
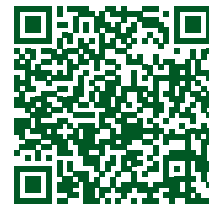


## Imigrante: the first Brazilian ginger cultivar

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**Abstract:** *Imigrante is the first ginger cultivar registered in Brazil. It's suitable for cultivation in the central mountainous region of Espírito Santo state, the country's largest producing region of origin. In three regional evaluation trials, it showed a fast and early growth cycle, reaching an average productivity of 145 t ha<sup>-1</sup>.*

**Keywords:** *Participatory breeding, genetic heritage, morpho-agronomic descriptors, genetic diversity*

### INTRODUCTION

Ginger (*Zingiber officinale* Roscoe) plant belongs to the Zingiberaceae family. Originally from southwest Asia, it has been known and used for thousands of years for its medicinal properties, which help with colds, digestion, combat rheumatism, neuralgia, colic, and nausea due to its anti-inflammatory, anti-ulcer, anti-nausea, antibacterial, hypoglycemic, antioxidant, and thermogenic effects, among others (Elpo et al. 2008, Nicácio et al. 2018).

Ginger is an herbaceous perennial crop under commercial cultivation. Seedlings are produced by dividing the rhizomes, with a recommended spacing of 20 x 30 cm between plants. The species develops optimally in regions with warm climates and sandy, well-drained soils rich in organic matter. Healthy rhizomes should be chosen for planting, and crop rotation should be used to reduce the occurrence of pests and diseases (Carmo and Balbino 2015).

The first root harvest can be carried out between six and ten months after planting, coinciding with the beginning of senescence of the aerial part. After harvesting, the roots should be washed carefully and dried in the sun for four days. Alternatively, they can be consumed while fresh (Vaz and Jorge 2006).

In Brazil, it is believed that this plant arrived after its discovery around the 16th century and has already been seen in its wild state by naturalists (Palharin et al. 2008). Ginger has been cultivated in several Brazilian states such as Paraná, Santa Catarina, São Paulo, and in the Central Serrana region of Espírito Santo State, more precisely in the municipalities of Santa Leopoldina and Santa Maria de Jetibá, which are considered the largest producers and

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exporters of fresh rhizome in the country. The production is mainly located on rural properties that are predominantly family-based (SEAG 2024).

Although this species ranks fourth among the main economically important crops in the state, little research has been conducted on ginger. The Imigrante cultivar results from the only ginger breeding program currently underway in the country, which is linked to the Postgraduate Program in Agroecology at Ifes Campus Alegre. This program adopted the strategy of participatory genetic improvement, as it was conducted with farmers, with their effective participation, thus identifying local demands that accelerated the search for superior genetic materials already in the farmers' possession.

The release of cultivars contributes to the increase in the productivity of ginger crops. The Ifes ginger breeding program aims to find cultivars with high production potential, greater disease resistance, and ideal rhizome architecture to meet the foreign market, which is the main target for marketing ginger from Espírito Santo. Moreover, cultivar development will enable farmers to access better-quality products and increase the crop's economic potential.

## ORIGIN AND DEVELOPMENT OF THE CULTIVAR

Ginger (*Zingiber officinale* Roscoe) is propagated vegetatively and has a high degree of heterozygosity, which favors the genetic variability of the species. Considering these characteristics and the demand of the productive sector, a participatory genetic improvement program was conducted in collaboration with farmers in the region. Over approximately fifteen years, superior plants were selected based on the productivity and commercial characteristics of the rhizomes, giving rise to seven genetic materials evaluated in this study. Genotypes were selected by mass selection, marking outstanding plants for producing seed rhizomes used in new plantings. Although molecular markers were used during the initial selection phase to assist in identifying genetic variability, the current work focuses solely on morpho-agronomic traits of the Imigrante cultivar.

The evaluation trials were conducted on three rural properties in Santa Leopoldina and Santa Maria de Jetibá, the country's main ginger-producing region. The locations where the trials were conducted were the rural community of Caramuru de Cima (lat 20° 02' 26" S, long 40° 44' 46" W) and the community of Rio das Pedras (lat 20° 16' 74" S, long 40° 67' 40" W; lat 20° 14' 22" S, long 40° 72' 35" W). The trials were conducted in a randomized block design with four replications, containing double plots of 2 m in length, spaced one meter between plots and 0.15 cm between plants.

The planting areas were characterized by sloping relief, sandy soil, and sprinkler irrigation three times a week. Plantings were carried out on September 1, 2022, and the harvest dates were July 20 and 21, 2023. The mounding type (quantity) consisted of three mounds over time, with 14 liters of chicken litter per plot in each mound.

Quantitative and qualitative traits were evaluated. The qualitative traits were divided into: Growth habit (GH) – Analysis through observation and classification according to its habit as erect, semi-erect, semi-prostrate, and prostrate; Ligule margin (LM) – Observation analysis and classification as entire, serrated, and toothed; Leaf division (LD) – Observation analysis and classification as simple and compound; Leaf shape (LS) – Observation analysis and classification as lanceolate, linear, elliptical, and oblong; Leaf color (LC) – Observation analysis and classification as green, yellowish green, and dark green; Rhizome skin color (RSC) – Observation analysis and classification as light yellow, yellow, light brown, and reddish; Rhizome pulp color (RPC) – Observation analysis and classification as light yellow, yellow, dark yellow.

The quantitative traits were split into: Internode length (IL) - Measurement from one node to the other (mm) of the plant stem using a caliper; Stem width (SW) – Measurement of the diameter in the basal part of the plant (mm) using a caliper; Rhizome diameter (RD) - Measurement of the diameter (mm) of the rhizome in the median part using a caliper; Rhizome weight (RWE) - Weighing of the rhizomes using a digital commercial scale (g); Rhizome width (RWI) - Measurement of the width using a caliper (mm); Rhizome length (RL) - Measurement of the length (cm) using an aluminum ruler; Number of tillers per plot (NTP) - Counting the number of tillers per plot (un); Productivity (PROD) – calculated by the average number of rhizomes multiplied by the total weight, adjusted by the useful area of the plot ( $t\ ha^{-1}$ ).

## CULTIVAR TRAITS

This genotype has relevant traits for ginger cultivation, such as high productivity, elongated rhizome architecture, rapid and early growth, and high competitiveness against weeds.

Anatomical description of the plant in the field

The Imigrante cultivar is an erect plant that can reach a height of over 150 cm. Its leaves have an entire ligule margin with a simple division. The leaf shape is lanceolate, with alternating orientation and green coloration (Table 1; Figure 1A).

Description of the inflorescence

The inflorescences of the Imigrante cultivar have ellipsoid spikes that form at the apex of the peduncles that sprout from the rhizome. The flowers are yellow-reddish and are zygomorphic or bilateral and hermaphrodite. The orbicular floral bracts have a toothed calyx and corolla surrounding a single flower (Figure 1B).

Table 1. Qualitative morpho-agronomic descriptors applied in pre-harvest and post-harvest of ginger between 2022 and 2023

Cultivar	GH <sup>1</sup>	LM	LD	LS	LC	RSC	RPC
Imigrante	Erect	Entire	Simple	Lanceolate	Green	Light brown	Yellow

<sup>1</sup> GH: Growth habit; LM: Ligule margin; LD: Leaf division; LS: Leaf shape; LC: Leaf color; RSC: Rhizome skin color; RPC: Rhizome pulp color.



Figure 1. A: Stem of the Imigrante ginger cultivar with distichous and alternate leaves; B: Flowers of the Imigrante cultivar showing a yellow-reddish color; C: Rhizome of the Imigrante cultivar showing the elongated size of the rhizome fingers, which favors the commercialization of this cultivar for the foreign market; D: Imigrante cultivar in the field, demonstrating the erect and tall shape of the plant, with producer Alexandre Lemk Belz.

**Table 2.** Quantitative morpho-agronomic traits applied in pre-harvest and post-harvest ginger between 2022-2023

Imigrante Cultivar	Quantitative descriptors						
	IL <sup>1</sup>	SW	RD	RWE	RWI	RL	NTP
Site 1	43.50	5.225	24.42	500.00	18.21	20.00	40.22
Site 2	38.42	6.00	25.13	520.00	20.00	25.00	25.22
Site 3	40.71	5.67	26.06	522.33	22.21	30.63	30.43
Average	40.88	5.63	25.20	514.11	20.14	25.21	31.95

<sup>1</sup> IL: Internode length (mm); SW: Stem width (mm); RD: Rhizome diameter (mm); RWE: Rhizome weight (g); RWI: Rhizome width (mm); RL: Rhizome length (cm); NTP: Number of tillers per plot (un); PROD: Productivity (t ha<sup>-1</sup>).

Traits of the rhizome

The rhizome of Imigrante ginger is elongated, with an average length of 25.21 cm, an average weight of 514.11 g, and a field productivity of 145,000 t ha<sup>-1</sup>. Therefore, it is considered highly productive. The rhizome architecture is elongated and free of entangled fingers, showing an export pattern (Figure 1C).

Performance

Quantitative and qualitative morpho-agronomic traits were determined to characterize the rhizomes cultivated in Santa Leopoldina and Santa Maria de Jetibá. The quantitative descriptor results were an internode length of 40.88 mm, a stem width of 5.63 mm, a rhizome diameter of 25.20 mm, a rhizome weight of 514.11 g, a rhizome width of 20.14 cm, a rhizome length of 25.21 cm, a count of the number of tillers per plot of 31.95 (u), and a productivity of 145,003 t ha<sup>-1</sup> (Table 2).

The Imigrante cultivar was selected for release due to its consistently high productivity across three evaluation environments, superior rhizome architecture favorable for export markets, and strong acceptance by local producers involved in the participatory selection process. These combined attributes validate its recommendation as the first official Brazilian ginger cultivar.

Production of seed rhizomes

The Imigrante cultivar is registered under number 57096 with the Ministry of Agriculture, Livestock and Food Supply (MAPA). Mr. Alexandre Lemk Belz, a rural producer who is a partner in the project and the holder of the genetic material, was responsible for the basic production of seed rhizomes.

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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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