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Assessment on the Current Status of Coffee Arabica (*Coffea arabica* L) Landraces Diversity in Coffee Belt Areas of Western Oromia, Ethiopia

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Abstract: *Coffea arabica* L. belongs to the Rubiaceae family, and the genus Coffea and its primary center of origin is Ethiopia. Coffee is an evergreen dicotyledon tree. It ranks second in global trade after petroleum as an essential commodity for beverages and as a profitable export good. The survey was carried out in three western Oromia zones: East Wollega, West Shoa, and Horoguduru Wollega. The assessment was carried out over the cropping seasons of 2020 and 2021. A total of 306 coffee farms were addressed from all zones, with 15 farms from each Woreda. Coffee landrace diversity was measured using plant height, cherry size, cherry color, and canopy habits. The landrace differences were identified using coffee phenotypic markers. As a result, coffee landraces showed genetic variation in all variables studied. In total, 38.24 percent of observations were open canopy, 46.08 percent were small cherry size, 44.12 percent were tall plant height, and 43.79 percent were. Around half of the entire landraces in the east Wollega Zone had small cherry sizes, open canopy habits, and recent had small cherry sizes, 30.37 percent had medium cheery sizes, and 21.03 percent had giant cherry sizes. The open canopy habit made up 43.46 percent of the canopy, while the intermediate and compact canopy habits made up 34.11 percent and 22.44 percent of the canopy, respectively. Most landraces in the Horoguduru Wollega Zone were modest and cheerful. More than half of the landraces tested developed tall plants with pale red cherry colors. The majority of landraces in the west Shoa Zone exhibited intermediate canopy behaviors (40 percent). More than half (60%) of the cherries sampled were medium in size and plant height. Light red made about 80percent of the cherry color. As a result of the findings, a significant quantity of genetic variation in coffee arabica was observed, leading to the recommendation of landrace collection for future breeding programs.

Keywords: Assessment, Landrace, Diversity, *C. arabica*, Traits

1. Introduction

Coffee (*Coffea arabica* L.) is the most important woody crop in the world [13]. The Coffeae (Rubiaceae) tribe includes 11 genera, including the closely related Coffea and Psilanthus [10]. The subgenus Coffea, includes 103 species and all species are containing with different amount and type [12]. The other species of coffea is liberica coffee and it is grown in Africa and Asia which accounts 1 % of global. *Coffea arabica* is the only tetraploid species in the genus and is self-fertile, while other species are diploid and generally self-incompatible [20]. Commercial coffee production relies only on two species, *Coffea arabica* and Coffea. canephora Pierre ex Froehner contributing 60% and 40%, respectively, of the global market [27]. Coffee is grown in more than 60 nations throughout the globe. Three countries, namely Brazil, Honduras, and Columbia, account for more than two-thirds of global production. Africa contributes 12% of global production, down from 30% in the 1970s. Arabica coffee accounts for over 60% of total world production. In Ethiopia, more than 90% is produced in the Western, Southern, South Western and Eastern parts of the country. The total area coverage of coffee in Ethiopia is estimated to be around 800,000 ha, of which about 95% is produced by 4 million small scale farmers [8].

Ethiopia is the origin of Arabica coffee and produces high-quality coffee for both domestic use and export [5, 23, 24]. Ethiopia is first in Africa's in Arabic coffee growing and ranking fifth and tenth in the world in terms of production and exports respectively [18, 19]. In 2020 cropping season, the total area covered by productive coffee is estimated to 540,000 hectares and 450,000 metric tons yield was collected [26] (USDA, 2020). From total yield produced in the country, more than half of it is consumed in local market [1, 9]. Still coffee is number one foreign exchange source and known as "green gold" for the country. In total production, smallholder producers account more than 90% which are in the Western, South Western, Eastern, and Southern regions [4, 22]. Coffee production employs an estimated 1.2 million smallholder farmers [4, 22]. Total land under coffee production in Ethiopia reaches 700474.69 ha with estimated production of 469091.124tons. The production per hectare is 0.67ton/ha. Coffee production is a time and labor consuming, manual operation that most growers enlist the help of their immediate family to complete. In Ethiopia coffee can grow in an altitude range of 550 to 2750masl Gambella to southeast and northern respectively. But coffee Arabic best performed and produced in 1300-1800masl with rainfall distribution of 1500mm to 2500mm. Ideal temperature for coffee production is 15 to 25oc. The soil requirement of coffee varies from sandy loam to heavy clay while the dominant soil types are acidic (pH 4.2-6.8) red, reddish brown lateric loams or clay loams of volcanic origin and total annual rainfall varies from 750 to 2,400 mm [11, 14].

The Ethiopian coffee is the central High genetic diversity of coffee Arabica was reported by different scholars [17, 31]. The existence of such high genetic diversity of a self-pollinated Arabica coffee is believed to be attributed to the availability of extremely diverse agro-ecological variations under which coffee grows in Ethiopia, evolutionary tendencies or changes of the species or natural mutations occurring to the population of the crop [6]. Over 90% of the world's Arabica coffee genetic diversity found in Ethiopia indicating the significance of Ethiopian coffee genetic resources to the future of the world coffee industry [29].

In a coffee improvement effort, having access to both primary and secondary gene pools is critical. However, in recent years, genetic erosion and habitat destruction caused by modern agriculture has increased from time to time, while old coffee stumping and uprooting is widely practiced in western Oromia, resulting in the direct extirpation of coffee landraces and a big coffee improvement crisis. As a result, the following activity was devised to evaluate the existing diversity of coffee arabica in the study region and to document coffee diversity information for coffee researchers.

2. Study Procedure and Materials

2.1. Study Area

The research was carried out in three zones in western Oromia: East Wollega, Horo guduru Wollega, and West Shoa. East Wollega had 12 coffee belt districts surveyed, Horo Guduru Wollega had three districts surveyed, and west Shoa had only one district surveyed. The presence of old coffee trees or landraces with zonal and district approved personnel led to the selection of districts and kebeles. 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 [16].

2.2. Method of Data Collection

The coffee farm must be the same age, similar cultural practice, shade status and healthy plants was selected for these data. 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, cherry color, cherry size and canopy of the plant data was collected as follows:

1) Plant height: above grown height of the plant was considered. The plant above 5m was considered as tall, the plant above three below five meter was considered as medium plant height, the plant below two meter was considered as short plant height.
2) Canopy habit: plants were classified as based on [30] as compacted below one meter canopy, intermediate between one and two meter and above three meter was considered as open canopy habit.
3) Cherry color: a cherry color was identified by observation and indicator.

2.3. Data Analysis

Collected data was subjected to R-computer software and Microsoft excel computer program.

3. Results

In total, 306 coffee farms were assessed. The findings revealed a wide range of landrace variation across the whole area of study in plant height, cherry size, cherry color, and canopy habits.

Table 1. *Study area description and major coffee production system of the area.*

Districts	Number of farms assessed	Latitude range	Longitude range	Altitude range (masl)	Major production system practiced
Sibu Sire	16.00	09° 13.620'-09° 11.221'	036° 53.085'-036° 50.628'	1930-2078	Garden and semi forest
Diga	54.00	09° 03'939''-08° 43.304'	036°.26'452''-036° 35'008''	1298-1508	Semi forest
Nunu kumba	9.00	08° 44.814'-08° 43.304'	036° 46.283'-036° 35.008'	1498-2198	Garden
Sasiga	25.00	09° 13.657'-09° 08.713'	036° 28.241'-036° 28.348'	1582-1876	Semi forest
Limu	15.00	09° 46.556'-09° 43.436'	036° 27.998'-036° 27.401'	1912-2122	Garden and semi forest

Districts	Number of farms assessed	Latitude range	Longitude range	Altitude range (masl)	Major production system practiced
Gidda Ayana	29.00	09° 49.881-'09° 10.145'	036° 40.917'-036° 38.262'	1745-2078	Garden
Wayu tuka	16.00	08°57'.106''-08°57'.569''	036°41'.177''-036°40'.293''	1644-1890	Garden
Haro Limu	7.00	09°55'.920''-09°55.846'	036°18'.136''-036°17'.735''	1822-1892	Semi forest
Ebantu	5.00	09°58'.504''-09°58'.502''	036°22'.489''-036°22'.486''	1889-1990	Garden
Kiremu	6.00	09°50'.537''-09°50'.810''	036°53'.946''-036°57'.430''	1704-1821	Garden and semi forest
Gudaya Bila	15.00	09°15'.820''-09°15'.952''	036°59'.955''-036°59'.971''	1926-1984	Garden
Jima arjo	17.00	08° 42'.770''-08°47'.692''	036°27'.391-036°32'.369	1620-2011	Garden
Abe Dongoro	70.00	09° 36'.768''-09° 38'.102''	036° 53.252'-036° 49.909'	1603-1952	Semi forest
Guduru	6.00	09° 28'.396''-09° 30'.713''	037° 28.404'-037° 28.854'	2018-2347	Garden
Ababo Guduru	6.00	09° 39'.224''-09° 41'.860''	037° 31.244'-037° 32.316'	1970-2344	Garden
Danno	10.00	08°43'.354''-08°49'.190''	037°17.339'-037°22.064'	1796-1944	Garden

3.1. Morphological Traits

Canopy habit: The coffee landraces were classified into three types based on canopy habit: compact, moderate, and open. There were 26.80 percent compacted canopy habits, 34.97 percent intermediate canopy habits, and 38.24 percent open canopy habits among the total observations. The majority of the coffee landraces had an open canopy habit, according to the observations (Table 2).

Cherry size: Landraces were classified as small, medium, and large depending on cherry size. Among the total observations, 46.08 percent were small cherry sizes, 32.67 percent were medium cherry sizes, and 21.24 percent were large cherry sizes. According to the observations, the most of the coffee landraces had small cherry sizes (Table 2).

Table 2. *Diversity of C. arabica across different districts in canopy habit and cherry size, Western Oromia, Ethiopia.*

Woredas	Average year	Number assessed farms	Canopy habit			Cherry size		
			Compact	Intermediate	Open	Small	Medium	Large
Sibu Sire	33.00	16.00	18.75	12.50	68.80	50.00	25.00	25.00
Diga	32.00	54.00	18.52	35.19	46.30	29.63	46.30	24.07
Nunu kumba	25.00	9.00	22.22	33.33	44.40	55.56	22.22	22.22
Sasiga	60.00	25.00	20.00	32.00	48.00	36.00	24.00	40.00
Limu	32.00	15.00	26.67	53.33	20.00	66.67	26.67	6.67
Gida Ayana	33.00	29.00	17.24	44.83	37.90	68.97	17.24	13.79
Wayu Tuka	36.00	16.00	25.00	25.00	50.00	62.50	25.00	12.50
Haro Limu	40.00	7.00	14.29	28.57	57.14	71.43	28.57	0.00
Ebantu	38.00	5.00	20.00	20.00	60.00	60.00	40.00	0.00
Kiremu	50.00	6.00	16.67	16.67	66.67	66.67	16.67	16.67
Gudaya Bila	46.00	15.00	33.33	53.33	20.00	67.00	20.00	13.00
Jima Arjo	32.00	17.00	41.18	29.41	29.41	24.00	41.00	35.29
AbeDongoro	60.00	70.00	38.00	64.00	3.00	38.00	64.00	3.00
Guduru	25.00	6.00	50.00	50.00	0.00	33.33	50.00	16.67
Ababo Guduru	26.00	6.00	50.00	33.33	16.70	66.67	16.67	16.67
Danno	38.00	10.00	30.00	40.00	30.00	20.00	60.00	20.00
Total		306	26.80	34.97	38.24	46.08	32.67	21.24

Plant height: based on plant height, landraces were classified as tall, medium and short type. From total observations 44.12% was tall, 35.29% was medium height while 20.59% was short. From the results of the observations, most of the landraces were tall in height while some of them were short (Table 3).

Cherry color: Cherry hue landraces were divided into three groups: light red, red, and brown. Light red color observations accounted for 43.79 percent of total observations, followed by red color observations accounting for 38.89 percent. Brown cherry color 17.32 percent is the lowest observation (Table 3).

Table 3. *Diversity of C. arabica across different Woredas Western Oromia, Ethiopia in plant height and cherry color.*

Woredas	Average year	Number assessed farms	Plant height			Cherry color		
			Tall (%)	Medium (%)	Short (%)	light red (%)	Red (%)	Brown (%)
Sibu Sire	33.00	16.00	25.00	25.00	62.50	12.50	37.50	37.50
Diga	32.00	54.00	18.52	29.63	59.26	11.11	57.41	24.07
Nunu kumba	25.00	9.00	11.11	33.33	55.56	11.11	33.33	55.56
Sasiga	60.00	25.00	20.00	48.00	20.00	32.00	40.00	40.00
Limu	32.00	15.00	20.00	66.67	20.00	13.33	26.67	53.33
Gida Ayana	33.00	29.00	13.79	31.03	51.72	17.24	41.38	44.83
Wayu Tuka	36.00	16.00	25.00	43.75	31.25	25.00	25.00	50.00
Haro Limu	40.00	7.00	28.57	42.86	42.86	14.29	14.29	57.14
Ebantu	38.00	5.00	20.00	40.00	40.00	20.00	20.00	60.00

Woredas	Average year	Number assessed farms	Plant height			Cherry color		
			Tall (%)	Medium (%)	Short (%)	light red (%)	Red (%)	Brown (%)
Kiremu	50.00	6.00	33.33	33.33	33.33	33.33	16.67	50.00
Gudaya Bila	46.00	15.00	33.33	66.67	20.00	13.33	33.33	33.33
Jima Arjo	32.00	17.00	17.65	41.18	35.29	23.53	23.53	58.82
Abe-Dongoro	60.00	70.00	22.86	57.14	28.57	14.29	67.14	10.00
Guduru	25.00	6.00	0.00	66.67	16.67	16.67	33.33	66.67
Ababo Guduru	26.00	6.00	16.67	16.67	50.00	33.33	33.33	50.00
Danno	38.00	10.00	20.00	40.00	40.00	20.00	20.00	60.00
Total		306	44.12	35.29	20.59	43.79	38.89	17.32

3.2. The Diversity of Landraces Across Agro-Ecologies

3.2.1. East Wollega Zone

The results revealed that from the total observations 48.60 percent was small cheery sizes, 30.37 percent had medium cheery sizes, and 21.03 percent had large cheery sizes. The open canopy habit accounted for 43.46 percent of the canopy, whereas intermediate and compact canopy habits accounted for 34.11 percent and 22.44 percent, respectively (Figure 1). In plant height, 44.12% of total observations were tall while the 35.95% and 19.39% was medium and short respectively (Figure 2). In cherry color, 43.79% was light red while the other 38.89% and 17.32% was red and brown color respectively (Figure 2).

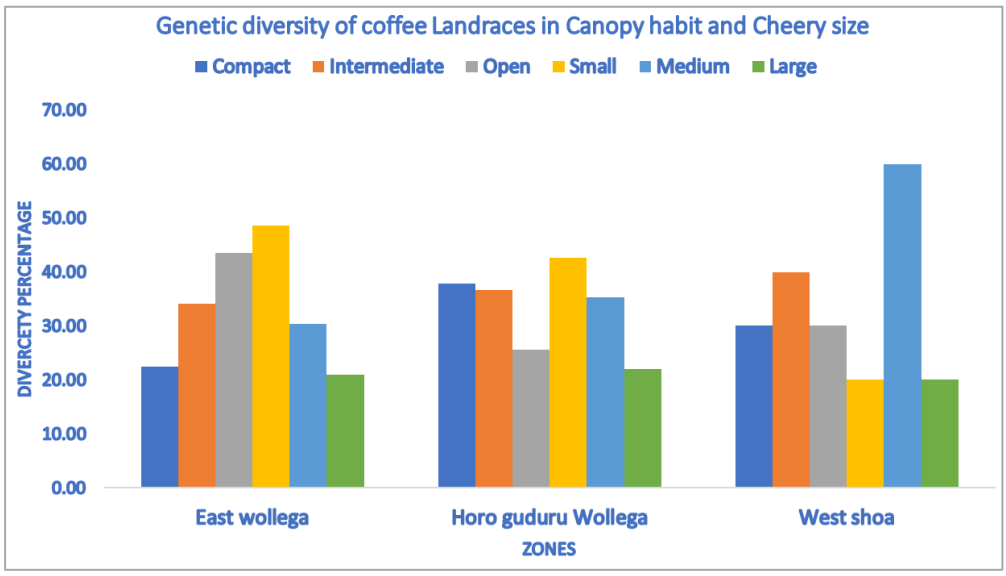

Figure 1. *Coffee arabica landrace diversity in Canopy habit (compact, Intermediate, Open) and Cheery size (small, medium, large) assessed from different Western Oromia Zones in percentile.*

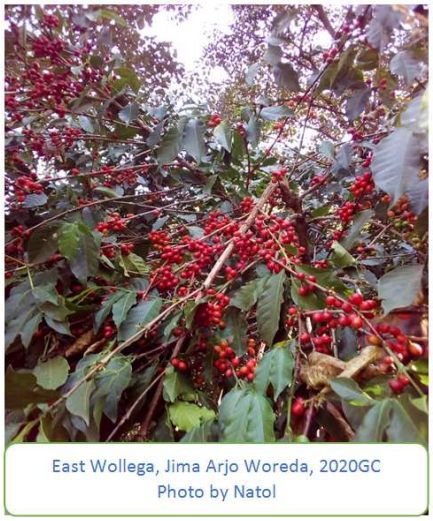

Figure 2. *A visual presentation of the coffee landraces found in Jima Arjo Woreda, East Wollega.*

3.2.2. Horo Guduru Wollega Zone

The result of the analysis showed that, small cheery sizes accounted for 42.68 percent of all cheery sizes, while medium and large cheery sizes accounted for 35.37 percent and 21.95 percent, respectively. The compact form accounted for 37.80 percent of canopy habit, while the intermediate and open types accounted for 36.59 percent and 25.61 percent, respectively (Figure 1). More than half (62.62%) was tall while the other 17.07% and 20.73% was medium and short plant height respectively. In cherry color more than half (54.88%) of the total observations were light red color while 29.27% was red color and 15.85% was brown cherry color (Figure 2).

3.2.3. West Shoa Zone

The result showed that, the majority of the landraces had intermediate canopy habits (40%) whereas the remaining 30% had compacted and open canopy habits. More than half of the observations (60%) were of medium cheery size, with the remaining 20% being of small and large happy size (Figure 1).

60% of total observations were medium height while the other 40% was tall (20%) and short (20%) plant height. In cherry color, 20% was brown in color and the other 80% was light red (40%) and red (40%) (Figure 2).

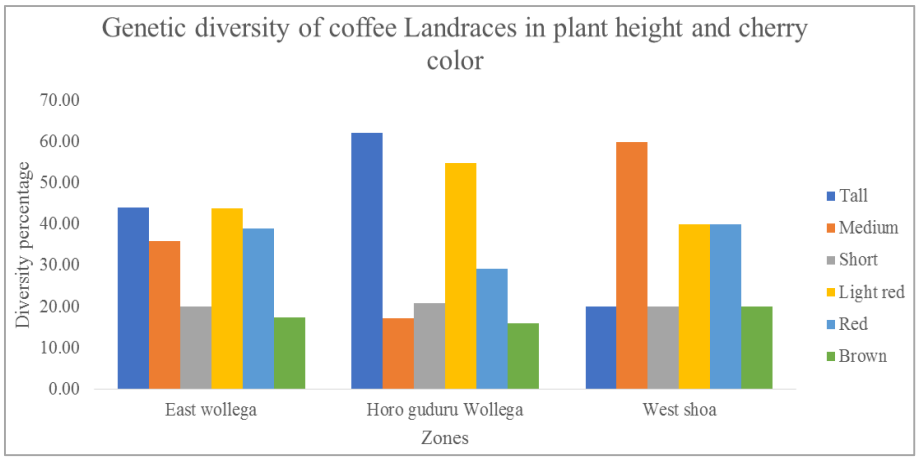

Figure 3. *Coffee arabica landrace diversity in plant height (tall. Medium and short) and Cherry color (Light red, Red and Brown) assessed from different Western Oromia Zones in percentile.*

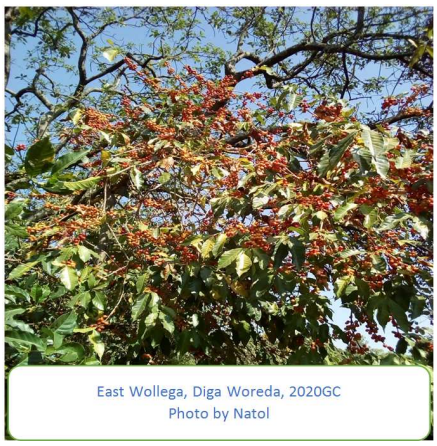

Figure 4. *A visual presentation of the coffee landraces found in Diga Woreda, East Wollega.*

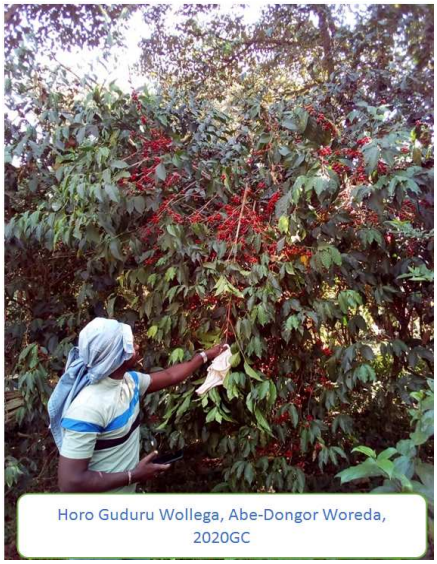

Figure 5. *A visual presentation of the coffee landraces found in Abe Dongoro, East Wollega.*

4. Discussions

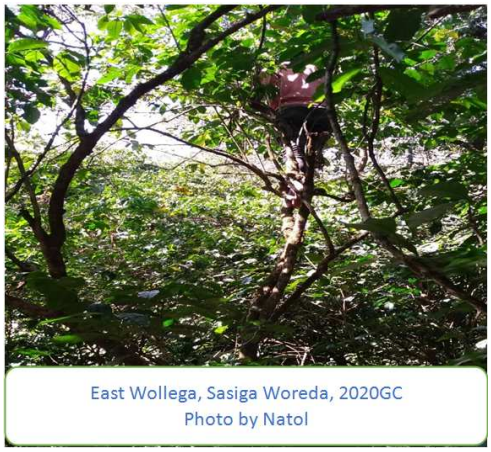

Figure 6. *A visual presentation of the coffee landraces found in Sasiga Woreda, East Wollega.*

The observed genetic diversity among landraces may be due to the genetic differences among individuals within a population. In the study area, big diversity was observed in East Wollega which is due to the availability of the landraces. The variability observed is the core of plant breeding and an opportunity for plant breeders and big resource as a whole for the country [3, 7, 15, 28]. Also, [21] found a genetic diversity among Limu coffee landraces molecularly. In the same line, [25] were found a tremendous diversity of among different collected coffee landrace in different morphological traits in different parts of Ethiopia. Different authors [2, 6, 7, 15], reported the availability of high genetic diversity in southwestern parts of Ethiopia, but our study revealed that there is also un ample genetic diversity of coffee landraces in western parts of the country like East Wollega and Horro guduru Wollega.

5. Conclusions and Recommendation

Current assessment substantiated the existence of sufficient diversity among coffee landraces in the study area in various morphological traits. For all traits studied, the study's findings verified the existence of considerable genetic heterogeneity across *Coffea arabica* landraces. Almost all of the Woredas under investigation displayed diversity in various features. Landraces were once endangered in most coffee-growing areas due to climate change, stumping and uprooting of old coffee trees due to low productivity. As a result, coffee's diversity is endangered. Hence there is a chance to take use of these opportunities to generate genotypes that perform better than existing varieties for improved coffee productivity, and it's a valuable resource in the future coffee improvement program.

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