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Germplasm characterization of *Coffea arabica* L. accessions based on agronomic traits

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ABSTRACT: Genetic resources embody the reservoir of essential natural variability for cultivated species breeding programs. The objective of this study was to select Arabica coffee accessions from the Minas Gerais Coffee Germplasm Collection grounded in agronomic traits. The productivity, quantified in bags per hectare, of 25 accessions was evaluated across four harvests, as was the percentage of maturation and floating beans. Genetic parameters were estimated for these attributes, aiming to glean insights into the potential for genetic gain and to facilitate decision-making in breeding practices. The REML/BLUP procedure was used to estimate variance components and predict random effects within the agronomic data. Genetic variability was observed among the studied accessions for productivity and the percentage of dried/pass fruits, indicating potential for genetic gain through selection within this group of accessions. There is potential for genetic breeding through selection, leading to subsequent enhancement in the means of the evaluated traits, notably in accessions MG0223 (Pacamara), MG0438 (Mundo Novo x S795 UFV 335-04), MG0194 (Caturra Amarelo Colombiano), MG0420 (Mundo Novo x S795 UFV 315-04), and MG0036 (Bourbon Amarelo). These results highlight the potential of these accessions to produce specialty coffees and their suitability for future breeding programs aimed at improving beans quality and productivity in Brazil.

Key words: coffee; germplasm collection; heritability; parameter estimation; productivity

Caracterização de germoplasma de *Coffea arabica* L. com base em características agronômicas

RESUMO: Os recursos genéticos representam o reservatório de variabilidade natural essencial para programas de melhoramento de espécies cultivadas. O objetivo deste estudo foi selecionar acessos de café arábica da Coleção de Germoplasma de café de Minas Gerais com base em características agronômicas. A produtividade, em sacas por hectare, de 25 acessos foi avaliada em quatro colheitas, assim como a porcentagem de maturação e de frutos chochos. Estimaram-se os parâmetros genéticos para essas características, visando informações sobre a possibilidade de ganho genético e o auxílio na tomada de decisões para práticas de melhoramento. O procedimento REML/BLUP foi utilizado para estimar os componentes de variância e prever os efeitos aleatórios dos dados agronômicos. Variabilidade genética foi observada entre os acessos estudados para produtividade e porcentagem de frutos secos/passas, indicando possibilidades de ganho genético por meio de seleção nesse grupo de acessos. Há potencial para ganho na seleção e aumento consequente nas médias das características avaliadas, especialmente nos acessos MG0223 (Pacamara), MG0438 (Mundo Novo x S795 UFV 335-04), MG0194 (Caturra Amarelo Colombiano), MG0420 (Mundo Novo x S795 UFV 315-04) e MG0036 (Bourbon Amarelo). Esses resultados destacam o potencial desses acessos para produzir cafés especiais e sua adequação para futuros programas de melhoramento visando melhorar a produtividade e a qualidade dos grãos no Brasil.

Palavras-chave: café; coleção de germoplasma; herdabilidade; estimação de parâmetros; produtividade

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Introduction

The success of genetic improvement programs has been made available more adapted and productive coffee cultivars available to farmers. One of the tools that enable this availability of cultivars was the Brazilian capacity to incorporate and use genetic resources, which are basic inputs for genetic improvement. The *Coffea arabica* species originates from southeastern Ethiopia, southeastern Sudan, and northern Kenya (Merot-l'Anthoene et al., 2019), therefore genetic materials carrying characteristics such as pest and disease resistance and adaptation to adverse environmental conditions are more easily found in Africa. Brazilian coffee farming would never have progressed without the systematic and growing importation of these genetic resources for coffee production (Mishra, 2019).

Although the cultivars available on the market already present high productive potential, new improvements may arise through the conduct of breeding programs to incorporate, through crossbreeding, genetic gains in productivity and characteristics of interest, aiming to obtain cultivars that ensure greater competitiveness and sustainability of coffee farming.

In response to this concern, the Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG), has maintained the Minas Gerais Germplasm Collection (CG-MG) for over a decade. The CG-MG focuses on activities related to the introduction, collection, exchange, characterization, and conservation of genetic resources of *Coffea arabica* and other *Coffea* species. These species include *C. canephora*, *C. racemosa*, and *C. dewevrei*, as well as interspecific hybrids represented by one or more varieties or introductions. Implemented at the Patrocínio Experimental Field - CEPC, the CG-MG is composed of 1596 accessions, mainly of *C. arabica*, with many cultivars and mutants, as well as valuable material collected in Ethiopia, representing spontaneous and sub-spontaneous wild forms of *C. arabica* (Botelho et al., 2017; Fassio et al., 2020; Nadaleti et al., 2022).

An important strategy used by breeding programs is the efficient characterization of existing germplasm collections, allowing the knowledge of preserved genetic diversity (Langridge & Waugh, 2019; Migicovsky et al., 2019). However, despite the mentioned diversity, the Arabica coffee genotypes are quite related, due to the narrow genetic base of the species, being in many cases difficult to phenotyping and identify. Thus, studies of agronomic and morphological characterization of coffee accessions are necessary and of great interest for genetic improvement.

Therefore, the objective of this study was to select Arabica coffee accessions from CG-MG, based on agronomic characteristics. To achieve this, genetic parameters were estimated for these characteristics, as they provide information about the possibility of genetic gain and assist in decision-making on breeding practices.

Materials and Methods

Experiment implementation and conduct

The CG-MG was established in 2005 at the Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG) Experimental Field in Patrocínio, Minas Gerais state, Brazil, in the Alto Paranaíba region, at an altitude of approximately 1,000 m. The soil is classified as dystrophic red-yellow latosol. The topography of the area is flat with a slight slope. The observed average annual temperature is 20.61 °C, with a maximum average annual temperature of 27.06 °C, a minimum average annual temperature of 15.95 °C, and an average annual precipitation of 1,200 mm. The climate is classified as Subtropical Temperate Mesothermal with summer rains, dry winters, and hot summers (Wca), according to Köppen (Martins et al., 2018).

The implementation and management of the accessions followed technical recommendations for coffee crop cultivation. The phytosanitary management was done preventively or curatively using chemical products, following the seasonality of pest and disease occurrence.

The spacing used was 3.5 m (between rows) × 1.0 m (between plants), resulting in a stand of 2,857 plants ha^{-1}. The experimental design used was a randomized complete block design (RCBD) with two replications, each composed of ten plants. All plants in the plot were considered useful for the evaluations.

Accesses evaluated

For this study, 25 accessions of *C. arabica* L. were selected by their potential immediate use in the genetic breeding program of EPAMIG, based on their previously identified quality characteristics of beverage and/or resistance to economically important diseases (Teixeira et al., 2012; Lara et al., 2014; Botelho et al., 2017; Fassio et al., 2020). Productivity in bags ha^{-1} was evaluated in the harvests of 2016, 2017, 2018, and 2019, between the months of May and July of each year. Immediately after the harvest, 300 mL samples of fruits from each plot were collected directly from the bag and stored in plastic nets with identification. From these samples, separation and counting of mature, green, and dry/pass fruits were performed. The data were converted to percentages. Subsequently, the percentage of floating fruits was quantified according to the methodology proposed by Antunes Filho & Carvalho (1979).

Statistical analysis

Using the productivity data for four crops evaluated in two biennials, the percentages of mature, green, and dry/pass fruits, and the percentage of floating fruits, variance components were estimated, and the prediction of random effects was performed using the REML/BLUP (restricted maximum likelihood/best linear unbiased prediction) procedure (Resende, 2016). For the analysis considering a single harvest, the employed model was $y = X\beta + Z\gamma + e$, where: $y_{(nx1)}$ is the vector of phenotypic observations, $\beta_{(bx1)}$

is the vector of the repetition effects (assumed to be fixed) added to the overall mean, $\gamma_{(gx1)}$ is the vector of the genotypic effects (assumed to be random), and $e_{(gx1)}$ is the vector of (random) errors or residuals. $X_{(nxb)}$ is the block incidence matrix; $Z_{(nxg)}$ is the genotype effect incidence matrix.

The use of m measurements in each genotype to achieve the desired accuracy fraction was obtained through the expression: $m = [f(1 - \rho)]/[(1 - f)\rho]$, where m is the estimated number of measurements to obtain accuracy fractions (f) of 70, 75, 80, 85, and 90%.

Results

Accuracy can be improved by adequate experimentation, increasing the number of measurements per plant. Table 1 presents the accuracies and efficiencies that would be obtained by using a higher number of harvests in the experimentation. It was found that the use of approximately four evaluated harvests is ideal for obtaining high accuracy values (≥ 70%) for most of the evaluated traits. For the percent green trait, which presented low heritability magnitude, only the evaluation of 10 harvests allows obtaining high accuracy values. On the other hand, for traits such as productivity and dry/pass fruits percent, the use of only two measurements is sufficient to achieve values above 70%, confirming the viability of selecting genotypes for this trait.

With the use of four harvests in productivity, an accuracy of 82% and an efficiency of 57% compared to a single measurement are observed. Regarding the characteristic percentage of dried/pass fruits, the efficiency of using four harvests compared to using only one is about 27%. Doubling this number to eight harvests, the accuracy for selection would only increase by 7%. On the other hand, the efficiency of immature fruits in the seventh measurement is over 100% compared to just one harvest.

Likelihood ratio test (LRT) showed significant effects for productivity and percentage of dry fruits, based on the genotypic variances, indicating that selecting the best genotypes can result in a substantial increase in the genetic value of populations for these traits (Table 2). The heritability and genetic variation coefficients suggest the possibility of selection for productivity and percentage of dry fruits (20 and 49%, respectively), as the mean heritability of each accession was significant for these two traits (67 and 79%, respectively). These parameters indicate that the experimental design was appropriate, and the predicted genetic values are close to the true values, making it easier to select for these two characteristics. However, for other traits, the additive heritability within families were very low, indicating that selection for those traits is not possible.

Knowing the superior individuals in each characteristic allows for directed crosses aimed at obtaining segregating individuals that combine all desired traits, thereby increasing the efficiency of the genetic improvement program. Table 2 presents the predicted additive genetic values and genetic gain of each of the 25 accessions for the studied characteristics. The productivity of the plants ranged from 14.71 to 31.76 bags per hectare, with an average of 20.84 bags per hectare. The percentage of ripe fruits varied between 27.78 and 45.35%, with an average of 34.11%. For green fruits, the variation ranged from 10.47 to 13.76%, with an average of 11.87%. The percentage of dried/pass fruits showed a wider range, from 70.91 to 202.23%, with an average of 44.16%. Finally, the percentage of floating fruits ranged from 6.54 to 15.43%, with an average of 8.55%.

When considering the predicted additive genetic values for productivity, the accessions MG0036 (Bourbon Amarelo), MG0194 (Caturra Amarelo Colombiano), MG0223 (Pacamara), MG0420 (Mundo Novo × S795 UFV 315-04), and MG0438 (Mundo Novo × S795 UFV 335-04) stood out. In terms of the percentage of ripe berries, the accessions MG0165 (Maragogipe Amarelo), MG0194 (Caturra Amarelo Colombiano), MG0289 (Hibrido de Timor UFV 376-01), MG0420 (Mundo Novo × S795 UFV 315-04), and MG0438 (Mundo Novo × S795 UFV 335-04) stood out. The selection of the accessions MG0420 (Mundo Novo × S795 UFV 315-04) and MG0438 (Mundo Novo × S795 UFV 335-04) would also be indicated when the selection of green berries is interesting, aiming at the use of harvesting scaling technologies.

On the other hand, the selection of accessions with a percentage of dry berries aims at the earliness of the crop and indicates that the accessions MG0540 (BE 5 Wush-Wush × Hibrido de Timor), MG0603 (K 7 IAC 1151-2 c1003 UFV 165-04), MG 0615 (DK 1/6 UFV 302-40), and MG0694 (Caturra

Table 1. Accuracy (Ac) and efficiency (Ef) obtained from different numbers of measurements for productivity, percentage of ripe fruits, green fruits, dried/pass fruits, and percentage of floating fruits.

m	Productivity		Ripe		Green		Dried/pass		Floating	
	Ac	Ef	Ac	Ef	Ac	Ef	Ac	Ef	Ac	Ef
1	0.58	1.00	0.50	1.00	0.31	1.00	0.81	1.00	0.45	1.00
2	0.71	1.29	0.63	1.32	0.42	1.38	0.89	1.16	0.58	1.34
3	0.78	1.46	0.71	1.52	0.49	1.64	0.92	1.23	0.65	1.56
4	0.82	1.57	0.76	1.67	0.55	1.85	0.94	1.27	0.70	1.72
5	0.84	1.66	0.79	1.77	0.59	2.02	0.95	1.30	0.74	1.84
6	0.87	1.72	0.82	1.86	0.62	2.17	0.96	1.32	0.77	1.94
7	0.88	1.77	0.83	1.93	0.65	2.29	0.96	1.33	0.79	2.02
8	0.89	1.81	0.85	1.99	0.68	2.40	0.97	1.35	0.81	2.09
9	0.90	1.85	0.86	2.03	0.70	2.50	0.97	1.35	0.82	2.15
10	0.91	1.88	0.87	2.07	0.71	2.59	0.97	1.36	0.84	2.20

Table 2. Estimates of the components of means and predicted additive genetic value (u + g) for the traits productivity (Prod. sc ha^{-1}), percentage of ripe fruits (RIP), green fruits (GR), dried/pass fruits (D/P), and percentage of floating fruits (FL) of the 25 studied accessions, and predicted improved mean $\bar{X}$_sel and predicted additive genetic gain (GS%) of the five most productive accessions.

Accessions	Name	Prod.	RIP	GR	D/P	FL
MG0173	Maragogipe Vermelho	14.78	34.88	10.47	56.65	8.53
MG0587	Dilla & Alghe x Híbrido Timor	15.13	28.52	11.42	63.00	6.70
MG0165	Maragogipe Amarelo	15.82	38.50	11.72	43.97	8.20
MG1079	Cavimor UFV 357-04	16.43	34.10	11.94	51.65	7.95
MG0603	K 7 IAC 1151-2 c1003 UFV 165-04	16.99	29.72	11.29	63.15	7.20
MG 0615	DK 1/6 UFV 302-40	17.36	28.66	10.82	67.34	7.04
MG1156	Cavimor MS	17.67	37.82	12.92	40.77	9.70
MG0540	BE 5 Wush-Wush x Híbrido Timor	17.73	27.78	10.53	70.39	7.70
MG0025	Bourbon Vermelho	18.55	30.63	10.83	23.98	12.61
MG0027	Bourbon Vermelho	18.85	34.78	12.78	46.60	9.28
MG1059	Sarchimor UFV 350-98	19.35	38.46	12.86	38.97	8.28
MG0043	Bourbon Amarelo	20.04	27.85	13.21	18.86	13.11
MG0694	Caturra Amarelo x CIFC H358/5	20.65	27.96	10.33	70.91	6.87
MG0009	Bourbon Amarelo	20.69	31.34	10.71	23.10	15.43
MG 0131	Sumatra	21.03	37.56	12.56	42.10	7.95
MG0289	Híbrido de Timor UFV 376-01	21.28	39.48	12.67	37.84	8.70
MG0563	Bourbon N 197 x Híbrido Timor	21.95	30.72	11.92	60.39	6.70
MG0011	Bourbon Vermelho	21.98	30.27	11.42	22.07	8.70
MG0554	Bourbon N 39 x Híbrido Timor	22.14	32.62	10.60	60.53	6.54
MG0187	Caturra Vermelho	24.51	33.92	13.76	43.91	7.62
MG0036	Bourbon Amarelo	25.05	31.54	11.27	20.23	7.79
MG0420	Mundo Novo x S795 UFV 315-04	25.65	42.07	12.94	31.53	8.20
MG0194	Caturra Amarelo Colombiano	25.90	41.23	11.98	37.46	6.79
MG0438	Mundo Novo x S795 UFV 335-04	29.72	45.35	13.32	25.35	8.87
MG0223	Pacamara	31.76	37.07	12.53	43.21	7.29
	σ_g^2	28.43*	61.81	5.98	348.33*	14.07
	r	0.20	0.15	0.06	0.49	0.12
	h^2_{mg}	0.67	0.40	0.18	0.79	0.33
	Average	20.84	34.11	11.87	44.16	8.55
	$\bar{X}$_sel	27.61	39.45	12.41	31.55	7.78
	GS%	32.51	15.66	4.53	-28.55	-8.91

σ_g^2 - Genotypic variance. r - repeatability at the plot level, given by $[(\sigma_g^2 + \sigma^2_{perm})/\sigma_f^2]$. h^2_{mg} - heritability of genotype means. $\bar{X}$_overall - overall mean of the experiment. $\bar{X}$_sel - predicted improved mean, with GS% representing the predicted additive genetic gain of the five most productive accessions.
*Significant at 5% level according to likelihood ratio test.

Amarelo × CIFC H358/5) obtained the highest gains. It was found that for most of the accessions, there was a higher percentage of well-grained fruits compared to floating ones, with a variation range from 6.79 to 15.43%.

The five individuals more productive have average productivity 27.61 sc ha^{-1}. This value is 32.51% higher than the overall average of all evaluated accessions over four years of experimentation. As such, the gains from selecting these accessions were 15.66% for the percentage of ripe fruits, 4.53% for the percentage of green fruits, and a decrease of 28.55 and 8.91% for the percentage of dry/passed fruits and the percentage of floating fruits, respectively. These results indicate good possibilities for genetic progress in this group of five accessions.

Discussion

Conservation of genetic diversity is crucial to ensure food security and the adaptation of crops to climate change. In this sense, CG-MG plays a crucial role as a repository of valuable genetic resources that need to be conserved. Our coffee breeding program aims not only to conserve this genetic diversity but also to develop new, more productive, resistant, and adapted cultivars to the challenges of coffee farming in Brazil.

Previous studies have been conducted to identify CG-MG accessions carrying important genes that can be used to improve disease resistance (Botelho et al., 2017), morphological traits of interest (Teixeira et al., 2012; Lara et al., 2014) and quality characteristics of beverage (Fassio et al., 2020). From these studies, 25 accessions with desirable traits were selected for characterization in terms of productivity since this is considered the main selection criterion in coffee breeding programs. The selection of plants involves the evaluation of various yield-related traits, such as the percentage of floating fruits, uniformity of ripening, and other characteristics.

Accuracy is a measure associated with precision in selection and has the property of informing confidence in the evaluation and predicted genetic value for the genotype, with higher magnitudes indicating higher precision (Resende & Duarte, 2007). In the present study, considering the estimated individual repeatability, it was possible to observe that the adoption of four productivity evaluations indicates high precision, which symbolizes low absolute deviations between true genotypic values and those estimated or predicted and facilitates obtaining significant genetic gains.

Selection based on a single harvest can be influenced by random factors, such as variations in climate and soil conditions, which can affect the performance of individual plants compared to others. Thus, the results of this study demonstrate that at least four harvests are necessary for the selection of the most promising plants to be made reliably, corroborating other studies on Arabica coffee for obtaining agronomic data (Moreira et al., 2022; Merga et al., 2023). Therefore, the evaluation cycle used in this study was sufficient to efficiently discriminate the productive potential of the accessions.

The variance components, genetic and phenotypic parameters estimated for the evaluated traits showed means and variances compatible with other studies on Arabica coffee cultivars (Botelho et al., 2017; Moreira et al., 2022). Based on the estimates of variance components (Table 2), productivity was chosen for the selection of accessions, as it presented high magnitude heritability and is the main selection criterion for coffee plants (Mochida et al., 2019).

Genetic gain is inversely proportional to selection intensity, which quantifies the number of individuals selected (Cobb et al., 2019). Thus, in this study, it was considered necessary to work with a larger number of individuals (five accessions, selection intensity of 20%) to ensure a minimum effective number that allows greater efficiency in subsequent selection steps. This strategy will optimize the choice of more promising parents for generating progenies with better agronomic performance, such as increased productivity.

The coffee plant has a behavior of bienniality, characterized by the annual alternation of high and low productivities, commonly attributed to the decrease in plant reserves in years of high yields, which causes, due to the lower growth of plagiotropic branches, the production in the following year to be low (Vieira Júnior et al., 2019). Therefore, for data analysis, the biennials were considered.

The accessions MG0223 (Pacamara), MG0438 (Mundo Novo × S795 UFV 335-04), MG0194 (Caturra Amarelo Colombiano), MG0420 (Mundo Novo × S795 UFV 315-04) and MG0036 (Bourbon Amarelo) stood out, with average yields ranging from 27.16 to 37.2 sc ha^{-1}. It should be noted that these values are higher than the average productivity of the state during the experiment period, which was 26.80 sc ha^{-1} (Conab, 2019).

The investigation of the productive potential of these materials should be continued, as they are genotypes of great agronomic interest. The Pacamara cultivar was developed in El Salvador, derived from the crossing of the Pacas cultivar with the Maragogipe cultivar of red fruits. Its grains are characterized by their large size, which can measure up to 30% more than grains of other coffee varieties (López-García et al., 2016). In addition, its shape is rounded, differing from the grains of other varieties that tend to be more elongated. It is a variety that adapts well to different climatic conditions, but is most found in high altitude regions, such as El Salvador, Guatemala, Mexico, Nicaragua, and Honduras.

Bourbon Amarelo is characterized by superior quality of the drink and high precocity in fruit maturation (Romano et al., 2022), which can be 20 to 30 days earlier than Mundo Novo. Similarly, the drink quality of Caturrra is excellent, as this material was likely originated from a natural mutation in the Bourbon cultivar (Fernandes et al., 2022). The Caturra cultivar is widely grown in many Latin American countries, in high altitude regions, fertile soils, and high annual rainfall. However, due to its lack of rusticity and low vegetative vigor, the coffee plants experience premature depletion, compromising their longevity under Brazilian growing conditions.

Accessions MG0438 (Mundo Novo × S795 UFV 335-04) and MG0420 (Mundo Novo × S795 UFV 315-04) also stood out. The S 795 is a *C. arabica* L. widely grown in India and Southeast Asia, carrying the genetic factor SH_2, SH_3, and SH_5, which provide resistance to several races of *H. vastatri* (V.A. & Panakaje, 2022). Thus, these F_3 progenies will have their generations advanced to homozygosity for availability to producers who face coffee rust as a limiting factor for their production.

The results of this study indicate that Pacamara, Colombian Caturra, and Bourbon amarelo can be a planting option for Brazilian commercial crops that seek drink quality, as their drinks are highly appreciated by consumers for their sweet flavors and peculiar aroma. It is worth noting that the spacing used in CG-MG (one meter between plants) leads to lower yields, as the use of denser planting systems tends to increase productivity.

For most accessions, a higher percentage of well-granulated fruits was observed compared to floating ones, with a variation range for flat fruits of 6.79 to 15.43%. According to Carvalho et al. (2006), less than 10% of floating fruits is considered ideal by breeders during evaluation and selection of coffee plants in a breeding program. Thus, the values found for most studied accessions are considered satisfactory, except for accessions MG0009 (Bourbon amarelo), MG0025 (Bourbon vermelho), and MG0043 (Bourbon amarelo).

Coffee plants produce fruits with different maturation stages in the same production cycle due to having more than one flowering. Uniform maturation was not observed in this study. According to Partelli et al. (2021), to obtain satisfactory drink quality, 80% of the fruits must be mature at the time of harvest. These same authors state the difficulty in defining the ideal harvest point to meet this condition. In our study, the harvests were carried out between May and July of each year, with an average of 44% of fruits in the passa/seco stage, 34% mature, and 11% green. The results indicate that these accessions may have early maturation compared to other commercial cultivars, which could subsequently lead to the development of cultivars that allow for the scaling of the maturation cycle for harvest.

Regarding the percentage of mature fruits, accessions MG0165 (Maragogipe amarelo), MG0194 (Caturra amarelo colombiano), MG0289 (Hibrido de Timor UFV 376-01), MG0420 (Mundo Novo × S795 UFV 315-04), and MG0438 (Mundo Novo × S795 UFV 335-04) stand out with gains of around 7 to 11%. The selection of accessions MG0420 (Mundo Novo × S795 UFV 315-04) and MG0438 (Mundo Novo × S795 UFV 335-04) would also be indicated when selecting green fruits.

When considering the percentage of ripe fruits, accessions MG0165 (Maragogipe Amarelo), MG0194 (Caturra amarelo colombiano), MG0289 (Híbrido de Timor UFV 376-01), MG0420 (Mundo Novo × S795 UFV 315-04) and MG0438 (Mundo Novo × S795 UFV 335-04) stand out with gains obtained around 7 to 11%. The selection of accessions MG0420 (Mundo Novo × S795 UFV 315-04) and MG0438 (Mundo Novo × S795 UFV 335-04) is also recommended when the selection of green fruits is of interest, aiming at their use in harvest scaling technologies. On the other hand, accessions MG0540 (BE 5 Wush-Wush × Híbrido Timor), MG0603 (K 7 IAC 1151-2 c1003 UFV 165-04), MG 0615 (DK 1/6 UFV 302-40), and MG0694 (Caturra amarelo × CIFC H358/5) obtained the highest gains in percentage of dried/overripe fruits.

Among the outstanding materials, MG0223 (Pacamara), MG0194 (Caturra amarelo colombiano), and MG0036 (Bourbon amarelo) have potential to produce specialty coffees. These results have important implications in terms of agricultural management to assist farmers in producing higher quality coffee beans and ultimately improving their revenues, especially in times of global oversupply, as Brazil is the world's largest coffee producer. The identified superior accessions are promising options for integration into coffee breeding programs.

Conclusions

There was genetic variability among the studied accessions for the productivity and percentage of dried/pass fruits characteristics, indicating possibilities of obtaining genetic gains through selection in this group of accessions.

The estimates of genetic parameters, such as heritability and genetic gain, confirm the feasibility of selecting accessions based on productive traits, provided that long-term selection strategies. There is potential for selection gains and consequent elevation of the averages of the evaluated traits, mainly in accessions MG0223 (Pacamara), MG0438 (Mundo Novo × S795 UFV 335-04), MG0194 (Caturra Amarelo Colombiano), MG0420 (Mundo Novo × S795 UFV 315-04), and MG0036 (Bourbon Amarelo).

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Compliance with Ethical Standards

Author contributions: Conceptualization: JCRA, CEB; Data curation: MGPS, NDHS, LOF; Formal analysis: MGPS, JCRA, AAP; Investigation: MGPS, JCRA, NDHS, LOF, CEB; Methodology: MGPS, JCRA; Writing – original draft: MGPS, JCRA, NDHS, AAP, LOF, CEB; Writing – review & editing: JCRA, NDHS, CEB.

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