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SHORT COMMUNICATION

Assessment of Genetic Divergence for Bean Traits in *Coffea arabica* Germplasm

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Abstract

About 68 *Coffea arabica* accessions are being maintained in the germplasm bank at Coffee Research Sub Station in North Kodagu, Karnataka, India. Evaluation of these accessions for bean parameters indicated a wide variability for "A" grade bean percentage (9–82.9%) and bean density (15.08–25.96 g).

Keywords: Arabica, Bean traits, Coffee, Germplasm.

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Introduction

Coffee is one of the most consumed beverages worldwide, with about three billion cups consumed every day. The genus *Coffea* encompasses more than one hundred species (Mishra *et al.,* 2014). Nonetheless, only two species *viz., Coffea arabica* (arabica) and *Coffea canephora* (robusta), are cultivated on a commercial scale. All coffee species are diploid (2n = 22) and self-incompatible except *C. arabica,* which is a natural allo-tetraploid self-compatible species (2n = 44). In the world market, arabica coffee is preferred over robusta coffee because of its superior bean characteristics and beverage quality. The arabica coffee grown all over the world is derived from either typica or bourbon genetic base, which has resulted in low genetic diversity among the cultivated arabicas (Van der Vossen, 1985). Coffee quality is mainly assessed on bean traits (size, shape, color, density and occurrence of defective beans) and sensorial attributes (acidity, aroma, taste and body). Within the same variety, bigger bean size fetches better price and thus coffee variety having a higher percentage of "A" grade beans is preferable. Arabica coffee is one of the world's most valuable agricultural commodities and its economic value is determined to a larger extent by bean characteristics and liquor qualities. However, selection for these traits is constrained by the low genetic variability of arabica coffee. Genetic improvement of bean quality can be successful if knowledge of the variability pattern present is available before embarking on exploitation by breeding. Screening of arabica accessions available in the germplasm bank is one way of identifying the variability for bean parameters. In light of the increasing demand for high-quality coffee with superior bean and beverage characteristics, there is a need to evaluate the arabica accessions available in the germplasm bank, as most of the

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Table 1: List of arabica accessions used in the study

Code	*Accession number*	*Accession name*	*Source*	*Code*	*Accession number*	*Accession name*	*Source*
AG 1	S.1463	Typica	Guatemala	AG 35	S.1584	Dalecha	Portugal
AG 2	S.1464	Bourbon	Guatemala	AG 36	S.1699	Mbirizi de Mulungo	Portugal
AG 3	S.1465	Pache	Guatemala	AG 37	S.1726	Candina Marca	Portugal
AG 4	S.1467	Sumatra	Guatemala	AG 38	S.2126	S6 Cioccie (113/1)	Portugal
AG 5	S.1468	Surinam	Guatemala	AG 39	S.2127	S6 Cioccie (113/2)	Portugal
AG 6	S.1469	San Ramon	Guatemala	AG 40	S.2128	S4Agaro (110/5)	Portugal
AG 7	S.1470	Blue Mountain	Guatemala	AG 41	S.2129	S4Agaro (110/2)	Portugal
AG 8	S.1471	Padang	Guatemala	AG 42	S.1483	Kents KP423	Tanzania
AG 9	S.1472	Phillippinian	Guatemala	AG 43	S.1586	K7 Ruiru	Tanzania
AG 10	S.1473	Gudaluope	Guatemala	AG 44	S.1741	Barbuk Sudan	Tanzania
AG 11	S.1495	Tafarikela	Ethiopia	AG 45	S.1742	Margogype	Tanzania
AG 12	S.1497	S12 Kaffa	Ethiopia	AG 46	S.1743	Giesha	Tanzania
AG 13	S.1768	Murta	Ethiopia	AG 47	S.1648	Costa Rica	France
AG 14	S.1782	Badabuna Gimma Kaffa	Ethiopia	AG 48	S.1652	Macenta	France
AG 15	S.1783	Babaca Kaffa	Ethiopia	AG 49	S.1653	Togokouma	France
AG 16	S.1784	Misan Taferikala	Ethiopia	AG 50	S.1655	Makablou	France
AG 17	S.1785	Ainamba Kaffa	Ethiopia	AG 51	S.1659	Kouti	France
AG 18	S.1587	Rume Sudan	Kenya	AG 52	S.1660	Kenya	France
AG 19	S.1590	Dalle Mixed	Kenya	AG 53	S.1661	Nkourgam	France
AG 20	S.1591	Dalle Melavalle	Kenya	AG 54	S.1662	Foumbon	France
AG 21	S.1593	Gimma galla sidamo	Kenya	AG 55	S.1663	Reunion	France
AG 22	S.1502	Bourbon Mayagese	Congo	AG 56	S.1664	Nicaragua	France
AG 23	S.1504	Mysore	Congo	AG 57	S.1667	Mazeron	France
AG 24	S.1690	C.arabica-Green tip	Congo	AG 58	S.1490	Bourbon Amarelho	USDA
AG 25	S.1691	Las Palmas	Congo	AG 59	S.1491	Bourbon Vermelho	USDA
AG 26	S.1692	Barbarina	Congo	AG 60	S.1492	Caturra Amarelho	USDA
AG 27	S.1693	Coorg	Congo	AG 61	S.1494	Munda Novo	USDA
AG 28	S.1694	Puerto Rico	Congo	AG 62	S.1734	Martinigue	Ceylon
AG 29	S.1695	Antiqua	Congo	AG 63	S.1735	Dernum	Ceylon
AG 30	S.1696	Granza Bloomy	Congo	AG 64	S.1576	S26 Enneria	FAO
AG 31	S.1697	Tumbadir	Congo	AG 65	S.1656	Salvadur	Guinea
AG 32	S.1698	Local Bronze De Mulungu	Congo	AG 66	S.1700	COF297	East Africa
AG 33	S.1582	S16 Wollamo	Portugal	AG 67	S.1737	Madagascar	Middleton
AG 34	S.1583	S17 Yergalam	Portugal	AG 68	S.1905	SL34 Ruiru	Burma

accessions are yet to be characterized for bean traits. Thus, the objective of the study was to examine the variability for bean traits of the arabica accessions available in the germplasm bank. The most promising accessions identified from this screening exercise can be exploited as a potential genetic stock for developing arabica plants with superior bean traits.

About 68 *Coffea arabica* accessions having a designated identity were used for the current study. These arabica accessions are part of exotic gene bank introduced from different parts of the world, including the wild Ethiopian landraces collected during an FAO-sponsored expedition to Ethiopia in 1964 (Narasimmaswamy, 1965), were introduced to coffee research sub-station at Kodagu district (Karnataka)

Table 2: Genetic divergence in 68 *Coffea arabica* accessions for bean traits

Code	*"A" grade bean (%) **	*Besan density (g)***	*Code*	*"A" grade bean (%)**	*Besan density (g)***
AG 1	55.8 ± 1.13	17.03 ± 0.20	AG 35	48.4 ± 1.84	20.33 ± 0.25
AG 2	59.3 ± 1.41	17.22 ± 0.27	AG 36	9.00 ± 1.70	16.81 ± 0.28
AG 3	57.1 ± 1.48	16.89 ± 0.22	AG 37	61.4 ± 2.19	17.95 ± 0.20
AG 4	38.9 ± 1.34	15.89 ± 0.30	AG 38	40.0 ± 3.04	19.62 ± 0.29
AG 5	49.0 ± 1.48	17.39 ± 0.23	AG 39	41.0 ± 1.77	18.47 ± 0.34
AG 6	50.0 ± 1.98	19.05 ± 0.21	AG 40	57.1 ± 1.27	21.61 ± 0.14
AG 7	67.6 ± 1.63	17.97 ± 0.12	AG 41	36.6 ± 2.47	18.39 ± 0.29
AG 8	64.3 ± 1.06	17.00 ± 0.18	AG 42	51.6 ± 3.18	17.93 ± 0.13
AG 9	65.0 ± 0.78	16.68 ± 0.37	AG 43	69.0 ± 1.63	17.37 ± 0.33
AG 10	45.0 ± 1.13	17.20 ± 0.25	AG 44	34.3 ± 1.56	17.79 ± 0.17
AG 11	12.3 ± 1.27	16.13 ± 0.23	AG 45	25.6 ± 2.33	15.80 ± 0.23
AG 12	61.3 ± 2.12	20.51 ± 0.23	AG 46	40.5 ± 2.26	17.44 ± 0.31
AG 13	31.5 ± 1.84	15.70 ± 0.13	AG 47	52.4 ± 1.70	17.45 ± 0.20
AG 14	73.5 ± 1.56	25.96 ± 0.27	AG 48	35.0 ± 1.98	18.50 ± 0.11
AG 15	36.4 ± 1.63	17.76 ± 0.39	AG 49	62.0 ± 2.05	19.73 ± 0.23
AG 16	22.4 ± 1.41	19.11 ± 0.37	AG 50	39.7 ± 2.19	16.72 ± 0.21
AG 17	40.2 ± 1.84	16.99 ± 0.27	AG 51	54.3 ± 2.05	17.76 ± 0.23
AG 18	12.3 ± 1.98	15.08 ± 0.14	AG 52	60.1 ± 3.11	17.00 ± 0.09
AG 19	20.3 ± 1.77	15.87 ± 0.13	AG 53	43.3 ± 2.83	18.58 ± 0.22
AG 20	31.6 ± 1.56	16.84 ± 0.21	AG 54	47.5 ± 2.40	18.11 ± 0.10
AG 21	31.7 ± 1.34	17.77 ± 0.35	AG 55	45.4 ± 1.70	19.45 ± 0.21
AG 22	55.6 ± 1.77	19.65 ± 0.37	AG 56	61.7 ± 2.26	17.05 ± 0.10
AG 23	56.8 ± 1.84	18.53 ± 0.31	AG 57	60.1 ± 2.40	18.62 ± 0.18
AG 24	33.0 ± 2.12	17.63 ± 0.24	AG 58	47.1 ± 1.84	17.63 ± 0.15
AG 25	67.8 ± 1.77	18.80 ± 0.18	AG 59	53.8 ± 2.33	18.00 ± 0.20
AG 26	38.0 ± 1.34	17.70 ± 0.27	AG 60	64.6 ± 2.47	18.16 ± 0.20
AG 27	72.2 ± 1.34	18.62 ± 0.15	AG 61	49.9 ± 2.90	16.27 ± 0.20
AG 28	67.3 ± 1.70	18.79 ± 0.19	AG 62	82.9 ± 2.83	19.16 ± 0.18
AG 29	18.0 ± 2.19	16.93 ± 0.20	AG 63	72.0 ± 2.97	18.72 ± 0.15
AG 30	48.6 ± 1.70	19.14 ± 0.14	AG 64	43.2 ± 1.77	18.26 ± 0.22
AG 31	55.5 ± 1.70	16.68 ± 0.13	AG 65	48.6 ± 1.13	16.15 ± 0.14
AG 32	43.7 ± 1.70	17.42 ± 0.18	AG 66	38.0 ± 2.26	16.43 ± 0.26
AG 33	57.7 ± 1.77	18.25 ± 0.15	AG 67	49.6 ± 2.12	18.49 ± 0.14
AG 34	19.6 ± 1.91	17.63 ± 0.16	AG 68	51.6 ± 2.62	19.40 ± 0.20
CD (5%)				3.6	0.25

Values are average of two harvest seasons; **- Values are average of two harvest seasons with three determinations per harvest season.

in 1967. These arabica accessions are being maintained following the recommended agronomic practices (Table 1).

The handpicked ripe fruits from all the plants in each arabica accession were pooled and 12 kg of fruits were processed by wet method. In the wet method, the fruits are pulped to remove the outer skin. Each fruit usually yields two beans, which are covered by a thin layer of mucilage, mostly consisting of sugars and pectin. The mucilage is removed using an aqua-washer machine and the resulting coffee beans are soaked in water for about 6 hours to remove the residual mucilage clinging to the coffee bean. Then, the coffee samples are sun-dried until the moisture level in the coffee samples reaches 10%. The moisture content in the coffee bean samples was determined by a Sinar moisture analyzer (Sinar Technology, AP 6060 model England). The coffee thus processed is called parchment coffee. The parchment coffee samples were de-husked using peeler-cum-polisher machine (Marshall-Fowler Group, PP7/ LS-407 model UK) to obtain the bulk coffee bean sample. The bulk coffee bean samples were winnowed to remove all extraneous matters, weighed and then subjected to size grading.

The bulk coffee bean samples were size-graded using a standard screen (McKinnon Co., Aberdeen, Scotland). The "A" grade beans were separated using screen number 17 (6.65 mm size). The peaberries and imperfect beans present in the "A" grade bean were manually removed. The total weight of the "A" grade bean was measured using a sensitive analytical balance (Precisa 320 XB model, Switzerland). The percentages of "A" grade bean was calculated following the standard formula (total quantity of "A" grade bean (g)/ total quantity of bulk coffee bean sample (g) x 100). To measure the density of coffee beans, one hundred numbers of perfectly shaped "A" grade beans were weighed using a sensitive electronic analytical balance (Precisa 320 XB model, Switzerland) in triplicates. The data were subjected to analysis of variance according to the least significant difference test to indicate statistically significant differences between the arabica accessions following the Agress package (version 3.01 data entry module and version 7.01 ANOVA package).

The mean data on "A" grade bean percentage and 100 "A" grade bean weight (density) recorded in 68 arabica accessions during two consecutive seasons were presented in Table 2. Among the 68 arabica accessions evaluated, significantly (p = 0.05) highest "A" grade beans (82.9%) were recorded in Martinique accession from Ceylon (S.1734) followed by 73.5% in Badabuna Gimma Kaffa accession from Ethiopia (S.1782), 72.2% in Coorg accession from Congo (S.1693) and 72% in Dernum accession from Ceylon (S.1595). The lowest "A" grade percentage (9%) was recorded in Mberizi de Mulungo's accession from Portugal (S.1699). About 30 out of 68 accessions recorded over 50% of "A" grade percentage ranging from 50% (S.1469-San Ramon accession from Guatemala) to 82.9% (S.1734-Martinique accession from Ceylon). The range of "A" grade bean percentage recorded in the present study (9–82.9%) was in good agreement with the previous report (Das *et al*., 2021).

Of the 68 arabica accessions examined, significantly (p = 0.05) highest bean density (25.96 g) was registered in Badabuna Gimma Kaffa accession from Ethiopia (S.1782) followed by 21.61 g (S.2128 - Agaro 110/5 accession from Portugal), 20.51 g (S.1497- S12 Kaffa accession from Ethiopia) and 20.33 g (S.1584 – Delecha accession from Portugal). The lowest bean density (15.08 g) was recorded in Rume Sudan accession from Kenya (S.881). The bean density recorded in the current study ranged from 15.08 to 25.96 g with an overall average of 17.96 g and the results differed from the previous reports, which ranged from 13.12 to 19.13 g with an average of 15.2 g (Yonas *et al.,* 2014), 14.99 to 17.07 g with a mean of 16.27 g (Fabrício, 2016), 7.74 to 24.21 g with an average of 17.1 g (Gizachew and Hussein, 2017), 16 to 22 g (Lison, *et al.,* 2020) and 17.63 to 19.8 g (Das *et al*., 2021).

The success of a new arabica variety depends on bean traits and cup quality. The results of the present study indicated that the Badabuna Gimma Kaffa accession from Ethiopia recorded superior bean traits. As reported by Santaram (2005), the cup quality of most of the Ethiopian accessions scores a fair average quality (FAQ) rating and this prompts that Badabuna Gimma Kaffa seems to be a prospective donor for developing arabica plant with superior bean traits. However, it is proposed to evaluate the genetic variance of 68 arabica accessions for cup quality as a future line of work.

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