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Initial vegetative and reproductive development of coffee cultivars in Vale do Ribeira Paulista

Desenvolvimento vegetativo e reprodutivo inicial de cultivares de café no Vale do Ribeira Paulista

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Highlights

It is possible to grow arabica coffee in the Vale do Ribeira Paulista.
Low incidence of pests and diseases in the arabica coffee grown in humid climates.
Coffee growing as alternative for socio-economic development of Vale do Ribeira.

Abstract

This research is related to the performance evaluation of twelve *Coffea arabica* cultivars in Vale do Ribeira Paulista, in order to generate consistent information for the technical recommendation for cultivation in the region. The experiment was set in February 2018, at the Experimental Campus of the São Paulo State University "Júlio de Mesquita Filho" - UNESP in Registro, SP, Brazil, in a spacing of 3.00 x 0.60 m, in a randomized block design with three replications. The following parameters were evaluated: stem diameter, number of plagiotropic branches, plant height, number of internodes of plagiotropic branches, length of the first plagiotropic branch, incidence of brown spots and phoma leaf spot, infestation by leaf miner and yield. The results showed a good adaptation of all cultivars to growing conditions in Vale do Ribeira Paulista, with higher and faster vegetative development of large coffee cultivars. The productive potential of cultivars in the first harvest was similar to the performance of the same cultivars in traditional growing regions, with emphasis on 'Arara' and 'Catucaí Amarelo 24/137', with about 55 bags ha^{-1} of processed coffee. There was no incidence of rust disease in the experimental evaluation period, unlike other biotic agents such as leaf miner, phoma-spot and brown eye spot.

Key words: Adaptability. *Coffea arabica.* Regional development. Yield.

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Resumo

Nossa pesquisa se relaciona à avaliação do desempenho de doze cultivares de *Coffea arabica* no Vale do Ribeira Paulista, gerando informações consistentes para a recomendação técnica de cultivo na região. O experimento foi instalado em fevereiro de 2018, no Câmpus Experimental da Universidade Estadual Paulista "Júlio de Mesquita Filho", em Registro, SP, Brasil, em espaçamento de 3,00 x 0,60m, delineamento experimental de blocos casualizados, três repetições e parcelas de oito plantas, sendo considerada como parcela útil apenas as seis plantas centrais. Foram avaliados o diâmetro de caule, o número de ramos plagiotrópicos, a altura das plantas, o número de internódios dos ramos plagiotrópico, o comprimento do primeiro ramo plagiotrópico, a incidência de cercosporiose e mancha-de-phoma em folhas dos cafeeiros, a infestação por bicho-mineiro e, estimada a produtividade das cultivares. Nossos resultados evidenciaram uma boa adaptação de todas as cultivares às condições de cultivo no Vale do Ribeira Paulista, com maior e mais rápido desenvolvimento vegetativo das cultivares de porte alto. O potencial produtivo das cultivares na primeira colheita revelou-se semelhante ao desempenho das mesmas cultivares em regiões tradicionais de cultivo, com destaque para as cultivares Arara e Catucaí Amarelo 24/137, com cerca de 55 sacas.ha^{-1} de café beneficiado. Não houve incidência de ferrugem no período de avaliação experimental, ao contrário de outros agentes bióticos como, bicho-mineiro, mancha-de-phoma e cercosporiose.
Palavras-chave: Adaptabilidade. *Coffea arabica.* Desenvolvimento regional. Produtividade.

Introduction

The economy of Vale do Ribeira Paulista is based on agricultural and fishing activities. Although most rural producers in the region practice subsistence agriculture, the activity has great potential for expansion due to the current availability of modern technologies for agricultural exploitation and the proximity to large consumer centers, such as the capitals of the states of São Paulo and Paraná. The cultivation of bananas, table tomatoes and tangerines, as well as the creation of cattle herds, represent 98% of the regional agricultural activity. Studies related to the suitability of Vale do Ribeira Paulista for coffee cultivation began in Pariquera-Açu, in the early 70s, with the evaluation, by the Instituto Agronômico de Campinas, of coffee progenies from the species *Coffea canephora* and *Coffea arabica.* Although the results of the experiment with *C. canephora* have not been published (Fazuoli, personal communication), as a function of the very low fruit production, some *C. arabica* progenies presented quite reasonable yield, being considered promising for cultivation in the region (Fazuoli, Braghini, Guerreiro, & Saes, 2015; Silva, Carvalho, Bruzi, Guimarães, & Simões, 2016).

Even though it is not a traditional crop in the region, farmers have been looking for an alternative source of income in coffee cultivation, with the adoption of management practices without any technological reference and with an option for cultivars, made on a subjective basis, since adaptability and the stability of the current 135 Brazilian registered arabica coffee cultivars were evaluated only in the main producing regions of the country (A. M. Carvalho et al., 2016).

However, the recommendation of cultivars for Vale do Ribeira Paulista depends on the knowledge of the interaction among genotypes, represented by the cultivars, and this specific cultivation environment (Andrade et al., 2013).

Therefore, this research is related to the performance evaluation of twelve *Coffea arabica* cultivars in Vale do Ribeira Paulista, in order to generate consistent information for the technical recommendation for cultivation in the region.

Material and Methods

The experiment was set in early February 2018, at the Experimental Campus of the São Paulo State University "Júlio de Mesquita Filho" – UNESP, located in the municipality of Registro, SP, Brazil (24°32'10.1"S; 47°51'55.5"W). Twelve *C. arabica* cultivars were evaluated: Siriema VC 4, resistant to the leaf miner; *Leucoptera coffeella,* Guérin-Méneville and rust, *Hemileia vastatrix,* Berkeley & Broome; Obatã IAC 1669-20, Obatã IAC 4739, IAC 125 RN, Paraíso MG H 419-1, Catucaí Amarelo 2SL, Catucaí Amarelo 24/137 and Arara, resistant to rust disease, *H. vastatrix;* and Catuaí Vermelho IAC 99, Catuaí Amarelo IAC 62, Mundo Novo IAC 379-19 and Acaiá IAC 374-19, susceptible to both pathogens. The trial was carried out with and without chemical control to the respective biotic agents.

The experimental design was in randomized blocks, with three replications and plots of eight plants; the six central plants were considered useful. The sixteen treatments were planted in a spacing of 3.0 m between rows x 0.60 m between plants. Rust control in experimental plots of cultivars susceptible to the pathogen was carried out through three applications, in October 2019, February 2020 and July 2020, with fungicide, using Ciproconazole as an active ingredient (80 g L^{-1}), at a dose of 750 mL of commercial product per hectare, considering a flow of 400 liters of nozzle per hectare. The leaf miner was controlled with insecticide applications with the active ingredient chlorantraniliprole (350 g kg^{-1}), at a dose of 90 g of commercial product per hectare, considering a flow rate of 400 liters of nozzle per hectare. Other management practices such as weed control, foliar and soil fertilization, as well as sprouting of orthotropic branches, were used in the crop as needed and technically recommended.

The variables plant height (PH), stem diameter (SD), number of plagiotropic branches (NPB), number of internodes of plagiotropic branches (NIPB) and length of the first plagiotropic branch (LFPB) were measured in July and November 2018 and February and April 2019. Data were subjected to statistical analysis with the aid of the R software (R Development Core Team [R], 2010).

The average yield, expressed in bags ha^{-1}, was obtained by converting coffee harvested on the farm, between May and July 2020, i.e. two years after planting, 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 which, after drying until reaching 11% moisture (b.u.), were processed.

The incidence of brown eye spot, *Cercospora coffeicola* Berk. & Cooke, in the leaves was evaluated monthly between August 2019 and July 2020. The incidence of phoma leaf spot was evaluated monthly between January and July 2020, through the percentage of leaves with symptoms in non-destructive samples of one hundred leaves per plant. The population fluctuation of leaf miner was evaluated between August 2019 and July 2020.

The growth increments of the variables PH, SD, NPB, NIPB and LFPB were calculated from the difference between the first and the last evaluation, carried out respectively in July 2018 and April 2019, and the values obtained were used in the calculation of Pearson correlation coefficients with the aid of the Selegen-REML/BLUP software (Resende, 2007).

Results and Discussion

Plant growth can be defined as net carbon accumulation and other organic components in plants, and carbon gain is determined by local availability of light, water and nutrients (Barbieri, Rossielo, Silva, Ribeiro, & Morenz, 2012). Studies on growth analysis of plant species make it possible to monitor plant development as a whole, as well as the contribution of the different organs in total growth, allowing to know their functioning and structure.

The values related to the initial vegetative development of Arabica coffee cultivars in Vale do Ribeira Paulista, presented in Table 1, revealed significant differences between average SD, PH, LFPB, NPB, NIPB and the estimated yield of the cultivars evaluated.

SD varied between 32.76 cm, in cultivar Mundo Novo IAC 379-19, and 23.00 cm, in Cultivar Acaiá IAC 474-19, without significant differences between all large or small cultivars, susceptible or resistant to rust. ‘Siriema VC 4’, in turn, presented SD equal to 16.60 cm, differing from all other treatments.

Cultivar Siriema VC 4 also presented the lowest mean value for NPB (16.2), differing statistically from the other treatments that formed a relatively homogeneous group, with means ranging from 21.2 to 37.07 plagiotropic branches per plant. The performance of the cultivars evaluated through LFPB follows a similar pattern, and cultivars Siriema VC 4 and Acaiá IAC 479-19 were those with lower values (35.33 cm and 36.27 cm, respectively), statistically different from the group consisting of the other treatments, whose means varied between 42.73 cm and 60.50 cm. It should be observed that LFPB corresponds to the radius of a circumference equivalent to the plant crown projection diameter and has direct implication in the definition of suitable spacing for crop deployment.

A greater response diversity was verified in relation to the NIPB, and smaller means were also observed in cultivars Siriema VC 4 (231.00) and Acaiá IAC 479-19 (197.33), while ‘IAC 125 RN’, ‘Catucaí Amarelo 24/137’ and ‘Catuaí Amarelo IAC 62’ presented higher NIPB, with 624.33, 564.93 and 535.73 internodes, respectively. The NIPB refers to the average measurement of internodes of plagiotropic branches of the primary nature of a plant, fourteen months after planting. This variable is a good indicator of the available quantity of productive buds, considered one of the main yield components (A. M. Carvalho et al., 2017).

Table 1

Mean values and standard deviation of variables stem diameter (SD), plant height (PH), length of the first plagiotropic branch (LFPB), number of plagiotropic branches (NPB), number of internodes of plagiotropic branches (NIPB) and estimated yield of Arabica coffee cultivars, in Registro, SP

Cultivars[1]	SD[2]	NPB[2]	NIPB[2]	PH[2]	LFPB[2]	Yield[3]
	cm	n°	n°	cm	cm	bag ha^{-1}
Large, susceptible to rust and leaf miner						
Mundo Novo IAC 379-19**	32.76$^{\pm5.17}$a	33.60$^{\pm0.69}$a	494.80$^{\pm82,69}$b	134.97$^{\pm8,31}$a	59.23$^{\pm9,37}$a	34.93b
Mundo Novo IAC 379-19***	28.31$^{\pm4.18}$a	28.53$^{\pm6.82}$a	318.60$^{\pm97,57}$c	119.07$^{\pm27,74}$a	52.33$^{\pm14,16}$a	18.83d
Acaiá IAC 474-19**	23.00$^{\pm9.99}$a	21.20$^{\pm9.73}$b	197.33$^{\pm107,78}$d	87.17$^{\pm34,40}$b	36.27$^{\pm18,94}$b	21.27c
Acaiá IAC 474-19***	26.15$^{\pm7.68}$a	28.53$^{\pm4.97}$a	409.73$^{\pm103,16}$c	110.83$^{\pm16,18}$a	53.27$^{\pm10,46}$a	11.60d
Small, susceptible to rust and leaf miner						
Catuaí Vermelho IAC 99**	27.21$^{\pm1.99}$a	30.67$^{\pm1.97}$a	478.93$^{\pm62.59}$b	111.93$^{\pm40.11}$a	48.90$^{\pm1.65}$a	28.57c
Catuaí Vermelho IAC 99***	28.10$^{\pm1.52}$a	32.93$^{\pm1.80}$a	472.40$^{\pm19.55}$b	97.07$^{\pm2.61}$a	46.20$^{\pm7.56}$a	27.50c
Catuaí Amarelo IAC 62**	29.13$^{\pm0.86}$a	33.87$^{\pm0.46}$a	388.67$^{\pm40.51}$c	101.63$^{\pm9.00}$a	50.70$^{\pm4.68}$a	36.17b
Catuaí Amarelo IAC 62***	27.98$^{\pm0.69}$a	37.07$^{\pm2.20}$a	535.73$^{\pm39.11}$a	106.43$^{\pm2.93}$a	53.07$^{\pm6.00}$a	29.43c
Small, rust resistant						
Obatã IAC 1669-20*	27.33$^{\pm3.74}$a	28.13$^{\pm0.92}$a	320.40$^{\pm59.75}$c	81.73$^{\pm8.11}$b	45.63$^{\pm2.94}$a	27.60c
Obatã IAC 4739*	27.57$^{\pm2.05}$a	28.67$^{\pm1.62}$a	342.93$^{\pm52.27}$c	80.53$^{\pm6.53}$b	42.73$^{\pm8.10}$a	41.03a
IAC 125 RN*	29.55$^{\pm1.60}$a	30.93$^{\pm2.60}$a	624.33$^{\pm25.66}$a	85.70$^{\pm9.69}$b	44.70$^{\pm1.30}$a	36.43b
Catucaí Amarelo 2SL*	25.73$^{\pm0.76}$a	29.87$^{\pm3.84}$a	435.33$^{\pm95.99}$b	98.50$^{\pm2.08}$a	51.07$^{\pm2.41}$a	34.73b
Catucaí Amarelo 24/137*	31.99$^{\pm1.73}$a	34.13$^{\pm3.95}$a	564.93$^{\pm88.51}$a	113.60$^{\pm0.72}$a	59.63$^{\pm1.60}$a	40.00a
Paraíso MG H419-1*	23.89$^{\pm4.96}$a	26.40$^{\pm2.12}$a	442.13$^{\pm33.40}$b	79.87$^{\pm3.07}$b	46.17$^{\pm6.80}$a	15.00d
Arara	28.14$^{\pm0.47}$a	29.47$^{\pm3.26}$a	389.93$^{\pm63.73}$c	89.87$^{\pm13.32}$b	60.50$^{\pm7.46}$a	48.53a
Small, resistant to rust and leaf miner						
Siriema VC 4***	16.60$^{\pm6.38}$b	16.20$^{\pm9.62}$b	231.00$^{\pm133.25}$d	54.00$^{\pm22.43}$c	35.33$^{\pm19.82}$b	17.30 d
CV (%)	13.10	14.33	22.86	13.87	16.08	13.18

[1]Means of cultivars followed by the same letter do not differ by the Scott-Knott test, at 5% probability. [2]Mean values measured 14 months after planting; [3]Values estimated from fruit production in 2020. *with leaf miner control; **with rust and leaf miner control; ***without chemical control.

The lowest vegetative growth of 'Siriema VC 4', evidenced by the variables SD, NPB, NIPB and LFPB, can be in part explained by the type of seedling used for setting the experiment since, unlike the other cultivars, all of a seminal nature, Siriema VC 4 is a clonal cultivar propagated by somatic embryogenesis (Maciel, Rodrigues, Pasqual, & Carvalho, 2016), which has the cylindrical format of the crown with shorter side branches as a vegetative characteristic, as shown in Table 1.

Comparing the evolution of plant growth in the field, Almeida, Silvarolla, Fazuoli and Stancato (2008) concluded that the vegetative development of seedlings spread by somatic embryogenesis is greater than that of seedlings of seminal origin, in the first seven months after planting. This performance certainly occurs as a function of which cloned laboratory seedlings are taken to the field, only two years after the start of *in vitro* cultivation, with more mature ontogenetic development compared to traditional seedlings. Unlike seminal seedlings, clones are older seedlings produced throughout the year, and are not always in the ideal conditions for planting, performed predominantly at the end of the year, with a higher incidence of rainfall. This can help explain the slower vegetative development when compared to seminal cultivars, in the experimental conditions of Vale do Ribeira Paulista.

The growth in height, evaluated fourteen months after planting, through the distance between the collar and the apex of the plants, showed the existence of three groups, the first represented by cultivars Mundo Novo IAC 379-19, Acaiá IAC 474-19, Catuaí Vermelho IAC 99, Catuaí Amarelo IAC 62, Catucaí Amarelo 24/137 and Catucaí Amarelo 2SL, with means ranging from 97.07 cm to 134.97 cm; The second, by cultivar Siriema VC 4, with a mean of 54.0 cm and an intermediate group, consisting of the other cultivars with height ranging from 79.87 cm and 89.87 cm.

The size of Arabica coffee is determined by the expression of a single dominant, called *caturra* (Ct) (Carvalho, Mônaco, Fazuoli, Costa & Medina, 1984). Large plants such as those of cultivars Mundo Novo IAC 379-19 and Acaiá 479-19 are homozygous for the recessive allele (*ctct*); while small coffee trees, such as those of the other cultivars, have the Ct genotype. However, plant height growth also has a polygenic component strongly influenced by the cultivation environment, a phenomenon easily noticed in the experimental conditions since, despite the difference in size between the evaluated cultivars, it is observed that the average height values of some small cultivars such as 'Catuaí' and 'Catucaí' were statistically similar to the averages of some large cultivars.

Plant growth in height and the increase in the diameter of their crowns show a very rapid development of Arabica coffee in this region of humid subtropical climate with hot summer, classified as Cfa by the Köppen-Geiger criterion and characterized by permanent high temperatures and humidity, as seen in the water balance for the evaluation period of plants in the field (Figure 1); these conditions are added to other important characteristics of the region, such as low altitude – 25 m – and soils classified as argisols.

Despite the difference in size between the cultivars evaluated, it is observed that the mean values of PH for some small cultivars were statistically similar to the means of some large cultivars. However, it is important to emphasize that the mean values of PH and LFPB show a very fast plant growth in this region, characterized by permanent high temperatures and humidity. Thus, it can be concluded, even with these initial results, that large cultivars should be neglected in relation to those with a more compact architecture or, if cultivated, they should certainly be submitted to a more intense pruning regime.

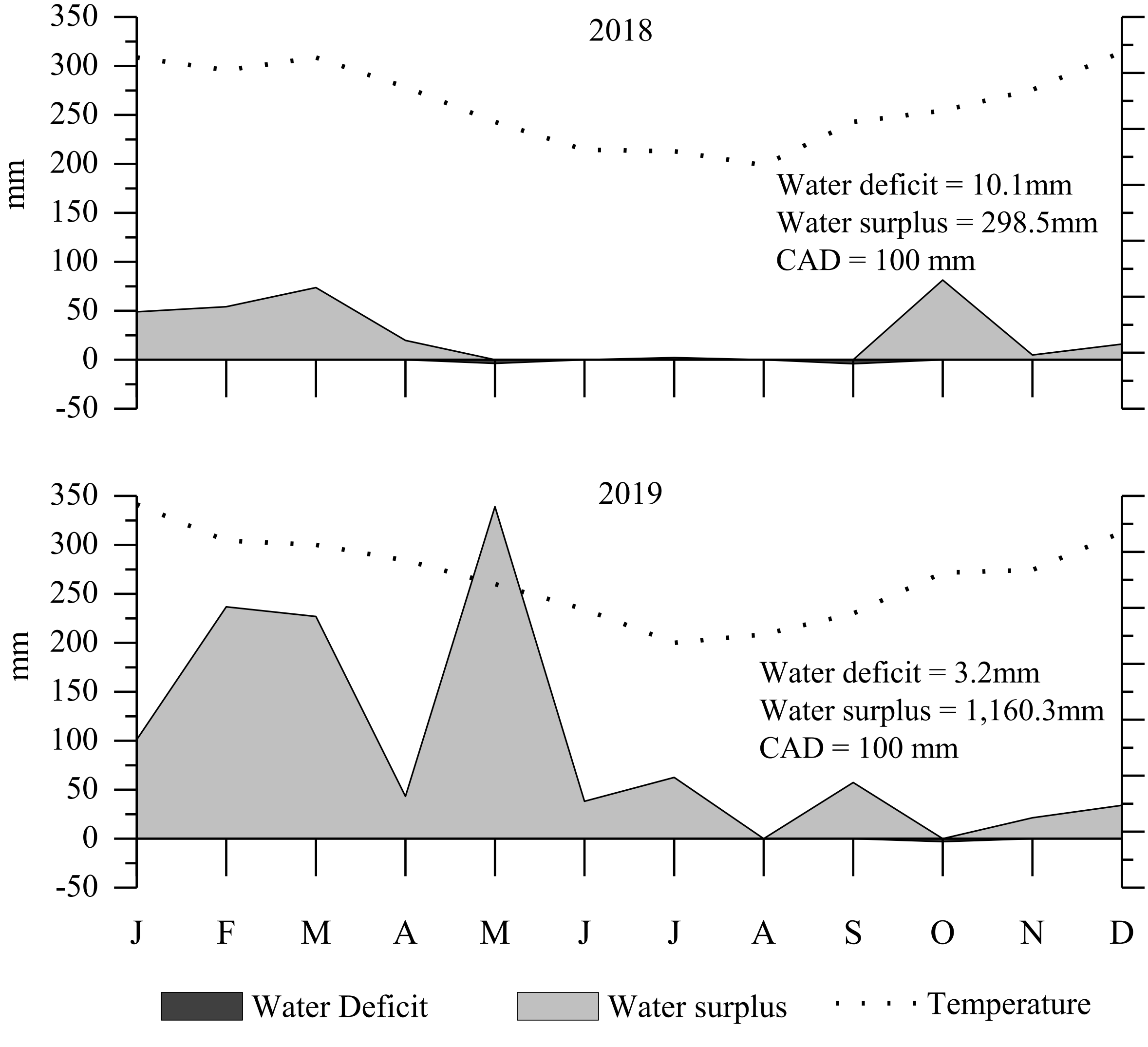

Figure 1. Analysis of the water balance in Registro, SP, from January 2018 to May 2019.

The yield of cultivars estimated in bags of processed coffee per hectare was quite variable, and cultivars Arara, Obatã 4739 and Catucaí Amarelo 24/137 were the most productive, in an average of two years, with 48.53, 41.03 and 40.0 bags ha^{-1}, respectively. 'Catuaí Amarelo IAC 62', Mundo Novo IAC 379/19, IAC 125 RN and Catucaí Amarelo 2SL with respectively 36.17, 34.93, 36.63 and 34.73 bags ha^{-1}, are situated in a second group and four other cultivars form a group with average yield that varies between 21.27 and 29.43 bags ha^{-1}. The less productive cultivars were Acaiá IAC 479-19, Siriema VC 4 and Paraíso MG H419-1.

Although the combination of harvests in biennium should improve experimental precision, as it reduces the effects of biennial production (Figueiredo et al., 2013) and plant production should be evaluated in at least four consecutive harvests, due to the perennial nature of the crop. species and the stability achieved in the fourth harvest (Figueiredo et al., 2013), the initial yield of the first harvest in Vale do Ribeira Paulista is similar to what is observed in traditional Brazilian regions and reveals the potential for cultivation of Arabica coffee in the region.

The calculation of Pearson correlation coefficient is a widely used strategy in plant breeding, since the association between variables can allow early identification and selection of plants. The results calculated for the mean increment values of the variables SD, NPB, NIPB, PH and LFPB, presented in Table 2, ranged between 0.55 and 0.879 being, in their entirety, significant when compared by the t test at 5% probability. For the most part, the correlations can be considered of high magnitude, among them, SD/NPB (0.87), SD/NIPB (0.72), SD/LFPB (0.71), NPB/NIPB (0.89) and PH/LFPB (0.77). The correlation coefficients between the variables SD and NPB and the estimated yield of the cultivars were, respectively, 0.63 and 0.60, both significant at 5% probability. These values were not included in Table 2, since vegetative development was evaluated between July 2017 and April 2018, and the first fruit production was only obtained in mid-2020. Two phenotypic correlations that had the highest values are highlighted: SD/NPB (0.87) and NPB/NIPB (0.89).

Table 2
Correlation coefficients calculated between the mean increment values of the variables stem diameter (SD), number of plagiotropic branches (NPB), number of internodes of plagiotropic branches (NIPB), plant height (PH) and length of the first plagiotropic branch (LFPB), measured between July 2018 and April 2019, in Registro, SP

	SD	NPB	NIPB	PH	LFPB
SD		0.76*	0.72*	0.63*	0.71*
NPB			0.89*	0.55*	0.69*
NIPB				0.56*	0.65*
PH					0.77*

*Significant at 5% probability, by the t test.

Given these results, there is an indication that plants with a higher number of plagiotropic branches are associated with a higher number of internodes of plagiotropic branches, thus highlighting the productive potential of cultivars with higher values for these characteristics. Regarding stem diameter, this high correlation with the growth in the number of plagiotropic branches is probably related to the greater need for the sap transport system to support greater growth with a larger plant crown diameter.

The incidence of biotic agents of importance for the cultivation of Arabica coffee was evaluated from August 2019, eighteen months after planting. The results obtained during the evaluation period are shown in Figure 2.

Orange rust caused by the fungus *H. vastatrix* is the main coffee disease in terms of range and damage. Depending on the altitude, climatic conditions and nutritional status of the plant, rust can cause losses of up to 50% in production (A. M. Carvalho et al., 2017). For this reason, resistant cultivars susceptible to the fungus, such as Mundo Novo IAC 379-19, Acaiá IAC 474-19, Catuaí Vermelho IAC 99 and Catuaí Amarelo IAC 62, were included in the experimental design, in plots with and without chemical control. The chemical control of the disease started in October 2019, and cannot be considered responsible for the absence of symptoms, since there was no incidence of the disease, even in the experimental plots of susceptible cultivars not subjected to chemical control.

On the other hand, the incidence of the leaf miner was observed in a generalized way, but at relatively low levels, being of greater magnitude in cultivars Catuaí IAC 99, Catuaí IAC 62, Mundo Novo IAC 379-19 and Acaiá IAC 474-19, all susceptible to rust. However, with the beginning of chemical control, in October 2019, the pest population level, assessed through the percentage of injured leaves, was greatly reduced, remaining this way until the end of the evaluations.

It is observed that pest incidence also decreased in the plots of susceptible cultivars not subjected to chemical control and this can be attributed to the population fluctuation of the pest which, in other producing regions in the states of Minas Gerais and São Paulo, are characterized by a higher incidence in September and October, followed by a decrease in subsequent months. The results of this study show the effectiveness of chemical pest control. However, longer-term studies must be continued to determine the real need for control since, unlike regions exposed to the intensive use of chemicals, the diversity of natural enemies in the region can act favorably in reducing pest population.

The results presented in Figure 2 show some variability among cultivars regarding the reaction to phoma-spot. In the period of highest incidence, the infection rate was close to 40% in ‘Catuaí Amarelo IAC 62’, followed by ‘Mundo Novo IAC 379-19’, ‘Catuaí Vermelho IAC 99’ and ‘Catucaí Amarelo 24/137’, with about 35% and by the cultivars of the germplasm Sarchimor IAC 125 RN, Obatã IAC 1669-20 and Arara, with approximately 25% of infected leaves. Very low infection levels were observed in ‘Obatã IAC 4739’, ‘Paraíso MG H419-1’ and ‘Siriema VC 4’.

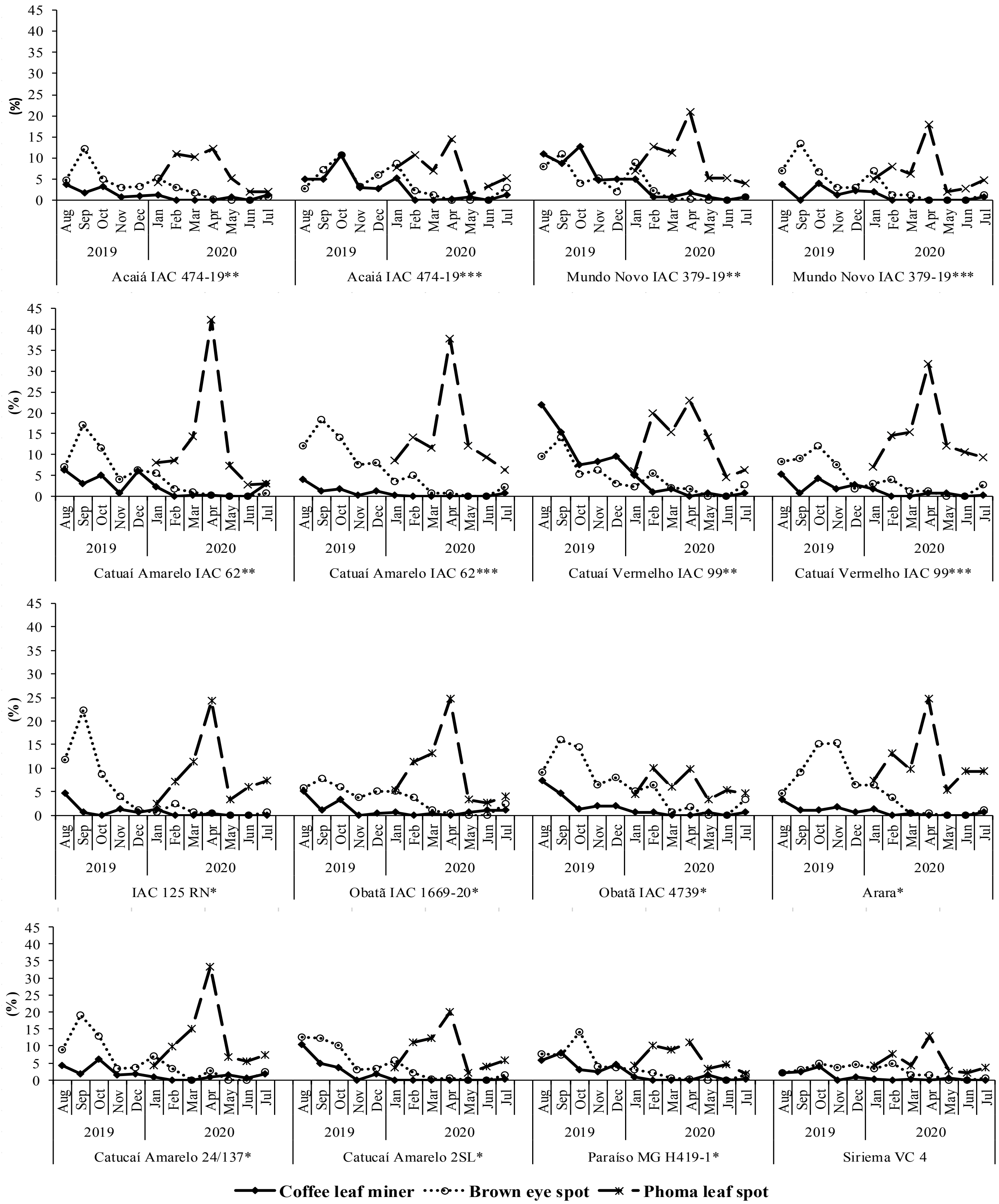

Figure 2. Incidence of leaf miner, phoma spot and brown eye spot evaluated between August 2019 and July 2020, in *Coffea arabica* cultivars, with chemical control of leaf miner (*), leaf miner and rust (**) and without chemical control (***), in Registro, SP.

The occurrence of brown eye spot on leaves of Arabica coffee cultivars manifested at levels higher than those related to the leaf miner, certainly favored by the high temperatures, relative humidity and light intensity, conditions that favor the development of the pathogen and its manifestation in susceptible hosts (A. M. Carvalho et al., 2012; Pereira et al., 2020). The results presented in Figure 2 show a greater presence of leaves with symptoms of the disease between September and November, with a higher incidence, in this period, in cultivars Catuaí Amarelo IAC 62, IAC 125 RN, Obatã IAC 4739, Arara and Catucaí Amarelo 24/137.

In summary, the results of this study show that the levels of yield, right in the first harvest, are similar to those observed in traditional producing regions, a fact indicative of the viability of cultivation in Ribeira Paulista. The edaphoclimatic conditions in the region favor the rapid vegetative development of plants, suggesting that small cultivars should be more suitable for cultivation.

Conclusions

All coffee cultivars had good adaptation to the growing conditions in Vale do Ribeira Paulista, with greater and faster vegetative development of large cultivars.

The productive potential of coffee cultivars in the first harvest was similar to the performance of the same cultivars in traditional growing regions, with emphasis on 'Arara' and 'Catucaí Amarelo' 24/137, with 48.53 and 40.00 bags ha^{-1} of processed coffee, respectivelly.

There was no rust disease incidence in the experimental evaluation period, unlike other biotic agents such as leaf miner, phoma spot and brown eye spot.

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References

Almeida, J. A. S., Silvarolla, M. B., Fazuoli, L. C., & Stancato, G. C. (2008). Embriogênese somática em genótipos de *Coffea arabica L. Coffee Science, 3*(2), 143-151. Recuperado de http://www.sbicafe.ufv.br:80/handle/123456789/5764

Andrade, V. T., Rezende, J. C., Botelho, C. E., Carvalho, G. R., Gonçalves, F. M. A., & Carvalho, A. M. (2013). Interação genótipo x ambiente em progênies de Mundo Novo por modelos não lineares e multiplicativos. *Bragantia, 72*(4), 1-8. doi: 10.1590/brag.2013.054. Recuperado de 10.1590/brag.2013.0 54

Barbieri, E., Jr., Rossielo, R. O. P., Silva, R. V. M. M., Ribeiro, R. C., & Morenz, M. F. F. (2012). Um novo clorofilômetro para estimar os teores de clorofila em folhas do capim Tifton 85. *Ciência Rural, 42*(12), 2242-2245. doi: 10.1590/S0103-84782012005000109

Carvalho, A. M., Cardoso, D. A., Carvalho, G. R., Carvalho, V. L., Pereira, A. A., Ferreira, A. D., & Carneiro, L. F. (2017). Comportamento de cultivares de cafeeiro sob a incidência das doenças da ferrugem e cercosporiose em dois ambientes de cultivo. *Coffee Science, 12*(1), 100-107. Recuperado de http://www.sbicafe.ufv.br:80/handle/123456789/8266

Carvalho, A. M., Mendes, A. N. G., Botelho, C. E., Oliveira, A. C. B., Rezende, J. C., & Rezende, R. M. (2012). Desempenho agronômico de cultivares de café resistentes à ferrugem no Estado de Minas Gerais, Brasil. *Bragantia, 71*(4), 481-487. doi: 10.1590/S0006-87052013005000007

Carvalho, A. M., Rezende, J. C., Rezende, T. T., Ferreira, A. D., Rezende, R. M., Mendes, A. N. G., & Carvalho, G. R. (2016). Relationship between the sensory attributes and the quality of coffee in different environments. *African Journal of Agricultural Research, 11*(38), 3607-3614. doi: 10.5897/AJAR 2016.11545

Carvalho, A., Mônaco, L. C., Fazuoli, L. C., Costa, W. M., & Medina, H. P, F°. (1984). Hereditariedade do porte reduzido do cultivar Caturra. *Bragantia, 43*(2), 443-458. doi: 10.1590/S0006-870519 84000200015

Fazuoli, L. C., Braghini, M. T., Guerreiro, O., F°, & Saes, L. A. (2015). Avaliação de progênies de Icatu e das cultivares Catuaí Vermelho, Catuaí Amarelo e Obatã IAC 1669-20 de *Coffea arabica* no Vale do Ribeira, SP. *Anais do Congresso Brasileiro de Pesquisas Cafeeiras,* Poços de Caldas, MG, Brasil.

Figueiredo, L. P., Borém, F. M., Cirillo, M. A., Ribeiro, F. C., Giomo, G. S., & Salva, T. J. G. (2013). The potential for high quality bourbon coffees from different environments. *Journal of Agricultural Science, 5*(10), 87-98. doi: 10.5539/jas.v5n10p87

Maciel, A. L. R., Rodrigues, F. A., Pasqual, M., & Carvalho, C. H. S. (2016). Acclimatization of coffee (Coffea racemosa x Coffea arabica) somaclones obtained from temporary immersion bioreactor system (RITA®). *Australian Journal of Crop Science, 10*(2), 169-175, 2016. Recuperado de https://search.informit.org/ doi/10.3316/informit.030798745715401

Pereira, D. R., Nadaleti, D. H. S., Rodrigues, E. C., Silva, A. D., Malta, M. R., Carvalho, G. R., & Carvalho, S. P. (2020). Genetic and chemical control of coffee rust (*Hemileia vastatrix* berk et br.): impacts on coffee (Coffea arabica l.) quality. *Journal of the Science of Food and Agriculture, 100*(7), 1-10. doi: 10.1002/jsfa.10914

R Development Core Team (2010). *R: a language and environment for statistical computing.* Vienna: R Foundation for Statistical Computing.

Resende, M. D. V. (2007). *O software Selegen Reml/Blup.* Campo Grande: EMBRAPA Informação Tecnológica.

Silva, J. A., Carvalho, S. P., Bruzi, A. T., Guimarães, R. J., & Simões, L. C. (2016). Genetic diversity among coffee tree progenies Big Coffee VL based on growth traits and production. *Genetics and Molecular Research, 15*(4), 1-8. doi: 10.4238/gmr15049066