Use of Exotic Interracial and Wide Crosses for Common Bean Cultivar Development

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Introduction. There seems to be adequate useful genetic variation among cultivars for such traits as resistance to anthracnose, *Bean common mosaic virus* (BCMV), and rust. However, favorable alleles and quantitative trait loci (QTL) controlling these traits are not uniformly distributed across different market classes, races, and gene pools. Moreover, cultivars have inadequate resistance for angular leaf spot, ascochyta blight, *Bean golden yellow mosaic virus* (BGYMV), bruchids, common bacterial blight, leafhoppers, and white mold to mention a few. Thus, it is essential to identify, introgress, and pyramid favorable alleles and QTL from across different market classes, races, and gene pools within cultivars; from wild populations within the primary gene pool; and from related species in the secondary and tertiary gene pools. Use of exotic germplasm assures continuous availability of useful variation, maximizes selection gains, and helps develop new plant type, maturity group, and market classes. It also helps breed for durable pest resistance, especially when caused by variable pathogens and insect biotypes.

To facilitate introgression and pyramiding of favorable alleles and QTL from distantly related germplasm, it is essential to know the genetic distance of the donor germplasm in relation to the cultivars under improvement. The greater the distance, the more difficult it is to introgress and pyramid favorable alleles and QTL from exotic germplasm. Differences in growth habit, phenology, and seed traits affect the quality and quantity of useful genetic variation within hybrid populations and selection gains. For example, a large proportion of the tropical and sub-tropical germplasm is poorly adapted in the U.S., because of its sensitivity to longer day-lengths, and undesirable climbing growth habit. Consequently, the bi-parental crosses using conventional pedigree, bulk-pedigree, and single-seed-descent selection methods yield little or no progress. Instead, backcrossing or recurrent selection would be required.

A three-stage breeding strategy is often advisable for introgression and pyramiding of favorable alleles and QTL from exotic germplasm (Kelly et al., 1998; Singh, 2001). In the first step, favorable alleles and QTL from specific germplasm are introgressed in the cultivar to be improved. Secondly, favorable alleles and QTL from all other sources are pyramided in a similar adapted background. Finally, the resulting elite germplasm are crossed with other elite breeding lines and cultivars to develop new cultivars. Thus, the genetic variation within a population decreases from step one to step three. However the proportion of useful genetic variation increases accordingly. There are numerous examples of introgression and pyramiding of favorable alleles and QTL from exotic germplasm. Nonetheless, due to space limitations, only a few examples will be given here to highlight the importance of exotic germplasm for cultivar improvement. For further details please refer to Miklas (2000) and Singh (2001).

Introgression of Favorable Alleles and QTL Between Market Classes Within a Race. In-determinate upright growth habit Type II was introgressed from tropical black cultivars in determinate Type I navy beans in Michigan to increase yield and facilitate mechanical harvest. Type II growth habit was also introgressed into Type III Brazilian 'mulatinho' and 'carioca', and Central American small red cultivars. Resistance to BCMV was introgressed from red Mexican to great northern and pinto beans in the U.S., and from small red mottled (San Cristobal 83) to Central American small red.

Introgression of Favorable Alleles and QTL Between Races Within A Gene Pool. Growth habit Type II and resistance alleles *I* for BCMV, *Ur-3* and *Ur-11* for rust, and/or *Co-4* [2] for anthracnose were introgressed from race Mesoamerica into race Durango great northern, pinto, pink, and/or small red cultivars. Similarly, *bgm-1* allele for resistance to BGMV and BGYMV was introgressed from race Durango to Mesoamerica, BCMV and rust resistance from race Mesoamerica to Jalisco, and biological nitrogen fixation and *Apion godmani* resistance from race Jalisco to Mesoamerica cultivars.

Introgression of Favorable Alleles and QTL Between the Andean and Middle American Gene Pools. Resistance to anthracnose, BCMV, BGMV, BGYMV, and rust was introgressed from the Middle American to Andean germplasm. On the other hand resistance to anthracnose and rust was introgressed from the Andean to Middle American germplasm. Worthy of special mention is the project lead by Dr. J. Rennie Stavely at USDA-ARS in collaboration with the Michigan State University, North Dakota State University, University of Florida, and University of Nebraska. The Andean rust resistance alleles *Ur-4* and *Ur-6* were combined with the Middle American alleles *Ur-3* and *Ur-11* and BCMV and BCMNV resistance alleles *I* and *bc-3* into great northern, pinto, and other market classes (Pastor-Corrales, 2003).

Introgression of Favorable Alleles and QTL From Wild Common Bean. Introgression of high level of resistance to bruchids (*Zabrotes subfasciatus* Boheman) from wild common bean to cultivars is a singular well-documented example. Although over a half-dozen resistance alleles with varying effects exist at the arcelin locus, the multi-lines must be used to combine them in a cultivar. Use of electrophoresis and ELISA techniques have helped breeding for resistance to bruchids.

Introgression of Favorable Alleles and QTL From the Secondary Gene Pool. *Phaseolus* species in the secondary gene pool are known to possess such desirable traits as resistance to anthracnose, ascochyta blight, BGMV, BGYMV, BYMV, common and halo bacterial blights, and white mold. But, only moderate level of resistance to BGMV, BGYMV, common bacterial blight, and white mold have been introgressed into common bean. Instability of the interspecific genotype and fast reversal to common bean phenotype has been the major limitations.

Introgression of Favorable Alleles and QTL From the Tertiary Gene Pool. Some accessions of *P. acutifolius* possess high level of resistance to bruchids [*Acanthoscelides obtectus* (Say)], leafhoppers (*Empoasca kraemeri* Ross & Moore), drought, heat, and common bacterial blight, among other traits. But, only high level of resistance to common bacterial blight has been introgressed and pyramided into common bean.

Future Prospects. A relatively large proportion (>90%) of available variability within *Phaseolus* species still remains to be adequately evaluated and utilized for cultivar development. Despite substantial progress made thus far there are hardly cultivars with resistance to four or more abiotic and biotic stresses. Introgression of favorable alleles and QTL from exotic germplasm therefore must continue. Help from germplasm curators, and long-term federal, state, and private funding are essential for exotic germplasm conversion and enhancement, and cultivar development.

References

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