Morphological trait characterization of Enset(Ensete ventricosum landrace with Quantitative and Qualitative methods, in Gurage Zone, Central Ethiopia

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Research Article

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Abstract

Enset (Ensete ventricosum) is a perennial plant growing from 1200masl to 3100 masl and used as a major multipurpose crop in Ethiopia. Quantitative characterization of Enset is one of the curtail information to determine the yield of enset and qualitative characterization is important to determine the *genetic variability of Enset. Wolkite University was conserving enset landrace since 2014, which is collected in different enset growing areas with the objective of morphological characterization of Enset landrace with both quantitative and qualitative trait characterization methods at the Yefereziye Enset conservation site from 2020 to 2021. The evaluation was conducted as a single plot experiment method with a total of 15 plants within a column, and each plant was planted with the size of 1.5m intervals. The data were collected randomly and tagged with five Enset landraces within a row. The data shows a higher significance (P < 0.001) within the enset landrace. Based on Pseudostem height, Pseudostem circumference, and plant height quantitative characterization, the following enset landrace Ankogena(136.6cm(1.34m), 127.8cm(1.3m) and 466.6cm(4.67m)), Ginbeniye (113.6cm(1.14m), 156cm (1.56m) and 354cm(3.54m)) and Erake (119cm(1.2m), 124.8cm(1.25m) and 410.4cm(4.1m)) enset landrace the higher performance respectively followed by Lemat, Fereziye, Gimbwe and Keribote enset landrace. Whereas the lower enset landrace performance was recorded from Cherkiwe (88cm(0.88m), 60.6cm(0.61m), and 336.6cm(3.4m)) and Ayides 55.4cm(0.55m), 6 8.4cm(0.68m) and 208cm 2.08m)) respectively. From the data, Ankogena, Ginbeniye, and Erake enset landrace were a higher performance compared to another enset landrace and recommended to the local farmer and for all food-insecure countries cultivating enset landrace to improve the livelihood.*

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 between 1600 and 3000 masl 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 [5, 4, 6]. Male farmers generally prefer male enset landraces, which are late maturing and disease resistant, but with a lower quality of *amicho* and *kocho*, but female farmers prefer female enset landraces, which mature earlier and have tastier *kocho* and *amicho*, but are less vigorous and more susceptible to disease [3]. At the farmers' level, the same landraces may have different vernacular names depending on the ethnic or linguistic groups and agro-ecological zones. Choro and 'Ketano' enset landraces are used by farmers in two districts of Kaffa province for the same landrace [5]. 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 [3]. 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 [5]. Farmers differentiate landraces based on phenotypic characteristics, such as the color of the petiole, midrib, and leaf sheath, angle of leaf orientation, size, and color of leaves, and circumference and length of the pseudostem [7; 6]. Vernacular names are often descriptive and reflect the variety of landraces in places of origin, morphology, as well as agronomic and cooking characteristics [8].

Enset is a major multipurpose crop in Ethiopia, which has been identified as the center of origin and diversity of enset [9; 10;11]. 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 [12]. 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 costaple food [13]. Onset is important for food security for human beings and feeding for animals during drought time [14]. The number of landraces grown is closely linked to the importance of enset for a certain ethnic group [15]. More than 20% of Ethiopia's population depends on Enset for human food, fiber, animal forage, construction materials, and medicines [16; 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 people [18;19]. After a successful fermentation process, pseudostem and corm are important for human food and are eaten as bread and enjera form, leaf and leaf sheath is important for an animal, dried midrib is important for the industrial product [19]. In addition to as a portion of food, some of the onset landraces are of medicinal value (especially their corms) for both humans and livestock to cure bone fractures, broken bones, diarrhea and are used as birth control [20;16;13]. 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 [21]. Enset provides an important dietary starch source, as well as fiber, medicine, animal fodder, roofing, and packaging. It stabilizes soils and microclimates and has significant cultural importance [22]. In the Gurage zone, Guraye, Astara, Kibnar, and Deree enset landrace was locally identified to cure bone fractures and broken bone repairing. In addition to this Cherkiwe (Yefurenzir) enset landrace is important in discharging placenta phenotypically reddish color leaves and Yedemert or Lobo identified as to cure liver disease treatment because its special character is a red sap when it is cutting midribs of a plant of enset landrace.

Being perennial, enset improves local climate and soil conservation, and soil erosion management of [23]. In traditional agriculture, farmers have a wealth of knowledge in tackling varieties selected for their socioeconomic and environmental conditions[14]. Enset in Ethiopia: a poorly characterized received relatively little research attention [22]. 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, and susceptibility to disease [24; 25; 26]. Therefore, this research was conducted with the objective of morphological trait characterization of Enset landrace by quantitative and qualitative trait methods in Gurage zone at the Yefereze Enset conservation site.

Methodology

Experimental Design and treatment arrangement

The experiment was conducted in SNNPR in Gurage zone, in Wolkite University at Yefereze Enset conservation site. The study was conducted using 18 enset landraces, which were collected from Gurage Zone, and both western and eastern Gurage part, and Yemi special Woreda conserved since 2014, along with two control (Lemat and Ankefuye) Enset landraces. All enset landraces were planted within 1.5m intervals and 15Enset landraces were planted in each row. The assessment was conducted according to [27], and 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^{0}C	173.4mm -222.8 mm Per month	4.9

Source [28].

Table 2
Area of Enset landrace collection

No.	Enset landrace	Areas of collection	No.	Enset landrace	Areas of collection
1	Keribote	East Gurage	10	Ankefuye	West Gurage
2	Kibo		11	Shertiye	
3	Gewada		12	Genbenye	
4	Kambatiyr	West Gurage	13	Gimbwe	
5	Kanchiwe		14	Ayidas	
6	Yefurenzir		15	Cherkiwe	Yemi special woreda
7	Lemat		16	Gesero	
8	Adiya Ehire		17	Ankogena	
9	Fereziye		18	Erake	
Source [29]					

Data collection

All quantitative and qualitative trait data were collected for randomly five tagged plants with the insertion of two plants in each row. Plant height(cm), Pseudostem height(cm), Pseudostem circumference(cm), Leaf number, leaf length(cm), leaf width(cm), and petiole length(cm) are Quantitative trait characterization methods whereas the qualitative traits are Pseudo Stem color, leaf tip color, Upper leaf color, Lower leaf color, upper Midrib color, lower midrib color, petiole colors was characterized by the color chart and Shape of leaf lobes, Matured leaf shape[24; 26]. Propagation of Enset landrace was conducted on the virgin soil by of six years old Enset landrace.

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 [30].

Results and Discussion

3.1. Effect of plant height on Enset landrace

Plant height is a highly significant difference ($P < 0.001$) among Enset landraces. The longer plant height was recorded at Ankogena which is (466.6cm(4.67m)) followed by Erake enset landrace which is(410.4cm(4.1m)).

nonsignificant plant height data were recorded from Fereziye, Yefurenzir, Adiya Ehire, Shertiye, Genbeniye, Cherkiwe enset landrace which is varied from (369.2-336.6cm (3.7m to 3.4m)) within Enset landrace this is classified as an intermediate plant while medium plant heights were recorded from Lemat, Gimbwe, Gesero, Kerbte, Gewada, Ankefuye Enset landrace. The shortest plant height was recorded from Aydes (208cm(2.08m)) and Kibo(209.4cm(2.1m)(Table, 3). Among these landraces, Yefurenzir and Cherkiwe there are medicinal values or displacing the placenta when the animal is burning if the placenta is not displacing from their body. All landraces were important for human food after fermentation and animal food as a green feed. The result is varied within the landrace, this is maybe a genetic variation of Enset. The result is in line with the work of [31;11; 32]. Mature height ranges from 2 m to 10 m for enset plants. According to farmers, corm size, tissue quality of starch, root structure for harvestability, drought, frost, and disease tolerance are all variables among clonal genotypes. [33] reported that wild and domesticated enset differ in growth pattern, with the former increasing girth more consistently with age and the latter attaining larger girth earlier in development

3.2. Effect of Enset landrace on pseudostem height

The result shows that the pseudostem height is significant at ($P < 0.001$). The higher pseudostem height was recorded from Ankogena enset landrace which is 136.6cm(1.37m) followed by Erake, Fereziye, Genbeniye which is 119cm(1.2m), 113.6cm(1.14m) and 113.6 cm(1.14m) respectively. Medium Enset landrace height was recorded from kanbatiyr, Kinchiwe, Yefurenzir, Lemat, Adiya Ehire, Gimbwe Gasero, Ankefuye, Shertiye, and Cherkiwe ranging from 102.6(1.03m) to 86.8cm(0.86m). Whereas the shortest pseudostem height was recorded from Kibo, Aydes, and Kerbte which is 55.4cm(0.55m), 62.4cm(0.62m), and 69.6cm(0.7m) respectively (Table 3).

3.3. Effect of Enset landrace on leaf length

The result shows that leaf length is highly significant at ($P < 0.001$) among enset landraces. The higher leaf length was recorded from Ankogena, Erake, and Fereziye enset landrace which is 329.8cm(3.3m), 291.4cm (2.9m), and 255.6cm (2.56m) respectively followed by Genbeniye kanbatiyr, Kinchiwe, Yefurenzir, Lemat, Adiya Ehire, Gimbwe Gasero, Ankefuye, Shertiye, and Cherkiwe. Whereas the shortest leaf lengths were recorded from kibo, Aydes, Kerbte, and Gesero enset landrace which are 147cm (1.47m), 152.6cm(1.53m), 179.4cm(1.79m), and 177.2cm(1.77m) respectively (Table 3).

Table 3
Quantitative trait character of Enset landrace

Enset landrace	Plant Height (cm)	Pseudo stem Height(cm)	leaf Length (cm)	Pseudo Circumference (cm)	Leaf Width (cm)	No. of leaf plant	Petiole Length
Kambatiyr	302.8efg	92.8def	210hefdg	122.8abcd	52.6defg	11.8ab	15.2cd
Kanchiwe	301.8efg	86.8ef	215hecfdg	88gefd	54.6cdef	8.8efhg	12.6def
Yefurenzir	337.8cde	99.8cde	238cd	79feg	56.4bcd	8.2hfg	42.2a
Lemat	329.4efd	101.8cd	227.6cdef	95bcdefg	48.4hig	10.2bcde	7.4g
Adiya Ehire	332.4cdef	97.4def	235cdef	84.8fge	50.4ghef	11.6ab	22.4b
Fereziye	369.2c	113.6bc	255.6bc	104.4fdebc	56.4bcd	9.8cdef	18.8bc
Gimbwe	284gh	88.4def	195.6hfg	108bdce	54.8cde	11.6ab	14.8cd
Gesero	310.2efg	94edf	177.2hij	131.2ab	47hi	7.6h	23b
Erake	410.4b	119b	291.4ab	124.8abcd	71.4a	9.2edfgh	11.4defg
Keribote	263h	69.6gh	179.4hij	106.74bdec	49.2hfg	11.4abc	9.4efg
Ankogena	466.4a	136.6 a	329.8a	127.8abc	76a	10.8bcd	12.4def
Kibo	209.4i	62.4h	147j	79feg	43ij	10.6bcd	15.2cd
Gewada	296.8fgh	83.4fg	197.2hefg	124.2abcd	59.6bc	12.8a	8fg
Ankefuye	287.8gh	90.6edf	197.2hefg	79feg	49.8efgh	10.4bcde	19.4bc
Shertiye	347.6cd	102.6cd	245cd	93.4gcedf	58.4bc	10.8bcd	13.2de
Genbenye	354cd	113.6bc	191.4hig	156a	60.4b	11ab	11.6defg
Cherkiwe	336.6cde	99cde	237.6cde	60.6g	50.2efhg	8gh	45.4a
Aydes	208i	55.4h	152.6ji	68.4fg	40.8j	9.6edfg	21.2b
CV	9.25	12.29	14.89	28.87	8.01	13.42	20.5
LSD	37.283	14.7	40.787	37.1	5.55	1.74	4.65

Means with the same letter in a column are not significantly different among the treatments

3.4. Effect of Enset landrace on pseudo stem circumference

The result shows that pseudostem circumference is highly significant at ($P < 0.001$).The higher pseudostem circumference was recorded from Genbeniye, Ankogena, Gewada, Gesero, and Kanbatiyr enset landrace which is156cm (1.56m), 127.8cm (1.28m), 124.2cm(1.24m), 131.2cm(1.31m) and122.8cm(1.23m) respectively followed by Lemat, Fereziye, Gembwe, kerbte, which is 95cm (0.95m), 104.4cm(1.04m), 108cm(1.08m) and 106.74 cm(1.07m) respectively. Whereas the shallowest pseudostem circumference was recorded from Kibo, Cherkiwe, Aydes, Ankefuye, Adiya Ehire, Lemat, Yefurenzir, Shertiye, and Kanchiwe which is,79cm(0.79m),

60.6cm(0.066m),68.4cm(0.68m),79cm(0.79m), 84.8cm0(0.85m), 95cm (0.95m), 79cm90.79m), 93.4cm(0,93m)and88cm(0.88m) respectively (Table 3). The result agrees with the work of [34] reported that the enset landrace is highly vigorous within enset cultivars. [22] reported that pseudostem shape and varies from domesticated enset land land-race. [11; 32] reported that corm size, tissue quality of starch, root structure for harvestability, drought, frost, and disease tolerance are all variables among clonal genotypes.

3.5. Effect of Enset landrace on leaf width

The result shows that the pseudostem height is highly significant at ($P < 0.001$). The higher leaf width was recorded from Ankogena and Erake enset landrace which is 76cm(0.76m) and 71.4cm(0.71m), respectively followed by Genbeniye, Shertiye, Gawada, Fereziye, and Yefurenzir. Medium Leaf width was recorded from Cherkiwe, Ankefuye, Kerbte, Adiya, Ehire, Lemat, and Kanbatiyr, Whereas the narrow leaf width was recorded from Kibo Aydes, Kerbte, and Gesero which is 43cm(0.43m), 40.8cm(0.41m) and 47cm(0.47m) respectively (Table 3). The result agrees with the work of [34] reported that leaf size with different cultivars varies from enset landrace. [22] reported that leaf width and size vary from domesticated enset landrace

3.6. Effect of Enset landrace on the number of leaves per plant

The result shows that the number of leaves per plant is significant at ($P < 0.001$). The higher leaves number was recorded from Gawada, Genbeniye, Kerbte, Gimbwe, Adiya Ehire, and Kanbatiyr enset landrace which is 11- 12.8 ranges followed by Shertiye, Ankefuye, kibo, Ankogena, Kerbte, Fereziye, and Lemat enset landrace. The lower number of leaves was recorded from Cherkiwe, Aydes, Erake, Yefurenzir Gesero, and Kanchiwe Enset landrace (Table 3).

3.7. Effect of Enset landrace on petiole length

The result shows that petiole lengths are significantly at ($P < 0.001$). The higher petiole length was recorded from Cherkiwe and Yefurenzir which is 45.4cm and 42.2cm, respectively, followed by Ayides, Gesero, Adiya Ehire, Ankefuye, Fereziye, Gimbwe, ranging from 21.2 to 18.8. the medium length was recorded from Kibo, Ankogena, Kanbatiyr, Shertiye, and kanchiwe with the range of 15.2 to 12.4. Whereas the lower petiole length was recorded Genbeniye, Kerbte, Erake, Gawada, and Keribte, which is 11.6 cm and 8cm, respectively (Table 3). [22] reported that leaf width and size vary from domesticated enset landrace.

3.8. Qualitative trait character of Enset landrace

Locally, farmers are identifying types of Enset landrace based on qualitatively trait character. Farmers classified enset cultivars based on phenotype character [34]. [35] reported that identification of enset clones based on morphological characters and principal color is common for Farmers. [36] reported that the most important morphological descriptors included pseudostem circumference, corm weight, and fiber yield, with maturity period and number of leaves also contributing useful information. This suggests that there is indeed high diversity in desirable crop traits. [6; 37]. However, due to the vast number of landraces and considerable variability between individuals, the degree of precision and consistency in morphological studies is unclear.

From the assessment, qualitative character of Enset varied among Enset landraces. Pseudostem color characterization of Kanbatiyr, Kanchiwe, Ferezeye, Ankefuye enset, lad race was red in color, Yefurenzir, Lemat, Ankogena, and Ginbeniye had Black with the stripe of green color. Adiya, Ehire, and Shirtiye were light green. Gesero and Kerbte had Browne in addition to the other Gimbwe enset landraces were Browne and Black pseudostem (Table 4). The result agrees with the work of [34], where color of pseudostem varies from landrace to

landrace and reported that 34.6% of landrace was green, 23.1% was light green, 30.8% was deep brown and 11.5% red color. [22] reported that leaf color of landrace is varied from cultivated enset, landraces mainly green, red, yellow, and purple color, and wild enset is predominantly green (also referred to as 'white' in Ethiopia)

In upper leaf color characterizing, all enset landraces were deep green color whereas Cherkiwe and Yefurenzir had reddish in phenotypic characterization. The Lower leaf color character, Cherkiwe is red and Yefurenzir Blackish color, but the other Enset landraces were light green (Table, 4), The result agrees with the report of [22] reported that leaf color of landraces is varied within cultivated enset landraces mainly Green, red, yellow, purple color. [26] reported that the upper-side leaf lamina color and the most frequent was light green

Upper midrib character of Enset landrace of Lemat landrace is Black with a stripe of red color, Cherkiwe landrace is red color, Gimbewe landrace is black color in upper midrib color characterization whereas in under- side midrib characterization Gimbwe, Gesero, Erake, Kerbte, and Shirtiye enset landraces were a reddish color, the other enset landraces were red color (Table, 4). The result agrees with the report of [22] reported that the midrib color of the landrace is varied from cultivated enset landraces which are green, red, yellow, purple, and black color. [26] The upper-side midrib color light-to-medium green with black patches and black stripes, and rusty brown with green lines was observed. The most abundant upper-side midrib color across all altitude groups was light-to-medium green with black patches and black stripes. Under-side midrib color classes in all six regions revealed a greater abundance of orange-red with green lines in Dawro and Gurage.

Landraces of Kanbatiyr, Yefurenzir, Kerbte and Ankefuye red color, Lemat, Gimbwe, Gewada, Shertiye, and Genbeniye enset landraces were a Black color, Aydes, Kibo and Gesero is green color, Kanchiwe light green, Adiya Ehire, and Erake landrace was Black and green color, Cherkiwe is greenish petiole color character (Table, 4). [22] reported that petiole color is varied from cultivated enset landraces and some landraces were green, red, yellow, purple, and black color. [26] The upper-side petiole color of enset landrace populations was predominantly light-to-medium green with black patches and black streaks, followed by purple-brown with green lines and black spots in Dawro, Gamo Gofa, and Gurage. [5; 6], Farmers from Dawro, Gamo Gofa, and Gurage grow different enset landraces in the same plot of land and distinguish different enset landraces mainly through under-side petiole and midrib color. [24] reported that the under-side petiole colors were mainly light-to-medium green with brown stripes (2) and red with black patches (10) across the four altitude ranges.

The leaf tip edge of all enset landraces was blackish color except Ayides enset landrace was browne in leaf tip color character (Table, 4). The result agrees with [26] report that The most frequent leaf tip edge color was brown in Dawro, Gamo, Gofa, and Gurage locations. [38] reported that the most predominant leaf tip edge color in enset was brown-purple. [26] the concluded leaf tip edge color and the under-side midrib color were relatively monomorphic, while the under-side petiole color and upper-side midrib color, and upper-side petiole color had an intermediate diversity. Some of the qualitative traits character and stage growth of enset landrace (Fig. 1)

Table 4. Qualitative trait character of Enset landrace at Yefereze Research site

Enset landrace	Pseudo Stem 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
Kanbatiyr	Red	Black	Oblong	Elliptical	D. green	L. Green	Green	Red	Red
Kanchiwe	Red	Black			D. green	L. Green	Green	Red	L. Green
Yefurenzir	Black	Black			D. green	Black	Green	Red	Red
Lemat	Black	Black			D. green	L. Green	Black & Red	Red	Black
Adiya Ehire	Light green	Black			D. green	L. Green	Green	Red	Black & Green
Fereziye	Red	Black			D. green	L. Green	Green	Red	Reddish
Gimbwe	Browne& Black	Black			D. green	L. Green	Dark	Reddish	Black
Gesero	Browne	Black			D. green	L. Green	Green	Reddish	Green
Erake	Reddish	Black			D. green	L. Green	Green	Reddish	Black & Green
Kerbte	Browne	brown			D. green	L. Green	Green	Reddish	Red
Ankogena	Black	Black			D. green	L. Green	Green	Red	Brown
Kibo	Green	Black			D. green	L. Green	Green	Green	Green
Gewada	Green	Black			D.green	L. Green	Green	Red	Black
Ankefuye	Red	Black			D.green	L. Green	Green	Red	Red
Shertiye	L. Green	Black			D.green	L. Green	Green	Reddish	Black
Genbeniye	Black	Black			D.green	L. Green	Green	Red	Black
Cherkiwe	Green	White			Redish	Red	Red	Red	Greenish
Aydes	Green	Browne			D.green	L. Green	Green	Red	Green

Key:- D., Deep green, L. light green

3.9 Effect of enset landrace on sucker number

The number of suckers per plant is varied in enset landraces. The higher number of suckers were recorded from Yefereze enset landrace which is 52 suckers /plant followed by Kanchiwe, Ankogena, and Lemat which is 43 to 32 of suckers per mother plant. Kanbatiyr, Ankefuye, Gesero, Kibo, Gewada, Shertiye, Genbeniye, Gimbwe, Gewada, Kibo, Keribote, AdiyaEhie, Yefurenzir enset landraces are medium sucker number which is the range of 20-27sucker. Whereas the lowest sucker numbers were recorded from Cherkiwe Aydes enset landrace which is 19 and 18 suckers (Table 5). In the Gurage area, most farmers are propagating the enset from the age of 3-4year old enset landrace and one mother plant will produce 40–150 suckers/plant. The lower number of suckers were recorded, this is maybe the pseudostem circumference and age of the mother plant. The result agrees with the report of [7]. The number of suckers produced per rhizome varied depending on soil conditions, cultivar, type, size and age of the mother plant rhizome, amount of rainfall, land preparation, and time of planting. On average, enset farming household cultivates between 200 and 400 plants and consumes about 10 to 20 plants annually. Therefore, 1 to 4 parent rhizomes can fulfill the annual requirement for enset planting materials [39;5].

Table 5
Effect of Enset landrace on sucker number.

Name of Enset landrace	Effective Sucker number	Name of Enset landrace	Effective Sucker number
Kanbatiyr	26	Ankogena	36
Kanchiwe	43	Kibo	23
Yefurenzir	20	Gewada	22
Lemat	32	Ankefuye	25
AdiyaEhie	21	Shertiye	20
Fereziye	52	Genbeniye	21
Gesero	27	Cherkiwe	19
Keribote	22	Aydes	18
Kibo	24	Gimbwe	21
Gewada	23		

3.7. Correlation analysis of Enset landrace on quantitative character

Highly significant ($p < 0.001$) positive correlation was observed among the character of Pseudostem (95.1%) leaf length (88.5%), and leaf width (81.45%) with plant Height. Leaf length (76.9%), leaf width (71.8%), Pseudostem circumference (23%) with Pseudostem length. Leaf width (75.4%) with leaf length, leaf width (27.5%), number of leaves (20.9%) with pseudostem circumference. The number of leaves (15.4%) with leaf width. Whereas a

negative correlation was observed between the character of petiole length (33.9%) with pseudostem circumference and pseudostem circumference (18.9%) with leaf length. None significant correlation was observed among quantitative trait characters (Table 6).

Table 6. Correlation analysis of Enset land race for block one

	hi	PS	LL	PC	LW	NO	PL
hi							
PS	0.951***						
LL	0.88***	0.769***					
PC	0.201*	0.23**	-0.189				
LW	0.814***	0.718***	0.754***	0.275**			
NO	-0.035	-0.054	0.006	0.209*	0.154		
PL	-0.003	-0.004	0.024	-0.34	-0.21	0.466***	
				0.001	0.02	0.001	
if P≤ 0.001*** P ≤ 0.01 ** P ≤ 0.05 *							

Conclusions and Recommendations

Enset is a perennial plant and matures in five to seven years based on enset landrace climatic growing from 1200masl to 3100 masl. In tropical areas maturing within a short period of time, whereas in temperate areas maturing lately. An enset germplasm at Yerefezy research station has clear differences in morphology with substantial differences in growth rate [22], result shows that both quantitatively and qualitative enset landrace is varied. Pseudostem height, pseudostem circumference, corm size, corm circumference, and plant height are one of the best criteria to determine the yield of enset landrace both for the farmer and in the research field. Whereas the qualitative character is evaluating the phenotypic variability of enset landrace color. Both quantitative and qualitative character characterization is indicating the genetic variability of the enset landrace. Based on Pseudostem height, Pseudostem circumference, and plant height, the following enset landraces Ankogena, Ginbeniye and Erake, Gesero and Kanbatiyer enset landraces were performed well followed by Lemat, Fereziye, Gimbwe, and Kerbte enset landrace. Moderate yield defining traits were recorded from Kanchiwe, Yefurenzir, Adiye, Ehire, Kibo, Ankefuye, and Shertiye enset landrace, whereas the lower yield defining traits were recorded from Cherkiwe and Ayides landraces. Therefore, from the results, the following enset landrace, Ankogena, Ginbeniye, and Erake enset landraces were higher performance compared to other enset landraces and recommended to the local farmer and for all food-insecure countries to cultivate enset landrace to improve the livelihood. [22] reported that enset is an underexploited starch crop with significant potential in Ethiopia and beyond.

Abbreviations

masl *meters above sea levele*

mm mele meter

cm cent meter

m meter

N North

E East

Hi plant height

Ps pseudo stem height

LL Leaf length

PC Pseudo stem circumference

PL Petiole length

LW leaf width

NO Number of leaf

P Probability

Declarations

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Authors' Contributions

All data collection and data analysis carried by both researchers. For publication, the final manuscript was written by Ashenafı Mitiku.

Availability of data and materials

All data generated or analyzed in this study are included in this manuscript, and available in the corresponding Authors.

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

Written permission to conduct the research was obtained from the Wolkite University College of Agriculture and Natural Resource of Research and Development Directorate office research committee (Ref. no of WKU/RDD/355/13/19, date of Decenber 02, 19). This research was conducted as ongoing research part at Cheha Woreda Yefereze Enset Conservation Research site. Yefereze Enset conservation site was established by Wolkite University since 2013.

Consent for publication

Not applicable

Competing of interests

The author declares that there is no conflict of interest and it is our original work.

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Figures

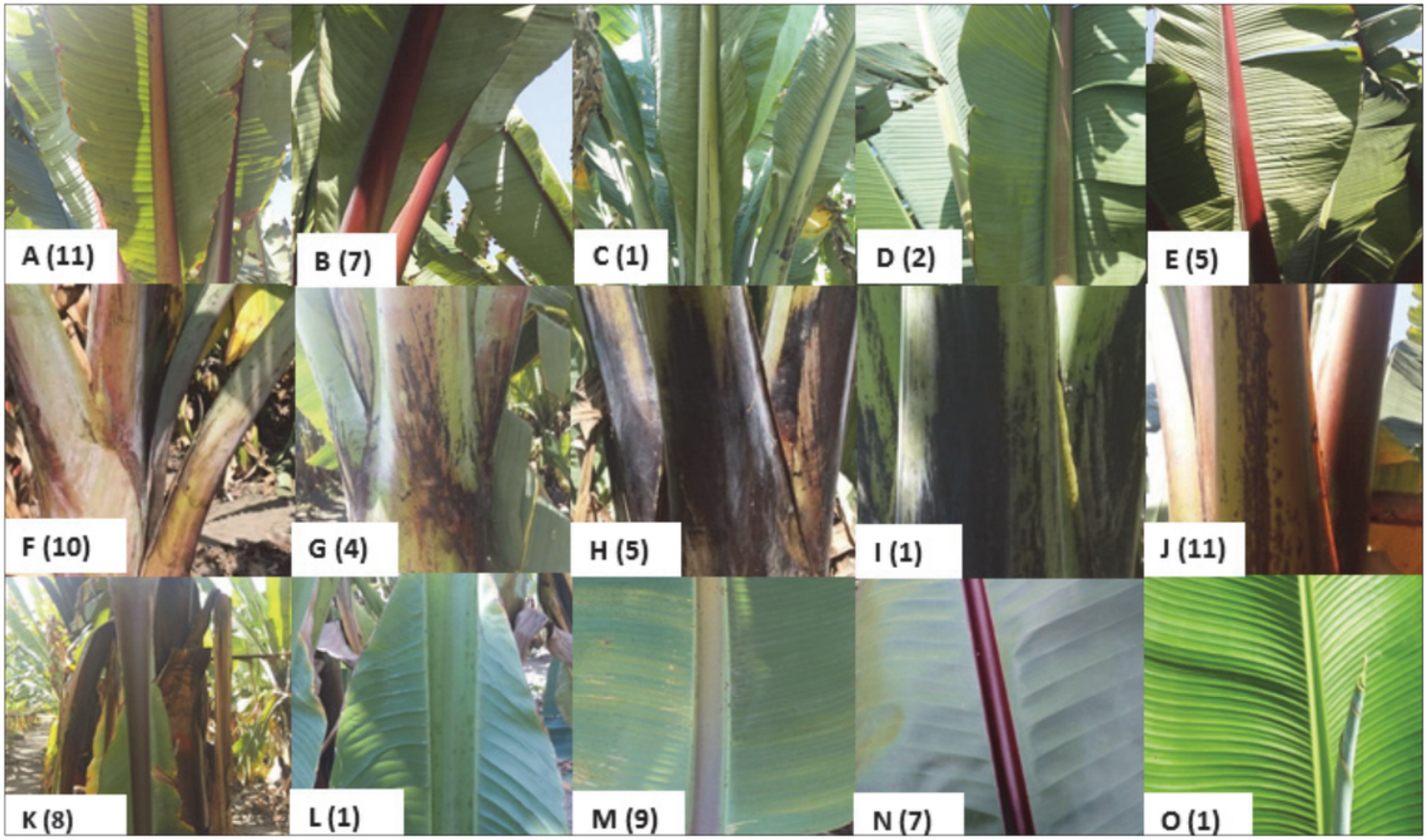

Figure 1

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

Source [40]

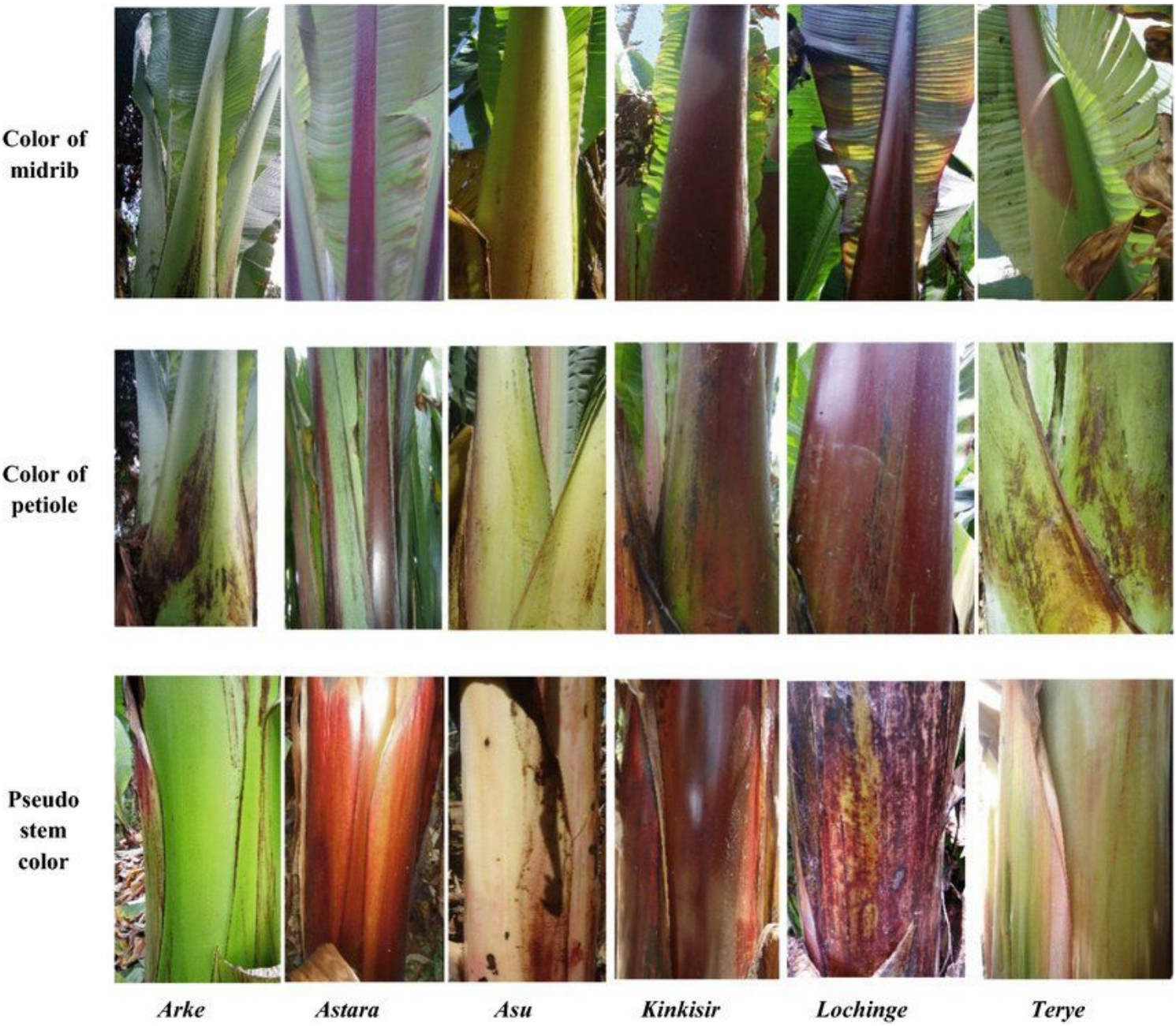

Figure 2

Figure1. Qualitative trait character of enset land race.

Source [41]

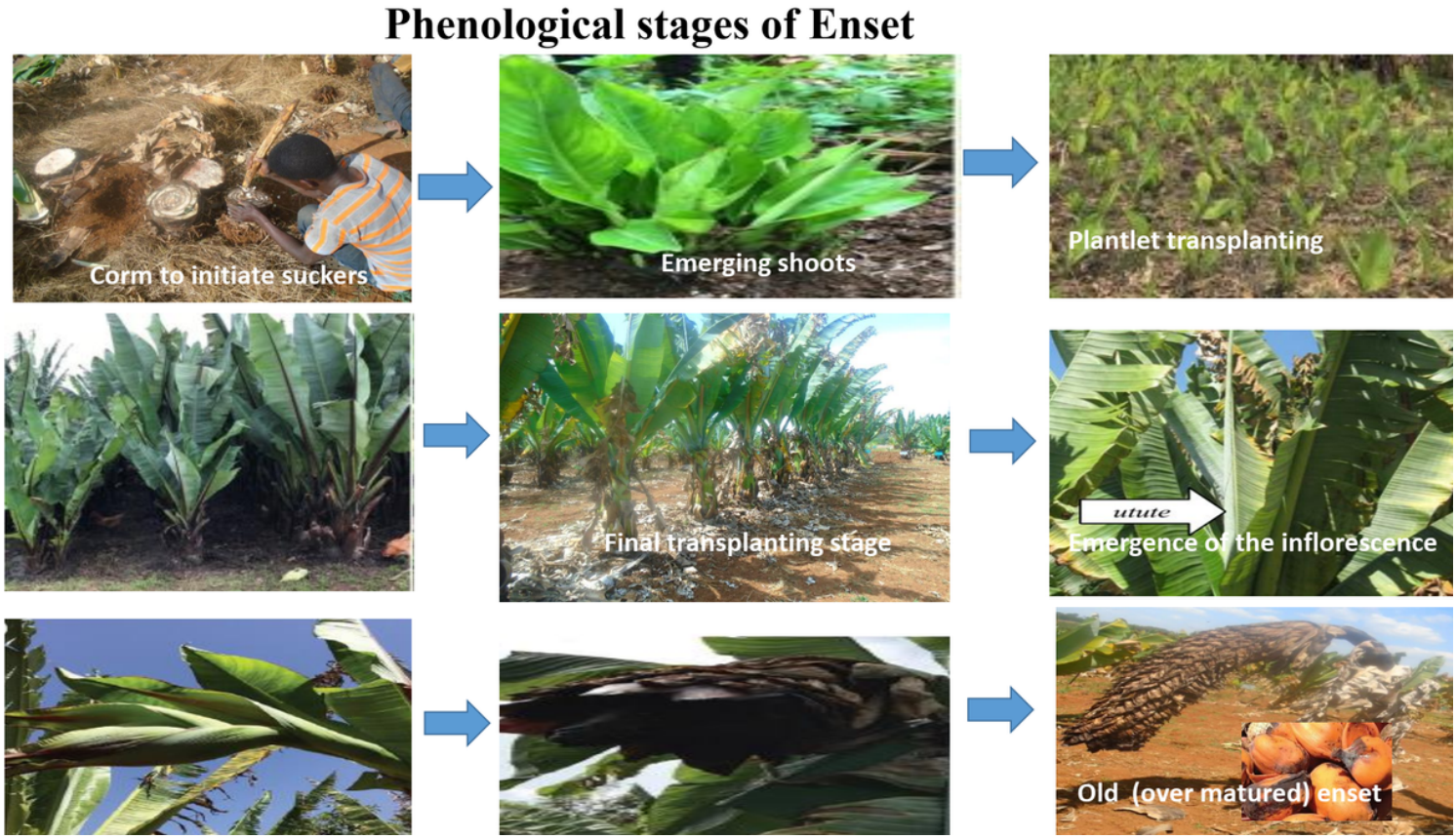

Figure 3

Figure 2. Growth stage of Enset landrace

3LQQMxU:8vpDGAv