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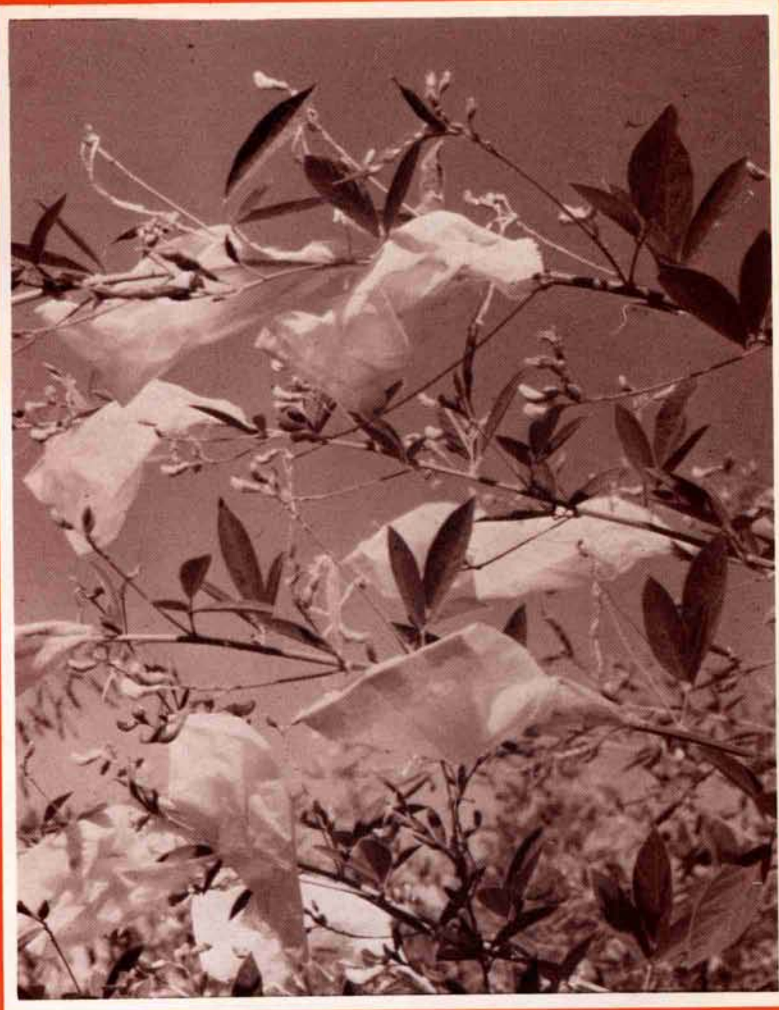

Food Legume Improvement and Development

Proceedings of a workshop held at The University of Aleppo, Syria, 2-7 May 1978

Geoffrey C. Hawtin and George J. Chancellor, Editors

CANADA

Published by The International Center for Agricultural Research in the Dry Areas and International Development Research Centre

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IDRC–126e

Food legume improvement and development: proceedings of a workshop held at the University of Aleppo, Aleppo, Syria, 2–7 May 1978. Ottawa, Ont., IDRC, 1979. 216 p.:ill.

/IDRC publication/. Compilation of workshop papers on /legume/ /food production/ in the /Middle East/ and /North Africa/ — discusses agro/bioclimatology/ and /cultivation system/s, /nutrition/al value and /food composition/; /plant production/ (particularly of /chickpea/s, /lentil/s, and /faba bean/s), /agricultural research/, /cultivation practice/s for /plant protection/; /plant disease/s, /insect/ /pest/s, /disease resistance/, /weed control/ problems (use of /herbicide/s in /arid zone/s); /plant breeding/ and /genetic improvement/. /IDRC mentioned/, /list of participants/.

UDC: 633.3 ISBN: 0-88936-202-5

Microfiche edition available

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and the
International Development Research Centre

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Methods of Population Improvement in Broad Bean Breeding in Egypt

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The commercial varieties of broad bean currently used in Egypt are the latest in a series of varieties evolved through individual plant selection or hybridization in the cultivated Egyptian landraces, which are mainly of the medium- and small-seeded types. These varieties have a rather extended flowering period and are tolerant to chocolate spot (*Botrytis fabae*) and rust (*Uromyces fabae*), the most common fungal diseases of the country, especially severe in the North Delta of the Nile. As a result, the large-scale distribution and adoption of these improved types has led to a considerable improvement in both the level and stability of seed yield.

Selection from this rather narrow genetic base has, however, tended to result in varieties with very similar branching, flowering, and fruiting characteristics, and it seems that most of the original genotypic variation available from natural sources within the country has been exploited. As a consequence, little further progress is expected from the traditional improvement scheme involving selection from local land varieties. Despite this, studies of selected strains collected from different parts of the country have revealed differences in agronomic characters that could be used for further improvement and so this method still continues to be a part of the overall Egyptian breeding program.

In addition to the selection program, improvement efforts have also focused extensively on biparental crosses involving selections of landraces or landraces and introductions and aimed at improving disease resistance and adaptability. However, to date, only 1 cross out of 66, NA 29 (Holland) × Giza 1 (Commercial variety) has proved highly successful. This cross has resulted in the production of two varieties, namely Giza 3 and Giza 4, through the pedigree method. Giza 3 is tolerant to fungal diseases and has an average seed yield 11% greater than its parent Giza 1; it is well adapted to production in the North Nile Delta region. In contrast, Giza 4 is much more widely adaptable, yielding 5% more than Giza 3 in the South Delta and Middle Egypt regions and 6% more than the local variety Revaia 40 in Upper Egypt.

Population Improvement

In spite of the advances achieved by past breeding efforts it appears that line breeding based on recombinations from biparental crosses does not permit rapid progress in broad bean improvement. New approaches are thus needed to achieve the improvements in yield level and stability that seem possible.

Broad bean stands midway between a completely self-fertilized and a completely cross-fertilized crop, having on average one-third outcrossing and two-thirds selfing. In Egypt, considerable variation was found in the percentage of cross pollination, and this could be attributed to the varying climatic conditions affecting the prevalence of insect pollinators. However, unlike most self-fertile crops, broad beans require the action of an insect alighting on the flower to cause the dehiscing anthers to come in contact with the stigma (a process known as tripping). So, despite being only 33% cross pollinated, broad beans may be considerably reliant upon insects, specifically wild bees, to give adequate fertilization and hence good pod set. This is one of the reasons why seed yields tend to vary greatly between years and locations, depending to a large extent on the wild bee population.

In England, studies on the possibility of producing a completely autofertile broad bean crop have revealed the presence of many of the necessary characters in available lines but, in general, in association with low levels of seed yield and adaptation. The total number of pods per plant has been found to be a good selection index for improving seed yield in broad beans; however, a negative correlation between seed weight and pods/plant tends to limit the improvements that are possible by using this criterion.

It thus appears that there is considerable scope for improvement of this crop by methods aimed at breaking the association between low yield and high autofertility levels on the one hand and low number of pods per plant and high seed weight on the other. Even in the absence of linkages between characters, frequent hybridization is necessary to release variability, which is the prerequisite for selection. Therefore, a population improvement program that involves continual crossing designed to give the maximum opportunity for the rearrangement of genes in linkage groups and designed to provide a wide range of genetic backgrounds against which the genes and gene arrangements can be expressed seems to be the best method of tackling this problem. In addition, continuous selection will be essential so that the improvements generated by each series of crosses are accumulated and concentrated in the population. A system of recurrent selection, under which pressure is applied to a freely intercrossing population and the selected material is again intercrossed and subjected to selection, so that a series of crossing and selection cycles result in continuous genetic improvement, appears to be the breeding method best suited to satisfying both these criteria. This method, by which the population itself is improved from generation to generation, steadily increases the chance of identifying individuals with the required combinations of characters. These individuals are then propogaged as pure lines and form the new variety for multiplication.

Establishing Populations

Recognizing the potential of this breeding method, the broad bean improvement program in Egypt has been focusing on recurrent selection since 1974. Nine composite populations aimed at achieving varieties with higher adaptability, disease resistance, and good protein quality have been established in the intervening 4 years. Entries included in these composites are characterized by genetic diversity and desirable agronomic characters. They include cultivated landraces, hybrid derivative lines selected from yield trials, commercial varieties, and introductions. Each entry is represented by 5–10 seeds in each composite, which is grown in a 1 or 2 Saran screen compartment (mesh=20×20 mm) of 7.20 m ×3.60 m × 1.80 m in size.

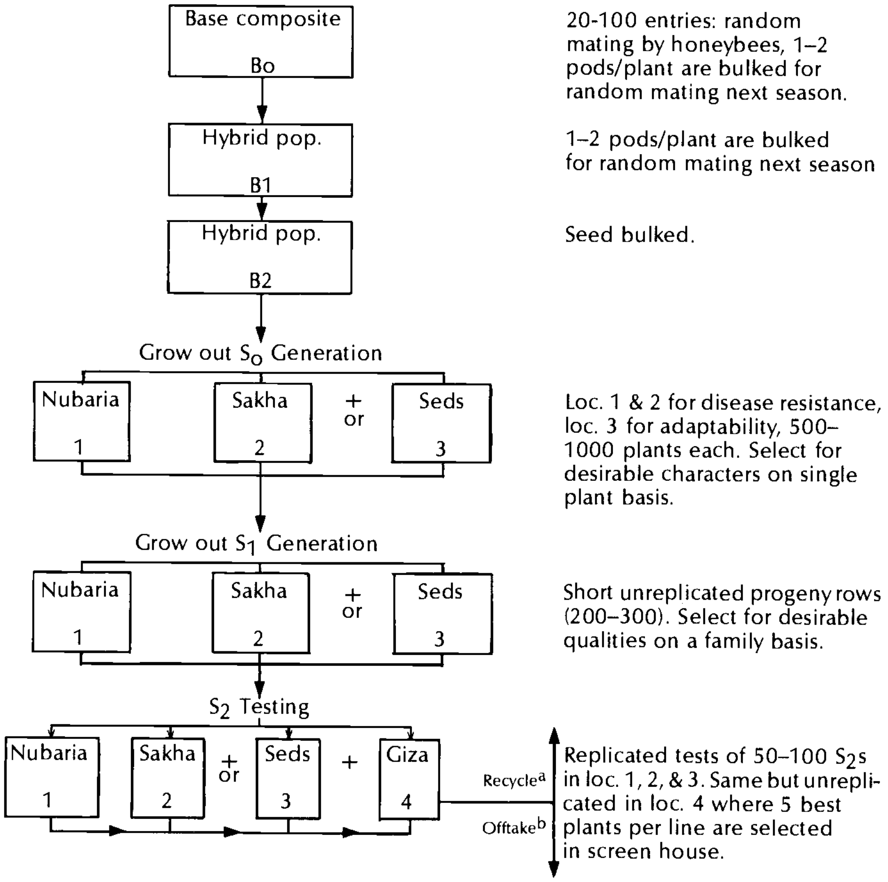
Increasing Random Mating by using Honeybees

To increase both cross-pollination and seed set, a small framed nucleolus beehive (60 × 45 cm) is placed in each Saran compartment immediately following flower initiation. The hive is supplemented with a new brood of honeybees every 10–15 days during the flowering season, which usually extends for up to 60 days. Studies using a genetic marker have indicated that, under these conditions, cross pollination can be as high as 79.9%. It thus appears that this technique is very useful as a breeding method to ensure a freely intercrossing population.

Recurrent Selection

Random mating, using the honeybees, is continued in the composite for three seasons, the composite in the second and third seasons being composed of the seed bulk from one or two pods sampled from each plant grown in the previous season. The remnant seed bulk can be handled as a hybrid bulk population on which the pedigree or improved bulk breeding method is applied to identify lines with the desirable characteristics.

After three seasons of recombination, the populations are then grown out for selection. Composites destined for selection with regard to disease resistance are grown at the Nubaria and Sakha research stations, and while those to be selected for adaptability, protein content, and other characters are grown at Seds. Replicated tests for yield determination are carried out in the S_2 generation at these three locations in addition to Giza, where the best selected lines from all the locations are grown for selection and recycling (Fig. 1).



[a]*Only the five selections in each of the 10% best performing lines over locations are recycled.*

[b]*Offtake for pedigree, selection, or bulk population improvement can be done at all stages.*

Fig. 1. Recombination and selection procedure for population improvement in broad beans (Vicia faba L).

With this program it is hoped that selection from continuously improving populations will result in the continuous generation of improved high-yielding disease-resistant and adaptable varieties suitable for production in Egypt.