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Morphological Diversity of Coffee Arabica (Coffea arabica L) Landraces in Guji and West Guji, Southern Oromia, Ethiopia

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A B S T R A C T

Ethiopia is the birthplace and center of Arabica coffee's genetic diversity (Coffea arabica L., Rubiaceae). More genetically diverse strains of C. arabica exist in Ethiopia than anywhere else in the world. The study aimed to assess the morphological diversity of Arabica coffee landraces in Guji and West Guji zones, southern Ethiopia. The study was conducted in 11 districts of Guji and west Guji zones. Data were collected from 162 coffee farms across the selected of 11 districts, focusing on morphological traits such as plant height, canopy habit, cherry color, cherry size and leaf tip color. Results showed that large variability within and among districts. Most landraces exhibited medium plant height (37.6%), open canopy habit (38.1%), medium cherry size (39.1%), and red cherry color (79.2%) and brown leaf tip color (43.1). The observed morphological diversity indicated that coffee genetic resources in the zones. The study underlines the need for conservation strategies to preserve these unique genetic resources for future coffee breeding program and production.

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INTRODUCTION

The genetic diversity of Arabic coffee (Coffea arabica L., Rubiaceae) originated and is concentrated in Ethiopia (Vavilov 1951). Most of the genetic diversity of native (wild) Arabica coffee is found in the afromontane rain forest, which is located in the east and west of the Great Rift Valley (Bayetta et al., 2008). About 15–16 million people in Ethiopia depended on the cultivation of coffee for their livelihood. Additionally, it accounts for roughly 10% of the county's crop production and 34% of its foreign exchange earnings (Tadesse et al., 2015)

In Ethiopia, coffee accounted for 5.65% of all small-scale peasant farmers' land (794,403.50 hectares), yielded 5.87 yields (qt/hectare), and produced 5,455,663.58 quintals of product in 2021–2022(CSA, 2022). Ethiopia's production of arabica coffee has progressively increased from 6 million bags 10 years ago to over 8.15 million bags in 2022, making it Africa's top producer overall and the third-largest grower in the world (GAIN, 2022). The availability of very varied agro ecological conditions under which coffee grows in Ethiopia, evolutionary tendencies or modifications of the species, or natural mutations occurring in the crop population are thought to be the reasons for the high genetic diversity of self-pollinated Arabica coffee. More than 90% of the genetic variety of Arabica coffee worldwide is found in Ethiopia, demonstrating the importance of Ethiopian coffee genetic resources for the global coffee industry's future.

Ethiopia is the hub for the genesis, diversification, and spread of the coffee plant, according to botanists and scientists, because it possesses more genetically different strains of C. arabica than any other place in the world (International, 2018). The populations of C. arabica from the southwest region of Ethiopia exhibit substantial genetic variety, according to a number of phenotypic and molecular investigations. As a result, the forests in this region are favorable for the species in situ conservation. According to Sylvain (1958) and Meyer (1968), Ethiopian coffee populations exhibit a significant degree of variability in a number of phenotypic traits. Additionally, Montagnon & Bouharmont (1996) discovered that populations of C. arabica taken from Ethiopia had greater phenotypic variety than cultivated populations of the plant from other countries.

Coffee is the major cash crop in Guji and West Guji zones, which serves as a major means of cash for the livelihood of coffee farming families. Evaluation of genetic diversity within a crop plant is important, as it determines the extent to which the crop can be improved or changed by selection (Dabholkar, 1999). The high genetic diversity of coffee landraces in Guji and West Guji serves as a valuable source for selecting and characterizing traits such as disease resistance, high yields, and superior aroma and flavor. Despite the high genetic diversity in the zones morphological diversity of the landrace is not quantified. And currently in zones coffee genetic resource is subjected to genetic erosion as a result of deforestation due to forest for investment, resettlement, fire wood, construction, replanting with improved varieties, expansion of land for food crops and others. Therefore, the current study was undertaken to assessing the variability with the following objective: - To assess the availability morphological diversity of Coffee Arabica landrace in Guji and West Guji zones.

LITERATURE REVIEW

Coffee Arabica (Coffea arabica L.) is one of the most economically important and widely consumed beverages in the world, with Ethiopia recognized as its center of origin and genetic diversity (Anthony et al., 2002). Among various coffee-growing regions in Ethiopia, Guji and West Guji Zones in Southern Oromia are known for their rich repository of Arabica coffee landraces, cultivated under diverse agroecological conditions. These landraces possess high morphological and genetic variability, which contributes significantly to the resilience, quality, and adaptability of coffee plants (Tesfaye et al., 2013).

Morphological diversity refers to the observable phenotypic variations among plant populations, including traits such as leaf shape, plant height, bean size, fruit color, and canopy architecture. These variations are essential not only for crop improvement programs but also for conservation efforts, particularly in the face of climate change and market demands (Yigzaw, 2005). Several studies conducted in Ethiopia have indicated a high degree of morphological heterogeneity among Arabica coffee populations, often influenced by local farming practices, microclimates, and elevation gradients (Bayetta, 2001; Alemayehu et al., 2008).

In the Guji and West Guji zones, traditional farming systems and selective propagation by farmers over generations have played a significant role in preserving diverse landraces. These landraces are locally adapted and often display unique characteristics in flavor, bean structure, and stress tolerance. According to Taye et al. (2017), farmers in these regions often recognize and classify landraces based on vernacular names and morphological traits, indicating deep indigenous knowledge associated with coffee cultivation.

Despite the significance of this morphological diversity, systematic scientific characterization remains limited. Recent efforts have aimed to document and assess these variations through agro-morphological descriptors developed by the International Plant Genetic Resources Institute (IPGRI), enabling better understanding and utilization of coffee genetic resources. Such studies are crucial for breeding programs aimed at enhancing yield, disease resistance, and cup quality while ensuring the conservation of Ethiopia's invaluable coffee heritage.

In conclusion, the morphological diversity of Coffea arabica landraces in Guji and West Guji represents a critical genetic resource. Its documentation and conservation are vital for sustaining coffee production in Ethiopia and globally. Continued research integrating both morphological and molecular tools is necessary to fully harness this diversity for future coffee improvement initiatives.

METHODOLOGY

Description of study area

The study was conducted on coffee landrace producing districts of Guji and west Guji zone. Both zones are one of the known coffee-growing areas in the southern Oromia of Ethiopia. The study was conducted in a total of eleven (11) districts, eight districts from Guji and 3 districts from west Guji zone. The districts were selected based the availability of coffee landrace from Guji and west Guji zone (Figure 1).

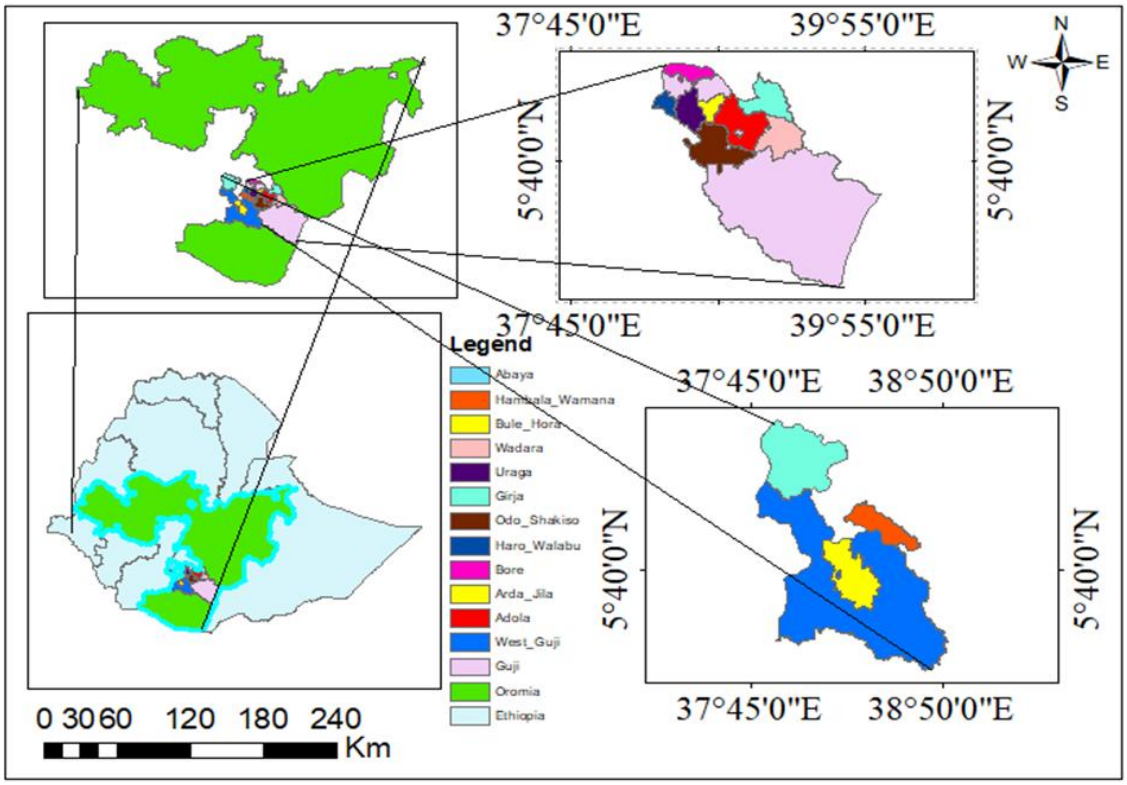

Figure 1. Map of study area

Sampling Procedure and methods

For this assessment, districts were purposively selected based on the availability of coffee landrace and likewise kebeles from each district purposively selected based on the availability of coffee landrace this was carried out by discussing with zonal and districts agricultural office. Eight districts from Guji zone and three districts from West Guji were addressed for this study. Coffee plants were characterized by coffee experts and breeders after samples were gathered purposefully from selected kebeles. Coffee characterization was done based on Arabica coffee morphological descriptors for characterization purpose, as described by the International Plant Genetic Resources Institute.

Method of Data Collected

Data were collected plant based; a given plant was selected based on the morphological appearance from the whole farm. Data was collected from the selected mother plant. The history of the plant was recorded and plant height, leaf tip color, cherry color, cherry size and canopy of the plant data were collected as follows

Plant height and Canopy habit

Plant height: above grown height of the plant was considered. The plant above 5m was considered as tall, the plant above three and below five meter was considered as medium plant height, the plant below two meter was considered as short plant height. Canopy habit: plants were classified as based on as

compacted below one meter canopy, intermediate between one and two meter and above three meter was considered as open canopy habit.

Cherry size and Cherry color

Cherry size was classified as small, medium, and large depending on cherry size. Cherry color was identified by observation and indicator.

Data management and analysis

Collected data was managed on Microsoft excel computer and descriptive analysis subjected to SPSS software.

RESEARCH RESULT AND DISCUSSION

In total, 162 coffee farms were assessed. The study showed that a wide range of coffee landrace variability across the whole studied districts of Guji and west Guji zones in morphological traits of coffee arabica (plant height, cherry size, cherry color, canopy habits, and tip leaf color)

Morphological Parameters

Plant height: Plant height was one parameter for morphological characterization of plants: based on plant height, coffee landraces in the study area were classified as tall, medium and short type. From total observations from both zones (30.7%) were tall, (37.6%) were medium height, and (31.7%) were short. The result of observation showed that most of the landraces were medium in height, followed by short and tall. Across districts, there was a variation among landraces in plant height (Table1).

Canopy habit: During this study coffee landraces were classified into three types of canopy habit as: compact, moderate, and open. There were (25.80%) compacted canopy habits, (36.1%) intermediate canopy habits, and (38.1%) open canopy habits among the total assessed farms. The majority of the coffee landraces had an open canopy habit, according to the observations. Across districts, there was a variation among landraces in canopy habit (Table 1).

Table 1. Diversity of C. arabica across different districts of Guji and west Guji zone in Canopy habit and plant height during 2020/2021.

Zone	Districts	Mean Year	Canopy habit		Plant height			
			Compact	Intermediate	Open	Tall	Medium	Short
Guji	Wadara	11.76	23.5	47.1	29.4	29.4	64.7	5.9
	Girja	21.62	12.5	50.0	37.5	37.5	37.5	25.0
	Adola Rede	27.62	23.8	47.6	28.1	14.3	47.6	38.1
	Odo Shakiso	37.82	21.6	35.3	43.1	43.1	21.6	35.3
	Uraga	45	30	40	30	40	30	30
	Arda Jila/M/B	31.17	30.4	39.1	30.4	30.4	47.8	21.7
	Bore	71.11	22.2	44.4	33.3	66.7	22.2	11.1
	Haro Walabu	29	16.7	16.7	66.7	16.7	33.3	50
	Bule Hora	53.95	-	-	-	22.7	40.9	36.4
W/ Guji	Abaya	27.8	60	40	-	40	20	40
	H/ Wamana	60	20	26.7	53.3	13.3	43.3	43.3
	Total %	-	25.2	36.1	38.1	30.7	37.6	31.7

Note; W/Guji=West Guji, Arda Jila/M/B= Arda Jila Mea Boko, H/Wamana =Hambela Wamana.

Leaf tip color: During this study coffee landraces were classified into four types of Leaf tip color as: brown, green, light brown and light green. There were (43.1%) brown leaf tip color, (41.1%) green leaf tip color, (8.4%) light brown leaf tip color and (7.4%) light green leaf tip color among the total assessed farms. The majority of the coffee landraces had a brown leaf tip color next by green leaf tip color, according to the observations. Across districts, there was a variation among landraces in leaf tip color (Table 2).

Table 2. Diversity of C. arabica across different districts Guji and west Guji zone in Canopy habit and plant height during 2020/2021.

Zone	Districts	Mean Year of coffee	Leaf tip color %			
			Brown	Green	L. Brown	L. Green
Guji	Wadara	11.76	52.9	23.5	17.6	5.9
	Girja	21.62	37.5	12.5	37.5	12.5
	Adola Rede	27.62	33.3	38.1	14.3	14.3
	Odo Shakiso	37.82	37.3	52.9	5.9	3.9
	Uraga	45	40	60	-	-
	Arda Jila/M/B	31.17	47.8	34.8	4.3	13
	Bore	71.11	33.3	55.6	-	11.1

	Haro Walabu	29	83.3	16.7	-	-
	Bule Hora	53.95	50	22.7	18.2	9.1
W/Guj	Abaya	27.8	60	-	-	40
i	Hambela Wamana	60	60	40	-	-
	Total %		43.1	41.1	8.4	7.4

Note; W/Guji=West Guji, Arda Jila/M/B= Arda Jila Mea Boko, L. Brown=Light Brown, L. Green= Light green.

Cherry size: During the coffee Landraces were classified as small, medium, and large depending on cherry size. From the total observations, 39.1% were medium cherry sizes, 36.6% were large cherry sizes, and 24.3% were small cherry sizes. According to the observations, the most of the coffee landraces had medium cherry sizes (Table 3).

Cherry color: Cherry hue landraces were divided into three groups: light red, red, and yellow. From the totally observed coffee landraces (79.2 %) were red cherry, (18.3%) light red and (2.5%) were yellow cherry color (Table 3).

Table 3. Diversity of C. arabica across different districts of Guji and Wes Guji zone in cherry color and cherry size during 2020/2021.

Zone	Districts	Mean	Cherry color %			Cherry Size %		
		Year	Yellow	Light red	Red	Large	Medium	Small
	Wadara	11.76	11.8	29.4	58.8	17.6	58.8	23.5
	Girja	21.62	-	12.5	87.5	37.5	37.5	25.0
	Adoal Rede	27.62	4.8	19	76.2	23.8	57.1	19
	Odo Shakiso	37.82	-	13.7	86.3	41.2	29.4	27.5
Guji	Uraga	45	-	-	100	20	60	20
	Arda Jila/M/B	31.17	-	13	87	39.1	47.8	13
	Bore	71.11	22.2	-	77.8	44.4	33.3	22.2
	Haro Walabu	29	-	16.7	83.3	50	33.3	16.7
W/Guji	Bule Hora	53.95	-	22.7	77.3	45.5	40.9	13.6
	Abaya	27.8	-	20	80		40	60
	H/Wamana	60	-	33.3	66.7	43.3	20	36.7
	Total %		2.5	18.3	79.2	36.6	39.1	24.3

Note; W/Guji=West Guji, Arda Jila/M/B= Arda Jila Mea Boko, H/Wamana =Hambela Wamana

DISCUSSION

During this study, the results indicated that there was variation in morphological characters among the coffee landrace of Guji zone. This was may be due to genetic diversity among the individual population of landraces. The observed variability presents an opportunity for breeding programs to develop high-yielding, drought-resistant, and disease-resistant varieties with superior quality. Abdi et al., (2020) stated that the presence of phenotypic variability among the accession reveals that there is a good chance of improving coffee

accessions through selection and hybridization. Similar to our finding various authors reported morphological variability of coffee Arabica in Ethiopia. For instance, Meseret et al., (2021) reported the morphological diversity characters among evaluated arabica coffee landraces at Awada. Abdi et al., (2020) also reported that there is considerable phenotypic variation in coffee accessions grown in eastern Ethiopia. In addition, Natol et al., (2022) found that sufficient diversity among coffee landraces in various morphological characters in western Ethiopia.

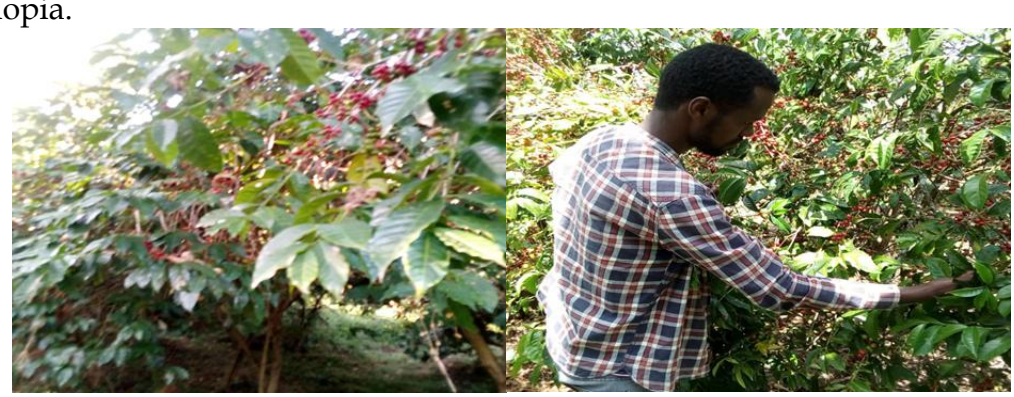

Figure 2. Pictures taken by authors during study

CONCLUSIONS AND RECOMMENDATIONS

This study showed considerable morphological diversity among Arabica coffee landraces in the studied districts of Guji and West Guji zones, southern Ethiopia. Landraces showed variability in morphological traits: plant height, canopy habit, cherry size, and cherry color. Most landraces exhibited medium plant height, open canopy habit, medium cherry size, red cherry color and brown leaf tip color, this indicated the coffee genetic abundance of the study area. However, these genetic resources face threats of genetic erosion due to deforestation, land-use changes, and the introduction of improved varieties. So, it's recommended: establish in situ and ex situ conservation programs to preserve the genetic diversity of coffee landraces in Guji and West Guji zones. Utilize the diverse landraces in breeding programs to develop disease-resistant and high-yielding varieties with superior cup quality. Give awareness for local communities in conservation of coffee landraces. Further research for molecular studies is needed to provide deeper insights into the genetic diversity of Arabica coffee in the study area.

ADVANCED RESEARCH

Future research should integrate molecular techniques such as SSR or SNP markers to complement morphological data and uncover the genetic structure of Arabica coffee landraces in Guji and West Guji. This will aid in identifying traits linked to disease resistance, yield, and cup quality. Combining genetic data with environmental analysis will support targeted breeding, conservation strategies, and adaptation planning under climate change.

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