Journal of Agricultural Science; Vol. 12, No. 2; 2020
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Growth and Productivity of Irrigated Coffee Trees (*Coffea arabica*) in Ceres-Goiás

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Received: July 3, 2019 Accepted: December 17, 2019 Online Published: January 15, 2020

doi:10.5539/jas.v12n2p138 URL: https://doi.org/10.5539/jas.v12n2p138

Abstract

The objective of this work was to evaluate the growth and productivity of cultivars and progenies of arabica coffee under irrigation by driping in Ceres-Goiás. It was conducted in the experimental area of the Goiano Federal Institute-Ceres Campus. A total of 35 treatments were randomized blocks with four replications, from January 2017 to August 2018. At 30 and 36 months after planting, the diameter of the orthotropic branch, canopy diameter, plant height, number of nodes in the plagiotropic branch 1, length of the plagiotropic branch 1, number of nodes in the plagiotropic branch 2, length of the plagiotropic branch 2, length of the plagiotropic branches 1 and 2, number of nodes of the plagiotropic branches 1 and 2 and productivity were evaluated in 2018. The linear simple correlations were estimated in all evaluated characteristics. There was a difference in growth and yield of the evaluated genotypes. There is a positive correlation among the vegetative characters and the productivity. Catucaí Amarelo 2SL presented higher growth than the other evaluated genotypes. The genotypes Catiguá MG 1, Acauã Novo, Acauã 2 and 8, Catucaí Amarelo 24/137, Catucaí Amarelo 2SL, Asa Branca, Paraíso H419-10-6-2-10-1, Catuaí Vermelho IAC 15, Acauã, Sarchimor MG 8840, IPR 98, Araponga MG 1 and Obatã Vermelho IAC 1669-20 were the ones that had the highest productivity.

Keywords: production, genotypes, vegetative characters, irrigation

1. Introduction

The coffee tree originates in Africa, from regions where there is an extensive period of drought. This fact led several species of this plant genus to develop an adaptation to different edaphoclimatic conditions (Aerts et al., 2017; Herrera & Lambot, 2017). Due to its high demand and economic relevance, it is therefore necessary to find genetic material that adapts to different regions and presents higher productivity.

The custom of drinking coffee was given by the Arabs (Aerts et al., 2017). Currently, it is considered the most consumed beverage in the world, Brazil being the second largest consumer, losing only to the United States (CECAFÉ, 2018). Its importance in the world agricultural scenario is due not only to the economic bias, but also to political and socio-cultural aspects (Aerts et al., 2017).

In 2018, there was a record in coffee exports, but this growth was already accelerating since 2012 (ICO, 2018a). In Brazilian agribusiness, production in the 2017-2018 crop year was 51 million bags of coffee and this represents 31.9% of world production, followed by Vietnam, 18.5% and Colombia, 8.8% (ICO, 2018b).

Commercial coffee began to be produced also in the Cerrado and its expansion occurred because production can be favored by aspects such as topography and temperature, combined with irrigation, fertilization and production technologies (Krohling et al., 2017). Goiás is in the eighth position in the national ranking, where 195.4 thousand sacks, exclusively of the Arabica type, were produced that year under irrigation regime (CONAB, 2018).

The increase in night minimum temperatures has been a factor that has affected the production of coffee, in the last harvests, in several places like Tanzania, Colombia, India and Southeast Africa (Krohling et al., 2017). Producers of coffee from around the world are looking for solutions to optimize production, lower costs, and worry about sustainability, through partnerships between scientists and cooperatives, both governmental and nongovernmental, focusing on training and search for new research and modern production techniques (Lambot et al., 2017).

Comparing the vegetative characteristics with productivity is an important method to study the adaptation of genotypes, observing their performance in a certain region (Rodrigues et al., 2012). The main criterion of selection in coffee is productivity and, for the recommendation of cultivars, it is essential to observe the interaction of the genotype with the environment (Krohling et al., 2017). Genetic variability is a determinant of the differences between coffees (Kitzberger et al., 2014). The genetic divergence among Arabic coffee cultivars can be decisive in the adaptation to the edaphoclimatic conditions of the environment, some being more resistant to pests, diseases, abiotic factors, water deficit, among others.

The evaluation of the cultivar architecture during its development cycle allows the selection of those that are more resistant and, at the same time, more productive. Productivity is one of the most important variables, especially when irrigation is used (Vicente et al., 2015). Studies on the architecture of the coffee tree have collaborated very effectively with the breeding programs, in the recommendation of new cultivars through the selection and validation of coffee progenies (Castanheira et al., 2016). The identification of cultivars with greater tolerance to different edaphoclimatic conditions becomes an essential factor for the growth of the national coffee industry. The objective of this study was to evaluate the growth and productivity of cultivars and progenies of arabica coffee with drip irrigation under Ceres - Goiás soil and climatic conditions.

2. Material and Methods

The experiment was implemented in April 2015, but this study was conducted from March 2017 to October 2018, at the Goiano Federal Institute-Campus Ceres, located in the mesoregion of the Centro Goiano, in the city of Ceres-GO. For the evaluations of this work, the data of the second production cycle, that is, of the 2017/2018 harvest, were considered. The municipality of Ceres is located in the Valley of São Patrício, has the geographical coordinates and edaphoclimatic conditions, respectively: South latitude 15°21′00.67″, West longitude: 49°35′56.98″, approximate altitude of 570 m.

The climate of the region, according to the classification of Köppen, is Aw type, warm and semi-humid with well defined season, from May to September, with average annual temperature of 27.7 °C, with minimum and maximum averages of 19.0 and 36.4 °C, respectively. The average annual rainfall is about 1,601 mm. The relief is gentle. The soil is characterized as Red Latosol (Santos et al., 2013).

For chemical characterization of the soil, samples were collected about two months before the experiment was installed. The chemical and physical properties of the soil in the experimental area are: 37.7% sand, 8.3% silt and 54.0% clay; pH (in water) = 5.80; M.O. = 20.30 g dm^{-3} (colorimetric); P = 12.8 mg dm^{-3}; K = 0.2 cmol dm^{-3}; Ca = 3.0 cmolc dm^{-3}; Mg = 1.80 cmolc dm^{-3}; H + Al = 2.70 cmolc dm^{-3} (SMP buffer at pH 7.5); and V = 65.7%. The methodology used for all soil analyzes followed the recommendations of Embrapa (2013) and were done at the Soil Laboratory of the Goiano IF-Ceres Campus.

The fertilization was done according to the recommendation of the 5th modified approach of the Soil Fertility Commission of the State of Minas Gerais (Guimarães et al., 1999) and based on the results of the soil analysis.

Nitrogen (ammonium sulphate) and potassium (potassium chloride) applications were carried out in 3 plots on 09/22/2017, 06/10/2017 and 10/20/2017. On the other hand, phosphate fertilization (single super phosphate) was carried out, in a single application, on 02/09/2017. 130 kg/ha of N, 150 kg/ha of P_2O_5 and 100 kg/ha of K_2O were applied.

Pest and disease control was done by means of constant monitoring, according to the need of the crop. In the interlining of the coffee plantation, Brachiaria (Urochloa decumbens) was planted with the purpose of favoring the chemical and physical-water attributes of the soil, optimizing its structure and increasing the water storage capacity (Rocha et al., 2016). The weeds were controlled along the planting line, brushing when necessary. Phytosanitary control was performed according to the need of the crop, in an equal manner, in all treatments.

The experiment was conducted in a randomized complete block design (DBC), with 35 genotypes (treatments) and four replicates. Each plot was composed of ten plants, whose spacing was 3.50 × 0.75 meters, constituting an area of 26.25 m^2 per plot, totaling an experimental area of 3,675 m^2 with 1,400 plants. As a useful part, eight central plants of the plot line were considered, totaling an area of 21 m^2.

Thirty-one cultivars (Oeiras MG 6851 (EPAMIG), Catiguá MG 1 (EPAMIG), Sacramento MG 1 (EPAMIG), Catiguá MG 2 (EPAMIG), Araponga MG 1 (EPAMIG), Paraiso MG 419-1), Pau Brazil MG 1 (EPAMIG), Catiguá MG 3 (EPAMIG), Topaz MG 1190 (EPAMIG), IPR 104 (IAPAR), Sarchimor MG 8840 (EPAMIG), Catucaí Vermelho 20/15 cova 476 (PROCAFÉ), Tupi IAC (IAC), IPR 98 (IAPAR), IPR 99 (IPA 99), IPA 99 (IAC), Obatã Vermelho IAC 1669-20 (IAC), Obatã Amarelo IAC 4932 (IAC), Catuaí Vermelho IAC 15 (IAC), Catuaí Amarelo IAC 062 (PROCAFÉ), Catucaí Amarelo 24/137 (PROCAFÉ), Catucaí Amarelo 20/15 cova 479 (PROCAFÉ), Catucaí Vermelho 785/15 (PROCAFÉ), Catucaí Amarelo 2SL (PROCAFÉ) (PROCAFÉ), Asca Branca (PROCAFÉ), IBC-Palma 2 (PROCAFÉ), Acauã (PROCAFÉ), Acauã Novo (PROCAFÉ), and four advanced progenies [23]. II (EPAMIG), H-419-3-3-7-16-4-1 (EPAMIG), Paradise H 419-10-6-2-12-1 (EPAMIG), Paradise H 419-10-6-2-10-1 (EPAMIG)], all of the Coffea arabica species. The choice of these genotypes occurred because they were low in size, more resistant to rust and to the miner.

The irrigation was of the drip-type type, consisting of simple 16 mm polyethylene lateral lines and self-compensating emitters, with a flow of 2.2 L h^{-1}, spaced 0.5 m apart. Irrigations were carried out in three irrigation shifts: Monday, Wednesday and Friday, according to ETc of the accumulated crop of the previous non-irrigated days. The applied blade was the same for all plots and calculated as a function of the accumulated reference evapotranspiration (ETo) of the Class A tank, located in the meteorological station of the institute itself. The blades are shown in Figure 1.

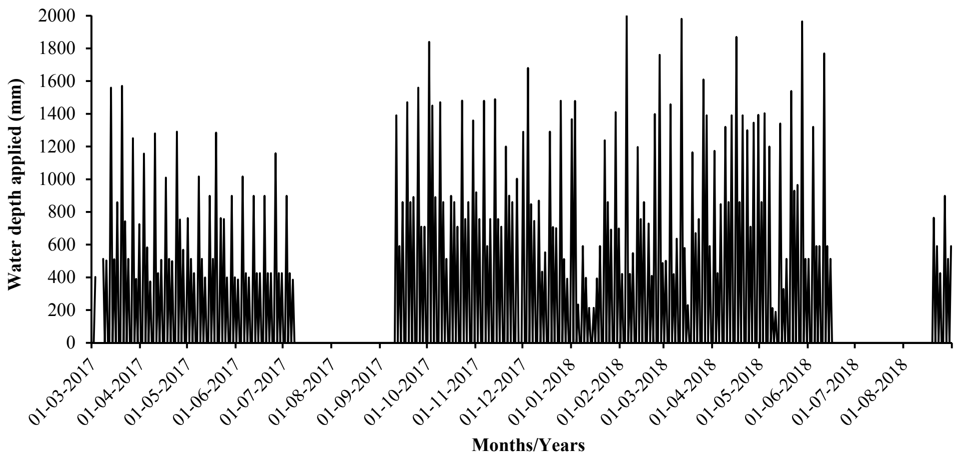

Figure 1. Water depth applied in the experiment

Note. Water depth applied in the experiment from March 2017 to August 2018.

In order to standardize flowering, controlled water stress management was adopted, suspending irrigation between 10/07/2017 to 11/09/2017 (62 days) and 18/06/2018 to 20/08/2018 (63 days) (Guerra et al., 2005).

To estimate coffee ETc, the daily meteorological data were used during the conduction of the experiment, obtained through the meteorological station of the Goiano Federal Institute-Ceres Campus, which is located near the experimental area. Through the Class A tank, reference evapotranspiration (ETo) was estimated according to the Penman-Monteith model (Allen et al., 1998). The crop evapotranspiration (ETc) was determined as a function of the ETo values, taking into account the crop coefficient (Kc) equal to 1 [new crop (1 to 3 years) and spacing 2 – 3.6 × 0.5 – 1.0] (Oliveira et al., 2007).

The relative humidity was assigned by INMET, registered by the Automatic Meteorological Station, located in the Municipality of Itapaci-GO (Figure 2). The values of maximum, average and minimum temperatures during the period of the experiment are presented in Figure 3. The values of relative humidity and temperature were assigned by the National Institute of Meteorology (INMET), a meteorological station in the city of Itapaci, distant 51.1 km from the city of Ceres, and the weather conditions are similar to the location of the experiment.

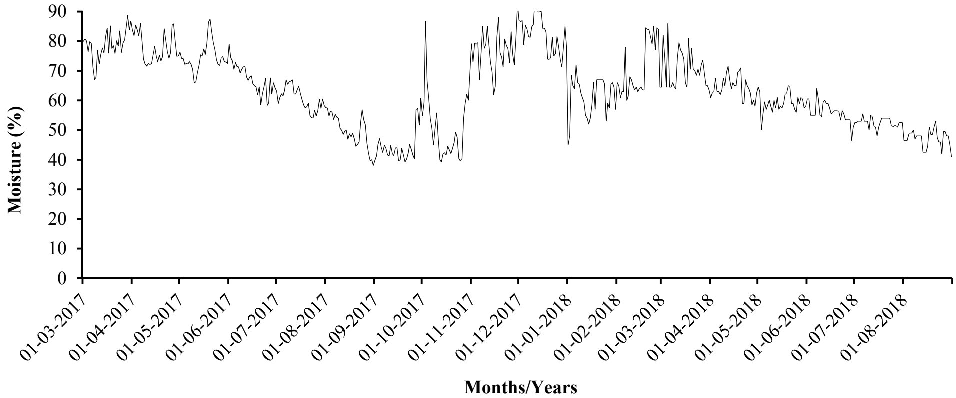

Figure 2. Relative air humidity

Note. Relative air humidity recorded from March 2017 to August 2018.

Source: INMET-Itapaci-GO.

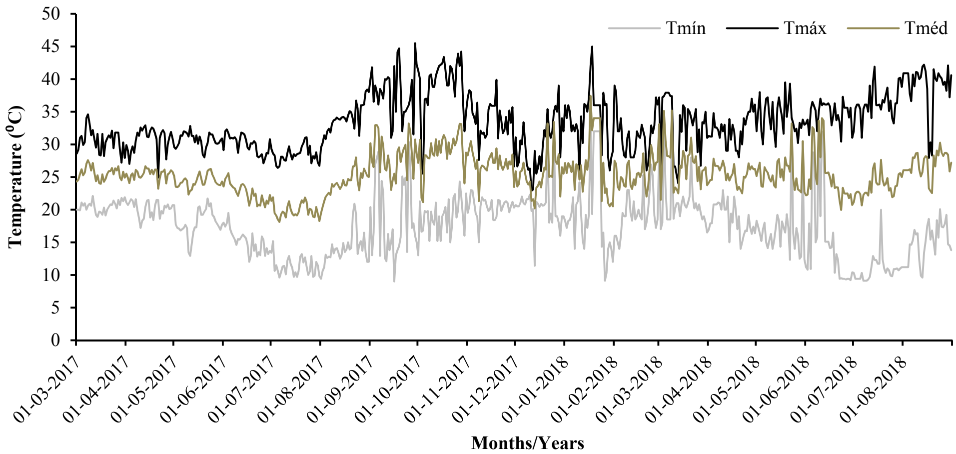

Figure 3. Maximum, average and minimum temperature

Note. Maximum, average and minimum temperature values from March 2017 to August 2018, in the municipality of Ceres-GO.

Source: INMET-Itapaci-GO.

The values of the daily readings of evapotranspiration of the Class A Tank of the Goiano IF-Ceres Campus from March 2017 to August 2018 are shown in Figure 4.

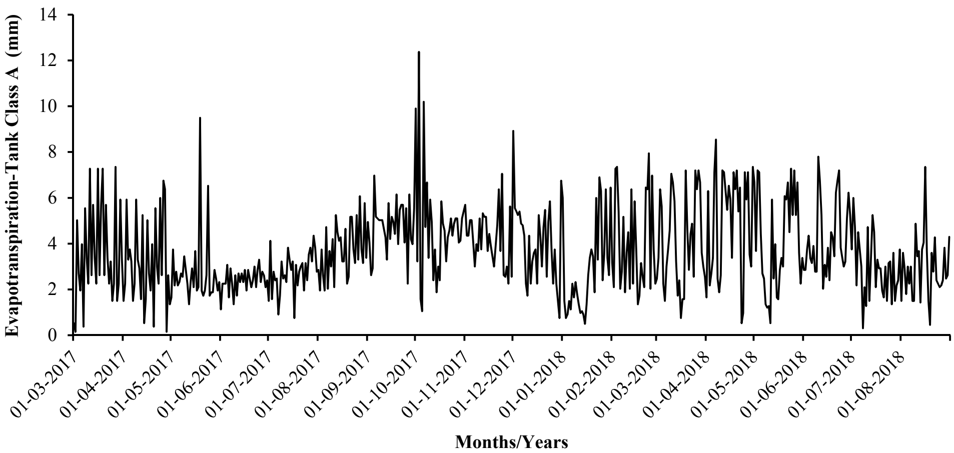

Figure 4. Evapotranspiration monitored by the class A tank

Note. Evapotranspiration monitored by the class A tank from March 2017 to October 2018. Source: Meteorological Station of the Goiano Federal Institute-Campus Ceres.

The pluviometric rainfall from March 2017 to August 2018, at the Goiano IF-Ceres Campus, based on data from the Itapaci-Goiás Automatic Weather Station, is described in Figure 5.

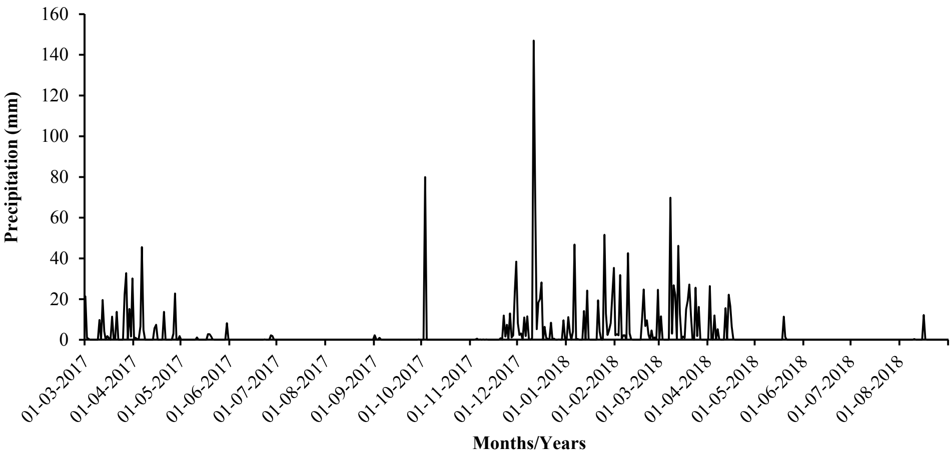

Figure 5. Pluviometric precipitation

Note. Pluviometric precipitation recorded from March 2017 to August 2018, at the Itapaci-GO Automatic Weather Station.

Source: INMET.

The variation values of the Photoperiod during the experiment period are shown in Figure 6.

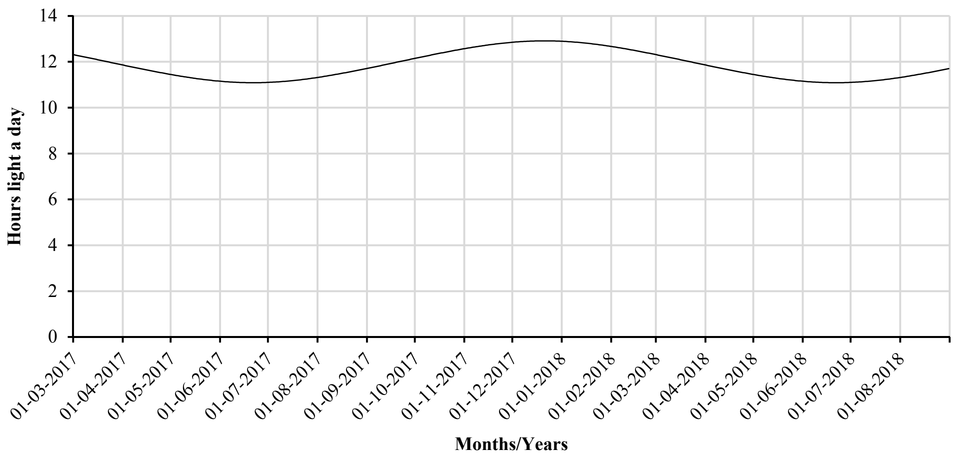

Figure 6. Photoperiod recorded during the conduction of the experiments

Note. Photoperiod recorded during the conduction of the experiments, from March 2017 to August 2018. Anápolis Station-GO, INMET (2018).

The amount of light hours per day varies, depending on the time of year. In Ceres-GO, in the period from March 2017 to August 2018, the minimum was 11 h; 4 min; 24 s in June and the maximum was 12 h; 54 min; 36 s in December (INMET, 2018).

The vegetative growth assessments were at 30 and 36 months after planting (MAP), in October 2017 and April 2018, respectively. In the four central plants, the diameter of the orthotropic branch, measured in millimeters, was evaluated with the aid of the digital caliper, at 5 cm from the ground; cup diameter, measured in centimeters; height of plant, in centimeters, measurement of soil level to the apical bud of the orthotropic branch; number of nodes of the orthotropic branch; number of nodes of plagiotropic branch 1, length of plagiotropic branch 1, number of nodes in plagiotropic branch 2, length of plagiotropic branch 2, length of plagiotropic branches 1 and 2, number of nodes of plagiotropic branches 1 and 2. The length and number of nodes of the plagiotropic branches 1 and 2, are the ones that make up the second pair of branches, above the neck of the plant.

Fruit harvest was by manual melting in the cloth, in July 2018, when the majority of the fruits reached cherry or pass stage, and also the "sweeping" coffee was collected. The coffee harvested was dried in the sun, in terreiro and then heavy, in the form of coffee in coconut, which was benefited. The ratio between the amount of coffee in coconut and coffee benefited was obtained and, subsequently, the productivity of coffee benefited per portion of the useful area was calculated, thus determining the productivity per hectare.

The data obtained in the evaluations were submitted to analysis of variance using the SISVAR program and the comparison and grouping of means were performed by the Scott-Knott test, at 5% probability of error. Simple linear correlation analysis was performed between all evaluated characteristics.

4. Discussion

The genotypes showed significant differences in relation to growth at 30 MAP and 36 MAP as well as in coffee productivity, as presented in Tables 1 and 2. According to the presented productivity averages, the genotypes were divided into three groups: (13 genotypes), mean (13 genotypes) and lowest (nine genotypes) productivity (Figure 7). The correlation between productivity and the ten phenological characteristics evaluated at 36 months after planting was significant, except for number of nodes in the plagiotropic branch 2 (Table 3).

The genotypes Catiguá MG 1, Catuaí Vermelho IAC 15, Catucaí Amarelo 24/137, Acauã 2 and 8, Paraíso H 419-10-6-2-10-1 presented smaller diameter of the orthotropic branch in the two evaluated periods, but are among the which belong to the group with the highest average productivity. The correlation was significant at 5% (0.17) between the number of bags of 60 kg of coffee benefited per hectare and the diameter of the orthotropic branch (Table 3). The correlation between the diameter of the orthotropic branch and plant height was significant at 1% (0.69) as can be seen in Table 3. The Yellow Catucaí 2SL was the genotype with the best performance for these two characteristics, in the two evaluated epochs is in the group of the most productive genotypes. There is a growth synchrony between these two variables, to support the plant (Rodrigues et al., 2012).

The correlation between canopy diameter and yield of coffee benefited per hectare was significant at 1% (0.36), as can be seen in Table 3. The IBC-Palma 2 was the one with the smallest crown diameter, in the two evaluated periods and also the lower productivity.

The Catucaí Amarelo 2SL showed higher plant height than the other genotypes in the two evaluated periods and also belongs to the most productive group. However, it is worth noting that there is a preference for lower plants, since it facilitates management and harvesting (Rodrigues et al., 2012). At 36 MAP, 12 genotypes were in the lowest group and three of them are also more productive: Catiguá MG 1, IPR 98 and Paraíso H 419-10-6-2-10-1.

Observing the number of nodes of the orthotropic branch, at the 30 MAPs, 11 genotypes are in the group that presented the greatest number of nodes (Table 1), but three of them had higher productivity: Araponga MG 1, Acauã and Acauã Novo. This was the only variable analyzed in which the Catucaí Amarelo 2SL did not present better performance in the two seasons and in the ten characteristics evaluated. With less orthotropic nodes, at the same evaluation time, there are four genotypes, but two of them are among the most productive: Sarchimor MG 8840 and Asa Branca.

The correlation between the number of nodes in the plagiotropic branch 2, at 36 months after planting and the productivity was not significant (0.12), as can be seen in Table 3. Study of four arabica coffee cultivars in the city of Ervália-MG, Martinez et al. (2007) found, at a spacing of 2.5 × 0.75 m, a non-significant correlation between MAP production and number of plagiotropic branches.

At 36 MAP, seven genotypes showed the highest number of orthotropic nodes (Table 2) and three of them were among the highest productivity (Figure 8), which are: Araponga MG 1, Catucaí Amarelo 2SL and Acauã. Among the four with the lowest numbers of orthotropic nodes, the White Wing is one of the most productive and the IBC-Palma 2 was the least productive of all the genotypes of the experiment. As shown, the number of nodes in the orthotropic branch did not influence productivity.

When evaluating the number of nodes of the plagiotropic branch 1, at the 30 MAPs, eight genotypes presented the highest values, three of them being among the ones that obtained the highest productivity: Catuaí Vermelho IAC 15, IPR 98, Catucaí Amarelo 2SL. Five genotypes had a smaller number of nodes of the plagiotropic branch 1, two of them being among the most productive: Araponga MG 1, Acauã 2 and 8 and one of them is the one that had the lowest productivity of all, the IBC-Palma 2, according to shows Table 2. At 36 MAP, according to Table 2, five genotypes had better performance and among these, two present higher productivity: Catuaí Vermelho IAC 15, Catucaí Amarelo 2SL. With less number of nodes of the plagiotropic branch 1, four genotypes, among them the IBC-Palma 2, with low productivity.

At 30 MAP, two genotypes showed lower length of the plagiotropic branch 1: Catiguá MG 3 and IBC-Palma 2 (Table 1). At 36 MAP, seven genotypes presented a lower length of the plagiotropic branch 1, two of them having high productivity: Catiguá MG 1, Acauã 2 and 8 and genotype IBC-Palma 2, with low productivity. With the longest length of the plagiotropic branch 1, in both evaluations was the Catucaí Amarelo 2SL, which also presented high productivity.

The variable length of the plagiotropic branch 2 was statistically divided into five groups at 30 MAP. With longer length is only the Catucaí Yellow 2SL. In the group with the lowest plagiotropic branch length 2, there are Oeiras MG 6851, Catiguá MG 1, Pau Brasil MG 1, Catiguá MG 3, Acauã 2 and 8 and IBC-Palma 2. The 36 MAPs are five groups with higher values of length are: Catucaí Amarelo 2SL, Catucaí Amarelo 20/15 cova 479, Sabiá Tardio or Sabiá 398 and Asa Branca. In the group of the lowest values are Oeiras MG 6851, Catiguá MG 3 and IBC-Palma 2.

Table 1. Growth data of genotypes evaluated at 30 MAP

Genotypes	D	Dcopa	Alt	NROrt	NRP1	CRP1	NRP2	CRP2	CTRP	NNTRP
	-------- mm -------		cm			cm		--------- cm ---------		
Oeiras MG 6851	46.85d	132.38e	182.69f	38.94c	17.63c	62.75d	22.25b	73.25e	136.00e	39.88c
Catiguá MG 1	46.69d	150.75d	183.50f	39.19c	18.50c	65.13c	24.06b	79.56e	144.69d	42.56c
Sacramento MG 1	53.43b	181.63b	210.50c	43.44a	17.69c	68.00c	25.81a	95.50c	163.50c	43.50c
Catiguá MG 2	46.97d	148.06d	182.19f	38.56c	15.50d	60.00d	28.44a	90.56c	150.56d	43.94c
Araponga MG 1	48.29c	166.75c	206.56c	44.56a	16.56d	65.50c	26.94a	91.50c	157.00d	43.50c
Paraíso MG 419-1	46.99d	153.25d	182.81f	41.25b	21.13c	70.19c	27.31a	83.31d	153.50d	48.44b
Pau Brasil MG 1	48.52c	132.25e	181.25f	40.63b	17.69c	58.81d	23.56b	78.88e	137.69e	41.25c
Catiguá MG 3	45.82d	118.38f	178.69f	34.50d	12.38d	50.13e	20.69b	76.38e	126.50e	33.06d
Topázio MG 1190	48.25c	165.06c	192.63d	42.75a	21.19c	71.50c	29.88a	92.50c	164.00c	51.06b
23 II	52.45b	169.88c	198.50d	37.44c	19.44c	80.69b	24.00b	94.69c	175.38b	43.44c
IPR 104	48.77c	159.88c	188.06e	41.50b	23.88b	75.25c	27.13a	87.19d	162.44c	51.00b
Sarchimor MG 8840	51.01b	165.25c	194.69d	35.44d	20.19c	74.00c	25.06b	89.00c	163.00c	45.25c
Catucaí Vermelho 20/15cova 476	46.12d	156.75d	189.19e	42.63a	21.81b	72.56c	28.38a	90.13c	162.69c	50.19b
Tupi IAC 1669-33	45.58d	146.44d	179.25f	39.69c	17.75c	63.06d	24.44b	81.13d	144.19d	42.19c
Obatã Vermelho IAC 1669-20	49.50c	179.75b	190.75e	38.38c	24.06b	82.44b	28.38a	94.56c	177.00b	52.44b
Obatã Amarelo IAC 4932	49.80c	152.88d	182.25f	35.38d	17.63c	63.69d	22.88b	86.50d	150.19d	40.50c
Catuaí Vermelho IAC 15	46.00d	173.31b	192.81d	42.00b	26.44a	85.06b	26.31a	85.94d	171.00c	52.75b
Catuaí Amarelo IAC 062	47.80d	175.31b	199.38d	42.94a	26.69a	83.50b	30.13a	95.88c	179.38b	56.81a
IPR 98	48.98c	172.06c	186.44e	41.06b	27.94a	83.81b	27.63a	87.88d	171.69c	55.56a
IPR 99	50.61c	161.81c	193.00d	39.25c	20.81c	73.44c	27.13a	93.06c	166.50c	47.94b
IPR 100	48.82c	179.56b	192.44d	42.56a	30.63a	91.00b	28.75a	92.00c	183.00b	59.38a
IPR 103	49.36c	179.88b	201.38d	41.50b	22.44b	82.19b	29.43a	99.44c	181.63b	51.88b
Catucaí Amarelo 2SL	60.47a	220.56a	268.69a	42.25b	30.88a	111.13a	27.50a	115.63a	226.75a	58.38a
Catucaí Amarelo 24/137	46.96d	160.06c	196.13d	40.63b	21.69b	71.69c	26.81a	89.81c	161.50c	48.50b
Catucaí Amarelo 20/15 cova 479	51.66b	188.00b	221.13b	45.94a	29.25a	91.31b	30.88a	97.75c	189.06b	60.13a
Catucaí Vermelho 785/15	47.65d	138.94e	188.44e	43.88a	23.94b	70.31c	30.81a	86.06d	156.38d	54.75a
Acauã 2 & 8	47.28d	145.88d	186.13e	40.94b	16.44d	59.19d	21.19b	72.44e	131.63e	37.63d
Sabiá Tardio ou Sabiá 398	47.20d	183.94b	192.00d	43.19a	27.50a	86.31b	34.19a	101.38b	187.69b	61.69a
Asa Branca	48.48c	189.06b	193.94d	36.25d	23.88b	88.81b	26.88a	104.13b	192.94b	50.75b
IBC-Palma 2	46.94d	85.06g	189.44e	38.44c	12.75d	46.38e	19.06b	71.63e	118.00e	31.81d
Acauã	49.62c	174.13b	194.88d	42.44a	25.31b	81.88b	26.31a	89.19c	171.06c	51.63b
Acauã Novo	47.90d	176.56b	193.50d	43.69a	22.81b	74.94c	27.38a	93.75c	168.69c	50.19b
H-419-3-3-7-16-4-1	49.29c	170.44c	188.13e	40.19b	27.63a	87.31b	28.06a	93.13c	180.44b	55.69a
Paraíso H 419-10-6-2-12-1	44.86d	150.75d	174.06f	39.81c	22.31b	72.06c	26.94a	81.38d	153.44d	49.25b
Paraíso H 419-10-6-2-10-1	47.59d	155.19d	175.19f	38.75c	22.56b	74.44c	26.56a	87.31d	161.75c	49.13b
CV (%)	9.61	11.87	6.96	9.14	31.13	22.75	23.88	16.68	15.35	20.60

Note. Diameter of the orthotropic branch (D), Cup diameter (Dcopa), Plant height (Alt), Number of nodes of the orthotropic branch (NROrt), Number of nodes of plagiotropic branch 1 (NRP1), Length of plagiotropic branch 1, number of nodes in the plagiotropic branch 2 (NRP2), length of the plagiotropic branch 2 (CRP2), length of the plagiotropic branches 1 and 2 (CTRP), number of nodes of the plagiotropic branches 1 and 2 (NNTRP) genotypes of Coffea arabica at 30 months of age. Means followed by the same lowercase vertical letter do not differ by Scott-Knott test at the 5% error probability level.

Table 2. Growth data of genotypes evaluated at 36 MAP

Genotypes	D	Dcopa	Alt (cm)	NROrt	NRP1	CRP1	NRP2	CRP2	CTRP	NNTRP
	-------- mm -------		cm			cm		--------- cm ---------		
Oeiras MG 6851	55.38c	143.63f	202.13e	46.13c	16.56d	65.44e	25.13c	77.25d	142.69e	41.69c
Catiguá MG 1	57.71c	165.63e	208.06e	46.38c	19.38c	67.31e	25.88c	91.06c	158.38d	45.25c
Sacramento MG 1	63.06b	181.25c	225.69c	50.75b	22.81b	84.81c	28.81b	106.81b	191.63c	51.63b
Catiguá MG 2	57.07c	150.44f	199.75e	46.13c	15.81d	59.81e	25.19c	87.88c	147.69d	41.00c
Araponga MG 1	56.33c	169.00d	221.06c	51.25a	19.31c	78.00c	28.63b	97.69b	175.69c	47.94c
Paraíso MG 419-1	55.21c	156.44e	203.00e	48.25b	24.56b	75.69d	28.06b	90.94c	166.63d	52.63b
Pau Brasil MG 1	56.68c	157.38e	200.69e	46.06c	19.25c	65.75e	27.13c	87.75c	153.50d	46.38c
Catiguá MG 3	55.65c	126.75g	195.06e	39.88d	13.63d	54.19e	21.06d	74.13d	128.31e	34.69d
Topázio MG 1190	58.32b	176.63d	216.00d	52.25a	25.69b	79.88c	33.88a	103.44b	183.31c	59.56a
23 II	60.20b	177.75d	217.00d	44.50c	21.50c	86.50c	28.75b	100.94b	187.44c	50.25c
IPR 104	57.44c	175.81d	213.94d	50.06b	24.25b	79.75c	29.19b	94.88b	174.63c	53.44b
Sarchimor MG 8840	59.41b	172.00d	214.88d	45.25c	20.00c	76.63d	26.81c	98.69b	175.31c	46.81c
Catucaí Vermelho20/15cova 476	57.66c	170.44d	219.69c	52.81a	24.94b	82.63c	29.75b	98.75b	181.38c	54.69b
Tupi IAC 1669-33	52.59c	157.13e	201.63e	47.44c	19.13c	70.13d	25.81c	84.25c	154.38d	44.94c
Obatã Vermelho IAC 1669-20	60.73b	187.69c	212.06d	45.44c	24.69b	84.19c	28.75b	99.50b	183.69c	53.44b
Obatã Amarelo IAC 4932	60.95b	170.81d	203.13e	43.81d	20.81c	74.81d	24.81c	96.44b	171.25c	45.63c
Catuaí Vermelho IAC 15	56.95c	179.94c	216.31d	50.00b	29.06a	88.00c	28.81b	95.69b	183.69c	57.88b
Catuaí Amarelo IAC 062	58.60b	181.06c	223.13c	50.81b	26.00b	87.06c	30.81b	101.81b	188.88c	56.81b
IPR 98	56.54c	178.00d	208.75e	50.69b	25.38b	80.50c	29.44b	96.75b	177.25c	54.81b
IPR 99	59.62b	175.94d	211.06d	48.13b	22.63b	80.69c	28.88b	98.19b	178.88c	51.50b
IPR 100	59.95b	200.25b	217.06d	50.31b	32.06a	98.56b	33.44a	105.31b	203.88b	65.50a
IPR 103	58.60b	193.19b	226.81c	49.13b	24.69b	87.69c	31.56b	105.81b	193.50c	56.25b
Catucaí Amarelo 2SL	75.77a	225.13a	292.50a	51.44a	30.63a	111.56a	30.38b	123.13a	235.69a	61.00a
Catucaí Amarelo 24/137	57.14c	166.13e	226.81c	49.69b	23.06b	79.44c	28.25b	92.44c	171.88c	51.31b
Catucaí Amarelo 20/15 cova 479	60.66b	198.88b	247.94b	54.69a	29.81a	96.56b	34.56a	109.00a	205.56b	64.38a
Catucaí Vermelho 785/15	58.23b	147.13f	212.69d	52.31a	23.38b	71.75d	31.56b	89.06c	160.81d	54.94b
Acauã 2 & 8	58.46b	159.25e	214.13d	48.19b	18.81c	65.69e	26.69c	85.38c	151.06d	45.50c
Sabiá Tardio ou Sabiá 398	55.36c	192.75b	214.25d	50.19b	28.88a	93.88b	38.06a	116.19a	210.06b	66.94a
Asa Branca	56.41c	190.69b	214.44d	42.50d	25.94b	100.31b	29.94b	113.44a	213.75b	55.88b
IBC-Palma 2	54.91c	115.38g	202.13e	42.13d	15.19d	56.75e	17.31d	66.12d	122.88e	32.50d
Acauã	56.32c	186.50c	220.13c	51.38a	25.38b	82.94c	30.69b	99.19b	182.13c	56.06b
Acauã Novo	58.94b	186.75c	216.56d	50.13b	21.50c	71.81d	28.25b	95.63b	167.44d	49.75c
H-419-3-3-7-16-4-1	55.42c	179.13c	210.44d	49.19b	22.25c	83.38c	30.69b	100.56b	183.94c	52.94b
Paraíso H 419-10-6-2-12-1	57.42c	155.56e	198.06e	48.94b	21.38c	75.75d	24.69c	83.63c	159.38d	46.06c
Paraíso H 419-10-6-2-10-1	55.18c	158.94e	194.88e	46.31c	22.81b	79.25c	26.94c	93.94b	173.19c	49.75c
CV (%)	9.67	9.68	6.29	9.43	25.76	20.01	22.16	15.63	14.05	18.66

Note. Diameter of the orthotropic branch (D), Cup diameter (Dcopa), Plant height (Alt), Number of nodes of the orthotropic branch (NROrt), Number of nodes of plagiotropic branch 1 (NRP1), Length of plagiotropic branch 1, number of nodes in plagiotropic branch 2 (NRP2), length of plagiotropic branch 2 (CRP2), length of plagiotropic branches 1 and 2 (CTRP), number of nodes in plagiotropic branches 1 and 2 (NNTRP) in Coffea arabica genotypes at 36 months of age. Means followed by the same lowercase vertical letter do not differ by Scott-Knott test at the 5% error probability level.

Table 3. The correlation between productivity and the ten phenological characteristics evaluated at 36 months after planting

	sc ha^{-1}	D	Dcopa	Alt	NROrt	NRP1	CRP1	NRP2	CRP2	CTRP	NNTRP
sc ha^{-1}	1.00										
D	0.17*	1.00									
Dcopa	0.36**	0.52**	1.00								
Alt	0.22**	0.69**	0.69**	1.00							
NROrt	0.17*	0.24**	0.46**	0.54**	1.00						
NRP1	0.26**	0.31**	0.73**	0.49**	0.46**	1.00					
CRP1	0.24**	0.41**	0.78**	0.57**	0.38**	0.86**	1.00				
NRP2	0.12^{ns}	0.19*	0.64**	0.40**	0.57**	0.66**	0.59**	1.00			
CRP2	0.23**	0.46**	0.83**	0.61**	0.45**	0.67**	0.75**	0.77**	1.00		
CTRP	0.25**	0.46**	0.86**	0.63**	0.44**	0.82**	0.94**	0.72**	0.93**	1.00	
NNTRP	0.21**	0.28**	0.75**	0.49**	0.56**	0.92**	0.80**	0.90**	0.79**	0.85**	1.00

Note. Simple correlation (r) between the variables analyzed, productivity in coffee bags benefited, per hectare (sc ha^{-1}), diameter of the orthotropic branch (D), cup diameter (Dcopa), plant height), number of nodes in the plagiotropic branch 2 (NRP2), number of nodes in the plagiotropic branch 2 (CPR2), number of nodes in the plagiotropic branch 2 (NRP2), number of nodes in the plagiotropic branch 1 (NRP1)), length of plagiotropic branches 1 and 2 (CTRP), number of nodes of plagiotropic branches 1 and 2 (NNTRP), in the year 2018, of 35 genotypes of Coffea arabica, at 36 MAPs. Ceres-GO, 2018. **, * are significant at 1 and 5% of error probability, respectively. ns = not significant.

The correlation of the variable length of the plagiotropic branch 2, at 36 MAP, was significant at 1%, with the length of the plagiotropic branch 1 (0.75), the number of nodes in the plagiotropic branch 2 (0.77), the number of in the plagiotropic branches (0.79) and in the crown diameter (0.83), as shown in Table 3.

With the longest length of the plagiotropic branches, at 30 MAP and at 36 MAP, there is only Catucaí Amarelo 2SL. With the lowest values in the length of the plagiotropic branches, the 30 MAPs are: Oeiras MG 6851, Pau Brasil MG 1, Catiguá MG 3, Acauã 2 and 8 and IBC-Palma 2. The 36 MAPs in the group of the lowest values are: Oeiras MG 6851, Catiguá MG 3 and IBC-Palma 2.

As shown in Table 3, the correlation was significant at 1%, between the variable length of the plagiotropic branches with: crown diameter (0.86), number of nodes in the plagiotropic branch 1 (0.82), number of nodes in the plagiotropic branch 1 (0.94), plagiotropic branch length 2 (0.93) and productivity (0.25).

The number of nodes is important because it indicates how many productive buds exist in the plagiotropic branches, thus being very relevant for productivity (Assis et al., 2018). At 30 MAP, eight genotypes showed higher numbers of total nodes in the plagiotropic branches: Catuaí Amarelo IAC 062, IPR 98, IPR 100, Catucaí Amarelo 2SL, Catucaí Amarelo 20/15 cova 479, Catucaí Vermelho 785/15, Sabiá Tardio or Sabiá 398 and H-419-3-3-7-16-4-1. Among these, the IPR 98 and Catucaí Amarelo 2SL are also in the group of genotypes with higher productivity.

At 36 MAP, in the group with the largest numbers of total nodes in the plagiotropic branches are: Topázio MG 1190, IPR 100, Catucaí Amarelo 2SL, Catucaí Amarelo 20/15 cova 479, Sabiá Tardio or Sabiá 398. Only Catucaí Amarelo 2SL is in the group of the most productive. The genotypes with the lowest numbers of total nodes in the plagiotropic branches at the 30 MAPs were: Catiguá MG 3, Acauã 2 and 8 (belonging to the most productive group as well) and IBC-Palma 2, are: Catiguá MG 3 and IBC-Palma 2.

Most of the correlations of growth characteristics among each other and between productivity were significant, as observed in Table 3. Similar results were found by Carvalho et al. (2010), when evaluating the growth characteristics of coffee trees in the initial stages of development and to determine their correlations with the first productivity of crops grown in different environments.

Regarding the productivity of cultivars and progenies of arabica coffee, under drip irrigation conditions in the 2018 crop, it can be seen, observing Figure 7, that it was significant, by the analysis of variance, at the 1% probability level of error. The average yield of the treatments, for this crop was 19.55 sc ha^{-1}. According to CONAB (2018), the average yield of Arabica coffee in Goiás in the 2018 harvest, a year of positive biennial, reached 33.09 sc ha^{-1} in irrigated crops.

In the group with higher productivity were the genotypes: Catiguá MG 1, Acauã Novo, Acauã 2 and 8, Catucaí Amarelo 24/137, Catucaí Amarelo 2SL, Asa Branca, Paraiso H 419-10-6-2-10-1, Catuaí Vermelho IAC 15, Acauã, Sarchimor MG 8840, IPR 98, Araponga MG 1 and Obatã Vermelho IAC 1669-20. The productivity of these genotypes varied between 21.92 and 36.61 sc ha^{-1}. They are genotypes of low size, for the most part, however, Catucaí Amarelo 2 SL belongs also to the group of the highest averages of plant height. Low-sized plants facilitate handling with crop and harvest.

Of the thirteen most productive genotypes, two cultivars obtained a productivity higher than this state average, in the 2018 crop, Araponga MG 1, with 36.3 sc ha^{-1} and Obatã Vermelho IAC 1669-20, with 36.61 sc ha^{-1} (approximately 10.6% more, productivity). The genotype IPR 98 (33.0 sc ha^{-1}) was in the state average. It then shows the potential for adaptation of some genotypes to planting in this region.

Carvalho et al. (2005), studying the agronomic performance of coffee cultivars in the state of Minas Gerais, found that in Turmalina, Catucaí Amarelo 2SL and Obatã Vermelho IAC 1669-20 were in the group with higher productivity, considering a general average of four harvests. Carvalho et al. (2017) found that in the municipalities of Lavras and Patrocínio, among three groups, Araponga MG 1 was in the less productive group, considering an average of productivity in the 2011/2012 and 2012/2013 harvests.

The group of those that presented average productivity, were nine cultivars [Paraíso MG 419-1, Catiguá MG 3, IPR 104, Tupi IAC 1669-33, Catuaí Amarelo IAC 062, IPR 99, IPR 100, IPR 103, Catucaí Amarelo 20/15 cave 479, Sabiá Tardio or Sabiá 398] and three advanced progenies [23II, H-419-3-3-7-16-4-1 and Paradise H 419-10-6-2-12-1]. Their average ranged between 15.2 and 20.6 bags of coffee benefited per hectare.

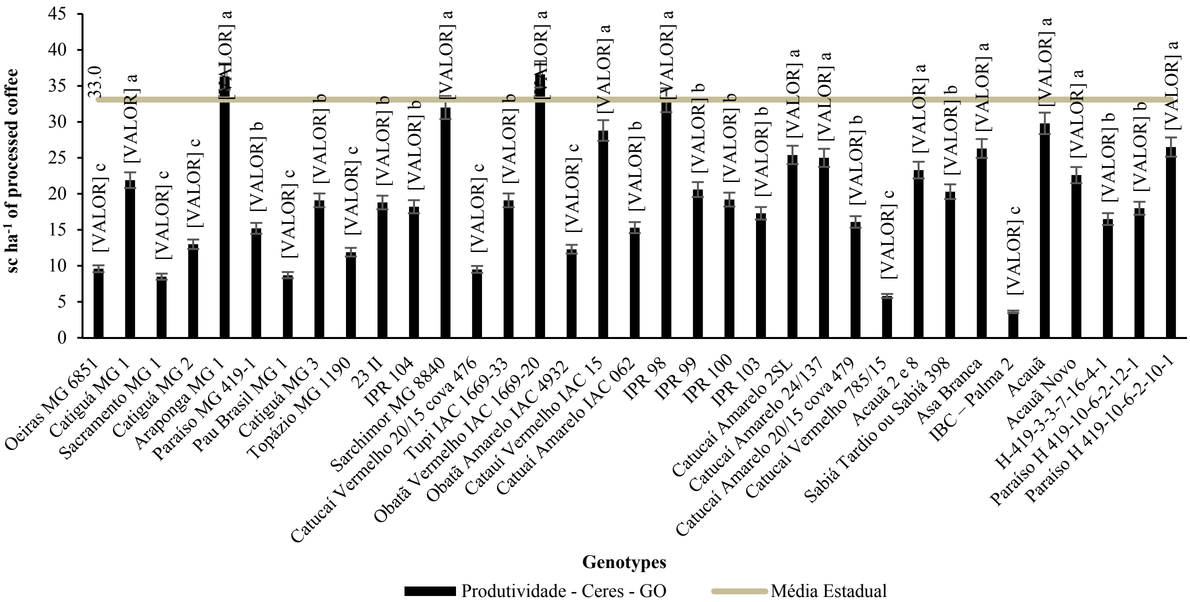

Figure 7. Productivity of coffee benefited

Note. Productivity of coffee benefited (60 kg/ha) of 35 genotypes of Coffea arabica, compared to the average state of Goiás, in the 2018 harvest.

Among the 35 recommended genotypes, Oeiras MG 6851, Sacramento MG 1, Catiguá MG 2, Pau MG Brasil 1, Topázio MG 1190, Catucaí Vermelho 20/15 cova 476, Obatã Amarelo IAC 4932, Catucaí Vermelho 785/15, IBC-Palma 2 The productivity of coffee bags benefited from 60 kg of coffee ranged from 3.6 to 13.0 bags of coffee benefited per hectare. The IBC-Palma 2 was the least productive genotype, being therefore the least indicated for these growing conditions, because it is only a little.

5. Conclusions

There was a difference in growth and yield of the evaluated genotypes.

There is a positive correlation between the vegetative characters and between them and the productivity, in the second crop, of coffee.

Catucaí Amarelo 2SL presented higher growth than the other evaluated genotypes.

The genotypes Catiguá MG 1, Acauã Novo, Acauã 2 and 8, Catucaí Amarelo 24/137, Catucaí Amarelo 2SL, Asa Branca, Paraíso H 419-10-6-2-10-1, Catuaí Vermelho IAC 15, Acauã, Sarchimor MG 8840, IPR 98, Araponga MG 1 and Obatã Vermelho IAC 1669-20 were the ones that had the highest productivity in the year 2018.

Acknowledgements

The authors are grateful to the Goian Federal Institute-Campus Ceres for the support given to the Research Support Foundation of the State of Goiás-FAPEG for the research assistance in the implementation of the experiment, to the National Council for Research and Scientific and Technological Development-CNPq, and Dr. Antônio Alves Pereira (Agricultural Research Company of the State of Minas Gerais-EPAMIG) for the supply of seeds of the coffee genotypes.

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