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Genetic Diversity Analysis among Anchote (*Coccinia abyssinica*) Accessions in Western Ethiopia

[1]Tilahun Wondimu, [2]Sentayehu Alamerew, [3]Amsalu Ayana and [2]Weyessa Garedew
[1]Oromia Agricultural Research Institute, Bako Agricultural Research Center, P.O. Box, 03, Bako, Ethiopia
[2]College of Agriculture And Veterinary Medicine, Jimma University Jimma, Ethiopia
[3]Integrated Seed Sector Development Ethiopia Program, Addis Ababa, Ethiopia

Corresponding Author: Sentayehu Alamerew, College of Agriculture And Veterinary Medicine, Jimma University, Jimma, Ethiopia Tel: +0251(0)471110102

ABSTRACT

Forty nine anchote landrace populations collected from South and Western parts of Ethiopia were evaluated for 17 pheno-morphic and agronomic traits of yield and yield related traits in simple lattice design at Bako Agricultural Research Center during 2011 cropping season. The objectives of the study were to classify the population into relatively homogenous group and to identify the major traits contributing to the overall diversity of the population. The data were subjected to D^2 analysis and the populations were clustered in to 5 different major groups according to their similarity levels and this makes the accessions to become moderately divergent. This dataset was reduced to three significant Principal Components (PCs) that cumulatively explained 93.50% of the variance. About 56.30% of the variance accounted for by the first PC alone resulted largely from the variations in contrasting effects of discriminatory traits like fruit yield per plant, fruit length, fruit weight, fruit diameter, hundred seed weight, petiole length, number of fruit per plant, leaf length, average root length, internodes length, vine length and root yield per plant. Overall, the study confirmed the presence of character diversity in anchote landraces. This assessment of traits diversity can assist geneticist and breeders to identify populations with desirable characteristics for inclusion in variety breeding program. Further evaluation at multi-location is suggested in the future.

Key words: *Coccinia abysinica*, genetic divergence, principal component

INTRODUCTION

Anchote (*Coccinia abysinica*) is one of the most important root crop grown in South and Western parts of Ethiopia (Hora, 1995; Schippers, 2000). It has economic (food, feed and income), medicinal and socio-cultural values (Hora, 1995). Anchote is rich in carbohydrates, proteins, vitamins and minerals as compared to other root crops (Fekadu, 2011). Moreover, traditional medicinal practitioners use anchote to treat different type of diseases such as diabetes, gonorrhea, tuberculosis, asthma and cholesterol lowering. It owns it's both centers of origin and diversity in Ethiopia (Getahun, 1985). The crop is endemic to Ethiopia and its cultivation as a root crop is little known elsewhere in the world. Hence, the primary source of variation for the genetic improvement of the crop rests heavily upon the indigenous genetic resources. So far, there is no previous study on anchote germplasm which demonstrated the existence of broad genetic variation in many of the phenotypic traits studied except, some information generated on nutritional content of the crop. At present, the institute of biodiversity conservation and research of Ethiopia maintains an ex situ reserve of only 20 anchote germplasm. In addition, there is no national and regional agent who took the responsibility for the improvement for this imperative crop.

Genetic diversity is essential to meet the diversified goals of plant breeding such as breeding for increasing yield, wider adaptation, desirable quality and pest and disease resistance. Efficient utilization of anchote genetic resources requires comprehensive and systematic collection, evaluation and characterization. To this effect, multivariate analysis has, amongst others, proved useful for characterization and classification of plant genetic resources evaluated for several phenol-morphic and agronomic traits. Genetic divergence analysis estimates the extent of diversity existed among selected genotypes Mondal *et al*. (2003). Genetic divergence in crop plant was reported by Kabir *et al*. (2009) in 24 genotypes of pointed gourd and Bijaya *et al*. (2009) in 26 genotypes of cassava. Therefore, the objectives of this study were to classify the germplasm populations into similar groups and to identify the traits accounting for the gross diversity of the population through multivariate analysis of quantitative traits.

MATERIALS AND METHODS

Forty nine anchote accessions obtained from Debre Zeit Agricultural Research Center were used in this study (Table 1). The study was conducted at Bako Agricultural Research Center

Table 1: Lists of anchote germplasm accessions used in this study

Accessions	Woreda/ district	Altitude (m.a.s.l.)	Accessions	Woreda	Altitude (m.a.s.l.)
207984	Asosa	1400	90802-1	A/Chomen	1980
DD	Gidda Gebo	2359	90801	A/Chomen	1780
DD-1	Gidda Gebo	2359	90802	A/Chomen	1780
223085	Digga Leka	2200	223108	Ale	2150
223086	Digga Leka	2200	223109	Ale	2150
223092	Sibu Sire	1900	223110	Ale	2150
223093	Sibu Sire	1900	223112	Bedelle	1980
223094	Sibu Sire	1900	223108-1	Ale	1920
223096	Guto Wayu	2100	223109-1	Ale	2050
223097	Guto Wayu	2100	223104	Dedo	1800
223098	Guto Wayu	2100	223105	Dedo	1800
223099	Jimma Arjo	2560	223113	Manna	1980
223100	Jimma Arjo	2560	240407G	Dacha	2150
223101	Jimma Arjo	2560	240407B	Decha	2000
DIGGA	Digga	2123	229702-1	Hulet Iju Enese	1890
KICHI	Gute	1821	220563	Bako Tibe	1780
KUWE	Sibu Sire	1987	220563-1	Bako Tibe	1750
SODDU	Sibu Sire	1823	223087	Gimbi	2300
DIGGA-1	Digga	2123	223088	Gimbi	2300
223096-1	Guto Wayu	2320	223090	Gimbi	2300
223086-1	Digga Leka	2180	GM	Gimbi/A/Sena	2400
KICHI-1	Gute	1821	230566	Gimbi	1820
KUWE-1	Sibu Sire	1987	223090-1	Gimbi	2112
223097-1	Guto Wayu	2230	223087-1	Gimbi	2165
DIGGA-2	Digga	2123			

(at 1650 m above sea level) in Western Ethiopian agro ecologies on nitosols under rain fed conditions of 2011 cropping season. The experiment was laid out in 7×7 Simple Lattice Design (Yates, 1936). The plot size was 5 rows of 2 m length and 40 cm between rows (4 m^2) and 20 cm between plants within a row. Trials were hand planted on flat bed (plot) with 2 seeds per hill at depth of 5 centimeter and it was tinned to 1 seedling per hill after a month of planting to get 125, 000 plant population per hectare. Fertilizer were applied as Diammonium Phosphate (DAP) and urea at the rate of 46 kg N and 20 kg P_2O_5 (Girma and Gudeta, 2007). All recommended rate of P_2O_5 were applied at the time of planting, while N was applied in split, half at the time of planting and the remaining half at the start of vine development. Crop management practices such as weeding, cultivation etc., were performed as per recommendation.

Data on 17 quantitative traits were recorded on plant basis with 10 plants from each accession by random sampling method from the middle rows and marked at early stage before the vines development. Data were recorded for quantitative traits by adopting descriptors of cucurbits (ECPGR, 2008) and descriptors of sweet potato (Huaman, 1991). The data were collected on vine number, days to 50% emergence, number of fruits per plant, fruit yield per plant (kg), 100 seeds weight (g), root yield per plant (kg), root length (cm), fruit weight (g), fruit diameter (cm), fruit length (cm), number of seeds per fruit, root diameter (cm), internodes length (cm), leaf length (cm), vine length (cm), petiole length (cm) and internodes diameter (mm).

All subgroups are fused into a single cluster as per the procedure of the Johanson and Wichern (1992). The number of cluster was determined by following the approach suggested by Copper and Milligan (1988). The genetic distances between clusters were estimated by Mahalanobis (1936). The test was done aganist the tabulated values of χ^2 for 'p' degrees of freedom where "p" is the number of quantitative characters considered characters (Singh and Chaudhary, 1985). Important characters in each principal component were identified by using the formula suggested by Johanson and Wichern (1992).

RESULTS AND DISCUSSIONS

Cluster analysis based on pooled mean of 17 quantitative traits of 49 anchote accessions grouped the accessions into 5 clusters (Fig. 1). The first, second, third, fourth and 5 cluster consisted 14 (28.57), 14 (28.57), 10 (20.41), 10 (20.41) and 1 (2.04)% accession, respectively indicating the tested plant material were moderately divergent. In line with this finding, Quamruzzaman *et al.* (2011) reported similar in 20 local sponge gourd genotypes of Bangladesh, Masud *et al.* (1995) in sweet gourd and Khan (2006) in pointed gourd. The clustering pattern of the anchote accessions under this study revealed that the accessions collected from the same location were grouped into different clusters. The probable causes for the existence of related genotypes in different regions of origin were attributed to the unrestricted movement of anchote seeds from area to area by man as well as wild animals (Hora, 1995). It is in line with the finding of Khan (2006) in pointed gourd.

The cluster mean of different characters of 49 anchote accessions is presented in Table 2. Cluster I was differentiated by the highest cluster mean value for number of seeds per fruit (62.350) but by the lowest internodes length (11.338 cm), internodes diameter (0.418 cm), vine number (2.600) and root diameter (5.997 cm). Cluster II was characterized by having the highest cluster mean values for internodes length (12.225 cm), root diameter (7.093 cm) and average root yield per plant (0.381 kg) while, lowest for traits days to 50% emergence, fruit length, petiole length values and fruit diameter. Highest cluster mean values for traits leaf length (13.724 cm), vine

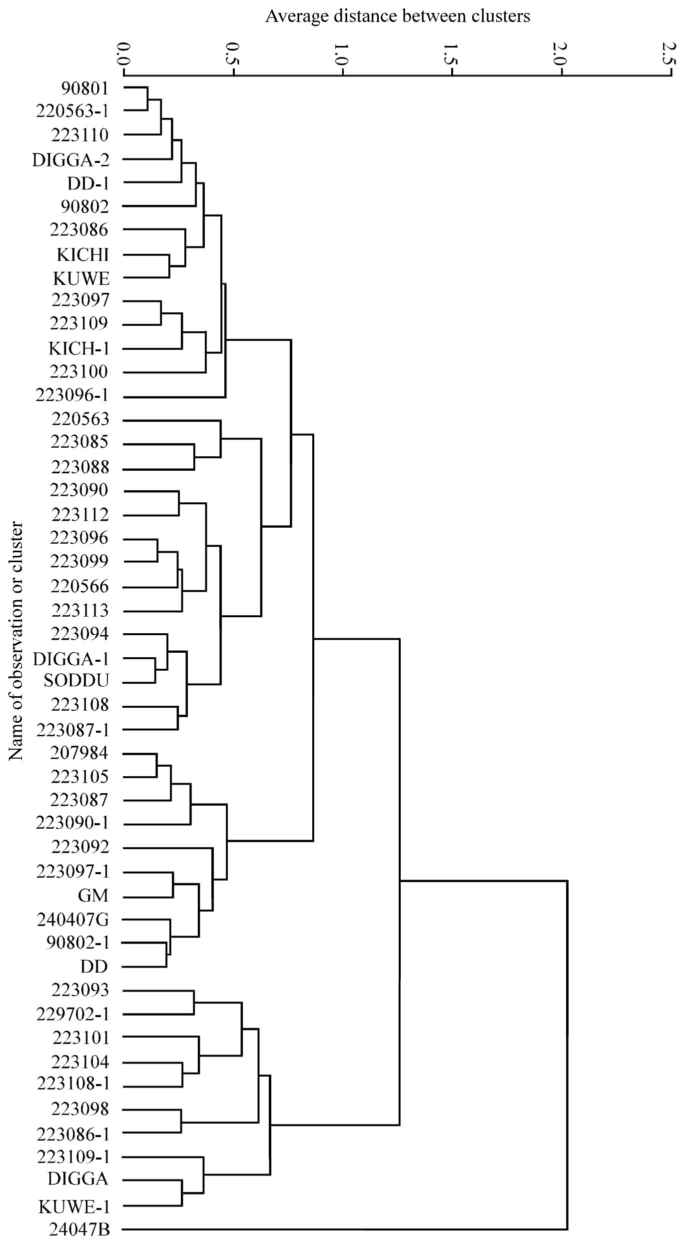

Fig. 1: Dendrogram of 49 anchote accessions into 5 clusters based on 17 quantitative characters

No. (3.3), fruit length (2.598 cm), No. of fruits per plant (6), average fruit weight (47.557 g), 100 seed weight (3.195 g), fruit diameter and average fruit yield per plant (0.289 g) but lowest for vine length, root length and average root yield per plant were the properties of anchote accessions in cluster III. Cluster IV distinguished by highest mean value for internodes diameter (0.455 cm) but lowest in number of seeds per fruits. Finally, Cluster V was differentiated by highest cluster mean value for days to 50% emergence (14), petiole length (15.962 cm), vine length (332.49 cm) and root length (10.20 cm) while, lowest for number of fruits

Table 2: Mean value of 17 characters for the 5 clusters of 49 anchote accessions tested at BARC (2011/12)

	Cluster				
Characters	1	2	3	4	5
Days to 50% emergence	11.533	11.000*	11.600	11.385	14.000**
Petiole length	12.186*	11.725	12.655	12.543	15.962**
Leaf length	12.097*	12.082	13.724**	12.658	13.316
Internodes length	11.338*	12.225**	11.525	11.861	11.905
Internodes diameter	0.418*	0.420	0.426	0.455**	0.443
Vine length	239.671	267.820	180.161*	219.124	332.490**
Vine No.	2.600*	3.000	3.300**	3.115	3.000
Fruit	2.535	2.386*	2.598**	2.400	2.453
Fruit diameter	2.030**	1.928*	2.076	1.958	2.021
No. of fruit $plant^{-1}$	5.616	5.570	6.003**	5.923	4.029*
Average fruit weight	42.026	43.293	47.557**	41.567	31.820*
No. of seeds per fruit	62.350**	41.641	47.166	34.256*	36.369
Hundred seed weight	2.753	2.585	3.195**	3.008	2.450*
Average fruit yield $plant^{-1}$	0.232	0.247	0.289**	0.239	0.125*
Root length	9.630*	9.970	9.336	9.927	10.200**
Root diameter	5.997*	7.093**	6.276	6.537	6.540
Average root yield $plant^{-1}$	0.305	0.381**	0.283*	0.337	0.375

***Lowest and highest cluster mean values, respectively

Table 3: Average inter cluster divergence (D^2) value in 49 anchote accessions tested at BARC (2011/12)

Cluster	II	III	IV	V
I	23.748	32.413*	17.859	177.568**
II	-	14.224	49.323**	108.507**
III		-	82.988**	69.664**
IV			-	273.986**

*Significant at 0.05 (X^2) = 27.59, **Significant at $p<0.01$ (X^2) = 33.41

per plant, average fruit weight, 100 seed weight and average fruit yield per plant. The present study was in agreement with finding of Prasad *et al.* (1993) in cucumber.

Mahalanobis distance (D^2) of the 5 clusters of 49 anchote accessions based on 17 quantitative traits is presented in Table 3. Highly significant ($p<0.01$) inter cluster distance was observed between all clusters (I, II, III, IV) and clusters V while significant ($p<0.05$) inter cluster distance between cluster I and III. The smallest and non significant inter cluster distance (14.224) was noted between clusters II and III while, large and highly significant inter cluster distance (273.968) was noted between cluster IV and V indicating anchote germplasm accessions among clusters are moderately divergent. Similarly, the highly significant inter cluster distances indicated high opportunity for obtaining transgressive sergeants.

Souza and Sorrels (1991) pointed out that categorizing germplasm accessions into morphologically similar, more particularly genetically similar groups is useful for selecting parents for crossing. Falconer (1981) reported that genetic diversity has probably arisen through diversity in origin (geographical separation), ancestral relationship, gene frequency and morphology. These workers indicated that plants differing in either 1 or more of these factors would differ by significant number of genes. Singh and Chaudhary (1985) also reported divergence analysis is performed to identify the diverse genotypes for hybridization purpose so that genotypes grouped

Table 4: Eigen values, total variance, cumulative variance and eigen vectors for 17 characters in 49 anchote accessions tested at BARC (2011/12)

	Principal components		
Characters	1	2	3
Days to 50% seedling emergence	0.544	0.578	-0.320
Petiole length	0.727	0.599	0.067
Leaf length	0.613	0.578	0.385
Internodes length	-0.546	-0.570	0.567
Internodes diameter	-0.752	0.203	0.068
Vine length	-0.728	-0.661	-0.135
Vine No.	0.547	0.357	0.755
Fruit	0.804	0.586	-0.080
Fruit diameter	0.752	0.653	0.001
No. of fruit plant^{-1}	0.710	0.640	0.005
Fruit weight	0.774	0.398	0.456
No. of seeds fruit^{-1}	0.482	0.199	-0.797
Hundred seed weight	0.730	0.611	0.217
Fruit yield plant^{-1}	0.805	0.404	0.403
Root length	-0.834	-0.535	0.044
Root diameter	-0.405	-0.656	0.582
Root yield plant^{-1}	-0.662	-0.708	0.188
Eigen value	9.571	4.845	1.462
Total variance (%)	56.300	28.500	8.600
Cumulative variance (%)	56.300	84.800	93.500

together are less divergent than genotypes which fall into different clusters, particularly clusters separated by the largest statistical distance (i.e., between cluster IV and IV followed by cluster I and V) show the maximum divergence.

Eigen values, percent of total variance, percent of cumulative variance and eigen vectors for 17 quantitative characters in 49 anchote accessions results are given in Table 4. The first 3 principal components having eigen values between 1.00 and 9.571 were extracted from the mean of 17 normalized quantitative traits of 49 anchote accessions. A variance of 56.30, 28.50 and 8.60% were extracted from the first to the third components, respectively and 93.50% of the total variance was explained by these 3 components and a total of 99.63% variation was extracted from the first 6 principal components. The cumulative variance of 93.50% by the first three axes with eigen values of >1.0 indicates that the identified traits within these axis exhibited great influence on the phenotype of the landraces and could effectively be used for selection among them.

The characters contributing more to the divergence are given greater emphasis for deciding on the cluster for the purpose of further selection and the choice of patterns for hybridization (Jagadev *et al.*, 1991). Similarly, Nwabueze and Anoruoh (2009) reported cumulative variance of 90.90% for the first 3 axes in Cassava genotypes. Nwabueze and Anoruoh (2009) observed three principal components explained about 81.30% of the total variation in the functional properties of the cassava flours. Afuape *et al.* (2011) as well reported a cumulative variance of 70.09% for the first three axes (56% variation for principal component 1) in the evaluation of 9 sweet potato genotypes and had found total root number, weight of total roots, weight of biomass and biomass dry matter as the important traits that distinguished the elite materials they worked with. Yang *et al.* (2008) reported the results of principal component analysis that showed cumulative ratio of contribution with the first 4 components total variation of 85.69%.

The variables with coefficients i.e., elements of eigen vector of large absolute magnitude (close to unity) reflect a strong influence while those of small magnitude (near zero) reflect little influence for a particular variable (DeLacy and Cooper,1990). Characters with higher coefficients (0.6) on the PC axes should be considered more important (Jeffrey, 1980) as cited in Balkaya *et al.* (2010).

Accordingly, the first principal component which accounted for 56.30% of the total variability among anchote accessions were mainly due to the contrasting effects of discriminatory traits like average fruit yield per plant (0.805), fruit length (0.804), average fruit weight (0.774), fruit diameter (0.752), 100 seed weight (0.73), petiole length (0.727), No. of fruit per plant (0.710), leaf length (0.613), average root length (-0.834), internodes length (-0.752), vine length (-0.728) and average root yield per plant (-0.662).

The contrasting effect of quantitative traits such as average root yield per plant (-0.708), vine length (-0.661), root diameter (-0.656), 100 seed weight (0.611), No. of fruits per plant (0.64) and fruit diameter (0.653) contributed chiefly to the variation of principal component 2 (28.50%). Finally, the 8.60% variation for the third principal component were mostly due to variation contributed by contrasting effects of traits like number of seeds per fruit (-0.797) and vine number (0.755).

In line with this finding Mathew *et al.* (1986) reported that fruit weight per plant was the major contributor towards divergence in *Cucumis melo*. Masud *et al.* (1995) found that fruit weight was one of the important contributors to genetic divergence in sweet gourd. Khan (2006) observed that fruit weight, number of fruits per plant and weight of fruits per plant were the higher contributors to the divergence in pointed gourd.

CONCLUSION

Generally the present study confirmed the existence of wide phenotypic variation in the species in many of the traits assessed. This variation offers ample opportunity for the genetic improvement of the crop through breeding.

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