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CULTIVAR RELEASE

IAC 1850: High yielding carioca common bean cultivar

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Abstract: *IAC 1850 is a common bean cultivar with a carioca (beige-colored with brown stripes) seed coat, average cycle of 88 days, semi-upright plant architecture, tolerance to seed coat darkening, 1000 seed weight of 280 grams, resistance to the main diseases in common bean, and a high average yield (2,857 kg ha^{-1}) obtained in 36 experiments conducted in different regions in Brazil.*

Keywords: *Phaseolus vulgaris L., plant breeding, resistance to darkening, disease resistance.*

INTRODUCTION

Common bean (dry edible bean or simply "beans") is one of the most important legume crops in Brazil and throughout the world, it is considered a staple and low-cost protein source, consumed in several under-developed countries, an excellent source of fiber, iron and amino acids (CIAT 2016). Furthermore, beans strongly reinforce food and nutrition security among poor consumers, while according to Li et al. (2017) its consumption also reducing the risk of cardio-vascular disease and diabetes.

Common bean is grown in diverse regions of the world, but it is most highly concentrated in areas of tropical and subtropical climate (Singh et al. 1992). Although it is grown throughout Brazil and is considered a staple food for the population, yield is considered to be low. Mean yield of carioca bean in the three annual crop seasons, according to CONAB (2018), was 1,379 kg ha^{-1}, whereas the crop has a yield potential of up to 4,500 kg ha^{-1} (Wutke et al. 2014). One of the common bean cultivars classified as "colored" by the Companhia Nacional de Abastecimento – Conab (National Food Supply Agency) is carioca (beige/cream-colored with brown stripes), which corresponds to approximately 65% of common bean production in Brazil in 2006 according to Silva and Wander (2013).

Factors responsible for low yield of common bean include the technologies used in growing the crop, such as inadequate use of machines and implements and the lack of use of recommended fertilizers, soil amendments, and irrigation; biotic factors such as pests, diseases, and weeds; and abiotic factors such as thermal variations, water deficit, and edaphic factors concerning the chemical composition, structure, compaction, low fertility, and acidity of the soil (Fageria et al. 2015).

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Due to concentration of production in carioca bean, Brazilian farmers have had to bear price declines in periods in which product stocks increase and supply is excessive. For carioca bean production, sale of excess stocks on the international market is not an alternative because there is low demand for this type of common bean, unlike pinto beans (cream-colored with brown specks). Therefore, common bean breeding programs become extremely important to be able to exploit the variability of the species to reduce costs, create business opportunities, and stimulate consumption.

In the Common Bean Breeding Program at the Instituto Agronômico - IAC (PMGF-IAC), genetic studies guide definition of the methods used for crop breeding, which must be increasingly efficient to develop adapted cultivars that maintain yield under growing conditions in unfavorable locations. The breeder needs to consider various factors besides yield; genotypes need to meet criteria of agronomic interests and market demands, such as resistance to the main diseases of common bean, resistance to abiotic factors, shorter cooking time, resistance to seed coat darkening, and a high percentage of beans that remain whole after cooking (Carbonell et al. 2010).

The goal of breeding programs is to develop common bean cultivars that increase production, trade, and consumption, together with agronomic management of the crop considering low cost, environmental conservation, nutritional quality, and product technology. Thus, the cultivar IAC 1850 was developed by the PMGF-IAC to meet these requirements. It was registered in 2018 under number 38613 in the National Cultivar Registry of the Brazilian Ministry of Agriculture (MAPA/RNC).

GENETIC ORIGIN AND DEVELOPMENT

The cultivar IAC 1850 originated in 2012 in a cross between the lines Seleção 940 x Seleção 847 as part of the PMGF-IAC for carioca common bean. The parents involved in this cross were progenies of selections involving several multiple crosses for improving characteristics of resistance to anthracnose and to fusarium wilt, upright plant architecture, stability in production in diverse environments, and high yield. In 2013, 15 F_1 seeds were sown in a greenhouse to obtain 684 seeds of the F_2 generation, which were conduct by pedigree breeding method. The F_2 seedlings were inoculated with a mixture of races 65, 81 and 321 of the anthracnose (*Coletotrichum lindemuthianum*) pathogen under controlled laboratory conditions, and 32 $F_{2:3}$ resistant seedlings were obtained in 2014. Also in 2014, the 32 $F_{2:3}$ progenies were evaluated in the field for reaction to fusarium wilt (*Fusarium oxysporum*) and 125 individual $F_{2:4}$ plants were selected. The 125 progenies of the $F_{2:4}$ generation were sown in five-meter rows in the research and development unit in the municipality of Capão Bonito-SP (UPD - IAC Capão Bonito), for evaluation of diverse agronomic characteristics. Four $F_{2:5}$ plants of the progeny number 90 were selected and codified under the numbers Gen90-1A, Gen90-2A, Gen90-3A and Gen90-4A. The "Gen" abbreviation refers to the PMGF-IAC and the letter "A" corresponds to anthracnose resistance, as the progenies were subjected to anthracnose in the F_2 generation.

In the 2015 dry crop season, the four $F_{2:5}$ lines were sown in the research and development unit UPD-IAC Mococa in the municipality of Mococa-SP, using a randomized block statistical design with three replications. In the winter crop season of the same year, the four lines were sown with other lines of the PMGF-IAC at the Centro Avançado de Seringueira e Sistemas Agroflorestais – IAC, in the municipality of Votuporanga, SP, for evaluation of reaction to fusarium wilt, and the line Gen90-4A was selected. This line came to be designated as Gen90-4A-160. The number 160 corresponds to the field plot position of the Gen90-4A line. The Gen90-4A-160 line was sown in the 2015 rainy crop season on the Santa Elisa Farm of the Instituto Agronômico - IAC in the municipality of Campinas, SP. In this evaluation, the line had excellent agronomic performance and was recommended together with other lines to compose the Value of Cultivation and Use - VCU trials for the 2016/2017 biennial period.

YIELD CAPACITY

The VCU experiments were conducted in 36 environments over the years 2016 and 2017 in three sowing seasons and in municipalities of the states of São Paulo and Goiás (Table 1). The cultivars used as controls for the carioca group were IAC Milênio and BRS Perola. The line Gen90-4A-160 (IAC 1850) had excellent agronomic performance for yield (Table 1). In twelve environments per crop season in two years of evaluation, the line Gen90-4A-160 (IAC 1850) showed a mean yield of 2,975 kg ha^{-1}, 2,607 kg ha^{-1}, and 2,989 kg ha^{-1} in the rainy, dry, and winter crop seasons, respectively, compared to the mean yield values of the two controls per crop season of 2,566 kg ha^{-1}, 2,252 kg ha^{-1}, and 2,596 kg ha^{-1},

respectively. In combined analysis of the three crop seasons, the mean yield of the line Gen90-4A-160 (IAC 1850) was 2,857 kg ha^{-1}and the mean of the control cultivars was 2,463 kg ha^{-1}.

OTHER CHARACTERISTICS

The plant of the cultivar IAC 1850 has semi-upright plant architecture and type II indeterminate growth habit. Its mean cycle is 90 days from emergence to physiological maturity, in accordance with crop growing conditions, considered to be intermediate cycle. The cultivar IAC 1850 has carioca beans with a beige-colored seed coat with brown stripes.

Table 1. Bean seed yield (kg ha^{-1}) in 2016/2017 VCU experiments grown in 36 environments in three crop seasons

Location	Season	Year	IAC 1850 (kg ha^{-1})	Control (kg ha^{-1})		Mean yield of the controls	CV (%)
				BRS Perola	IAC Milênio		
Capão Bonito - SP	Rainy	2016	4717*	3925	4212	4069	14.39
Mococa - SP	Rainy	2016	2979	2779	2312	2546	15.28
Campinas - SP	Rainy	2016	2521	1725	2625	2175	24.10
Cristalina - GO	Rainy	2016	1775	1888	1775	1832	24.35
Formosa - GO	Rainy	2016	2683	2808	2250	2529	19.80
Santo Antonio de Goiás - GO	Rainy	2016	3971	3746	3660	3703	14.11
Capão Bonito - SP	Dry	2016	2250	2246	2195	2221	12.37
Mococa - SP	Dry	2016	2638	2402	2398	2400	15.05
Campinas - SP	Dry	2016	2825*	1254	2236	1745	18.29
Cristalina - GO	Dry	2016	3021*	2296	2450	2373	12.85
Formosa - GO	Dry	2016	3350	2500	3890	3195	17.42
Santo Antonio de Goiás - GO	Dry	2016	3408*	2892	2990	2941	14.46
Ribeirão Preto - SP	Winter	2016	1983	1703	1750	1727	11.92
Votuporanga - SP	Winter	2016	2300	1739	1850	1795	9.70
Campinas - SP	Winter	2016	2956*	2000	2120	2060	10.33
Cristalina - GO	Winter	2016	4604*	2333	3500	2917	22.53
Santo Antonio de Goiás - GO	Winter	2016	2654	2082	2565	2324	13.80
Formosa - GO	Winter	2016	1733	1638	1687	1663	10.08
Capão Bonito - SP	Rainy	2017	1254	1145	1210	1178	16.00
Mococa - SP	Rainy	2017	2471	2188	2223	2206	15.23
Campinas - SP	Rainy	2017	2963*	1996	2150	2073	16.10
Cristalina - GO	Rainy	2017	4583*	3067	3285	3176	14.25
Formosa - GO	Rainy	2017	3542	3217	3365	3291	10.09
Santo Antonio de Goiás - GO	Rainy	2017	2242	2054	1990	2022	16.19
Capão Bonito - SP	Dry	2017	1375	1245	1100	1173	15.45
Mococa - SP	Dry	2017	1872	1650	1780	1715	22.40
Campinas - SP	Dry	2017	4233	3890	3915	3903	21.00
Cristalina - GO	Dry	2017	2042	1998	1640	1819	10.01
Formosa - GO	Dry	2017	2558	2446	1890	2168	20.10
Santo Antonio de Goiás - GO	Dry	2017	1713	1515	1240	1378	23.70
Ribeirão Preto - SP	Winter	2017	2354	2243	2305	2274	14.60
Votuporanga - SP	Winter	2017	2363	2150	2040	2095	19.80
Campinas - SP	Winter	2017	3783	3670	3374	3522	17.80
Cristalina - GO	Winter	2017	3196	3146	2980	3063	19.00
Santo Antonio de Goiás - GO	Winter	2017	3364	3250	3205	3228	14.00
Formosa - GO	Winter	2017	4583	4315	4650	4483	15.10
Mean of the rainy season (kg ha^{-1})			2975	2545	2588	2540	18.0
Mean of the dry season (kg ha^{-1})			2607	2195	2310	2252	19.7
Mean of the fall-winter season (kg ha^{-1})			2989	2522	2669	2596	15.2
Overall mean (kg ha^{-1})			2857	2421	2522	2463	17.5

* Dunnett test (p>0.05)

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

Season	IAC 1850		IAC Milênio		BRS Pérola	
	Cooking Time (min)	**Protein Content** (%)	**Cooking Time** (min)	**Protein Content** (%)	**Cooking Time** (min)	**Protein Content** (%)
Winter 2016	33.31	19	33.30	20	35.21	19
Winter 2017	36.71	20	32.40	19	32.27	19
Rainy 2016	29.30	21	30.35	19	35.25	20
Rainy 2017	30.31	18	32.50	21	30.03	21
Dry 2016	28.45	19	29.30	21	29.25	21
Dry 2017	27.35	20	28.40	20	31.11	19
Mean	30.90	20	31.04	20	32.19	20

The mean 1000 seed weight is 280 grams, and it is resistant to early seed coat darkening.

Under natural growing conditions, the cultivar IAC 1850 is moderately resistant to anthracnose (*Colletotrichum lindemuthianum*), to angular leaf spot (*Phaeoisariopsis griseola*), to fusarium wilt (*Fusarium oxysporum*), to common bacterial blight (*Xanthomonas axonopodis* pv. *phaseoli*), and to bacterial wilt (*Curtobacterium flaccumfaciens* pv. *Flaccumfaciens*).

As shown in the mean test Dunnet ($p>0.05$) (Table 2), mean cooking time (30.9 min) and bean protein content (20%) of the cultivar IAC 1850 were similar to those of the controls. These results qualify the cultivar to be able to be well received by the consumer market.

TECHNICAL RECOMMENDATIONS AND SEED PRODUCTION

The cultivar IAC 1850 is recommended for cultivation in the rainy, dry, and winter crop seasons in the states of São Paulo e Goiás and in the rainy and dry seasons in the states of Paraná, Santa Catarina, Rio Grande do Sul, and Mato Grosso do Sul. A between-row spacing of 50 cm and 10 plants per linear meter, resulting in 200,000 plants per hectare.

IAC 1850 was registered in 2018 in the MAPA/RNC under number 38613 and has seed production available in the Núcleo de Produção de Sementes do Instituto Agronômico – IAC.

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