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*CULTIVAR RELEASE*

# Andina - first clonal cultivar of high-altitude conilon coffee

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**Abstract:** *Andina is a conilon coffee variety originated from a selection of clones discovered by farmers. It was cultivated and evaluated for yield and plant vigor an altitude of 850m asl. Five genotypes (A1, NV2, NV8, P1 and Verdim TA), with a mean yield of 51.3 bags per hectare per year.*

**Keywords**: *Coffea canephora, plant resistance, climate change.*

## INTRODUCTION

The world coffee production is around 174 million bags per year. The cultivar Arabica (*Coffea arabica*) accounts for 59.7% and the cultivar Robusta/Conilon (*C. canephora*) for 40.3% of this total, (USDA 2019). The annual income from the entire coffee chain is around USD 173,000 million (ICO 2019). According to the National Company of Supply of Brazil (CONAB), Brazilian coffee provides approximately 32% of the global production (CONAB 2019). In view of the population growth and the growing vulnerability to climatic alterations, it is increasingly important to invest efforts in form of sustainable and environmentally responsible actions to raise coffee yield and quality.

Conilon coffee is a self-sterile diploid plant and allogamous due to gametophytic self-incompatibility. Vegetatively propagated plants carry the traits inherited from the mother plant, which ensures a uniform crop development, higher yields, better fruit quality and the possibility of producing varieties with a differentiated maturation cycle (Partelli et al. 2014).

*Coffea canephora* tolerates temperatures of up to 37 ºC, based on the maintenance or reinforcement of photoprotection and antioxidant mechanisms (Martins et al. 2016, Rodrigues et al. 2016). The growth of *C. canephora* cv. Conilon under field conditions is delayed when the mean minimum temperature is < 17 ºC and > 31 ºC (Partelli et al. 2010, Covre et al. 2016). Such temperature extremes can negatively affect the physical plant traits, e.g., by reducing grain weight and yield (Ramalho et al. 2018). An option to mitigate thermal stress on coffee is cultivation at higher altitudes; however, temperature drops to levels below 13 ºC/8 ºC (day/night) induce several metabolic alterations in Conilon coffee, with a negative impact on yield (Partelli et al. 2009, Batista-Santos et al. 2011, Scotti-Campos et al. 2014).

Some tolerance characteristics have been observed at positive low temperatures, varying according to the *Coffea* species and genotype, with specific

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levels of reinforcement of antioxidant mechanisms and dynamics and alterations in the lipid matrix of the chloroplast membrane (Partelli et al. 2011, Ramalho et al. 2014). In this regard, cultivar Andina is an appropriate *C. canephora* variety for cultivation at elevated altitudes. This cultivar, represented by five clones, has been tested at an altitude of 850 m asl and is registered by the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA). Twenty-seven *C. canephora* cultivars are currently registered in Brazil; of these, Andina is the first cultivar recommended for high-altitude cultivation (http://sistemas.agricultura.gov.br/snpc/cultivarweb/cultivares_registradas.php).

Studies have investigated the response of *C. canephora* in colder regions of Brazil, according to the latitude or altitude (Mistro et al. 2004, Barbosa et al. 2014, Silva et al. 2015, Rodrigues et al. 2016, Mistro et al. 2019), but none of the efforts culminated in the registration of a cultivar with high yielding potential, as in the case of Andina.

## BREEDING PROCESS

The plant lines were initially selected, vegetatively propagated by cuttings and planted together in the same competition assay. The selected genotypes to be examined were 13 genotypes of cultivar Vitória Incaper 8142 and 12 other genotypes with high yielding potential and traits of agronomic interest for the species, selected by farmers of the state of Espírito Santo. Twenty-eight genotypes were planted (25 propagated by cuttings and three by seeds originating from Emcapa 8141 – Robustão Capixaba) in the municipality of Morrinhos (lat 17º 49’ 30.00’’ S, long 49º 12’ 01.00’’ W, alt 850 m asl), Goiás.

The region is characterized by a precipitation deficit from April to October, a flat topography, wavy relief and an annual mean temperature of 20 ºC. Minimum air temperatures range from 10 to 20 ºC and low-temperature peaks beneath 10 ºC occur in the winter, as observed in May, June and July 2013, July 2014 and June and August 2016 (Figure 1 A, B, C and D), reaching 6.9 ºC in July 2014 (Figure 1B). These temperatures are extremely low for the productive development of *Coffea canephora*.

The experiment was set up as a randomized block design with four replicates, with five plants each. Plants were pruned to control the number of orthotropic stems, to a standard density of 12,000 - 15,000 stems per hectare. The area was weeded mechanically and chemically once a year and fertigated. No micronutrients, insecticide, or fungicide were applied during the experimental period. The study area was irrigated during the growing seasons of 2013 and 2014, but not in 2015 and 2016. The plant spacing was 3.5m x 1m, i.e., 3.5 $m^2$ per plant.

Four harvests were performed in the study period. The coffee cherries of each plot were harvested separately per

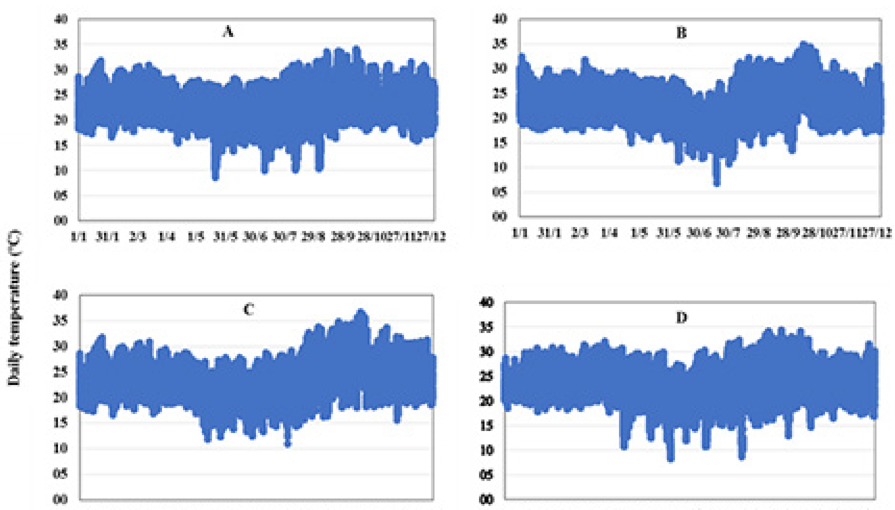


*Figure 1.* Air temperatures in 2013 (A), 2014 (B), 2015 (C) and 2016 (D), in the municipality of Morrinhos (lat 17º 49’ 30.00’’ S, long 49º 12’ 01.00’’ W, alt 850 m asl), Goiás, Brazil.

***Table 1.*** Annual yield and mean yield (bags of 60 kg ha$^{-1}$) of three and four growing seasons of genotypes of cultivar Andina

| Genotype | Yield 1st year | Yield 2nd year | Yield 3rd year | Yield 4th year | Mean of four harvests | Mean of three harvests | Maturation cycle |
|---|---|---|---|---|---|---|---|
| | | | | Bags ha$^{-1}$ | | | - |
| Verdim TA | 13.77 | 43.59 | 99.14 | 72.13 | 57.16 | 71.62 | Intermediate |
| NV 2 | 45.05 | 49.29 | 100.9 | 38.97 | 58.56 | 63.06 | Early |
| A1 | 44.77 | 83.32 | 61.21 | 34.57 | 55.97 | 59.70 | Intermediate |
| NV 8 | 22.78 | 66.01 | 77.81 | 26.09 | 48.17 | 56.63 | Intermediate |
| P1 | 10.47 | 78.15 | 40.29 | 17.85 | 36.69 | 45.43 | Late |
| Mean Andina | 27.38a | 64.07a | 75.87a | 37.92a | 51.31a | 59.29a | |
| Mean Vitória* | 11.68b | 31.51b | 29.13b | 6.01b | 19.58b | 22.22b | |

* All genotypes of cultivar Vitória Incaper 8142 were evaluated in the competition assay. Means followed by equal letters, in the columns, do not differ, by Dunnett test, at 5% probability.

genotype and the grain yield measured in liters per plot and later converted into bags of processed coffee per hectare, where 320 L = one 60-kg bag of processed grain (Barbosa et al. 2014, Oliosi et al. 2016). Yield per hectare was computed based on the plant spacing.

## PERFORMANCE

Yield data of the four harvests were used to choose the plants for the competition assay and to select genotypes (Table 1). Of all genotypes evaluated in the trial, based on traits such as yield and apparent plant vigor, five were selected as superior (A1, NV2, NV8, P1 and Verdim TA) and used to develop a new clonal cultivar, named Andina. The mean yield over four harvests of the five genotypes was 51.3 bags per hectare per year. As the plants were still young at the first harvest, the overall mean yield across the three harvests of the five genotypes was 59.3 bags per hectare per year. The mean cultivar yield may be considered low; however, the lack of irrigation in two growing seasons and absence of phytosanitary measures should be taken into account. Moreover, the mean yield of cultivar Andina was 166% higher than that of cultivar Vitória Incaper 8142 (13 genotypes), under the same high-altitude conditions as in Morrinhos - GO (Table 1). It is noteworthy though that cultivar Vitória Incaper 8142 was not developed for the high altitudes and low temperatures (Fonseca et al. 2004) for which the genotypes of cultivar Andina were selected. Although seemingly low, the yield of cultivar Andina was 56% higher than the mean yield of Conilon coffee in Brazil in the growing season 2018 and 111% higher than the national mean in the 2017 growing season (CONAB 2019). Moreover, the winter temperatures were far lower than 10 ºC, reaching 6.9 ºC on July 19, 2014 (Figure 1A, B, C and D), which is extremely low for the development of most *Coffea canephora* genotypes. Nonetheless, the clones of cultivar Andina were not incapacitated by this fact.

During the years of evaluation, the selected genotypes proved to be well-adapted to high-altitude conditions, since even at 850 m asl their growth and yield performance was satisfactory, and no severe attacks by the main coffee pests or diseases and no flowering/pollination problems were observed. The plants were vigorous and leafy throughout the entire crop cycle. Under the soil-climatic conditions for which the cultivar was developed, the maturation cycle of the genotypes was classified as: early-maturing - NV2; intermediate - Verdim TA, A1 and NV8; and - P1 (Table 1).

Cultivar Andina is recommended for Brazilian states at latitudes of < 22° S, altitudes of < 900 m and a minimum air temperature not lower than 8 ºC for more than 10 days per year. It is worth emphasizing that this was the first field study addressing the selection of *C. canephora* genotypes adapted to high altitudes. Further studies, involving the physiological, anatomical and biochemical characterization of the genotypes, are underway.

## CLONE MAINTENANCE AND DISTRIBUTION

The coffee cultivar Andina is registered in Brazil (no. 39441) by the National Registry of Cultivars (*Registro Nacional de Cultivares*, RNC) of the Ministry of Agriculture, Livestock and Supply (*Ministério da Agricultura, Pecuária e Abastecimento*, MAPA). The Federal Institute Goiano and the Federal University of Espírito Santo are responsible for the maintenance of the genotypes of cultivar Andina.

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