*Fusarium* spp.	
8.2.7	*Leveillula taurica*	
8.2.8	*Mucor mucedc*	
8.2.9	*Penicillium* spp.	
8.2.10	*Phytophthora capsici* L.	Root rot
8.2.11	*P. citrophthora* (R.E. & E.H. Smith)	
8.2.12	*Rhizoctonia solani* Kühn	Damping off
8.2.13	*Rhizopus nigricans*	
8.2.14	*Sclerotinia* spp.	
8.2.15	*Stemphylium botriosum*	
8.2.16	Other (specify in the NOTES descriptor, 11)	

8.3 BACTERIA

8.3.1	*Pseudomonas syringae*	Soft fruit rot
8.3.2	*Xanthomonas vesicatoria*, race 1	Bacterial spot, race 1
8.3.3	*X. vesicatoria*, race 2	Bacterial spot, race 2
8.3.4	Other (specify in the NOTES descriptor, 11)	

8.4 VIRUSES

8.4.1 Alfalfa mosaic virus

8.4.2 Aster ringspot virus

8.4.3 Cucumber mosaic virus

8.4.4 Curly-top virus

8.4.5 Pepper mottle virus

8.4.6 Potato virus Y

8.4.7 Stolbur mosaic virus

8.4.8 Tobacco etch virus

8.4.9 Tobacco leaf curl virus

8.4.10 Tobacco mosaic virus

8.4.11 Veinbanding virus

8.4.12 Other (specify in the NOTES descriptor, 11)

9. ALLOENZYME COMPOSITION

This may prove to be a useful tool for identifying duplicate accessions

10. CYTOLOGICAL CHARACTERS AND IDENTIFIED GENES

For details see Lippert *et al.*, 1966 (see references page 15)

11. NOTES

Give additional information where descriptor state is noted as 'Other' as, for example, in descriptors 4.2.3, 8.1.9 etc. Also include here any further relevant information