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Yield, maturation, and beverage quality of arabica coffee progenies under selection in Rondonia state, Brazil

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In this paper, we studied coffee bean yield, maturation, and other characteristics of special progenies of Arabica coffee (*Coffea arabica* L.) grown under high temperatures in a low altitude region in the state of Rondonia, Brazil. We evaluated 29 progenies developed by the Instituto Agronômico de Campinas – IAC, namely, 24 F_2BC_2 progenies of Obatã (*C. arabica* with introgressions of *C. canephora*) x (*C. eugenioides* 4n x *C. arabica*), three F_3 progenies of Catuaí x Glaucia, and two H419 lines. Seven cultivars were used as controls. A randomized block design was used with three replications, spacing of 3.0 × 1.0 m, and ten plants per plot. All the crop seasons showed a significant difference for the hulled coffee yield trait. In combined analysis, significant difference was detected among progenies, among controls, and in the progeny vs control contrast. In the average of the four harvests, hulled coffee yield was 29.30 bags ha^{-1}. The F_2 progeny Obatã x (Catuaí x EUG DP x MN) C.1594 stood out from the others with a mean yield of 47.37 bags ha^{-1}. The cultivars received beverage scores from 40 to 62, "rioysh" to "hard" beverage classification, while the progenies had scores from 40 to 80, "rio" to "barely soft" beverage classification. In regard to the maturation cycle, eleven progenies were late (April), eleven intermediate (March), and seven early (February). For continuity of advancement of generations, 104 plants were selected, derived from 22 progenies with the best productive performance, late maturation cycle, and good beverage quality.

Key words: *Coffea arabica* L., coffee plant breeding, heat tolerance.

INTRODUCTION

The estimate for the production of the coffee crop (Arabica and Canephora species) in 2014, indicates that Brazil will harvest 44.57 million bags of 60 pounds of processed coffee. With this result this season breaking the trend of growth of production, since the harvest of 2005 had been watching us the highs biannuality (annual

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alternation between large and small productions), including getting down the last harvest that was low (Conab, 2014). The result represents a reduction of 9.33% or 4.58 million bags compared with the production of 49.15 million bags obtained in the preceding cycle. Arabica represents 72.4% of total production coffee country. According to Conab, the reduction is due to the severe drought seen in the first months of 2014 and the reversal of biannuality in some producing regions.

Coffee consumption in the world in 2020 will be 166.10 million bags, which represents a 17% increase compared to the 2012 production of 142 million bags. Brazil is currently the largest producer and exporter of coffee beans, achieving a record harvest of 49.2 million bags in 2013. Among several factors, the high temperatures have limited the growth and expansion of Arabica coffee in various countries, including Brazil. The *C. arabica* species reveals its greatest potential at mean annual temperatures ranging from 18 to 23ºC. Above this range, innumerable physiological disorders are observed in the flowers and fruits of the coffee plant, resulting in yield losses and poor beverage quality. The incidence of high temperatures leads to early maturation of the fruits, resulting in loss of quality (Camargo, 1985; Damatta and Ramalho, 2006). High air temperatures during flowering, associated with an extended dry season, results in aborted flowers and, consequently, significant yield reductions (Fazuoli et al., 2007).

Due to the high temperatures registered in most of the state of Rondonia, near 26ºC, all the coffee grown in the state is of the *C. canephora* species (Robusta coffee), Arabica coffee not being represented in production. All the Arabica coffee consumed in Rondonia and other states of the North region is imported from typical production regions such as Minas Gerais and São Paulo (Souza and Santos, 2009). Since 98% of the production of the state is composed of Robusta coffee beans, local industries produce coffees with a minimum percentage of Arabica coffee. Many coffees available to the local consumer are practically 100% Robusta coffee. In North region, the per capita annual consumption is 4.80 kg of roasted coffee, and there is an estimated demand of 1.66 million bags. Aiming to meet this demand only with blends,would be necessary 830 thousand bags of Arabica coffee for the composition, considering a 50% Arabica / 50% Robusta percentage. In addition, there is the perspective of an increase in coffee consumption and in the specialty and gourmet coffee market (Abic, 2013).

Currently, there are no Arabica coffee cultivars recommended for the state of Rondonia, where the genetic materials used are of unknown origin, or even cultivars from other regions that were introduced without recommendation. In contrast, the perception of an increasing demand for Arabica coffee in the region, associated with growth in the specialty and gourmet coffee market, accounts for the interest in developing a cultivar adapted to the edaphic and climatic conditions of the region.

The present study reports the yield, maturation cycle, and beverage quality of progenies especially selected in the IAC for adaptation to the conditions of the state of Rondonia.

MATERIALS AND METHODS

The experiment was set up in September 2005 in the experimental field of Embrapa in the municipality of Ouro Preto do Oeste, RO, Brazil, geographic coordinates of 10º44'53"S and 62º12'57"W. The climate is classified as Tropical Rainy, Aw (Köppen classification), with a mean annual temperature of 25.8°C and mean annual rainfall of 2,000 mm. Mean altitude of the region is 240 m and relative air humidity is around 82% most of the year.

A total of 36 Arabica coffee genotypes were evaluated, consisting of 29 progenies and seven control cultivars. The progenies are derived from hybridizations carried out in the Instituto Agronômico de Campinas – IAC, Campinas, SP, Brazil (Medina Filho et al., 2012), from late maturity cultivars of high yield performance and good beverage quality. From these crosses, 126 backcrossed hybrids of Obatã (BC_2) with *C. arabica* x (*C. eugenioides* 4n x *C. arabica*) were obtained. Under study in Campinas, 24 of them were selected for very late maturity (F_2BC_2), characteristic of *C. eugenioides*, desirable for the tropical conditions of Rondonia. Three F_3 progenies of Catuaí x Glaucia and two H419 lines were also selected since they exhibited late maturity. The cultivars Bourbon Amarelo, Catuaí Amarelo, Catuaí Vermelho IAC 15, Obatã, Obatã Vermelho (late), Oeiras, and Topázio MG 1190 were used as controls.

A randomized block experimental design was used with three replications, ten plants per plot, and spacing of 3.0 × 1.0 m. The experiments were evaluated during four crop season (2007/2008, 2008/2009, 2009/2010 and 2011/2012) and conducted according to the fertilization recommendations coffee. The normal management practices used for the crop were adopted. Problems in the release of funds in 2010 made it unfeasible the cultivation and harvesting of the 2010/2011 season, making it impossible to collect data. Yield was assessed in 60 kg bags of hulled coffee per hectare (bags ha^{-1}). Harvest was carried out in individual plots, measured in liters of "café da roça" (coffee fruits of mixed maturity) per plot. Subsequently, the volume of coffee harvested was converted to bags ha^{-1}, considering the mean yield of a bag of 60 kg of hulled coffee for each 480 L of "café da roça". This yield corresponds to the regional average.

The fruit maturation of the *C. arabica* species in climatic conditions of Rondonia usually occurs in february. Thus, the maturation cycle of the plants was determined considering the interval of 20 to 30 days between harvests. The criterion for classification: Early (E) in february; Intermediate (I) in march; Late (L) in april.

The percentage of poorly filled fruits was obtained from an initial sample of one liter of coffee from which one hundred fruits in the cherry stage were deposited in a container with water to count the number of floater fruits (Medina Filho and Bordignon, 2003).

For the evaluations of beverage quality, samples were harvested manually from four different points of the middle upper third of the plants. The collection period was from the months of February to April, before the beginning of harvest, depending on the degree of maturity of the plot. A manual pulper with continual water flow was used for processing. The coffee was dried on a covered cement yard, until reaching a moisture level of approximately 11%. The dried samples were hulled and placed in paper packaging until analysis. Sensory analysis of the beverage quality was performed by two cuppers, with only one determination or cupping per cupper

Table 1. Summary of combined analysis of variance and estimates of heritability (h^2) and selective accuracy ($\hat{r}_{\hat{g}g}$) for hulled coffee yield (bags ha^{-1}) in regard to the 2007/2008, 2008/2009, 2009/2010, and 2011/2012 crop seasons (Ouro Preto do Oeste, Rondonia, Brazil, 2013).

SV	DF	Mean square
		Hulled coffee(bags ha^{-1})
Blocks	2	408.9916
Treatments	35	567.3459**
Progenies	28	575.5037**
Controls	6	419.1006**
Progenies vs. controls	1	1228.4018**
Crop seasons	3	37331.4234**
Treatments x crop seasons	105	192.2146**
Progenies x crop seasons	84	200.3860**
Controls x crop seasons	18	146.9110**
Progenies vs. Contr. x crop seasons	3	235.2379*
Residue	286	69.6340
Overall mean	29.30	
Heritability (h^2)	87.73	
Selective Accuracy ($\hat{r}_{\hat{g}g}$)	81.32	

**, *: Significant, at 1 and 5% by the F test, respectively.

for each sample. Each sample composed of three cups was analyzed for sensory characteristics by the protocol of the Specialty Coffee Association of America (SCAA, 2014) in regard to aroma, clean cup, uniformity, sweetness, body, acidity, flavor, aftertaste, balance, and overall impression. The combination of these properties determined the value of the overall score of each sample.

The yield data of hulled coffee were subjected to analysis of variance with the significance of the effects verified by the F test at 5% probability. Selective accuracy ($\hat{r}_{\hat{g}g}$), determined by means of the expression $\hat{r}_{\hat{g}g} = (\mathrm{F}-1/\mathrm{F})^{1/2}$ (in which F is the value of the F test of Snedecor for the genotype effect (Resende and Duarte, 2007), was estimated to check experimental precision. Analyses of variance and gain in selection were carried out using the computational software Genes (Cruz, 2013).

RESULTS

Combined analysis of all the crop seasons shows a significant difference among treatments for the hulled coffee yield characteristic (Table 1). The same result was observed among progenies and among controls, manifesting the large genetic variability among the genotypes evaluated. The analyses among crop seasons also exhibited significant differences for yield.

The progeny vs. control contrast was also significant for hulled coffee yield, indicating that the progenies and controls had different behaviors for this characteristic (Table 1). The breakdown of the sum of squares of the progeny x crop season source of variation indicated significance for yield, showing that the behavior of the progenies was not the same in all the harvest seasons (Table 1). The significant progeny vs. control x crop season interaction for hulled coffee yield indicated that the performance of the progenies was different from that of the controls, in all the crop seasons. In Table 2, the mean values of the progenies and of the controls are indicated, where it may be observed that most of the progenies were greater than the controls in coffee bean production. All the crop seasons showed selective accuracy estimates of high magnitude (75.25% < $\hat{r}_{\hat{g}g}$< 91.79%), indicating good experimental precision. The lowest mean yield was observed in the 2007/08 crop season (8.61 bags ha^{-1}).

The low yield is due to the fact that this was the first production. In the 2008/09 crop season, the overall mean value was 18.93 bags ha^{-1}. In 2009/2010 and 2011/2012, satisfactory yields were obtained, with mean values of 48.05 and 41.55 bags ha^{-1}, respectively. These yields obtained in the experimental field studied are expressive if we consider the geographic location, latitude, and local climatic conditions of low altitude and high temperatures (Figure 1). The mean value of the four harvests was 29.30 bags ha^{-1} (Table 2), and the mean value of the progenies was 30.11 bags ha^{-1}, 14% above the mean value of the controls (25.85 bags ha^{-1}). It should be noted that 22% of the genotypes exhibited yields above 35 bags ha^{-1}, among which the F_2 progeny Obatã x (Catuaí x EUG DP x MN) C.1594 stands out, with a mean value of 47.37 bags ha^{-1} (Table 2). It is interesting to note that the heritability estimated for hulled coffee yield of this experimental field was 87.73% (Table 1), stimulating subsequent selections. The overall

Table 2. Mean estimate of the agronomic traits of 29 progenies and seven cultivars of *Coffea arabica* in regard to hulled coffee yield (bags ha^{-1}), percentage of poorly filled fruits (%), maturation cycle, and color of the fruits for the crop seasons of 2007/2008, 2008/2009, 2009/2010, and 2011/2012. Ouro Preto do Oeste, Rondonia, Brazil, 2013.

Progenies	Hulled coffee (bags ha^{-1})	Poorly filled fruits (%)	Maturation cycle[1]	Fruit color[2]
Progenies				
F_2 Obatã x (Catuaí x EUG DP x MN) C.1594	47.37	13	L	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1595	38.73	19	I	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1597	38.38	12	E	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1575	37.68	18	E	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1526	36.98	21	I	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1576	36.40	10	L	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1627	35.93	16	I	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1578	35.23	18	L	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1528	33.02	14	I	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1560	32.32	20	I	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1608	32.20	16	L	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1518	31.73	22	L	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1583	31.50	21	I	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1585	31.38	10	I	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1552	31.03	18	L	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1633	30.92	19	L	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1515	30.45	20	I	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1564	29.87	9	I	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1587	27.88	23	L	R
F_3 Catuaí x Gláucia C.277	27.30	17	E	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1551	26.13	23	I	R
H419-10-6-2-10 (Paraíso - Sítio Jatobá)	25.32	16	E	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1562	22.28	26	E	R
F_3 Catuaí x Gláucia C.175	21.47	17	E	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1605	21.23	14	L	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1599	20.07	10	I	R
H419-10-6-2-3-27 (Canteiro 5 - 23)	20.07	10	E	Y
F_3 Catuaí x Gláucia C.182	19.72	12	L	R
F_2 Obatã x (Catuaí x EUG DP x MN) C.1635	19.48	19	L	R
Cultivars				
Obatã Vermelho Tardio (Prop. Altair)	35.93	10	E	R
Obatã	30.33	22	I	R
Bourbon Amarelo	26.95	10	E	Y
Catuaí Vermelho IAC 15	23.92	16	E	R
Catuaí Amarelo	21.47	15	E	Y
Topázio MG 1190 (Canteiro 8 – 23)	21.35	12	E	R
Oeiras (Canteiro 5 – 33)	19.95	22	E	R
Overall Mean	29.30	16.4		
Mean of progenies	30.11			
Mean of controls	25.85			

[1]E = Early; I = Intermediate; L = Late. [2]R = Red; Y = Yellow.

percentage of poorly filled fruits was 16.4%; the mean of the cultivars was 15.3%, and of the progenies 16.7% (Table 2). In the years evaluated, there was no incidence of coffee rust, probably due to the high temperatures

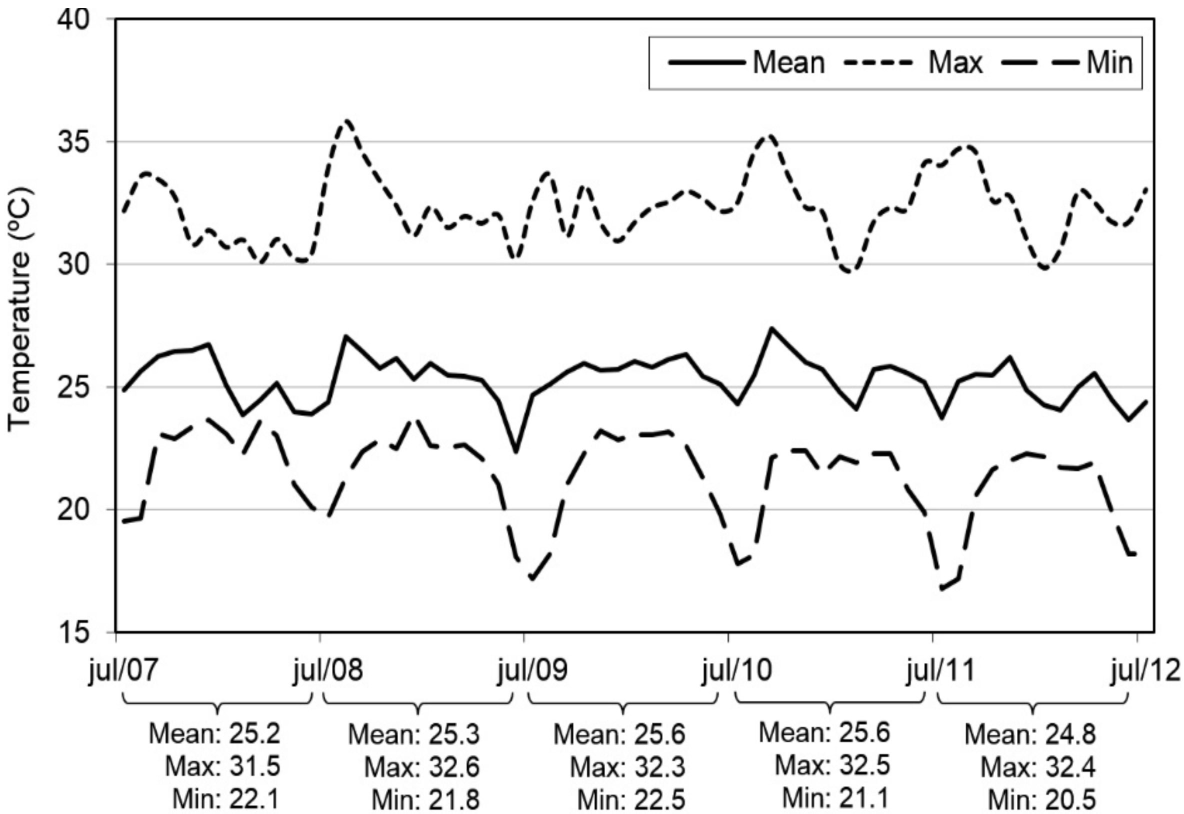

Figure 1. Monthly representation of mean, maximum, and minimum temperatures during the period from July/2007 to July/2012 in Ouro Preto do Oeste, Rondonia. Mean, maximum, and minimum temperatures are also represented by crop seasons (2007/2008, 2008/2009, 2009/2010 and 2011/2012) (Ouro Preto do Oeste, Rondonia, Brazil, 2013).

throughout the crop cycle.

Evaluation of four crop seasons of production allowed the reliability of the genetic parameters in each set of crop seasons to be verified (Table 4). It is fitting to note that only the evaluation of the 1st and 2nd crop season would already be sufficient to estimate the genetic parameters with efficiency, with a coefficient of determination (R^2) of 74.68%. With the inclusion of the 3rd harvest, the value of the R^2 estimates changed little, reaching 78.37%. This information is important because in breeding programs like the one carried out, in which there is the need for advancing generations, the earlier selection is performed, the more dynamic the process of obtaining lines is. In relation to the maturation cycle, it was observed that all the harvests were carried out from the months of February to April. In regard to the difference between progenies, eleven were classified as late cycle (April), 11 as intermediate cycle (March), and 7 as early cycle (February) (Table 2). The control cultivars exhibited an early maturation cycle, except for Obatã, with an intermediate cycle.

Sensory analyses showed that the scores for Overall Quality and SCAA values of the cultivars ranged from 1 to 3 and from 40 to 58, respectively, with beverage types from rioysh to hard (Table 3). The estimates of the same parameters for the progenies proved to be more interesting, with values ranging from 1 to 3.5 and 40 to 80, with beverage types from hard to barely soft.

DISCUSSION

The high accuracy observed in analysis of all the crop seasons shows that the experimental field was well conducted in the various crop years, providing good reliability to the genotypic values obtained for hulled coffee yield. The use of accuracy as a measure of experimental precision, suggested by Resende and Duarte (2007), has the advantage of not depending on the mean, which provides greater security in the use of phenotypic expression as an indicator of genotypic variation. Accuracy values greater than 70% indicate high experimental precision.

The productive performance of the progenies evaluated under the climatic conditions of Rondonia are very similar to the observations in trials for evaluation of progenies conducted by Carvalho et al. (2010) and Botelho et al. (2007) in the southern region of Minas Gerais. Thus, the

Table 3. Estimate of the sensory analyses of 29 progenies and seven cultivars of *Coffea arabica* in regard to Density, Type of beverage, Residual Flavor, Q Global and SCAA, in reference to the 2009/2010 crop year (Ouro Preto do Oeste, Rondonia, Brazil, 2013).

Progenies	Density	Type of beverage	Residual flavor	Q Global	SCAA
Progenies					
F_2 Obatã x (Catuaí x EUG DP x MN) C.1594	1.02	Hard	Harsh/sweet	3	65
F_2 Obatã x (Catuaí x EUG DP x MN) C.1595	1.03	Barely soft	Desir/unbalanced	3	64
F_2 Obatã x (Catuaí x EUG DP x MN) C.1597	1.02	Hard	Astringent	2	56
F_2 Obatã x (Catuaí x EUG DP x MN) C.1575	1.03	Hard	Dirty	1.5	56
F_2 Obatã x (Catuaí x EUG DP x MN) C.1526	1.01	Hard	Harsh	3	60
F_2 Obatã x (Catuaí x EUG DP x MN) C.1576	1.03	Hard	Harsh/acid	2	60
F_2 Obatã x (Catuaí x EUG DP x MN) C.1627	1.03	Barely soft	Des/harsh/sweet	3.5	66.5
F_2 Obatã x (Catuaí x EUG DP x MN) C.1578	1.01	Hard	Und/harsh/bitter	2	60
F_2 Obatã x (Catuaí x EUG DP x MN) C.1528	1.00	Barely soft	Desirable/sweet	3.5	65
F_2 Obatã x (Catuaí x EUG DP x MN) C.1560	1.02	Hard	Harsh	3	67
F_2 Obatã x (Catuaí x EUG DP x MN) C.1608	1.02	Barely soft	Des/sweet/astr	3.5	66
F_2 Obatã x (Catuaí x EUG DP x MN) C.1518	1.02	Hard	Harsh	2	51
F_2 Obatã x (Catuaí x EUG DP x MN) C.1583	1.01	Barely soft	Des/sweet/wodef	3	65
F_2 Obatã x (Catuaí x EUG DP x MN) C.1585	1.00	Hard	Harsh/bitter	2.5	56
F_2 Obatã x (Catuaí x EUG DP x MN) C.1552	1.04	Barely soft	Citri/bodied/sweet	4	80
F_2 Obatã x (Catuaí x EUG DP x MN) C.1633	1.01	Hard	Harsh/astr	2.5	60
F_2 Obatã x (Catuaí x EUG DP x MN) C.1515	1.00	Hard	Undesir/strange	1	51
F_2 Obatã x (Catuaí x EUG DP x MN) C.1564	1.02	Hard	Undesir/astr	1.5	57
F_2 Obatã x (Catuaí x EUG DP x MN) C.1587	1.01	Hard	Harsh	2	57
F_3 Catuaí x Gláucia C.277	0.99	Hard	Undesir	2	52
F_2 Obatã x (Catuaí x EUG DP x MN) C.1551	1.03	Barely soft	Des/bodied/sweet	4	80
Paraíso (H419-10-6-2-10 - Sítio Jatobá)	1.03	Hard	Harsh	3	60.5
F_2 Obatã x (Catuaí x EUG DP x MN) C.1562	1.01	Hard	Astr/acid	2.5	62
F_3 Catuaí x Gláucia C.175	1.01	Hard	Dirty	2	56
F_2 Obatã x (Catuaí x EUG DP x MN) C.1605	1.03	Rioysh	Und/dirty	1	40
F_2 Obatã x (Catuaí x EUG DP x MN) C.1599	1.02	Hard	Harsh	2	58
H419-10-6-2-3-27 (Canteiro 5 – 23)	1.02	Hard	Undesirable	1.5	53
F_3 Catuaí x Gláucia C.182	1.01	Hard	Harsh	2	55
F_2 Obatã x (Catuaí x EUG DP x MN) C.1635	1.02	Barely soft	Des/bodied	3.5	65
Cultivars					
Obatã Vermelho Tardio (Prop. Altair)	1.03	hard	Harsh/unbal	3	58
Obatã	1.03	hard	Harsh/green	2	56
Bourbon Amarelo	1.05	rioysh/rio	Undes/chemical	1	40
Catuaí Vermelho IAC 15	1.01	hard	Desirable	3	62
Catuaí Amarelo	1.00	hard	Undesir	2	55
Topázio MG 1190 (Canteiro 8 – 23)	0.98	hard	Harsh	2	57
Oeiras (Canteiro 5 – 33)	0.98	hard	harsh	2	53.5

results obtained showed that growing of Arabica coffee in the region of Rondonia is promising and provides technical and scientific information that stimulate the progress of the breeding program with the selection of new progenies. The estimate of heritability near 87% corroborates this statement since it indicates the proportion of genetic variance relative to total phenotypic variance, that is, the inheritable proportion of the total variability (Mohsin et al., 2009).

On the maternal side, the gene pool of these progenies is derived from the cultivar Obatã, which is highly productive, but demanding in nutrition and water. It has quite a late cycle in the conditions of the Southeast of Brazil and has resistance to various strains of coffee rust, introgressed characteristics of *Coffea canephora.* On the paternal side, part of the gene pool is derived from the species *Coffea eugenioides* which, under the conditions of Campinas, is also quite late and has good beverage

Table 4. Estimate of the coefficient of determination (R^2) in relation to the number and time period of harvests.

No. of harvests	Crop seasons	Component	R^2
2	1st and 2nd	0.5959	74.68
2	2nd and 3rd	0.4774	64.63
2	3rd and 4th	0.4475	61.83
3	1st, 2nd, and 3rd	0.5470	78.37
3	2nd, 3rd, and 4th	0.3270	59.31
4	All the crop seasons	0.3980	72.56

Values in reference to sets of two, three, and four crop seasons (Ouro Preto do Oeste, Rondonia, Brazil, 2013).

quality, characteristics which segregate in its progenies of backcrosses for *C. arabica* and which were especially selected so as to take advantage of the edaphic and climatic conditions of Rondonia. This study reflects the importance not only of preservation of the genetic resources of *Coffea* and the like, but also the effective use of genetic variability in coffee breeding, meeting the agroindustrial demands of the crop and the regional socioeconomic needs.

The same control cultivars studied here were evaluated by Teixeira et al. (2013) in a competitive trial of cultivars in the municipality of Ouro Preto do Oeste, RO, during the same period. It was observed that the yields and maturation cycles were very similar, indirectly indicating good reliability of the data obtained, which confirm the low adaptation of traditional Arabica cultivars and the superiority of diverse progenies studied in regard to production, late maturation, and beverage quality. Several of them proved to be productive, late, and with good beverage quality, some obtaining 80 points and Overall Quality 4, indices not seen before for Arabica coffees in Rondonia.

Apparent density did not show expressive relationships with other properties, likewise for roasting and its uniformity. Without great differences or restrictions, most of the genotypes exhibited reasonable body, acidity, and bitterness and, with rare exceptions, hard beverage to better, with quite variable residual flavors, some indicative of incomplete maturation and others with desirable characteristics that affected the values of Overall Quality and of the SCAA score. Acidity, which was generally agreeable, exhibited citric profiles of orange or lime. Chocolate notes were present in almost all the samples. The beverage of some progenies also stood out through marked mildness, absent in the beverage of all the cultivars.

In no progeny was the percentage of floaters excessive, a result similar to that found by Botelho et al. (2010) in trials in the southeast of Brazil, indicating that this characteristic was not affected by the high temperatures of Rondonia. The yield of the progenies was the main criterion used to measure their tolerance to thermal stress. Wahid et al. (2007) affirm that heat tolerance is the capacity of the plant to develop and produce under high temperature conditions. Falconer and Mackay (1996) show that the grain yield trait is governed by various genes of small effect on the phenotype, indicating that this trait is quantitative, strongly affected by the environment.

According to Bardin-Camparotto et al. (2012), the thermal factor has an effect on the maturation cycle of the coffee fruits, which when subjected to thermal stress conditions tend to exhibit an earlier maturation cycle. Late maturation was also an important selection criterion. High incidence of rains in the state of Rondonia occurs during the months of October to March. Thus, cultivars with maturation after this period facilitate harvest, drying in the yard, and promotion of better beverage quality.

To proceed with the breeding plan with a view toward the development of varieties of *C. arabica* adapted to Rondonia and similar regions, individual selection of plants was carried out taking into consideration the genealogical distribution, the characteristics of the progenies, and the individual properties of the plants in relation to the others of the progeny. Thus, 104 plants were selected, deriving the F_3BC_2 generation. The plants, genealogically, are derived from 22 progenies elected for their productive performance, late maturation cycle, and good beverage quality. Figure 2 schematically indicates the annual productive performance of the five best progenies selected.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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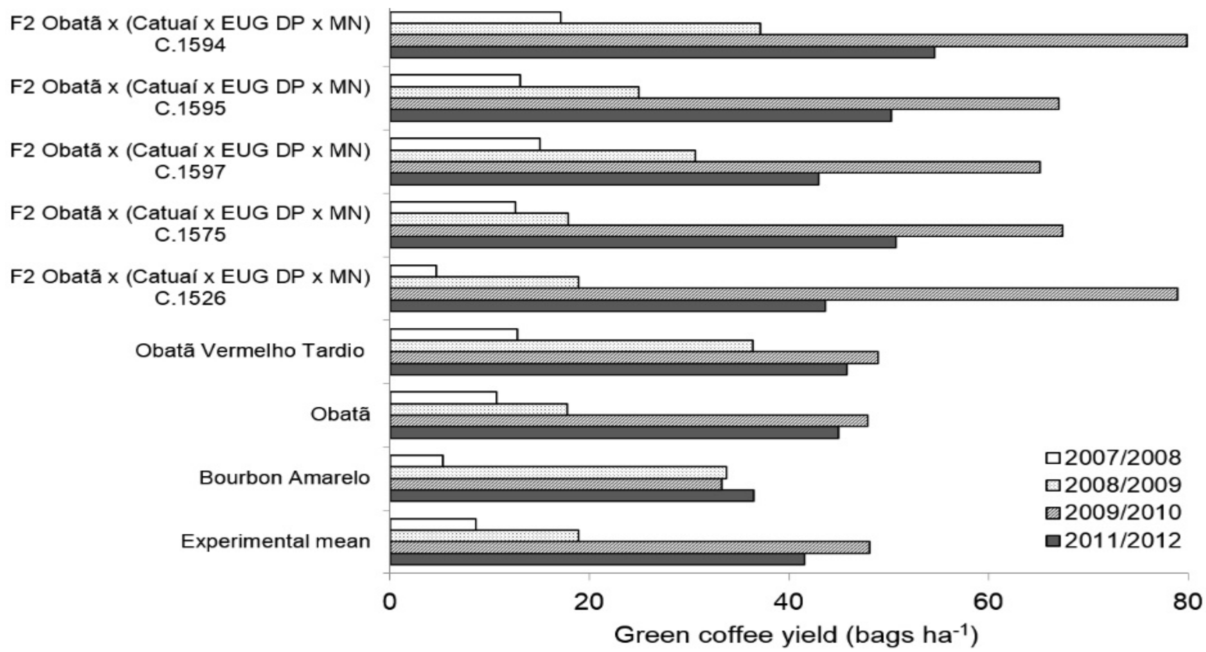

Figure 2. Annual performance of five Arabica coffee progenies and three cultivars that showed the best yield during the 2007/2008, 2008/2009, 2009/2010, and 2011/2012 crop seasons (bags ha^{-1}) (Ouro Preto do Oeste, Rondonia, Brazil, 2013).

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