Nativa, Sinop, v. 12, n. 2, p. 312-319, 2024.
Pesquisas Agrárias e Ambientais
DOI: https://doi.org/10.31413/nativa.v12i2.16177

ISSN: 2318-7670

Agronomic performance of Conilon coffee clones in the humid subtropical climate of Registro, Vale do Ribeira, SP, Brazil

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Submitted on: 08/22/2023; Accepted on: 05/18/2024; Published on: 05/23/2024.

ABSTRACT: Coffee, a globally traded and profitable commodity, is pivotal in many countries' economies and social development. In the Vale do Ribeira, a region of significant socio-environmental importance, coffee farming has the potential to boost local family agriculture through the diversification of agricultural production, with a focus on Conilon coffee (*Coffea canephora* Pierre), which thrives in hot and humid climates. In this context, our study's in situ evaluation of the agronomic performance of Conilon coffee clones is of utmost importance. We assessed the vegetative growth, incidence of pests and diseases, productivity, and grain ripening of various Conilon coffee clones in Registro, located in the humid subtropical environment of Vale do Ribeira. Clones 401 and 410 demonstrated superior vegetative growth. Pests and diseases, such as leaf miner, Phoma, and Cercosporiosis, were more prevalent during higher temperatures, while rust was a concern in cooler temperatures. The most productive clones were 13V, 407, 403, and 409, with a higher percentage of grains in the "cherry" stage, making them the most promising for cultivation in the region.
Keywords: brown eye spot; leaf miner; Mata Atlântica; plant growth; yield.

Desempenho agronômico de clones de café conilon submetidos ao clima subtropical úmido do Vale do Ribeira

RESUMO: O café é uma das commodities mais negociadas e lucrativas globalmente, desempenhando um papel crucial na economia e no desenvolvimento social de muitos países. No Vale do Ribeira, uma região de grande importância socioambiental, a cafeicultura tem potencial para favorecer a agricultura familiar local através da diversificação da produção agrícola, com ênfase no café conilon (*Coffea canephora* Pierre), que é adaptado a ambientes de clima quente e úmido. Nesse contexto, a avaliação *in situ* do desempenho agronômico de clones de café conilon é essencial para identificar as opções mais promissoras. O presente estudo avaliou o crescimento vegetativo, a incidência de pragas e doenças, a produtividade e a maturação de grãos de diferentes clones de café conilon em Registro, localizado no ambiente subtropical úmido do Vale do Ribeira. Os clones 401 e 410 se destacaram pelo crescimento vegetativo superior. Em relação às pragas e doenças, houve maior incidência de bicho mineiro, Phoma e Cercosporiose durante períodos de temperatura mais elevada, enquanto a ferrugem foi mais relevante em temperaturas amenas. Os clones mais produtivos foram 13V, 407, 403 e 409, apresentando maior porcentagem de grãos no estágio "cereja", sendo considerados os mais promissores para o cultivo na região.
Palavras-chave: cercosporiose; bicho mineiro; Mata Atlântica; crescimento vegetativo; produtividade.

1. INTRODUCTION

Coffee cultivation is significant to the Brazilian economy and is recognized internationally for technological advancements and product quality (BARBOSA et al., 2019). Brazil is one of the leading producers and exporters of coffee worldwide, holding a prominent international position and being the second-largest consumer of the beverage globally (ICO, 2020). It should be noted that coffee is the second largest commodity in the world, generating $91 billion annually (ICO, 2020). The total cultivation area in the country was 2.24 million hectares in 2023, producing 55.07 million bags of coffee, each weighing 60 kg (CONAB, 2023). Of this total production, approximately 30% was Conilon coffee (*Coffea canephora Pierre*) (CONAB, 2023).

The climate has a significant influence on the potential for coffee cultivation, determining both the productivity and quality of the beverage, as well as the need for specific technologies such as irrigation and the use of chemical control for pests and diseases (LORENZETTI et al., 2015; OVALLE-RIVERA et al., 2015; FERRÃO; MUNER, 2017; TAVARES et al., 2018; HERERA, 2019; MENDONÇA et al., 2019; MOURA et al. 2021). Typically, Conilon coffee is cultivated in low-altitude regions (up to 800m), where the air temperature ranges between 22°C and 26°C and annual rainfall ranges between 1,200 mm and 1,800 mm (Ferrão et al., 2019). Espírito Santo and Roraima states are the main Brazilian producers, representing 63% and 19% of the national total, respectively (CONAB, 2023).

The Vale do Ribeira Paulista, located in southeastern Brazil, encompasses 22 municipalities within the state of São Paulo, situated within the Hydrographic Basin of the Ribeira de Iguape River. Renowned for its rich biodiversity in aquatic and terrestrial ecosystems, the region hosts a significant portion of the world's remaining Atlantic Forest, partitioned into various Permanent Preservation Areas (PPAs) (IBGE, 2016). In these PPAs, traditional communities, including indigenous groups, quilombolas, and caiçaras, engage in subsistence agricultural or extractive activities, often organized into associations (IANOVALI et al., 2018). With some municipalities having over 50% of their territory covered by Permanent Preservation Areas (APP), industrialization and urban expansion are restricted, leading to the service sector and agriculture forming the backbone of the local economy (IBGE, 2016). The agriculture in this region is characterized by a prevalence of banana and peach palm production (IBGE, 2016). Sustainable agricultural development, relying on family labor and production diversification, is a major challenge for the region (CARVALHO et al., 2022).

Despite its limited historical presence, the Vale do Ribeira holds potential for coffee production, particularly Conilon coffee. While its climate differs from traditional Arabica coffee production regions like São Paulo and Minas Gerais (TERAMOTO et al., 2019), it boasts temperature, air humidity, and rainfall patterns conducive to Conilon coffee cultivation (FERRÃO et al., 2019). Consequently, research focusing on clone selection and technology establishment for coffee production in this region holds significance.

Based on the provided information, this study assesses vegetative growth, production, and pest and disease incidence in different Conilon coffee clones grown in Vale do Ribeira Paulista. It aims to provide insights into conilon coffee production feasibility in the region, identifying clones best suited to its distinct climatic characteristics.

2. MATERIAL AND METHODS

The experiment was carried out at the Faculdade de Ciências Agrárias do Vale do Ribeira - Universidade Estadual Paulista "Júlio de Mesquita Filho", located in Registro (24°31'58" S; 47°51'46" W, 25 m), where the coffee seedlings were set in March 2018. Both setting and the assays were conducted according to the technical recommendations for the coffee crop in the state of São Paulo (HAIJ et al., 1997); phytosanitary management was used to control diseases with chemical products recommended for coffee plantations.

According to the Pedological Map of São Paulo State (ROSSI, 2017), the soil used is classified as Dystrophic Yellow/Red Latosol with medium texture. The soil in the experimental area, before the experiment was set, in the 0 to 0.2 m layer, had the following characteristics: pH 4.9; 29 g dm^{-3} MOS; 449 and 18 mg dm^{-3} of P and S, respectively; 9.9; 76; 32; 150 mmolc dm$_{-3}$ of K, Ca, Mg and CTC, respectively; 79% V; 135; 62; 6.1; 18.4; 0.88 mg dm^{-3} of Fe, Mn, Cu, Zn and B, respectively, 386, 205, 409 g kg^{-1} of clay, silt and clay, respectively. In the 0.2 to 0.4 m layer, the following characteristics were observed: pH 4.9; 34 g dm^{-3} MOS; 462 and 11 mg dm^{-3} of P and S, respectively; 6.3; 75; 33; 160.2 mmolc dm^{-3} of K, Ca, Mg and CTC, respectively; 72% V; 132; 42; 6.5; 13.0; 1.06 mg dm^{-3} of Fe, Mn, Cu, Zn and B, respectively, 405, 196, 399 g kg^{-1} of clay, silt and clay, respectively.

The municipality of Registro has a climate classified as Cfa according to the Koppen criteria and is common in the greater part of the Vale do Ribeira Paulista (IBGE, 2016), with high cloudiness and relative humidity throughout the year. Throughout the year, there is a predominance of cloudy and partly cloudy sky conditions, with a low frequency of clear skies (TERAMOTO et al., 2019). To describe the prevailing atmospheric conditions in Registro during the experimental period, we utilized daily data on air temperature (T_{air}), relative humidity (RH), and cumulative rainfall released by the National Institute of Meteorology (INMET) and the Integrated Center for Agrometeorological Information (CIIAGRO).

In the experiment, twenty clones of Conilon coffee developed and provided by the Capixaba Institute for Research, Technical Assistance and Rural Extension (INCAPER), one of the main research institutions responsible for the genetic improvement program of Conilon coffee in Brazil, were evaluated. Among the 20 clones, eight belong to the Vitória – Incaper 8142 (NCR 20417) cultivar and the rest to the Marilândia ES8143 (NCR 37678) cultivar. Table 1 presents the information regarding the tested clones.

Table 1. National Cultivar Registry (NCR) number and characteristics of the tested clones.
Tabela 1. Número do Registro Nacional de Cultivares (RNC) e características dos clones testados.

NCR	Characteristics	Clones
20417	High vegetative vigor, moderately rust-resistant	2V, 3V, 4V, 5V, 6V, 8V, 10V and 13V.
37678	High vegetative vigor, moderate resistance to rust and leaf miners, drought tolerance.	401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411 and 412.

The experimental design was a Randomized Complete Block Design (RCBD) with three replications. Each plot consisted of ten plants, with the six central plants considered useful plots. The spacing between rows was 3.0 m, and the spacing between plants was 1.0 m, resulting in a density of three plants/ha, totaling 10,000 plants/ha. Regarding agronomic performance, plant growth (in 2020, the second year of crop formation), incidence of pests (in 2021) and initial yield in 2021 and 2022 were evaluated. Throughout the experimental period, pruning management was not required, and it should commence after the fourth harvest with production pruning. Furthermore, cultivation occurred independently of irrigation.

Plant growth was evaluated about the following variables: (i) stem diameter (SD), measured in millimeters, in the plant collar region, with the aid of a caliper; (ii) several plagiotropic branches (NPB), evaluated by counting all primary lateral branches that were longer than 5 cm; (iii) plant height (PH), measured in centimeters, from the base of the plant to the apical bud stem, with the aid of a graduated ruler; (iv) number of nodes in plagiotropic branches (NNPB), evaluated by counting all nodes in plagiotropic branches; and (v) length of the first plagiotropic branch (LFPB), evaluated by measuring the first plagiotropic branch above the plant collar, with the aid of a graduated ruler.

The incidence of diseases and pests was analyzed through monthly evaluations of incidence of rust (*Hemileia vastatrix*), brown eye spot (*Cercospora coffeicola*), Phoma (*Phoma spp.*) and leaf miner (*Leucoptera coffeella*), according to the method proposed by Moraes (1998): (vii) incidence of brown eye spot on the leaves of coffee trees, evaluation of the leaves of the third or fourth pair, from the tip of branches in the middle third of useful plants; (viii) incidence of leaf miner on the leaves of coffee trees, based on the evaluation of the leaves of the third or fourth pair from the tip of the branches of the middle third of useful plants, counting intact mines and those with signs of predation by wasps, from live and dead BMC (coffee tree miner) caterpillars; (ix) incidence of Phoma spot on coffee leaves, assessment of the youngest leaves at the tip of branches in the middle third of the plants; (x) incidence of leaf rust on coffee trees: evaluation of the leaves of the lower third of the plants (coffee planting row).

The harvest began approximately 270 days after the start of flowering, which was visually verified by the presence of flower buds (ANTUNES; CARVALHO, 1954). Initial production was evaluated having the following aspects as a reference: (xi) Average yield, expressed in bags ha-1, obtained by converting coffee harvested on the farm between June and August 2021 and from May to July 2022 into processed coffee; the conversion factor was obtained through the actual yield of each cultivar, that is, the volume of harvested coffee necessary for the production of a 60 kg bag of processed coffee (L per bag). For the calculation, samples of 3L coffee were separated from each experimental plot, and after drying until 11% moisture (b.u.) was reached, the samples were processed. For the calculation, samples of three liters of coffee were separated from each experimental plot, which, after drying, reached 11% moisture (b.u.) and were then processed. (xii) Percentage of parchment fruits (ripe), fruit samples from the six central plants of each plot (500mL per plot), in plagiotropic branches located in the four quadrants, carried out when most of the fruits of the plot were in the parchment stage. (xiii) Percentage of green fruits, fruit samples from the six central plants of each plot (500mL per plot), in plagiotropic branches located in the four quadrants. (xiv) Percentage of raisins/dried fruits: fruit samples from the six central plants of each plot (500mL per plot) in plagiotropic branches located in the four quadrants. (xv) Percentage of floaters: The methodology proposed by (ANTUNES; CARVALHO, 1954) is that 100 parchment fruits are placed in water; those that remain on the surface are considered floaters.

The data obtained and used in evaluating agronomic performance were submitted for analysis of variance, considering a statistical model with repeated measurements over time with the Sisvar software (FERREIRA, 2020). For the variables where the difference between treatments was significant, the means of the clones were grouped by the Scott-Knott test at 5% probability.

3. RESULTS

Figure 1 presents information about air temperature (T_{air}), relative humidity (RH) and cumulative rainfall in Registro during the experimental period (averages refer to the period from January 2018 to December 2022). The vertical lines show the standard deviation values, which serve as a reference for verifying the interannual variability. Large standard deviations indicate high interannual variability.

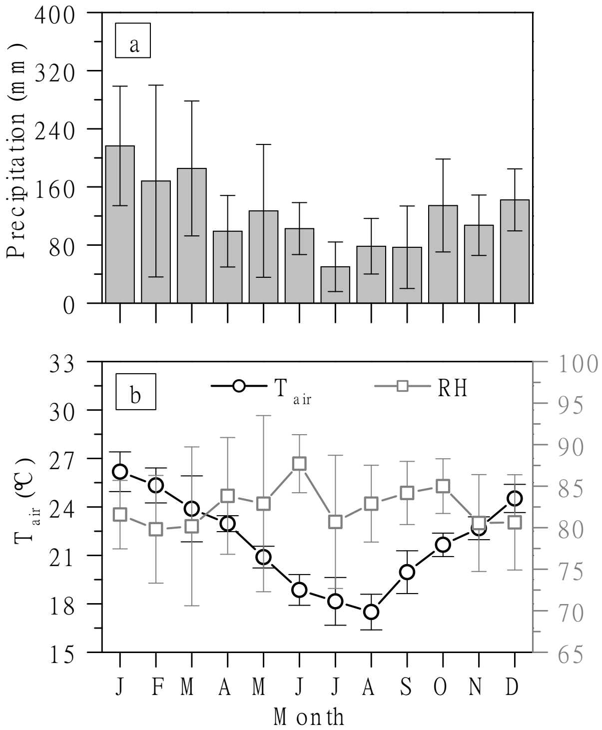

Figure 1. Air temperature (T_{air}), relative humidity (RH) and accumulated rainfall in Registro, interannual monthly averages from 2018 to 2022.

Figura 1. Temperatura do ar (T_{air}), umidade relativa do ar (RH) e precipitação acumulada em Registro, médias mensais interanuais de 2018 a 2022.

The air temperature varied between 26.18±1.23 ºC and 23.88±2.04ºC during the austral summer, while it remained between 17.49±1.10ºC and 18.86±0.84ºC in the winter, during the austral winter (Figure 1b). January and August are the hottest and coldest months, respectively. Regarding RH (Figure 1b), it is greater than 80.0% in all months of the year, being higher in the austral autumn and winter months. The wettest and driest months are June and December, respectively. The highest accumulated rainfall values occur during the austral spring and summer months, and the lowest occurs during the austral winter. However, in all months of the year, accumulated rainfall greater than 50mm is recorded (Figure 1a). The rainfall is well distributed throughout each month of the year, with an average monthly frequency of 4 days with rainfall occurring on all of them, and the maximum period of days without rainfall being recorded as less than 12 days. The annual accumulated rainfall was 1712.14±348 mm.

Below are the results of the agronomic evaluation of the tested coffee clones about vegetative growth, incidence of pests and diseases, and productivity. Table 2 presents the results observed in evaluating the plant growth of Conilon coffee clones cultivated in Registro, a representative environment about a large part of Vale do Ribeira Paulista.

Table 2 shows the highest PH values were observed in clones 401 and 410, respectively, 105.45 and 112.55 cm in height. These PH values correspond to twice the smallest PH observed, 54.25 cm, in clone 6V. The length of the first plagiotropic branch (LFPB) showed no significant difference between clones.

The number of nodes in the plagiotropic branches (NNPB) was higher in clones 13V, 401, 402, 403, 406 and 410, presenting values above 80 nodes. In general, the

Marilândia cultivar clones exhibited the highest values of NNPB and NPB, which are directly related to productivity in Conilon coffee. Regarding the number of plagiotropic branches (NPB), the clones that presented superior results were 4V, 5V, 8V, 10V, 13V, 401, 402, 403, 406, 407, 410 and 412, with the highest values observed. The lowest NPB value was observed in clone 6V, with 6.6 plagiotropic branches in the plant. Stem diameter (SD) was larger and statistically different in clones 2V and 410, respectively, 30.81 and 26.96 mm.

Table 2. Plant height (PH), growth of the first plagiotropic branch (GFPB), number of nodes in plagiotropic branches (NNPB), number of plagiotropic branches (NPB) and stem diameter (SD) of *Coffea canephora* in the second year of formation.
Tabela 2. Altura da planta (PH), crescimento do primeiro ramo plagiotrópico (GFPB), número de nós nos ramos plagiotrópicos (NNPB), número de ramos plagiotrópicos (NPB) e diâmetro do caule (SD) de *Coffea canephora* no segundo ano de formação

Clones	PH (cm)	GFPB (cm)	NNPB (units)	NPB (units)	SD (cm)
2V	90.95 b	42.33 a	60.80 b	8.80 b	30.81 a
3V	87.65 b	55.36 a	54.10 b	9.10 b	25.03 b
4V	56.30 d	52.30 a	71.60 b	10.70 a	19.91 c
5V	85.20 b	55.73 a	57.20 b	10.50 a	23.83 b
6V	54.25 d	36.58 a	33.80 b	6.60 b	18.37 c
8V	86.40 b	56.23 a	69.50 b	10.50 a	24.51 b
10V	76.85 c	52.73 a	60.60 b	11.10 a	20.26 c
13V	82.20 b	52.65 a	81.00 a	12.10 a	22.98 b
401	105.45 a	58.90 a	91.20 a	11.40 a	23.63 b
402	75.50 c	56.52 a	85.30 a	12.80 a	22.61 b
403	92.00 b	57.50 a	111.90 a	12.70 a	21.73 c
404	74.90 c	31.00 a	74.20 b	7.00 b	17.53 c
405	75.40 c	65.25 a	52.80 b	9.00 b	21.56 c
406	88.20 b	59.90 a	82.60 a	11.70 a	24.92 b
407	72.70 c	52.85 a	65.80 b	10.00 a	21.92 c
408	74.60 c	50.20 a	52.40 b	9.00 b	23.01 b
409	67.05 c	52.00 a	47.00 b	8.10 b	20.39 c
410	112.55 a	75.56 a	109.00 a	12.50 a	26.96 a
411	83.45 b	41.03 a	48.85 b	8.75 b	23.18 b
412	73.70 c	48.70 a	63.80 b	11.30 a	20.48 c
CV (%)	12.56	19.56	29.80	14.50	11.56

Means followed by the same letter do not differ by the Scott-Knott test at 5% probability.

Figure 2 depicts the results of rust, brown eye spot, Phoma, and leaf miner incidence evaluation in the tested clones during 2021. A notable prevalence of Phoma is observed, peaking from December to May across almost all Conilon coffee clones, varying severity depending on genetic material (Figure 2). Rust was more pronounced in clones 10V and 402, manifesting from June to December. Other clones began showing rust from August onwards, with varying degrees of susceptibility observed throughout the year; November and December exhibited the highest disease intensity. Special mention should be made of clones 404, 2V, 3V, and 4V, which presented good tolerance to rust. Brown eye spot was detected in November, December, January, and February, varying between clones 3V, 5V, 8V, 10V, 13V, 401, 402, 404, 405, 408, 409, and 411. In this study, the incidence of the leaf miner was higher in October, when it was observed in most clones, except 6V, 13V, and 412.

In Table 3, the initial production data observed in Conilon coffee clones are presented, based on the 2021 and 2022 harvests, taking into account the yield of processed coffee (60 kg ha^{-1} bags) and the coffee percentages in parchment, green, raisin, dry, and floater stages that comprise production.

Considering the production of processed coffee per hectare, the following clones were superior to the others: 2V, 3V, 8V, 13V, 401, 403, 407, 409, 410 and 411. The number of beans in the "parchment" stage was higher in clones 13V, 406, 405, 402, 407, 403, 404, 4V, 409, and 401, which presented values varying between 44.5 and 61% of parchment beans. Specifically, the highest percentage of parchment beans at harvest was observed in clone 401, with 61% of harvested beans.

Green beans were detected in greater quantity in clones 3V, 5V, 8V, 408, and 412; among them, the one with the highest amount of green beans was clone 8V, with 63.7% green beans. The clones that showed results significantly lower than the number of green beans were: 401, 4V, 403, 407, 404, 405, 409, 6V, 13V, 402, 411, 406, 410, 2V, and 10V, with percentages between 11.4 and 37.9% of the total harvested beans.

Dry beans were observed in greater quantity in clones 3V, 4V, 6V, 13V, 403, 405, 406, 407, 410, and 411, ranging from 8.2% in clone 411 to 16.8% in clone 405. The clones that presented a significantly lower percentage of dry beans were: 412, 408, 5V, 401, 8V, 10V, 402, 2V, 409, and 404, representing percentages between 1.4 and 5.6% dry beans. In this case, it should be observed that the lowest percentage was found in clone 412 (1.4% of dry beans of the total harvested beans).

4. DISCUSSION

The evaluation of the agronomic performance of different genetic *Coffea canephora* materials is essential for the viability of coffee production since the plant species is allogamous, and cross-fertilization occurs differently from *Coffea arabica*, which is an autogamous species in which self-fertilization occurs, once it is self-compatible. Therefore, in the production of Conilon coffee without genetic variability, there is no fertilization and, consequently, the production of coffee fruits (EMBRAPA, 2014). In addition to evaluating agronomic performance, it is also interesting to evaluate the compatibility between genetic materials to guarantee reproduction and subsequent production with maximum yield (FERRÃO et al., 2019).

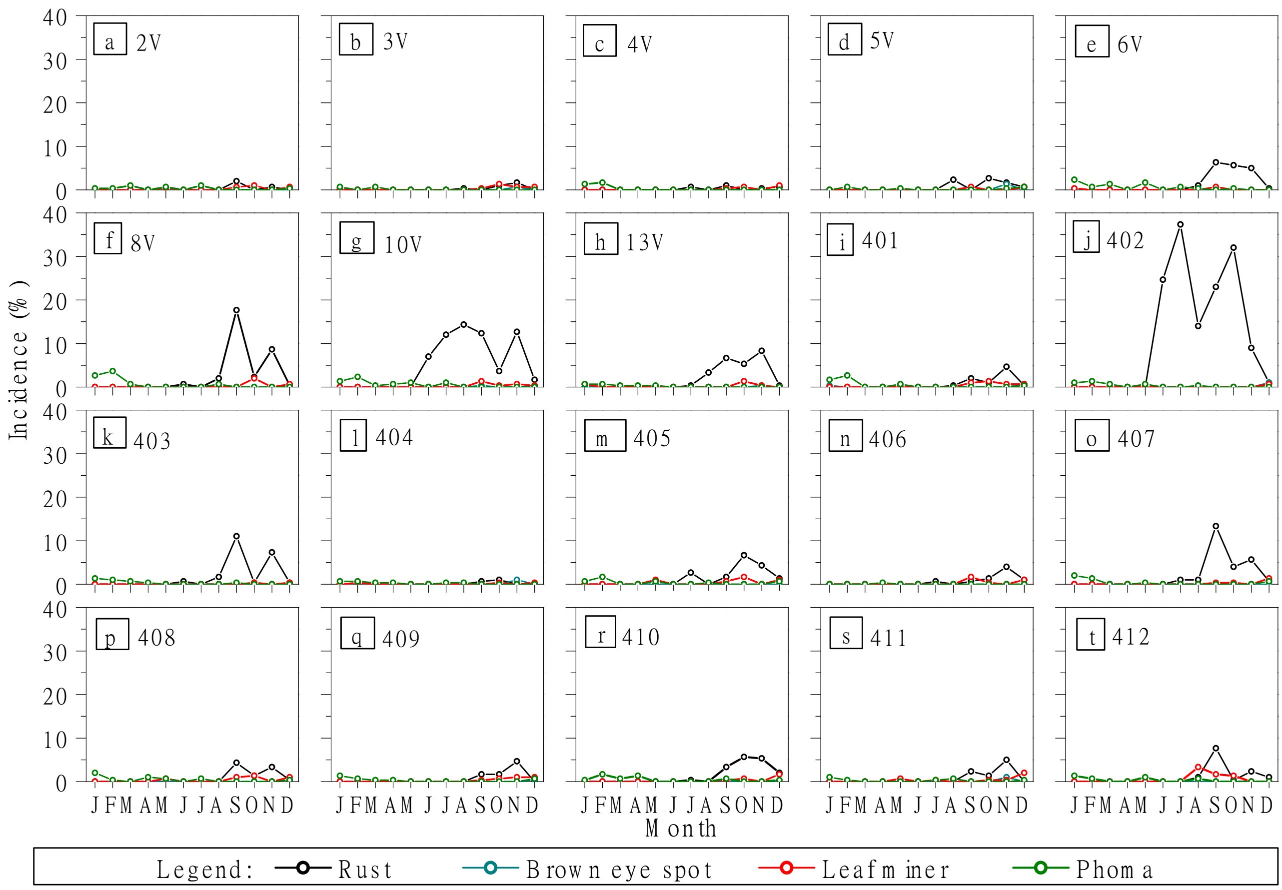

Figure 2. Incidence of diseases and pests on *Coffea canephora* leaves under the Vale do Ribeira Paulista environment, including rust, brown eye spots, phoma and leaf miners, from January to December 2021.
Figura 2. Incidência de pragas e doenças sobre as folhas do *Coffea canephora* submetido ao ambiente do Vale do Ribeira Paulista, em relação à ferrugem, cercosporiose, Phoma e bicho mineiro, de janeiro a dezembro de 2021.

Table 3. The mean initial yield of the initial harvests 2021/2022 and 2022/2023 and the mean percentage of fruits parchment (ripe), green, raisin, dry and floater fruits.
Tabela 3. Média de produtividade inicial das colheitas iniciais de 2021/2022 e 2022/2023 e percentuais médios de grãos em pergaminho (cereja), verdes, passas, secos e chocho.

Clones	Yield (bags ha^{-1})	Parchment (%)	Green (%)	Raisin (%)	Dry (%)	Floater (%)
2V	52.9 A	38.3 B	34.6 B	22.9 A	4.2 B	2.7 A
3V	49.1 A	16.4 B	50.8 A	24.1 A	8.6 A	6.7 A
4V	29.3 B	57.8 A	12.6 B	18.0 A	11.5 A	2.7 A
5V	33.8 B	30.0 B	59.6 A	7.1 A	3.3 B	5.3 A
6V	27.7 B	41.9 B	24.3 B	23.2 A	10.5 A	3.3 A
8V	42.1 A	27.0 B	63.7 A	5.5 A	3.8 B	11.3 A
10V	23.9 B	42.1 B	37.9 B	16.1 A	3.9 B	0.7 A
13V	50.3 A	44.5 A	26.7 B	15.7 A	13.1 A	0.1 A
401	49.6 A	61.0 A	11.4 B	17.2 A	3.4 B	4.7 A
402	29.3 B	54.5 A	27.0 B	14.2 A	4.2 B	0.1 A
403	35.3 A	57.1 A	13.8 B	21.1 A	8.1 A	0.7 A
404	23.5 B	57.4 A	19.7 B	17.2 A	5.6 B	2.3 A
405	23.5 B	48.0 A	20.7 B	14.4 A	16.8 A	4.7 A
406	19.2 B	46.7 A	29.8 B	13.8 A	9.7 A	0.7 A
407	41.3 A	56.1 A	18.3 B	15.0 A	10.5 A	4.0 A
408	20.0 B	38.4 B	48.0 A	11.1 A	2.4 B	2.7 A
409	37.3 A	58.2 A	23.7 B	12.7 A	5.4 B	1.7 A
410	44.1 A	30.5 B	32.6 B	29.0 A	7.8 A	0.1 A
411	46.3 A	24.2 B	29.4 B	38.2 A	8.2 A	1.3 A
412	32.9 B	35.9 B	48.7 A	13.9 A	1.4 B	0.7 A
Mean	35.6	43.30	32.03	17.53	7.13	2.80
CV (%)	20.5	26.11	51.40	49.78	49.16	162.66

Means followed by the same letter do not differ by the Scott-Knott test at 5% probability.

Climatological information regarding air temperature, relative humidity, and rainfall is important in selecting coffee genetic material and production systems (SILVA et al., 2018). These atmospheric variables directly impact crop yield and the need for specific cultivation practices and technologies, such as irrigation and pest and disease control (FERRÃO et al., 2020; FERRÃO; MUNER, 2017).

During the experimental period, the atmospheric conditions remained ideal for developing and producing Conilon coffee. Throughout most months of the year, the air temperature remained within the range considered suitable for the crop, ranging between 22°C and 26°C (FERRÃO et al., 2019). Furthermore, the rainfall was well distributed in frequency and volume throughout the year, providing favorable conditions for water availability in the soil (CARVALHO et al., 2022). These favorable conditions allowed for production without the need for irrigation.

The air temperature and relative humidity patterns observed throughout the year in Registro favored the incidence of most pests and diseases considered in this study. The most critical period was from August to November, when up to three were recorded simultaneously.

The leaf miner is one of the main pests whose larval stage damages the leaves of coffee plants (PEREIRA et al., 2007). Its incidence is more intense in hot and dry climates, with air temperatures between 25°C and 27°C and relative humidity below 70% (PARRA, 1985). These conditions shorten the insect's life cycle, and the low relative humidity decreases the incidence of fungi that parasitize the leaf miner. During the experimental period, a higher incidence of leaf miners was observed between July and October when the conditions of air temperature and relative humidity were favorable. Most clones showed infestation during this period, except for 6V, 13V, and 412. Carvalho et al. (2022) also reported a higher incidence of leaf miners during the same year in cultivating arabica coffee in Registro. Therefore, the phytosanitary management of the crop in the region needs to be carried out before this moment of high temperatures so that preventive control and chemical control can begin in June.

The incidence of rust was more intense between July and September under conditions of mild air temperatures and high relative humidity. During these months, the air temperature remained between 21.6°C and 23.6°C, with relative humidity > 80%, conditions considered ideal for the disease's proliferation (CAPUCHO et al., 2013). Among the tested clones, five showed good tolerance to rust, with the majority belonging to the 'Vitoria Incaper 8141' cultivar: clones 2V, 3V, and 4V. Mendonça et al. (2019), in Cachoeiro de Itapemirim/ES/Brazil, also found good resistance to rust in these same clones of the 'Vitoria Incaper 8141' cultivar.

The incidence of Phoma occurred during the austral summer, when air temperatures and relative humidity were elevated, conditions that favor the occurrence of this fungal disease (MENDONÇA et al., 2019; LORENZETTI et al., 2015). Although the occurrence of Phoma was recorded, it is important to highlight that the incidence was low. The low incidence of this disease in the evaluated clones can be attributed to both high cloudiness and balanced nutrition (LORENZETTI et al., 2015).

Regarding vegetative growth, the observed results align with the literature (BUSATO et al., 2022), indicating that the evaluated clones showed satisfactory growth up to the second year of formation. An important characteristic to be considered in Conilon coffee cultivation is its ruggedness, manifested in the plant's resistance to abiotic stresses such as variations in water availability and extreme temperatures, strengthening its natural defenses against pests and diseases (MOURA et al. 2021). This resilient characteristic may explain the greater vegetative vigor observed in clones 401 and 410 from 'Marilândia ES8143'. Another factor that may have contributed to the increased vegetative vigor is the high cloudiness characteristic of the region, which reduces the incidence of direct solar radiation and stimulates branch elongation and leaf area expansion (OVALLE-RIVIERA et al., 2015).

In Brazil, the state of Espírito Santo stands out as the main producer of Conilon coffee, recording production of 10.8 million bags and average productivity of 24.4 bags per hectare during the experimental period (harvests 2021/2022 and 2022/2023) (CONAB, 2022). In this study, approximately 75% of the evaluated clones demonstrated an initial productivity superior to the state of Espírito Santo average during the same period, highlighting the potential of the Vale do Ribeira for Conilon coffee cultivation.

The analysis of fruit percentages at different stages of maturation provides information about flowering characteristics throughout the harvest season. Clones 401 and 407 presented a higher percentage of fruits at the ripe stage, indicating an earlier and more uniform onset of flowering compared to the other evaluated clones and high productivity. On the other hand, clones 3V, 4V, 6V, 405, 406, 409, and 412 showed a relatively uniform distribution of percentages among fruit maturation stages, highlighting the occurrence of multiple flowerings throughout the year.

Another noteworthy result is the high yields associated with rust resistance observed in clones 2V and 3V. This extremely interesting factor allows for the recommendation of these clones for cultivation in the Vale do Ribeira without the need for chemical control measures against this disease.

5. CONCLUSIONS

Clones 401 and 410 were established faster, resulting in greater plant growth. The climatic conditions of the Vale do Ribeira region interfere with the incidence of diseases and pests studied, requiring greater care and monitoring for the leaf miner.

The most productive clones were 2V, 3V, 8V, 13V, 401, 403, 407, 409, 410 and 411. A high yield was associated with rust disease tolerance for clones 2V and 3V. Analyzing agronomic performance, it can be concluded that clones 2V, 3V, 13V and 401 are indicated for cultivation under Registro-SP conditions. The continuity of this research, combined with new studies with Conilon coffee, is essential for consolidating the crop in the state of São Paulo.

6. REFERENCES

ANTUNES FILHO, H.; CARVALHO, A. Melhoramento do cafeeiro. **Bragantia**, v. 13, n. 14, p. 165-179, 1954.

BARBOSA, I. P.; COSTA, W. G.; NASCIMENTO, M.; CRUZ, C. D.; OLIVEIRA, A. C. B. Recommendation of *Coffea arabica* genotypes by fator Analysis. **Euphytica**, v. 215, n. 178, p. 1-10, 2019. https://doi.org/10.1007/s10681-019-2499-x

BUSATO, C.; REIS, E. F. dos; OLIVEIRA, M. G.; GARCIA, G. de O.; BUSATO, C. C. M.; PARTELLI, F. L. Different nitrogen levels on vegetative growth and yield of conilon coffee (*Coffea canephora*). **Ciência Rural**, v. 52, n. 12, e20200770, 2022. https://doi.org/10.1590/0103-8478cr20200770

CAIXETA, E. T.; RESENDE, M. D. V.; ALKIMIM, E. R.; SOUSA, T. V.; OLIVEIRA, A. C. B.; PEREIRA, A. 'A.; ALVES, R. S. **Aceleração do melhoramento do cafeeiro via seleção genômica: agilidade e eficácia no lançamento de novas cultivares**. Brasilia: Embrapa Café, 2022. 54p.

CAPUCHO, A. S.; ZAMBOLIM, L.; CABRAL, P. G. C.; MACIEL-ZAMBOLIM, E.; CAIXETA, E. T. Climate favourability to leaf rust in Conilon coffee. **Australasian Plant Pathology**, v. 42, p. 511-514, 2013. https://doi.org/10.1007/s13313-012-0187-6

CARVALHO, A. M.; BOTELHO, C. E.; FERREIRA, A. D.; TERAMOTO, E. T.; LIMA, A. E.; MIYAZAKI JÚNIOR, F. S.; GUERREIRO-FILHO, O. Initial vegetative and reproductive development of coffee cultivars in Vale do Ribeira Paulista. **Semina: Ciências Agrárias**, v. 43, n. 3, p. 961-972, 2022. https://doi.org/10.5433/1679-0359.2022v43n3p961

CONAB_Companhia Nacional de Abastecimento. **Boletim da safra de café: 4º Levantamento de Café – Safra 2022**. Disponível em: <http://www.conab.gov.br/info-agro/safras/cafe/boletim-da-safra-de-cafe>. Acesso em: 15 mar. 2023.

CONAB_Companhia Nacional de Abastecimento. **Acompanhamento da safra brasileira - café, safra 2023**. Disponível em: https://www.conab.gov.br. Acesso em: 05 mai. 2024.

EMBRAPA_Empresa Brasileira de Pesquisa Agropecuária. (2014). **Genoma completo do café canephora é sequenciado pela primeira vez no mundo**. Disponível em: https://www.embrapa.br/en/busca-de-noticias/-/noticia/2364670/genoma-completo-do-cafe-canephora-e-sequenciado-pela-primeira-vez-no-mundo. Acesso em: 15 mar. 2023.

FERRÃO, M. A. G.; MENDONÇA, E. F.; SENRA, F. B.; VOLPI, P. S.; VERDIN, A. C.; COMÉRIO, M. Origin, geographical dispersion, taxonomy and genetic diversity of *Coffea canephora*. In: FERRÃO, R. G. et al. (ed.). **Conilon coffee**. 3rd ed. upd. and exp. Vitória: INCAPER, 2019. cap.4, p.85-109.

FERRÃO, R. G.; FERRÃO, M. A. G.; VOLPI, P. S.; FONSECA, A. F. A.; VERDIN FILHO, A. C.; COMÉRIO, M. Cafés Conilon e Robusta: potencialidades e desafios. **Informe Agropecuário**, v. 41, n. 309, p. 17-25, 2020.

FERREIRA, D. F. SISVAR: a computer analysis system to fixed effects split plot type designs. **Revista Brasileira de Biometria**, v. 37, n. 4, p. 529-535, 2019. https://doi.org/10.28951/rbb.v37i4.450

IANOVALI, D.; ADAMS, C.; RIBEIRO FILHO, A. A.; KHATOUNIAN, C. A. Produtividade agrícola e mudanças socioculturais: a agricultura quilombola no Vale do Ribeira-SP Brasil. **Desenvolvimento e Meio Ambiente**, v. 49, p. 221-238, 2018. https://doi.org/10.5380/dma.v49i0.54697

IBGE_Instituto Brasileiro de Geografia e Estatística. **Perfil dos Estados e dos Municípios Brasileiros – Censo 2016**. Disponível em: <http://www.ibge.gov.br/home/estatistica/economia/perfilmunic/2014/>. Acesso em: 10 ago. 2022.

ICO_International Coffee Organization. **Historical data on the global coffee trade**. Available on: https://www.ico.org. Acessed in: 10 Fev. 2024.

LORENZETTI, E. R.; POZZA, E. A.; SOUZA, P. E.; SANTOS, L. A.; ALVES, E.; SILVA, A. C.; MAIA, F. G. M.; CARVALHO, R. R. C. Effect of temperature and leaf wetness on *Phoma tarda* and phoma leaf spot in coffee seedlings. **Coffee Science**, v. 10, n. 1, p. 1-9, 2015.

MENDONÇA, R. F.; JESUS JUNIOR, W. C.; FERRÃO, M. A. G.; MORAES, W. B.; BUSATO, L. M.; FERRÃO, R. G.; TOMAZ, M. A.; FONSECA, A. F. A. Genótipos de café conilon e sua reação à ferrugem alaranjada. **Summa Phytopathology**, v. 45, n. 3, p. 279-284, 2019. https://doi.org/10.1590/0100-5405/183017

MORAES, D. R.; HOMECHIN, M.; BUENO, J. T.; BECKER, C. A. V. Avaliação de fungicidas para controle simultâneo da ferrugem (*Hemileia vastatrix*) e da cercosporiose (*Cercospora coffeicola*) do cafeeiro. **Summa Phytopathologica**, v. 24, p. 168-171, 1998.

OVALLE-RIVERA, O.; LÄDERACH, P.; BUNN, C.; OBERSTEINER, M.; SCHROTH, G. Projected shifts in *Coffea arabica* suitability among major global producing regions due to climate change. **PlosOne**, v. 10, n. 4, e0124155, 2015. https://doi.org/10.1017/S0007485307005202

PAGOTO, A. L. R.; OLIVEIRA, V. S. Initial development of clonal seedlings of *Coffea canephora* submitted to different irrigation depth. **International Journal of Plant & Soil Science**, v. 28, n. 3, p. 1-7, 2019. https://doi.org/10.9734/ijpss/2019/v28i330108

PARRA, J. Biologia comparada de *Perileucoptera coffeella* (Guérin-Meneville, 1842) (Lepidoptera - Lyonetiidae) visando ao seu zoneamento ecológico no Estado de São Paulo. **Revista Brasileira de Entomologia**, v. 29, n. 1, p. 45-76, 1985.

PEREIRA, E. J. G.; PICANÇO, M. C.; BACCI, L.; CRESPO, A. L. B.; GUEDES, R. N. C. Seasonal mortality factors of the coffee leaf miner, Leucoptera coffeella. **Bulletin of Entomological Research**, v. 97, n. 1, p. 421-432, 2007. https://doi.org/10.1017/S0007485307005202

RAIJ, B.; CANTARELLA, H.; QUAGGIO, J. A.; FURLANI, A. M. C. **Boletim 100: Recomendações de adubação e calagem para o Estado de São Paulo**. Campinas: Editora Instituto Agronômico de Campinas, 1997. 285p.

RESENDE, L. S.; POZZA, E. A.; LUZ, A. L. F.; SOUZA, P. E.; VILELA, M. S.; CASTANHEIRA, D. T.; GUIMARÃES, R. J. Brown eye spot incidence during the vegetative stage of coffee grown in soil under sustainable management. **Pesquisa Agropecuária Brasileira**, v. 57, n. 1, p. 1-11, 2022. https://doi.org/10.1590/S1678-3921.pab2022.v57.02477

ROSSI, M. **Mapa pedológico do Estado de São Paulo: revisado e ampliado**. 1 ed. São Paulo: Instituto Florestal, 2017. 118p.

SCALON, J. D.; MATEUS, A. L. S. S.; ZACARIAS, M. S. Análise espaço-temporal do nível de infestação do bicho-mineiro *Leucoptera coffeella* (Guérin Menèville & Perrottet.

1842) (Lepidoptera: Lyonetiidae) em cafezal orgânico (*Coffea arabica* L.). **Coffee Science**, v. 8, n. 3, p. 347-353, 2013.

SILVEIRA, H. M.; SENNA, D. S.; ARAÚJO, J. B. S.; SILVA, M. W.; TURBAY, E. R. M. G.. Análise econômica de consórcios do cafeeiro conilon com espécies perenes e florestais no sul do Espírito Santo. **Revista Brasileira de Agroecologia**, v. 15, n. 5, p. 222-235, 2020. https://doi.org/10.33240/rba.v15i5.23125

TAVARES, P. da S.; GIAROLLA, A.; CHOU, S. C.; SILVA, A. J. de P.; LYRA, A. de A. Climate change impact on the potential yield of Arabica coffee in southeast Brazil. **Regional Environmental Change**, v. 18, n. 3, p. 873-883, 2018. https://doi.org/10.1007/s10113-017-1236-z

TERAMOTO, E. T.; SILVA, D. C. C.; SANTOS, C. M.; MACHADO, L. P.; ESCOBEDO, J. F. Estimativa da radiação global diária a partir de variáveis meteorológicas comuns em ambiente subtropical úmido. **Nativa**, v. 7, n. 6, p. 693-701, 2019. http://dx.doi.org/10.31413/nativa.v7i6.7948

Acknowledgments: The authors would like to express their gratitude to the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for funding under grants [FAPESP grant numbers 2020/14029-4 and 2022/16545-5].

Authors' contribution: M.S.B.O. - investigation or data collection, statistical analysis, and writing (original draft); A.M.C. - conceptualization; funding acquisition; methodology, investigation or data collection, statistical analysis, administration or supervision, validation, writing (original draft); L.J.G.G. - methodology and writing (original draft). S.F. - writing (original draft); G.N.G. - investigation or data collection; E.T.T. - methodology, investigation or data collection, statistical analysis, validation, writing (original draft), and writing (review and editing). All authors read and agreed to the published version of the manuscript.

Review by institutional committee: Not applicable.

Ethics committee: Not applicable.

Data availability: The data of this research can be obtained by request from the corresponding author via e-mail.

Conflict of Interest: The authors declare no conflict of interest. Supporting entities had no role in the study's design; in the collection, analysis, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.