Received: 7 October 2020 | Accepted: 25 January 2021

DOI: 10.1002/agj2.20617

Agronomy Journal

ARTICLE

Agronomic Application of Genetic Resources

Proportion of ripe fruit weight and volume to green coffee: Differences in 43 genotypes of *Coffea canephora*

Fábio Luiz Partelli[1] | **Gleison Oliosi**[1] | **Jéssica Rodrigues Dalazen**[2] | **Cleidson Alves da Silva**[3] | **Henrique Duarte Vieira**[4] | **Marcelo Curitiba Espindula**[5]

[1] Dep. de Ciências Agrárias e Biológicas, Univ. Federal do Espírito Santo, BR 101 Norte, Km 60, Bairro Litorâneo, São Mateus, Espírito Santo CEP: 29932-540, Brazil

[2] Rede de Biodiversidade e Biotecnologia da Amazônia Legal, Univ. Federal de Rondônia, Rodovia BR 364, km 9,5, Porto Velho, Rondônia CEP 76801-059, Brazil

[3] Dep. de Agricultura, Univ. Federal de Lavras, Lavras, Minas Gerais CEP: 37200-000, Brazil

[4] Centro de Ciências e Tecnologias Agropecuárias, Univ. Estadual Norte Fluminense-Darcy Ribeiro, Avenida Alberto Lamego, 2000, Campos dos Goytacazes, Rio de Janeiro CEP: 28013-602, Brazil

[5] Centro de Pesquisa Agroflorestal de Rondônia, Empresa Brasileira de Pesquisa Agropecuária, Rodovia BR 364, Km 5,5, Porto Velho, Rondônia CEP: 76815-800, Brazil

Correspondence
Fábio Luiz Partelli, Dep. de Ciências Agrárias e Biológicas, Univ. Federal do Espírito Santo, BR 101 Norte, Km 60, Bairro Litorâneo, CEP: 29932-540, São Mateus, Espírito Santo, Brazil.
Email:

Associate Editor: Jean McLain

Abstract

The processing yield or performance, which includes drying and depulping of coffee fruits, can be calculated as the relationship between the volume of ripe coffee fruits and green coffee weight and is a relevant characteristic for the development of new cultivars. The purpose of this study was to evaluate the processing performance of 42 genotypes and one population of *Coffea canephora*. The treatments consisted of 42 *C. canephora* genotypes propagated by cuttings and one seed-derived population arranged in a randomized block design with three replications. The genotypes were harvested when 80% of the fruits were in the ripe stage (red berries). We evaluated the relationship of the volume to weight of ripe fruit (ripe fruit volume [RFV]/ripe fruit weight [RFW]), the percentage of seed per fruit (% of seeds), the yield (in liters of ripe coffee) required to produce a 60-kg bag of green coffee, and the relationship between RFW and dry green bean weight (RFW/dry seed weight [DSW]). The results were subjected to ANOVA, and the means were grouped by the Scott–Knott test ($p \leq .05$). The mean yield of the evaluated genotypes was 347.57 L bag^{-1} of green coffee (between 294.01 and 439.72 L bag^{-1}). A lower seed per fruit percentage identifies genotypes with a lower yield and higher RFW/DSW ratio. The genotypes Z21, 700, AD1, LB1, Emcapa 143, and AP required less than 315 L of ripe coffee to produce one 60-kg bag of green coffee beans.

1 | INTRODUCTION

The genus *Coffea* comprises at least 124 species (Davis et al., 2011), of which *Coffea arabica* L. and *Coffea canephora* Pierre ex A. Froehner are the most relevant in economic terms. Worldwide, Brazil is the largest coffee producer and exporter (ICO, 2020). This scale of production and the productive capacity of the plantations can be attributed to the development and implementation of new technologies that have steadily optimized the efficiency of the production process.

Abbreviations: DSW, dry seed weight; RFV, ripe fruit volume; RFW, ripe fruit weight.

Coffea canephora is classified as a diploid plant (2n = 2x = 22 chromosomes), and its reproductive system has a gametophytic self-incompatibility mechanism that favors allogamy and raises the genetic variability among plants of this species (Carvalho et al., 1991; Nowak et al., 2011; Vázquez et al., 2019). Based on this genetic variability, plants with different characteristics can be identified (Dubberstein et al., 2020; Giles et al., 2018, 2019; Martins, Partelli, Ferreira, et al., 2019). In a next step, genotypes can be selected for different cultivation purposes, but selection is always focused on the key trait productivity (Bonomo, et al., 2017; Bragança et al., 2001; Partelli et al., 2019, 2020). Productivity is directly linked to yield and varies according to the cultivation conditions (Lima et al., 2008) and mainly according to the genotype (Silva et al., 2018, 2020).

For each genotype, the proportion of cherry coffee to green coffee (yield) can be associated with fruit seed size and other characteristics, such as presence of floating fruits and flat and peaberry seeds (Vaccarelli et al., 2003). The variability in green coffee yield between cultivars is wide (30–64%), which indicates the possibility of successful selection of coffee lines with higher profitability (Medina Filho & Bordignon, 2003).

A volume of 320 L of ripe coffee is commonly considered equivalent to a 60-kg bag of green coffee. This empirical relationship is used both in the field and in scientific studies to estimate the plantation productivity (Herzog et al., 2018; Oliosi et al., 2016). However, in recent years, new and increasingly productive genotypes with higher yields have been developed. Thus, the objective of this study was to evaluate the proportion of mature cherry to green coffee yield of 42 of *C. canephora* genotypes, propagated by cuttings, and of one seed-derived coffee population.

Core Ideas

- The relationship between ripe fruit weight and dry green coffee weight can vary up to 30.4%.
- The percentage of fruit peel and seeds differs between the studied genotypes.
- Genotypes with lower seed percentage have lower yields.

2 | MATERIALS AND METHODS

The experiment was carried out on a rural property in the county of Nova Venécia, in the northern region of Espírito Santo, from 2014 to 2019 (18° 39′ 43″ S, 40° 25′ 52″ W; mean altitude, 200 m asl; mean of annual temperature, 23 °C). According to the Köppen classification, the predominant regional climate is Aw (tropical with a dry season) (Alvares et al., 2013). The soil of the experimental site is classified as dystrophic Red-Yellow Latosol with a clayey texture and hilly relief (Santos et al., 2018). The meteorological data of the evaluated period were recorded at a weather station in Nova Venécia (Figure 1) installed approximately 7 km away from the experimental area (18.695° S, 40.390° W; mean altitude, 156 m asl).

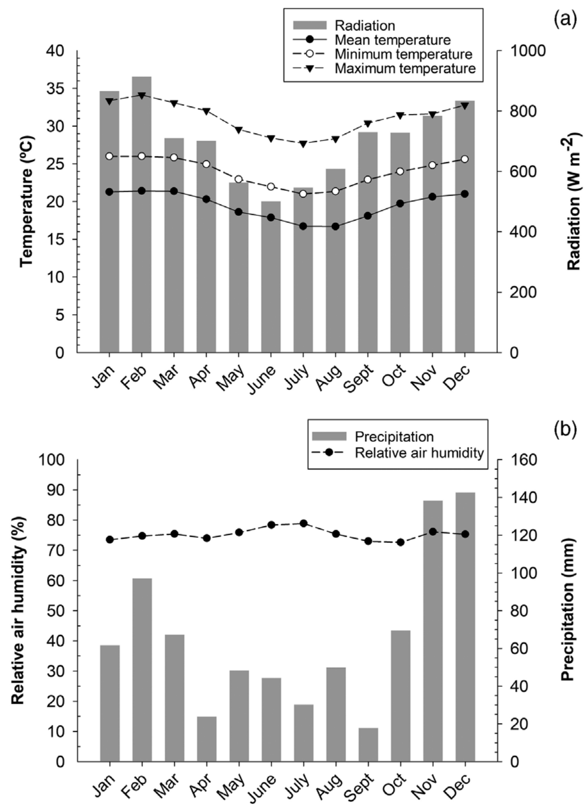

FIGURE 1 Mean values of (a) solar radiation and maximum, mean and minimum air temperature and (b) relative air humidity and precipitation in five growing seasons (2014, 2015, 2016, 2017, 2018, and 2019), recorded at the meteorological station of Nova Venécia, Espírito Santo, Brazil. To ensure the maintenance of an adequate soil moisture level, drip irrigation was used. The water balance was calculated daily based on crop evapotranspiration, rainfall, and soil water storage characteristics

In 2014, the experiment was initiated with the planting of coffee seedlings in a private commercial coffee plantation. The treatments consisted of 42 genotypes of *C. canephora* propagated by cuttings and one seed-derived coffee population (Table 1). Most of the genotypes had been selected by coffee farmers of the region but were rarely tested in studies with field experiments. All of them belong to the Conilon variety. The crop was grown in full sun at a spacing of 3 m between plant rows and 1 m between plants, resulting in 3,333 coffee trees per hectare. The cultural treatments were applied as suggested by crop-specific technical guidelines (i.e., weed

TABLE 1 List of the 43 evaluated *Coffea canephora* genotypes (treatments), Nova Venécia, Espírito Santo, Brazil

Treatment	Name	Treatment	Name	Treatment	Name
1	Verdim R	16	Pirata	31	Cheique
2	B01	17	Peneirão	32	P2
3	Bicudo	18	Z39	33	Emcapa 02
4	Alecrim	19	Z35	34	Emcapa 153
5	700	20	Z40	35	P1
6	CH1	21	Z29	36	LB1
7	Imbigudinho	22	Z38	37	122
8	AD1	23	Z18	38	Verdim D
9	Graudão HP	24	Z37	39	Sementes
10	Valcir P	25	Z21	40	Emcapa 143
11	Beira Rio 8	26	Z36	41	Ouro Negro 1
12	Tardio V	27	Ouro Negro	42	Ouro Negro 2
13	AP	28	18	43	Clementino
14	L80	29	Tardio C		
15	Bamburral	30	A1		

Note. Genotype 33 belongs to 'Emcapa 8111'; genotypes 34 and 39 belong to 'Emcapa 8131' (Bragança et al., 2001). Genotypes 1, 11, 15, 16, 30, and 43 belong to 'Tributun' (Giles et al., 2019; Partelli et al., 2020); genotypes 30 and 35 belong to 'Andina' (Martins, Partelli, Golynski, et al., 2019; Partelli et al., 2019). Treatment 39 was derived from seed-propagated plants. All analyzed genotypes belong to the varietal group Conilon.

control with herbicides and brush cutters, preventive phytosanitary management, liming, fertilization, and drip irrigation). The experimental design consisted of randomized blocks with three replications and with information within the plots because the plots were evaluated in four consecutive growing seasons (2016, 2017, 2018, and 2019) for the weight/volume ratio of mature coffee and in two consecutive harvests (2017 and 2018) for the other traits. The experimental plots consisted of seven plants, of which the five central plants were evaluated.

The genotypes were harvested when 80% of the fruits were in the red-berry stage, according to the maturation cycle of each genotype, which can be early, medium, late, and super late. The ripe fruit weight (RFW) and ripe fruit volume (RFV) were evaluated in the field, immediately after harvest, in a graduated 12-L bucket and on an electronic scale (capacity of 150 kg) in the growing seasons of 2016, 2017, 2018, and 2019.

Therefore, the means of each treatment were established based on the evaluation of 12 replications (3 blocks × 4 growing seasons), and the mature volume to mature weight ratio (RFV/RFW) was thus calculated.

After evaluating coffee weight and volume, in the 2017 and 2018 harvests, samples of 10 fruits per plot were collected and sent to the laboratory. Considering the four replications, 40 fruits per treatment were collected. The sample weight was measured on a precision scale (0.001 g), and the material was dried to constant weight in an oven with forced air circulation at 50 ˚C for approximately 170 h. Subsequently, the fruits were depulped by hand, the husk was separated from the seeds, and the weight of each part was determined on a precision scale to calculate seed percentage per fruit. This value indicates the percentage of the fruit weight that corresponds to seed weight.

Moisture was determined by the standard oven method, in four repetitions at 105 ˚C, for 24 h in a forced circulation oven (Brasil Ministério da Agricultura, Pecuária e Abastecimento, 2009). Fruit moisture was corrected from 0 to 12% moisture (Mo.), which is the moisture content at which coffee beans are commercialized. The moisture correction was calculated by the equation:

$$\text{Initial W.} * (100 - \text{Initial Mo.}) = \text{Final W.} * (100 - \text{Final Mo.})$$

where Initial W. = weight at 50 ˚C 170 h^{-1}, Final W. = weight at 105 ˚C 24h^{-1}, Initial Mo. = P. Initial - P. Final, and V Final Mo. = 88.

These calculations determined the seed weight with 12% moisture (i.e., dry seed weight [DSW]) and then the ratio of ripe fruit to dry seed weight at 12% moisture (RFW/DSW). The results were recorded in an electronic spreadsheet, the data were subjected to ANOVA by the F test ($p < .05$), and the means of the different treatments were grouped by the Scott–Knott test at 5% error probability.

The yield in liters and kilograms of ripe coffee per 60-kg bag of green coffee beans was derived from the ratios RFW/DSW and RFV/RFW, which are commonly used in the field to estimate productivity. In addition, the number of measures of mature coffee (1 measure unit = 20 kg) required for a 60-kg bag of processed coffee was also determined.

TABLE 2 Relationship between ripe fruit weight and processed dry seed weight (RFW/DSW) and relationship between ripe fruit volume and ripe fruit weight (RFV/RFW) of 42 *Coffea canephora* genotypes, and one seed-derived coffee population grown in Nova Venécia, Espírito Santo, Brazil

Genotypes	RFW/DSW	RFV/RFW	Genotypes	RFW/DSW	RFV/RFW
Verdim R	4.18b	1.59a	Z18	3.57c	1.54b
B01	4.34a	1.61a	Z37	3.95b	1.54b
Bicudo	3.85b	1.58a	Z21	3.22c	1.52b
Alecrim	3.67c	1.55b	Z36	3.51c	1.50b
700	3.24c	1.56b	Ouro Negro	3.74c	1.54b
CH1	3.89b	1.54b	18	4.50a	1.57a
Imbigudinho	3.59c	1.51b	Tardio C	3.67c	1.57a
AD1	3.20c	1.58a	A1	4.00b	1.52b
Graudão HP	3.44c	1.54b	Cheique	3.98b	1.56b
Valcir P	3.67c	1.55b	P2	3.42c	1.54b
Beira Rio 8	4.60a	1.59a	Emcapa 02	3.44c	1.57a
Tardio V	3.37c	1.63a	Emcapa 153	3.48c	1.54b
AP	3.38c	1.55b	P1	3.66c	1.51b
L80	3.88b	1.57a	LB1	3.39c	1.54b
Bamburral	3.95b	1.51b	122	3.63c	1.51b
Pirata	3.99b	1.59a	Verdim D	3.66c	1.53b
Peneirão	3.59c	1.52b	Sementes	3.64c	1.60a
Z39	3.72c	1.52b	Emcapa 143	3.34c	1.56b
Z35	4.06b	1.65a	Ouro Negro 1	3.66c	1.64a
Z40	3.78c	1.57a	Ouro Negro 2	3.46c	1.53b
Z29	3.81b	1.61a	Clementino	3.96b	1.50b
Z38	3.93b	1.58a	mean[a]	3.72	1.56

Note. Means followed by the same letter in a column do not differ by the Scott–Knott test at 5% probability. Coefficient of variation = RFW/DSW: 11.07%; RFV/RFW: 4.85%.

[a]Overall mean of the genotypes.

3 | RESULTS

The data of the analyzed variables differed significantly between the genotypes (Table 2). The relationship between ripe fruit weight and dry green coffee weight (RFW/DSW) discriminated the genotypes into three groups. The genotypes B01, Beira Rio 8, and 18 had the highest mean ratios (4.60, 4.50, and 4.34, respectively), indicating a lower seed yield. These three genotypes also constituted the group with the highest ratio between ripe fruit volume and weight (RFV/RFW) and the group with the lowest percentage of seeds per fruit (% of seeds) (Figure 2) (i.e., a lower yield of these genotypes, which is undesirable for coffee breeding and cultivation).

A second group was formed by 13 genotypes with intermediate yield, as indicated by the RFW/DSW ratio. For the third group, with 26 genotypes plus the seed-derived coffee population, this ratio was the lowest (Table 2). The RFW/DSW of the intermediate group ranged from 3.81 (Genotype Z29) to 4.18 (Verdim R), whereas the group with the lowest ratio had values between 3.20 (genotype AD1) and 3.78 (Genotype Z40).

In the evaluation of the RFV/RFW ratios, two groups were formed (Table 2). The first group with the highest values (lowest yield) comprised 16 genotypes and the seed-derived coffee population and had a mean ratio of 1.59. The lowest RFV/RFW ratio was 1.50, and the highest was 1.65 (i.e., a difference of 9.1% between the extremes). Comparatively, for the RFW/DSW ratio, the difference between the lowest and highest value was 30.4% (3.20–4.60) and 25.0% (48.31–64.44) for seed percentage. The minor variations between the RFV/RFW ratios indicate that this variable has little influence on the classification of genotypes for the quantity of cherry fruits needed for a given quantity of green coffee.

For seed weight percentage of the total fruit weight, four groups were formed (Figure 2). The first, with the highest percentage, contained nine genotypes, the second contained 15 genotypes, the third contained 12 genotypes plus the seed-derived population, and the fourth group, with the lowest seed percentage, comprised six genotypes. This characteris-

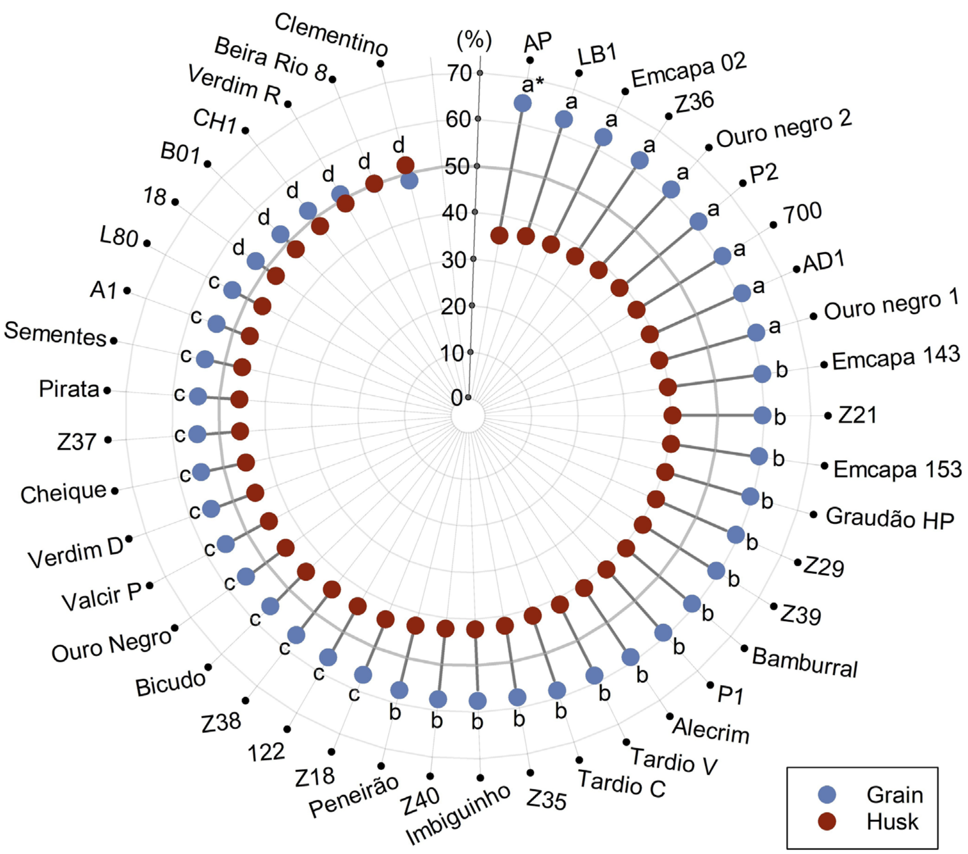

FIGURE 2 Genotypes followed by the same letters do not differ by the Scott–Knott test at 5% probability for the percentage of husk and seeds in the fruits. Coefficient of variation (%) = 6.56

tic informs the percentage of fruit weight related to the seed and percentage of fruit weight related to the husk. Therefore, it is expected that a higher seed weight percentage in the fruits is positively correlated with yield.

In general, the genotypes with lowest seed percentage are those with the lowest yield and the highest RFW/DSW ratio. This fact was confirmed by the highest RFW/DSW ratios and low seed percentages found for the genotypes Beira Rio 8, 18, and B01.

The group with the highest percentage of seed per fruit comprised the genotypes AP, LB1, Emcapa 02, Z36, Ouro Negro 2, P2, 700, AD1, and Ouro Negro 1, with a mean of 62.02% of seed per fruit. In agreement with the results of our study, Covre et al. (2016) found similar values for the genotype used in their study (Emcapa 02), with 65% of green coffee in relation to the RFW. The genotypes 18, B01, CH1, Verdim R, Beira Rio 8, and Clementino constituted the group with the lowest yields, with a mean of 51.08% of seeds per fruit.

A great variability between genotypes was observed in terms of the volume required to produce a 60-kg bag and for 1 ton of green coffee (Table 3). Yields ranged from 294.01 to 439.72 L of ripe coffee to obtain one 60-kg bag, which represents a 33.1% variation between the evaluated genotypes. The weight of mature coffee required for one bag of green coffee also varied between genotypes, as well as the proportion between weight measuring units (20 kg) of ripe coffee to one bag of green coffee.

Considering the mean of all genotypes, 347.57 L and 223.24 kg of cherry fruits are needed for one bag of green coffee (60 kg). The volume is higher than the value used commonly in the field of 320 L for a 60-kg bag. Among the tested genotypes, the yield of 10 exceeded this commonly used benchmark. The mean yield of the seed-derived plants was 348.06 L bag^{-1} or 223.24 kg bag^{-1} (i.e., very close to the overall mean of the evaluated genotypes).

The genotypes Z21, 700, AD1, LB1, Emcapa 143, and AP required less than 315 L of mature coffee for a 60-kg bag of green coffee beans (Table 3). These same genotypes were grouped in the cluster with the lowest RFW/DSW ratio, which was not observed for the RFV/RFW ratio. However, an analysis of the grouping for the RFV/RFW ratio shows that not all of these genotypes are part of the group with the lowest means. This suggests that the strongest influence on seed yield is the RFW/DSW ratio.

4 | DISCUSSION

The coffee yield, which is the ratio of the amount of ripe fruits to processed beans, differed between the evaluated genotypes,

TABLE 3 Mean yield in liters of ripe coffee per 60-kg bag, liters of ripe coffee per ton of processed beans, weight of ripe coffee per 60-kg bag, and proportion between the number of weight measuring units (20 kg) of ripe coffee (RC) for a 60-kg bag, 42 *Coffea canephora* genotypes, and one seed-derived coffee population grown in Nova Venécia, Espírito Santo, Brazil

Genotypes	Ripe coffee per 60-kg bag	Ripe coffee per ton of processed beans	Weight of ripe coffee per 60-kg bag	RC/ bag	Genotypes	Ripe coffee per 60-kg bag	Ripe coffee per ton of processed beans	Weight of ripe coffee per 60-kg bag	RC/ bag
	L bag^{-1}	L ton^{-1}	kg bag^{-1}			L bag^{-1}	L ton^{-1}	kg bag^{-1}	
Z21	294.01	4,900.09	193.05	10:1	Tardio C	345.15	5,752.42	220.24	11:1
700	303.23	5,053.84	194.33	10:1	Ouro Negro	346.39	5,773.22	224.65	11:1
AD1	303.49	5,058.16	192.19	10:1	Sementes	348.06	5,801.06	218.17	11:1
LB1	312.21	5,203.45	203.10	10:1	Clementino	355.48	5,924.64	237.36	12:1
Emcapa 143	312.26	5,204.33	200.38	10:1	Z40	356.18	5,936.34	226.70	11:1
AP	313.53	5,225.46	202.71	10:1	Bamburral	357.23	5,953.77	236.98	12:1
Ouro Negro2	316.46	5,274.37	207.42	10:1	Ouro Negro1	359.87	5,997.83	219.72	11:1
Z36	316.62	5,276.98	210.47	11:1	CH1	359.87	5,997.91	233.36	12:1
P2	316.70	5,278.41	205.36	10:1	Z37	363.78	6,062.99	236.84	12:1
Graudão HP	317.59	5,293.18	206.14	10:1	L80	364.68	6,077.98	232.62	12:1
Emcapa 153	322.45	5,374.16	208.92	10:1	A1	365.44	6,090.64	239.71	12:1
Emcapa 02	323.18	5,386.33	206.16	10:1	Bicudo	366.21	6,103.54	231.16	12:1
Imbigudinho	324.82	5,413.65	215.61	11:1	Z29	366.61	6,110.20	228.40	11:1
Peneirão	326.60	5,443.34	215.29	11:1	Cheique	372.10	6,201.69	238.83	12:1
Tardio V	329.95	5,499.11	202.35	10:1	Z38	372.53	6,208.90	235.89	12:1
122	330.03	5,500.44	217.93	11:1	Pirata	379.63	6,327.23	239.50	12:1
Z18	330.20	5,503.26	214.25	11:1	Verdim R	398.32	6,638.67	250.97	13:1
P1	332.50	5,541.62	219.70	11:1	Z35	402.23	6,703.88	243.46	12:1
Verdim D	336.65	5,610.83	219.62	11:1	B01	418.21	6,970.15	260.54	13:1
Z39	339.92	5,665.38	223.33	11:1	18	422.67	7,044.42	269.76	13:1
Valcir P	341.11	5,685.09	220.18	11:1	Beira Rio 8	439.72	7,328.62	275.76	14:1
Alecrim	341.46	5,691.02	220.40	11:1	mean[a]	347.57	5,792.76	223.24	11:1

[a]Overall mean of the genotypes.

indicating genetic variability within the set. This variability can be exploited in breeding programs, contributing significantly to the discrimination of superior genotypes (Giles et al., 2018).

Morphologically, coffee fruits are composed of the following parts: the pericarp (i.e., exocarp, mesocarp, and endocarp), the perisperm, and the endosperm, which is the storage tissue where the embryo is located (Castro & Marraccini, 2006). During processing, part of these fruit components is discarded, forming a mixture of residues called "coffee husk." The component endosperm is not discarded in this process because it is considered part of the bean, which is the commercialized part of the fruit. The higher or lower percentage of seed weight per fruit in different genotypes indicates genotypic variation of biomass allocation to the different fruit constituents. In contrast to the other genotypes, 18, B01, CH1, Verdim R, Beira Rio 8, and Clementino accumulate more energy in the form of biomass in the different fruit parts discarded after processing, which reduces the percentage of seed per fruit of these genotypes.

Green coffee yield is measured after drying and dehulling of the coffee fruits, and the higher or lower weight of green coffee beans is directly related to biomass accumulation in the fruits, which differs between the *C. canephora* genotypes (Prezotti & Bragança, 2014). The yield estimate based on the coffee fruit yield volume does not take the biomass accumulated in coffee fruits into consideration because the accumulated biomass can be different for the same fruit volume, according to the genotype. Thus, the dry matter accumulation in coffee fruits, especially in the endosperm, affects the green coffee yield based on fruit volume, indicating that genotypes with a higher green coffee yield per unit fruit volume may have more accumulated biomass in the fruits.

According to these results, the conventional value of 320 L bag^{-1} would lead to an overestimation of the crop productivity for some genotypes and to an underestimation in the case of others. However, based on the overall mean for all genotypes, the volume of 320 L bag^{-1} overestimates the productivity of *C. canephora* coffee. On the other hand, this practical rule of thumb of 320 L bag^{-1}, commonly observed by farmers, is an approximation because the harvested coffee is not always fully ripe (but includes dry and green cherries), and sometimes the coffee is left in the field for a few days.

5 | CONCLUSION

Under the study conditions, variability in the proportion of mature cherry to green coffee yield was observed between the *C. canephora* genotypes. The mean yield of the evaluated genotypes to produce one 60-kg bag of green coffee is 347 L or 223 kg.

Some genotypes have a higher proportion of mature cherry to green coffee yield. The genotypes Z21, 700, AD1, LB1, Emcapa 143, and AP stand out for needing less than 315 L of ripe coffee for the production of one 60-kg bag of green coffee.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGMENTS

This work was supported by The Universidade Federal do Espírito Santo; the Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (Grant 84320893); the Conselho Nacional de Desenvolvimento Científico e Tecnológico (Grants 420789/2016-2 and 304687/2017-0), and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Finance Code 001). The authors thank the first breeders (i.e., the farmers who performed the initial selection of most superior genotypes currently available) and the farmer Thekson Pianissoli.

ORCID

Fábio Luiz Partelli https://orcid.org/0000-0002-8830-0846
Gleison Oliosi https://orcid.org/0000-0001-8911-4976
Jéssica Rodrigues Dalazen https://orcid.org/0000-0002-6661-5302
Cleidson Alves da Silva https://orcid.org/0000-0003-2802-682X
Henrique Duarte Vieira https://orcid.org/0000-0002-1933-3249
Marcelo Curitiba Espindula https://orcid.org/0000-0001-7481-9746

REFERENCES

Alvares, C. A., Stape, J. L., Sentelhas, P. C., Gonçalves, J. L. M., & Sparovek, G. (2013). Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, *22*, 711–728. https://doi.org/10.1127/0941-2948/2013/0507

Bonomo, D. Z., Bonomo, R., Partelli, F. L., & Souza, J. M. (2017). Genótipos de café Conilon sob ajuste de diferentes coeficientes de cultura ajustados. *Irriga*, *22*, 236–248. https://doi.org/10.15809/irriga.2017v22n1p236-248

Bragança, S. M., Carvalho, C. H. S., Fonseca, A. F. A., & Ferrão, R. G. (2001). Variedades clonais de café Conilon para o estado do Espírito Santo. *Pesquisa Agropecuária Brasileira*, *36*, 765–770. https://doi.org/10.1590/S0100-204x2001000500006

Brazil Ministério da Agricultura, Pecuária e Abastecimento. (2009). *Regras para análise de sementes*. https://www.gov.br/agricultura/pt-br/assuntos/laboratorios/arquivos-publicacoes-laboratorio/regras-para-analise-de-sementes.pdf/view

Carvalho, A., Filho M., P. H., Fazuoli, L. C., Guerreiro Filho, O., & Lima, M. M. A. (1991). Aspectos genéticos do cafeeiro. *Revista Brasileira de Genética*, *14*, 135–183.

Castro, R. D., & Marraccini, P. (2006). Cytology, biochemistry and molecular changes during coffee fruit development. *Brazilian Journal of Plant Physiology*, *18*, 175–199. https://doi.org/10.1590/S1677-04202006000100013

Covre, A. M., Rodrigues, W. P., Vieira, H. D., Braun, H., Ramalho, J. C., & Partelli, F. L. (2016). Nutrient accumulation in bean and fruit from irrigated and non-irrigated *Coffea canephora* cv. Conilon. *Emirates Journal of Food and Agriculture*, *28*, 402–409. https://doi.org/10.9755/ejfa.2016-04-341

Davis, A. P., Tosh, J., Ruch, N., & Fay, M. F. (2011). Growing coffee: *Psilanthus* (Rubiaceae) subsumed on the basis of molecular and morphological data: Implications for the size, morphology, distribution and evolutionary history of *Coffea*. *Botanical Journal of the Linnean Society*, *167*, 357–377. https://doi.org/10.1111/j.1095-8339.2011.01177.x

Dubberstein, D., Partelli, F. L., Guilhen, J. H. S., Rodrigues, W. P., Ramalho, J. C., & Ribeiro-Barros, A. I. (2020). Biometric traits as a tool for the identification and breeding of *Coffea canephora* genotypes. *Genetics and Molecular Research*, *19*, gmr18541. https://doi.org/10.4238/gmr18541

Giles, J. A. D., Ferreira, A. D., Partelli, F. L., Aoyama, E. M., Ramalho, J. C., Ferreira, A., & Falqueto, A. R. (2019). Divergence and genetic parameters between *Coffea* sp. genotypes based in foliar morpho-anatomical traits. *Scientia Horticulturae*, *245*, 231–236. https://doi.org/10.1016/j.scienta.2018.09.038

Giles, J. A. D., Partelli, F. L., Ferreira, A., Rodrigues, J. P., Oliosi, G., & Silva, F. H. L. (2018). Genetic diversity of promising 'conilon' coffee clones based on morpho-agronomic variables. *Anais da Academia Brasileira de Ciências*, *90*, 2437–2446. https://doi.org/10.1590/0001-3765201820170523

Herzog, T. T., Silva, B. S. O., Silva, M. B., Partelli, F. L., & Souza, A. F. (2018). Efeito de fungicidas no cafeeiro Conilon. *Nativa*, *6*, 435–442. https://doi.org/10.31413/nativa.v6i5.5664

International Coffee Organization (ICO). (2020). *Trade statistics*. http://www.ico.org/new_historical.asp?section=Statistics

Lima, L. A., Custódio, A. A. P., & Gomes, N. M. (2008). Produtividade e rendimento do cafeeiro nas cinco primeiras safras irrigado por pivô central em Lavras, MG. *Ciência e Agrotecnologia, Lavras*, *32*, 1832–1842. https://doi.org/10.1590/S1413-70542008000600023

Martins, M. Q., Partelli, F. L., Ferreira, A., Bernardes, C. O., Golynski, A., Vieira, H. D., Freitas, M. S. M., & Ramalho, J. C. (2019). Genetic variability on nutrient contents in *Coffea canephora* genotypes cultivated at 850 meters of altitude in two crop seasons. *Functional Plant Breeding Journal*, *1*, 1–12. https://doi.org/10.35418/2526-4117/v1n1a6

Martins, Q. M., Partelli, F. L., Golynski, A., Pimentel, N. S., Ferreira, A., Bernardes, C. O., Ribeiro-Barros, A. I., & Ramalho, J. C. (2019). Adaptability and stability of *Coffea canephora* genotypes cultivated at high altitude and subjected to low temperature during the winter. *Scientia Horticulturae*, *252*, 238–242. https://doi.org/10.1016/j.scienta.2019.03.044

Medina Filho, H. P., & Bordignon, R. (2003). Rendimento intrínseco: Critério adicional para selecionar cafeeiros mais rentáveis. Informações Técnicas. *O Agronômico*, *55*.

Nowak, M. D., Davis, A. P., Anthony, F., & Yoder, A. D. (2011). Expression and trans-specific polymorphism of self-incompatibility RNases in *Coffea* (Rubiaceae). *PLOS ONE*, *6*, e21019. https://doi.org/10.1371/journal.pone.0021019

Oliosi, G., Giles, J. A. D., Rodrigues, W. P., Ramalho, J. C., & Partelli, F. L. (2016). Microclimate and development of *Coffea canephora* cv. Conilon under different shading levels promoted by Australian cedar (*Toona ciliata* M. Roem. var. Australis). *Australian Journal of Crop Science*, *10*, 528–538. https://doi.org/10.21475/ajcs.2016.10.04.p7295x

Partelli, F. L., Giles, J. A. D., Oliosi, G., Covre, A. M., Ferreira, A., & Rodrigues, V. M. (2020). Tributun: A coffee cultivar developed in partnership with farmers. *Crop Breeding and Applied Biotechnology*, *20*, e30002025. https://doi.org/10.1590/198470332020v20n1c21

Partelli, F. L., Golynski, A., Ferreira, A., Martins, M. Q., Mauri, A. L., Ramalho, J. C., & Vieira, H. D. (2019). Andina: First clonal cultivar of high-altitude conilon coffee. *Crop Breeding and Applied Biotechnology*, *19*, 476–480. https://doi.org/10.1590/1984-70332019v19n4c68

Santos, H. G., Jacomine, P. K. T., Anjos, L. H. C., Oliveira, V. A., Lumbreras, J. F., Coelho, M. R., Almeida, J. A., Araujo Filho, J. C., Oliveira, J. B., & Cunha, T. J. F. (2018). *Sistema brasileiro de classificação de solos* (5th ed.). Embrapa.

Silva, D. O., Ferreira, F. M., Rocha, R. B., Espindula, M. C., & Spinelli, V. M. (2018). Genetic progress with selection of *Coffea canephora* clones of superior green coffee yield. *Ciência Rural*, *48*, e20170443. https://doi.org/10.1590/0103-8478cr20170443

Silva, L. O. E., Schmidt, R., Valani, G. P., Ferreira, A., Ribeiro-Barros, A. I., & Partelli, F. L. (2020). Root trait variability in *Coffea canephora* genotypes and its relation to plant height and crop yield. *Agronomy*, *10*, 1394. https://doi.org/10.3390/agronomy10091394

Vaccarelli, V. N., Medina Filho, H. P., & Fazuoli, L. C. (2003). Relação entre rendimentos, frutos chochos e sementes tipo moca em diversos híbridos Arabusta. *Bioscience Journal*, *19*, 155–165. http://200.19.146.79/index.php/biosciencejournal/article/view/6482

Vázquez, N., López-Fernández, H., Vieira, C. P., Fdez-Riverola, F., Vieira, J., & Reboiro-Jato, M. (2019). M. BDBM 1.0: A desktop application for efficient retrieval and processing of high-quality sequence data and application to the identification of the putative *Coffea* S-Locus. *Interdisciplinary Sciences: Computational Life Sciences*, *11*, 57–67. https://doi.org/10.1007/s12539-019-00320-3

How to cite this article: Partelli FL, Oliosi G, Dalazen JR, da Silva CA, Vieira HD, Espindula MC. Proportion of ripe fruit weight and volume to green coffee: Differences in 43 genotypes of *Coffea canephora*. *Agronomy Journal*. 2021;1–9. https://doi.org/10.1002/agj2.20617