SCS207 Querência: a high-yield carioca bean cultivar with superior grain size, color, and health attributes for southern Brazil

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Abstract – SCS207 Querência is a new carioca common bean variety, developed by the Agricultural Research and Rural Extension Company of Santa Catarina (EPAGRI). This cultivar exhibits excellent grain yield, has high adaptability and stability, along with improved plant health, particularly showing moderate resistance to anthracnose (*Colletotrichum lindemuthianum*). Its plants are semi-erect with an indeterminate growth habit, making them suitable for mechanical harvesting. Its grains are characteristic of the carioca group, with a light beige background and a typical brown stripe. Its cultivation is recommended throughout southern Brazil during the main growing season (first) and the second season ("safrinha").

Index terms: *Phaseolus Vulgaris*; Anthracnose resistance; Breeding; Lineage description; Seed production.

SCS207 Querência: cultivar de feijão carioca de alta produtividade, tamanho, cor de grãos e sanidade superior para o Sul do Brasil

Resumo – SCS207 Querência é a nova cultivar de feijão comum, do grupo de grãos carioca, desenvolvida pela Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina (Epagri). Essa cultivar apresenta excelente rendimento de grãos e possui alta adaptabilidade e estabilidade, associada à melhor sanidade de plantas, especialmente com resistência moderada à antracnose (*Colletotrichum lindemuthianum*). As plantas possuem arquitetura semiereta com hábito de crescimento indeterminado, sendo adaptadas à colheita mecanizada. Seus grãos são característicos do grupo carioca, com fundo bege claro e listra marrom típica. É indicado seu cultivo em toda a região Sul-brasileira nos períodos de safra e de safrinha.

Termos de indexação: *Phaseolus vulgaris*; Resistência à antracnose; Melhoramento genético; Descrição de linhagens; Produção de sementes.

Introduction

The common bean (*Phaseolus vulgaris* L.) is the most important legume for human food consumption worldwide (Síntese, 2023). It is considered one of the staple foods in the Brazilian diet, essential to ensure food and nutritional security. Consumed daily throughout the country, beans have high nutritional value, serving as a source of plant-based protein, vitamins, fiber, and minerals (Ferreira *et al*., 2021).

National production exceeds 3 million tons per year, and it is estimated that more than 87% of this total is destined for domestic consumption, contributing to the diet of Brazilians. The southern region is the leading producer of this legume, accounting for approximately one-third of total bean production. Among the three southern states, Santa Catarina has the highest productivity, surpassing 1,800 kg ha^{-1}; however, the total cultivated area poses a challenge for increasing production in the state (CONAB, 2024).

The Common Bean Breeding Program of the Agricultural Research and Rural Extension Company of Santa Catarina (EPAGRI) aims to develop high-yield cultivars with grain quality, drought tolerance, resistance to anthracnose (*Colletotrichum lindemuthianum*), and other diseases, like 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).

To develop common bean cultivars, EPAGRI conducts around 50 cross combinations each year and evaluates nearly 1,000 segregating families in the

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field for each generation. Additionally, it performs phenotypic selection, value for cultivation and use (VCU) tests, and tests for disease resistance, grain quality, and drought tolerance (Kavalco *et al.*, 2022). The objective of this study was to register and present this new bean cultivar developed by Epagri.

The importance of Bean Cultivation

Beans are the main source of plant-based protein, calcium, iron, phosphorus, and B-complex vitamins for human nutrition in various countries, considered a fundamental pulse for food security in Brazil (Kavalco *et al.*, 2022). In addition to providing multiple health benefits, beans hold significant socioeconomic importance due to their relatively low cost, wide availability, and accessibility for millions of people.

Figure 1 presents historical data on the planted area, production, and productivity of beans in the southern region, clearly highlighting the significant increase in agronomic potential over the years. In 1980, recorded bean productivity was around 670 kg per hectare, with a cultivated area of approximately 1.4 million hectares, resulting in a production of 970 thousand tons. Although the cultivated area for this legume has been reduced by more than half, today, after 44 years marked by a series of transformations in the agricultural sector, there is a 57% increase in productivity exceeding 1,500kg per hectare, with a planted area of approximately 500 thousand hectares and production of over one million tons (CONAB, 2024).

This progress is attributed to genetic improvement and the evolution of cultivars, which has allowed for a satisfactory level of production due to the increase in crop productivity, despite the reduction in planted area. This effect is also observed in other crops, where the significant increase in productivity results from ongoing research aimed at developing more

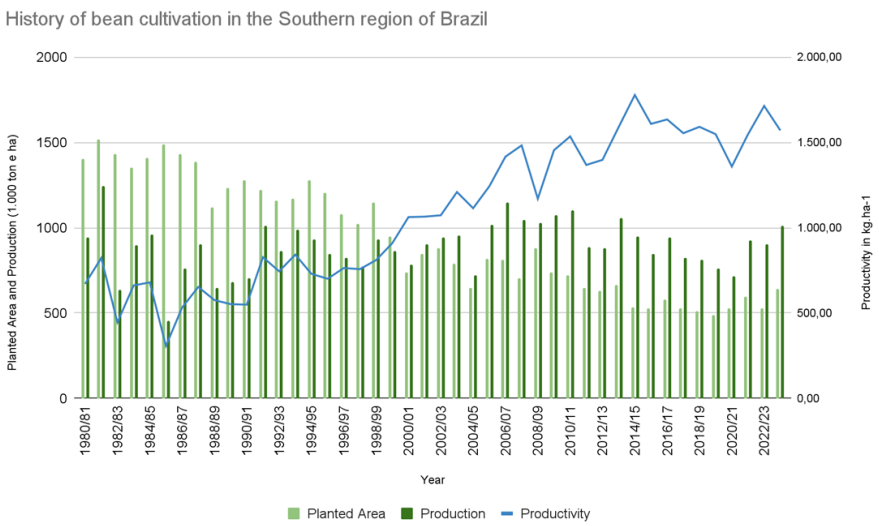

Figure 1. History of production, planted area, and productivity of beans in the Southern region of Brazil. Epagri/CEPAF – Chapecó, 2024

Figura 1. *Histórico de produção, área plantada e produtividade do feijão na região Sul do Brasil. Epagri/CEPAF – Chapecó, 2024*

productive and resilient cultivars, combined with the development of soil management strategies, modernization of agriculture, and the enhancement of existing techniques (Kavalco *et al.*, 2024).

Bean consumption per person in Brazil has declined over the years. In 2010, each Brazilian consumed an average of 16 kg of beans per year; by 2021, consumption had fallen to 12 kg, a reduction of 25% over 11 years (Síntese, 2023; Conab, 2024). Per capita consumption decreased due to various factors, among which the substitution for more accessible and convenient foods (Ibrafe, 2024).

Breeding method

Hybrid seeds were obtained through the hybridization of BRS Campeiro (black seeds) and IAC Tybatã (carioca seeds) carried out during the 2000/01 season. A generation advance was conducted in 2001 to obtain the F_2 generation. During the 2001/02 and 2002/03 crop seasons, the F_2 and F_3 generations were grown in the field without selection. The F_4 population was cultivated in the field during the 2003/04 crop season, with bulk selection and grain color selection. Negative selection was applied to the F_5 population (2004/05) to eliminate type 4 indeterminate plants, disease-susceptible plants, and plants with long vines. Grain quality and color selection were performed after harvest.

The F_6 generation was conducted in the field during the 2005/06 crop year, involving the selection of individual plants to obtain superior lineages for agronomic traits such as plant size, health, number of pods, grain quality, and color. The evaluation of F_7 lines was conducted in the subsequent season (2006/07), focusing on plant size, productivity, health, and grain quality selection. The F_8 generation was evaluated in the field with the selection of lines based on productive performance, grain quality, and the health of plants and pods. The F_9 and F_{10} generations were evaluated in the field, with individual plant selection for agronomic performance and disease tolerance. Preliminary and family tests for color, size, uniformity, and yield evaluation were performed during the 2012/13 and 2013/14 crop seasons, corresponding to the F_{11} and F_{12} generations, respectively, using a randomized complete block experimental design with four

replications in four-row by four-meter plots. Four promising lines from the same cross were identified and evaluated through VCU tests during the growing season and off-season periods of the 2014/15, 2015/16, 2016/17, 2017/18, 2018/19, and 2019/20 agricultural years. The experimental design used in the VCU trials was a randomized block design with four replications, comprising plots of four four-meter rows each. A total of 40 genotypes were tested, including superior cultivars and breeding lines of carioca and black beans in five different locations each season. Trials were analyzed individually by location and season, and a combined analysis of adaptability and stability was conducted at the end of the evaluation cycle (Cruz and Regazzi, 1997) to identify the best lines. For cultivar registration with the Ministry of Agriculture, Livestock, and Food Supply (MAPA), results for each line and the respective comparison between cultivars was presented, with an analysis of variance and statistical difference determined by the calculated and tabulated F values. After identifying the top lineage (CHC 01-175-01), the production of genetic seeds was initiated and purified in the following years. All selection cycles (Figure 2) were conducted in Chapecó, SC (27°05'24" S, 52°39'05" W, at an altitude of 668 m).

Figure 2. Breeding methodology and selection cycles of SCS207 Querência new common-bean cultivar. Epagri/CEPAF – Chapecó, 2024

Figura 2. *Metodologia de melhoramento e ciclos de seleção da nova cultivar de feijão SCS207 Querência. Epagri/CEPAF – Chapecó, 2024*

Yield potential of SCS207 Querência

SCS207 Querência demonstrated agronomically superior productivity compared to the controls at all locations evaluated over the six years of cultivation. When comparing the grain yield of SCS207 Querência to the cultivars BRS Pérola and SCS202 Guará, the new cultivar showed a relative average yield that was 127% higher during the main growing season and the second season in 2014/15 and 2015/16 (Table 1). When compared solely to the control BRS Pérola during the same period, it demonstrated a superiority of 128.18%; when compared exclusively to SCS202 Guará, it was 126.48% higher for grain yield.

In comparison to the cultivars IPR Campos Gerais and BRS Pérola, SCS207 Querência exhibited a 110% higher relative average productivity in 2016/17 and 2017/18 (Table 2), with an average grain yield surpassing that of the two control cultivars during both the main growing season and the second season. When compared solely to IPR Campos Gerais, it demonstrated a superiority of 103.58% in grain yield, and in relation to BRS Pérola, it was 117.88% higher.

In relation to the controls IPR Campos Gerais and BRS Estilo, SCS207 Querência once again exhibited a 110% higher relative average productivity during the growing seasons of 2018/19 and 2019/20, with an average yield of 3,110.18kg ha^{-1}. In Campos Novos, the average grain yield reached 5,121kg ha^{-1} during the main growing season, marking the best performance recorded among the various locations for the

Table 1. VCU performed in Santa Catarina, Brazil, in the 2014/2015 and 2015/2016, crop years during the first and second sowing seasons for SCS207 Querência (CHC 01-175-01) compared with SCS202 Guará and Pérola cultivars

Tabela 1. *VCU realizado em Santa Catarina, Brasil nas safras de 2014/2015 e 2015/2016, durante a primeira e segunda safra, para a cultivar SCS207 Querência (CHC 01-175-01), em comparação com as cultivares SCS202 Guará e Pérola*

Location	Crop Season	Year	SCS207 Querência (kg ha^{-1})	Comparison cultivars (kg ha^{-1})		Comparison cultivars Mean	CV (%)
				Guará	Pérola		
Santa Catarina							
Canoinhas	First	2014/15	3931,53	3059,15	3147,33	3103,24	12,14
Chapecó	First	2014/15	3640,87	2221,5	2679,68	2450,59	13,68
Ponte Serrada	First	2014/15	2289,91	2159,75	2285,91	2222,83	23,8
Chapecó	Second	2014/15	2935,94	2760,21	2532,22	2646,22	9,99
Urussanga	Second	2014/15	2465,65	1648,68	1664,63	1656,66	22,27
Xanxerê	Second	2014/15	2451,4	2516,03	2680,52	2598,28	11,83
Canoinhas	First	2015/16	4075,5	3778,5	4053,78	3916,14	12,2
Chapecó	First	2015/16	4006,71	2804,33	2612,16	2708,25	14,17
Ponte Serrada	First	2015/16	2595,74	1241,25	847,91	1044,58	26,89
Canoinhas	Second	2015/16	1550,5	1253,6	1354,2	1303,9	14,91
Chapecó	Second	2015/16	3302,8	2838,15	2184,64	2511,4	9,53
Ituporanga	Second	2015/16	1610,5	1278,9	1150	1214,45	13,31
Mean			2904,75	2296,67	2266,08	2281,38	
Relative (%)				126,48	128,18	127,32	

Relation: percentage ratio for the average grain yield of SCS206 Potência compared with other cultivars.
Relação: razão percentual para o rendimento médio de grãos da cultivar SCS206 Potência em comparação com outros cultivares

Table 2. VCU performed in Santa Catarina, Brazil, in the 2016/2017 and 2017/2018, crop years during the first and second sowing seasons for SCS207 Querência (CHC 01-175-01) compared with SCS202 Guará and Pérola cultivars.

Tabela 2. *VCU realizado em Santa Catarina, Brasil nas safras de 2016/2017 e 2017/2018, durante a primeira e segunda safra, para a cultivar SCS207 Querência (CHC 01-175-01), em comparação com as cultivares Campos Gerais e Pérola*

Location	Crop Season	Year	SCS207 Querência (kg ha^{-1})	Comparison cultivars (kg ha^{-1})		Comparison cultivars Mean	CV (%)
				Campos Gerais	Pérola		
Canoinhas	First	2016/17	4148,9	3545,4	3110	3327,7	16,07
Chapecó	First	2016/17	4159,1	4819,3	3576	4197,65	10,39
Campos Novos	First	2016/17	4052,6	3761,4	2269,9	3015,65	13,58
Chapecó	Second	2016/17	3391,7	3253,4	3598,8	3426,1	10,43
Ituporanga	Second	2016/17	3006	2190,8	2570,8	2380,8	18,47
Xanxerê	Second	2016/17	2737,7	2458,3	2305	2381,65	14,6
Ponte Serrada	First	2017/18	4790	5276,42	3964,19	4620,31	10,92
Canoinhas	First	2017/18	3757,51	3960,55	3964,99	3962,77	11,97
Campos Novos	First	2017/18	4422,98	4547,41	3803,33	4175,37	9,88
Ituporanga	Second	2017/18	1998,5	1603,5	1475,6	1539,55	14,8
Urussanga	Second	2017/18	1563,7	1449,1	1384,9	1417	19,18
Xanxerê	Second	2017/18	2979,8	2724,4	2764,7	2744,55	8,37
Mean			3417,37	3299,17	2899,02	3099,09	
Relative (%)				103,58	117,88	110,27	

Relation: percentage ratio for the average grain yield of SCS206 Potência compared with other cultivars.
Relação: razão percentual para o rendimento médio de grãos da cultivar SCS206 Potência em comparação com outros cultivares.

value for cultivation and use (VCU) assessments over the six years of evaluation (Table 3). When compared solely to the control IPR Campos Gerais, it showed a relative average yield that was only 103.58% higher, and compared to BRS Estilo, it was 118.61% higher.

SCS207 Querência production potential is 4,800 kg ha^{-1}, with an average yield of 3,800kg ha^{-1} during the main growing season and 2,500kg ha^{-1} during the second season in Santa Catarina, over the years of evaluation for value for cultivation and use (VCU).

Other characteristics

The main phenotypic characteristics of SCS207 Querência are the absence of anthocyanin in its hypocotyl and stem, a type II indeterminate growth habit, moderate resistance to anthracnose and angular leaf spot, adaptation to mechanical harvesting, a crop cycle of 85 days, semi-erect stature, medium-green leaves at the fourth node, 75% cream and 25% brown carioca grains, and white flowers (Table 4).

According to Proctor and Watts (1987), SCS207 Querência grains harvested in the 2014/2015 and 2015/2016 seasons had a cooking time of 20 minutes. The protein content of the grains was 21%. The cooking times for BRS Pérola and Carioca control cultivars were 22:30 minutes and 23:30 minutes, with protein contents of 22% and 24%, respectively.

SCS207 Querência has superior grain yield, with a potential of over 4,800kg ha^{-1}. This cultivar shows resistance to pathogen races 64, 73, 91, and 337, an intermediate reaction to races 65, 71, 81, and 89, and susceptibility to races 08 and 72 of *Colletotrichum lindemuthianum*, based on the scale by Pastor-Corrales *et al*. (1995).

Technical recommendations and seed production

SCS207 Querência was registered by the Brazilian Ministry of Agriculture, Livestock and Food Supply on October 14, 2021 (no. 48.139) and it is protected by the SNPC since November 16, 2021 (no. 21806.000118/2021). The Common Bean Genetic Breeding Program of EPAGRI produces the genetic seed.

Considering its high yield potential, adaptability and stability, SCS207 Querência is recommended for growing in the first and second sowing seasons in Santa Catarina, Paraná, and Rio Grande do Sul.

Table 3. VCU performed in Santa Catarina, Brazil, in the 2018/2019 and 2019/2020, crop years during the first and second sowing seasons for SCS207 Querência (CHC 01-175-01) compared with Campos Gerais and BRS Estilo cultivars
Tabela 3. *VCU realizado em Santa Catarina, Brasil nas safras de 2018/2019 e 2019/2020, durante a primeira e segunda safra, para a cultivar SCS207 Querência (CHC 01-175-01), em comparação com as cultivares Campos Gerais e BRS Estilo*

Location	Crop Season	Year	SCS207 Querência (kg ha^{-1})	Comparison cultivars (kg ha^{-1})		Comparison cultivars Mean	CV (%)
				Campos Gerais	BRS Estilo		
Chapecó	First	2018/19	2968,15	3154,88	1698,99	2426,94	14,89
Canoinhas	First	2018/19	2506,4	2771,7	2462,2	2616,95	12,38
Campos Novos	First	2018/19	4129,4	3586,2	2651,1	3118,65	19,93
Ituporanga	Second	2018/19	2019	1734,1	1730,6	1732,35	14,32
Chapecó	Second	2018/19	3200,4	3219,7	2489,5	2854,6	10,75
Xanxerê	Second	2018/19	2688,4	2721,6	2627,4	2674,5	14,14
Canoinhas	First	2019/20	2441,75	2506,47	2560,22	2533,35	11,39
Campos Novos	First	2019/20	5121	4906,98	4370,75	4638,87	8,06
Xanxerê	First	2019/20	3897,93	4088,57	3742,63	3915,6	9,27
Ituporanga	Second	2019/20	3125,4	2247,88	2530,63	2389,26	8,33
Xanxerê	Second	2019/20	2114,14	2000,76	1980,29	1990,53	14,18
Mean			3110,18	2994,44	2622,21	2808,33	
Relative (%)				103,87	118,61	110,75	

Relation: percentage ratio for the average grain yield of SCS206 Potência compared with other cultivars.
Relação: razão percentual para o rendimento médio de grãos da cultivar SCS206 Potência em comparação com outros cultivares.

Table 4. Phenotypic and biological characteristics of SCS207 Querência common bean cultivar
Tabela 4. *Características fenotípicas e biológicas da cultivar de feijão comum SCS207 Querência*

CHARACTERISTIC		SCS207 QUERÊNCIA
Plant		
	Hypocotyl color	Green
	Plant structure	Semi erect
	Growth habit	Undetermined type III
	Guide length	Medium
	Stem	With no anthocianin
	Leaf color (4th node)	Medium green
	Average cycle of emergency to flowering	42 days
	Average cycle of emergency to harvest	85 days
	Adaptation to mechanical harvesting	Adapted
Grain		
	Grain color	Carioca
	Flower color	White
	Grain shape	Eliptical
	Degree of flatness	Half full
	Weight of thousand grains	255 grams
	Average time of cooking	20 minutes
	Average protein grain content	21,00%
Desease reaction		
	Anthracnose (*C. lindemutianum*)	MR
	Angular leaf spot (*Isariopsis griseola*)	MS
	Bacterial blight (*X. campestris pv. phaseoli*)	MS
	Fusarium wilt (*F. oxysporum*)	MR
Indicated growing region		SC, PR and RS

Abbreviations: MR – Moderately Resistant; MS – Moderately Susceptible; SC – Santa Catarina, PR – Paraná and RS – Rio Grande do Sul.
Abreviações: MR – Moderadamente Resistente; MS – Moderadamente Suscetível; SC – Santa Catarina, PR – Paraná e RS – Rio Grande do Sul.

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