

## IAC Veloz: a new early-cycle black bean cultivar

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**Abstract:** *The black bean cultivar IAC Veloz developed by the dry edible bean (or common bean) breeding program of the Instituto Agronômico-IAC stands out because of its early cycle, upright plant type, 1000 seed weight of 220 grams, and mean yield potential of 3770 kg ha<sup>-1</sup> in a total of 18 environments.*

**Keywords:** *Phaseolus vulgaris, early maturity, disease resistance.*

### INTRODUCTION

Dry edible bean, or common bean (*Phaseolus vulgaris*), is prominent in the Brazilian diet because of its numerous benefits to human health (Lovato et al. 2018). The seeds (commonly known as grain) with a *carioca* (beige with brown streaks) or black seed coat are most consumed in Brazil and preferred by consumers. They are emphasized in crop breeding programs that develop commercial common bean types.

In addition to early maturity and yield potential, plant growth habit and resistance to diseases are essential traits for releasing new cultivars in the production market. Bean seeds should also have high technological and nutritional quality. This makes the entire plant breeding process, beginning with selection of parents, an important strategy for developing cultivars (Carbonell et al. 2010, Leite et al. 2015).

Considering surveys for the 2018-2019 crop year, the area planted to black beans is 74.5% less than the area dedicated to growing common bean with colored (*carioca* and streaked) seed coats (CONAB 2020), influenced by regionalized consumption habits related to grain type and by the Brazilian preference for the *carioca* seed coat. Brazilian breeding programs have developed cultivars mainly for these two types, and this is confirmed by the equivalent yield potential of the cultivars released on the market. Still according to CONAB in 2020, the total beans production in the crop 2018-2019 was 3.02 million tons, of which 493 thousand tons are black beans, with mean yield of 1476 kg ha<sup>-1</sup>.

Studies evaluate the genetic progress of common bean mainly in regard to yield of bean seeds and their components, according to Ribeiro et al. (2003) and Chiorato et al. (2010), among other authors. Barili et al. (2016) evaluated the genetic progress of black bean for approximately five decades (1960 to 2013) and observed gains for grain yield, especially after 1989, which amounted to

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2.42% annually. The authors also state that improvements occurred for other important traits, such as grain appearance, plant architecture, number of pods per plant, number of beans per pod, and 1000 seed weight.

In light of the above, the aim of this paper is to present the cultivar IAC Veloz (advanced line GEN PR 10-4-4-23) as a new alternative in black bean, which stands out in different environments by its early maturity and yield potential.

## GENETIC ORIGIN AND DEVELOPMENT

Over the years, in a continual process of development of new cultivars for the production sector, the common bean breeding program of the Instituto Agronômico-IAC has made cultivars available to the market that have high yield potential, resistance to the main diseases of common bean, and marketing traits important for the product packaging industry (Carbonell et al. 2008, Carbonell et al. 2010, Chiorato et al. 2012, Carbonell et al. 2014 and Chiorato et al. 2018).

The practice of hybridization, followed by selection of superior plants, constitutes a routine activity within breeding programs for the purpose of making improved cultivars available. Thus, various hybrid combinations are obtained for selection of the one that associates a higher number of favorable traits. In this case, specifically, hybridization between two elite cultivars, one of them with a carioca seed coat (IAC Imperador) and another with a black seed coat developed by the Instituto Agronômico do Paraná – IAPAR, called IPR Tuiuiú, gave rise to the advanced line GEN PR 10-4-4/23, registered as IAC Veloz in the Ministério da Agricultura, Pecuária e Abastecimento – MAPA (Brazilian Ministry of Agriculture). The cultivar began to be developed in 2010 from hybridization between IAC Imperador (hardiness and early maturity) and IPR Tuiuiú (quality of the black bean broth and tolerance to bacterial blight), generating 18 hybrid seeds ( $F_1$ ), which were multiplied the same year to obtain the  $F_2$  generation.

The seeds of the  $F_2$  generation were pre-germinated and transplanted in boxes containing vermiculite with sterilized substrate. Seven days after transplanting, in the laboratory, the seedlings were inoculated with three physiological races (65, 81, and 321) of anthracnose (*Colletotrichum lindemuthianum*). Fifteen seedlings were considered resistant to all the races inoculated, and they were individually transplanted in pots and grown in a greenhouse, being conducted by the genealogical method. In the 2010 rainy season, the 15 progenies selected were grown in the field, providing for selection within progenies of 35 plants of the  $F_{2,3}$  generation, which resulted in the opening of lines, which were once more sown in the field in the following season (winter/2011). This time, they were sown in an area with natural contamination of *Fusarium oxysporum*, and one plant within each one of the 35 progenies in the  $F_{2,4}$  generation was selected.

In the 2011 rainy season, the progenies selected ( $F_{2,5}$  generation), already considered lines, together with another 495 lines derived from crosses in the program, composed the competition trials. The lines derived from the cross between IAC Imperador x IPR Tuiuiú were called GEN PR 10-4-4/X, where GEN refers to the genotype; PR refers to a bean with a black seed coat; 10 refers to the year of obtaining the cross (2010); 4 refers to the hybrid combination (IAC Imperador x IPR Tuiuiú); 4 refers to the plant selected in relation to resistance to anthracnose; and X is in regard to the line selected from among the 35 extracted from the cross in question. After that, these 35 advanced lines were evaluated, with priority given to grain yield, early maturity, sieve yield, seed coat color, and plant height and growth habit, considering a total of four environments in the state of São Paulo: Campinas, Capão Bonito, Mococa, and Tatuí. Plants were evaluated in the three crop seasons up to the  $F_{2,8}$  generation. The advanced line number X = 23 (GEN PR 10-4-4-23) was selected to conduct the value for cultivation and use (VCU) trials, due to the traits evaluated and the performance shown.

The VCU trials began in 2013 by the common bean breeding program of IAC, which, in addition to GEN PR10-4-4/23, included 10 other advanced lines developed by the program, with the cultivars IAC Diplomata and IAC Una used as standards controls in evaluation. The VCU trials were carried out in three crop seasons and in two crop years, following the requirements established by MAPA for setting up and conducting trials. In these trials, the line GEN PR10-4-4/23 exhibited mean yield of 2591.01 kg ha<sup>-1</sup>, which was superior to the controls IAC Diplomata and IAC Una, which exhibited mean yields of 2510.04 kg ha<sup>-1</sup> and 2475.23 kg ha<sup>-1</sup>, respectively. The performance shown, together with early maturity, led to recommendation of the line GEN PR10-4-4/23 to the production sector with the name of IAC Veloz because of its early 75-day cycle from emergence to physiological maturity.

## YIELD CAPACITY

The mean grain yield of the cultivar IAC Veloz, compared to the two control cultivars, was higher in all three locations evaluated in the rainy crop season 2014; and in Capão Bonito at this same time, the cultivar exhibited maximum yield in relation to the other seventeen environments evaluated, at 3770.83 kg ha<sup>-1</sup>. The cultivar IAC Veloz exceeded the mean yield of the two controls in 67% of the environments evaluated (Table 1).

This yield superiority of the cultivar IAC Veloz was observed for the combined environments, considering each crop season, with the exception of the winter crop season, for which there was no significant difference (Table 2). The mean yield values of IAC Veloz, considering six environments per crop season, were 2724.47 kg ha<sup>-1</sup>, 2012.79 kg ha<sup>-1</sup>, and 3035.78 kg ha<sup>-1</sup> in reference to the rainy, dry, and winter crop seasons, respectively. Considering combined analysis of the environments tested in the three crop seasons of common bean in the state of São Paulo, according to agroecological zoning, the overall mean of grain yield was 2591.01 kg ha<sup>-1</sup>, 2510.04 kg ha<sup>-1</sup>, and 2475.23 kg ha<sup>-1</sup> for the rainy, dry, and winter crop seasons, respectively (Table 2). Through the results presented, the production performance associated with resistance to different races of anthracnose and Fusarium wilt, and early maturity in regard to the crop cycle, make the cultivar IAC Veloz an excellent alternative for growing in the different regions of the state of São Paulo.

**Table 1.** Mean grain yield of the cultivar IAC Veloz and of the controls IAC Diplomata and IAC Una in VCU trials carried out in the two-year period of 2013/2014/2015 in the three crop seasons indicated by agroecological zoning of the crop, considering only those trials with a coefficient of experimental variation lower than 25% as viable

Location	Crop season	IAC Veloz (kg ha <sup>-1</sup> )	Controls (kg ha <sup>-1</sup> )		Mean yield of the controls	Coefficient of variation (%)
			IAC Diplomata	IAC Una		
Capão Bonito	Rainy/2013	2991.70	3491.70	2945.80	3218.75	10.60
Mococa	Rainy/2013	2995.80	2554.20	2487.50	2520.85	9.14
Tatuí	Rainy/2013	2380.15	2322.15	2116.37	2219.26	15.60
Capão Bonito	Dry/2014	1425.40	1537.50	1408.30	1472.90	20.00
Mococa	Dry/2014	2862.50	2995.80	2995.80	2995.80	13.89
Tatuí	Dry/2014	2380.50	2450.12	2225.45	2337.79	18.80
Ribeirão Preto	Winter/2014	2950.10	2980.14	2610.35	2795.25	15.04
Votuporanga	Winter/2014	2712.50	3220.83	2975.00	2975.00	12.62
Colina	Winter/2014	2700.20	2680.58	2705.86	2693.22	22.35
Itararé	Rainy/2014	1758.33	1600.00	1583.33	1591.67	21.86
Capão Bonito	Rainy/2014	3770.83	2762.50	3283.33	3022.92	14.03
Mococa	Rainy/2014	2450.00	2350.00	2391.67	2370.84	17.20
Mococa	Dry/2015	3245.83	2745.83	2879.17	2812.50	11.56
Capão Bonito	Dry/2015	1441.70	1604.20	1737.50	1670.85	20.56
Itararé	Dry/2015	720.80	462.50	700.00	581.25	7.69
Votuporanga	Winter/2015	4841.70	5541.70	4854.20	5197.95	23.88
Ribeirão Preto	Winter/2015	2400.00	1720.80	2204.20	1962.50	19.10
Colina	Winter/2015	2610.20	2330.25	2450.38	2390.32	12.74

**Table 2.** Mean grain yield (kg ha<sup>-1</sup>), experimental coefficient of variation (CV%), and least significant difference (LSD, Dunnett – p<0.05) in relation to the best standard cultivar for growing in the three common bean crop seasons, as well as in relation to the overall mean of the trait in 18 environments of the state of São Paulo that were part of the VCU trials for the two-year period of 2013/2014/2015

Common bean cultivars	Crop season			Mean (2013/2014/2015) (kg ha <sup>-1</sup> )
	Rainy (6 environments)	Dry (6 environments)	Winter (6 environments)	
IAC Veloz	2724.47	2012.79	3035.78	2591.01
IAC Diplomata	2513.43	1965.99	3050.69	2510.04
IAC Una	2468.00	1991.04	2966.67	2475.23
CV (%)	16.70	14.21	18.90	21.33
LSD (kg ha <sup>-1</sup> )	380	450	426	419

**Table 3.** Mean response for cooking time and crude protein content by the Dunnett test ( $p < 0.05$ ), evaluated in 18 environments in the state of São Paulo

Crop season	IAC Veloz		IAC Diplomata		IAC Una	
	Cooking time (min)	Protein content (%)	Cooking time (min)	Protein content (%)	Cooking time (min)	Protein content (%)
Rainy	37.77	20.50	33.12	21.50	32.74	20.50
Dry	30.85	50.50	29.38	21.00	31.93	21.00
Winter	27.43	20.50	27.27	22.00	29.51	20.00
Mean	32.02	20.50	29.92	21.50	31.39	20.50

## OTHER TRAITS

The cultivar IAC Veloz exhibited cooking time statistically equivalent to the controls when evaluated by the Mattson Cooker (Proctor and Watts 1987). Crude protein content evaluated by the micro Kjeldahl method (AOAC 1980, Bataglia et al. 1983) for the IAC Veloz cultivar had an overall mean performance similar to that of IAC Una, which was lower than IAC Diplomata, but was not significantly lower than the mean values exhibited by the controls (Table 3).

The IAC Veloz cultivar has a determined growth habit, upright plant type, 1000 seed weight of 220 grams, and 75-day cycle from emergence to physiological maturity. It is thus considered to be of early maturity, and its upright plant type facilitates mechanical grain harvest. Due to the early maturity and shorter exposure time in the crop field from sowing to harvest contributed this genotype had a intermediate performance when exposed to water deficit and to low temperature, as well as to high temperature in the reproductive phase. It exhibits resistance to the diseases of anthracnose, rust, and common mosaic, and moderate resistance to bacterial blight, angular leaf spot, Fusarium wilt, and bacterial wilt.

## TECHNICAL RECOMMENDATION AND SEED PRODUCTION

Due to the early cycle, upright plant type, grain yield, and tolerance to the pathogens of Anthracnose and *Fusarium oxysporum* shown by the IAC Veloz cultivar, it is recommended for growing in the rainy, dry, and winter crop seasons in the state of São Paulo, and may also be recommended for the rainy and dry crop seasons in the states of Paraná, Santa Catarina, Rio Grande do Sul, and Mato Grosso do Sul.

To correctly manage the crop and achieve the yield potential of the cultivar, we recommend between-row spacing of 50 cm and density of 12 plants per meter, resulting in a population of 240.000 plants per hectare. Other factors that may also affect the grain yield of the cultivar IAC Veloz are the crop season (rainy, dry, or winter), the growing region, and the technological level of production.

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