Cultivar and Germplasm Release

RELEASE OF 'HERMOSA' BLACK BEAN CULTIVAR[1]

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Black beans (*Phaseolus vulgaris* L.) are widely consumed in Puerto Rico and other Caribbean countries. The U.S. Census Bureau (2012) reported that 1,356,420 kg of black beans, valued at $1,458,000 were imported from the United States in 2012. At present, no black bean varieties have formally been released in Puerto Rico for local production. The objective of this research was to develop a locally-adapted black bean cultivar with resistance to the major diseases in Puerto Rico.

Bean golden yellow mosaic virus (BGYMV), a whitefly [*Bemisia tabaci* (Gennadius)]-transmitted begomovirus, threatens bean production in Central America and the Caribbean (Miklas et al., 2006; Coyne et al., 2003). Bean common mosaic virus (BCMV) is a seed-borne disease that can cause significant losses in seed yield and quality (Beaver and Osorno, 2009). In Puerto Rico, bean cultivars such as 'Morales' (Beaver and Miklas, 1999) and 'Verano' (Beaver et al., 2008) have the *bgm-1* and *I* resistance genes and the SW12 QTL that provide resistance to BGYMV and BCMV. Although Bean common mosaic necrosis virus (BCMNV), which is endemic to Puerto Rico, can cause a top necrosis reaction in bean cultivars that have an unprotected *I* gene (Kelly et al., 1994), the incidence of BCMNV is very low because farmers do not plant susceptible cultivars that can serve as a source of infection. Common bacterial blight, caused by *Xanthomonas axonopodis* pv. *phaseoli* (Smith) Vauterin et al., and web blight, caused by *Thanatephorus cucumeris* (Frank) Donk (anamorph: *Rhizoctonia solani* Kühn), are serious diseases of common beans planted in the humid tropics (Beaver et al., 2012; Zapata et al., 2011).

Origin

'Hermosa', a multiple disease resistant black bean adapted to the humid tropics, was developed and released cooperatively by the University of Puerto Rico (UPR) and the USDA-ARS. 'Hermosa' is resistant to BGYMV, BCMV, common bacterial blight and web blight. 'Hermosa' (UPR breeding line PR1147-1) was derived from the cross PR0518-10 / PR0401-257. PR0518-10 is a black bean breeding line derived from the cross 'Negro Veracruz' / PR9607-29 that was selected in Puerto Rico for resistance to web blight (Valentín-Torres et al., 2016) and adaptation to low N soils (Ruiz-Quiles, 2010). 'Negro Veracruz' is a black bean cultivar from Mexico considered a promising source of drought tolerance (Beebe et al., 2013). PR0401-257 is a pink bean sister line of PR0401-259 (Beaver et al., 2012), derived from the cross VAX 6 / MUS 83 // DOR482 / BAT 93, that was selected in Puerto Rico for heat tolerance and resistance to BGYMV, BCMV, common bacterial blight and web blight (Valentín-Torres et al., 2016).

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The crossing block was planted in a screenhouse at the USDA-ARS Tropical Agriculture Research Station at Mayagüez in January 2008. The F_1 nursery was planted at the Isabela Substation of the UPR Agricultural Experiment Station in October. Individual plants having desirable agronomic traits and black seed were selected from the F_2 nursery planted at the Isabela Substation in February 2009.

The $F_{2:3}$ lines were planted at the Isabela Substation in June 2009. The lines were evaluated in a trial using a Randomized Complete Block Design with three replications. The experimental units were single 1-m rows in which 10 seeds were planted. The spacing between rows was 0.76 m. At planting, granular fertilizer was applied at a rate of 20 kg/ha of N to allow the screening of bean lines in a low N environment. The $F_{2:3}$ lines were also planted without fertilization in June 2009 at the USDA-ARS Research Station at Isabela, Puerto Rico, in a root rot nursery (Porch et al., 2014). The $F_{2:3}$ lines were evaluated in a trial using a Randomized Complete Block Design with two replications. The experimental units were single 1-m rows in which 12 seeds were planted. The parents PR0518-10 and PR0401-257 were included as checks in the $F_{2:3}$ trials. Lines were selected based on seed type, agronomic traits and seed yield. The F_4 and F_5 generations were planted at the Isabela Substation in February and June 2010. The lines were evaluated in trials using a Randomized Complete Block Design with five replications. The experimental units were single 5-m rows in which 65 seeds were planted. The between row spacing was 0.76 m. The trials were not fertilized. Individual $F_{4:5}$ plants were selected from a sixth replication planted in June 2010. Lines were selected based on agronomic traits and seed yield potential in a low N soil.

In a greenhouse at the University of Puerto Rico-Mayagüez Campus, the most promising $F_{4:5}$ lines were mechanically inoculated with the NL3 strain of BCMNV using the techniques described by Morales (1989). In the $F_{4:5}$ generation, the predecessor of PR1147-1 segregated for susceptibility and systemic necrotic (*I* gene) reactions to BCMV. The $F_{5:6}$ lines were planted at the Isabela Substation in October 2010. Individual plants were harvested based on agronomic traits and seed type. The $F_{6:7}$ lines were planted at the Isabela Substation in January 2011. Seed of line PR1147-1 was bulk harvested.

Subsequent greenhouse evaluations found PR1147-1 to have the *I* gene for resistance to BCMV. The presence of the SCAR marker SW13 also confirmed that PR1147-1 has the *I* gene for resistance to BCMV (Melotto et al., 1996). PR1147-1 has the SR2 SCAR marker (Blair et al., 2007) linked to the *bgm-1* gene (Vélez et al., 1998). PR1147-1 also has the SW12 QTL (Miklas et al., 2000) for resistance to BGYMV. PR1147-1 exhibited high levels of resistance to BGYMV under severe disease pressure in a Bean Abiotic Stress Environment (BASE) 120 field trial planted at Zamorano University, Honduras in October 2015.

PR1147-1 showed a resistant reaction when inoculated at the USDA-ARS Tropical Agriculture Research Station with the 3353 and 484 strains of the common bacterial blight pathogen *Xanthomonas axonopodis* pv. *phaseoli* (Smith) Vauterin et al. (Table 1). PR1147-1 is resistant to bean rust *Uromyces appendiculatus* races endemic to Puerto Rico.

The performance of PR1147-1 was evaluated in four field trials planted at Isabela, Puerto Rico from 2012 to 2014. The experimental design was a Randomized Complete Block with five replications. The experimental units were single 2-m rows spaced at 0.76 m between rows. Twenty-five seeds were planted in each row. The overall mean seed yield of 'Hermosa' was similar to the check cultivars 'DPC-40' and 'Aifi Wuriti' (Table 2). The seed yield of 'Hermosa' was significantly higher than that of the check cultivars in the February 2014 planting, in which there was severe root rot pressure.

Field trials were conducted over two years at Isabela, Puerto Rico to evaluate the reactions of the bean lines to web blight. In 2015, a BASE 120 trial was planted at the Isabela Substation. Entries in the BASE 120 trials included elite lines from Puerto Rico, Zamorano, the International Center for Tropical Agriculture (CIAT) and Michigan State University. A Randomized Complete Block Design with two replications was used. The

TABLE 1.—*Common bacterial blight (CBB) reactions of elite lines evaluated in a screenhouse at the USDA-ARS-Tropical Agriculture Research Station, Mayagüez, Puerto Rico, during 2016.*

Line	CBB scores of strain *Xap* 484A[1] (1-9)	CBB scores of strain *Xap* UPR 3353[1] (1-9)
Bella	2.0	3.5
Hermosa	2.0	2.5
Bribri	8.0	8.5
Cardenal	8.5	9.0
Don Rey	9.0	9.0
Morales	9.0	9.0
VAX 6	1.0	1.5
LSD (0.05)	2.6	1.9
CV (%)	21.8	13.4

[1]Rated on the CIAT 1-9 scale where 1 = no symptoms and 9 = very severe symptoms (CIAT, 1987).

experimental units were single rows 1-m long with spacing of 0.76 m between rows. Thirteen seeds were planted in each 1-m row. In 2016, elite breeding lines were evaluated in a field trial using a randomized complete block design with five replications. The experimental units were single 2-m rows spaced 0.76 m between rows. Twenty-five seeds were planted in each row. The bean plants were inoculated with a AG-1-IB isolate of *Rhizoctonia solani* (Godoy-Lutz et al., 2008) about 30 days after emergence. The inoculum was prepared in the plant pathology laboratory at the Fortuna Substation of the UPR Agricultural Experiment Station at Juana Díaz, Puerto Rico. The plants were inoculated with a backpack sprayer late in the afternoon at a rate of 200 ml of inoculum (0.13 g of mycelium) + 20 ml of Tween 80 in 20 L of distilled water. Plants were evaluated for web blight reaction at 28 days after inoculation. The web blight reactions were evaluated using the scale proposed by CIAT where: 1 = no visible symptoms, 2 = < 5% of leaf area affected, 3 = 6-10% of leaf area affected, 4 = 11-20% of leaf area affected, 5 = 21-30% of leaf area affected, 6 = 31-40% of leaf area affected, 7 = 41-60% of leaf area affected, 8 = 61-85%, 9 = > 85% of leaf area affected (CIAT, 1987). Seed yield and percentage of damaged seed were measured. The results from the trials were analyzed using an analysis of variance. Means of the lines were compared using least significant differences ($P < 0.05$). 'Hermosa' had among the most resistant leaf reactions to web blight with mean scores of 4.2 and 3.3 in 2016 and 2015, respectively (Table 3). In 2016, 'Hermosa' produced a mean seed yield of 1,838 kg/ha and only 5% of the seed was damaged.

TABLE 2.—*Seed yield (kg/ha) of black bean lines planted at Isabela, Puerto Rico.*

Line	Dec. 2012	Jun. 2013	Feb. 2014	Jun. 2014	Mean
Hermosa	2364	2380	2982	1752	2370
DCP-40	2949	3153	1056	2030	2297
Aifi Wuriti	2895	2880	2083	2381	2560
Trial mean	2869	2164	1886	1693	2153
LSD (0.05)	576	525	872	482	
CV (%)	15.7	16.8	36.2	22.3	

TABLE 3.—*Performance of lines screened for reaction to web blight in trials planted at Isabela, Puerto Rico in 2015 and 2016.*

Line	Seed type	Days to flower in 2016	Days to maturity in 2016	Web blight score[1] in 2015	Web blight score[1] in 2016	Seed yield in 2016 (kg/ha)	Damaged seed in 2016 (%)
Hermosa	Black	35.2	73.0	3.3	4.2	1838	5.0
Amadeus 77	Small red	34.6	71.2	6.6	4.8	1817	10.8
PR0401-259	Pink	35.4	73.0	4.2	4.2	1566	3.0
Verano	White	35.4	72.6	4.0	3.8	1486	5.0
Bella	White	34.8	70.4	2.7	4.4	1187	13.6
Sankara	Black	36.2	70.8	7.7	6.0	919	21.0
Morales	White	35.2	70.4	6.6	6.4	680	29.4
LSD (0.05)		1.5	2.4	2.0	0.9	365	8.5
CV (%)		3.3	2.6	27.2	20.6	28.1	62.7

[1]Rated using the CIAT 1-9 scale where 1= absence of symptoms and 9 = > 85% of the leaf area damaged (CIAT, 1987).

TABLE 4.—*Performance of lines in the Bean Adaptation to Stress Environments (BASE 120) trials planted at Isabela, Puerto Rico in June and December 2015 and June 2016.*

Line	Seed type	Days to flower in 2016	Days to maturity in 2016	Seed yield in June 2015 (kg/ha)	Seed yield in Dec. 2015 (kg/ha)	Seed yield in June 2016 (kg/ha)
Hermosa	Black	36	75	1652	855	1310
Amadeus 77	Small red	35	71	219	402	1496
PR0401-259	Pink	35	73	304	417	1322
Verano	White	37	76	420	724	1492
Bella	White	36	76	1652	869	1574
Sankara	Black	39	70	341	917	1401
Morales	White	41	74	203	484	911

The performance of 'Hermosa' was evaluated in additional BASE 120 trials planted at the Isabela Substation. The trials were planted in May and November 2015 and June 2016. The experimental design was a Randomized Complete Block with five replications. The experimental units were single 3-m rows with 0.76 m between rows. The seeding density was 14 seeds per linear meter of row. The field trials received supplemental irrigation to avoid drought stress. Although the BASE 120 trials were not fertilized, the trials were inoculated at planting with *Rhizobium etli* (CIAT 632) and *R. tropici* (CIAT 899) at a concentration of 10^7 cells per milliliter of inoculum. Days to flowering and harvest maturity were noted, and seed yield was measured. The data were analyzed using the GLIMMIX model from SAS (SAS Institute, Cary, NC) to calculate the main effects and interactions and to compare the least squares means ($P \leq 0.05$). Planting dates and bean lines were considered as fixed effects while replication was considered a random effect within planting dates. A 95% probability level was used to establish statistical differences. There was severe root rot damage in the BASE 120 trials planted in June and December 2015 that reduced plant population, plant vigor and seed yield of many lines. 'Hermosa' produced vigorous plants that yielded more than most lines in the BASE 120 trials (Table 4). The overall mean root rot score of 'Hermosa' was 1.7 based on the CIAT 1-9 scale where 1 = no symptoms and 9 = very severe symptoms (CIAT, 1987). Vigorous and healthy root systems should enhance the ability of the plant to absorb soil nutrients. 'Hermosa' was among the highest yielding lines in the BASE 120 field trials (Table 5).

'Hermosa' (PR1147-1) has an indeterminate upright, Type II growth habit. 'Hermosa" initiates flowering at 35-36 d and reaches harvest maturity 73 to 75 d after planting (Tables 3 and 4). 'Hermosa' has a dull black seed with an average weight of 21 g/100 seed.

The release of 'Hermosa' provides bean producers in Puerto Rico with a potential niche crop. The disease resistance and superior performance of 'Hermosa' in low N soils should facilitate organic production of this bean cultivar.

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.

TABLE 5.—*Least square means for seed yield of the 10 highest yielding entries in the BASE 120 trials planted at Isabela, Puerto Rico in June and November 2015 and June 2016.*

Line	Seed yield (kg/ha)
PR1147-3	1466 ab[1]
Bella	1365 ab
PR1418-15	1312 abc
PR1483-105	1274 abcde
Hermosa	1272 abcde
PR1147-8	1270 abcde
PR1147-6	1251 bcde
TARS MST-1	1238 bcde
BIOF-2-106	1231 bcde
SB2-170	1177 bcde
Mean of trails	832

[1]Means followed by a different letter are significantly different at the 0.05 probability level.

LITERATURE CITED

Beaver, J. S., M. Zapata, M. Alameda, T. G. Porch and J. C. Rosas, 2012. Registration of PR0401-259 and PR0650-31 dry bean germplasm lines. *J. Plant Reg.* 6: 81-84.

Beaver, J. S. and J. M. Osorno, 2009. Achievements and limitations of contemporary common bean breeding using conventional and molecular approaches. *Euphytica* 168: 145-175.

Beaver, J. S., T. G. Porch and M. Zapata, 2008. Registration of 'Verano' white bean. *J. Plant Reg.* 2: 187-189.

Beaver, J. S. and P. N. Miklas, 1999. Registration of 'Morales' small white bean. *Crop Sci.* 39: 1257.

Beebe, S. E., I. M. Rao, M. W. Blair and J. A. Acosta-Gallegos, 2013. Phenotyping common beans for adaptation to drought. *Front Physiol.* 4(35): 1-20.

Blair, M. W., L. M. Rodríguez, F. Pedraza, F. Morales and S. Beebe, 2007. Genetic mapping of the bean golden yellow mosaic gemnivirus resistance gene *bgm-1* and linkage with potyvirus resistance in common bean (*Phaseolus vulgaris* L.). *Theor. Appl. Genet.* 114: 261-271.

CIAT (Centro Internacional de Agricultura Tropical), 1987. Standard system for the evaluation of bean germplasm. van Schoonhoven, A. and M. A. Pastor-Corrales (compilers). Cali, Colombia. 54 pp.

Coyne, D. P., J. R. Steadman, G. Godoy-Lutz, R. Gilbertson, E. Arnaud-Santana, J. S. Beaver and J. R. Myers, 2003. Contributions of the Bean/Cowpea CRSP to management of bean diseases. *Field Crops Res.* 82: 155-168.

Godoy-Lutz, G., S. Kuninaga and J. Steadman, 2008. Phylogenetic analysis of *Rhizoctonia solani* subgroups associated with web blight symptoms on common bean based on ITS-5.8S rDNA. *J. Gen. Plant Pathol.* 74: 32-40.

Kelly, J. D., G. L. Hosfield, G. V. Varner, M. A. Ubersax, S. D. Haley and J. Taylor, 1994. Registration of Raven black bean. *Crop Sci.* 34:55, 1406-1407.

Melotto, M., L. Afanador and J. D. Kelly, 1996. Development of a SCAR marker linked to the *I* gene in common bean. *Genome* 39: 1216-1219.

Miklas, P. N., J. D. Kelly, S. E. Beebe and M. W. Blair, 2006. Common bean breeding for resistance against biotic and abiotic stresses: From classical to MAS breeding. *Euphytica* 147: 105-131.

Miklas, P. N., V. Stone, M. J. Daly, J. R. Stavely, J. R. Steadman, M. J. Bassett, R. Delorme and J. S. Beaver, 2000. Bacterial, fungal and viral disease resistance loci mapped in a recombinant inbred common bean population ('Dorado'/XAN 176). *J. Amer. Soc. Hort. Sci.* 125: 476-481.

Morales, F. J., 1989. Bean common mosaic: screening for disease resistance. Centro Internacional de Agricultura Tropical (CIAT). Cali, Colombia. 28 pp.

Porch, T. G., S. Valentin, C. Estevez de Jensen and J. S. Beaver, 2014. Identification of soilborne pathogens in a common bean root rot nursery in Isabela, Puerto Rico. *J. Agric. Univ. P.R.* 98:1-14.

Ruiz-Quiles, L., 2010. Desarrollo de líneas de habichuela (*Phaseolus vulgaris* L.) con resistencia a BCMV, BGYMV y mejor adaptación en suelos bajos en N. M.S. Thesis. University of Puerto Rico, Mayagüez Campus. 72 pp.

U.S. Census Bureau, 2012. U.S. Trade with Puerto Rico and U.S. Possessions. FT895/12. https://www.census.gov/content/dam/Census/library/publications/2013/econ/ft895-12.pdf. Last verified (June 15, 2018).

Valentín-Torres, S., M. M. Vargas, G. Godoy-Lutz, T. G. Porch and J. S. Beaver, 2016. Isolates of *Rhizoctonia solani* can produce both web blight and root rot symptoms in common bean (*Phaseolus vulgaris* L.). *Plant Dis.* 100: 1351-1357.

Velez, J. J., M. J. Bassett, J. S. Beaver and A. Molina, 1998. Inheritance of resistance to bean golden mosaic virus resistance in common bean. *J. Amer. Soc. Hort. Sci.* 123: 628-631.

Zapata, M., J. S. Beaver and T. G. Porch, 2011. Dominant gene for common bean resistance to common bacterial blight caused by *Xanthomonas axonopodis* pv. *phaseoli*. E*uphytica* 179: 373-382.