ADAPTABILITY AND STABILITY OF *Coffea arabica* LINES IN THE WESTERN AMAZON

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ABSTRACT: Growing *Coffea arabica* in regions of the Western Amazon is limited by early maturation and by its limited adaptation to regions of low altitude and high temperature. The aim in this study was to quantify the genotype × environment interaction of *C. arabica* lines in four different environments of the Western Amazon, seeking to assist selection of new lines with greater adaptability and stability for the region. In the months of December 2012 and January 2013, four competitive trials were set up in municipalities of the states of Rondônia and Acre. Each trial was composed of 21 lines and 4 reference cultivars evaluated as controls recommended for planting in the southeast region. In combined analysis, significant differences were not detected between the cultivars and controls; the mean yield of hulled coffee was 12.05 bags ha^{-1}. The Alta Floresta Do Oeste environment has higher yield and is the only environment favorable for growing *C. arabica*; that environment is differentiated from the others through its higher altitudes and low temperatures. Through GGE biplot analyses, lines 12 and 13, identified as H514-7-10-6-9 and H514-7-10-6-2-3-9, were found to have results superior to the controls in the municipality of Alta Floresta Do Oeste, RO. The gain from selection of 56% obtained from line G12 and the gain of 46% obtained from line G13 show performance superior to the best control. The germplasm studied does not have genetic variability that contributes to selection of plants for adaptation to the low altitude and high temperatures in the amazonic region.

Index terms: Arabica coffee, genotype × environment interaction, GGE biplot.

ADAPTABILIDADE E ESTABILIDADE DE LINHAGENS DE *Coffea arabica* NA AMAZÔNIA OCIDENTAL

RESUMO: O cultivo do *Coffea arabica* em regiões da Amazônia Ocidental é limitado pela precocidade de maturação e pela sua menor adaptação a regiões de baixas altitudes e altas temperaturas. O objetivo neste trabalho foi quantificar a interação genótipo x ambientes de linhagens de *C. arabica* em quatro diferentes ambientes da Amazônia Ocidental, buscando subsidiar a seleção de novas linhagens de maior adaptabilidade e estabilidade para a região. Nos meses de dezembro de 2012 e janeiro de 2013 foram instalados quatro ensaios de competição em municípios dos estados de Rondônia e Acre. Cada ensaio foi composto por 21 linhagens e 4 cultivares referências avaliadas como testemunhas indicadas para plantio na região sudeste. Na análise conjunta, não foram detectadas diferenças significativas entre as linhagens e testemunhas, a média da produtividade de café beneficiado foi de 12,05 sacas $há^{-1}$. O ambiente de Alta Floresta Do Oeste apresenta maior produtividade sendo o único ambiente favorável para o cultivo de *C. arabica*, o qual se diferencia dos demais por apresentar altas altitudes e baixas temperaturas. Através das análises gráficas GGE biplot verificou-se que as cultivares 12 e 13 identificadas como H514-7-10-6-9 e H514-7-10-6-2-3-9 obtiveram resultados superiores as testemunhas no município de Alta Floresta Do Oeste, Rondônia. O ganho de seleção obtido de 56% e 46% respectivamente para linhagens G12 e G13 apresentou desempenho superior à melhor testemunha. O germoplasma estudado não apresentou variabilidade genética que subsidie a seleção de plantas adaptadas às regiões de baixa altitude e altas temperaturas da região amazônica.

Termos para indexação: Café arábica, interação genótipo x ambientes, GGE biplot.

1 INTRODUCTION

The species of the *Coffea* genus originate in regions of the African continent that are characterized by abundant and well-distributed rain with humidity near saturation in the rainy season (CRAPARO et al. 2015). *Coffea arabica* is a species native to tropical forests of Ethiopia distributed in an altitude range of 1600-2800 meters above mean sea level, with little variation in air temperature and annual mean temperature of 20ºC (MOAT et al. 2017).

Growing *C. arabica* in regions of the Western Amazon is limited by early maturation of its fruit, which ripens in the period of greatest rainfall from the months of February to April, and by its more limited adaptation to tropical regions, in comparison to the species *C. canephora* (TEIXEIRA et al. 2014; RODRIGUES et al. 2016a). Flower abortion can be observed in regions with temperatures above 30ºC for extended periods in the flowering phase (FERREIRA et al., 2013; RODRIGUES et al., 2016b).

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Climatic zoning for coffee growing classifies regions appropriate for planting as those with temperature from 22ºC to 26ºC and with accumulated water deficit of less than 200 mm (MAPA, 2011). The lack of information regarding development of *C. arabica* in bordering regions limits coffee growing and selection of new materials in the Western Amazon (TEIXEIRA et al., 2014).

Evaluation of new lines in regions of low altitude and high temperature can contribute to the development of new cultivars with greater resilience to climate changes. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2014), in the last fifty years, Brazil has had an increase of 0.7ºC in temperature, a value higher than the mean of global warming of 0.64ºC (FERREIRA; RIBEIRO; SOUZA., 2017). In coffee growing, high temperatures associated with longer dry periods can result in flower abortion, uneven ripening, lower yield, and greater earliness of fruit maturation (PETEK et al., 2009; CAMARGO, 2010). Although lines with greater adaptability to high temperatures have been reported (FAZUOLI; THOMAZIELLO; CAMARGO., 2007; BERGO et al., 2008; MARTINS et al., 2016), evaluations of adaptability and stability of cultivars of this species in the Amazon region are rare.

The greater expenditures of time and resources necessary for evaluation of experiments in different environments complicate quantification of the genotype × environment interaction of perennial species such as *C. arabica* (FURLANI et al., 2007). Such evaluations are performed in the final phases of the program, with the aim of developing new cultivars (SANTOS et al., 2011).

The genotype × environment interaction is associated with changes in the performance of genotypes in different environments, which limits the selection of cultivars with wide adaptability (RESENDE, 2002; ROCHA et al., 2016). When the genotype × environment interaction occurs, selection should consider genotypes of general adaptability, with a view toward recommendation for a set of environments, and identification of genotypes of specific adaptability, to capitalize on the effect of the interaction by selecting individuals adapted to specific environments (BORÉM; MIRANDA; FRITSCHE-NETO, 2017).

Different strategies can be used to quantify the stability and adaptability of the genotypes, understood as the predictability of their response and superior performance in a set of environments (SOUZA et al., 2017). Methods based on multivariate statistics have the advantage of allowing simultaneous evaluation of a large number of genotypes, characterizing the differential performance of the genotypes in different environments (TEN CATEN et al., 2011; ROCHA et al., 2015; SANTOS et al., 2017).

The GGE biplot model (genotype main effects + genotype by environment interaction) is based on principal component analysis to represent the response of genotypes in a set of environments, quantifying the interaction in two-dimensional diagrams that show the relations between the environments and genotypes (YAN et al., 2007). In addition, it has the advantages of using reference points in principal component analyses, as performed in the centroid method (MOURA et al. 2017).

The aim in this study was to quantify the genotype × environment interaction of *C. arabica* lines in four different environments of the Western Amazon to assist in developing new materials with greater adaptability and stability.

2 MATERIALS AND METHODS

In December 2012, four competitive trials were set up, three in municipalities in the state of Rondônia and one in the state of Acre, as detailed below.

Trial nº1 – Carried out in a coffee field in the municipality of Alta Floresta Do Oeste, RO, at 12º08´23.35´´S, 61º59´28.97´´W and 436 m AMSL. The climate in the municipality is the “Aw” type by the Köppen classification, defined as humid tropical, with a dry period during the winter and rainy period during the summer, mean temperature of 23.4°C, and mean annual rainfall of 1783 mm. Mean monthly temperature ranges from 22.3ºC to 24.0ºC, and the highest temperatures occur in August and September (SEDAM, 2012).

Trial nº2 – Carried out in the experimental field of the Empresa Brasileira de Pesquisa Agropecuária in the municipality of Porto Velho, RO, at 8°48’05.5”S, 63°51’02.7”W“ and 88 m AMSL. A rainy tropical climate with a dry winter predominates in the region, classified as “Am” type (Köppen), with a mean temperature of 26.0°C and mean annual rainfall of 2095 mm. September is the hottest month of the year (27.1°C), and May is the coolest (24.9°C) (SEDAM, 2012).

Trial nº 3 – Carried out at the Instituto Federal de Rondônia, Campus Ariquemes, in

Ariquemes, RO, at 9°57'09.8"S, 62°56'53.7"W and 126 m AMSL. The predominant climate is humid tropical, "Aw" type (Köppen), with a well-defined dry period, extending from June to August. Mean temperature is 25.4°C and mean annual rainfall is 2181 mm. Mean monthly temperature ranges from 24.5ºC to 26.2ºC, with the highest temperatures occurring in August and September (SEDAM, 2012).

Trial nº 4 – Carried out at 10°1'30.98"S, 67°42'21.77"W and 180 m AMSL. The predominant climate is humid tropical, "Aw" type (Köppen), with a well-defined dry season, extending from June to August. Mean temperature is 26.2°C and mean annual rainfall is 1935 mm. Mean monthly temperature ranges from 24.7ºC to 26.9ºC.

The monthly mean temperatures and rainfall indexes of the environments in which the competitive trials were set up are summarized in Figure 1.

Each trial was composed of 21 lines, as well as 4 reference controls that are currently recommended for planting in the Southeast region. A randomized block experimental design was used, with 25 treatments in three replicates, and four plants per plot. Plant spacing was 3 × 1 meters. Crop management practices were carried out according to the recommendations of the production system for the coffee crop in Rondônia (MARCOLAN et al., 2009). The trials of Alta Floresta Do Oeste and Porto Velho, RO, and of Rio Branco, AC, were irrigated from the first flowering to the beginning of the rainy season, which extends from July to October.

To estimate yield in bags of hulled coffee beans per hectare, each plot was harvested and weighed in the field. After that, samples of 3 kilograms were collected, which were dried on a cement drying yard with a "barge-type" (transparent mobile) covering until reaching 13% moisture content, thus obtaining the ratio between hulled coffee beans and harvested coffee fruit. The yield of hulled coffee in 60-kg bags per hectare was determined through the following equation:

$$\text{YIELD} = \frac{\frac{\text{ch}}{\text{np}}}{60} * 3.333 * \text{yratio}$$

where $YIELD$ is the coffee yield in bags of hulled coffee beans per hectare; ch is the amount of coffee fruit harvested per plot; np is the number of plants in the plot; 3,333 refers to the number of plants per hectare; is the yield ratio, obtained from division of the quantity of hulled coffee by the weight of harvested coffee fruit; and 60 corresponds to the weight in kilograms of a bag of hulled coffee.

To quantify the contribution of environments to performance of genotypes, the environmental quality index I_j was interpreted, estimated from the following expression:

$$I_j = \bar{y}_j - \bar{y}$$

where I_j is the environmental quality index; $\bar{y}_j$ is the overall mean yield of the genotypes in environment j, and $\bar{y}$ is the overall mean of the genotypes in all the environments. This index allows classification of the environments that have I_j greater than or equal to zero as "favorable", and environments with negative I_j as "unfavorable" (CRUZ; SOUZA CARNEIRO., 2006).

Genotypic variance among the clones in each environment was estimated individually based on hulled coffee yield (bags.ha^{-1}) in the crop seasons of 2014/15, 2015/16, and 2016/17, according to the statistical model:

$$Y_{ij} = m + G_i + B_j + E_{ij}$$

where Y_{ij} refers to hulled coffee yield of line i in block j; m is the experimental mean; G_i is the effect of line i; B_j is the effect of block j; and Y_{ij} is the mean error.

Upon observing homogeneity of the residual variances, combined analysis of variance of hulled coffee production was performed, according to the following model:

$$\text{Y}_{\text{ijk}} = \text{m} + \text{G}_\text{i} + \text{A}_\text{j} + \text{B}_\text{k} + \text{GA}_{\text{ij}} + \text{E}_{\text{ijk}}$$

where Y_{ijk} refers to hulled coffee yield of line i in block k, in harvest j; m is the experimental mean; G_i is the effect of genotype i; A_j is the effect of harvest j; B_k is the effect of blocks; GA_{ij} is the effect of the interaction between line i and harvest j; and E_{ijk} is the standard error. The effects of line were considered to be of a random nature, and those of harvests as fixed.

Evaluation of the genotype × environment interaction was made using the GGE biplot model (YAN, 2011), which considers the principal effect of genotype added to the effect of the G × E interaction in obtaining a scatter-plot in two planes that graphically represents the performance of the lines in the different environments. This scatter-plot is constructed by using the first two principal components of the principal component analysis obtained, associated with local regression models (SHUKLA et al., 2015).

In this method, the cosine of the angle between two environments corresponds to the genetic correlation between them, according to the following model presented by Yan et al. (2001):

$$Y_{ij} = \mu + \alpha_i + \beta_j + \Phi_{ij}$$

where Y_{ij} is the performance expected from genotype i in environment j; μ is the overall mean of the observations; α_i is the principal effect of genotype; β_j is the principal effect of environment; and Φ_{ij} is the interaction between genotype i and environment j. This model does not separate the effect of genotype G from the G x E interaction, which are maintained together in terms that are associated in a multiplicative manner:

$$Y_{ij} - \mu - \beta_j = g_{i1}e_{i1} + g_{i2}e_{i2} + \varepsilon_{ij}$$

where Y_{ij} is the expected yield of genotype i: μ is the overall mean of the observations; β_j is the principal effect of environment j; g_{i1} is the principal score of genotype i and e_{i1} of environment j; g_{i2} is the secondary score of genotype i e_{i2} and of environment j; and ε_{ij} is the residual not explained by either of the effects. Gains in yield from selection of genotypes of general adaptability, specific adaptability to favorable environments, and specific adaptability to unfavorable environments were interpreted for plant selection. The statistical analyses were performed using the software GENES (CRUZ, 2016).

The edaphic and climatic conditions were interpreted according to the Climatological Normals from 1981 to 2010, considering the rainfall (mm) and temperature (°C) measured and registered monthly (Figure 1).

3 RESULTS AND DISCUSSION

Yields in the municipalities of Ariquemes, Porto Velho, and Rio Branco were under 30 bags.ha^{-1}, with mean annual yields of 5.1, 6.4, and 10.9 bags.ha^{-1} of hulled coffee, respectively, over a period of three years. The environments of these municipalities are characterized by low altitude and by high daytime and nighttime temperatures (Figure 1). Souza et al., (2015) evaluated 33 *C. arabica* progenies in the state of Minas Gerais and observed two distinct groups. One group had higher yield, which ranged from 31.47 to 40.98 bags.ha^{-1}, and another with yield considered low, from 21.78 to 30.41 bags.ha^{-1}. Low yields limit the economic feasibility of the coffee crop. According to Alves et al. (2017), economic feasibility of the coffee field considers mean yields near 28 bags per hectare.

Ideal temperature for development of *C. arabica* is from 18°C to 23°C, and temperatures above 23ºC may result in accelerated development of fruit, which is harmful (Camargo; Camargo 2001; Bardin-Camparotto et al. 2012). Low altitude environments exhibited a high incidence of aborted flowers in all the years evaluated. According to Pezzopane et al. (2008) and Teixeira et al. (2015), flower abortion in the coffee crop is caused by dehydration and poor formation of the flowers, which are called "starlet" flowers (RODRIGUES et al., 2016a).

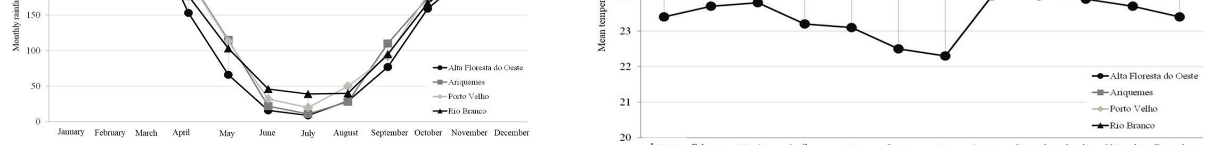

FIGURE 1 - Mean temperatures and monthly rainfall of the municipalities of Alta Floresta Do Oeste - RO, Ariquemes – RO, Porto Velho – RO, and Rio Branco – AC according to the Climatological Normals from 1981 to 2010.

TABLE 1 - Summary of the principal characteristics of the trials evaluated in the municipalities of Alta Floresta Do Oeste – RO, Ariquemes – RO, Porto Velho – RO, and Rio Branco – AC.

Environment	ALT	$Yield_{mn}$	$Yield_{min}$	$Yield_{max}$	I_j	CV%	F	h^2
Alta Floresta	436 m	25.9	9.5	55.6	14.2	27.19	3.08**	67.54
Ariquemes	126 m	5.0	0.7	10.7	-7.2	49.06	1.18^{NS}	15.86
Porto Velho	88 m	6.4	0.5	20.5	-5.6	40.25	4.44**	66.55
Rio Branco	180 m	10.9	1.0	21.7	-1.4	35.14	6.67**	85.02

ALT: altitude of the environment in which the trials were evaluated, **$Yield_{mn}$**: Mean yield of the trial, **$Yield_{max}$**: Yield of the best line in each one of the environments, **$Yield_{min}$**: Yield of the line that was least adapted in each one of the environments, **Ij:** environmental index, **CV%:** coefficient of variation percentage, **F:** F test of analysis of variance, **h2:** mean heritability of lines.

The best performance of the lines was observed in the municipality of Alta Floresta Do Oeste which exhibited mean yield of 25.9, with amplitude among lines ranging from 9.5 to 55.6 bags of hulled coffee per hectare (Table 1). The environmental index (Ij), defined as the contrast between the mean of each environment and the mean yield of all the environments, classified only this environment as favorable for coffee growing (MELO MOURA et al., 2014) (Table 1).

This environment has a rainfall regime similar to those of other regions, with an altitude of more than 400 m and average temperatures approximately 4ºC lower throughout all seasons of the year (Figure 1).

In addition to lower performance, environments of low altitude and high temperature also exhibited estimates of the parameters of experimental quality that indicate lower accuracy of the experiments conducted in these environments (Table 1). The coefficient of variation was considered adequate only for the Alta Floresta Do Oeste environment (FERRÃO et al., 2008).

To interpret the adaptability and stability of the lines in all the environments, a scatter-plot of the first two principal components of the GGE Biplot method was used (Figure 2). In this scatter-plot, proximity of the environments represents their similarity and proximity of the lines to the axis of the environment measures their yield stability. The Alta Floresta Do Oeste environment was favorable for coffee growing and was different from all other regions in relation to the yield ordering of the lines. The "which won where" biplot shows the formation of four mega-environments, and the lines G13 and G12, farthest from the y axis to the right of the scatter-plot, were the highest yielding in the favorable environment of Alta Floresta Do Oeste (Figure 2). The low adaptability associated with inconsistency in performance of the lines in the environments of low altitude and high temperature limits the selection of plants in these locations, and no genetic material was identified that stood out in these environments of the Western Amazon. Consequently, selection of superior lines and estimates of genetic progress were carried out considering only the Alta Floresta Do Oeste environment.

Individual analysis of variance in the Alta Floresta Do Oeste environment indicated that the effects of Lines, of Controls, and of Years were significant (Table 2). The non-significant effect of the line × year interaction indicates continuity in performance of the lines over time. The relationship between the estimates of the genetic coefficient of variation and the experimental coefficient of variation (CVr) indicates adequate conditions for obtaining gains from selection. Estimates of CVr near or higher than one characterize a favorable condition for obtaining genetic progress from plant selection (RAMALHO et al., 2000).

The estimates of heritability indicate predominance of the effect of genotypes on expression of production of hulled coffee, a result of differentiated genetic expression among lines (h^2 = 0.80). Teixeira et al. (2017) observed estimates of heritability for hulled coffee yield of 78.96% upon evaluating the performance of 256 genotypes of *C. canephora* in the region of Ouro Preto do Oeste, RO. Cardoso et al. (2016) also observed estimates of genotypic variance (88.83%) superior to the estimate of environmental variance for yield of 35 progenies in Machado, MG (Table 2).

The cultivar Catucai Amarelo 2SL was the best control, as it had a mean yield of 40.94 bags ha^{-1} (TEIXEIRA et al., 2015). This cultivar was selected through exhibiting high yields in regions of high temperatures. For its part, the cultivar Acauã obtained yield of 26 bags ha^{-1}, this cultivar has high resistance to water deficit (CARVALHO, 2008). Lines 12 and 13 were the highest yielding, surpassing the best control by 12% and 5%, respectively.

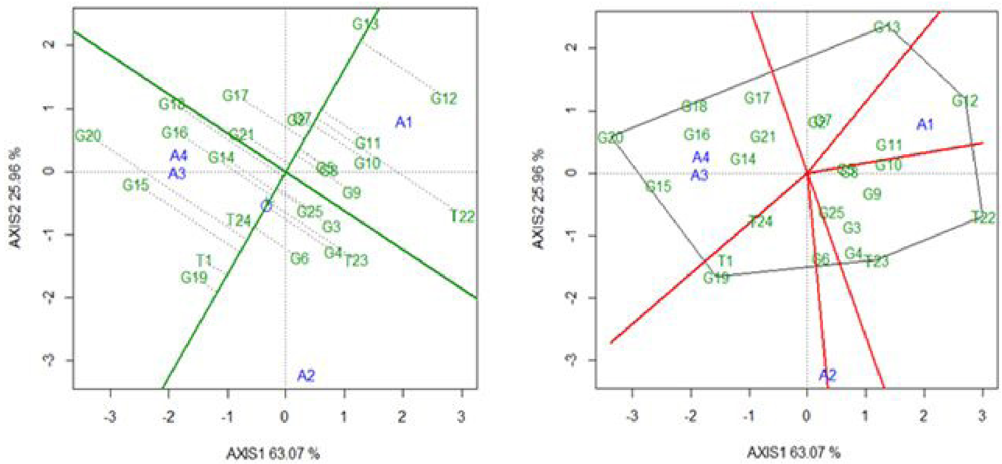

FIGURE 2 - GGE Biplot "Mean vs. Stability" and "which won where" for hulled coffee yield of 21 lines and 4 controls evaluated in 4 environments of the Western Amazon in the municipalities of A1. Alta Floresta do Oeste - RO, A2. Ariquemes - RO, A3. Porto Velho - RO, and A4. Rio Branco – AC.

TABLE 2 - Summary of ANOVA of the effects of lines and of years and of the principal genetic parameters estimated in the selection trial evaluated in the municipality of Alta Floresta Do Oeste, RO, in the years 2014-2015, 2015-2016, and 2016- 2017.

SV	DF	SS	MS	F
Blocks	2	2446.3	1223.2	
Treatments	(24)	(10983.2)	457.6	5.4**
Genotypes (Lines)	20	9239.7	462.0	5.4**
Control	3	1427.7	475.9	5.6**
Genotypes x Control	1	315.8	315.8	3.7^{NS}
Years	2	4491.0	2245.5	21.2**
Treatment x Year	(48)	(5074.2)	105.7	1.2^{NS}
Genotype x Year	40	4172.0	104.3	1.2^{NS}
Control x Year	6	891.9	148.6	1.7^{NS}
Group x Year	2	10.3	5.1	0.1^{NS}
Residue	148	12607.4	85.2	
Total	224	35602.2		
Overall mean	25.9			
Mean of lines	25.4			
Mean of controls	28.6			
CVe	35.7			
$Highest_{RMS}/Lowest_{RMS}$	2.1			
Genetic parameters				
Genotypic variance	41.9			
Variance Genotype x Year	4.20			
Residual Variance	85.2			
Heritability (mean)	81.6			
Intraclass correlation	33.0			
CVg	25.5			
CVg/CVe	0.7			

** Significant at 1% probability, * Significant at 5% probability, NS: not significant, SV: Source of variation, DF: degrees of freedom, SS: sum of squares, MS: mean square, F: F test of analysis of variance, CVe: Experimental coefficient of variation, CVg: Genetic coefficient of variation.

Lines 12 and 13 had higher yield than the best control, with mean yields of hulled coffee over three years of 41.42 and 38.84 bags ha^{-1}, respectively (Table 2). Teixeira et al. (2015) evaluated production over four crop seasons of *C. arabica* in Ouro Preto do Oeste, RO, and reported gain from selection of 44% through selection of line 12, with mean yields from three crop seasons of 51.20 bags ha^{-1}.

The germplasm studied do not show genetic variability that assists selection of plants adapted to regions of low altitude and high temperatures of the Western Amazon, characteristics of environments A2, A3, and A4. The environments were irrigated and, as such, water deficit did not occur in the growing region.

Lines 12 and 13 exhibited the best mean yields of 41.42 and 38.84 bags ha^{-1}; both have intermediate maturation cycles and have high tolerance to heat stress, factors important for development of the line, since the excess of radiation and high temperatures are the main factors limiting yield (SOUZA et al., 2011). The control Catucai Amarelo 2SLCAK, with an early maturation cycle and susceptibility to rust and resistance to water deficit (CARVALHO, 2008), obtained satisfactory performance, with a mean value of 36.90 bags ha^{-1}. For their part, the controls Acauã and Tupi, with early cycles and moderate resistance to rust (CARVALHO, 2008), obtained mean yields below 30 bags ha^{-1} (Table 3).

The *C. arabica* cultivation in low altitude regions of Western Amazonia depends on the identification of new lines of late maturation cycle and resistant to floral abortion, which were not observed in the evaluated breeding population.

TABLE 3 - Yield estimates of hulled coffee and of genetic progress from selection of lines in the municipality of Alta Floresta, RO. The dotted lines highlight the controls used in the experiments.

Lines	Identity	2014_2015	2015_2016	2016_2017	MeanYield	*$GS_{(\%)}$
12	H514-7-10-6-9	34.5	54.4	35.4	41.42	56.4
13	H514-7-10-6-2-3-9	26.0	44.1	46.4	38.84	46.7
22	Catucai Amarelo 2SL	30.0	51.4	29.3	36.90	39.4
11	H514-7-10-6-25	26.5	42.7	35.0	34.75	31.3
10	H514-7-10-6-29	25.1	42.6	32.2	33.30	25.8
7	H419-6-2-5-3-17	29.2	37.8	26.5	31.17	17.7
2	H419-10-6-2-1-6	30.3	39.3	21.4	30.34	14.6
9	H514-7-10-6-12	26.9	35.1	28.8	30.25	14.2
8	H514-7-10-6-17	28.2	23.0	35.2	28.80	8.8
23	Acauã	26.8	24.5	33.3	28.22	6.6
25	Obatã IAC1669-20	19.3	39.4	25.0	27.90	5.4
5	H419-10-6-2-1-8	25.0	31.0	26.8	27.59	4.2
17	P29 - Plant no.6	24.5	39.4	17.7	27.19	2.7
21	P109 - Plant no. 6	23.3	30.2	18.6	24.04	-9.2
3	H419-10-6-2-1-10	18.0	18.3	34.2	23.51	-11.2
4	H419-10-6-2-1-7	13.0	24.8	30.7	22.84	-13.7
14	P27 - Plant no.2	18.5	36.6	11.6	22.22	-16.1
16	P29 - Plant no. 5	16.2	31.7	17.0	21.65	-18.2
18	P94 - Plant no. 1	15.5	27.5	21.8	21.60	-18.4
6	H419-10-6-2-3-21	15.8	23.6	23.7	21.02	-20.6
24	Tupi	16.1	22.2	22.5	20.26	-23.5
1	UFV 8710	15.1	29.8	13.8	19.53	-26.2
19	P94 - Plant no. 5	13.6	24.2	11.5	16.43	-37.9
15	P27 - Plant no. 4	9.0	19.9	20.2	16.38	-38.1
20	P109-Plant no. 4	15.5	10.5	21.3	15.78	-40.4

* **GS(%)**: gain from selection.

4 CONCLUSIONS

The environments of Ariquemes, Porto Velho, and Rio Branco were not adequate for growing *C. arabica*. Lines 12 and 13, identified as H514-7-10-6-9 and H514-7-10-6-2-3-9, obtained results superior to controls for the municipality of Alta Floresta Do Oeste, RO, environment that is differentiated from the others by exhibiting higher altitudes and lower temperatures. The low yield and high instability of the cultivars in environments A2, A3, and A4 limit growing of *C. arabica* in these locations. Therefore no line adapted to environments of high temperature and low altitude was observed in the evaluated breeding population.

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