GENETIC RESOURCES IN BEANS, Phaseolus vulgaris, AND CIAT's GERMPLASM BANK [1]

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INTRODUCTION

This species presents the highest polymorphism within the American species of the *Phaseolus* genus.

Besides the great variation observed with regards to the growing habit characteristics; the colour of the grain possesses a high variation with regards adaptive factors and reaction to diseases and pests.

As it occurs in other grain legumes, its productivity per unit area is low, as compared with other cereals. Efforts made to significantly increase this factor have not, so far, been very successful.

Most of the work in breeding has been directed to the elimination of defects; incorporation of resistance to diseases and earliness. A little of the work has been focused on greater yields, by means of the hybridization of promissory lines, selecting the higher yielding segregants. A third approach is being adopted on the basis of a model of plants or ideotypes. In this last model, the final objective is maxium physiological efficiency.

The success obtained in this last scheme at CIMMYT and IRRI, on wheat and rice, respectively, is undeniable.

However, the creation of these cultivars, with a high range of adaptation and spectacular responses to fertilization, has brought with them the rapid displacement of local cultivars, with lesser aptitudes, to the detriment of the existing genetic variability.

For this reason, it necessary to preserve the original biological forms, an indispensable source for any present or future breeding program.

With beans we can count on the advantage that a large amount of samples can be kept for a long time, in a relatively small area, in the form of seeds. The requisites for this preservation are well established and can be oversimplified as two basic aspects: relative humidity and low storage temperature. Obviously, these are only achieved with good quality seed. Storage does not improve its qualities in any way.

AVAILABILITY OF GENETIC RESOURCES IN BEANS

Even though, in beans, the picture of genetic resources extinction is not as dramatic as in the case of cereals, we should not become careless, bearing in mind that active improvement programs in these species are being developed which,in a short period of time, will probably produce highyielding cultivars and high range adaptation,which will necessarily replace the present cultivars or local selections. Examples that enable us to foresee such a situation are found in the irrigated valleys of the coast of Peru where cultivars of prostrated growth, adapted to saline soils, and of stable yields, were replaced due to adoption of agricultural mechanization, by other shrubby crops of far less rusticity. The situation taking place in the Cauca River Valley should also be mentioned, in which the red grain, local cultivars, are being displaced by others of black grain, destined for export.

Many areas exist within Latin America, fortunately, that are situated in very irregular terrain, where agriculture is carried out under similar conditions to what they were one hundred years ago, and that still keep sufficient genetic variation to successfully set-up improvement programs.

Beans seem to have been cultured, simulteneously and over 7.000 years ago, in the mountain regions of Mexico and Peru.

They were domesticated before corn, which together with beans, constitute two of the main sources of food for human consumption in Latin America. The associated culture of both crops, corn-beans, still occupies a great part of the cultivated areas, specially in the high lands of the American tropics.

Such a length of time under culture has originated thousands of variants, in some cases sufficiently represented, as in the case of variants present in Mexico and Guatemala, in collections maintained at Pullman, Washington at INIA and the Post Graduate School of Chapingo, in Mexico.

The same cannot be said of the variants in the Andean regions of Bolivia, Peru, and Ecuador, which are scarcely represented in the Pullman Regional Center for plant introduction and in the bean collection of the EEA-La Molina, Peru.

Years after the Spanish conquest, this crop was taken to Europe, Asia, and Africa . It continued its evolution in these places; an outstanding example of this being the variation found in Turkey, where it is still important, hundreds of years after its introduction. The pods of yellow coloured characteristics seen in Asia gave origin to the wax or butter type snap bean. A good representation of this variety is also represented in Pullman, Washington.

Some wild forms, known as P. aborigineous have been collected and are found in institutions such as Harvard University and in Chapingo, Mexico.

In spite of their small number, some American related species have proved their utility in giving resistance to bacteriosis, Phaseolus acutifolius species and resistance to root diseases, Phaseolus coccineus.

Of all the American species of the Pheaseolus genus; however, the common bean is the most diversified and of greatest polymorphism. The environments in which they flourish cover an enormous geographic range, from Sweden to New Zealand. This encourages us to be optimistic in the search for materials that can be adapted to the lowland tropics, where it could be successfully and intensely cultivated.

INSTITUTIONS WITH BEAN COLLECTIONS

Table 1 shows the institutions and countries that have bean germplasm. This data was put together by the Genetic Resources and Ecology of Plants Unit, of FAO. Some additions have been made through personal contacts.

Of these, the Phaseolus sp. collection of USDA, situated at Pullman, Washington, has more than 6.000 introductions that have been collected in a great number of countries. Norwell (1951) and Gentry (1965-1968) collected many primitive materials in Central America and Mexico, which have proved to be very useful when testing their aptitudes in the face of pathogens.

Most of the collection has been characterized by taking notes on morphological types and focusing on exploring its possibilities for snap beans. Intensive research has been or is being carried out at other Experiment Station in U.S.A., from which have derived materials such as PI 203.958, in New York, with resistance to root rot; Nebraska, tolerance to bacteriosis;

Ohio, resistance to Empoasca; South Carolina, where they are studying the relation between seed colour and seedling vigour, and the problem of white seed snap beans. Due to difficulties caused by day length (photoperiod) for which many materials cannot be adapted to conditions in the U.S.A., Puerto Rico is used as a locality for this purpose, and to evaluate the Phaseolus collections along problems of the tropics which do not exist on the continent.

In 1973, the University of Colorado (Taximetrics Laboratory) adopted a computer program (Taxir) to register 36 describers.

This center in Colorado has played an active part in the interchange of seed, and materials from Pullman form an important part of collections maintained in several centers (Cambridge, La Molina).

The National Laboratory at Beltsville, offers the service of verification of PI numbers which coordinates any interchange of seed outside the U.S.A.

In some university centers, such as Harvard, certain wild materials are being studies such as P. aborigeneous.

At Wisconsin and Florida studies on protein quality are being conducted in beans.

Another important collection, due to the number of materials it contains, is that of Cambridge University, with more than 6.000 introductions. Most of these are PI's but also it has many local African races. Here, evolution studies have been carried out with the American species of Phaseolus, by students of Professor Hutchinson, such as Dr. Scott. The University works very closely with the East African Bean Improvement Program, under the direction of Dr. C. Leakey.

Other collections, such as those of the National Institute of Agricultural Research and the Post Graduate School of Chapingo, possess a consistant representation of the variability available in Mexico. At Chapingo, valuable samples are kept of wild forms and some natural interspecific crosses of vulgaris x coccineus (P. darwinianus). This institution has played an important role in the breeding of species in Mexico and some other countries, and valuable studies on the origin and taxonomy of beans have been carried out.

The Tropical Agronomic Center for Research and Education (CATIE), at Turrialba, through the PCCMCA, has played an important part in the improvement of beans in the Central America area. A number of studies to induce mutations have taken place at Turrialba, specially to change growing habits and grain colour, which are identified by the initials NEP.

The Panamerican School of Agriculture, in Zamorano, Honduras, which gathered together a large part of the beans of Central America is now in the process of reorganization.

The centers at Maracay and Palmira, in Venezuela and Colombia, respectively, have collected the variability present in those areas. Venezuela seems to have materials that are tolerant to acid soils (Aluminum toxicity). Colombia has valuable materials with resistance to angular leaf spot; light coloured, large sized seed and valuable bushy types.

The EEA bank, at La Molina, collects material with tolerance to saline soils, to nematodes, tolerance to drought, and probably to mites(Tetranichus sp.); a collection called "nuñas", round beans that are eaten toasted.

LISTA MUNDIAL DE COLECCION DE SEMILLAS DE
Phaseolus sp.

PAIS E INSTITUCION	No. DE MUESTRAS	FACILIDADES DE ALMACENAMIENTO
ARGELIA Institut National de la Recherche Agronomique, Jardin d'Essais	63	NO
AUSTRALIA Dept. of Agriculture, Burnley Gardens Melbourne, Victoria	300	NO
BELGICA Faculte des Sciences Agronomiques de L'Etat, Gembloux	450	NO
BRASIL Instituto Agronómico Campinas, Sao Paulo	1.300	SI
BULGARIA Institute of Genetics and Plant Breeding, Sofia	3.000	--
CANADA Dept. of Agricultre, Soil substation, Woodslee, Ontario	2.000	SI
CHILE Inst. de Investigaciones Agrícolas Min. de Agricultura, Santiago	700	--
COLOMBIA Ica-Palmira	1.400	SI
COSTA RICA Catie, Turrialba	3.000	SI
FRANCIA Inra, Station d'Amelioration des Plantus, Versalles	200	--
REINO UNIDO University of Cambridge and University of Reading	6.000	--
GRECIA Institute of Fodder Crops Larissa	149	NO
GUATEMALA Icta, Guatemala	500	NO

PAIS E INSTITUCION	No. DE MUESTRAS	FACILIDADES DE ALMACENAMIENTO
HONDURAS EAP, Zamorano	1.200	SI
Secretaria de Recursos Naturales	562	--
JAPON Tokachi Agricultural Experimental Sta. Hokkaido	620	SI
YUGOESLAVIA Plant Introduction and Acclimatisation Centre, Ljubljana	150	NO
MEXICO Colegio de Postgraduados Chapingo e Instituto Nacional de Investigaciones Agrícolas	6.500	SI
HOLANDA Institute for Horticultural Plant Breeding, Wageningen	250	NO
NICARAGUA Ministerio de Agricultura y Ganadería	80	--
NUEVA ZELANDIA Crop Research Div., Dept. of Scientific and Industrial Research, Christchurch	50	SI
PERU EEA - La Molina	1.400	SI
UGANDA Makerera, University College, Kampala	3.500	NO
PUERTO RICO Mayaguez Institute of Tropical Agric.	3.500	--
ESTADOS UNIDOS DE NORTE AMERICA Western Regional Plant Introduction Station, Pullman, Washington	6.000	SI
VENEZUELA Centro de Investigaciones Agronómicas Maracay	700	SI
INDIAS OCCIDENTALES Faculty of Agriculture, University of West Indies, Jamaica	160	SI

The Brazilian collection seems to have valuable genes that confer tolerance to Empoasca sp.

Materials with resistance to anthracnose have been developed in France and Belgium; as well as compatibility studies in crossings between Phaseolus species.

Australia has white grain materials of many bean types with resistance to blight and acid soils, such as the varieties Westralia and Redlands.

Holland has also developed materials with resistance to virosis, such as Processor.

THE NEED FOR NEW COLLECTIONS

In most cases we have knowledge neither of the collections nor of the areas sampled. One exception is the list obtained from the Progress Report of the National Program for Conservation of Crop Germplasm, of USDA (Table 2).

In an inventory of genetic resources in the diversity centers, developed by FAO and IBP, Jorge León states the necessity of exploring the Pacific coastal areas of Central America. The so-called P. aborigenous species is still found there. The Atlantic coast of Central America presents fewer cultivars variations but they are well suited to hot, humid conditions.

There are many primitive types in the mountains of Honduras. The P. coccineus species is also found in the high lands of Guatemala, while P. lunatus is spread throughout the low areas between Guatemala and Costa Rica, where some P. aborigeneus types are also found.

The inter Andean regions of Peru, Ecuador and Bolivia have not been

Table 2 EXPEDITIONS CARRIED OUT BY U.S.D.A. TO COLLECT BEANS

(*Phaseolus vulgaris* L.)

Name of collector	Date	Collection area
O.W.Norwell	1951	Central America
H.S.Gentry	1965	C.America & Mexico
H.S.Gentry	1966	Mexico
H.S.Gentry	1967	Mexico

Other explorers, with more general purposes, have also collected bean seeds.

Source: The National Program for Conservation of Crop Germplasm. 1971 adequately sampled. Similiarly, it is advisable to rescue the local selections that were cultivated, up to a decade ago, on the Peruvian coast, with tolerance to saline soils.

Undoubtedly, the principal system for gathering germplasm is by direct exploration by experts. Systematically planned and executed, with a clear picture of what is wanted to be collected; and mainly in the areas of genetic diversification.

Admittedly, few institutions are in a position to finance long expeditions to collect materials. They must have international funding and multidisciplinary specialists to insure the best results.

GERMPLASM INCREMENTATION, EVALUATION AND DOCUMENTATION

Due to the fact that, in most cases, proper seed storage facilities are not available, see table 1, seed have had to be added, year after year. Definitely, a large part of the original collections have lost their identities.

Large collections, in the hands of breeders who are under pressures to attain the objectives of their programs, have been neglected. Many collections disappear when the breeders retire or switch interests.

On most occasions collection evaluation projects exist, but they lack defined planning. Generally speaking, very little of this information has been used for practical ends. Most breeding programs have depended on the introduction of foreign gerplasm.

Few reports exist on these evaluations - the catalog edited annually at Pullman, the report on the evaluation of Venezuela's national collection of "caraota" ; Barrio's description of beans in Spain, of Puerta Romero.

Many evaluations remain anonymous, in field diaries, and others are sprinkled throughout reports of reduced circulation. Descriptive information necessary for evaluation is not found. It is almost impossible to define the origin of certain materials.

Pedigrees, the method most commonly used to establish affinities between cultivars, are confusing, with many forms of designation and abbreviation. It may be necessary to resort to DNA hybridization techniques to determine affinities or to electrophoresis to determine isoenzymes (polymorphic characters).

Information, therefore remains inaccessible, or accessible after considerable waste of time and effort. Knowledge accummulated in years of study cannot be used. It is in fact, easier to re-evaluate the materials than to search through literature or available research data reports.

A great gap has been filled by the report of the Bean Improvement Cooperative, in which researchers report, in simple form, on advances obtained from their evaluation.

CIAT'S GERMPLASM BANK

ITS FORMATION

Its initiation dates, from 1970, when the existing Grain Legume Program received 3780 entries of Phaseolus species, from the Regional Center for Plant Introduction, of Pullman, Washington, with the purpose of observing their behaviour under the sub-tropical conditions of Palmira. Later, following the decision made in 1972 to initiate a program to increase dry bean production in tropical and sub-tropical areas, seeds were received from several centers;

so that, do date, the appreciable number of 11.798 introductions, from 25 countries, has been reached. By this figure, CIAT has been recognize as the largest bean gerplasm center in the world, by the International Plant Genetics Resources Board.

Since 1975, gerplasm has been under the care of a specialized group, in charge of its evaluation, conservation and development.

SIGNIFICANCE OF THE CREATION OF THE INTERNATIONAL CENTER OF BEAN GENETIC RESOURCES

Because of its location, in an area of variability, where an active improvement program is taking place, and because of the variability that has so far been collected, CIAT'S gerplasm bank has become an important factor in the achievement of increased bean production in the tropical and sub-tropical areas of Latin America.

It is aimed at obtaining the natural variability that could be useful in enlarging the germplasm for breeding purposes.

Intensive evaluation, by an interdisciplinary group, of the aptitudes of agronomic importance in different media, and the information from them derived, will significantly increase their usefulness.

At the same time, seeds of useful materials produced in national programs which do not have adequate storage facilities, can be stored at this Center, thus freeing these programs of a heavy load.

Having a uniform system of evaluation, and hopefully this can be achieved shortly, the information that is gathered and communicated will be a powerful tool in the reaching of important advances in breeding.

It could also serve as a training center for young professionals in the fields of seed technology and plant exploration.

Seed interchange could be made easier, due to its favourable situation with regards the other centers.

MANNER OF OPERATION

It is this program's job to preliminarily augment and evaluate the bean collection. Most of the data necessary to characterize entries will be evaluated at CIAT, in Palmira.

Evaluations for adaptability, resistance to pests and pathogens not present in Palmira, will be carried out elsewhere. It is this program's duty to gather this information and communicate it.

Since we have materials that have problems in being reproduced in Palmira, alternative locations will be used. All those materials that prove promissory will be passed on to more demanding tests, carried out by different members of the bean team. Others will be destined to conservation for a long period of time.

Data will be registered on IBM cards for quick and permanent reference when required. For this, we count on a terminal line connected to the computer center in Bogotá, in the ICA section.

Conservation will be made by individual entries, with rejuvenation cycles, according to the results of germination tests that will be periodically conducted. This form of conservation is very efficient in preserving variability, even though it may not be preserved one hundred percent in its original form.

Seed remittances will be controlled in a manner that no entry received at CIAT is in danger of being lost.

DATA TO BE REGISTERED

These adhere to the recommendations evolved at the meeting of experts on genetic resources held at FAO, in Rome, 1967.

It consists in a basic register with the following data:

1. Register number CIAT-GØØØØ1, this allows space for 99.999 entries; permanent and uniform. It will be assigned only once and in chronological order, according to the sequence in which the materials are received.

It serves as a warning against lost identity and to locate and coordinate the registration of materials interchanged, reducing the efforts in maintaining materials.

2. Name or useful nomenclature of cultivar.

It is a functional nomenclature, specific for each stock.

A useful nomenclature could be an abbreviated pedigree.

Names will not be translated. Local names will be preserved.

3. Origin or source.

Serves to establish genetic identity. Avoids errors in the transmission of data. Includes the introduction year, donor country, entity ad individual donor.

4. Genetic origin.

Data useful to scientists.

Could be noted: a. by improvement or selection

b. origin by mutation.

c, origin by collection

SPECIFIC DATA OF CROP

These have the purpose of characterizing each one of the entries on the basis of stable characteristics, such as stem pigmentation, flower and seeds. Giving morphological and physiological data of intent, such as: growing habit, height of plant, number of nodes, dimension of leaves, reaction to photoperiod. Registering reactions to diseases and insects. Efficiency in forming bacterial nodules.

These data will be complemented by extra data reported by different programs, indication of noteworthy segregant mixtures, the existance of clean seed. These data will be coded numerically.

The minimum data required have been considered so that the other members of the bean team may receive preliminary data. The system will be flexible so that other useful data may be included in the future, such as the characteristics of the pods and roots.

The program is based on the SAS (Statistic Analysis System), developed at North Carolina University. A similiar program which existed already had to be modified on the introduction of new data to be evaluated.

WORK CARRIED OUT

Evaluations have been made on the Colombian site of Palmira (CIAT), Turipaná, Carimagua, Popayán and in Boliche, Ecuador. Cooperative evaluations have been made in Peru (tolerance to drought) and in Guatemala (tolerance to golden mosaic).

As a result, there are 750 promissory materials, many of which are being intensely evaluated and others are being used actively in hybridization.

A descriptive publication of these materials will be brought out in early 1976.

OTHER ACTIVITIES TAKING PLACE

Elimination of duplications, within the introductions received, on the basis of homology of nomenclature, characteristics and personal contacts.

Increase of collections with low number of seeds, in pots.

Complete data on promissory CIAT materials

Preparation of an illustrated manual to aid in the germplasm evaluation of characteristics.

Preparation of a catalog of entries of Phaseolus sp. present in CIAT'S germplasm.

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BEAN GERMPLASM

List of characteristics to be registered*

1. Days to emergence
2. Seedling vigour
3. Length of hypocotyl
4. Colour of hypocotyl
5. Size of foliole
6. Leaf area index
7. Height of canopy
8. Number of nodes at flowering
9. Number of nodes at maturity
10. Initiation of flowering
11. Duration of flowering
12. Colour of flower
13. Sensitivity to photoperiod
14. Growth habit
15. Height of plant
16. Thickness of stem
17. Number of clusters per plant
18. Number of pods per plant
19. Number of twigs with pods
20. Angle of twigs
21. Number of seeds per pod
22. Shape of seeds
23. Primary colour of seeds
24. Secondary colour of seeds
25. Seed brightness
26. Seed weight
27. Plant yield
28. Total dry matter
29. Harvest index
30. Lodging
31. Yield from replicated trials
32. Rust (*Uromyces phaseoli*)
33. Angular leaf spot (*Isariopsis griseola*)
34. Web blight (*thanatephorus cucumeris*)
35. Anthracnose (*Colletotrichum lindemuthianum*)
36. Root rot - several fungi
37. Common mosaic (CBMV)
38. Golden mosaic (GBMV)
39. Chlorotic mottle
40. Common bacterial blight (*Xanthomonas phaseoli*)

41. Empoasca sp.

42. Apion sp.

43. White fly

44. Tetranychus sp.

45. Tropical mites

46. Zabrotes sp.

47. Acanthoscelidae

48. Rhizobium efficiency index

49. Reference to other programs

50. Mixture of genotypes.

51. Clean seed

52. Species

* Together with these data, a basic register will be kept which includes: CIAT register number, entries, useful nomenclature, source, origin, etc.

CIAT COLLECTIONS, CLASSIFIED ACCORDING TO SOURCE OF SEED

Country	Number of collections
U.S.A.	4146
Australia	10
Puerto Rico	3
Mexico	743
Guatemala	409
United Kingdom	1387
Venezuela	313
Nicaragua	4
Costa Rica	1099
El Salvador	107
Colombia	280
Honduras	954
Ecuador	7
Haiti	2
Chile	128
Peru	119
Brazil	1033
Dominican Republic	1
France	12

Country	Number of collections
Surinam	2
Japan	34
Bolivia	1
Jamaica	3
New Zealand	20
Belgium	43

NUMBER OF INTRODUCTIONS IN CIAT, INCLUDING SOME SPECIES OF *Phaseolus* OF AMERICAN ORIGIN AND INTERSPECIFIC HYBRIDS

Phaseolus vulgaris	11.615
Phaseolus acutifolius	20
Ph. acutifolius var. latifolius	4
Phaseolus coccineus	18
Phaseolus dumosus	1
Phaseolus polistachyus	3
Phaseolus aborigeneus	1
Phaseolus lunatus	6
Hybrids	130
TOTAL	11.798

VARIATION FOUND IN BEANS, *Phaseolus vulgaris*, ON 1900 ENTRIES

EVALUATED IN 1975 AT PALMIRA, COLOMBIA

Days to emergence	Days to flowering	Height of plant in cms.	# clusters per plant	# pods per cluster
5-12	29-72	22-220	1-29	1-5

# pods per plant	# grains per pod	Weight 100 seeds (grms.)	Weight grain p/plant (grms.)	Days to harvest
3-47	2-10	12-58	1-37	61-110

BEAN GERMPLASM

Remittance of seeds

1973-1975

Place		No. of samples
Colombia		202
South America		2.286
Central America		5.843
North America		395
Europe and Australia		96
Asia		118
Africa		160
	TOTAL	9.100