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Genetic Diversity of Enset (*Ensete Ventricosum* (Weelw)) from Southern Ethiopia using Morphological Traits

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Abstract

South and South-western part of Ethiopia is repository for indigenous crop 'Ensete ventricosum'. To assess the diversity of these clones, study was carried out in Southern part Sheka zone, Ethiopia. The altitude of the study area ranged from lowland to highland. The study was conducted on-farm within these three agro-ecologies viz., lowland (Yeki), Midlan (Andiracha) and highland (Masha). The result indicated that there were significant variations among genotypes in few qualitative traits pseudostem and most quantitative traits. Moderate variations were observed among Enset clones in pseudostem and midrib color with Evenness (E) values of 0.59 and 0.54 respectively. Besides, the Ensete in the study area differ in stature ranging from minimum of 2 m to maximum of 7 m, leaf length 2.00 m-6.80 m, leaf width 0.4 m-0.98 m and psedustem circumference 1.00 m-2.90 m. The altitudinal effects on growth of Ensete were observed where the maximum growth parameters diversified Ensete clones were recorded at higher altitude and decreased with decrement of altitude indicating higher altitude to be conducive for Ensete productions and diverse Ensete genetic resources.

Keywords: Diversity; Ensete; Quantitative Traits; Qualitative Traits

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Introduction

There are different root and tuber crops grown in Ethiopia at different agro-ecologies. These include potato, sweet potato, taro, yam, cassava, anchote and *Ensete* are some of them. Each of them grows at different altitudinal range from lowland to highland of these crops; potato and *Ensete* are categorized under highland crop even though it can be grown at mid-altitude. Among these crops, *Ensete* and anchote are indigenous to Ethiopia [1].

Despite *Ensete* grouped under root and tuber crops, unlike other root and tuber crops, its corm and pseudo-stem are consumable part while all the rest parts are functional for multipurpose including construction materials, wrapping purpose, animal feed, medicinal value and etc. [2]. Mostly it is source of carbohydrate with low protein where producers supplement with other pulse crop to fill protein gap [1]. The crop is important food crop after cereal and pulse with coverage of 25% of arable land in southern region of Ethiopia supporting more than 6-7 persons per house [3].

In *Ensete* producing areas, there are diversified *Ensete* landraces cultivated where farmers plant separately for different purpose. These clones indigenously identified based on farmers experiences. Additionally, number of researchers conducted on-farm diversity study as well as compositional analysis and reported as there is diversity among assessed clones. For example, Tesfaye and Ludders [4] conducted on-farm diversity study and recorded about 86 named landraces. Similarly, Zerihun [5] in his survey study undertaken in eight zones of SNNPR of Ethiopia that 218 different *Enset* clones were recorded with their vernacular name; the survey result conducted in Kembata Tembaro zone by Melesse [6], detected *Ensete* clones diversity and the uses of clones were portrayed where total of 111 different *Ensete* clones were characterized by farmers, of which 21 of them have medicinal uses. Additionally, Semman [7] conducted survey study in Sheka zone and identified 90 *Ensete* clones based on farmer's morphological classification methods like leaf, mid-rib and pseudo-stem color. Besides, the Semman [7] assessed biochemical content of 14 *Enset* clones and clustered under three groups. However, most studies done at different *Ensete* growing region consider phenotypic and farmer's classification and naming based. To verify the extent and reality of the diversity

of the crop in the specific study area or to disqualify it, measuring and recording quantitative and qualitative traits of the crop is the base as benchmark and as a source of information to conserve and conduct further experiment on this indigenous crop. That was why this experiment was conducted to quantify the extent of *Ensete* clones diversity based on quantitative and qualitative parameters in Sheka zone, southern Ethiopia.

Materials and Method

Description of the study area

The study was conducted in *Enset* repository zone Sheka zone within three districts i.e. Masha, Yeki and Andiracha which found in South Nation Nationality People Regional State (SNNPRS) south part of Ethiopia. The zone has three agro-ecologies (lowland, midland and highland) laying between 7024'N-7052'N of latitude and 35°13'E-35°35'E longitude at an altitude ranging from 900 MASL-2800 MASL [2]. Agro-ecologically, Masha is found at highland agro-ecology at altitudinal range from 1800 MASL-2800 MASL. Andaracha is also located from mid to highland altitudinal range from 1400 MASL-2500 MASL whereas Yeki which is low to midland of 900MASL-1800MASL. Generally, the zone receives minimum and maximum annual rainfall of 1600 mm-2200 mm and minimum and maximum temperature of 21°C-29°C [2].

Collected data

Quantitative traits such as Plant Height (PH), Leaf Length (LL), Pseudostem Circumference (PsCr), Leaf Width (LW) and Petiole Length (PetL) were recorded in meter from 43 different *Enset* clones sampling three plants from each clone and district that were mature enough and uniform age managements.

Additionally, qualitative attributes like leaf color, pseudostem color, petiole color and mid-rib color were collected using banana descriptor with some modification as used by other scholars.

Data analysis

All quantitative trait data were subjected to Analysis of Variance (ANOVA) and analyzed using nested design (Enset clones were nested under each district) to investigate if significant differences exist among the locations using SAS Ver. 9.1.

To evaluate the *Enset* clones diversity, abundance, distributions, evenness and richness across the districts of Sheka zone, Simpsons' (1949) and Shannon-Weaver (1949) diversity indices were calculated using the following formula. Shannon diversity index $(H') = -\sum pilnpi;$ where pi is proportional abundance of ith clone (ni/N), Simpson diversity index $(S) = (1-D) = 1-\sum n((n-1)/\mathrm{N}(N-1))2$ *and* $D = -\sum(n/N)2,$ where D denoted for measure of probability that two individuals randomly selected from the same site, N=total number of farm surveyed or *Enset* producers or total number of individual clones, ni= is frequency of ith species.

Results and discussion

Qualitative and Quantitative Traits Based Enset Diversity

Qualitative data based *Enset* clones diversity

Analysis of Shannon-Weaver diversity index (H') of four morphological qualitative traits of 43 *Enset* clones was evaluated and presented in **Table 1**. The analysis of qualitative data for pseudostem color indicated, most numbers of clones had showed dark brown pseudostem color with 23.25% followed by greenish black leaf sheath with 16.27% and 13.95% respectively. The minimum diversified species were *Enset* with black spot on green (2.33%) and dark red to greenish yellow pseudostem color with 4.65% each **Table 1.**

Regarding leaf color, clones were predominantly deep green and dark green color with 39.53% and 37.21% respectively. Besides, though light greenish leaf cultivars were more about 13.95%, there were few clones with light-purple and purple color with 4.65% each respectively **Table 1.**

As far as petiole and leaf mid-rib color concerned, majority of clones were black (25.58%) and dark red with 18.60% petiole color and red (27.90%) and greenish red (20.93%) mid-rib color recorded. But, cultivars with purple and red with black stripe petiole color were few in numbers with 2.33% only. In the case of mid-rib color few clones with light red to red and purple midrib color (4.65%) were recorded. The same report was cited by Zerihun [5] in which frequency of petiole and mid-rib red color with red ranged second next to green color.

Additionally, evenness result also revealed moderate diversity index value for pseudostem (0.58) and petiole underside color 0.54, and minimum for leaf and mid-rib color each 0.47 and 0.34 respectively **Table 1.** Likewise, Mikias [8] recorded minimum and maximum *Enset* diversity index from 0.31 to 0.95 for leaf color and mid-rib color. Also, 0.94 for petiole underside as well as 0.83 for mid-rib underside color were reported. The mean ± Standard value of all traits in this analysis was 0.48 ± 0.1 detecting as there was minimum morphological evenness within the clones detecting variation of clones **Table 1**.

This was supported by classification of Shannon Weaver Diversity index (*H'*) as high when E>=0.75, moderate when E=0.5-0.75 and low when E<0.5 by Jamago [9]. The qualitative morphological result **Table 1** witnessed the view of farmers on identification of clones based on color of different plant parts.

These morphological variations of the clones provide an opportunity for improvement through breeding the crop and call for germplasm conservation [10].

Analysis of variance of quantitative trait based Enset clones diversity

The analysis of variance for *Enset* quantitative traits showed there were significant differences among *Enset* within the districts with all analyzed parameters except leaf width **Table 2.**

Table1: Frequency distribution and Shannon-Weaver diversity indices (*H'*) of qualitative traits.

Traits	Code	Description	Frequency of clones	%	$E=H'/H'_{max}$
Pseudostem color	1	Dark red to black	2	4.65	0.59
	2	Dark red to brown	4	9.3	
	3	Black spot on green	1	2.33	
	4	Redish yellow	3	6.98	
	5	Black	3	6.98	
	6	Dark red	3	6.98	
	7	Dark brown	10	23.25	
	8	Greenish black	7	16.27	
	9	Greenish yellow	2	4.65	
	10	Light green	6	13.95	
	11	Light red	2	4.65	
Leaf color	1	Light green	6	13.95	0.34
	2	Deep green	17	39.53	
	3	Green	16	37.21	
	4	Purple	2	4.65	
	5	Light purple	2	4.65	
Petiole color	1	Black	11	25.58	0.54
	2	Red	8	18.6	
	3	Yellowish green	5	11.63	
	4	Middle black with either side green	2	4.65	
	5	Green with black stripe	7	16.28	
	6	Green	4	9.3	
	7	Yellowish green	2	4.65	
	8	Purple	1	2.33	
	9	Red with black stripe	1	2.33	
	10	Light red	2	4.65	
Midrib color	1	Greenish red	9	20.93	0. 47
	2	Red	12	27.9	
	3	Purple	2	4.65	
	4	Green	7	16.28	
	5	Dark red	8	18.6	
	6	Light green	3	6.97	
	7	light red to red	2	4.65	
Mean					0.50 ± 0.1

Table 2. The summary of ANOVA for traits and their significance level for 43 *Enset* clones.

Traits	Mean square			CV (%)	Mean ± SD	Min	Max
	Wereda	Clones (wereda)	error				
PH (m)	7.07	1.47	0.43	14.16	4.51 ± 1.19	2.00	7.20
LL (m)	0.81	0.96	0.17	10.00	4.40 ± 0.92	2.00	6.80
PsCr (m)	0.47	0.25	0.20	10.72	1.88 ± 0.44	1.00	2.90
LW (m)	31.59	182.71	140.70	15.72	0.75 ± 0.14	0.40	0.98
PetL (cm)	23.13	19.94	8.591	3.35	0.28 ± 0.13	0.00	0.60
PH:Plant Height, LL: Leaf Length, PsCr: Pseudostem Circumference, LW: Leaf Width, PetL: Petiole Length							

The mean, minimum, maximum, root mean square of clones and coefficient of variation of all parameter were summarized in **Table 2**. Accordingly, maximum Plant Height (PH), Leaf Length (LL), Pseudostem Circumference (PsCr), Leaf Width (LW) and Petiole Length (PetL) were observed to be 7.2 m, 6.80 m, 2.90 m, 0.980 m and 0.60 m respectively. The minimum were recorded to be 2 m, 2 m, 1 m, 0.4 m and 0 m for plant height, leaf length, pseudostem circumference, leaf width and petiole length with mean of 4.1 m, 3.60 m, 1.68 m, 0.75 m and 0.25 m in that order.

Concerning the location effects, the mean separation result revealed that there was highly significance differences observed between all districts for plant height and pseudostem circumference **Table 2**. From the result one can understand that, even though clones nested under districts (wereda), as altitude

Table3. Summary of mean separation of districts on quantitative traits of 43 *Enset* clones

Districts	Plant height	Leaf length	Pseudostem circumference	Leaf width	Petiole length
Masha	5.05	4.32	1.90	76.07	29.02
Andiracna	4.58	4.16	1.87	74.98	27.0
Yeki	4.13	3.92	1.72	75.47	26.37
LSD	0.21	0.18	0.02	2.15	4.15

of the area increase, all parameters of *Enset* increase. The largest plant height, leaf length and pseudostem were found in Masha than Andiracha and in Andiracha than Yeki based on altitudinal variation.

But, there were no significant difference among the three districts with leaf width and petiole length. For leaf length, there is no significance difference observed between Andiracha and Masha but, there was difference between Andiracha and Yeki as well as Masha and Yeki districts **Table 3.** This might be due to agro-ecological variations where Masha and Andracha mainly highland areas while Yeki altitudinal range are low to midland.

Conclusion

The result of the study for both quantitative and qualitative attributes indicated that, there were variations among *Enset* clones. However, the extent of variation for different traits varies. Concerning qualitative trait, most *Enset* moderately vary in pseudostem and petiole color. Additionally, the quantitative trait measurements indicated difference among available *Enset* clones in most attributes except in leaf width and petile length. However, for more confirmation and thereby to conserve each *Enset* indigenous genetic resources separately, molecular characterization is very important.

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