Cultivar and Germplasm Release

RELEASE OF 'ROSALINDA' PINK BEAN CULTIVAR[1]

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The common bean is a staple food and an important source of protein in the Puerto Rican diet (Beaver et al., 2020a). Although dry beans are produced commercially throughout Central America and the Caribbean, Puerto Rico imports most food crops such as dry beans consumed on the island (Carro-Figueroa, 2002). A major goal of the Agricultural Experiment Station bean breeding program at the University of Puerto Rico, Mayagüez Campus is to develop locally adapted bean cultivars that can be used to increase food security. Recent releases of bean cultivars in Puerto Rico are resistant to major diseases and have a more erect plant architecture that would allow direct harvest with a combine. Mechanization of the cultivation and harvest operations is considered necessary for the efficient production of dry beans and to be competitive with imported dry beans (Thomas et al., 2006). Dry beans can be produced in rotation with crops such as sorghum [*Sorghum bicolor* (L.) Moench], maize (*Zea mays* L.), soybeans [*Glycine max* (L.) Merr.] and rice (*Oryza sativa* L.) that are consumed in Puerto Rico and are also imported. The same agricultural equipment and facilities can be used to produce, harvest, and store these crops. Farmers in Puerto Rico can increase productivity and more effectively compete with dry bean producers in temperate climates by sequential and multiple cropping of dry beans with other crops (Nassary et al., 2020; Waha et al., 2020). Farmers in Puerto Rico also have the option of harvesting maize, sorghum or soybeans as haylage or silage (Beaver et al., 2016; Daniel et al., 2019).

Several different market classes of beans consumed in Puerto Rico and other Caribbean countries include white, black, light red kidney, red mottled, pinto and pink beans (Voysest, 1983). The white bean cultivars released in Puerto Rico such as 'Bella' (Beaver et al., 2018), 'Beníquez' (Beaver et al., 2011) and 'Verano' (Beaver et al., 2008) can be cultivated for green-shelled or dry bean production. The light red kidney bean cultivar 'Badillo' (Beaver et al., 2010), the black bean cultivar 'Hermosa' (Beaver et al., 2018) and the pinto bean germplasm lines PR1572-19 and PR1572-26 (Beaver et al., 2020b) are locally adapted and were released for dry bean production. The objective of this research was to develop and release a locally adapted pink bean having disease resistance and competitive seed yield potential.

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Origin

'Rosalinda', a multiple virus resistant pink bean cultivar adapted to the humid tropics, was developed and released cooperatively by the University of Puerto Rico (UPR) and the United States Department of Agriculture, Agricultural Research Service (USDA-ARS). 'Rosalinda' is resistant to *Bean golden yellow mosaic virus* (BGYMV), *Bean common mosaic virus* (BCMV) and *Bean common mosaic necrotic virus* (BCMNV) and has an erect plant habit suitable for direct harvest with a combine. 'Rosalinda', tested as breeding line PR1519-25, was derived from the cross 'Beníquez'/PR0401-259. 'Beníquez' was derived from the cross PR0003-124/'Raven'. Line PR0003-124 is a white bean breeding line that was selected in Puerto Rico for resistance to BGYMV and root rot, and for tolerance to high temperature stress (Beaver et al., 2011). Line PR0003-124 was derived from the cross DOR483/'BelNeb RR-2'/MUS83/DOR483. 'Raven' is a black bean cultivar released by the Michigan Agricultural Experiment Station that has been adapted to Puerto Rico, an erect plant type and the *bc-3* gene for resistance to BCMNV (Kelly et al., 1994). 'Beníquez' has the *bgm-1* gene and the SW12 QTL for BGYMV resistance and the *I* and *bc-3* genes for resistance to BCMV and BCMNV. Line PR0401-259 is a heat tolerant and multiple disease resistant pink bean breeding line derived from the cross VAX 6///MUS 83/BelNeb//MUS83/DOR483 (Beaver et al., 2012). Line PR0401-259 has the *bgm-1* gene for resistance to BGYMV and the *I* gene for resistance to BCMV, and the SAP6 QTL for resistance to common bacterial blight, caused by *Xanthomonas axonopodis* pv. *phaseoli* (Smith 1897) Vauterin et al. 1995. The crossing block was planted in a screenhouse at the University of Puerto Rico, Mayagüez Campus in October 2010. The F_1 nursery was planted at the Isabela Substation of the UPR Agricultural Experiment Station in January 2011. Individual plants having desirable agronomic traits (earlier maturity, erect plant type, and better pod set) and pink seed were selected from the F_2 nursery planted at the Isabela Substation in June 2011. The summer planting also allowed the selection of plants with moderate levels of heat tolerance. The $F_{2:3}$ lines were planted at the Isabela Substation in October 2011. Pedigree selection was used to advance the lines from the F_4 to F_8 generation in trials planted in February 2012, June 2012, October 2012, June 2013 and October 2013. Seed of the $F_{7:8}$ breeding line PR1519-25, later named 'Rosalinda', was bulked and tested in a preliminary yield trial planted at the Isabela Substation in October 2014. The preliminary yield trial used a Randomized Complete Block Design with three replications. The experimental units were single 1-m rows in which 12 seeds were planted. The spacing between rows was 0.76 m. The Isabela Substation is located on the northwestern coastal plain of Puerto Rico (18.3° N, 67.3° E), where most green-shelled beans produced on the island are grown. The soil at the Isabela Substation is a Coto acidic clay (very-fine, kaolinitic, isohyperthermic Typic Hapludox). The mean annual precipitation and temperature are 1,524 mm and 29.3° C, respectively. A granular 10-10-10 fertilizer was applied at planting at a rate of 50 kg/ha of N-P-K. Weeds were controlled manually and with the use of the preplant herbicide S-metolachlor. Insect pests were controlled when deemed necessary using pesticides registered for use on beans in Puerto Rico. The performance of 'Rosalinda' was subsequently evaluated in six field trials planted at Isabela, in October 2015, October 2016, January 2017, December 2017, January 2018, and December 2019. 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. Management practices were the same as previously described. Between 50 and 60 days after planting, the entries in the trial were evaluated for natural infection of foliar diseases using the CIAT (1987) 1 to 9 rating scale, where 1 = no symptoms and 9 = very severe symptoms.

In a greenhouse at the University of Puerto Rico-Mayagüez Campus, 'Rosalinda' was mechanically inoculated with the NL3 strain of BCMNV using the techniques described by Morales (1989). 'Rosalinda' did not develop symptoms and was subsequently screened at the USDA-ARS Tropical Agriculture Research Station (TARS) in Mayagüez with the SCAR marker SW13 to confirm the presence of the *I* gene for resistance to BCMV (Melotto et al., 1996) and the CAPS marker eIF4E (Naderpour et al., 2010) for the *bc-3* gene for resistance to BCMNV. 'Rosalinda' has the SR2 SCAR marker (Blair et al., 2007) linked to the *bgm-1* gene (Vélez et al., 1998). 'Rosalinda' also has the SW12 QTL (Miklas et al., 2000) for resistance to BGYMV.

Characteristics

'Rosalinda' produced a mean seed yield of 2,649 kg/ha in seven trials conducted at the Isabela Substation from 2014 to 2019 (Table 1). The mean seed yield of 'Rosalinda' was significantly higher than the check cultivar 'Verano'. Mean seed yields of 'Rosalinda' were stable across trials, ranging from 2,004 to 3,518 kg/ha.

'Rosalinda' showed moderately resistant scores (4.3 and 4.6) to common bacterial blight when planted at Isabela during the warm and humid month of October (Table 2). When planted during the drier months of December and January, the mean common bacterial blight scores ranged from 1.2 to 3.4. On the other hand, 'Rosalinda' had a susceptible reaction of 9.0, using the CIAT (1987) 1 to 9 scale, at 21 days after inoculation at the USDA-ARS-TARS with the 484A strain of the common bacterial blight pathogen. During most years of testing, 'Rosalinda' was resistant to endemic bean rust (*Uromyces appendiculatus*) and angular leaf spot (*Pseudocercospora griseola*) races at Isabela. Rust did develop on 'Rosalinda' in a trial planted at Isabela in February 2021. During that growing season the rust race(s) were virulent to bean cultivars having the *Ur-3* resistance gene. 'Rosalinda' had a moderately susceptible web blight score of 6.0 on leaves in a trial planted at Isabela, in October 2020. However, seed damage in this trial was low (2.5%). Erect plant habit may have allowed pods of 'Rosalinda' to avoid damage caused by web blight.

'Rosalinda' represents the first release of a Mesoamerican race pink bean cultivar. The pink bean cultivar has an indeterminate upright, Type II growth habit. The erect habit of 'Rosalinda' allows pods to avoid touching the soil surface and helps to preserve seed quality. In the December 2017 planting at Isabela, 'Rosalinda' initiated flowering at 39 d and reached harvest maturity at 65 d after planting. 'Rosalinda' has white flowers and an average 100-seed-weight of 20 g. 'Rosalinda' can be used for green-shelled or dry bean production. Dry beans can be sold directly to consumers or canned during periods when local canning facilities are not being used for canning green pigeonpeas or other crops.

Results from canning trials conducted at Michigan State University found 'Rosalinda' to have acceptable appearance (K. Cichy, Research Geneticist and Leader of the USDA-ARS Food Legume Quality Genetics Laboratory, Michigan, personal communication). Based on a 1 to 5 scale, where 5=excellent and 1=poor, 'Rosalinda' had a mean appearance score of 2.93 which was significantly better than mean score of the pink bean check cultivar 'Rosetta' (2.47). In Puerto Rico, 'Rosalinda' would be suitable for green-shelled or dry bean production.

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 1.–*Seed yield of pink bean lines with bgm, I and bc-3 from the cross 'Benítquez'/PR0401-259 planted at the Isabela Substation in October 2014, October and December 2015, January and December 2017, and January 2019.*

	Seed yield (kg/ha)							
Line	Oct 2014	Oct 2015	Dec 2015	Jan 2017	Dec 2017	Jan 2018	Jan 2019	Mean
PR1519-11	2,793	1,894	3,215	2,883	2,285	2,077	3,339	2,616
15	2,990	2,003	2,711	2,673	2,469	1,940	3,591	2,564
22	3,068	2,099	2,960	2,602	2,565	1,820	3,212	2,543
'Rosalinda'	2,935	2,004	3,161	2,806	2,287	2,117	3,518	2,649*
PR1519-26	2,765	2,084	3,020	2,695	2,317	1,706	3,315	2,523
28	2,846	2,107	3,177	2,507	2,537	1,932	3,591	2,642*
29	2,846	2,327	3,143	2,973	2,316	1,723	2,902	2,564
32	2,760	2,191	2,558	2,724	2,208	1,883	3,047	2,435
37	2,682	2,402	2,929	2,674	2,323	1,569	3,356	2,542
'Verano'	2,548	1,968	2,906	2,362	2,266	1,381	3,024	2,318
Trial mean	2,644	2,132	2,924	2,695	2,316	1,810	3,303	2,531
LSD (0.05)	740	276	397	402	NS	345	NS	
C.V. (%)	17.2	10.3	10.8	11.7	10.5	15.0	12.1	7.5

*Mean seed yield significantly ($P < 0.05$) greater than the check cultivar 'Verano'

TABLE 2.—*Disease reactions of pink bean lines with bgm, I and bc-3 from the cross 'Beníquez'/PR0401-259 planted at the Isabela Substation in October 2014, October and December 2015, January 2018, and January 2019.*

	Common blight[1]						Angular leaf spot	Rust
Line	Oct 2014	Oct 2015	Dec 2015	Jan 2018	Jan 2019	Mean	Jan 2019	
PR1519-11	4.3	4.6	3.8	1.4	1.2	3.4	1.0	1.4
15	4.0	4.2	3.6	1.0	1.4	3.3	1.0	1.0
22	4.3	4.6	3.2	1.2	1.2	3.3	1.0	1.2
'Rosalinda'	4.3	4.6	3.4	1.6	1.2	3.3	1.0	1.6
PR1519-26	3.7	4.6	3.4	1.6	1.0	3.2	1.0	1.6
28	4.3	4.8	3.6	1.6	1.2	3.4	1.0	1.6
29	4.3	3.8	3.6	1.6	1.2	3.2	1.0	1.6
32	3.7	4.0	3.4	1.4	1.0	3.0	1.0	1.4
37	4.0	4.4	3.2	1.0	1.2	3.2	1.0	1.0
'Verano'	4.3	4.2	3.0	2.2	1.0	3.2	1.0	2.2
Trial mean	4.7	4.6	3.4	1.4	1.2	3.2	1.0	1.4
LSD (0.05)	NS	0.7	NS	0.6	NS	NS	NS	0.6
C.V. (%)	14.9	12.9	15.6	31.1	33.6	7.0	13.2	31.1

[1]Rated on the CIAT scale from 1 to 9 with 1 = no symptoms and 9 = very severe symptoms.

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