CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

IAC 2051: common bean cultivar of carioca type with slow seed coat darkening

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Abstract: *IAC 2051 is a common bean (Phaseolus vulgaris L.) cultivar with carioca-type seed coat, mean 1000 seed weight of 300g, indeterminate semi-upright type II growth habit, slow post-harvest seed coat darkening, resistance to Fusarium wilt, common bacterial blight, and three races of anthracnose, and mean yield of 2729 kg ha^{-1}.*

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

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is rich in protein, carbohydrates, vitamins, minerals, fibers, and antioxidant phenolic compounds (Silva et al. 2009). Brazilians consume an average of 17 kg inhab^{-1} year^{-1} of common bean, with frequency of three to seven times a week (Ribeiro et al. 2019). Among the different types of common bean grown, preference in the Brazilian consumer market is for carioca-type (cream-colored seed coat with brown streaks), followed by black bean, and then other types of bean grain (Faria et al. 2008).

In the 2018/2019 crop season, Brazil produced around 3.02 million metric tons of common bean in an area of 2.93 million hectares, led by the states of Paraná. In the same crop year, mean Brazilian yield was approximately 1031 kg ha^{-1}, though the mean yield for the state of São Paulo was much higher: 2363 kg ha^{-1} (CONAB 2020).

The increase in grain yield of common bean observed over the years is a result of improvement of crop management through use of inputs, suitable agronomic practices, and improved cultivars. Common bean breeding programs are important for increasing crop yield, and annual genetic gains obtained in common bean grain yield in Brazil range from 1.07% to 6.74% (Chiorato et al. 2010, Barili et al. 2016).

Adoption of a common bean cultivar by farmers depends not only on grain yield but also on other characteristics, such as resistance/tolerance to biotic and abiotic factors that can interfere in bean development, nutritional quality, technological aspects, such as seed-coat darkening and cooking time, and post-harvest characteristics of the grain (Carbonell et al. 2010, Chiorato et al.

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2015). For the consumers, post-harvest quality merits consideration, especially slow seed darkening during storage since consumers associate dark bean grain color with difficulty in cooking (Silva et al. 2008).

Thus, the aim of this paper is to present the common bean cultivar IAC 2051 (Gen 2017-26-3-DA410) of carioca-type, which has high yield potential, slow post-harvest seed darkening, and resistance to Fusarium wilt (*Fusarium oxysporum f. sp. phaseoli*), common bacterial blight (*Xanthomonas axonopodis pv*. *phaseoli)*, and *three races of* anthracnose (*Colletotrichum lindemuthianum*).

GENETIC ORIGIN AND DEVELOPMENT

The line Gen 2017-26-3-DA410 (IAC 2051) was developed from 2016 to 2018. In the winter of 2016, the carioca cultivar TAA Dama and the line SXB 410 (from the International Center for Tropical Agriculture [CIAT]), were crossed. From this cross, 20 F_1 seeds were obtained. These seeds were sown in a greenhouse in the rainy season of 2016 to obtain seeds of the F_2 generation. This multiplication provided 350 F_2 seeds.

In 2017, in the dry crop season, a sample of 50 pre-germinated F_2 seeds were transplanted to 5-liter pots in a greenhouse to identify plants with light-colored grain and with slow seed coat darkening after storage for 90 days. From this evaluation, 30 plants that exhibited slow seed-coat darkening and high 100-seed weight, characteristics of line SXB 410, were separated. The 30 plants selected in F_2 were identified as Gen 2017-1-DA410 to Gen 2017-30-DA410, in which Gen is the abbreviation used by the Common Bean Plant Breeding Program of the IAC; 2017 is the year in which the progenies were obtained; the sequence from 1 to 30 represents the total of 30 progenies selected in the $F_{2:3}$ generation; and the abbreviation DA410 refers to the parents used, with DA for the cultivar TAA Dama and 410 for the line SXB 410.

In the winter season of 2017, the 30 progenies were sown in a field on the Santa Elisa Farm of the Instituto Agronômico - IAC, Campinas, São Paulo. The seeds of each progeny were sown in 5-m rows at a spacing of 50 cm between rows. The aim of the experiment was to select plants within the progenies resistant to the soil pathogen *Fusarium oxysporum f. sp. phaseoli*. From this experiment was selected the progeny Gen 2017-26-DA410.

In the rainy season of 2017, each progeny of the $F_{2:4}$ generation was sown in a 5-m row, spaced 0.5 m apart, in the municipality of Capão Bonito, São Paulo. Growth habit, grain yield, yield components, and grain quality after harvest were evaluated. Five plants were selected within Gen 2017-26-DA410, which were identified as Gen 2017-26-1-DA410 to Gen 2017-26-5-DA410, thus obtaining the $F_{2:5}$ generation.

In 2018, in the dry season, the $F_{2:5}$ progenies were sown in the municipality of Mococa, São Paulo. The randomized block experimental design, with three replications, was adopted. Growth habit, grain yield, resistance to soil pathogens, and post-harvest seed coat darkening were evaluated. To evaluate the seed coat darkening, a chamber with ultraviolet light was used for selection of lines with seed coats that did not darken at 24 hours of exposure to ultraviolet light (Spitti et al. 2019). The line Gen 2017-26-3-DA410 exhibited slow darkening of grain and was incorporated in the Value for Cultivation and Use (VCU) trials. These trials began in the winter season of 2018 and finished in the dry season of 2020.

YIELD POTENTIAL

The mean grain yield of the line Gen 2017-26-3-DA410 (IAC 2051), compared to the three check cultivars, was higher in ten locations. In Mococa (dry season/2019), the cultivar IAC 2051 exhibited the highest yield (4250 kg ha^{-1}) (Table 1).

In combined analysis (Table 2), line Gen 2017-26-3-DA410 (IAC 2051) had mean yield of 2729 kg ha^{-1} in the VCU trials, which exceeded significantly the mean yield of the check cultivar IAC 1850 by 8%. The cultivar IAC 2051 exceeded the mean yield of the cultivars IPR Sabiá and TAA Dama by 32 and 27%, respectively.

Based on results obtained, the common bean breeding program of the Instituto Agronômico - IAC named the Gen 2017-26-3-DA410 line as IAC 2051. The name of the cultivar in reference to the number 20 corresponds to the year of release and the number 51 corresponds to the 51st common bean cultivar developed by the common bean breeding program of IAC.

OTHER CHARACTERISTICS

The cultivar IAC 2051 has an indeterminate semi-upright type II growth habit, mean 1000 seed weight of 300 grams, mean cycle of 90 days from emergence to physiological maturity, mean grain cooking time of 30 min, and mean protein content of 20%. In artificial inoculations with the pathogens that cause anthracnose (races 65, 83, and 89), Fusarium wilt (race 6), and common bacterial blight (XAP 19 isolate) (Table 3), under controlled conditions in the laboratory and greenhouse, the cultivar IAC 2051 exhibited resistance to these races and pathogens.

A between-row spacing of 50 cm and 12 plants per meter, which result in 240.000 plants per hectare, is recommended for the three cropping seasons. The yield of the cultivar IAC 2051 depends on the period of sowing, growing region, and technological level of the farmer (fertilization, disease and weed control, water supply, and other production factors).

Table 1. Grain yield of the cultivar IAC 2051 compared to the three check cultivars, in VCU experiments conducted in 18 environments in three crop seasons

Municipality	Crop season	IAC 2051 (kg ha^{-1})	Check (kg ha^{-1}) *			Mean yield of checks	CV (%)
			IAC 1850	IPR Sabiá	TAA Dama		
Votuporanga	Winter/2018	3972	3527	2825	3327	3226	7
Campinas	Winter/2018	3858	3575	2192	2442	2736	12
Mococa	Winter/2018	1950	2183	1542	1658	1794	13
Mococa	Rainy/2018	2545	2167	2021	1967	2051	6
Capão Bonito	Rainy/2018	2312	2042	2313	1938	2097	8
Campinas	Rainy/2018	2520	2138	1908	1896	1981	11
Capão Bonito	Dry/2019	1875	1750	2083	2000	1944	13
Campinas	Dry/2019	2613	1438	1296	1363	1365	12
Mococa	Dry/2019	4250	4042	2642	2600	3094	14
Campinas	Winter/2019	2575	2308	2642	2171	2374	11
Mococa	Winter/219	2317	1950	1825	1700	1825	10
Votuporanga	Winter/2019	3008	2875	1967	2100	2314	9
Monte Alegre do Sul	Rainy/2019	2700	2100	2925	2308	2444	11
Capão Bonito	Rainy/2019	3375	4333	3758	2775	3622	7
Mococa	Rainy/2019	4225	4642	1717	5075	3811	14
Campinas	Dry/2020	2842	2117	1933	1267	1772	18
Tatuí	Dry/2020	1921	1675	1302	1683	1553	8
Mococa	Dry/2020	268	442	260	200	301	13

*IAC 1850: indeterminate type II growth habit, semierect plant architecture, and resistence to the main diseases in common bean (Carbonell et al. 2019); IPR Sabiá: indeterminate type II growth habit and erect plant architecture; TAA Dama: indeterminate type III growth habit, prostrate plant architecture, and tolerance to seed coat darkening.

Table 2. Grain yield of the cultivar IAC 2051 in relation to the best check cultivar for growing in the three common bean crop seasons, as well as in relation to the combined mean of the trait in 18 environments of the state of São Paulo in 2018, 2019, and 2020

Common bean cultivar	Crop season (kg ha^{-1})			Combined mean (kg ha^{-1})
	Rainy (6 environments)	Dry (6 environments)	Winter (6 environments)	
IAC 2051	2946	2294*	2946*	2729*
IAC 1850	2903	1911	2736	2516
IPR Sabiá	2440	1585	2165	2063
TAA Dama	2659	1618	2232	2137
Mean	2373	1794	2303	2157
CV (%)	11	15	10	12
LSD (kg ha^{-1})*	244	260	231	141

*significant at 5% by the Dunnett test.

Table 3. Reaction of four cultivars of common bean to anthracnose (ANT), Fusarium wilt (FW), and common bacterial blight (CBB) artificially inoculated under laboratory conditions and greenhouse

Common bean cultivars	ANT[a] (Races 65, 83, and 89)	FW[b] (Race 6)	CBB[c] (Isolate XAP 19)
IAC 2051	R	R	R
IAC 1850	R	R	MR
IPR Sabiá	R	R	R
TAA Dama	S	MR	R

R: resistant to the pathogen; MR: moderately resistant to the pathogen; S: susceptible to the pathogen
[a] scoring scale adapted from Pastor-Corrales et al. (1995) using notes from 1 to 9. The plants with scores 1.0 to 3.0 were classified as resistant; from 3.1 to 6.0 as moderately resistant and from 6.1 to 9.0 as susceptible.
[b] scoring scale adapted from Pastor-Corrales and Abawi (1987) using notes from 1 to 9. The plants with scores 1.0 to 3.0 were classified as resistant; from 3.1 to 6.0 as moderately resistant and from 6.1 to 9.0 as susceptible.
[c] scoring scale adapted from Rava (1984) using notes from 1 to 6. The plants with scores 1.0 to 2.0 were classified as resistant; from 2.1 to 4.0 as moderately resistant and from 4.1 to 6.0 as susceptible.

TECHNICAL RECOMMENDATIONS AND SEED PRODUCTION

Considering its high mean yield and 1000-seed weight in addition to its slow seed-coat darkening, the cultivar IAC 2051 is recommended for growing in the rainy, dry, and winter crop seasons in the state of São Paulo, and for the rainy and dry crop seasons in the states of Paraná, Santa Catarina, Rio Grande do Sul, and Mato Grosso do Sul.

The IAC 2051 cultivar was registered in the National Cultivar Registry (Registro Nacional de Cultivares - RNC) of the Brazilian Ministry of Agriculture (Ministério da Agricultura, Pecuária e Abastecimento - MAPA) on August 3, 2020, under number 44819 and has seed production available in the Núcleo de Produção de Sementes do Instituto Agronômico – IAC.

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