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Research Article

Effect of Quantitative and Qualitative Phenotypic Traits on Enset (*Ensete ventricosum (Welw.) Cheesman*) Yields and Genotypes Determination in Gurage Zone, at Yefereze Enset Conservation Site

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Abstract

Enset is a perennial plant and a multi-purpose crop used in Ethiopia. Phenotypic traits were important to predict the production and productivity of enset. This research was conducted in Gurage Zone at Yefereziye enset conservation site with the objective of effect of quantitative and qualitative phenotypic traits on Enset (*Ensete ventricosum (Welw.) Cheesman*) yield and genotypes from 2020 to 2021. The evaluation was conducted using a single plot experiment method, with a total of 15 plants within a column. Data were collected randomly within five tagged Enset genotypes within a row. The result reveal that the quantitative data were highly significant (P≤0.001) among the enset genotypes. The higher pseudostem circumference, pseudostem height, and Plant height were recorded from Ashikit (121.4cm, 154.6cm and 494.2cm), Shebeshertiye (120.8cm, 139.4cm and 436.8cm), Zereta (118.4cm, 135.8cm and 438cm), Kanchiwe (130.4cm, 22.6cm and 418cm) and Zigbot (126cm, 120.8cm and 433.4cm), Yeshraqinqe (101 cm, 139.8 cm and 463.2cm); Ageremariam (103.8cm, 145.8cm and 480.4 cm) and Tikurbadedet (131cm, 110.6cm and 419cm) respectively. In qualitative trait assessment the dominant color trait was, for pseudostem brown 3 (0.4%), lower leaf part was light green (95.7%), upper part of midrib was green (95.7%), lower midrib was reddish (56.52%) and lower part of petiole was black (34.8%) colors within the enset genotyps. Therefore, from the current research the following enset land races were, Ashikit, Shebeshertiye, Zereta, Kanchiwe, Zigbot, Yeshraqinqe, Ageremariam and Tikurbadedet enset genotypes were well performance and recommended to the local farmer to enhance their livelihoods.

Keywords

Enset Genotypes, Quantitative Trait, Qualitative Trait

1. Introduction

Enset (Ensete *ventricosum* (Welw) Cheesman) is classified as a perennial monocarpic crop genetically classified as Order *Schistaminae* and family *Musaceae* [1]. Cheesman is the only known wild species in Ethiopia, which is believed to be its center of origin [2]. In Ethiopia locally known by its vernacular names *enset* or *koba* (by Amhara ethnic group), *asat* (Gurage), *weise* (Kambata), *werke* (Oromia), and *wassa* (Sidama) [3]. Enset is grown and distributed at altitudes be-

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tween 1600 and 3000 meters above sea level with an average annual rainfall of 1100 to 1500 mm and it is chiefly propagated vegetative [4]. Farmers' own taxonomic knowledge categorizes enset landraces into either male or female, based on particular morphological or phenological properties [4-6]. Male farmers prefer enset landraces, which are late maturing and disease resistant, but this enset land race is the lower quality of Amicho and Koch and characters as Male Enset landrace whereas the female farmers prefer earlier maturing and a tastier *kocho* and *amicho*, but this landrace is less vigorous and more susceptible to disease. This enset land race is classified as female enset [7]. At the farmers' level, the same landraces may have different vernacular names depending on the ethnic or linguistic groups and agroecological zones. Choro and 'Ketano' enset landrace are used by farmers in two districts of Kaffa province for the same landrace [4]. On the other hand, Mazia enset landrace was given the same name for different landraces across ethnical groups and agro-ecologies of Dawro and Wolaita but represents different landraces [7]. Women (*vs*. men) and elderly (*vs*. younger) farmers are generally more knowledgeable about the different attributes of enset landraces and able to recall more landraces than men during group discussions [4]. Farmers differentiate landraces based on phenotypic characteristics, such as the color of the petiole, midrib, and leaf sheath, angle of leaf orientation, size color of leaves, and circumference and length of the Pseudostem [6, 8]. Vernacular names are often descriptive and reflect the variety of landraces in places of origin, morphology, as well as agronomic and cooking characteristics [9].

Enset is a major multi-purpose crop in Ethiopia, which has been identified as the center of origin and diversity of enset [10-12]. Enset plays a central role in the economic, social, and cultural life of the diverse ethnic people in the south and southwestern part of the country [13]. In Ethiopia, Enset is one of the major economic and socio-cultural importance crops for a wide range of smallholder households as the staple and co-staple food [14]. Enset is important for food security for human beings and feeding animals during drought time [15]. The number of landraces grown is closely linked to the importance of enset for a certain ethnic group [16]. More than 20% of Ethiopia's population depends on Enset for human food, fiber, animal forage, construction materials, and medicines [7, 17]. The major foods obtained from Enset include kocho, bulla, and amicho, which are prepared through fermentation, and extraction of edible starch, respectively, and provide more than 65% of the caloric requirements of the people [18]. After a successful fermentation process Pseudostem and corm is important for Human food and are eaten as bread and enjera form, leaf and leaf sheath is important for an animal, and dried midrib is important for industrial product [18]. In addition to as a portion of food, some of the enset landrace of medicinal value (especially their corms) for both humans and livestock to cure bone fractures, broken bones, diarrhea and are used as birth control [1, 14, 19]. Medicinal landraces may be more threatened than others because when a person is ill, the medic is usually given the plant (free of charge) to cure the ailment of the patient, but the farmer does not have an economic reason to propagate and replant the medicinal landraces [20]. Enset provides an important dietary starch source, as well as fibers, medicines, animal fodder, roofing, and packaging. It stabilizes soils and microclimates and has significant cultural importance [21]. Being perennial, enset improves local climate and soil conservation, and soil erosion management [22]. In traditional agriculture, farmers have a wealth of knowledge in tackling varieties selected for their socioeconomic and environmental conditions [15]. Enset in Ethiopia: poorly characterized received relatively little research attention [21]. Characterization of enset germplasm using morphological traits shows much variability in quantitative and phenotypic observation, growth, and yield traits among enset accessions, including maturation rate, plant height, color, susceptibility to disease and provides detailed information for enset breeders to select parent plants [1, 23-30]. Morphological characteristics methods such as pseudostem color, midrib color, petiole patches (strips color), and agronomic characteristics such as reaction to drought, reaction to disease and pests, and maturity time are criteria for enset landrace evaluation and differentiate in farmers [31]. Enset is recognized as an underexploited starch crop with substantial potential not only in Ethiopia but also in other regions facing food insecurity [21].

Environmental factors are strangely influencing the morphological variation of enset landraces [30]. In addition, farmers also use sap color, corm shape, and corm color for the identification of landraces [32]. Elderly members of households are generally the best informed about enset diversity and this knowledge is transferred through oral tradition [13]. Therefore, this research was conducted with the objective of the effect of quantitative and qualitative phenotypic traits on Enset (*Ensete ventricosum (Welw.) Cheesman*) yield and genotypes at the Yefereze Enset conservation site.

2. Methodology

2.1. Experimental Design and Treatment Arrangements

Wolkite University has been conserving enset landraces since 2014 collected from various Enset-growing regions. The experiment was conducted in Central Ethiopia regional state in wolkite university enset conservation site at Yefereze research site. The study was conducted with a total of 23 enset genotypes, 5 enset genotypes were collected from Easten Gurage Zone while 18 from Westen Gurage zone. All enset genotypes were planted within 1.5m inter and intra row spacing and 15 Enset genotypes were planted in each row. The assessment was conducted According to [33] who is reported that the treatments were outlined using a single plot design.

Table 1. *Geographical and Climatic conditions of districts during the cropping season.*

District	Attitude	Temperature	Rainfall	Soil pH
Yefereze	2022masl 8.1N 37.90E	14 to 24 ℃	173.4mm -222.8 mm Per month	4.9

Source [34, 36]

Table 2. *Areas of Enset genotypes collection.*

No.	Enset landrace	Areas of collection	No.	Enset landrace	Areas of collection
1	Ageremariam		13	Kese	
2	Ashikit		14	Lemat	
3	Chama	East Gurage	15	Gaznar	
4	Zigbot		16	Shebeshertiye	
5	Kanchiwe		17	Tikurbadedet	
6	Amatre		18	Kekari	
7	Anichara		19	Tagaded	*West Gurage*
8	Aytquaqof		20	Tetteret	
9	Anichara		21	Zereta	
10	Amatre		22	Gefetano	
11	Benezhe		23	Ankefuye	
12	Dere				

Source [19]

2.2. Data Collection

The assessment was conducted from 2020 – 2021 cropping seasons. All quantitative and qualitative traits data were collected for randomly five tagged plants with the insertion of two plants in each row. For quantitate data, Plant height (cm), Pseudostem height (cm), Pseudostem circumference (cm), Leaf number, leaf length (cm), leaf width (cm), and petiole length (cm) collected for yield determining and for genetic variability determination, Pseudo Stem color, leaf tip color, Upper leaf color, Lower leaf color, upper Midrib color, lower midrib color, petiole colors were used [1, 26].

2.3. Data Analysis

All quantitative data were analyzed by SAS software methods version 9.2. The correlation analysis was analyzed by the procedure of proc corr [35]. The qualitative data was collected with observations of enset genotypes and categorized according to their color and analyzed using descriptive statics methods.

3. Results and Discussion

3.1. Effect of Plant Height on Enset Landrace

Analysis of variance revealed that plant was highly significant ($P \leq 0.001$) among Enset landraces. The higher plants heights were recorded in Ashikit (494.2cm), Ageremariam (480.4cm) and Yeshraqinqe (463.2cm) Shebeshertiye (436.8cm) and Zereta (438cm) enset land race followed by, Tikurbadede, Kanchiwe, Zigbot, Gaznar, and Dere Enset genotypes height is ranging from (433.4cm - 404.2cm) whereas the shortest plant heights were recorded from Chama, Tetteret, Anichara, Kekari, Ankefuye,. Gefetano, Kese, Benezhe, Ayitquaqof, Tagaded, moderate plant height whare as Amaret (236.8cm), and Lemat (240cm) Enset genotypes were the shortest plant height (Table 3). These findings align with previous research by [12, 36-38] who is reported that mature enset plants can range in height from 2 to 10 m. [39] reported that maximum Plant Height (7.2 m).

3.2. Effect of Enset Landrace on Pseudostem Height

The results indicate that pseudostem height is highly significant ($P < 0.001$) among enset genotypes The tallest pseudostem height was recorded from Zereta (135.8cm), Shebeshertiye (139.4cm), Ashikit (154.6cm), Yeshraqinqe (139.4cm) and Ageremariam (145.8cm) enset land races were the higher pseudostem height followed by Dere, Acharqa, Gaznar, Zigbot, Benezhe, kese, Tikurbadedet, Tetteret, and Kanchiwe enset genotypes were moderate pseudostem height and ranging from 122.6cm -107.6cm) whereas the shortest pseudostem height were recorded from Chama, Anichara, Kekari, Ankefuye, Gefetano, Lemat, Amaret, Ayitquaqof, and Tagaded which is 99.8cm - 63.4cm pseudostem height (Table 3). These findings are consistent with [30] who reported variability in pseudostem height and maturity time across different agroecologies and landraces. Cultural differences have also influenced the selection of enset varieties and phenotypic differences [30, 39-42]. reported that maximum values for Pseudostem circumference (2.90 m).

3.3. Effect of Enset Landrace on Leaf Length

The results indicate that leaf length is highly significant ($P \leq 0.01$) among enset landraces. The longest leaf lengths were recorded from Zereta (302.2cm), Shebeshertiye (297.4cm), Tikurbadedet (308.4cm), Ashikit (339.6cm), Zigbot (312.6cm), Yeshraqinqe (323.4cm), and Ageremariam (334.6cm) moderate leaf lengths were recorded from Chama, Tetteret, Anichara, Kekari, Ankefuye, Kanchiwe, Gaznar, Gefetano, kese, Benezhe, Acharqa, and Ayitquaqof which is the rang of (288.4cm -222cm) leaf length. Whereas the shortest leaf lengths were recorded from Lemat (176.6cm), Amaret (159.4cm) and Tagaded (186.4cm) enset land races (Table 3). [42] who reported maximum values for Leaf length (6.80 m). Significant morphological differences and growth rate variability among enset germplasms [21].

3.4. Effect of Enset Landrace on Pseudostem Circumference

The results shows that pseudostem circumference is highly significant ($P \leq 0.001$) among enset genotypes. The widest pseudostem circumferences were recorded from Shebeshertiye (120.8cm), Tikurbadedet (131cm), Ashikit (121.4cm), Kanchiwe (130.4cm), Zigbot (126cm), Tagaded (145.4cm) which is 145.4cm -120.8cm pseudostem circumference range followed by Zereta, Chama, Tetteret, Anichara, Yeshraqinqe, Gaznar, Ageremariam, Kese, Amaret and Amaret had moderate pseudostem circumference. The lower circumference was recorded from Kekari (92.8cm), Ankefuye (71.4cm), Gefetano (93.2cm), Lemat (79), Benezhe (99.6cm), Acharqa (98cm) and Ayitquaqof (94cm). There is high variability among enset land race the higher circumference was 145.4cm whereas the lower one is 71.4cm this is may be adaptability and genetic variability among enset landrace (Table 3). These findings are supported by [46] who reported high vigor among enset cultivars.[21] noted variability in pseudostem shape between domesticated and wild enset landraces. Additionally, [12, 43] reported variables such as corm size, starch quality, root structure, and tolerance to environmental stresses among clonal genotypes. [33] reported that highlighted differences in growth patterns between wild and domesticated enset, with wild types showing more consistent circumference increase with age compared to domesticated types, which achieve larger circumferences earlier in development. [39, 42] who reported maximum values for Pseudostem circumference was (2.90 m).

3.5. Effect of Enset Landrace on Leaf Width

The result reveals that leaf width is highly significant ($P \leq 0.001$) among enset genotypes. The widest leaf widths were recorded from the genotypes of Zereta (73cm), Shebeshertiye (68.2cm), Chama (70cm), Tikurbadedet (69.8cm), Ashikit (75.6cm), and Zigbot (74.6cm) followed by Kanchiwe, Yeshraqinqe, Gaznar, Ageremariam, Gefetano, Lemat, Kese, Acharqa, Acharqa, Tagaded and Tagaded whereas the narrow leaf width was recorded from Tetteret (55cm), Anichara (50.8cm), Kekari (51.8cm), Ankefuye (48.4cm), Benezhe (50cm) and Amaret (52.8cm) (Table 3). Leaf width was ranging from 75.6cm – 48.4cm among enset landrace this is may be effect of environmental and genetic variability within the enset genotypes. These findings are consistent with [43] who reported variability in leaf size among different enset cultivars. [21] also noted variations in leaf width and size among domesticated enset landraces. [39] who reported that maximum Leaf width was (0.98m). These findings align with [21], who reported variations in leaf width and size among domesticated enset landraces.

3.6. Effect of Enset Landrace on the Number of Leaf per Plant

The result shows that the number of leaves per plant is significant ($P \leq 0.001$) among enset landraces. The highest number of leaves per plant was recorded from Zereta (11.4), Tikurbadedet (12.2), Ashikit (11.6), Kanchiwe (11.4), Kese (11.4), Amaret (12.6), Ayitquaqof (12.2), Tagaded (12.4), and Dere (12.2) followed by Shebeshertiye, Chama, Tetteret, Kekari, Zigbot, Yeshraqinqe, Gaznar, and Lemat whereas the lower leaf number was recorded from Anichara (9.2), Ankefuye (8), Ageremariam (9), and Gefetano (9). Number of leafs per enset genotypes is ranging from 12.4 -8. This is due to genetic variability among enset land race (Table 3). These findings are consistent with [44] who reported that mean leaf sheath number and leaf sheath weight before decortication were higher for landraces from Gurage, West and South-West Shewa, and Yem special

woreda.

3.7. Effect of Enset Landrace on Petiole Length

The results reveals that petiole length was highly significant ($P \leq 0.001$) among enset genotypes.

The longest petiole length was recorded from Dere (30cm) followed by Zereta, Shebeshertiye, Chama, Tetteret, Anichara, Kekari, Ankefuye, Ashikit, Kanchiwe, Yeshraqinqe, Gaznar, Ageremariam, Gefetano, Kese, Benezhe, Acharqa, Ayitquaqof and Tagaded had medium petiol length whereas the shortest petiol length were recorded from Tikurbadedet (10.6cm), Zigbot (5.4cm), Lemat (9.8), and Amaret (13cm) (Table 3). Petiole length was among enset land races were varied from 30cm - 5.4cm within enset land race this is maybe effect of environmental factors and genetic variability within the land race. These findings are consistent with [39] who reported maximum values of petiole length (0.60 m), whereas the with minimum values was from 0 to 2.

Table 3. *Phonotypic character of Enset land race at Yefereze research site.*

List of Enset landrace	Plant Height (cm)	Pseudo Stem Height (cm)	Leaf Length (cm)	Pseudostem Circumferences (cm)	Leaf Width (cm)	No. of leaf / plant	Petiole Length (cm)
Zereta	438abcd	135.8abcd	302.2abcd	118.4bcde	73a	11.4abcde	18de
Shebeshertiye	436.8abcd	139.4abc	297.4abcd	120.8abcd	68.2abc	10.4defg	20cde
Chama	361.4efgh	99.80fihg	261.6defgh	106.8bcdef	70ab	10.6cdefg	20.4bcde
Tetteret	347.4gih	111.8efg	235.6figh	107.8bcdef	55efghi	10.8bcdef	17.8de
Anichara	319.8hi	88hi	231.8hijg	103.2cdefg	50.8hig	9.2fgh	17def
Tikurbadedet	419cde	110.6efg	308.4abcd	131ab	69.8ab	12.2abc	10.6g
Kekari	313hi	94.6hig	218.4hijk	92.8fgh	51.8fhgi	10.4defg	17def
Ankefuye	304.6hi	90.8hig	213.8ijk	71.4h	48.4i	8h	16.8ef
Ashikit	494.2a	154.6a	339.6a	121.4abcd	75.6a	11.6abcd	5.8hi
Kanchiwe	418cde	122.6cde	278cdefg	130.4ab	63.6bcd	11.4abcde	16.8ef
Zigbot	433.4bcd	120.8cdef	312.6abc	126abc	74.6a	9.2fgh	5.4i
Yeshraqinqe	463.2abc	139.8abc	323.4abc	101cdefg	59.4def	9.6fgh	22.4bc
Gaznar	413.2cdef	124.8bcde	288.4bcde	100.8defg	57.6defgh	10.4defg	18.2de
Ageremariam	480.4ab	145.8ab	334.6ab	103.8cdefg	60.6cde	9gh	17def
Gefetano	295.4hi	80.6ji	214.8hijk	93.2fgh	58.2defg	9gh	17.4de
Lemat	240j	63.4j	176.6kl	79hg	52.2fhig	9.6fgh	9.8gh
Kese	356.2fgh	108.6efhg	247.6efhgi	111.6bcdef	62.6bcde	11.4abcde	20.4bcde
Benezhe	329.8hi	107.8efhg	222hijk	99.6defg	50hi	9.8efgh	24.2b
Acharqa	398.6defg	117.6def	281cdef	98defg	61.2cde	9.2fgh	21bcd
Amatre	236.8j	64j	159.4l	114.8bcdef	52.8fhig	12.6a	13fg
Ayitquaqof	331.8hi	90.8hig	241efghi	94efgh	56.4defhg	12.2abc	18.2de
Tagaded	306.4hi	90.2hig	186.4jkl	145.4a	58.8def	12.4ab	17.4de
Dere	404.2cdefg	122.2cde	282cdef	101.8cdefg	60.6cde	12.2abc	30a
CV	12.8	15.7	14.5	18.6	10.1	12.66	19
LSD	59.756	21.67	47.519	25.183	7.6832	1.6814	4.0983

means with the same letter in a column was not significant different

3.8. Qualitative Trait Character of Enset Landrace

Farmers locally identify types of Enset landraces based on qualitative trait characteristics. [43] reported that farmers classify enset cultivars primarily by phenotype. [16] noted that morphological characters, especially color, are commonly used by farmers to identify enset clones. [29] highlighted pseudostem circumference, corm weight, fiber yield, maturity period, and number of leaves as important morphological descriptors contributing to the diversity in desirable crop traits. [1, 6, 45] noted, considerable variability and a vast number of landraces, which complicates precise and consistent morphological studies. Qualitative traits of Enset, such as pseudostem color, vary significantly among landraces.

From the assessment brown color is dominate in in pseudostem color characterization which is Zereta, Shebeshertiye, Chama, Tetteret, Tikurbadedet, Kese, and Tagaded enset landraces are a brown color which account 30.4% from the total color followed by green and reddish color which is Anichara, Ashikit, Dere, and Zigbot enset land races had a green color and Kanchiwe, Ageremariam, Yeshraqinqe and Gefetano had reddish color it account 13.04% for each color while light green color covering 8.7% which is Ayitquaqof and Benezhe landraces were light green. A mixture of green and black color was recorded from Gaznar enset land race and Amaret enset land race was brown and red color which account 4.4% for each landrace. Pseudostem variability was recorded from enset landrace this is may be landrace variability and environmental factors. (Table 4). These findings are consistent with [43] who reported a variety of pseudostem colors across landraces: 34.6% green, 23.1% light green, 30.8% deep brown, and 11.5% red. [39] also noted diverse pseudostem colors among enset clones, ranging from dark brown to greenish-black leaf sheaths, with some showing black spots on green or dark red to greenish-yellow pseudostem. [1] similarly observed varied qualitative characters among enset landraces.

The upper side of all assessed enset land races were deep green leaf color and the lower part of all enset land races were light green color. In addition to all enset land race leaf tips were black color and all enset land races were oblong leaf shape and Elliptical shape for matured enset land race (Table 4). This finding aligns with [30] who reported that the upper-side leaf lamina color most frequently observed among enset landraces was light green. [21] also noted variation in leaf color within cultivated enset landraces, including shades of green, red, yellow, and purple, with wild enset predominantly green. [39] reporting that the majority of leaf colors for enset landraces were deep green (39.53%) and dark green (37.21%), with light greenish varieties comprising 13.95%, and fewer clones exhibiting light-purple and purple colors (4.65% each).[44] who reported that brown was the most frequent leaf tip edge color observed in Dawro, Gamo Gofa, and Gurage regions.[30] also noted brown-purple as the predominant leaf tip edge color in enset.

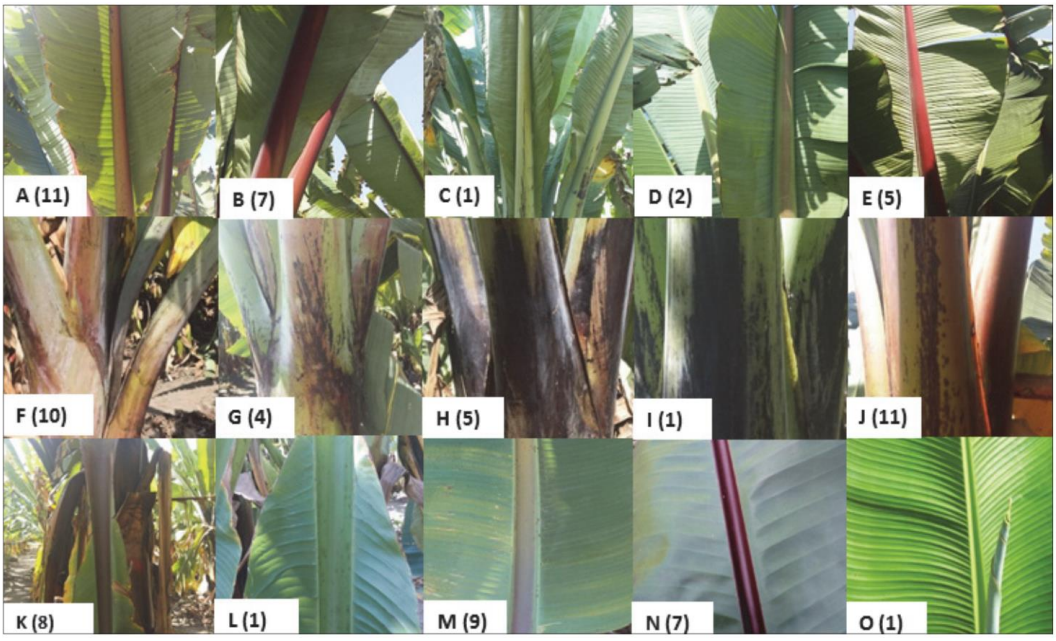
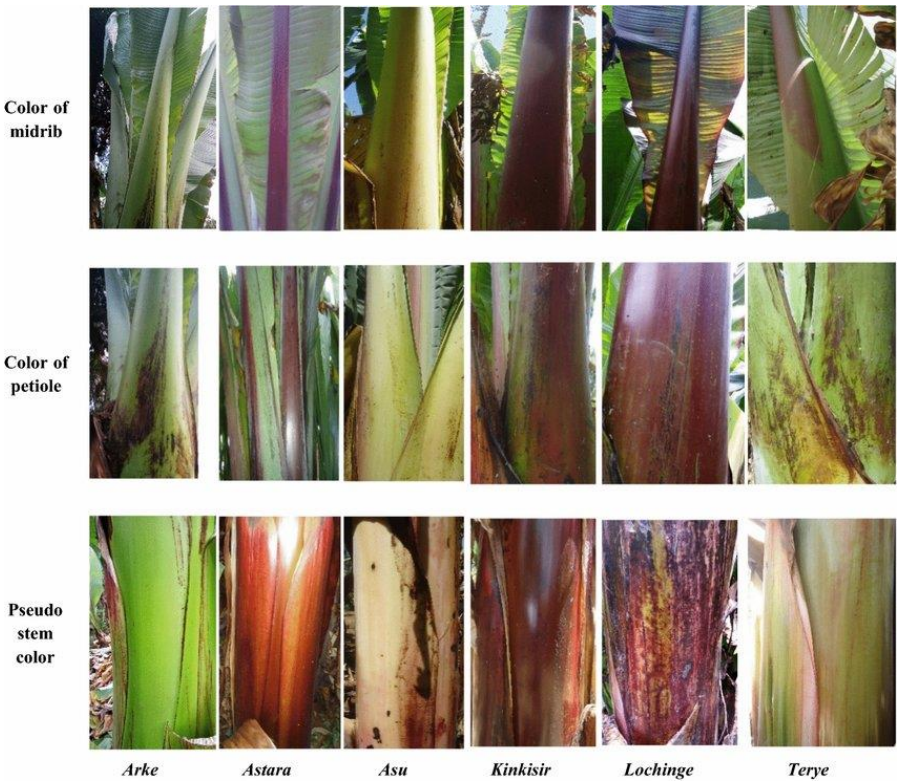


Figure 1. *Qualitative trait character of enset land race.*

A-E: Examples of morphological variation in under-side midrib colour; F-J: Examples of morphological variation in under-side petiole color; and K-O: Examples of morphological variation in upper-side midrib colour. Source

Source [1]

The majority of the upper midrib of enset land race was deep green which account 95.7% from the assessed enset land race but Gaznar enset land race was greenish color and account 4.3% from the assessed enset land race. High variability was recorded from the lower midribs which is reddish, red, green and green with the strike of red are the most identified color. Among the identified color reddish account 56.5% followed by red midrib color which is 34.8% whare as green and with the strike of red was account 4.4% (Table 4). These finding is consistent with [21] who reported varied midrib colors among cultivated enset landraces, including green, red, yellow, purple, and black. [44] also observed upper-side midrib colors ranging from light-to-medium green with black patches and stripes, to rusty brown with green lines, with the most abundant midrib color being light-to-medium green with black patches and stripes across all altitude groups. [44] further concluded that leaf tip edge color and under-side midrib color tended to be relatively uniform across landraces, whereas under-side petiole color, upper-side midrib color, and upper-side petiole color exhibited intermediate diversity. Some qualitative traits of character and growth stages of enset landraces are illustrated in Appendix.



Source [46]

Figure 2. *Phenology of Enset pseudo stem color, color of petiole, lower midrib of enset land race.*

leaf Length Measurement methods

Leaf Width Measurement methods

Figure 3. *Quantitative data measurement methods.*

The lower petiole was categorized in to six different color which is black, red, reddish, green, light green and the mixture of both green and black color was identified from the assessment. From the result black (30.44%), red (17.4%), green (21.74%) light green (4.4%), reddish (8.7%), and a mixture of green with black was (17.4%). Among black, red and mixture of green with black the most frequent color (Table 4). [21] noted that petiole color varies significantly among cultivated enset landraces, encompassing shades such as green, red, yellow, purple, and black. [30] reported that upper side petiole colors in enset landrace populations were predominantly light-to-medium green with black patches. [5, 6]. [1] reported that under-side petiole colors as predominantly light-to medium green with brown stripes and red with black patches across different altitude ranges. [39] further confirmed diversity in petiole colors among clones, with black (25.58%), dark red (8.60%), red (27.90%), and greenish red (20.93%) being the predominant colors, along with purple and red with black stripe patterns (2.33%). [21, 30, 39, 6] Reported that petiole colors in enset landraces reveals a wide range of variations, reflecting the rich diversity and unique characteristics of these cultivars across different regions.

Table 4. *Qualitative traits character of Enset land race at Yefereze Research site.*

enset landrace	Pseudostem Color	Leaf Tip Color	Shape of Leaf lobes	Matured leaf shape	Upper leaf Color	Lower Leaf Color	Upper Midrib Color	Lower Midrib Color	Petiole Color
Zereta	Browen	Black				Light Green	Green	Reddish	Green and Black
Shebeshertiye	Browen	Black				Light Green	Green	Reddish	Black
Chama	Browen	Black				Black	Green	Red	Red
Tetteret	Browen	Black				Light Green	Green	Reddish	Red
Anichara	Green	Black				Light Green	Green	Green	Green
Tikurbadedet	Browen	Black				Light Green	Green	Reddish	Black and Green
Kekari	Red	Black				Light Green	Green	Reddish	Red
Ankefuye	Red	Black				Light Green	Green	Red	Red
Ashikit	Green	Black				Light Green	Green	Reddish	Black and Green
Kanchiwe	Redish	Black				Light Green	Green	Red	Back
Zigbot	Green	Black	Oblong	Elliptical	Deep green	Light Green	Green	Red	Green
Ageremariam	Reddish	Black				Light Green	Green	Reddish	Black

enset landrace	Pseudostem Color	Leaf Tip Color	Shape of Leaf lobes	Matured leaf shape	Upper leaf Color	Lower Leaf Color	Upper Midrib Color	Lower Midrib Color	Petiole Color
Gaznar	Brown and red	Black				Light Green	Greenish	Red	Reddish
Ageremariam	Reddish	Black				Light Green	Green	Red	Black
Gefetano	Reddish	Black				Light Green	Green	Reddish	Black
Lemat	Black	Black				Light Green	Green	Red	Black
Kese	Brown	Black				Light Green	Green	Reddish	Black
Benezhe	light green	Black				Light Green	Green	Reddish	Green
Acharqa	Red	Black				Light Green	Green	Reddish	Reddish
Amatre	Green and black	Black				Light Green	Green	Reddish	Black & Green
Ayitquaqof	Greenish	Black				Light Green	Green	Reddish and	Greenish
Tagaded	Brown	Black				Light Green	Green	Green strike Red	Green
Dere	Green	Black				Light Green	Green	Red	Green

4. Correlation Analysis of Enset Landrace on Quantitative Character

A highly significant ($p<0.001$) positive correlation was observed among the trait of enset genotypes. Plant height was high correlation with pseudostem height (95.9%, leaf length (96.4%), pseudostem circumference (32.2%). pseudostem height was highly correlated with leaf length (87.8%), leaf length (31.7) and leaf width. Leaf length was highly correlated

with leaf width (67.5%) and pseudostem circumference (15.9%). Pseudostem circumference correlated with number leaf (36.9%) and leaf width (51.8%) and Leaf width was correlated with number of leaf (19.8%). Whare as negative and non-significant correlation was recorded from plant height with number of leaf (-4.4%) and (-0.1%), plant height with number of leaf (-4.3%), leaf length with number of leaf (-8.3%), and petiole length (-2.4%), pseudostem circumference was negative correlated with petiole length (22.9%) and leaf width with number of leaf (-19.8%) (Table 5).

Table 5. *Correlation analysis among the quantitative trait of Enest land race.*

	HI	Ph	LL	PC	LW	NO	PL
hi							
PS	0.959***						
LL	0.964***	0.878***					
PC	0.322*	0.317*	0.159*				
LW	0.699**	0.619**	0.675***	0.518**			
NO	-0.044	-0.043	-0.083	0.369**	0.198*		
PL	-0.001	0.059	-0.024	-0.229	-0.244	-0.026	

P≤ 0.001***; P ≤ 0.01 **; P≤ 0.05*. Hi, Plant height, Ph, pseudostem height, LL, leaf length, PC, pseudostem circumference, LW, leaf width, NO, number of leaf, PL, petiole length.

Young enset genotypes from 3–4-year

Step 2. Dig up enset genotypes

Step 3. Separating pseudostem from corm

Step 4. Separated corm

Step 5. Removing apical bud from the corm. Removing apical bud is important to germinate more than one enset seedling

Step 6. Filling of soil instead of apical bud

Step 7. Planting of the corm in the virgin soil, filling the soil and mulching by plant material

Step 8. Germinated Seedling from one plant will be varied from genotypes to genotypes

Step 9. One-year enset seedling from one plant will from 15-30Seeddling

Step 10. Disbursing the germinated seedling to reduce nutrient competition

Step 11. Disbursed seedling will continue up to four years

Step 12. Matured enset genotypes and read to process for food

Figure 4. *Growth Stage of Enset.*

Step 1. Five year and above enset genotypes

Step 2. Removing old leaf sheath and young leaf from pseudostem

Step 3. Dropping matured enset genotypes and separating pseudostem from corm

Matured corm

Separation of sheath from pseudostem

Crushing of leaf sheath in to small particle by cultural material

Chopping of the corm Corm will use as a food as soon as a west removed from corm.

Mixing both Crushed leaf sheath and chopped corm for a week to refilter Bulla

Putting both Crushed leaf sheath and chopped corm for further fermentation after two-three month it will use as a food

Amecho feeding from the field after boiling

Figure 5. *Processing of enset for foods.*

5. Conclusion

Enset is a multipurpose crop of which every part is thoroughly utilized. Enset is cultivated mainly for food. The types of food obtained from enset include kocho, bulla and amicho. Apart from their regular uses as food and used as animal feed, some enset landraces were also has medicinal value. The production and productivity of enset land races were affected by the types of enset and their management. Good management like application of animal manure, weeding, rounding disease occurrence and cultivation are important to increase the yield of enset. Yield of enset has been determined by pseudostem circumference, pseudostem height, Plant height in the study site. The farmers identify different enset landraces by looking at morphological characteristics color of pseudostem, petiole, and midrib, plant size and length and width of the leaf.

The analysis of variance reveals that the higher pseudostem circumference, pseudostem height, and Plant height were their role for determination of the quantitative trait. The result reveal that the quantitative data were highly significant ($P<0.001$) among the enset land race. The higher pseudostem circumference, pseudostem height, and Plant height were recorded from Ashikit (121.4cm, 154.6cm and 494.2cm), Shebeshertiye (120.8cm, 139.4cm and 436.8cm), Zereta (118.4cm, 135.8cm and 438cm), Kanchiwe (130.4cm, 22.6cm and 418cm) and Zigbot (126cm, 120.8cm and 433.4cm), Yeshraqinqe (101 cm, 139.8 cm and 463.2cm); Ageremariam (103.8cm, 145.8cm and 480.4 cm) and Tikurbadedet (131cm, 110.6cm and 419cm) respectively recorded. Medium yield determining trait were recorded from Chama, Tetteret, Anichara, Gefetano, Kese, Benezhe, Acharqa, Ayitquaqof, Gaznar, Tagaded and Dere enset landraces. The shortest pseudostem circumference, pseudostem height, and Plant height were recorded from the enset landrace of Kekari (92.8cm, 94.6cm and 313cm); Ankefuye (71.4cm, 0.8cm, and 304.6cm); Lemat (79cm, 63.4cm and 240cm) and Amaret (114.8cm, 64cm and 236.8cm) respectively.

From the qualitative trait assessment 30.4% of pseudostem color was brown color followed by green (17.4%); reddish (17.4%) and red color (13.04%) the other black, light green, mixture of green with black and mixture of brown with red account (4.4%, 8.7%, 4.4% and 4.4%) respectively. Light green color was dominant at the lower leaf characterization which is 95.7% but 4.3% of the enset land race count black color. The 95.7% upper part of midrib was green color

whereas 4.3% midrib greenish color. Reddish color was dominant at the lower midrib characterization which is 56.52% followed by red color (34.8%) both green and strike of green with red account 4.4% for each. The 30.44% lower part of petiole was black color followed by green (21.74%); red (17.4%) and mixture of both green with black (17.4%). greenish and reddish color cover 4.4% and 8.7% respectively.

6. Recommendations

Based on yield determining trait pseudostem height, pseudostem circumference, and plant height, Ashikit, Shebeshertiye Zereta, Kanchiwe) and Zigbot, Yeshraqinqe, Ageremariam and Tikurbadedet enset landraces are well performance during the assessment and recommended to the local farmer to enhance their livelihoods.

Abbreviations

Hi	Plant Height
PH	Pseudostem Height
LL	Leaf Length
PC	Pseudostem Circumference
LW	Leaf Width
No	Number of Leafs
PL	Petiole Length

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Author Contributions

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Conflicts of Interest

The authors have not declared any conflict of interests.

References

[1] Yemataw Z, Mohammed H, Diro M, Addis T, Blomme G (2012). Genetic Variability, Inter-Relationships and Path Analysis in Enset (Ensete ventricosum) Accessions. African Journal of Plant Science 6: 21-25.

[2] Vavilov NI (1952). The origin, variation, immunity, and breeding of cultivated plants. Chronica Botanica 2(1): 10.

[3] Yemataw Z, Tesfaye K, Chala A (2018). Agro-Morphological and Molecular Characterization of Enset (Ensete Ventricosum (Welw.) Cheesman) Landraces from Ethiopia. PhD dissertation in Addis Ababa University.

[4] sehaye Y, Kebebew F (2006). Diversity and cultural use of Enset (Ensetventricosum (Welw.) Cheesman) in Bonga in situ Conservation Site, Ethiopia. Ethnobotany Research and Applications 4: 147-157.

[5] Negash A (2001). Diversity and conservation of enset (Ensete ventricosum Welw. Cheesman) and its relation to household food and livelihood security in South-western Ethiopia. (The Netherlands: Wageningen University), 247 pp.

[6] Yemataw Z, Mohamed H, Diro M, Addis T, Blomme G (2014a). Enset (Ensete ventricosum) landrace selection by farmers and their cultural practices in southern Ethiopia. Genetic Resources and Crop Evolution 61: 1091-1104.

[7] Yemataw Z, Zeberga A, Yeshitla M, Muzemil S (2012). Morphological and use-value related management of enset (Ensete ventricosum (Welw.) Cheesman) diversity and distribution in SNNPRS, Ethiopia. Presented in Accra, Ghana 25-27.

[8] Shambulo A, Gecho Y, Tora M (2012). Diversity, challenges, and potentials of Enset (Ensete ventricosum) production; in the case of Offa Woreda, Wolaita Zone, Southern Ethiopia. Food Science and Quality Management 7: 24-31.

[9] Olango T, Tesfaye B, Marcello C, Mario E (2014). Indigenous knowledge, use, and on-farm management of enset (Ensete ventricosum (Welw.) Cheesman) diversity in Wolaita, Southern Ethiopia. Journal of Ethnobiology and Ethnomedicine 10: 41.

[10] Baker RED, Simmonds NW (1953). The Genus of Ensete in Africa. Bulletin 8: 234-236.

[11] Fekadu D (1996). Potential of Enset (Enseteventricosum) in ruminant nutrition in Ethiopia.

[12] Bizuayehu T (2002). Studies on landrace diversity, in vivo and in vitro regeneration of Enset (Ensete ventricosum Welw.). PhD Thesis, Awassa College of Agriculture, Awassa, Ethiopia.

[13] Almaz N (2001). Diversity and Conservation of Enset (Ensete Ventricosum Welw. Cheesman) and Its Relation to Household Food and Livelihood Security in South-western Ethiopia. Wageningen University and Research Centre, The Netherlands. 247p.

[14] Magule TO, Tesfaye B, Catellani M, Enrico P è M (2014). Indigenous knowledge, use and on-farm management of enset (Enset ventricosum (Welw.) Cheesman) diversity in Wolaita, Southern Ethiopia. Journal of Ethnobiology and Ethnomedicine 10 (41): 1-18.

[15] Belachew G, Aklilu A, Bewuketu H, Habtamu K (2017). Indigenous Knowledge of Enset (Ensete ventricosum (Welw.) Cheesman) Cultivation and Management Practice by Shekicho People, Southwest Ethiopia. Journal of Plant Sciences 5(1): 6-18.

[16] Zippel K, Kefale A (1995). Field guide to enset landraces of North Omo, Ethiopia. FRP Technical Pamphlet. Zürich: Eidgenössische Technische Hochschule.

[17] Ayele A, Omprakash S (2014). Extension of Enset Plant Product for Rural Development in Ethiopia. Jou. Agri. Econo., Extension andRural Development 2(3): 031-040.

[18] Hunduma T, Sadessa K, Hilu E, Oli M (2015). Evaluation of Enset Clones Resistance against Enset Bacterial Wilt Disease (Xanthomonas campestrispv. Musa cearum). J Veterinar SciTechnolo, 6(3): 1-7.

[19] Fetta N, Beira H, Kyallo M, Abush T, Temesgen M, Yao N (2019). Genetic diversity and population structure of enset (Ensete ventricosum Welw Cheesman) landraces of the Gurage zone, Ethiopia. Genetic Resources and Crop Evolution.

[20] Negash F (2007). Diversity and Indigenous Management of Enset (Ensete ventricosum (Welw.) Cheesman) landraces in Guraghe Zone, Southern Ethiopia. MSc thesis. Hawasa: Hawasa University.

[21] James SB, Manosh KB, Mark G, Guy B, Trude S, Heslop-H, Abebe MW, Admas B, Simon K, Steven J, Ermias LM, Aaron PD, Feleke W, Kathy W, Sebsebe D, Paul W (2019). Enset in Ethiopia: a poorly characterized but resilient starch staple, Annals of Botany 123(5-11): 747-766.

[22] Abraham Shumbolo, Yishak Gecho, and Melese Tora (2012). Diversity Challenges and Potentials of ENSET *(Ensete ventricosum)* Production: In Case of Offa District, Wolaita Zone and Southern Ethiopia. *Food Science and Quality Management.*

[23] Endale T (1997). Morphological characterization of enset (Ensete ventricosum (Welw.) Cheesman) landraces and the association of yield with different traits, 89 pp.

[24] Taboge E (1997). Morphological Characterization of Enset Accessions and the Association of Yield with Different Traits. Master's Thesis, Alemaya University, Alemaya, Ethiopia.

[25] Mikias Y, Mulugeta D (2009). Phenotype and genotype base variability study of enset (Ensete ventricosum (Welw.) Cheesman) landraces at Areka condition. In Proceedings of the 13th Annual Conference of the Crop Science Society of Ethiopia, 364 pp.

[26] Welde-Michael G, Bobosha K, Addis T, Blomme G, Mekonnen S (2008). Evaluation of enset landraces against bacterial wilt. African Crop Science Journal 16: 89-95.

[27] Yeshitila M, Diro M (2009). Phenotype and genotype base variability study of enset (Ensete ventricosum (Welw.) Cheesman) landraces at Areka condition. In Proceedings of the 13th Annual Conference of the Crop Science Society of Ethiopia, pp. 364.

[28] Bekele A, Diro M, Yeshitila M (2013). The diversity and associated yield components of enset (Ensete ventricosum) based on its agro morphological. Journal of Science 36: 49-54.

[29] Yeshitla M (2014). Cluster analysis for evaluation of genetic diversity in Enset (Ensete ventricosum (Welw.) Cheesman) accessions at Areka condition. Journal of Plant Sciences 2(1): 55-69.

[30] Yemataw Z, Blomme G, Muzemil S, Tesfaye K (2018). Assessing qualitative and phenotypic trait diversity in Ethiopian enset [Ensete ventricosum (Welw.) Cheesman] landraces. Fruits 73(6): 310-327.

[31] Habtamu T, Firew K (2020). Diversity of Enset (Ensete Ventricosum (Welw.) Cheesman) Landraces And Associated Indigenous Knowledge In Geta District, Gurage Zone, Ethiopia, Hawasa university.

[32] Temesgen M O, Bizuayehu T, Marcello C and Enrico P è M 2014 Indigenous knowledge, use, and on-farm management of enset (Ensete ventricosum (Welw.) Cheesman) diversity in Wolaita, Southern Ethiopia J. Ethnobiol. Ethnomed. 10 41.

[33] Kifle B, Demelash T, Gabisa G (2015). Screening of Some Coffee Arabica Genotypes Against Coffee Wilt Diseases (Gibberella Xylarioides Heim and Saccus) at Jimma, Southwest Ethiopia. International Journal of Sustainable Agricultural Research 2(3): 66-76.

[34] Teshome Y, Abdeta J, Habtamu K (2018). Characterization and classification of soils of Wolkite University research sites, Ethiopia. Eurasian Journal of Soil Science 7(4): 292-299 SAS (2009).

[35] SAS. 2009. SAS/STAT Statistical Software, version 9.2.; SAS Institute Inc.: Cary, NC, USA,

[36] Tsegaye A, Struik PC (2001). Enset (Ensete ventricosum (Welw.) Cheesman) kocho yield under different crop establishment methods as compared to yields of other carbohydrate-rich food crops. NJAS - Wageningen Journal of Life Sciences 49: 81-94.

[37] Tewodros M, Tesfaye W (2014). Farmers' indigenous knowledge and assessment of enset (Ensete ventricosum Welw. Cheesman) cultivars for major insect pests in Ojojia water shade Kembatatembaro zone, South Ethiopia. Sky Journal of Agricultural Research 3: 112-119.

[38] AbaDura NS, Beyene TM, Garadew W (2021). Genetic Diversity of Enset (Ensete Ventricosum (Weelw)) from Southern Ethiopia using Morphological Traits. Journal of Plant Sciences and Agricultural Research 5(1): 48.

[39] WestpHal E (1975). Agricultural systems in Ethiopia. Centre for Agricultural Publishing and Documentation: the Agricultural University of Wageningen, The Netherlands 123(163): 79-80.

[40] Brandt S, Spring A, Hiebsch C, McCabe S, Taboge E, Diro M, WeldeMichael G, Yentiso G, Shigeta M, Tesfaye S (1997). The Tree Against Hunger". Enset-based Agricultural Systems in Ethiopia. American Association for the Advancement of Science: Washington DC, America. 56 pp.

[41] Tsegaye A (2002). On indigenous production, genetic diversity and crop ecology of enset (Ensete ventricosum (Welw.) Cheesman). PhD dissertation, Wageningen University, The Netherlands. 198pp.

[42] Abdi A, Tafesse K (2020). On-farm genetic diversity and distribution pattern of Enset (Ensete ventricosum (Welw.) Cheesman) cultivars in Gedeo Zone of Ethiopia. Journal of Genetics, Genomics and Plant Breeding 4(4): 188-197.

[43] Yemataw Z, Muzemil S, Ambachew D, Tripathi L, Tesfaye K, Chala A, Farbos A, O'Neill P, Moore K, Grant M, Studholme DJ (2018). Genome sequence data from 17 accessions of Ensete ventricosum, a staple food crop for millions in Ethiopia. Data in Brief 18: 285-293.

[44] Yemataw Z, Chala A, Ambachew D, Studholme DJ, Grant M and Tesfay K 2017b. Morphological variation and inter-relationships of quantitative traits in enset (Ensete ventricosum (Welw.) Cheesman) germplasm from the south and south-western Ethiopia. Plants 6: 56. https://doi.org/10.3390/plants6040056

[45] Yemane T, Fassil K (2006). Diversity and cultural use of Enset (Enset ventricosum (Welw.) Cheesman) in Bonga in situ Conservation Site, Ethiopia. Ethnobotany Research and Applications 4: 147-157.

[46] Gizachew W, Feyissa T, Tesfaye K, Sebsebe D, Tadele Z (2019). Phenotypic diversity of enset (Ensete ventricosum (Welw.) Cheesman) landraces used in traditional medicine. Genetic Resources and Crop Evolution; Dordrecht 66(8): 1761-1772.