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Assessment of the quality characters of some promising Arabica coffee hybrids under highland environments in southwestern Ethiopia

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Abstract
Cup quality, often referred to as liquor quality is an important attribute of coffee and acts as yardstick for price determination. However, the identification of genotypes with superior quality merely depends on consideration of character or trait(s‘) with high heritability. The objectives of this study were to: (i) estimate the broad-sense heritability of coffee quality related characters (ii) to determine the performance of the eight promising F_1 coffee hybrids under highland local environments based on green bean physical and cup quality characteristics relative to that of the existing commercial cultivars in Southwestern Ethiopia. The mean value, genetic variances and heritability on an entry mean-basis were estimated across four environments. The mean difference among genotypes across environments for all ten of eleven studied variables were significant (*P* 0.01) except aromatic intensity taste. On this basis, the heritability estimates of the two green bean physical and two organoleptic cup quality characteristics were moderate to high (0.55±0.24 to 0.91±0.05), while the other seven characters exhibited low to moderate heritability (below 0.48±0.28). The GxE effects of these quality attributes with moderate to high heritability estimates was also not severing, suggesting selection based on single environment would be efficient for improving these traits on other sites. The Hybrids HC1 followed by HC3 and HC2 combined above average value for both green bean physical characteristics and desirable cup quality attributes and are more preferable.

Keywords: coffee hybrids, cup quality, green bean characters, GxE effect, heritability, proportion of variance components

1. Introduction
Coffee is the most valuable and traded commodity in the world next to fuel. In Ethiopia, it is still the main foreign currency earner with the lion share of about 25-30% (Alemayhu, 2014) [1]. Highland coffee environment is one of the major coffee growing environments in southwestern Ethiopia, the probable origin of Arabica coffee (*Coffea arabica* L.).

Apart from productivity, cup quality (Beverage quality), often referred to as liquor quality is an important attribute of coffee and acts as yardstick for price determination (Muschler, 2001) [2]; Kathurima *et al*., 2009) [3]. The current breeding in Ethiopia which considered bean quality in addition to increased yield and resistance to diseases is taken as new but complimentary strategies initiated in early1980 had led identification of some elite hybrids derived from their Southwestern Ethiopian coffee parental origin. The selection of the superior one from these hybrids for economically important character of low heritability can be maximized through increasing the efficiency of indirect selection of the secondary character or trait(s‘) that known to have high heritability. However, selection for quality traits in Arabica coffee is constrained by the prevalence of large genotype by environment (G × E) interactions together with low genetic variability within the species (Agwanda *et al*., 2003) [4]. Even with the existing such environmental influence, there will be a chance of identifying traits with high heritability estimates that could be used to lead an effective selection program. Wolaryo (1983) [5] in his multiple environment tests reported high heritability estimates for overall standard quality taste and Olika *et al*. (2011) [6] in his single environment test similarly, reported high heritability estimates for aromatic quality taste with their respective low and low to moderate heritability estimates for the other most liquor quality attributes. At present, there is dearth of information especially on studies that included a site effect in genetic parameter estimation of coffee quality to estimate the effect of GxE and most of the available information’s were run in single environment and the possible modification of genetic potential by local growing environments (G x E interaction) are ignored.

The objectives of this study were to: (i) estimate the broad-sense heritability of quality related characters (ii) determine the performance of the eight promising F_1 coffee hybrids under highland local environments based on green bean physical and organoleptic cup quality characteristics relative to that of the existing commercial cultivars in Southwestern Ethiopia. The information will be of importance to coffee breeders in future to follow arabica coffee breeding programs under highland environments.

2. Material and Methods
The study was conducted at two different sites for two production seasons in Gera district of the south-western region of Ethiopia. The study sites represent the highland humid coffee growing agro-ecology and are well known as hot spot for coffee berry disease (CBD). The sites were Gera Research Station and on-farm location around the station. Eight F_1 hybrids along two standard check varieties were evaluated in this study (Table 1). The experimental material

was laid out in a Randomized Block Design (RBD) with three replications and established in July, 2008 at both sites with comprising of sixteen coffee trees of each genotype in each plot. Recommended cultural practices were followed and observations were made on the green bean physical and organoleptic cup quality parameters for two seasons (2014 and 2016). The coffee sample preparation procedures for quality analysis and data collection techniques for three green bean physical and eight organoleptic cup quality characteristics as described by Abrar *et al.* (2014) [7] and elaborated by Fekadu *et al*. (2019) [8] were adopted. Analysis of variance was performed with the MIXED procedure of SAS version 9.2 (SAS, 2008) [9]. For the purposes of estimating hybrid means and comparing check entries with experimental hybrids, checks were considered fixed effects. Environment and replications were considered random effects. To estimate genetic components of variance, the genotypes were considered random effects and variance components for genotypes and genotype x environment interaction were estimated with the SAS MIXED procedure. Heritability and its approximate standard error for each trait were estimated for each trait using Mixed model of SAS across environments after Holland *et al.* (2003) [10]. Heritability on a entry-mean basis estimated as $h^2_{bs=}$ (σ^2g)/[σ^2g + σ^2ge/e + σ^2e/re], where σ^2g is the estimate of genotypic variance, σ^2ge is the estimate of genotype x environment variance, σ^2e is the estimate of error variance, r is the number of replication per environment and e is the number of environments. Genotype clustering was done by an agglomerate hierarchy cluster analysis, i.e., the clustering according to the degree of similarity determined on the basis of Euclidean distances.

Table 1: Description of the coffee hybrids and commercial checks used for the study

Code- name	Parent	Cross*	Cross categories†
HC¶1	P_1, 7455	P_1 X P_2	CBD res +Q x CBD res +Q
HC2	P_2, 7530	P_1 X P_3	CBD res +Q x CBD res +Q
HC3	P_3, 74153	P_1 X P_4	CBD res +Q x CBD res +Q
HC4	P_4, 74167	P_5 X P_2	CBD res +Q x CBD res +Q
HC5	P_5, 74158	P_3 X P_5	CBD res +Q x CBD res +Q
HC6		P_3 X P_2	CBD res +Q x CBD res +Q
HC7		P_1 X P_5	CBD res +Q x CBD res +Q
HC8		P_4 X P_2	CBD res +Q x CBD res +Q
Ababuna (HYCK)		hybrid check	CBD res x high yielder
74110 (VCK)		variety check	CBD res

* P=Parent, †CBD res = CBD resistant; Q = good quality; HY = high yielder; ¶HC =Hybrid coffee

3. Results and Discussion

3.1 Analysis of Variance

Mean performance differences among genotypes were significant ($P < 0.01$) for all quality characters across environments except aromatic intensity taste indicating the opportunity to select the genotypes with desirable characters. The hybrid and check means were not significantly different for most of the characters except the three bean physical characters and bitterness taste (Table 2).

3.2 Mean performance

The mean values of the test hybrid HC1, HC4 and HC6 were desirably higher than the best check for bean size, shape and make appearance and comparable for color attribute with best check, while least score for these three green bean physical characteristics was recorded by check variety VCK and hybrid HC5 (Table 3). On the contrary, the check variety VCK and hybrid HC5 together with hybrid HC1 had highest mean score for all desirable cup quality attributes (aromatic intensity, aromatic quality, acidity, body, flavor and overall quality tastes) ranged from 3.76 to 4.31 which is moderate to strong tastes, while the lower score for most these attributes other than aromatic intensity and aromatic quality was recorded by Hybrid HC4 and HC6 with a range of 3.42 to 3.88 which is medium value for cup quality attributes. Hybrid HC1 followed by HC3 and HC2 combined above average value for both green bean physical characteristics and desirable cup quality attributes. Cluster analysis was also grouped these hybrid genotypes and commercial check varieties based on their mean performance into three main clusters according to their germplasm composition (Figure 1), for instance the first main group formed by three subgroups which were mostly related in their pedigree joined together (Table 1) indicating that the important of gene in expression of these quality characters among studied coffee genotypes.

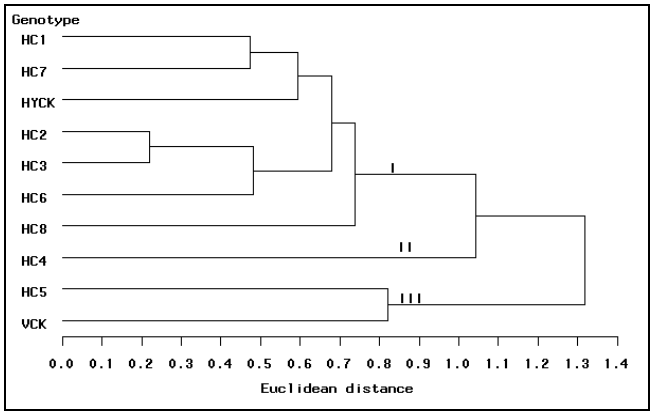

Fig 1: Dendrogram of the coffee genotypes considering green bean physical and organoleptic quality traits evaluated at Gera environments in Southwestern Ethiopia.

Table 2: Means of all entries, hybrids, and checks of arabica coffee evaluated at two locations for two years.

Entry	SC(14)	SM	Color	AI	AQ	AC	AS	BI	BO	FL	OAQ
All genotypes	97.00	4.49	4.65	3.96	4.01	4.75	0.63	0.46	3.76	3.70	3.69
Hybrids	97.42	4.53	4.66	3.93	4.01	3.74	0.63	0.48	3.75	3.68	3.68
Checks	95.28	4.32	4.58	4.07	4.01	3.78	0.63	0.38	3.77	3.75	3.75
Hybrids vs. Checks ‡	**	**	NS	*	NS	NS	NS	*	NS	NS	NS

SC14% = percent of above screen 14(5.60mm), SM = Shape and make AI =Aromatic Intensity, AQ =Aromatic Quality, AC = Acidity, AS= Astringency, BI= Bitterness, BO = Body, FL = Flavor and OAQ = Overall Quality; * = significant at P= 0.01. *= significant at P= 0.05. NS, non-significant.

Table 3: Mean green bean physical and cup quality traits of eight coffee hybrids and two checks evaluated across four Gera environments

Hybrids/ checks	SC(14)	SM	Color	AI	AQ	AC	AS	BI	BO	FL	OAQ
HC1	98.69	4.67	4.69	3.94	4.08	3.94	0.79	0.33	3.80	3.81	3.77
HC2	97.41	4.72	4.78	3.96	4.00	3.73	0.58	0.50	3.69	3.67	3.67
HC3	97.79	4.67	4.75	3.96	3.96	3.71	0.54	0.46	3.73	3.69	3.69
HC4	98.19	4.64	4.61	3.88	3.81	3.44	0.71	0.75	3.75	3.42	3.44
HC5	94.05	4.22	4.42	4.04	4.31	3.96	0.58	0.42	3.86	3.88	3.92
HC6	98.13	4.67	4.69	3.92	3.88	3.58	0.63	0.54	3.73	3.59	3.55
HC7	97.61	4.50	4.69	3.92	4.13	3.73	0.67	0.42	3.80	3.71	3.69
HC8	97.46	4.19	4.67	3.88	3.94	3.82	0.50	0.46	3.68	3.71	3.69
HYCK	96.41	4.53	4.61	4.04	3.98	3.78	0.71	0.42	3.77	3.72	3.74
VCK	94.16	4.11	4.56	4.10	4.04	3.78	0.54	0.33	3.78	3.78	3.76
Hybrids mean	97.42	4.53	4.66	3.93	4.01	3.74	0.63	0.48	3.75	3.68	3.68
Entries mean	97.00	4.49	4.65	3.96	4.01	3.75	0.63	0.38	3.77	3.75	3.75
Checks mean	95.28	4.32	4.58	4.07	4.01	3.78	0.63	0.38	3.77	3.75	3.75
LSD(0.05) for comparisons between											
Entries	0.66	0.23	0.26	NS	0.29	0.22	0.25	0.19	0.17	0.21	0.21
Hybrids vs Checks	0.37	0.13	0.14	NS	NS	NS	NS	0.11	NS	NS	NS
C.V%	0.83	6.31	6.98	7.99	9.03	7.21	48.89	50.21	5.49	7.07	7.12

HYCK= Hybrid check-Ababuna; VCK= variety chek-74110; SC14% = percent of above screen 14(5.60mm), SM = Shape and make AI =Aromatic Intensity, AQ =Aromatic Quality, AC = Acidity, AS= Astringency, BI= Bitterness, BO = Body, FL = Flavor and OAQ = Overall Quality. NS, non-significant

Table 4: Percentage contribution of genotype, genotype x environment interaction and error to the total components of their variances and estimates of broad sense heritability on an entry mean- basis (with standard error) for ten coffee genotypes

Variance components	SC(14)	SM	Color	AI	AQ	AC	AS	BI	BO	FL	OAQ
σ^2G	63.87	25.68	0.00	0.00	4.80	16.33	0.00	3.53	0.00	8.99	11.36
σ^2GE	19.11	20.27	12.40	0.00	4.73	8.16	24.81	32.94	15.69	13.48	9.09
σ^2e	17.02	54.05	87.60	100.00	90.47	75.51	75.19	63.53	84.31	77.53	79.55
h^2entry mean-basis	0.91±0.05	0.72± 0.05	0.00	0.00	0.36±0.35	0.67±0.18	0.00	0.20±0.44	0.00	0.48±0.28	0.55±0.24

SC14% = percent of above screen 14(5.60mm), SM = Shape and make AI =Aromatic Intensity, AQ =Aromatic Quality, AC = Acidity, AS= Astringency, BI= Bitterness, BO = Body, FL = Flavor and OAQ = Overall Quality.

Variance components and Heritability of Characters: Estimation of variance components were carried out using pooled data across two locations in two years combination following REML Procedure. Estimates of variance components of environment and genotype x environment interaction indicated non-significant environment effects and either non-significant or significant ($p < 0.05$) but complex interaction effects with lack of important genotypic difference (tables not included). The lack of environmental differences (year and location combinations) explained by the similarity of the two sites and the same processing procedures was being followed every year at each location. The percentage contribution of genotype and genotype x environment interaction variances towards total phenotypic variance is presented in Table 4. The contribution of genotype was high for the two highly heritable green bean physical characters (Shape and make appearance, 25.68% and bean size, 63.87%) and moderate for two cup quality characters (acidity, 16.33% and overall quality, 11.36%) as compared to corresponding genotype x environment interaction variances which ranged from 8.16% for acidity to 20. 27% for shape and make appearance and for the other quality attributes lower genotypic variances were exhibited. The broad-sense heritability of each trait on an entry mean-basis was ranged from 0.00 to 0.91±0.05 (Table 4). The heritability value derived from a genotypes evaluated over number of environment would increase the accuracy of the estimates of each traits (Falconer and Mackay, 1996) [11]. Organoleptic cup quality attributes had lower heritability (0.00 to 0.67±0.18) than green bean physical characteristics (> 0.72±0.18) other than bean colour which had shown minor genetic variation among the coffee hybrid genotypes. The lower or negligible heritability estimates for most of the organoleptic cup quality attributes could be explained by the highest proportion of the error variance towards total phenotypic variance though most of the quality attributes exhibited low experimental coefficient of variation (CV€ <10.00%) other than astringency and bitterness tastes (Table 3), suggesting the need of reducing residual variance which were dependent on the skill of the liquor technicians. Therefore, one way to reduce variance is refining the liquor quality assessment technique apart from increasing the genetic diversity level of the test materials to increase the heritability estimates of these quality characters.

4. Conclusion

The coffee quality assessment result showed that bean physical characters (bean size and shape and make appearance) and organoleptic cup quality characters (Acidity and overall quality tastes) exhibited moderately high and significant entry mean based broad sense heritability estimates and should respond to phenotypic selection. The G x E effect of these characters was also not severing. Hybrid HC1 followed by HC3 and HC2 combined above average value for both green bean physical characteristics and desirable cup quality attributes. These three hybrids had also shown superior or comparable to the best hybrid check- Ababuna in bean physical quality per se performance and the best variety check-74110 in desirably cup quality per se performance and thus directly can be used for commercial production and/ or future breeding purposes.

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6. References

1. Alemayehu AA. Coffee production and marketing in Ethiopia. European Journal of Business and management. 2014; 6(37):109-121.
2. Muschler RG. Shade improves coffee quality in a sub-optimal coffee zone of Costa Rica. Agrofor. Syst. 2001; 51:131-139.
3. Kathurima CW, Gichimu BM, Kenji GM, Muhoho SM, Boulanger R. Evaluation of beverage quality and green bean physical characteristics of selected Arabica coffee genotypes in Kenya. Afr. J. Food Sci. 2009; 3(11):365-371.
4. Agwanda CO, Baradat P, Eskes AB, Cilas C, Charrier A. Selection for bean and liquor qualities within related hybrids of arabica coffee in multi-local field trials. Euphytica. 2003; 131:1-14.
5. Walyaro DJA. Considerations in breeding for improved yield and quality in arabica coffee (*Coffea arabica* L.). A PhD thesis, Wageningen Agricultural University, 1983, 74-84.
6. Olika Kitila, Sentayehu Alamerew, Taye Kufa and Weyessa Garedew. Organoleptic Characterization of Some Limu Coffee (*Coffea arabica* L.) Germplasm at Agaro, Southwestern Ethiopia. International Journal of Agricultural Research. 2011; 6:537-549.
7. Abrar S, Negussie M, Meseret D. Hybrid Coffee (*Coffea arabica* L) Genotypes Quality Evaluation under different Environment of Southern Ethiopia. Greener Journal of Agricultural Sciences. 2014; 4(6):245-251.
8. Fekadu T, Sentayhu A, Dagne W. Variation and Genotype X Environment Interaction for Quality Characters among Selected Coffee Hybrids under Mid-Lowland Environments in Ethiopia. J. Biol. Chem. Research. 2019; 36(1)Part C:61-68.
9. SAS Institute, Inc. Statistical analysis system (version 9.2), SAS Institute, Cary, NC.USA, 2008.
10. Holland JB, Nyquist WE, Cervantes-Martinez CT. Estimating and interpreting heritability for plant breeding: Anupdate. In J. Janick (ed.), Wiley, New York. Plant breeding reviews, 2003; 22:9-111.
11. Falconer DS, Mackay TFC. Introduction to quantitative genetics, 4th ed. Longman Technical, Essex, UK, 1996.