

SCS206 Potência: high-yield and anthracnose-resistant black bean cultivar with superior adaptability and stability for Southern Brazil

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Abstract - SCS206 Potência is a common black bean cultivar developed by the Agricultural Research and Rural Extension Company of Santa Catarina (EPAGRI). This cultivar has excellent grain yield and high adaptability and stability associated with improved plant health, especially moderate resistance to anthracnose (*Colletotrichum lindemuthianum*). Its plants are semi-erect and have an indeterminate growth habit, as they are adapted to mechanical harvesting.

Index terms: *Phaseolus vulgaris*; genetic resistance to plant diseases; breeding; cultivar description; seed production.

SCS206 Potência: cultivar de feijão preto de alta produtividade e resistência à antracnose com adaptabilidade e estabilidade superiores para o Sul do Brasil

Resumo - SCS206 Potência é um cultivar de feijão comum, do grupo de sementes preta, desenvolvida pela Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina (Epagri). Esta nova cultivar apresenta excelente produtividade de grãos, alta adaptabilidade e estabilidade associada à melhor sanidade de plantas, especialmente com resistência moderada à antracnose (*Colletotrichum lindemuthianum*). As plantas possuem arquitetura semi-eretas com hábito de crescimento indeterminado, sendo adaptadas à colheita mecanizada.

Termos de indexação: *Phaseolus vulgaris*; resistência genética a doenças; melhoramento genético; descrição de cultivares; produção de sementes.

Introduction

Common bean (*Phaseolus vulgaris* L.) has the third largest planted area of grain crops in Brazil, with more than 2.6 million hectares cultivated and about 2.9 million tons produced, which is nearly 20% of world production (IBGE, 2022). Southern Brazil is responsible for about 40% of total national production and 96% of black bean production in the country (KAVALCO et al., 2017). Common bean is one of the most important sources of vegetable protein, calcium, iron, phosphorus, and B-complex vitamins for human consumption, as well as a staple food for more than 300 million people in parts of Eastern Africa and Latin America and the source of 65% of total protein consumed (PETRY et al., 2015). The biggest challenge for producers is to identify genotypes with superior

agronomic performance, including yield stability under different environmental conditions for the further agronomical success of cultivars (CRUZ & REGAZZI, 1997). The Common Bean Genetic Breeding Program of the Agricultural Research and Rural Extension Company of Santa Catarina (EPAGRI – Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina) aims to obtain high-yield cultivars with grain quality, drought tolerance, and resistance to anthracnose (*Colletotrichum lindemuthianum*) and other diseases, such as angular leaf spot (*Phaeoisariopsis griseola*), common bacterial blight (*Xanthomonas axonopodis* pv. *phaseoli*), and Fusarium wilt (*Fusarium solani* f. sp. *phaseoli* and *F. oxysporum* f. sp. *phaseoli*) (CANALE et al., 2020). For the development of common bean cultivars, EPAGRI performs about 50 crossbreeding combinations each year and evaluates

almost 1,000 segregating families in the field in each generation, besides performing phenotypic selection, Value for Cultivation and Use (VCU) tests, and tests for resistance to diseases, grain quality, and drought tolerance. The SCS206 Potência cultivar has high grain yield, moderate resistance to anthracnose and other diseases, agronomic superiority for adaptability and stability, precocity and improved plant health, and should be cultivated in fertile soils and areas without water deficit.

Genetic origin and development of SCS206 Potência

Figure 1 presents the steps to obtain SCS206 Potência. In the Common Bean Genetic Breeding Program of

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EPAGRI, the BRS Campeiro and FTS Soberano cultivars were hybridized in the 2004/2005 harvest season in order to combine grain yield, rusticity, and disease resistance, and around 20 F_1 plants underwent generation advancement in the 2005/2006 harvest season to obtain F_2 plants. Another generation advancement was performed in the 2008/2009 season, including around 3,000 F_2 plants to obtain F_3 seeds. The F_3 generation was conducted in the field for seed multiplication in the 2009/2010 season without selection, in 20-m-long plots of four lines with the mass harvested plants, using the bulk population method. F_4 was conducted in the field during the 2010/2011 harvest season with family selection and bulk harvest for agronomic traits of interest, such as disease resistance, number of pods per plant, agronomic morphology, and grain color and size. In the following season (2011/2012), by the evaluation of black bean families, F_5 plants were selected by plant and grain size, health, and the number of pods. The selection of families by grain quality and color was evaluated after the harvest period. F_6 was conducted in a preliminary field trial with the selection of superior lines during the 2012/2013 harvest season, when the CHP 04-239-01 lineage met the requirements for the agronomic traits of plant size, disease resistance, number of pods, and grain quality and color. In the following season (2013/2014), an intermediate test was conducted in the field and F_7 lines were evaluated. Selections were based on plant size, yield, disease resistance, and grain quality. The F_8 generation was evaluated in the 2014/2015 season by the Southern Brazilian VCU test. These tests were conducted in different municipalities in Santa Catarina, Paraná, and Rio Grande do Sul, via a collaborative evaluation network, with common breeding programs of other Southern and Southeastern Brazilian institutes, by the selection of strains to evaluate yield performance, grain quality, and disease resistance. In the 2015/2016 and 2016/2017 harvest seasons, VCU tests in Santa Catarina were performed with the F_9 , F_{10} , and F_{11} generations and yield and grain color, size, and uniformity

were observed in a randomized complete block experiment design with four replications and plots of four 4m rows in 30 different environments in Santa Catarina. This study identified the promising CHP 04-239-1 lineage, which was subjected to the registration and protection of the National Service for Cultivar Protection (SNPC – *Serviço Nacional de Proteção de Cultivares*) of the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA). The genetic seed production started in the 2019/2020 harvest season. All selection cycles were conducted in Chapecó, SC (geographic coordinates: 27°05'24.0"S 52°38'16.6"W; altitude of 668 m).

In 2015, 2016, 2017, 2018, and 2019, the stability and adaptability analyzes performed to select lines and compare cultivars in different tests showed that this lineage had high grain yield associated with stability and adaptability. During this period, it was maintained in tests due to these results, which were part of other studies that

were already published or would be published soon. Although this was not the most productive cultivar, it was tested for many years and remained among the best genotypes, which is of great interest to the Common Bean Genetic Breeding Program and rural producers looking for this type of genotype for grain production.

Yield potential of SCS206 Potência

CHP 04-239-1 was approved as SCS206 Potência (Figure 2) for plant architecture, disease resistance, and grain yield in all growing bean regions in Santa Catarina, Paraná, and Rio Grande do Sul, Southern Brazil, in the first and second sowing seasons.

The yield performance of SCS206 Potência was evaluated in the municipalities of Canoinhas, Campos Novos, Chapecó, Ituporanga, Ponte Serrada, Urussanga, and Xanxerê, Santa Catarina, in the 2014/2015,



Figure 1. Improvement methodology and selection cycles of the Common Bean Genetic Breeding Program of EPAGRI to obtain SCS206 Potência

Figura 1. Metodologia de melhoramento e ciclos de seleção do Programa de Melhoramento Genético de Feijão da Epagri, em Chapecó – SC, para obtenção do cultivar de feijão comum SCS206 Potência



Figure 2. SCS206 Potência characterization. A) Plants in vegetative development. B) Characterization of black beans. C) High flowering potential of plants

Photos: Sydney Antonio Frehner Kavalco

Figura 2. Caracterização do cultivar SCS206 Potência. A) Plantas em desenvolvimento vegetativo. B) Caracterização dos grãos com fundo preto. C) Elevado potencial de floração das plantas

Fotos: Sydney Antonio Frehner Kavalco

2015/2016 and 2016/2017 harvest seasons. Experimental crops were conducted in two sowing seasons: October and February (Table 1). BRS Campeiro and IPR Uirapuru were used for comparison, as these cultivars are highly productive and widely used in Santa Catarina. Experiments were conducted in a randomized block design with four replications and without

fungicide treatment and supplemental irrigation. Plots with four 5m-long lines, spaced 0.45m apart, and two center rows were evaluated. For statistical analysis (R CORE TEAM, 2020), the effects of genotypes were fixed and others effects were random. For all VCU evaluation cycles and intermediate and preliminary tests, ANOVA and the Scott-Knott clustering test (5%) for each

location and grain yield adaptability and stability per year were performed, and the cultivar presented promising results in consecutive years in both analyzes. F tests for each location showed differences among cultivars (data not show).

SCS206 Potência exceeded BRS Campeiro and IPR Uirapuru production by 6.02% and 16.52%, respectively,

Table 1. VCU performed in Santa Catarina, Brazil, in the 2014/2015, 2015/2016, and 2016/2017 crop years during the first and second sowing seasons for SCS206 Potência (CHP 04-239-1) compared with BRS Campeiro and IPR Uirapuru

Tabela 1. VCU realizado em Santa Catarina/Brazil nas safras de 2014/2015, 2015/2016 e 2016/2017, durante a primeira e segunda safra, para a cultivar SCS206 Potência (CHP 04-239-1), em comparação com as cultivares BRS Campeiro e IPR Uirapuru

Location	Sowing season	Year	SCS206 Potência (kg ha ⁻¹)	Comparison cultivars (kg ha ⁻¹)		Comparison cultivars Mean (kg ha ⁻¹)	CV (%)
				Campeiro	Uirapuru		
Canoinhas	First	2014/15	3423.11	3359.45	3111.96	3235.71	12.14
Chapecó	First	2014/15	3323.86	3596.81	3050.58	3323.70	13.68
Ponte Serrada	First	2014/15	3083.02	2787.95	2878.57	2833.26	23.80
Chapecó	Second	2014/15	2479.70	2347.22	2199.08	2273.15	9.99
Urussanga	Second	2014/15	2330.36	2487.75	1420.42	1954.09	22.27
Xanxerê	Second	2014/15	2423.48	2422.58	2442.11	2432.35	11.83
Canoinhas	First	2015/16	3886.00	3700.80	3655.90	3678.35	12.20
Chapecó	First	2015/16	3353.80	3407.40	2191.60	2799.50	14.17
Ponte Serrada	First	2015/16	2401.60	1495.90	1416.50	1456.20	26.89
Canoinhas	Second	2015/16	1405.20	1323.60	1064.60	1194.10	14.91
Chapecó	Second	2015/16	3127.40	2806.50	2609.20	2707.85	9.53
Ituporanga	Second	2015/16	1410.50	1300.70	1352.60	1326.65	13.31
Canoinhas	First	2016/17	3520.60	2962.60	3555.80	3259.20	16.07
Chapecó	First	2016/17	4192.30	3812.70	3452.40	3632.55	10.39
Campos Novos	First	2016/17	3699.20	3501.00	2988.60	3244.80	13.58
Chapecó	Second	2016/17	2747.30	2571.80	2600.40	2586.10	10.43
Ituporanga	Second	2016/17	2433.80	2435.30	2048.50	2241.90	18.47
Urussanga	Second	2016/17	2461.30	2447.20	2332.60	2389.90	14.60
Mean			2872.36	2709.29	2465.08	2587.19	
Relation (%)				106.02	116.52	111.02	

Relation: percentage ratio for the average grain yield of SCS206 Potência compared with other cultivars.

Relação: razão percentual para a produtividade média de grãos da SCS206 Potência comparada com outros cultivares.

for all locations and seasons (Table 1). On average, SCS206 Potência showed agronomic superiority of 11.02% for all evaluated locations. SCS206 Potência resulted in an average yield of 3431.50kg ha⁻¹ and 2313.23kg ha⁻¹ in the first and second seasons, respectively. Both values were higher than the average for BRS Campeiro (3180.51 and 2238.23kg ha⁻¹) and IPR Uirapuru (2922.43 and 2007.72kg ha⁻¹) in the first and second seasons, respectively.

Other characteristics

The main phenotypic characteristics of SCS206 Potência are the presence

of anthocyanin in its hypocotyl and stem, an indeterminate growth habit, a moderate resistance to anthracnose and angular leaf spot, the adaption to mechanical harvesting, a crop cycle of 86 days, its semi erect stature, a medium-green leaf in the 4th node, black grains, and purple flowers (Figure 1 and Table 2).

The cooking time of SCS206 Potência, which was evaluated according to Proctor and Watts (1987) with grains harvested in the 2016/2017 and 2017/2018 seasons, was 28 minutes. The protein content of grains was 21%. The cooking time of IPR Uirapuru and BRS Campeiro was 28.5 minutes and 29.5 minutes and both present 22%

protein content.

SCS206 Potência has a higher grain yield, with potential of 4.800kg ha⁻¹. This cultivar has resistance to 83 and 337 and intermediate reaction to 65, 73, 81, 89, and 91 *C. lindemuthianum* breeds, based on a scale by Pastor-Corrales et al. (1995). SCS206 Potência has agronomic superiority for adaptability and stability, precocity, and disease resistance. The period from its emergence to flowering was around 37 days and from its emergence to maturity was about 86 days. These plants have a semi-erect stature, type-3 indeterminate growth habit, and are adapted to mechanical harvesting (Table 2).

Table 2. Phenotypic and biological characteristics of SCS206 Potência

Tabela 2. Características fenotípicas e biológicas do cultivar de feijão comum SCS206 Potência

CHARACTERISTICS	SCS206 POTÊNCIA
Plant	
Hypocotyl color	Green/violet
Plant structure	Semi erect
Growth habit	Undetermined type III
Guide length	Medium
Stem	With anthocyanin
Leaf color (4th node)	Medium green
Average cycle from emergence to flowering	37 days
Average cycle from emergence to harvest	86 days
Adaptation to mechanical harvesting	Adapted
Grain	
Grain color	Black
Flower color	Violet
Grain shape	Medium elliptical
Degree of flatness	Full
Weight of 1,000 grains	236 grams
Average cooking time	28 minutes
Average protein content	21%
Disease resistance	
Anthraxnose (<i>Colletotrichum lindemutianum</i>)	MR
Angular leaf spot (<i>Phaeoisariopsis griseola</i>)	MR
Common bacterial blight (<i>Xanthomonas campestris</i> pv. <i>phaseoli</i>)	MS
Fusarium wilt (<i>Fusarium solani</i> f. sp. <i>phaseoli</i> and <i>F. oxysporum</i> f. sp. <i>phaseoli</i>)	MS
Growing region	SC, PR and RS

Abbreviations: MR: moderately resistant; MS: moderately susceptible; SC: Santa Catarina; PR: Paraná; and RS: Rio Grande do Sul.

Abreviaturas: MR: moderadamente resistente; MS: moderadamente suscetível; SC: Santa Catarina; PR: Paraná; e RS: Rio Grande do Sul.

Technical recommendations and seed production

Considering its high yield potential and adaptability and stability, SCS206 Potência is recommended for growing in the first and second sowing seasons in Santa Catarina, Paraná, and Rio Grande do Sul.

SCS206 Potência was registered by the Brazilian Ministry of Agriculture, Livestock and Food Supply on November 20, 2018 (no. 39.427) and is protected by the SNPC since April 3, 2019 (no. 21806.000213/2018). The Common Bean Genetic Breeding Program of EPAGRI produces the genetic and certified seed.

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