CULTIVAR RELEASE

IAC 2358 Unamax: A high-yielding common bean cultivar tolerant to *Colletotrichum lindemuthianum*

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Abstract: *The common bean cultivar IAC 2358 Unamax is characterized by a black seed coat and indeterminate type II growth habit. It has a 90-day growth cycle, mean 1000-seed weight of 260 grams, yield potential of 3,391.67 kg ha^{-1}, and tolerance to Colletotrichum lindemuthianum and Fusarium oxysporum.*

Keywords: *Phaseolus vulgaris, plant breeding, black beans*

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is an important agricultural crop in Brazil, largely due to its cultural and dietary significance. In the 2024/25 crop year, domestic consumption was estimated at 3.05 million tons, with national production of 3.3 million tons meeting internal demand. This production spreads across the main producing states, with Paraná leading at 926.9 thousand metric tons, followed by Minas Gerais (480.8 thousand tons) and Mato Grosso (330 thousand tons), according to the 2024/2025 crop survey from CONAB (2025).

However, the common bean crop has not always been so high yielding. Historically, the 1976/77 crop year resulted in a mean yield of 488 kg ha^{-1}, whereas the mean yield in the 2023/24 crop year was 1,134.97 kg ha^{-1} (CONAB 2024), an increase of 132.58%. However, in this same period, planted area decreased 37.03%. These data show not only the significance of national production, with total trade of 11.71 billion reals (Brazilian currency - BRL) in 2023 (IBGE 2023), but also genetic gains, reflected in increased yield, improved plant nutrient management, and the mitigation of limiting factors (Carbonell et al. 2012).

Genetic advances may affect various traits. In the case of black beans, the gains recorded between 1985 and 2006, as reported by Faria (2014), included improvements in yield, 100-seed weight, and resistance to lodging, with annual increases of 1.1%, 0.65%, and 1.7%, respectively.

In this context, the Common Bean Breeding Program of the Agronomic Institute (Programa de Melhoramento Genético de Feijoeiro do Instituto Agronômico – PMGF-IAC) has played a fundamental role. Since 1932, it has prioritized achieving genetic gains in traits such as resistance and tolerance to biotic and abiotic stresses, early maturity, and nutritional and technological quality (Bezerra et al. 2021).

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Thus, in 2023, the cultivar IAC 2358 Unamax was released, which features high-quality bean broth, a hardy root system, and plant health.

GENETIC ORIGIN AND DEVELOPMENT

Development of the cultivar IAC 2358 Unamax began in the 2017 winter crop season by crossing the genotype BRS Esteio and the Gen 104-2A-292 line. Prior to that, the parental line Gen104-2A-292 had been developed from recombination of the IPR Colibri × IAC Imperador genotypes with IAC Carioca Eté. The IAC Carioca Eté cultivar is a carioca seed coat genotype with high yield and tolerance to anthracnose (*Colletotrichum lindemuthianum*). It does not have the commercially preferred light-colored seed coat trait but nevertheless served as a gene donor for the IAC 2358 Unamax cultivar.

In the 2017 crop season, seeds of the F_1 generation (BRS Esteio × Gen104-2A-292 line) were sown in a greenhouse to obtain F_2 seeds. In the 2018 winter crop season, these seeds were artificially inoculated under controlled conditions (temperature, moisture, and photoperiod) with races 65 and 81 of *Colletotrichum lindemuthianum*, resulting in 15 plants tolerant to these physiological races. These tolerant plants were transplanted in a greenhouse to obtain the $F_{2:3}$ generation. In this generation, 6 plants were excluded for lacking target traits, such as anthracnose tolerance or upright growth habit.

Seeds from the 9 selected plants resulted in families that were sown in the 2018 rainy crop season in Campinas, SP, for the purpose of selection. Subsequently, the $F_{2:4}$ generation was harvested and then planted in Tatuí, SP, in the 2019 dry crop season. Plants were selected, generating the $F_{2:5}$ generation. These seeds were sown in Capão Bonito, SP, and once more selected at harvest of the $F_{2:6}$ generation. The plants selected in $F_{2:6}$ were designated as lines. Then, from the 2019 rainy crop season up to the 2022 dry crop season, Value for Cultivation and Use (VCU) trials were conducted, including the Gen104-2A-292 line. The results showed that this cultivar outperformed the check cultivars IAC Veloz and BRS Esteio. The PMGF-IAC chose the name IAC 2358 Unamax based on its maintainer (Instituto Agronômico - IAC), its recommendation in 2023, and its position as the 58th cultivar developed by the PMGF-IAC. Unamax is the trade name, combining a reference to the previous cultivar IAC Una with “max” to emphasize its improved yield.

Table 1. Grain yield of the IAC 2358 Unamax cultivar compared to the mean yield of the two check cultivars, by site, crop season, and year

Site	Crop season	‘IAC 2358 Unamax’ (kg ha^{-1})	Check cultivars (kg ha^{-1})		Mean yield of the check cultivars	CV (%)	F value calculated
			IAC Veloz	BRS Esteio			
Votuporanga, SP	Winter 2020	1,226.67	976.67	1,286.00	1,131.34	16.69	1.56
Mococa, SP	Rainy 2020	2,754.63	2,324.07	2,134.26	2,229.17	20.70	1.87
Capão Bonito, SP	Rainy 2020	3,391.67	3,660.00	3,670.83	3,665.42	10.11	2.23*
Tatuí, SP	Rainy 2020	2,612.50	2,595.83	2,337.50	2,466.67	16.43	2.10*
Campinas, SP	Dry 2021	2,932.50	2,338.33	2,555.00	2,446.67	18.43	6.13*
Capão Bonito, SP	Dry 2021	2,662.50	2,020.83	2,550.00	2,285.42	22.20	3.25*
Campinas, SP	Winter 2021	2,620.83	1,695.83	2,843.50	2,269.67	19.75	3.06*
Votuporanga, SP	Winter 2021	2,909.26	2,826.76	2,797.60	2,812.18	12.73	1.16
Tatuí, SP	Winter 2021	1,716.67	1,243.50	1,300.00	1,271.75	24.87	1.93
Mococa, SP	Winter 2021	1,194.30	980.33	1,541.45	1,260.89	16.98	4.65*
Campinas, SP	Rainy 2021	1,691.67	1,837.50	2,600.00	2,218.75	16.57	7.25*
Capão Bonito, SP	Rainy 2021	2,545.83	2,250.00	2,341.67	2,295.84	13.98	2.85*
Campinas, SP	Dry 2022	1,494.00	512.67	1,212.00	862.34	17.49	3.71*
Capão Bonito, SP	Dry 2022	2,189.67	2,322.67	2,562.33	2,442.50	17.49	3.71*
Mean of rainy (1st season)		2,599.26	2,533.48	2,616.85	2,575.17	15.19	3.56*
Mean of dry (2nd season)		2,319.60	1,798.65	2,197.08	1,997.87	19.11	5.23*
Mean of fall-winter (3rd season)		1,933.55	1,544.62	1,953.71	1,749.17	18.81	4.39*
Overall mean (combined)		2,281.62	1,970.36	2,260.08	2,115.22	17.39	5.82*

* Significant at 5% in the F-test

YIELD POTENTIAL

The cultivar IAC 2358 Unamax showed a higher mean yield across crop seasons compared to the mean yields of the check cultivars, with a statistically significant difference at the 5% probability level according to the F-test (Table 1). The observed yield advantages were 24.26 kg ha^{-1} in the rainy season, 321.73 kg ha^{-1} in the dry season, and 184.38 kg ha^{-1} in the fall–winter season. Considering the overall mean values, the cultivar IAC 2358 Unamax showed superiority of 166.44 kg ha^{-1}, corresponding to approximately three more of the standard 60-kg bags of black beans per hectare.

OTHER CHARACTERISTICS

The IAC 2358 Unamax cultivar of the black bean commercial group has an indeterminate type II growth habit, with a medium to long main stem and semi-upright architecture, reaching a maximum height of 80 cm. Its 1000-seed weight is 260 grams. The plant growth cycle is 32 days from emergence to flowering and 90 days from emergence to physiological maturity, considered a normal cycle for this variety.

Bean cooking time is a focus in common bean breeding, with efforts directed toward reducing this time (Wood 2016). Conversely, increasing the protein content is a desirable goal, as this trait enhances the nutritional quality and digestibility of the bean grains (Koehler et al. 1987). The data for the IAC 2358 Unamax cultivar show that it has short cooking time and adequate protein content (Table 2).

The overall mean cooking time for the IAC 2358 Unamax cultivar was 1.68 min shorter than that of the IAC Veloz check cultivar and 87 seconds shorter than that of BRS Esteio. For the protein content trait, the new cultivar exhibited an increase of approximately 1.01% compared to the older cultivars.

In regard to disease resistance and tolerance (Table 3), the IAC 2358 Unamax cultivar shows tolerance to *Colletotrichum lindemuthianum* (anthracnose) and *Fusarium oxysporum*, and moderate resistance to bacterial blight (*Xanthomonas phaseoli* pv. *phaseoli*). Anthracnose inoculation was carried out using a spore suspension (10^6 spores mL^{-1}) inoculated

Table 2. Cooking and nutritional quality of the bean grain of the newly released IAC 2358 Unamax cultivar compared to two check cultivars: IAC Veloz and BRS Esteio

Site	IAC 2358 CULTIVAR		Check cultivars			
			IAC Veloz		BRS Esteio	
	Cooking time[1] (min)	Protein content[2] (%)	Cooking time (min)	Protein content (%)	Cooking time (min)	Protein content (%)
Mean of rainy (1st season)	37.89	20.33	40.20	19.67	39.03	20.00
Mean of dry (2nd season)	33.19	19.75	34.64	20.00	34.15	19.50
Mean of fall-win (3rd season)	28.20	20.33	29.56	20.00	28.67	20.33
Overall mean (combined)	33.10	20.10	34.78	19.90	33.97	19.90

[1] Analyzed using the Mattson Cooker procedure (Proctor and Watts 1987). [2] The micro-Kjeldahl method was applied to determine crude protein content, following the procedures outlined by A.O.A.C. (1980) and Bataglia et al. (1983).

Table 3. Intrinsic traits and reaction to pathogens in the field

Cultivar	Physiological maturity cycle (days)	No. 12 sieve yield (%)	1000-Seed Weight (grams)	Reaction to Anthracnose[1] physiological races			Reaction to *Fusarium oxysporum*[2]	Reaction to Angular leaf spot[3]	Reaction to CBB[4]
				65.773	81	465			
IAC 2358 Unamax	90	85	260	T	T	T	T	R	MR
IAC Veloz	82	85	270	T	S	S	T	R	T
BRS Esteio	90	85	270	S	S	T	MR	R	S

R: resistant to the pathogen; T: tolerant to the pathogen; MR: moderately resistant to the pathogen; S: susceptible to the pathogen. [1] Disease severity was evaluated using the scoring scale proposed by Rava et al. (1993), ranging from 1 to 9, where scores from 1 to 3 indicate tolerance and scores from 4 to 9 indicate susceptibility. [2] Disease severity was evaluated using the scale proposed by Schoonhoven and Pastor-Corrales (1987), where scores from 1 to 3 indicate tolerance and scores from 4 to 9 indicate susceptibility. [3] Evaluated under field conditions. [4] Disease severity was evaluated using the scale proposed by Rava (1984), ranging from 0 to 6, with values from 0 to 2.0 considered tolerant and values from 2.1 to 6.0 considered susceptible.

onto both sides of the primary leaves of five plants per cultivar. After inoculation, plants were maintained under controlled photoperiod, humidity, and temperature conditions. The races of *C. lindemuthianum* were previously identified using the set of differential cultivars described by Pastor-Corrales (1991). However, due to the high variability among isolates classified as race 65, additional cultivars were required to accurately determine the specific race (Ribeiro et al. 2016). Based on this complementary analysis, the new race was designated as "65." to distinguish it from the original classification, and the result corresponds to this specifically identified race. Evaluations for *Fusarium oxysporum* were conducted on five plants per cultivar, using a root-slit inoculation method with a spore suspension at 10^6 spores mL^{-1}. The same number of replicates was used for the bacterial blight assay, in which a suspension of 10^8 CFU mL^{-1} was inoculated into a slit on the primary leaf. In addition, angular leaf spot assessments were carried out under field conditions.

TECHNICAL RECOMMENDATIONS AND SEED PRODUCTION

The IAC 2358 Unamax cultivar is recommended for the rainy and dry crop seasons for the states of Rio Grande do Sul, Santa Catarina, Paraná, Mato Grosso do Sul, and São Paulo. In São Paulo, the recommendation extends to the fall/winter crop season as well. In sowing, a row spacing of 50 cm and 8 plants per linear meter are recommended, corresponding to 160,000 plants per hectare.

Yield performance will depend not only on the crop season but also on the growing region and the technological level of the farm property. Areas not zoned for common bean growing and water-logged soils should be avoided.

The cultivar was registered on 3 January 2023 under number 53423 in the National Cultivar Registry (Registro Nacional de Cultivares - RNC).

DATA AVAILABILITY

The datasets generated and/or analyzed during the current research are available from the corresponding author upon reasonable request.

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