

## IAC 1849 Polaco: *carioca* common bean cultivar with an early maturity and tolerance to seed darkening

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**Abstract:** IAC 1849 Polaco is a common bean cultivar with a *carioca* (beige/cream-colored with brown stripes) seed coat, 75-day mean maturity, semi-upright plant architecture, tolerance to seed darkening, mean 1000-seed weight of 240 grams, resistance to the main diseases in common bean, and mean seed yield of 2464 kg ha<sup>-1</sup> obtained in 18 experiments.

**Keywords:** *Phaseolus vulgaris* L., plant breeding, tolerance to seed darkening, early maturity.

### INTRODUCTION

Common bean (*Phaseolus vulgaris*) is an important source of protein in the human diet and, in some countries, one of the main sources. These countries seek to supply consumption demands through domestic production; the main producer countries are also large consumer countries. The main types of common bean (dry edible bean) consumed in Brazil have *carioca* (beige/cream-colored with brown stripes) or black seed coats due to the preference of the Brazilian population for a product with a pleasing appearance of the bean grain, allied with pleasing taste, high nutritional quality, and sustainability of the food produced.

Common bean breeding, especially for the *carioca* commercial type that represents 79% of the dry bean market in Brazil (Ribeiro et al. 2019), contributes in a preponderant manner to the high technological level of the crop, has resulted in high seed yields, more than 4500 kg per ha (Wutke et al. 2014), high seed quality, short cooking time, and delayed seed darkening, which adds value to the final product. Thus, obtaining cultivars that combine the attributes of high seed yield and quality in the field and after harvest are desirable in common bean breeding programs.

Early maturity and delayed seed darkening are increasingly desired traits in bean production and in the consumer market, and these qualities are notably

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present in the cultivar IAC 1849. Delayed grain darkening is related to market preferences for carioca beans with a lighter bean grain color, recognizing consumers' association of this aspect with beans that are easy to cook, even though this has not been proven scientifically (Ribeiro et al. 2019).

The early maturity of the IAC 1849 Polaco is related to production and yield aspects of the crop, reducing costs on plant management and reducing use of agricultural chemicals through lower exposure to biotic stresses, due to the shorter crop maturity. In a similar way, for abiotic factors, early maturity bean cultivars require less irrigation and energy up to the end of their 75-day cycle compared to a cultivar with a normal 90-day cycle (Buratto et al. 2007).

In 1998, the Coordenadoria de Assistência Técnica Integral (Agency for Integral Technical Assistance), SP – Cati registered the cultivar Carioca Precoce (MAPA/RNC 00456) in the Registro Nacional de Cultivares (Brazilian National Cultivar Registry) of the Ministério da Agricultura, Pecuária e Abastecimento (Brazilian Ministry of Agriculture) - MAPA/RNC. This cultivar was traditionally grown by farmers in the state of São Paulo but had serious problems of susceptibility to common bacterial blight and low yield. Introduction of the early maturity trait in carioca cultivars through breeding programs resulted in registration of the cultivar IAC Imperador in 2012 (MAPA/RNC 29886) and later, in 2013, of the cultivars IPR Curió (MAPA/RNC 30616), IPR Andorinha (MAPA/RNC 30617), and TAA Gol (MAPA/RNC 31004), and, in 2017, of BRS FC104 (MAPA/RNC 36426). A condition desired by breeding programs is that reduction in the bean crop maturity not reduce bean yield or other agronomical traits (CultivarWeb 2019, [http://sistemas.agricultura.gov.br/snpc/cultivarweb/cultivares\\_registradas.php](http://sistemas.agricultura.gov.br/snpc/cultivarweb/cultivares_registradas.php)).

The cultivar IAC 1849 Polaco was developed to meet the demands of the bean production chain and offer a product with early maturity and high quality, stable grain yield, resistance to the main diseases in common bean, and tolerance to seed darkening. IAC 1849 Polaco was registered in 2019 under MAPA/RNC number 41704 in the National Cultivar Registry of the Brazilian Ministry of Agriculture.

## GENETIC ORIGIN AND DEVELOPMENT

The cultivar IAC 1849 Polaco was developed by the common bean breeding program of IAC. In 2012, a cross was made between the cultivar IAC Imperador (early maturity and carioca seed coat) (Chiorato et al. 2012) and a landrace genotype called Branquinho, not registered in MAPA and used by farmers in the state of Mato Grosso for exhibiting reduced darkening of the seed coat over long periods of storage. From the crosses made, 12  $F_1$  seeds were selected and sown in 2013 to obtain the  $F_2$  seeds. The seedlings of the  $F_2$  seeds were inoculated in the laboratory, under controlled temperature and moisture conditions, with a mixture of physiological races 65, 81, and 321 of the anthracnose pathogens and 20 resistant plants were selected.

The 20  $F_{2:3}$  plants selected were transplanted in pots and harvested individually, i.e., these  $F_3$  seeds harvested were immediately sown in the 2014 dry crop season (in January) in the IAC experimental field for evaluation of resistance to the *Fusarium oxysporum* fungus, through the natural contamination already existing in the area. In this experiment, selections were made within the progenies, and  $F_4$  seeds were harvested from 20 plants. In the 2014 winter crop season, the 20 progenies of the  $F_4$  plants were selected in an area with natural contamination of *Fusarium oxysporum*.

In this generation, one plant from each progeny was selected and  $F_5$  seed harvested. In October 2014, the rainy crop season,  $F_5$  seeds were part of an experiment containing 495 lines from other IAC crosses of the Common Bean Breeding Program of IAC (PMGF-IAC). This experiment was also sown in the municipality of Campinas in an area contaminated with *Fusarium oxysporum*. An advanced early maturing line Gen 78-1A-59 was selected. The name of the line refers to:

**Gen:** Abbreviation used to designate advanced lines in the common bean breeding program of IAC.

**78:** Number of the cross combination performed between the genotypes IAC Imperador x Branquinho.

**1A:** Number of the pot in which the plant selected in the anthracnose resistance evaluations was obtained. The number 1 means the number of the pot, and the letter A means that it was resistant to anthracnose.

**59:** number of the line from the field where the line was selected in the  $F_5$  generation of the experiment, resistant to *Fusarium oxysporum* wilt.

In 2016 dry crop season, the line Gen 78-1A-59 was part of the Value for Cultivation and Use (VCU) trials in the state of São Paulo for the 2016/2017 biennial period, together with 10 other advanced lines developed by the IAC breeding program.

## YIELD CAPACITY

The VCU experiments were conducted in 18 environments over the years 2016 and 2017 in the three different crop seasons in municipalities of the state of São Paulo (Table 1). The cultivars used as controls for the *carioca* group were IAC Sintonia, IAC Milênio, and BRS Pérola. As observed in Table 1, the line Gen 78-1A-59 exhibited a mean overall yield of 2464 kg ha<sup>-1</sup>, statistically equal to the check cultivars BRS Perola, IAC Milenio and IAC Sintonia in the VCU trials. Due to the good yield performance compared to the other standard control cultivars, together with its early cycle of around 75 days (data not shown), as well as exhibiting high tolerance to seed coat darkening a trait highly desired by the production sector, the line Gen 78-1A-59 will be recommended for growing by the Instituto Agrônômico - IAC under the name of IAC 1849 Polaco.

In the numbering 1849 used to designate the name of the cultivar, 18 refers to the year 2018, the year the genotype was reported for recommendation to the productive sector, and 49 corresponds to the forty-ninth common bean cultivar developed by the common bean breeding program of IAC.

## OTHER CHARACTERISTICS

The plants of the IAC 1849 Polaco cultivar have a semi-upright plant architecture and type I determinate growth habit. The mean cycle is 75 days from emergence to physiological maturity, in accordance with environmental growing conditions, and it is considered to have an early maturity. The cultivar IAC 1849 Polaco has *carioca* type seeds grains with a cream-colored seed coat with light brown stripes. The mean 1000-seed weight is 240 grams, and it has delayed seed darkening.

**Table 1.** Grain yield (kg ha<sup>-1</sup>) of common bean cultivars in 2016/2017 VCU experiments conducted in 18 environments in three different crop seasons

Location	Crop season	Year	Gen 78-1A-59 (kg ha <sup>-1</sup> )	Controls (kg ha <sup>-1</sup> )			Mean yield of controls	CV (%)
				BRS Pérola	IAC Milênio	IAC Sintonia		
Mococa	Rainy	2016	2167	2246	1846	2338	2143	12.37
Campinas	Rainy	2016	1850	1254	929	1933	1372	18.29
Capão Bonito	Rainy	2016	4375	3746	3779	3992	3839	14.11
Tatuí	Dry	2016	1980	2402	974	2273	1883	15.05
Campinas	Dry	2016	3467	3925	4017	3708	3883	14.39
Capão Bonito	Dry	2016	2250	1725	1654	2529	1969	24.61
Ribeirão Preto	Winter	2016	1775	1888	2275	1988	2050	24.90
Campinas	Winter	2016	2988	2779	2933	3517	3076	15.28
Votuporanga	Winter	2016	2760	2808	3658	2949	3138	19.80
Mococa	Rainy	2017	2175	2296	2896	2471	2554	12.85
Campinas	Rainy	2017	2320	2605	2330	2650	2528	16.21
Capão Bonito	Rainy	2017	2150	2250	1860	2050	2053	18.12
Tatuí	Dry	2017	2220	1890	1910	2345	2048	21.23
Campinas	Dry	2017	2455	2505	2630	2255	2463	18.36
Capão Bonito	Dry	2017	2650	2160	2225	2710	2365	11.78
Votuporanga	Winter	2017	3133	2500	2458	2325	2428	17.42
Ribeirão Preto	Winter	2017	1450	1780	1560	1110	1483	23.25
Campinas	Winter	2017	2180	1960	2100	2235	2098	22.87
Mean of Rainy (1st) (kg ha <sup>-1</sup> )			2506	2400	2273	2572	2415	23.85
Mean of Dry (2nd) (kg ha <sup>-1</sup> )			2504	2435	2235	2637	2436	17.35
Mean of Fall-Wint. (3rd) (kg ha <sup>-1</sup> )			2381	2286	2497	2354	2379	19.95
Overall Mean (kg ha <sup>-1</sup> )			2464	2373	2335	2521	2410	18.29

\* Dunnett test (p<0.05).

**Table 2.** Technological and nutritional quality: mean values of cooking time by the Mattson Cooker and percentage of protein by the microKjeldahl in common bean seeds, grown in the 2016/2017 biennial

Crop Season	Gen 78-1A-59		IAC Milênio		BRS Pérola	
	Cooking Time (min)	Protein Content (%)	Cooking Time (min)	Protein Content (%)	Cooking Time (min)	Protein Content (%)
Winter 2016	33.26	18	38.38	19	37.14	19
Winter 2017	26.99	18	36.92	19	30.39	18
Rainy 2016	31.58	19	38.38	20	33.36	18
Rainy 2017	33.89	18	36.95	19	35.62	19
Dry 2016	31.31	19	32.55	19	31.79	20
Dry 2017	26.99	20	27.31	20	27.87	20
Mean	30.6	18.6	35.1	19.3	32.7	19

Under natural growing conditions, the IAC 1849 Polaco cultivar is resistant to anthracnose (*Colletotrichum lindemuthianum*) and moderately resistant to angular leaf spot (*Phaeoisariopsis griseola*), fusarium wilt (*Fusarium oxysporum*), bacterial blight (*Xanthomonas campestris*), and bacterial wilt (*Curtobacterium flaccumfaciens* pv. *flaccumfaciens*).

As shown in Table 2, for combined analysis of the data, the mean cooking time (31.4 min) by the Mattson Cooker (Proctor and Watts 1987) and protein content in the grain (18%) by microKjeldahl method (AOAC 1980, Bataglia et al. 1983) of the IAC 1849 Polaco cultivar were similar to those of the controls. These results qualify the cultivar to achieve good acceptability in the consumer market.

## TECHNICAL RECOMMENDATION AND SEED PRODUCTION

The cultivar IAC 1849 Polaco is recommended for growing in the rainy growing season, dry growing season, and winter growing season in the state of São Paulo, and in the rainy growing season and dry growing season in the states of Paraná, Santa Catarina, Rio Grande do Sul, and Mato Grosso do Sul. A between-row spacing of 50 cm and 12 plants per <sup>linear</sup> meter is recommended, resulting in 240.000 plants per hectare.

IAC 1849 Polaco was registered in the MAPA/RNC in 2019 under number 41704 and seeds are available from the Núcleo de Produção de Sementes (Seed Production Center) of the Instituto Agrônômico – IAC.

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