BREEDING METHODS IN LEGUME CROPS

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Introduction

The breeding methods used in legume crops are essentially the same as those for the other self-pollinated species. These shall include collection of varieties to form the germplasm pool, evaluation of the varietal collection, hybridization, evaluation of the hybrid progenies and the subsequent segregating populations. In the evaluation of both the varietal collections and the segregating generations, the plant breeder keeps a keen eye for outstanding plants or lines with the objective of increasing them so as to release them for commercial production.

While the general procedures of breeding are more or less the same, the specific methods vary depending on the crop one is working on and the breeding objectives, which in turn are influenced by the specific conditions prevalent in the country as well as the demands of the consumer.

The legume breeding program in the Philippines is no exception to this general trend. There are many legume crops of importance in the Philippines, but more efforts have been placed on the improvement of Mungbeans (*Vigna radiata* (L.) Wilczek), soybeans (*Glycine max* (L.) Merr.) and peanuts (*Arachis hypogaea* L.). To a lesser extent, breeding efforts involve cowpea, winged beans, field beans, pigeon peas, chick peas, rice beans, and adzuki beans. The priority on mungbeans, soybeans and peanuts has been dictated largely by the demands for these legume crops in the Philippines.

Methods of breeding

1. Varietal collection and evaluation

Varieties are collected from all over the Philippines as well as from other countries. Some of the foreign introductions were obtained from international centers such as the Asian Vegetable Research and Development Center (AVRDC), International Center for Tropical Agriculture (CIAT), International Crops Research Institute from Semi-Arid Tropics (ICRISAT), International Institute of Tropical Agriculture (IITA), and United States Department of Agriculture (USDA). The varietal collection of the Institute of Plant Breeding as of July, 1977 is as follows:

Legume Crop	No. of Varieties
Mungbean (*Vigna radiata* (L.) Wilczek)	2099
Soybean (*Glycine max* (L.) Merr.)	1198
Peanut (*Arachis hypogaea* L.)	274
Cowpea (*Vigna unguiculata* (L.) Walp)	349
Winged Bean (*Psophocarpus tetragonolobus* (L.) DC)	18
Field Bean (*Phaseolus vulgaris* L.)	400
Pigeon Pea (*Cajanus cajan* (L.) Millsp)	412
Chick Pea (*Cicer arietinum* L.)	400
Rice Bean (*Vigna umbellata Roxc.*)	39
Adzuki Bean (*Vigna angularis* Wight)	23

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The collections are grown in observational nurseries where preliminary evaluation as well as seed multiplication are undertaken. In the Philippines, the collections are evaluated in terms of their disease and insect pest resistance and adaptability to the growing conditions in the country. For mungbeans, soybeans and peanuts, the reactions to the following diseases are evaluated:

a) Mungbeans: Cercospora leaf spot, powdery mildew anthracnose, and rust
b) Soybeans: rust, bacterial blight, bacterial pustules, mosaic and Sclerotium blight
c) Peanuts: rust, mosaic, Sclerotium blight, black spot

The varietal collections are also evaluated in terms of their reaction to insect pests like bean fly, bean aphids, Southern green stink bug and bean weevil.

2. Hybridization

The choice of the parental lines in the hybridization program depends on the breeding objectives. For example, the breeding objectives of the Mungbean improvement program in the Philippines are as follows:

1) High seed yield.
   The average yield of mungbeans in the Philippines is 0.55 ton/ha. The new varieties developed through hybridization yield about two tons per hectare.
2) Resistance to diseases and insect pests
3) Earliness and uniform pod maturity.
4) High seedling vigor and medium plant stature.
5) Seedcoat color and seed quality. Filipinos have general preference for the yellow seeded varieties.
6) Adaptation to intensive cropping system. Mungbeans are grown in mixed cropping as well as in intercropping systems. They are grown before or after a rice crop as well as in spaces under the plantation crops such as coconut, rubber and oil palm and in between rows of slow-growing crops like sugar cane.

Therefore, varieties found to be resistant to the disease and insect pests and possessing the other desirable traits in the observational nurseries are crossed with the widely grown varieties and also among themselves. Hundreds of crosses are produced every year. In addition to the two-way crosses, three-, four-, six- and even eight-way crosses are performed, in order to broaden the genetic base of the subsequent segregating generations from which selections of the high yielding and resistant varieties shall be done.

3. Screening and evaluation of advanced generations

In legume breeding several methods may be applied such as pedigree method, bulk population method, pure line breeding, and mass selection.

a. Pedigree Method. In this method, superior types are selected in the F_2 generation and grown in the successive generations, keeping the record of all parent-progeny relationships. In the advanced generations, F_3 and F_4, selection is practiced for the best plants in the best families and in F_5 of F_6 the selection emphasis is put on the best families. With the pedigree record retained, one will be able to select only one or two families with a common ancestor. The final evaluation of the outstanding families is then undertaken including precise yield tests and quality tests.

b. Bulk Population Method. In this method, F_2 are grown in a single plot and are harvested in bulk to be planted the next season. The plant breeder may repeat this process as many times as he deems it necessary. During this period natural selection plays a role in shifting the gene frequencies to the bulk population. In addition to the natural selection, the plant breeder aids by roguing the undesired plants. The derived type will then be subjected to final evaluation.

c. Pure Line Breeding. This method involves the selection of individual plants in a heterogeneous population. Progeny rows from individual plant selections are observed and

evaluated. This evaluation may extend for several generations. Outstanding lines are selected and then grown in replicated trials with the established commercial varieties as check. The lines that show better performance than the check may then be released by the plant breeder for commercial production.

d. Mass Selection. Like the pure line breeding, individual plants are also selected from a heterogeneous population in the mass selection method. Progeny rows from individual plants are also evaluated and outstanding lines selected. Seeds from the outstanding plants are bulked to constitute the derived type or variety.

Depending on the many factors that influence a breeding program, the plant breeder may use different combinations of these methods. For example, in the Philippines we follow the bulk population method up to the F_3 or F_4 and then individual plant selections are made. Seeds from each individual plant selection are grown in a row for critical evaluation. Only the outstanding plants from the row are further grown for evaluation and purification. After three or four generations, the outstanding lines may now be included in the preliminary yield tests and eventually in the advanced yield tests.

Some of the introduced varieties would compare favorably with the existing commercial varieties. Such varieties are purified and eventually released following the pure line method of breeding.

Some of the outstanding varieties of the legume crops produced by these methods are:

1) Mungbean
   a. E. G. Glabrous #3
   b. MG50 - 10A (G)
   c. CES 55
   d. CES 87
   e. UPL-Mg2 (PAG-ASA)
   f. MD15-2
   g. EGMY-17
2) Soybeans
   a. CES 434
   b. L 114
   c. T K. No. 5
   d. Clark 63
   e. UPL - Sy2
   f. B - 256
3) Peanut
   a. E. G. Bunch
   b. CES - 101
   c. UPL - Pn2 (Mekong)
   d. E. G. Red

Yield tests

Part of the evaluation of the promising lines or varieties is the yield testing program. In the Philippines yield tests are conducted at two levels: preliminary tests, where promising lines and varieties are grown in three-row plots, six meter long and replicated three times at the UPLB experiment station. Outstanding lines are selected and tested in the advanced yield trials which are conducted at several locations in the country.

These yield trials not only evaluate the yielding capabilities of these lines but also their regional adaptability. The varieties or lines with the highest yield performance and wide range of adaptability are recommended to the Philippine Seedboard for commercial production. The regional tests also allow the selection of varieties or lines for specific regions in the Philippines.

Table 1. Advanced yield tests of mungbeans in the Philippines

Cropping Conditions	No. of Locations
Upland monoculture	7
Lowland rice paddy	
Before rice	4
After rice	4
Mixed cropping	
With sugar cane	4
With coconut	3
With corn	3

Screening techniques

Part of the evaluation of the varietal collections and the segregating populations is represented by the reactions to the common diseases and insect pests. In the screening for the legume diseases, three methods are used in the Institute of Plant Breeding:

a Natural epiphytotics. Diseases like rust, Cercospora leaf spot, and powdery mildew are of common incidence in the Mungbean farms in the Philippines. In the UPLB experiment station, the continuous cropping of mungbean further encourages the continuous high incidence of these diseases. It is, therefore, easily possible to use these natural epiphytotics as one of the screening methods for mungbean.

The common diseases of soybeans and peanuts show the same trend as the mungbean diseases. Our screening efforts for these diseases, therefore, depend to a large extent on the natural epiphytotics.

b Artificial Inoculation. In addition to the natural epiphytotics, the screening for disease resistance is done in the laboratory and in the green house. The lines and varieties found to be resistant in the field are further tested in the greenhouse. In the artificial inoculation work, the plants are given higher doses of the inoculum to make certain that the varieties or lines are resistant and do not escape.

c Biochemical Method. A method for screening for disease resistance was recently devised in the Institute of Plant Breeding. This method makes use of the differences in the enzyme content and the enzyme activities of the resistant and susceptible plants which can be detected by electrophoresis. Using this technique individual plants may be tested at seedling stage and only those that show resistant reaction shall be allowed to mature and produce seeds.