TAS Trends in Agricultural Sciences

OPEN ACCESS

Evaluation and Selection of Advanced Arabica Coffee Lines in Horo Guduru Wollega, Western Ethiopia

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ABSTRACT

Background and Objective: The demand for Arabica coffee in developed and developing countries is exponentially increasing. Arabica coffee is the spinal cord of the Ethiopian economy, and it is the leading commodity in generating foreign exchange income. Hence, this study was conducted to evaluate Arabica coffee accessions of Horro Guduru Wollega and to select advanced lines for the next breeding program. **Materials and Methods:** The experiment was established at Melko in 2016/2017 using an augmented design with three blocks. Twenty-five accessions and four checks were included in the study. Three representative coffee trees were randomly selected per plot for growth data recording, and the yield data for each coffee genotype were recorded per plot. Four years of clean coffee yield and nine yield-related traits data were recorded and analyzed using R software. **Results:** The present findings manifested the existence of variability among testing materials in some harvesting seasons and yield-related traits. Even though the pooled mean of clean coffee yield showed a non-significant difference, about 12 accessions showed comparable yield performance with the check, which were released for the south-southwestern areas. The top twelve high yielders showed 1741.68 to 2414.33 kg/ha mean yield performance. **Conclusion:** In general, these advanced lines were selected and recommended to be further evaluated for yield, yield-related, and quality under well-managed and uniform plots at representative locations of their original areas.

KEYWORDS

Arabica coffee, genetic variability, promising lines, selection and improvement

INTRODUCTION

Coffee is the second-leading commodity in the world market after fuel. It is one of the most widely consumed beverages worldwide[1]. Among the 124 identified coffee species[2], Arabica coffee is the dominant species in production[3,4], and in customer preference globally[5]. It accounts for up to 65% of the total world coffee production[6].

ISSN: 2957-9449 (Online)
ISSN: 2957-9430 (Print)
https://doi.org/10.17311/tas.2025.287.298

Received: 22 May, 2025
Accepted: 03 Jul. 2025
Published: 31 Dec. 2025

The coffee market is growing due to the increasing interest in and culture of coffee consumption among the populations of developed countries such as Italy, the United States, Japan, China, the Philippines, and India[7,8]. Additionally, the rise of small coffee houses and coffee pot market businesses in developing countries like Ethiopia is another contributing factor to the growth of the coffee market. Furthermore, the various health benefits of coffee consumption, such as reducing the risk of diabetes, burning fat, and boosting energy through caffeine, are significant drivers of market growth[9].

Ethiopia is the fifth-largest coffee producer in the world and the largest in Africa. In Ethiopia, Arabica coffee accounts for 30-35% of the total foreign exchange income generated by commodities[10,11]. In the 2023/2024 fiscal year, Ethiopia exported a total volume of 298,500 ton to the global market and earned USD 1.43 billion in revenue from coffee exports. This demonstrates that coffee's contribution to the country's economy is very high relative to other commodities. Additionally, about 25% of Ethiopians' livelihoods depend directly or indirectly on coffee[12,13]. The growing demand for Arabica coffee at both the national and international levels underscores the need to increase production, enhance productivity, and develop advanced technologies.

Despite its unrepresentative importance, coffee production and productivity are below expectations. The average national coffee productivity is 650 kg/ha, which is extremely low[14]. Additionally, inconsistent production has been observed from year to year, creating challenges for small-scale livelihoods, the country's annual income, and the coffee industry in general[15,16]. To address these problems effectively, yield improvement, the development of climate-smart varieties, and the application of appropriate field management technologies are key factors.

Some Ethiopian coffee-producing agro-ecologies still lack improved coffee varieties. The Horo Guduru Wollega Zone, well known for its quality coffee production, is among the coffee-producing areas that lack improved varieties. This area is characterized by diverse garden and semi-forest coffee production systems. However, small-scale farmers in the region rely on their cultivars, which are not experimentally certified. This leads to the use of low-yielding cultivars that are uncertified in quality, poorly adapted to the environment, and susceptible to diseases and abiotic stresses. To address these challenges, various accessions were collected from the Horo Guduru Zone and evaluated for yield and yield-related traits over eight years. This study was conducted to characterize and evaluate Arabica coffee accessions from Horo Guduru Wollega and to select advanced lines for the next breeding program.

MATERIALS AND METHODS

Study area: The experiment was conducted at the Jimma Agricultural Research Center (JARC). The JARC is located 10 km from Jimma City and 364 km from Addis Ababa, the capital city of Ethiopia. It is found at 1753 m.a.s.l., and at 7°40'00"N and 36°47'00"E direction. The area receives 1572 mm annual rainfall with 11.6 and 26.3°C minimum and maximum temperatures, respectively. The area is well known for its edaphic and climatic conditions, suitability for coffee production. The soil of the area is characterized as Nitosols, red and well-drained, with a pH of 4.37-6, and medium to high in CEC (cation exchange capacity).

Plant materials and experimental design: A total of twenty-five coffee accessions were collected in 2015 from the Horro Guduru Wollega Zone and its surroundings (Table 1). These accessions were collected from different gardens and semi-forest coffee production systems. However, one accession (Ab5) completely vanished during the early time after two years of field planting due to its poor performance during field evaluation. Thus, 24 accessions and 4 checks, a total of 28 coffee genotypes, were involved in this study. The field experiment was established in 2016 using an augmented design with three blocks. Tested materials were not replicated, but checks were replicated in an incomplete block following the augmented design principle. Augmented design was used due to a lack of seeds. Six coffee trees were planted per plot with a spacing of 2×2 m between coffee trees and plots. Field management practices like shade, mulching, weeding, fertilizer, and coffee trees management were applied following standard procedure or recommendation[17].

Table 1: Data passport of coffee accessions

Sr. No.	Accession code	Region	Zone	Woreda	Specific location	Alt (m.a.s.l.)
1	Abe01/015	Oromia	H/Guduru	Abedongoro	Chokorsa	1730
2	Abe02/015	Oromia	H/Guduru	Abedongoro	Lage	-
3	Abe03/015	Oromia	H/Guduru	Abedongoro	Lage	1730
4	Abe04/015	Oromia	H/Guduru	Abedongoro	Lage	170
5	Abe05/015	Oromia	H/Guduru	Abedongoro	Lage	1730
6	Abe06/015	Oromia	H/Guduru	Abedongoro	Lafoni	1742
7	Abe07/015	Oromia	H/Guduru	Abedongoro	Lafoni	1742
8	Abe08/015	Oromia	H/Guduru	Abedongoro	Lafoni	1765
9	Abe09/015	Oromia	H/Guduru	Abedongoro	Sadeka	1765
10	Abe10/015	Oromia	H/Guduru	Abedongoro	Sadeka	1765
11	Abe11/015	Oromia	H/Guduru	Abedongoro	LaftoJafafa	1740
12	Abe12/015	Oromia	H/Guduru	Abedongoro	LaftoJafafa	1740
13	Abe13/015	Oromia	H/Guduru	Abedongoro	Kesadi	-
14	Abe14/015	Oromia	H/Guduru	Abedongoro	-	-
15	Abe15/015	Oromia	H/Guduru	Abedongoro	-	-
16	Abe16/015	Oromia	H/Guduru	Abedongoro	Harbu	-
17	Abe17/015	Oromia	H/Guduru	Abedongoro	Harbu	-
18	Abe18/015	Oromia	H/Guduru	Abedongoro	-	-
19	Abe19/015	Oromia	H/Guduru	Abedongoro	Lubuqici	-
20	Abe20/015	Oromia	H/Guduru	Abedongoro	Haleli	-
21	Abe21/015	Oromia	H/Guduru	Abedongoro	Lage	-
22	Abe22/015	Oromia	H/Guduru	Abedongoro	-	-
23	Abe23/015	Oromia	H/Guduru	Abedongoro	-	-
24	Abe24/015	Oromia	H/Guduru	Abedongoro	-	-
25	Abe25/015	Oromia	H/Guduru	Abedongoro	-	1650
Checks						
1						74110
2						744
3						Dessu
4						75227

Data recorded: Three representative coffee trees were randomly selected for growth data recording, and the yield data were recorded per plot[18]. Major growth parameters data such as plant height, node number of main stem, height up to the first primary branch, length of the first primary branch, girth (main stem diameter), number of primary branch, number of bearing primary branch, number of secondary branch and canopy diameter were recorded at the cherry maturity stage. Three representative sample coffee trees were taken per plot, and growth data were recorded. For yield data, fresh red cherries were recorded per plot and converted to clean bean coffee yield, which was expressed in kg/ha. The yield data were recorded for four consecutive years.

Data analysis: All growth and yield data were subjected to R-software version 4.3.3 for further statistical analysis[19]. Before carrying out further data analysis, data uniformity was tested for each parameter. A random model was used to compute the variability among the tested materials.

The following statistical random model was used to estimate phenotypic variability in quantitative traits:

$$Y_{ij} = \mu+g_i+b_j+\varepsilon_{ij}$$

where, y_{ij} is the phenotypic value for the genotype i and block j, μ is the population mean, gi is the random genotypic effect, bk is the effect of kth block, and and ε_{ij} is the random effect of residuals.

The significant difference among genotypes was tested at a 5% probability level ($p<0.05$). The mean separation among genotypes was tested using the critical difference (CD). Genetic parameters such as phenotypic variability (PV), genetic variability (GA), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), genetic gain (GA), genetic gain as percentage of mean (GAM) and broad sense heritability (HBS) were computed according to Johnson *et al.*[20] and Janick[21].

Components of variance: Genotypic (σ^2g), error (σ^2e), and phenotypic (σ^2p) variance were computed as follows:

$$\sigma^2e = Mse/r$$

Where:
Mse = Mean square of error
σ^2g = (Msg-Mse)/r
Msg = Mean square of genotypes
r = Replication

and:

$$\sigma^2P = \sigma^2e + \sigma^2g$$

Broad sense heritability: Calculated as follows:

$$Hb^2 = \sigma^2g/\sigma^2p$$

where, σ^2g is genotypic variance and σ^2p is phenotypic variance; Heritability was classified as low (0-20%), moderate (20-50%), and high (>50%).

Estimation of expected genetic advance: Calculated as:

$$GA = (K)\ (\sigma p)\ (Hb^2)$$

Where:
GA = Expected genetic advance
σp = phenotypic standard deviation
Hb^2 = Heritability in the broad sense
K = Selection differential (K = 2.06 at 5% selection intensity)

Genetic advance as a percent of mean:

$$GAM = (GA/X) \times 100$$

where, GA and X represent genetic advance and sample mean, respectively; GAM was categorized as low (0-10%), moderate (10-20%), and high (>20%).

Phenotypic and genotypic coefficient of variation: Computed as follows:

$$GCV = \frac{\left(\sqrt{\sigma^2}g\right)}{x}$$

and:

$$PCV = \frac{\left(\sqrt{\sigma^2}p\right)}{x}$$

where, GCV is genotypic coefficient of variance, PCV is phenotypic coefficient of variance, and x is general mean; PCV and GCV categorized as low (0-10%), moderate (10-20%), and high (>20%).

RESULTS

Yield performance of coffee genotypes: Variability was revealed among testing materials in yield performance in some years. Highly significant difference (p<0.01) was tested among the whole treatments and tested materials (augmented treatments) in 2020/2021 year; in 2020/2021 and 2022/2023 harvesting seasons, significant difference (p<0.05) was observed between tested materials and checks (Table 1 and Appendix Table 1). Despite the high yield gap recorded among testing materials, the pooled mean clean coffee yield of over four years showed statistically non-significant differences among treatments. The yield performance of coffee accessions ranged from 2416.33 to 1122.92 kg/ha, which showed a twofold difference between high and low performing coffee genotypes (Appendix Table 1).

The combined yield of all genotypes revealed the highest yield record in the 2022/2023 harvesting season (Fig. 1). The lowest clean coffee yield was recorded during the early season (2019/2020). In the 2020/2021 and 2021/2022 harvesting seasons, almost all the same mean clean yields were recorded.

Appendix Table 1: Mean of clean coffee yield (kg/ha) from 2019/2020-2022/2023 harvesting seasons

Genotypes	2019/2020	2020/2021	2021/2022	2022/2023	Mean
Abe1	509.55	1129.23	1321.51	1737.37	1174.41
Abe10	1733.19	2113.08	2132.96	2150.72	2032.48
Abe11	697.64	3220.35	2822.39	2924.95	2416.33
Abe12	937.41	1828.40	1690.94	1788.21	1561.24
Abe13	1305.76	1800.05	1749.32	3613.00	2117.03
Abe14	1406.54	1994.37	3003.10	2191.03	2148.76
Abe15	1118.11	1729.71	1899.44	3352.38	2024.91
Abe16	1706.50	2274.43	2308.10	1558.58	1961.90
Abe17	1093.09	1729.49	1732.63	869.14	1356.09
Abe18	853.49	1903.20	406.96	1580.16	1185.95
Abe19	313.47	1654.22	2221.74	3177.27	1841.68
Abe2	632.57	1597.60	1324.29	2252.37	1451.71
Abe20	733.60	1549.14	2088.86	3011.86	1845.87
Abe21	638.04	2162.30	1791.40	2853.40	1861.28
Abe22	770.09	1196.52	1082.50	1442.55	1122.92
Abe23	1103.69	2575.96	2619.84	1773.37	2018.21
Abe24	669.31	1497.32	2204.23	2587.91	1739.69
Abe25	997.35	2517.86	1924.84	3711.03	2287.77
Abe3	832.73	1440.31	1810.23	2207.75	1572.75
Abe4	436.58	1369.00	1146.37	1910.01	1215.49
Abe6	994.31	1389.43	1641.21	2065.41	1522.59
Abe7	1103.78	1154.25	2389.03	1341.22	1497.07
Abe8	754.54	1958.22	2193.04	2574.71	1870.13
Abe9	978.68	1628.63	1504.99	1562.23	1418.63
Dessu	1400.89	2134.58	1751.86	3485.66	2193.25
74110	506.77	1319.04	2034.13	2466.55	1581.62
744	1307.87	2269.96	1815.80	3410.36	2201.00
75227	725.23	2216.15	1466.77	3183.05	1897.80
Mean	937.88	1834.03	1859.94	2385.08	1754.23
CV (%)	36.00	10.61	27.34	35.00	24.87
Ci-Cj	682.21*	396.01**	1004.82	1784.37	895.45
BiVi-BiVji	1321.09	766.86**	1945.83	3455.42	1734.03
Vi-Vj	1181.62	685.90**	1740.40	3090.62	1550.96
Ci-Vj	1078.66	626.14*	1588.76	2821.34*	1415.83

CV: Coefficient of variation, CD: Critical difference, Ci-Cj: Between two control treatments, BiVi-BiVj: Between two augmented treatments, Vi-Vj: Between two treatments and Ci-Vj: Between control treatment and augmented treatment

The mean yield performance trends across years for each coffee genotype are indicated in Fig. 1 and Appendix Table 1. Almost all coffee genotypes showed low yield performance during the first two harvesting seasons (2019/2020 and 2020/2022). The biennial bearing characteristic was revealed by coffee genotypes. The insignificant mean yield difference was observed between 2020/2021 and 2021/2022 harvesting seasons (Fig. 1). For most coffee genotypes, high fruits bearing were observed in the 2022/2023; but, the lowest crop load was recorded in the 2019/2020 harvesting season (Fig. 1 and Appendix Table 1).

Performance in growth characteristics: Significant difference ($p<0.05$) was observed among augmented coffee accessions and all genotypes in main stem girth and plant height (Table 2). Highly significant variable ($p<0.01$) was detected between augmented accessions and checks in plant height; whereas, between augmented accessions and checks, significantly different performance was recorded in the number of bearing primary branches and the number of nodes per main stem. The performance of coffee genotypes ranged from 166.58 to 271.00 cm in plant height and 29.30 to 55.40 mm in main stem girth. Also, about 25 to 46 and 19 to 55 performance differences in the number of nodes on the main stem and the number of bearing primary branch were recorded among genotypes, respectively (Table 2).

Table 2: Mean performances of coffee genotypes in growth parameters

Genotypes	CD	G	HUFPB	LFPB	NBPB	NNM	NPB	NSB	PH	Yield
Abe1	199.07	41.19	31.00	78.67	33.03	34.53	66.69	92.03	213.75	1174.41
Abe10	154.19	33.29	23.92	67.42	19.44	25.11	47.94	66.03	166.58	2032.48
Abe11	172.03	35.22	32.25	84.08	28.78	24.78	41.94	89.03	192.58	2416.33
Abe12	206.69	36.07	31.58	87.42	25.44	28.11	53.94	119.36	206.92	1561.24
Abe13	167.03	32.75	33.58	67.08	27.44	28.11	55.28	87.69	218.58	2117.03
Abe14	190.86	29.30	32.58	87.42	28.11	31.44	58.94	105.69	218.58	2148.76
Abe15	200.94	31.81	34.08	84.25	38.11	25.44	49.61	88.53	199.42	2024.91
Abe16	160.86	31.99	27.58	72.08	23.11	30.78	58.94	124.03	176.92	1961.90
Abe17	165.53	44.25	32.25	141.08	31.44	29.11	60.28	103.69	225.58	1356.09
Abe18	186.57	39.38	24.42	69.58	33.86	34.69	64.03	93.94	236.67	1185.95
Abe19	199.57	42.03	24.75	70.58	27.19	32.69	60.36	54.61	234.00	1841.68
Abe2	209.57	50.76	32.30	104.37	32.03	34.86	69.03	139.36	238.08	1451.71
Abe20	178.57	45.56	17.42	59.58	25.53	29.36	56.03	50.28	198.00	1845.87
Abe21	209.40	55.07	24.75	97.25	31.53	33.69	64.36	133.61	261.67	1861.28
Abe22	193.57	51.93	24.75	75.92	54.19	37.36	77.69	127.61	266.67	1122.92
Abe23	193.57	48.39	25.75	78.92	32.53	34.03	64.36	104.28	235.00	2018.21
Abe24	178.74	51.73	18.08	67.25	40.86	39.69	77.36	114.28	271.00	1739.69
Abe25	161.24	49.19	23.42	75.58	37.19	38.03	74.36	155.94	226.33	2287.77
Abe3	194.57	45.33	29.00	98.33	34.36	36.19	70.69	61.03	254.75	1572.75
Abe4	207.74	55.40	37.00	75.33	44.03	36.19	70.69	61.03	260.42	1215.49
Abe6	209.40	51.11	33.00	93.00	39.69	36.19	50.69	98.69	265.75	1522.59
Abe7	207.74	45.21	29.33	87.67	29.03	27.53	55.36	70.36	224.75	1497.07
Abe8	200.24	52.95	34.33	82.00	32.36	46.19	62.03	126.03	236.42	1870.13
Abe9	173.57	45.42	30.00	94.00	25.36	28.53	57.03	88.69	205.75	1418.63
Checks										
Dessu	180.83	40.94	28.44	68.33	26.00	31.44	60.78	72.44	224.00	2193.25
74110	168.28	41.20	37.00	86.00	22.89	25.67	50.11	65.22	192.56	1581.62
744	175.94	42.31	29.33	71.44	29.00	30.56	57.89	100.00	202.56	2201.00
75227	194.72	45.67	29.89	75.56	27.22	31.11	59.33	91.11	221.22	1897.80
Mean	186.47	43.41	28.99	82.15	31.42	32.19	60.56	95.88	224.09	1754.23
CV (%)	8.66	4.55	22.14	14.07	15.75	8.87	11.01	25.27	4.50	24.87
Ci-Vj(CD5	50.61	6.22	20.61	35.84	15.07*	8.86*	20.79	74.12	31.44**	1415.83
BiVi-BiVj (CD5%)	61.98	7.62*	25.24	43.89	18.45	10.85	25.46	90.78	38.50*	1734.03
Vi-Vj (CD5%)	55.44	6.81*	22.50	39.26	16.50	9.71	22.77	81.20	34.44*	1550.96
Ci-Cj (CD5%)	32.01	3.93	13.04	22.67	9.53	5.60	13.15	46.88	19.88*	895.45

CV: Coefficient of variation, CD: Critical difference, Ci-Cj: Between two control treatments, BiVi-BiVj: Between two augmented treatments, Vi-Vj: Between two treatments, Ci-Vj: Between control treatment and augmented treatment, *$p<0.05$ and **$p<0.01$, respectively. NB: Those that didn't mark either by * or ** were non-significant. PH: Plant height, NNM: Node number of main stem, HUFPB: Height up to the first primary branch, LFPB: length of the first primary branch, G: Girth, NPB: Number of primary branch, NBPB: Number of bearing primary branch, NSB: number of secondary branch and CD: Canopy diameter

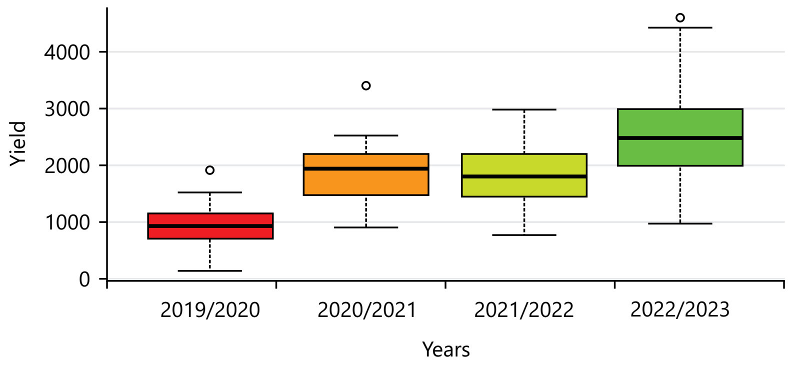

Fig. 1: Boxplot of yield (kg/ha) by year

Table 3: Estimates of genetic parameters for different traits

Traits	Mean	PV	GV	EV	GCV	GCV Category	PCV	PCV category	ECV	Hb	Hb category	GA
PH	224.09	546.45	447.42	99.03	9.44	Low	10.43	Medium	4.44	81.88	High	39.49
HUFPB	28.99	10.29	<NA>	42.57	<NA>	<NA>	11.06	Medium	22.50	<NA>	<NA>	<NA>
G	43.41	25.12	21.24	3.87	10.62	Medium	11.55	Medium	4.53	84.58	High	8.74
LFPB	82.15	242.10	113.38	128.72	12.96	Medium	18.94	Medium	13.81	46.83	Medium	15.03
NPB	60.56	53.00	9.71	43.29	5.15	Low	12.02	Medium	10.86	18.32	Low	2.75
NBPB	31.42	45.40	22.65	22.74	15.15	Medium	21.44	High	15.18	49.90	Medium	6.94
NSB	95.88	866.36	315.77	550.59	18.53	Medium	30.70	High	24.47	36.45	Medium	22.13
NNM	32.19	16.61	8.74	7.87	9.18	Low	12.66	Medium	8.71	52.62	Medium	4.42
CD	186.47	244.94	<NA>	256.67	<NA>	<NA>	8.39	Low	8.59	<NA>	<NA>	<NA>
YIELD	1754.2	141599.2	<NA>	200880	<NA>	<NA>	21.45	High	25.55	<NA>	<NA>	<NA>

PH: Plant height (cm), NNM: Node number of main stem, HUFPB: Height up to the first primary branch (cm), LFPB: Length of the first primary branch (cm), G: Girth (mm), NPB: Number of primary branch, NBPB: Number of bearing primary branch, NSB: Number of secondary branch and CD: Canopy diameter (cm), PV: Phenotypic variability, GA: Genetic variability, GCV: Genotypic coefficient of variation, EV: Environmental variability, ECV: Environmental coefficient of variation, PCV: Phenotypic coefficient of variation, GA: Genetic gain, GAM: Genetic gain as percentage of mean and HB: Broad sense heritability, NB: <NA> for negative GV detected (GCV, GCV category, Hb, Hb category, GA, GAM and GAM category could not be computed)

Genetic components of yield and yield-related traits: Almost all traits exhibited moderate genetic diversity (10-20%). However, plant height, number of nodes per primary branch, and number of primary branches showed low genetic coefficient of variation (GCV) (<10%) (Table 3). Except for canopy diameter, all traits showed moderate (10-20%) to high (>20%) phenotypic coefficient of variation (PCV). High broad-sense heritability (hSB) (>60%) was recorded for plant height and stem girth. Whereas, agronomic traits such as node number of main stem (NNM), length of the first primary branch (LFPB), number of bearing primary branches (NBPB), and number of secondary branches (NSB) exhibited medium hBS. Negative genetic variability (GV) was detected for traits such as height up to the first primary branch (HUFPB), canopy diameter (CD), and yield, which leads to not applicable (NA) for genetic parameters. The observed negative value may be due to high environmental or a greater magnitude of environmental contribution in phenotypic value than genetic value.

High genetic advance over mean (GAM) (>20%) was recorded for main stem girth (G), number of bearing primary branches (NBPB), and Number of secondary branches (Fig. 2). Length of the first primary branch, number of nodes per main stem, and plant height were exhibited medium GAM (10-20%).

Advanced line selection: Even though a non-significant difference was depicted among the tested, between the tested vs checks in most years, some genotypes showed high-yielding potential. Twelve pipelines exhibited comparable performance with high-yielding checks in pooled mean yield (Table 4). The highest yield, 2416.33 kg/ha was recorded by Abe11. This genotype showed a 215.33 kg/ha yield advantage over the best check 744. Also, pipelines such as Abe10, Abe13, Abe14, Abe15, Abe23, and Abe25 showed 2018.21-2287.77 kg/ha in the mean of clean coffee yield over four years. Other lines such as Abe16, Abe19, Abe20, Abe21, and Abe8 yielded performance ranging from 1861.28-1961.90 kg/ha.

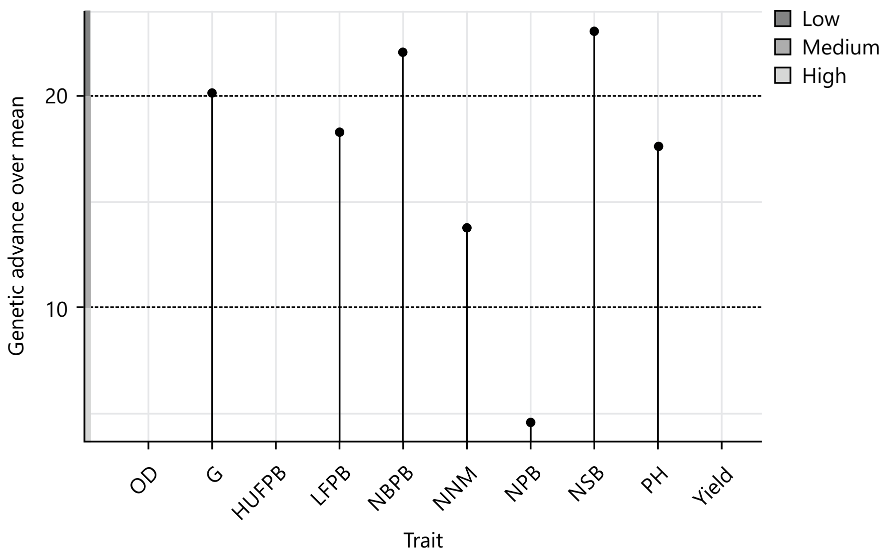

Fig. 2: Genetic advance over the mean

Table 4: Top twelve high-yielding coffee accessions in clean coffee yield (kg/ha)

Genotypes	2019/2020	2020/2021	2021/2022	2022/2023	Mean
Abe10	1733.19	2113.08	2132.96	2150.72	2032.48
Abe11	697.64	3220.35	2822.39	2924.95	2416.33
Abe13	1305.76	1800.05	1749.32	3613.00	2117.03
Abe14	1406.54	1994.37	3003.10	2191.03	2148.76
Abe15	1118.11	1729.71	1899.44	3352.38	2024.91
Abe16	1706.50	2274.43	2308.10	1558.58	1961.90
Abe19	313.47	1654.22	2221.74	3177.27	1841.68
Abe20	733.60	1549.14	2088.86	3011.86	1845.87
Abe21	638.04	2162.30	1791.40	2853.40	1861.28
Abe23	1103.69	2575.96	2619.84	1773.37	2018.21
Abe25	997.35	2517.86	1924.84	3711.03	2287.77
Abe8	754.54	1958.22	2193.04	2574.71	1870.13
Checks					
Dessu	1400.89	2134.58	1751.86	3485.66	2193.25
74110	506.77	1319.04	2034.13	2466.55	1581.62
744	1307.87	2269.96	1815.80	3410.36	2201.00
75227	725.23	2216.15	1466.77	3183.05	1897.80
Mean	937.88	1834.03	1859.94	2385.08	1754.23
CV (%)	36.00	10.61	27.34	35.00	24.87
Ci-Cj	682.21*	396.01**	1004.82	1784.37	895.45
BiVi-BiVji	1321.09	766.86**	1945.83	3455.42	1734.03
Vi-Vj	1181.62	685.90**	1740.40	3090.62	1550.96
Ci-Vj	1078.66	626.14*	1588.76	2821.34*	1415.83

CV: Coefficient of variation, CD: Critical difference, Ci-Cj: Between two control treatments, BiVi-BiVj: Between two augmented treatments, Vi-Vj: Between two treatments and Ci-Vj: Between control treatment and augmented treatment

DISCUSSION

Genetic variability was exhibited among testing materials in yield and agronomic traits. In agreement, some scholars confirmed the existence of variability among Arabica coffee accessions in yield performance[15,22-25]. Despite a high yield gap recorded among testing materials, the pooled mean clean coffee yield of over four years showed statistically non-significant differences among treatments. The yield performance of coffee accessions ranged from 2416.33 to 1122.92 kg/ha, which showed twofold difference between high and low performed coffee genotypes (Appendix Table 1).

The biennial bearing characteristic was revealed by coffee genotypes. High bearing of cherries was exhibited in 2020/2021 and 2022/2023 harvesting seasons; but in 2019/2020 and 2021/2022 low bearing was recorded. In line with this, findings confirmed that the availability of yield bienniality characteristic of Arabica coffee[15,26-29].

Variability was manifested among augmented treatment, whole treatment and between augmented treatments and checks in some agronomic traits (Table 2). This implies that the possibility to select best performing promising line using indices traits. Similarly, Gebreselassie *et al.*[30] reported variability among Arabica coffee genotypes in morphological traits. Findings realized that yield-related traits are among the indicators for selection of high yielding coffee genotypes[23,31].

Lateral branches such as a number of primary branches and secondary branches, are among the indices traits for high yielding genotype selection. Under normal conditions, they are positively associated with clean coffee yield. Despite non-significant difference was revealed among augmented accessions and between augmented vs checks in a number of primary branch and secondary branch, 42 to 77 and 50 to 156 differences were recorded for the highest and lowest performed accessions, respectively. In agreement, different scholars confirmed the availability genetic diversity among *Coffea arabica* L. germplasms in Agronomic traits[30,32-34].

Moderate genetic diversity was revealed among Arabica coffee genotypes in almost all agronomic traits. Number of secondary and number of bearing primary branches showed moderate GCV (10-20%) and high PCV (>20%); plant height and stem girth recorded high broad-sense heritability (>60%). Additionally, high genetic advance as a percentage of mean (GAM) (0.20%) was recoded for number of bearing primary branches (NBPB), stem girth and secondary branches. This elucidated that these traits can be used as indices for high yielder pipe line selection. Similarly, Atinafu *et al.*[35] and Weldemichael *et al.*[36] low to high GCV and PCV were recorded for Agro-morphological traits. In line with this, moderate broad-sense heritability was recorded for NSB, LFPB and NBPB[23,31,37]. Also, Atinafu *et al.*[35] found medium value of hBS for NSB. Additionally, Akpertey *et al.*[31] and Kitila *et al.*[38] reported than high GAM in main stem diameter and number of secondary branch of Arabica coffee.

Low GAM (<10) was recorded for number of primary branch. This finding contradicts with the finding of Degefa *et al.*[39], who reported moderate GCV in number of primary branch and low GAM in length of the first primary branch. The present findings depicted that if the top five high yielders are selected using over four mean yields, about 22 number of secondary can be improved per cycle of selection over population (Table 3); also, 39.49 cm genetic gain in plant height, 8.74 mm in main stem girth and 4 number of node per main stem can be obtained. As these traits have significant and strongly positive correlation with clean coffee yield[31,40], they play momentous role for high yielding selection of Arabica coffee pipe lines.

About twelve promising lines were showed 2416.33 to 1841.68 kg/ha yield performance and relatively good in agronomic traits. The present results provided important insight as these lines have good yielding potential. Thus, taking them to their original location and testing over representative locations of coffee producing areas of Horo Guduru Zone may enable them to express their actual yield potential. Hence, selecting these twelve pipe line as advance line and testing them in uniform plot for further evaluation in yield, disease resistance and quality is momentous. In agreement, a total of 15 and 25 advanced lines were selected from 88 and 120 Arabica coffee accessions, respectively[15,28].

CONCLUSION

A significant difference was tested among the augmented accessions in clean coffee yield for some harvesting seasons. Additionally, significantly variability was found in plant height, number of node per main stem and main stem girth. Twelve lines exhibited clean coffee yield performance ranging from 1841.68-2416.33 kg/ha, while Abe11 recorded a 215.33 kg/ha clean coffee yield improvement over best check 744. Therefore, these twelve lines are recommended for selection as advanced lines and further testing for yield, yield components, quality, and disease resistance across representative coffee-producing areas in the Horro Guduru.

SIGNIFICANCE STATEMENT

This study discovered the availability of genetic diversity among Arabica coffee accessions of Horro Guduru Wellega Origin. The findings highlight the selection of the best-performing pipeline to develop improved varieties for the locality. Accordingly, twelve promising lines of Arabica coffee were selected from the base population for further evaluation under the representative agroecology of the Horo Guduru District. These materials will help researchers as a genetic resource for coffee genetic improvement. The present findings will also be used by different scholars and the coffee industry.

ACKNOWLEDGMENT

The authors thank the Ethiopian Institute of Agricultural Research for financing the experiment; also, the authors highly appreciate Jimma Agricultural Research Center for its technical and logistic support during the field experiment. Additionally, the authors would like to appreciate the coffee breeding and genetics team for their inestimable support during data collection and their involvement in field experimental plots management starting from its establishment to the end of the experiment.

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