Cultivar and Germplasm Release

*RELEASE OF 'XRAV-40-4' BLACK BEAN (*PHASEOLUS VULGARIS *L.) CULTIVAR*[1]

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Black bean (*Phaseolus vulgaris* L.) production in the lowlands of Mexico, Central America and the Caribbean is threatened by viral diseases (Godoy-Lutz et al., 2004; Flores-Estévez et al., 2003; Rosas et al., 2000). Bean golden yellow mosaic virus (BGYMV), a whitefly [*Bemisia tabaci* (Gennadius)]-transmitted begomovirus, can cause significant reduction in common bean seed yield when susceptible bean cultivars are planted in Central America and the Caribbean (Coyne et al., 2003). Bean common mosaic virus (BCMV) and bean common mosaic necrosis virus (BCMNV) are seed-borne diseases that also cause yield loss in susceptible cultivars (Beaver and Osorno, 2009). Recently released black bean cultivars in Central America have the *bgm-1* and *I* resistance genes and the SW12 QTL (Miklas et al., 2006) that provide resistance to BGYMV and BCMV. Unfortunately, bean cultivars with an unprotected *I* gene produce a top necrosis reaction when infected with BCMV (Beaver et al., 2003). Bean lines that combine the dominant *I* and the recessive *bc-3* genes have resistance to all known strains of BCMV and BCMNV (Kelly et al., 1994). The objective of this research was to develop black bean breeding lines for Central America and the Caribbean that pyramid genes for resistance to BGYMV, BCMV and BCMNV.

Origin

A multiple disease resistant black bean adapted to the humid tropics, 'XRAV-40-4' was developed and released cooperatively by the Puerto Rico (UPR) and Nebraska (UNL) Agricultural Experiment Stations, the USDA-ARS, the Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF), the Escuela Agrícola Panamericana, Zamorano, Honduras, and the National Seed Service of the Ministry of Agriculture of

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the Republic of Haiti. Derived from the cross 'PR0003-124/'Raven', 'XRAV-40-4' combines resistance to BGYMV, BCMV, and BCMNV. Breeding line PR0003-124 is a white bean line derived from the cross 'DOR483/BelNeb RR-2//MUS83/DOR483' that was selected in Puerto Rico for resistance to BGYMV and root rot, and for tolerance to high temperature stress. Results from screening with the SR2 (Blair et al., 2007) and SW13 (Melotto et al., 1996) SCAR markers support the hypothesis that PR0003-124 has the *bgm-1* gene (Vélez et al., 1998) for resistance to BGYMV and the *I* gene for resistance to BCMV. Line PR0003-124 also has the SW12 QTL for resistance to BGYMV. 'Raven' is a black bean cultivar developed and released by the Michigan Agricultural Experiment Station that has an erect habit and the *bc-3* gene for resistance to BCMNV (Kelly et al., 1994). 'Raven' was selected for adaptation to the tropics as a breeding line in the Michigan State University dry bean winter nursery planted in Isabela, Puerto Rico.

Disease susceptibility

The F_1 nursery was planted at the UPR Isabela Substation in October 2000. Individual plants having desirable agronomic traits and black seed were selected from the F_2 nursery. The $F_{2:3}$ lines were screened in the laboratory at the UPR, Mayagüez Campus for the presence of the SCAR marker SR-2 linked to the *bgm-1* gene for resistance to BGYMV. The $F_{3:4}$ line XRAV 40-4 was screened in the greenhouse during the summer of 2002 at the UNL for BCMNV reaction using the NL3 and NL8 strains. The inoculated plants of the line XRAV 40-4 did not develop symptoms to the virus. The presence of the SCAR marker SW13 provided support that this line combined the *I* and *bc-3* genes for resistance to BCMV and BCMNV. The $F_{4:5}$ generation was screened in the field in the Dominican Republic in a trial planted at San Juan de la Maguana in November 2002. The bean lines at this site were exposed to BGYMV and to the NL8 and NL3 strains of BCMNV that were present at this site. Lines that did not develop symptoms to these viral diseases were selected. Pedigree selection was used at the Escuela Agrícola Panamericana in 2003 to select individual plants from F_6 plant rows. The seed of line XRAV-40-4 was bulked in the F_7 generation.

Breeding line XRAV-40-4 was screened again at the USDA-ARS Tropical Agriculture Research Station laboratory with SCAR markers and was found to have the SR2 marker for the *bgm-1* gene (Vélez et al., 1998), the SW12 QTL for BGYMV resistance (Miklas et al., 2000) and the SW13 marker for the *I* gene for BCMV resistance (Melotto et al., 1996). Line XRAV-40-4 was also mechanically inoculated in a greenhouse at the University of Puerto Rico Mayagüez Campus with the NL3 strain to confirm resistance to BCMNV. Infected tissue was homogenized using a mortar and pestle to prepare the inoculum. Carborundum and a 0.01 M phosphate buffer were added before applying the inoculum. The plants were inoculated 8 to 10 days after planting by gently applying the inoculum to the upper surface of the primary leaves. Reactions to the virus were evaluated 7 to 10 days after inoculation. Line XRAV-40-4 is resistant to bean rust races endemic to Puerto Rico. Line XRAV-40-4 had susceptible reactions when inoculated at the USDA-ARS Tropical Agriculture Research Station with the 3353 and 484A strains of the common blight pathogen *Xanthomonas axonopodis* pv. *phaseoli* (Smith) Vauterin et al.

Cultivar Description

Breeding line 'XRAV-40-4' has an indeterminate upright Type II growth habit. Plants initiated flowering at approximately 37 d, and reached harvest maturity 63 d after emergence in Haiti. Seed of 'XRAV-40-4' is black opaque with an average weight of 18 g/100 seed in the Dominican Republic and Honduras. The seed size and ovoid shape are acceptable for black bean production in Central America and the Caribbean.

TABLE 1.—*Performance of elite black bean lines planted in Haiti, Puerto Rico and the Dominican Republic in 2010, 2011 and 2012.*

			Haiti		Puerto Rico			Dominican Republic				
			Seed yield (kg/ha)									
Line	Days to flower	Days to maturity	Damien 2011	Damien 2012	Isabela 2010	Isabela 2011	Isabela 2012	Arroyo Loro 2011	La Jagua 2012	Arroyo Loro 2012	100 seed weight (g)	Mean seed yield (kg/ha)
PR1165-2	38.2	65.2	2,178	1,524	2,056	2,561	2,718	1,621	781	1,676	17.1	1,889
PR1165-3	38.0	65.8	2,475	1,798	2,411	2,477	3,242	1,903	1,083	1,799	16.5	2,149
PR1165-5	38.0	64.4	2,150	1,576	2,468	2,799	3,290	1,663	1,052	1,945	18.6	2,118
PR1165-17	36.6	64.4	2,615	1,406	2,056	2,291	2,364	1,473	1,073	2,407	17.6	1,961
PR1165-18	38.0	65.0	2,970	1,530	2,411	2,456	2,717	1,508	870	2,005	18.2	2,058
PR1165-19	38.4	64.4	2,785	1,481	2,468	2,399	2,856	1,624	1,094	1,852	17.7	2,070
PR1165-20	36.4	65.0	2,310	1,435	1,832	2,321	2,494	1,462	841	1,833	17.5	1,816
DPC-40	36.6	64.4	2,568	1,786	2,095	2,236	2,949	1,753	1,127	1,534	17.6	2,006
Aifi Wuriti	37.8	65.0	2,580	1,292	2,143	2,079	2,895	1,424	1,101	1,558	17.6	1,884
XRAV-40-4	37.2	63.2	2,685	1,712	1,710	2,252	3,164	1,366	1,404	1,819	17.2	2,014
Mean	37.5	64.7	2,532	1,554	2,165	2,378	2,869	1,580	1,043	1,862	17.6	
LSD (0.05)	NS	NS	NS	319	839	NS	576	NS	NS	NS	0.8	
CV (%)	4.1	2.1	19.4	16.0	29.0	18.3	15.6	20.0	24.0	28.7	3.8	

TABLE 2.—*Performance of elite black bean lines in a trial planted in Haiti and Puerto Rico during the 2010-2012 growing seasons.*

Line	2010 Haiti seed yield (kg/ha)	2010 Puerto Rico seed yield (kg/ha)	2011 Puerto Rico seed yield (kg/ha)	2012 Puerto Rico seed yield (kg/ha)	Mean
XRAV-40-4	2,747	3,065	2,466	3,488	2,942
DPC-1	2,524	2,372	2,094	2,872	2,466
DPC-40	2,488	2,132	1,916	3,172	2,427
DPC-2	1,783	2,662	1,836	2,981	2,316
DPC-3	1,915	2,009	2,151	3,261	2,334
DPC-5	1,401	1,731	1,717	3,070	1,980
Aifi Wuriti	804	1,963	1,661	2,672	1,775
Mean	1,952	2,293	1,977	3,073	2,324
LSD(0.05)	694	609	523	NS	
CV(%)	29.4	20.9	20.3	16.9	

Yield

The performance of 'XRAV-40-4' was evaluated from 2010 to 2012 in 12 field trials conducted in Puerto Rico, the Dominican Republic and Haiti. This line produced a mean seed yield of 2,014 kg/ha which was similar to the check cultivars 'DPC-40' (2,006 kg/ha) and 'Aifi Wuriti' (1,884 kg/ha) (Tables 1 and 2). Breeding line XRAV-40-4 is a sister line of the BGYMV, BCMNV and BCMV resistant black bean cultivar 'DPC-40' which has proven to be widely accepted by growers in the Dominican Republic and Haiti (Godoy-Lutz et al., 2010). During 2011 and 2012, 'XRAV-40-4' was an entry in the regional ERSAT trial that was conducted in 11 environments in Central America (Honduras, Nicaragua, El Salvador and Costa Rica) and the Caribbean (Dominican Republic). Averaged over two years, 'XRAV-40-4' produced an overall mean seed yield of 1,744 kg/ha compared with 1,533 kg/ha for the local check cultivar (J.C. Rosas, personal communication). Breeding line 'XRAV-40-4' produced the highest mean seed yield in the 2012 ERSAT trials conducted in six environments.

The release of 'XRAV-40-4' provides bean producers in Central America and the Caribbean with insurance against the potential emergence of BCMNV. In Puerto Rico, the widespread use of bean cultivars with the unprotected *I* gene has helped to prevent the spread of BCMNV. Unfortunately, landrace varieties with no virus resistance are commonly planted in Haiti which can threaten bean cultivars with the unprotected *I* gene. We expect 'XRAV-40-4' to be released in Central America as 'Azabache 40' and in Haiti as 'Sankara'.

Availability of Seed

Small quantities of breeder seed may be obtained from the first author. Plant variety protection will not be sought for this cultivar.

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