CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

IAC 2153 and IAC 2156: cranberry and dark red kidney common bean cultivars for new markets

Sérgio Augusto Morais Carbonell[1], Gabriel de Moraes Cunha Gonçalves[1*], Jean Fausto de Carvalho Paulino[1], Sara Regina Silvestrin Rovaris[1], Caléo Panhoca de Almeida[2], João Guilherme Ribeiro Gonçalves[1], Rogério Soares de Freitas[3] and Alisson Fernando Chiorato[1]

Crop Breeding and Applied Biotechnology
21(4): e39852147, 2021
Brazilian Society of Plant Breeding.
Printed in Brazil
http://dx.doi.org/10.1590/1984-70332021v21n4c56

Abstract: *IAC 2153 and IAC 2156 are new common bean cultivars with special bean grains for new markets, especially the international market. They have a mean hundred-seed weight of 50 g, mean cooking time of 32 min, resistance to anthracnose and Fusarium wilt, and moderate resistance to common bacterial blight.*

Keywords: *Phaseolus vulgaris L., special beans, seed coat color*

INTRODUCTION

Brazil is the third largest producer and largest consumer of common bean (dry edible bean) worldwide. In the 2020/21 crop season, it produced 2,23 tons of seeds, with a mean yield of approximately 1.300 kg ha^{-1} (CONAB 2021). The bean varieties most grown and consumed in Brazil are of Mesoamerican origin, of the *carioca* (cream-colored with brown streaks) and black seed coat types (Perseguini et al. 2015, Pereira et al. 2021). However, bean export demand from Brazil is around 160 thousand tons (CONAB 2021), especially for beans with other types of bean grains consumed in diverse countries (Kläsener et al. 2020). The special beans, especially the white, red, and *rajado* (pinto-type, cream-colored with reddish streaks) beans, are widely consumed in the international market (Pereira et al. 2016, Carbonell et al. 2020).

Among the main characteristics of these special group beans are differences in seed coat coloring and bean grain size (Chiorato et al. 2008). Prominent types of special bean grains for export are: i) navy and alubia, both with white seed coat, with differences in bean grain size; ii) dark red kidney (DRK) and light red kidney (LRK), both of large size, with differences in the intensity of the red seed coat; and iii) pinto, calima, and cranberry, with differences regarding bean grain size and the streaks or stripes of other colors (Kläsener et al. 2020, Pereira et al. 2021). Of these, the cranberry (cream-colored seed coat with red stripes) and red kidney (red) commercial groups are important for the international consumer market, especially for countries with high demand for these types of bean grain, such as the United Kingdom (Schneider 2002) and Canada (Hou et al. 2018).

So as to meet especially foreign demand, to promote Brazilian bean production for export, and to increased consumption of different types of beans in the

***Corresponding author:**
E-mail: gabriel_demoraes@hotmail.com
ORCID: 0000-0003-2964-972X

Received: 06 October 2021
Accepted: 11 November 2021
Published: 25 November 2021

[1] Instituto Agronômico de Campinas, Centro de Grãos e Fibras, 13.075-630, Campinas, SP, Brazil
[2] Instituto Agronômico de Campinas, Centro de Recursos Genéticos Vegetais, 13.075-630, Campinas, SP, Brazil
[3] Instituto Agronômico de Campinas, Centro de Seringueira e Sistemas Agroflorestais, 15.505-970, Votuporanga, SP, Brazil

Brazilian domestic market, Brazilian common bean breeding programs have released new special bean cultivars with high yield potential, ideal plant architecture for mechanized harvest, and resistance to the main bean diseases (Pereira et al. 2016, Carbonell et al. 2020, Pereira et al. 2021).

In order to meet the demands of the international market and diversify the domestic market, the Programa de Melhoramento Genético de Feijoeiro (PMGF-IAC) released two new common bean cultivars with special grain types named IAC 2153 (cranberry) and IAC 2156 (dark red kidney).

GENETIC ORIGIN AND DEVELOPMENT

The line F6/7-99 (IAC 2153) was developed in 2016 from crosses between the genotypes IAC Nuance × Cranberry Argentino (NC); and the line OTG 07-9-1 (IAC 2156) was developed in 2007 from crosses between the genotypes DRK 18 × Bolinha Vermelho (DB). IAC Nuance was the first cranberry-type cultivar released by PMGF-IAC and has high yield (Carbonell et al. 2020). The Cranberry Argentino, DRK 18, and Bolinha Vermelho genotypes are accessions from the PMGF-IAC and were used as sources of resistance to anthracnose and Fusarium wilt.

The F_1 seeds obtained from NC and DB crosses were sown in pots located in a greenhouse to obtain F_2 generation seeds. After harvesting, these seeds were submitted to pathogenicity tests using a mixture of two different anthracnose (*Colletotrichum lindemunthianum*) races: 65 and 81. A total of 13 seedlings from the NC cross and 18 seedlings from the DB cross showed high resistance and were transplanted into pots under greenhouse conditions. These $F_{2:3}$ plants were harvested, and the progeny from the NC cross was selected for brindle color pattern seed coat and rounded grains like the cranberry bean; and the DB progeny was selected for tubular grains, with a preference for the longest and DRK type.

The 13 families from the NC cross showed the expected bean grain pattern and were selected, whereas among the 18 families from the DB cross, only nine were selected. The selected $F_{2:3}$ NC and DB families were sown in the municipality of Campinas, SP, aiming at selection within families. Altogether, 12 individual plants with superior agronomic fitness were selected from the NC cross and 15 from the DB cross, giving origin to the $F_{2:4}$ families.

The families of both crosses were sown again in the dry season – the NC $F_{2:4}$ families in Campinas, SP, in 2018, and the DB $F_{2:4}$ families in Tatuí, SP, in 2009. Visual selection was performed, resulting in seven plants from the NC families and five plants from the NB families, giving origin to the $F_{2:5}$ generations, which were sown in the winter crop season in 2018 in Mococa, SP, and in the rainy crop season in 2009 in Capão Bonito, SP, respectively. Selection within families was carried out again, with seven $F_{2:6}$ plants being selected from the NC families and six $F_{2:6}$ plants from the DB families, which were considered lines.

Among the seven NC $F_{2:6}$ lines, the F_6/ 99 line (F_6 = self-fertilization generation; and 99 = original plot) exhibited larger grain size in relation to the others. The NC $F_{2:6}$ lines were sown again in the rainy crop season in 2018 in Mococa, SP, and Capão Bonito, SP. The F_6/99 lines performed better than the others in both locations. Due to self-pollination, the F_6/99 line was renamed F_7/99 and was included in VCU trails specifically for other grain types initiated by the PMGF-IAC in 2019.

In relation to the six $F_{2:5}$ lines from the DB cross, OTG 07-9-1 (07 = 2007 year of cross; 9 = 2009 year of obtaining the line; and 1 = sequence of the lines) was the most prominent line. However, in the same year, the PMGF-IAC decided to release genotypes with tubular shape and striped color grain, which culminated in the release of the cultivars IAC Boreal and IAC Harmonia (Chiorato et al. 2008), and for that reason, the OTG 07-9-1 line was stored in the Germplasm Bank of the PMGF-IAC in 2010. With demand from the consumer market and exporters for expansion of the diversity of cultivars with other types of bean grains and great demand by packers and exporters for the DRK bean type, the PMGF-IAC decided to once more, evaluate OTG 07-9-1 in VCU trials, comparing it with other grain types, for which testing began in 2019.

PERFOMANCE

The VCU trials were conducted in ten environments in the state of São Paulo during the 2019 and 2020 years. In the dry crop season, the trials were conducted in the municipalities of Campinas, Capão Bonito, and Tatuí; in the winter

crop season, were conducted in Mococa and Campinas; and, in the rainy crop season, were conducted in Monte Alegre do Sul e Capão Bonito. The cultivar IAC 2153 stood out in the municipalities of Mococa (Winter/20), Monte Alegre do Sul (Rainy/19), and Capão Bonito (Rainy/19), with grain yield of 2083, 1703 and 1700 kg ha^{-1}, respectively. Otherwise, the cultivar IAC 2156 stood out in Campinas (Dry/20), Tatuí (Dry/20), Mococa (Winter/19), Mococa (Winter/20), Capão Bonito (Rainy/19), and Capão Bonito (Rainy/20) (Table 1).

The results of combined analysis for grain yield show that the cultivars IAC 2153 and IAC 2156 not statistically different from the IAC Nuance and IAC Tigre in the VCU trials (Table 2). However, in absolute values, the cultivar IAC 2156 exceeding the mean yield of the two control cultivars by 39 kg ha^{-1}.

The cultivars IAC 2153 and IAC 2156 were registered in 2021 under number 48141 and 48144, respectively, in the *Registro Nacional de Cultivares* of the *Ministério da Agricultura, Pecuária e Abastecimento* (MAPA/RNC).

OTHER AGRONOMIC TRAITS

Both cultivars IAC 2153 and IAC 2156 have a semi-up plant architecture, one hundred seed weight of 50 g and cooking time of 32 min. IAC 2153 has a mean cycle of 78 days and mean of crude protein content of 20%, while IAC 2156 has a mean cycle of 80 days and mean of crude protein content of 19.5%. In artificial inoculations trials, both cultivars were resistant to three races of *Colletotrichum lindemuthianum*, to *Fusarium oxysporum* f.sp. *phaseoli*, and moderately resistant to *Xanthomonas axonopodis* pv. *Phaseoli*.

The IAC 2153 and IAC 2156 were registered as suitable for growing in all crop seasons in the state of São Paulo and in rainy and dry crop seasons in South of Brazil. For both cultivars, row spaced at 0.5 m and 12 plants per linear meter,

Table 1. Grain yield (kg ha^{-1}) and coefficient of variation (CV%) in VCU experiments conducted in 10 environments in dry, winter, and rainy crop seasons

Municipality	Crop Season	IAC 2153	IAC 2156	Control cultivar		**Mean yield of control cultivars**	**CV** (%)
				IAC Nuance	**IAC Tigre**		
Campinas	Dry/19	1096	1654	863	2675	1769	19
Capão Bonito	Dry/20	1169	1388	1298	1521	1409	18
Campinas	Dry/20	486	880	1075	541	808	24
Tatuí	Dry/20	788	1738	925	1275	1100	12
Mococa	Winter/19	979	2121	1288	1704	1496	19
Campinas	Winter/19	1379	371	1478	1442	1460	16
Mococa	Winter/20	2083	2155	2052	1368	1710	19
Monte Alegre do Sul	Rainy/19	1703	784	1275	797	1036	16
Capão Bonito	Rainy/19	1700	1283	1232	1233	1233	22
Capão Bonito	Rainy/20	3130	3842	3640	3971	3806	23

* IAC Nuance (cranberry type): Determinate type I growth habit, semi-upright plant architecture; IAC Tigre (pinto bean type): Indeterminate type II growth habit and semi-upright plant architecture (Carbonell et al. 2020).

Table 2. Combined analysis of grain yield of the cultivars IAC 2153, IAC 2156, IAC Nuance, and IAC Tigre in dry, winter, and rainy crop seasons

Cultivar	**Yield grain** (kg ha^{-1})			
	Crop season			
	Dry	Winter	Rainy	
	(4 environments)	**(3 environments)**	**(3 environments)**	**Overall mean**
IAC 2153	885	1480	2178	1451
IAC 2156	1415	1549	1970	1622
IAC Nuance	1040	1606	2049	1513
IAC Tigre	1503	1505	2000	1653
Mean	1211	1535	2049	1560
CV (%)	19	19	24	22
LSD (kg ha^{-1})*	274	423	669	255

*significant at 5% by the Dunnett test.

which result in 240.000 plants per hectare, is recommended. The Seed Production Center of the Instituto Agronômico (IAC) is responsible for seed production of the cultivars.

ACKNOWLEDGMENTS

The authors thank Embrapa Rice and Beans for providing the XAP 19 isolate.

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