CULTIVAR RELEASE

SCS453 Noninha and SCS454 Carvoeira – new banana cultivars of the Prata subgroup

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Abstract: *'SCS453 Noninha' and 'SCS454 Carvoeira' are new banana cultivars derived from the subgroup Prata (AAB). In comparison with the latter, 'SCS453 Noninha' has a low pseudostem height, 'SCS454 Carvoeira' a high yield and both unchanged fruit characteristics. Both also have increased resistance to Panama wilt and 'SCS454 Carvoeira' to Sigatoka.*

Keywords: *Musa* spp., breeding, spontaneous mutation, pome subgroup

INTRODUCTION

Banana is one of the most widely grown, traded and consumed fruits in the world, and the global production of banana and plantain (cooking banana) reached over 150 million tons in 2020 (FAO 2022). According to FAO (Food and Agriculture Organization of the United Nations), since the 1960s, Brazil has been among the 10 largest banana producers in the world and, with an acreage of 455,004 hectares and an output of around 6.8 million tons, has nowadays become the sixth largest producer (FAO 2022). Banana (*Musa* spp.) is native to Southeast Asia and Oceania and domestication began more than 6,000 years ago (Perrier et al. 2011). According to these authors, selection for traits of interest played a fundamental role in the development of new genotypes derived from existing varieties, for banana cultivation. Currently, the main commercial varieties are derived from the species *M. acuminata* (genome A) and its hybrids with *M. balbisiana* (genome B), of which the most important are the triploid genotypes of the genomic groups AAA, AAB and ABB (Perrier et al. 2011). The subgroup Prata (also known as subgroup Pome), of the genomic group AAB, represents the most consumed type of banana in Brazil and comprises about 10 cultivars registered by the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA 2022). Despite the relevance of subgroup Prata, the limited number of cultivars makes the crop susceptible to possible biotic/abiotic problems. In this sense, the greater the diversity within the subgroup, the more resilient it becomes to such problems. With the aim of increasing the range of cultivars available to growers and widening the genetic basis of the Prata subgroup, the Company of Agriculture Research and Rural Extension of Santa Catarina (Epagri) developed, in partnership with two banana producers, the new cultivars SCS453 Noninha and SCS454 Carvoeira. The objective of this article is to present the main characteristics of these cultivars.

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ORIGIN AND BREEDING METHOD

The two cultivars were selected separately in Criciúma, a district near the southern coast of Santa Catarina, Brazil, by two banana growers in 2012. Both genotypes were generated by spontaneous mutation of cv. Prata Anã. The main feature that drew attention to 'SCS453 Noninha' (Figure 1a) was the low height of the pseudostem (Figure 2a) and the main characteristic of 'SCS454 Carvoeira' (Figure 1b) was a higher yield (Figure 2b). After selection of the genotypes, small orchards were planted at the Epagri Experimental Station Itajaí (EEI) (lat 26° 57' 08.9'' S, long 48° 45' 38.9'' W, alt 12 m asl) to confirm the stability of the observed characteristics. After this confirmation, similar experiments to VCU trials were implanted, with a main experiment in the EEI and with "satellite" experiments in three municipalities of state of Santa Catarina (Biguaçu, Corupá and Massaranduba). The experiment was arranged in a randomized complete block design, in which the factor was the varieties (SCS453 Noninha and SCS454 Carvoeira; and cv. Prata Anã, from which both were derived, and cv. SCS451 Catarina, the most commonly planted of the Prata subgroup in Santa Catarina). The main variables analyzed were bunch weight, cycle length, resistance to Panama disease and morphological traits. Panama disease symptoms were evaluated every 30 days based on disease incidence (plants with or without typical Panama disease symptoms). The chi-square test (95% reliability) was applied to analyze the association between disease incidence and evaluated genotypes. The other variables were evaluated in each production cycle by Student's t test (95% reliability). Missing data of plants killed by the Panama disease were disregarded, except for the variable "bunch weight", for which, in these cases, production was considered null (0 kg). The experiment had four blocks with four plots of which each one contained 12 plants, i.e., a total of 48 plants per variety, 192 plants in total, and was evaluated over five production cycles. The units implemented in the municipalities were used to visually confirm the results obtained at EEI.

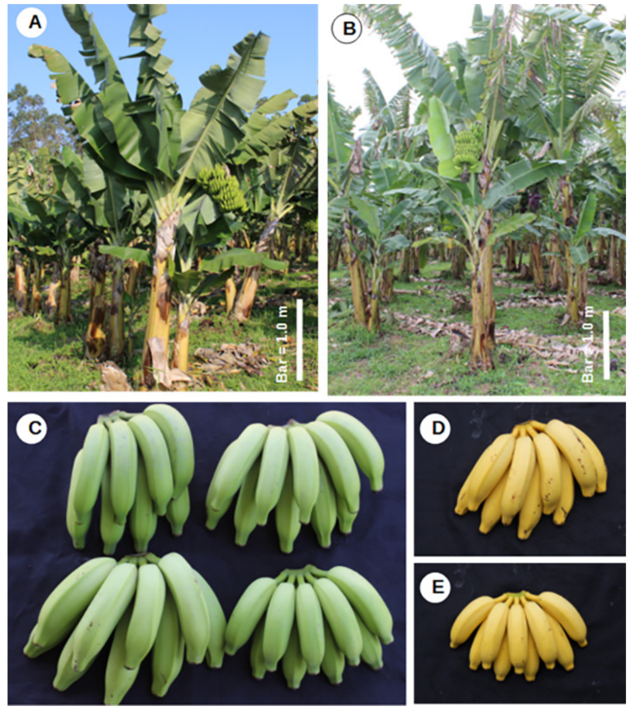

Figure 1. SCS453 Noninha and SCS454 Carvoeira, new banana cultivars from the Prata subgroup.

A) Producing plant of 'SCS453 Noninha'; B) Producing plant of 'SCS454 Carvoeira'; C) Below - Hand of green fruits of 'SCS454 Carvoeira' (left) and of the 'SCS453 Noninha' (right), Above - Hand of green fruits of 'Prata Anã' (left) and 'SCS451 Catarina' (right); D) Hand of ripe bananas of 'SCS454 Carvoeira'; E) Hand of ripe bananas of 'SCS453 Noninha'.

In the post-harvest studies, four bunches per plot were studied, i.e., a total of 16 bunches per cycle and variety, evaluated in the first four cycles. The variables °Brix and length of external fruit curvature were evaluated in each production cycle by Student's t test (95% reliability).

Another experiment was carried out to evaluate the level of resistance to the Sigatoka disease complex. Plants of each genotype were cultivated without fungicide spray. Disease severity in the different genotypes was evaluated every 20 days over five production cycles, on a 0 to 6 score scale proposed by Gauhl et al. (1993), where 0 = no symptoms; 1 = lesions on less than 1% of the leaf area or a maximum of 10 lesions; 2 = lesions on 1 to 5% of the leaf area; 3 = lesions on 6 to 15% of the leaf area; 4 = lesions on 16 to 33% of the leaf area; 5 = lesions on 34 to 50% of the leaf area; 6 = lesions on 51 to 100% the leaf area. From these scores, the disease severity index and area under the disease progress curve (AUDPC) were calculated (Gonçalves et al. 2021). The experiment was arranged in a randomized block design, with four replications. Three central plants per replication were evaluated and the data subjected to Bartlett and Shapiro-Wilk tests to check for homogeneity of variance and normality. Means were grouped by the Scott-Knott criterion (95% reliability).

With regard to the characteristics of interest of the new cultivars, the experimental results were promising for the banana production chain. The new cultivars were clearly distinguishable from others, homogeneous and stable over successive generations, and are available for the Brazilian agribusiness, thus meeting the requirements of the national legislation (law no. 10.711/2003), known as Brazilian Law of Seeds (BRASIL 2020).

GENETICS

Both new cultivars, SCS453 Noninha and SCS454 Carvoeira, resulted from the selection of spontaneous mutations of cv. Prata Anã. Varieties from spontaneous mutations are usually genetically very close to those from which they were derived, since the main characteristics of the original variety are maintained, however, with some phenotypic differences. For this reason, both new varieties were genotyped and the ploidy levels analyzed, to compare them with 'Prata Anã' and 'SCS451 Catarina'.

For genotyping, DNA extraction of leaf samples was based on the protocol of Doyle & Doyle (Doyle and Doyle 1990, Klabunde et al. 2021). The total DNA for each sample was amplified via PCR using 19 microsatellite molecular markers selected by Christelová et al. (2011), and the amplified products were genotyped by capillary electrophoresis on an automated DNA sequencer (ABI3500). A total of 45 SSR alleles (mean of 2.36 alleles locus^{-1}) were detected in the genotypes. Nevertheless, the molecular markers were not able to differentiate the cultivars SCS454 Carvoeira, Prata Anã and SCS451 Catarina from each other. Cultivar SCS453 Noninha only differed from the other three with regard to one SSR locus, Ma_3_90 (Christelová et al. 2011), for which differences in the two amplified alleles were observed.

To compare the ploidy levels, leaf samples were collected and stored for about 14 hours at 2 to 10 ºC. Each genotype was represented by a set of four sub-samples (~40 mg), each of which was collected from a different "family". The samples were chopped on an ice-cooled Petri dish, with 500 ml of Otto I solution (0.1 M citric acid, 0.5% v/v Tween 20, at 2 - 10 ºC) and then stored in a styrofoam box at room temperature for 1 to 3 hours. Then, Otto II solution (Na_2HPO_4), supplemented with propidium iodide and RNAse (both at 0.25 µg mL^{-1} in the final Otto II solution) was added to the samples and after15 min, the ploidy level of the samples was analyzed in a BD FACS-CANTO II flow cytometer (BD Biosciences, San Jose, CA), and a 5-min reading of each sample performed. This experiment was replicated three times. The ploidy levels between the genotypes were compared based on the histogram peaks, which indicated that both new varieties are equally triploid, and have the same ploidy level as the cultivar of origin ('Prata Anã') and 'SCS451 Catarina'.

MORPHOLOGICAL DESCRIPTION AND AGRONOMIC PERFORMANCE

The fact that cvs. of the Prata subgroup are basically generated by the selection of spontaneous mutants means that the entire subgroup has a standard morphology. Thus, according to international descriptors (IPGRI 1996), which use rather generalized classification levels, 'SCS454 Carvoeira' does not differ morphologically from 'Prata Anã' and 'SCS451 Catarina'; and 'SCS453 Noninha' differs from the others in only four descriptors (plant height, leaf blade length, leaf blade length/width ratio and stalk length), among a total of more than 100 descriptors. However, a statistical analysis of the phenotypic traits showed that the cultivars differed in some key traits.

A comparison of cvs. SCS453 Noninha and Prata Anã, indicated a shorter plant height of the new cultivar and no difference in the pseudostem perimeter at 30 and 100 cm (Figures 2c and 2d), which confirms the characteristics of smaller size and good robustness. In the first three cycles, bunch weight of cv. 'SCS453 Noninha' was lower (Figure 2b), however, there were no differences in the fourth and fifth cycles, which we believe to be a consequence of the greater resistance of 'SCS453 Noninha' to the Panama disease (p = 1.88e-18) (Figure 3a). The data also confirm the slightly smaller fruit size of the new cultivar compared to 'Prata Anã' fruit (Figure 1c), since the results for 'SCS453 Noninha' for fruit size and diameter are always smaller or marginally smaller (Figures 4a and 4b). The number of leaves at harvest of cv. SCS453 Noninha was lower in all cycles (Figure 4c), evidencing the greater susceptibility to the Sigatoka complex (Figure 3b). Although the total cycle period did not differ between the varieties in any cycle studied, the time between inflorescence emission and harvest was longer in the third and fourth cycles for 'SCS453 Noninha' (Figures 4e and 4f), which may have increased susceptibility to the Sigatoka complex.

The data also confirm the initial observations related to the higher yield of 'SCS454 Carvoeira' in relation to 'Prata Anã', since the bunch weight of 'SCS454 Carvoeira' was either higher (1st, 3rd, 4th and 5th cycles) or marginally higher (2nd cycles) than that of 'Prata Anã' (Figure 2b). In this sense, although the number of hands of 'SCS454 Carvoeira' (Figure 4d) was always smaller, fruits were invariably larger and the diameter greater (Figure 1c; Figures 4a and 4b).

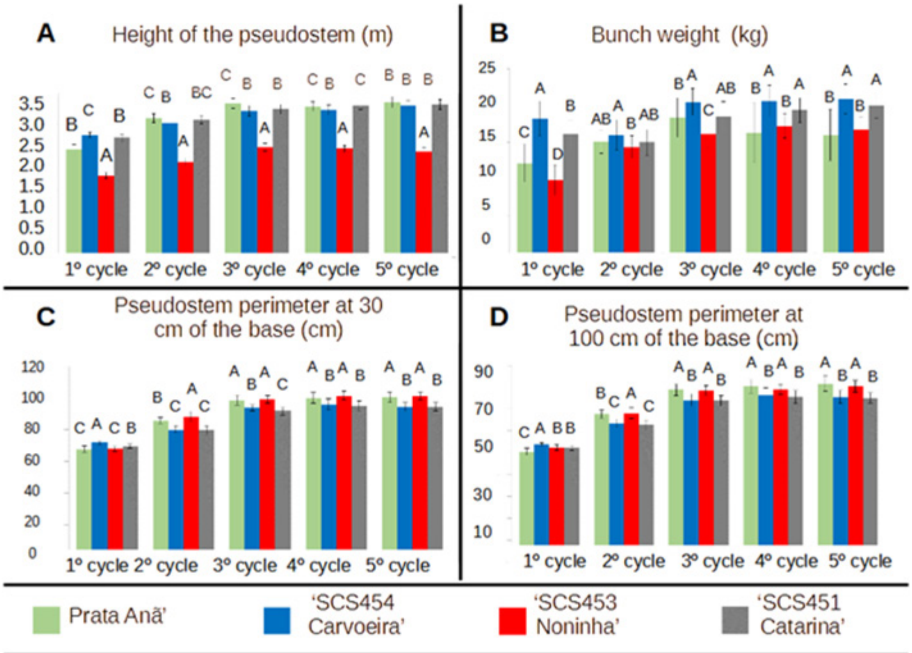

Figure 2. Bar diagrams of pseudostem height, bunch weight and pseudostem perimeters of cvs. Prata Anã, SCS454 Carvoeira, SCS453 Noninha and SCS451 Catarina in the first five cycles. In all cycles, means in columns followed by different letters differed by Student's t test (95% reliability).

Similarly to cv. SCS453 Noninha, Panama disease incidence on 'SCS454 Carvoeira' was lower than on 'Prata Anã' (p = 1.44e-15) (Figure 3); in addition, 'SCS454 Carvoeira' was also slightly more resistant to the Sigatoka complex (Figure 3b), which may explain the higher, or marginally higher, number of viable leaves at harvest (Figure 4c). This characteristic may also be linked to the shorter time between inflorescence emission and harvest (Figure 4e), although the total cycle period did not differ (Figure 4f).

For the vast majority of Brazilian consumers, the type of banana fruit is the main basis of buying behavior. In this aspect, the two new cultivars meet the standards of the Prata subgroup fruit type (morphological characteristics) (Figures 1c, d and e), although the fruits of 'SCS453 Noninha' are slightly smaller and those of 'SCS454 Carvoeira' slightly larger. In addition to the morphological characteristics, the fruits of the two new cultivars apparently maintain the same

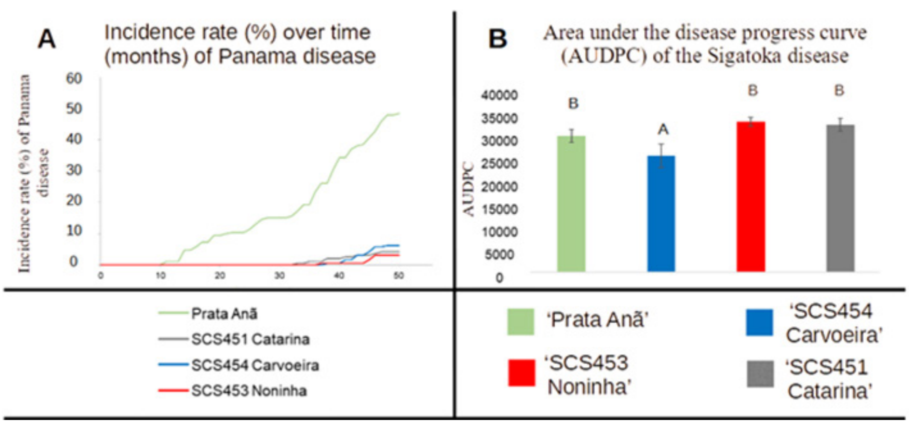

Figure 3. Evaluation of the resistance levels of 'SCS454 Carvoeira' and 'SCS453 Noninha' to Panama disease and the Sigatoka disease complex.

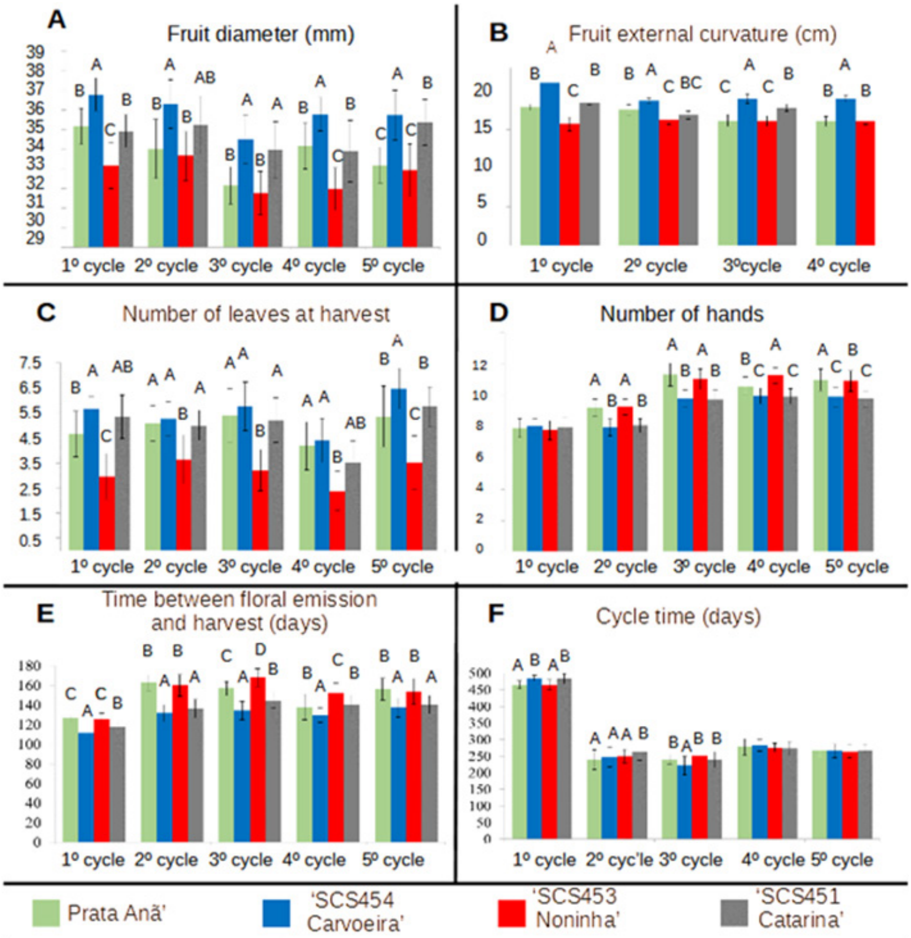

Figure 4. Bar diagram of fruit diameter, fruit external curvature, number of leaves at harvest, number of hands, time between floral emission and harvest and of total cycle period of cvs. Prata Anã, SCS454 Carvoeira, SCS453 Noninha e SCS451 Catarina in the first five cycles. F) Total cycle period (days) (for the first cycle – time between planting and first harvest; for the other cycles – time between two subsequent harvests). In all cycles, means in columns followed by different letters differed by Student's t test (95% reliability).

organoleptic characteristics of the Prata subgroup. A few minor differences, mainly a sharper flavor of the fruits of 'SCS453 Noninha' compared to the other varieties of the Prata subgroup, can be explained by the higher °Brix content [total mean of 23.12 ('SCS453 Noninha'); 21.92 ('Prata Anã'); 20.78 ('SCS454 Carvoeira') and 21.62 ('SCS451 Catarina')].

OTHER FEATURES

As the new cultivars were derived from 'Prata Anã', all management recommendations, from planting to harvesting, are the same as for the other varieties of the Prata subgroup (Livramento and Negreiros 2016). However, since the plant of cv. SCS453 Noninha is smaller, a slightly higher planting density may be suggested, of up to 1600 plants ha^{-1} (approximately 2.5 x 2.5 m) under similar subtropical conditions. Avoiding planting this cultivar in areas exposed to severe water stress is also recommended, since in such environments, the plants may have difficulties in releasing the inflorescence (choking), an effect that is intensified by cold temperatures. On the other hand, both new cultivars are relatively resistant to plant fall and pseudostem breakage caused by strong winds, since this resistance is a characteristic of the Prata subgroup when compared to other subgroups (Scherer et al. 2018); however, the cultivar SCS453 Noninha, due to its greater robustness, is even more resistant to such adverse effects of strong winds.

FUTURE PERSPECTIVES

Both new cultivars produce fruits according to the standards of the Prata subgroup, and can supply part of the great demand of the fresh banana market in Brazil. One of the clearest trends on the world fruit market is a reduced size of commercialized fruits. This tendency is met by cv. SCS453 Noninha, with a slightly smaller fruit size than the current standard of banana fruits of the Prata subgroup. However, according to information of banana producers in Santa Catarina (personal communication), this trend has not yet reached the state and the middlemen (intermediate purchasers who supply the markets) still prefer large Prata fruits. In this case, the fruits of cv. SCS454 Carvoeira are promising, for being slightly larger than the current standard fruit size of the Prata subgroup.

PROPAGULE AVAILABILITY

The seedlings of cvs. SCS453 Noninha and SCS454 Carvoeira (registration nº 48297 and 48301, respectively, by the National Register of Cultivars RNC-MAPA) can only be sold by licensed companies. For more information: Itajaí Experimental Station – Rodovia Antônio Heil, 6800, Itajaí, SC. E-mail: eei@epagri.sc.gov.br. Phone: (47) 3398-6000.

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