Potential Contributions ofAndean Beansthe Genetic Improvement of Black Beans

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U ñique traits that may contribute to the genetic improvement of black beans are found in the Andean bean gene pool. The purpose of this paper is to identify a few of these traits and discuss strategies that can be used to facilítate the transfer of alíeles between gene pools.

Bean golden mosaic (BGMV) is an important disease in both Central America and the Caribbean. In recent years, much progress has been made in the identification of specific genes for resistance to this disease. The recessive gene, bgm-1, which is of Middle American origin, has been usedto improve the BGMV resistance of black, small red, red mottled, and snap beans (Table 1). The bgm-1 gene confers a non-chlorotic reaction to bean golden mosaic virus (BGMV). Velez et al. (1 998) reported that two genes control the BGM reaction of the resistant Andean bean line DOR 303. A recessive gene, bgm-2, confers a non-chlorotic reaction to BGMV. This gene has been shown to be nonalielic to bgm-1. Red mottled and small red lines are being developed at the University of Puerto Rico which should combine the bgm-1 and bgm-2 resistance genes.

The BGMV reaction of lines which pyramid these resistance genes has yet to be determined. The presence of the dominant gene, Bgd, in DOR 303 results in a dwarfing reaction when plants are infected with BGMV. This is considered to be an undesirable trait because the dwarf plants are unproductive. The bgm-2 and Bgd genes do not appear to be linked because light red kidney lines have been selected at the University of Puerto Rico that have the non-chlorotic reaction to BGMV without the dwarfing response. The red moftled landracevarieties' PompadourG'and 'Pompadour J' have been reported to have modérate levels of BGMV resistance but the nature and inheritance of this resistance has not been determined.

Nevertheless, the small red variety Tío Canela 75' which has high levels of BGMV resistance is the product of an inter-gene pool cross between the Andean red mottled variety 'Pompadour J' and the Middle American sources of BGMV resistance DOR 483 and DOR 391 (Rosas et. al, 1997).

Common bacterial blight (CBB) caused by *Xanthomonas campestris* pv. *phaseoli* is another

Table 1. Sources of different reactions to bean golden mosaic virus.

Trait	Inheritance	Source	Gene Pool
Non-chlorosis	Bgm-1	A 429	Middle American
Non-chlorosis	Bgm-2	DOR 303	Andean
Delayed symptom expression	Quantitative	DOR 364	Middle American
Normal pod development	Bgp	DOR 482	Middle American
Dwarf plants	Bgd	DOR 303	Andean

important bean disease in Central America and the Caribbean. Several Andean bean lines in the PROFRIJOLCaribbeanAdaptationNurseries have expressed useful levels of resistance to CBB (PROFRIJOL, 1995). One of the most promising red mottled lines is MUS-PM-31-F5 which combines CBB and web blight resistance. Beaver et al. (1 992) reported that certain landrace varieties of red mottled beans had resistance to CBB. In Puerto Rico, 'Pompadour K' has been used as a parent in many crosses because this red mottled variety has resistance to both CBB and rust.

Andean beans also have the potential to contribute to rust [*Uromyces appendiculatus* (Pers.) Unger var. *appendiculatus]* resistance of black beans. Field evaluations conducted in Honduras

Pijao and avirulent to the Andean parents (Table 2). Subsequently, crosses were made between lines that produced a differential reaction when inoculated with a particular pathotype. Rust reactions of F2 plants derived from cross between ICA Pijao and Pompadour K fit a 3:1 resistant/ susceptible segregation pattern. Bokosi etal. (1995) identified a simple dominant gene in the red mottled landrace variety 'PC-50' which confers resistance to bean rust pathotypes of diverse origin. Once Andean genes for rust resistance are identified, molecular markers for these genes should be identified in order to facilítate the transfer of this resistance to black beans and other seed types.

Table 2. Rust reaction of F3 lines evaluated in the greenhouse at the University of Nebraska in 1994.

Cross	F3 Line	Rust Isolate			
		D91SJ1b	D85C1-1	PR911-3C	PR912
ICA Pijao x Pompadour K	9359-258-12	-	+	-	+
	9359-255-9	-	+	-	-
ICA Pijao x Miss Kelly	9359-247-4	+	+	+	+
	9359-249-3	-	+	+	+

Source: Halpay (1994).

found the line BelMiDak RR-1 to have rust resistance when exposed to highly virulent pathotypes. This line combines Ur-11, a Mesoamerican resistance gene, with Ur-4, a resistance geneof Andean origin (Stavelyetal., 1992). Lines in the same nursery having only the Ur-11 gene (Pi 1 81996) and lines with the Ur-4 gene (Early Gallatin) were susceptible to rust. Although some Andean lines are recognized to have durable resistance to rust, little is known about the inheritance of this resistance. At the University of Nebraska, Halpay (1 994) evaluated F3 lines from the inter-gene pool crosses ' ICA Pijao x Pompadour K', 'ICA Pijao x Miss Kelly' and' ICA Pijao x Montcalm' using pathotypes of rust that were virulent to ICA

Dense abaxial leaf pubescence found on beans of Andean origin has been reported to be related to adult plant resistance to bean rust (Mmbaga and Steadman, 1992). Field evaluations in Puerto Rico of red mottled lines from the Pompadour landrace collection found pubescent lines to have more rust resistance than near- glabrous red moftled lines (Table 3). Oviedo (1989) found the dense leaf pubescence of the red mottled variety 'PC-50' to be a simple dominant trait and Bokosi et al. (1995) reported that the specific gene for rust resistance in PC-50 was not linked with dense leaf pubescence. In 1996, field evaluations of the VIFURE at Zamorano found that most lines with resistance to angular leaf spot *(Phaeoisariopsis griseola)* were

Andean lines with dense leaf pubescence. The potential contribution of dense pubescence or specific resistance genes from Andean lines to this increasingly important disease deserves further attention. The author is not familiar with any black bean line with dense leaf pubescence. The transfer of the dense leaf pubescence to small red beans has already been initiated at the University of Puerto Rico and it may be possible to identify black-seeded progeny from these populations that have dense leaf pubescence.

The light red kidney variety Indeterminate Jamaica Red' has been found to have heattolerance in the Caribbean and in California. In Puerto Rico, Indeterminate Jamaica Red produced greater seed yield than DOR 303 by producing a greater number of seed pod and a greater 100 seed weight. Baiges et al. (1996) found the heritability of heat tolerance in Indeterminate Jamaica Red to be low to intermedíate which suggests that field selection for heat tolerance should be conducted using advanced lines in replicated triáis. Indeterminate

Table 3. Rust reaction of red mottled landrace lines evaluated in Puerto Rico from 1994 to 1997.

Line		1994		1996		1997	
	Pub. score 1/	Pustule size2/	Percent inf. 3/	Pustule size2/	Percent inf. 3/	Pustule size2/	Percent inf. .3/
Larga comercial	6	1	0	1	0	1	0
Pomjor 17	5	1	0	1	0	1	0
Pomjor 19	5	1	0	1	0	1	0
Pomjor 5	5	1	0	1	0	1	0
Pomjor 8	5	1	0	1	0	1	0
Derrumba 8	5	1	0	1	0	1	0
Pacasas 12	5	1	0	1	0	1	0
Váson 4	1	3,4	1	3,4	3	5C,4,3	5
Chijar 31	1	2,3	<1	2,3	>1	4,5C,3	5
Chijar 35	1	3,4	3	3,4	1	4,5C,6C	5
Vason 19	1	3,4	1	3	1	5C,6C	10
Vason 21	1	3,4,5,6	<1	3	1	5C,6C	10
Vason 22	1	3,4	1	4,5	1	5C,6C	15
Pacasas 31	1	3,4,5	<1	3	>1	6C,5C	5

1/ Rated on a scate from 1 to 6 where 1= glabrous and 6= dense pubescence.

2/ Rated on a scale from 1 to 6 where 1= no pustules and 6= pustule diameter > 0.8 mm. C = chlorosis.

3/ Percent leaf area infected with rust.

Jamaica Red should be crossed with black beans such as Negro Tacaná and XAN176, which already have useful levels of heat tolerance, in order to deveiop progeny which may have higher levels of tolerance to this abiotic stress.

Dudley (1982) recommended that at least one backcross should be conducted if one parent has more favorable alíeles than the other parent. Backcrossing, therefore, should improve the probability of recovering desirable progeny from crosses between bean lines from the Andean and Middle American gene pools. After making the backcross, breeders should consider advancing the lines a few generations using single seed descent in order to increase the frequency of progeny with the desired trait (Table 4). In most cases, two backcrosses can be conducted before screening lines for the desired trait

Figure 1. Planting genetic dwarf bean plants in pots.

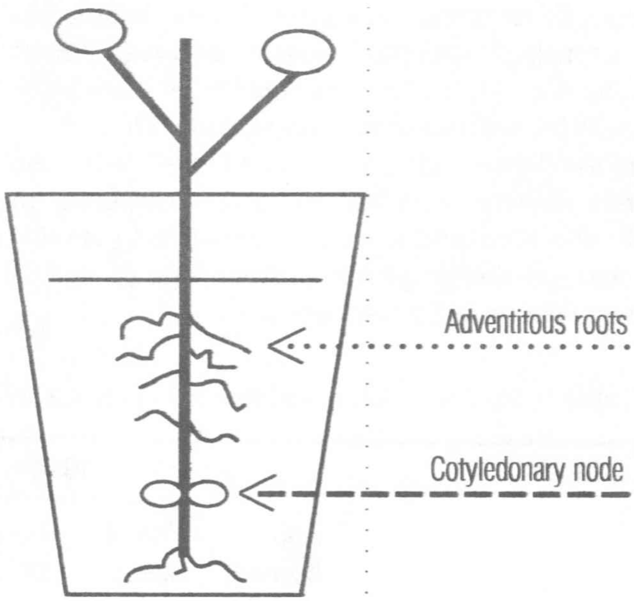

Table 4. Mínimum number of plants to evalúate In order to have a 99% probability that at least 1 plant has the desired genotype when using one and two backcrosses.

Generation after one backcross	One gene	Generation after Two backcrosses	One gene
BC1F2	35	BC2F2	72
BC1F3	23	BC2F3	47
BC1F4	19	BC2F4	40
BC1F5	18	BC2F5	37

Source: Beaver and Macchiavelli (1998).

Bean crosses between the Middle American and Andean gene pools often produce hybrid dwarf s (Singh and Gutiérrez, 1984). The black-seeded variety ICA Pijao, which does not possess the DL **genes, can be used as a bridge in making crosses** with beans of Andean origin. In Puerto Rico, we have been successful obtaining seed from hybrid dwarfs by promoting the growth of adventitious root growth above the cotyledonary node (Beaver, 1993). Hybrid dwarf plants are identif ied in the f ield and transplanted to pots (Figure 1). A portion of the main stem above the cotyledonary node is covered with soil and frequent irrigation is used to promote adventitious root growth.

Bean breeders of all seed types benefit from **the preservation of biodiversity. Unique resistance** to BGMV, common bacterial blight and rust already has been identified in the Pompadour landrace collection from the Dominican Republic. 'Pompadour checa' (G6616) is the source of gene resistance to bean common mosaic in small red varieties such as 'Catrachita'. It is, therefore, important for bean breeding programs in the

Caribbean to collect and characterize their Andean bean landraces. Special attention should be paid tothe collection of landrace varietiesfrom hillsides where sources of tolerance to abiotic stress such as drought and low fertility may exist.

LITERATURE CÍTED

1. Baiges, S., J.S. Beaver, P.N. Miklas and J.C. Rosas. 1996. Evaluation and selection of dry beans for heat tolerance. Ann. Rep. Of the Bean Improv. Coop. 39:88-89.

2. Beaver, J.S. and R. Macchiavelli. 1998. Breeding strategies for pyramiding genes for disease resistance. Ann. Rep. of the Bean Improv. Coop. 41: (Submifted).

3. Beaver, J.S. 1993. A simple method for producing seed from crosses hybrid dwarfs derived from crosses between Middle American and Andean gene pools. Ann. Rep. of the Bean I(nprov. Coop. 3628-29.

4. Beaver, J.S. J.R. Steadman and D.P. Coyne. 1992. Field reaction of landrace components of red mottled beans to common bacterial blight. HortScience 27:5051.

5. Bokosi, J.M., D.P. Coyne, J.R. Steadman, D. O'Keefe and J. Reiser. 1995. Inheritance and association of specific rust resistance, stem color, leaf pubescence, and flower color in common bean. Ann. Rep. of the Bean Improv. Coop. 38:141-142.

6. Dudley, J.W. 1982. Theory for transfer of alíeles. Crop Sci. 22:632-637.

7. Halpay García, M. J. 1994. Evaluation de cinco poblaciones de habichuela (Phaseolus vulgafis L.) para su reacci6n a diferentes aislamientos de roya (Uromyces appendiculatus). M.S. Thesis. University of Puerto Rico. Mayaguez, Puerto Rico. 87 p.

8. Mmbaga, M.T. and J.R. Steadman. 1992. Adult plant resistance assodated with leaf pubescence in common beans. Plant Disease 76:1230-1236.

9. Molina Castafieda and J.S. Beaver. 1998. Inheritance of normal pod development in bean golden mosaic resistant common beans. HortScience (Submifted).

10. Oviedo Terrero, F. 1989. Caracterizaci6n y herencia de la pubescencia erecta en genotipos de habichuela (Phaseolus vulgaris L.). M.S. Thesis University of Puerto Rico. Mayaguez, Puerto Rico.

11. PROFRIJOL. 1995. Informe 1993-1994. Vivero de adaptaci6n Caribeiio. Documento 95:4 del Oficina de Coordinaci6n Regional de PROFRIJOL. San Cristóbal, Rep6blica Dominicana.

12. Rosas, J.C.,0.1. Varelaand J.S. Beaver. 1997. Registration of Tío Canela 75 Small Red Bean. Crop Science 37:1391.

13. Singh, S.P. and J. Gutiérrez. 1984. Geographical distribution of the DL, and DL2 genes causing hybrid dwarfism in Phaseolus vulgaris L., their association to seed size and their association their significance to breeding. Euphytica 33:337-345.

14. Stavely, J.R., J. Steinke, R.T. McMillan, K.F. Grafton, J.R. Steadman, J.D. Kelly, D.P. Coyne, D.T. Lindgren and M.J. Silbernagel. 1992. Rust resistant bean germplasm releases. Ann. Rep. ofthe Bean Improv. Cooperative. 35:228-229.

15. Velez, J., M.J. Bassett, J.S. Beaver and A. Molina. 1998. Inheritance of resistance to bean golden mosaic virus in common bean. J. of Amer. Soc. Hort. Sci. (Submifted).