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Genetic Diversity Studies among some Genotypes of Grain Amaranths (*Amaranthus spp*) in Mubi, Adamawa State.

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ABSTRACT

Field experiment was conducted during 2014 cropping season at the Department of Crop Science Research Farm, Adamawa State University, Mubi to study "Genetic diversity among 17 accessions of grain amaranths". Twelve of these genotypes obtained from Tanzania and five from Nigeria (Adamawa State) were evaluated in a Randomized Complete Block Design replicated three times to study agronomic (quantitative) and morphological (qualitative) characters. From the results obtained, it was evident that there was highly significant differences ($P \leq 0.01$) in almost all the agronomic characters studied; indicating presence of genetic variability among the accessions of amaranths. At 10% similarity coefficient, the dendrogram gave a clear separation of the 17 genotypes into three clusters; with accession 15 sourced from Uba area (Nigeria) clustering (Cluster 1) with the Tanzania collections and accession 10 which was among Tanzania collection clustering with Uba collection (Cluster 3). High yielding accessions 10, 14 and 16 from cluster 3, can be exploited in hybridization programme for improvement of amaranths.

Keywords: Diversity, Principal component analysis, Dendrogram,and *Amaranthus*

Introduction

The crop Amaranth (*Amaranthus spp L.*) belongs to the family *Amaranthaceae* originating from Western, Central and South America and the major centers of distribution are Tropical America, India, Africa and Australia (Randle, 1959). Grain *Amaranthus* is an erect annual with a short life cycle of two to three months; wide spreading in hot, semi-arid and equatorial climates. Its cultivation and consumption is becoming increasingly popular and more than 60 varieties are cultivated in Asia, Australia, Indian, North and South America, Europe and Africa (Spetter and Thompson, 2007). The yield per hectare of this crop in Nigeria is low (7.60t ha^{-1}) when compared to that of United State of America (77.27t ha^{-1}) and world average yield (14.27t ha^{-1}) (FAOSTAT, 2007). The largest production area of Amaranths was Mexico (around the year 1400), later production of amaranth was forgotten (Putnam, 1990); but recently it cultivation and breeding has been rediscovered (Vilkonis, 2001). The grain is rich in trace elements (zinc, selenium and copper). Zinc is important for memory, wound healing and serve as immunity booster for people with AIDS (Timothy and Dawn, 2012).

Weston *et al.,* (2014), characterized 39 accessions of *Amaranthus* using agro-morphological traits. A dendrogram gave a clear separation amongst the accessions into three main groups based on plant height, yield and growth habit. The highest yielding accessions were *A. hypochondriacus* and *A. tricolor* for amaranth seed and leafy vegetable respectively, showing high diversity among *Amaranthus spp.* Multivariate techniques have been successfully used to classify and measure genetic diversity in many crops such as black gram (Ghafoor and Ahmed 2003), pea (Amurrio *et al* 1995), and amaranths (Varalakshmi 2004). Studies on vegetable amaranths showed presence of wide range of diversity in leaf and stem traits (Xiao *et al.,* 2000 and Wu *et al*., 2000*).* A total of 16 accessions of *A. hybridus* from NIHORT, evaluated by Oboh, (2007) for multivariate analysis showed a wide range of diversity in most of quantitative traits studied. Classification of accessions revealed 4 distinct groups; which could serve as breeding lines for genetic improvement of *A. hybridus.*

Diversity studies will provide information on distinctness, similarities, duplicates and overlap based on agronomic characters which correspond strictly to their genetic status. The objectives of this study are to determine the genetic diversity among 17 accessions of amaranths based on agro-morphological characters; and to quantify the magnitude of variation for agronomic traits.

Materials and Methods

The experimental was conducted during 2014 cropping season at the Research Farm of the Department of Crop Science, Adamawa State University, Mubi. The experimental site was incorporated with poultry manure (15t/ha) and left for two weeks for proper decomposition. The total land area for this trial measured 42m x 8m (i.e. 336m^2) and each plot was 4m^2 with 0.5m alley. For this study, twelve accessions were obtained from Tanzania and five from Hong and Gombi Local Government Area, Adamawa State (Table 1). The treatments (17 accessions) were laid out in a Randomized Complete Block Design replicated three times. Weeding was carried out at 2 and 4 weeks after sowing (WAS) to minimize weed competition with the plants. The plants fertilized at 4 WAS with urea (30kgN/ha) and karate sprayed weekly to control insect pests.

Data Collection

(a) **Agronomic data:** Agronomic data collected are: Plant height, number of leaves/plant, days to first flowering, days to 50% flowering, stem diameter, branches/plant, leaf width, leaf length, Inflorescence length, 500-seed weight, and grain yield.

(b) **Morphological data:** The following morphological data were collected: Growth habit, branching index, leaf shape, stem pubescence, spines in leaves axils, leaf pubescence, leaf pigmentation pattern, leaf margin, terminal inflorescence attitude, terminal inflorescence shape, inflorescence density, inflorescence color, petiole pigmentation, seed color, seed shape, stem pigmentation and prominence of leaf veins. Data collected was subjected to analysis of variance using SAS, (1998) and means were separated using Duncan Multiple Range Test.

Table 1: List of Accessions used in the study and their place of collection

S/No	Accession Name	Place of Collection
1	Accession 1	Tanzania
2	Accession 2	Tanzania
3	Accession 3	Tanzania
4	Accession 4	Tanzania
5	Accession 5	Tanzania
6	Accession 6	Tanzania
7	Accession 7	Tanzania
8	Accession 8	Tanzania
9	Accession 9	Tanzania
10	Accession 10	Tanzania
11	Accession 11	Tanzania
12	Accession 12	Tanzania
13	Accession 13	Garkida, Adamawa
14	Accession 14	Garkida, Adamawa
15	Accession 15	Uba, Adamawa
16	Accession 16	Uba, Adamawa
17	Accession 17	Uba, Adamawa

Results and Discussion

Mean square values and mean performance of eleven agronomic characters of *Amaranthus* during 2014 cropping season are presented in Tables 2 and 3. Highly significant ($P < 0.01$) effects was recorded for plant height, days to 50% flowering, branches/plant, leaf length, inflorescence length and grain yield and a significant ($P < 0.05$) effects was observed for days to first flowering, number of leaves/plant, stem diameter, leaf width and 500 seed weight. These observations confirm the presence of variability among the accessions of amaranths as earlier reported Sravanthi *et al.,* (2012) in grain *Amaranthus*.

Table 2: Mean square values for agronomic traits of *Amaranthus* genotypes evaluated, 2014 cropping season

Source of Variation	DF	DFF	D50F	PLH	NOL	STD	BPP	LWH	LLH	IFL	500SWT	GYD
Accession	16	184.71*	213.48**	1101.09**	659.31*	0.10*	20.58**	5.24*	14.54**	597.33**	0.08*	7618.53**
Replication	2	2.53^{ns}	2.37^{ns}	606.69^{ns}	247.39^{ns}	0.04^{ns}	1.16^{ns}	0.66^{ns}	1.83^{ns}	0.77^{ns}	0.04^{ns}	803.94^{ns}
Error	32	1.72	3.04	197.89	925.64	0.05	3.09	0.95	1.93	1.21	0.04	3410.08
Coef. of Variation		4.34	4.35	8.66	36.69	13.71	16.94	10.27	7.64	1.99	4.08	41.95
Mean		30.18	40.08	162.53	82.31	1.69	10.38	9.51	18.15	55.17	4.71	139.21

, * = significant at P < 0.05; P < 0.01 at level of probability, ns = Not significant, DFF =days to first flowering**,** D50F = days to 50% flowering, PLH = plant height (cm), NOL = number of leaves per plant, STD = stem diameter (cm), BPP = branches per plant, LWH = Leaf width (cm), LLH= leaf length (cm)**,** IFL **=** inflorescence length (cm), 500 SWT = 500 seed weight (g), GYD = grain yield (kg/ha).

Table 3: Mean separation for agronomic characters evaluated among 17 accessions of Amaranths in Mubi during 2014 cropping season

Accession	DFF	D50F	PLH(cm)	NOL	STD(cm)	BPP	LWH(cm)	LLH(cm)	IFL(cm)	500SWT(g)	GYD(kg/ha)
Acc 9	26f	28f	200.17a	94.67a	1.86a-d	11.73b-d	7.73f	17.13eh	44.90h	4.66a-c	503.67c
Acc 15	35d	44c	183.37ab	73.57a	1.90ab	8.90de	10.33b-d	19.90a-d	49.10g	4.67a-c	695.15a-e
Acc 8	37b-d	48b	177.17a-c	88.57a	1.87a-c	15.73e	10.40b-d	20.73a-c	40.67i	4.82a-c	724.18a-e
Acc 11	32e	36d	176.90a-c	75.40a	1.60a-d	13.60a-c	8.53d-f	17.83d-g	57.80f	4.65a-c	634.68a-e
Acc 1	21g	35d	176.13a-c	69.23a	1.82a-c	10.43c-e	9.67b-e	15.47hg	85.67a	4.99a	521.67c-e
Acc 3	27f	52a	174.87a-c	67.23a	1.71a-c	12.73a-c	8.87ef	16.20f-h	65.80d	4.70a-c	398.39de
Acc 12	36cd	53a	170.9b-d	81.20a	1.67a-d	14.53ab	10.87a-c	20.33a-d	46.17h	4.81a-c	266.40e
Acc 6	45a	53a	170.53b-d	104.87a	1.93ab	7.77e	10.37b-d	18.10d-g	26.33j	4.74a-c	486.82de
Acc 16	37b-d	45c	167.37b-e	64.40a	1.98a	9.30de	11.03ab	21.33ab	46.37h	4.49c	1100.76ab
Acc 13	39bc	45c	159.63b-f	107.80a	1.65a-d	12.73a-c	9.00c-f	18.73c-f	56.87f	4.73a-c	894.40a-d
Acc 10	23g	28f	155.73c-f	103.37a	1.32d	8.90de	9.03c-f	15.77gh	56.90f	4.61a-c	1161.25a
Acc 7	27f	35d	153.87c-f	91.40a	1.44cd	8.67de	8.63d-f	17.27e-h	69.03c	4.44c	578.72b-e
Acc 2	22g	31ef	146.33d-g	64.23a	1.69a-d	9.00de	8.73ef	17.07e-h	75.67b	4.88ab	650.0a-e
Acc 14	39b	43c	144.30d-g	77.47a	1.87a-c	8.49de	12.50a	22.40a	50.50g	4.49c	1072.75a-c
Acc 5	22g	34de	141e-g	100.13a	1.50b-d	9.20de	7.50f	14.67h	56.67f	4.88ab	685.77a-e
Acc 4	23g	34de	139.23fg	70.37a	1.52b-d	7.77e	8.20ef	16.73e-h	63.67e	4.96a	575.85b-e
Acc 17	22g	35d	125.40g	76.63a	1.57a-d	7.03e	10.20b-d	18.93b-e	45.97h	4.52bc	882.50a-d

DFF =days to first flowering**,** D50F = days to 50% flowering, PLH = plant height, NOL = number of leaves per plant, STD = stem diameter, BPP = branches per plant, LWH = Leaf width, LLH = leaf length**,** IFL **=** inflorescence length, 500 SWT = 500 seed weight, GYD = grain yield.

Integrated diversity for morphological and agronomic characters using Principal Component Analysis (PCA) and dendrogram among 26 characters gave 8 principal component axes that recorded eigen values greater than 1 (Table 4). These 8 PCAs accounted for 86% of total variation On the first PCA axis most of the characters contributed low positive coefficients (Table 5), with exception of seven characters that had negative coefficients. The 2nd PC axis recorded high eigen value (3.93) and accounted for 15% of total variation but alongside with the first axis explained 41% of the total variation. On this axis stem diameter, days to 50% flowering, inflorescence color and branches/plant recorded high positive loading. Characters of great significance in the 3rd quadrant are: Leaf width, inflorescence density index and seed shape. In addition, 10% of the variation unexplained in PC axes 1, 2 and 3 was recorded in the 4th PC axis explaining 62% of the total variation. In multivariate analysis by Shukla *et al.* (2010) using 39 strains of amaranths, the first four PCs similarly contributed 67.55% of variability. The 5th PC axis accounted for 8% of total variation; but alongside with the other four PC axes explained 70% of the total variation; while the first six PC axes accounted for 77% of total variation.

Table 4: Eigenvalues, proportion and cumulative % for 26 PC axes based on agronomic and morphological traits among 17 accessions of *Amaranthus*.

Principal component axis	Eigen value	Proportion	Cumulative (%)
1.	6.58	0.26	0.26
2.	3.93	0.15	0.41
3.	3.07	0.11	0.52
4.	2.50	0.10	0.62
5.	2.03	0.08	0.70
6.	1.77	0.07	0.77
7.	1.40	0.05	0.82
8.	1.11	0.04	0.86
9.	0.97	0.04	0.90
10.	0.80	0.03	0.93
11.	0.59	0.02	0.95
12.	0.50	0.02	0.97
13.	0.28	0.01	0.98
14.	0.22	0.01	0.99
15.	0.18	0.01	1.00
16.	0.09	0.00	1.00
17.	0.00	0.00	1.00
18.	0.00	0.00	1.00
19.	0.00	0.00	1.00
20.	0.00	0.00	1.00
21.	0.00	0.00	1.00
22.	0.00	0.00	1.00
23.	0.00	0.00	1.00
24.	0.00	0.00	1.00
25.	0.00	0.00	1.00
26.	0.00	0.00	1.00

Table 5: Eigen vectors for first 6 principal component axes estimated for 26 morphological and agronomic characters among 17 accessions of *Amaranthus*

Descriptor	PRIN 1	PRIN 2	PRIN 3	PRIN 4	PRIN 5	PRIN 6
GH	0.31	-0.66	0.04	0.21	-0.83	0.27
BI	0.23	0.15	-0.30	-0.06	0.16	0.08
LS	0.23	-0.22	0.20	0.03	-0.30	-0.25
LPUB	0.13	0.15	0.17	0.23	-0.32	0.22
LPP	0.32	0.13	0.04	0.09	0.07	0.04
LM	0.15	0.06	0.26	0.03	0.06	-0.38
TIA	0.29	0.02	0.17	0.17	17	0.21
TIS	0.20	0.12	0.00	0.03	0.16	0.20
IDI	0.16	0.03	0.38	0.21	0.03	-0.12
IC	-0.16	0.32	0.17	-0.13	0.09	-0.17
PP	-0.07	0.13	0.02	0.37	0.15	-0.32
SC	-0.06	0.26	-0.33	-0.01	-0.12	0.22
SS	-0.14	0.10	0.37	0.06	0.30	0.31
SPG	-0.20	0.27	0.23	-0.23	-0.02	-0.20
PLV	0.20	-0.14	-0.32	-0.20	0.20	-0.08
PLH	0.15	0.04	0.03	-0.11	0.57	-0.15
NOL	0.15	0.05	0.06	-0.25	0.07	0.52
DFF	0.31	0.23	0.05	0.09	0.04	0.16
D50F	0.23	0.34	-0.11	-0.08	-0.08	0.06
STD	0.01	0.41	-0.05	0.13	0.13	0.12
BPP	0.00	0.31	-0.28	0.13	0.33	-0.04
LWH	0.06	0.15	0.70	0.44	0.01	-0.03
LLH	0.17	0.04	-0.03	0.43	0.20	0.16
IFL	-0.30	-0.10	-0.15	0.24	0.05	0.02
500 SWT	-0.12	0.27	0.13	-0.24	-0.18	-0.02
GYD	0.20	-0.27	0.13	0.12	0.15	-0.08

GH = growth habit, BI = branching index, LS = leaf shape, LPUB = leaf pubescence, LPP = Leaf pigmentation, LM = Leaf margin, TIA = Terminal inflorescence attitude, TIS = Terminal inflorescence shape, IDI = Inflorescence density index, IC = Inflorescence color, PP = Petiole pigmentation, SC = Seed color, SS = Seed shape, SPG = Stem pigmentation, PLV = Prominence of leaf vein, PLH = Plant height, NOL = Number of leaf, DFF = Days to first flowering, D50F = Days to 50% flowering, STD= Stem diameter, BPP = Branches per plant, LWH = Leaf width, LLH = Leaf length, IFL = Inflorescence length, 500 SWT = 500 seed weight, GYD = grain yield.

From the results of PCA 1 by PCA 2 (Figure 1), based on agro-morphological traits, accessions within each cluster seem to be more closely related to each other than accessions in other clusters. The relatedness of accessions in quadrant 1 was due to high discriminatory character of stem diameter, leaf width, leaf length, number of leaves and branches/plant. At 10% similarity coefficient, the dendrogram (Figure 2) gave a clear separation among the accessions into 3 clusters. This result corroborates with the findings of Shukla *et al.*, (2010) in amaranths.

Furthermore, Joshi *et al.,* (2011) characterization study using 31 accessions of amaranths, showed a wide range of variability in 8 quantitative traits. Wu *et al.,* (2000) studied 229 genotypes of *Amaranthus* observed wide diversity in agronomic traits. Similar results were also reported by Xiao *et al.,* (2000) and Varalakshmi, (2004) in amaranths.

The dendrogram constructed showed that accession 15 obtained from Nigeria (Uba area), clustered with accessions from Tanzania. Likewise accession 10 which obtained from Tanzania clustered with accessions from Nigeria. Comparative performance of the 17 accessions of *Amaranthus* provided a clear indication of the superiority of accession 14 found in cluster 3; which had medium flowering trait, higher leaf width, leaf length and grain yield. Accessions 10 and 16 in this same cluster 3 were also the highest grain yielders (Table 3).

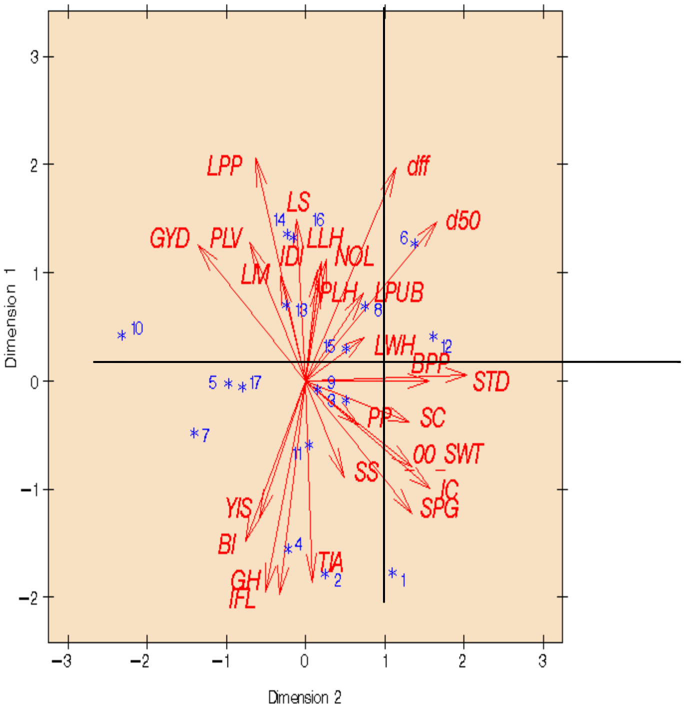

Figure 1: PCA plot of 17 Amaranths accessions based on agro-morphological characters.

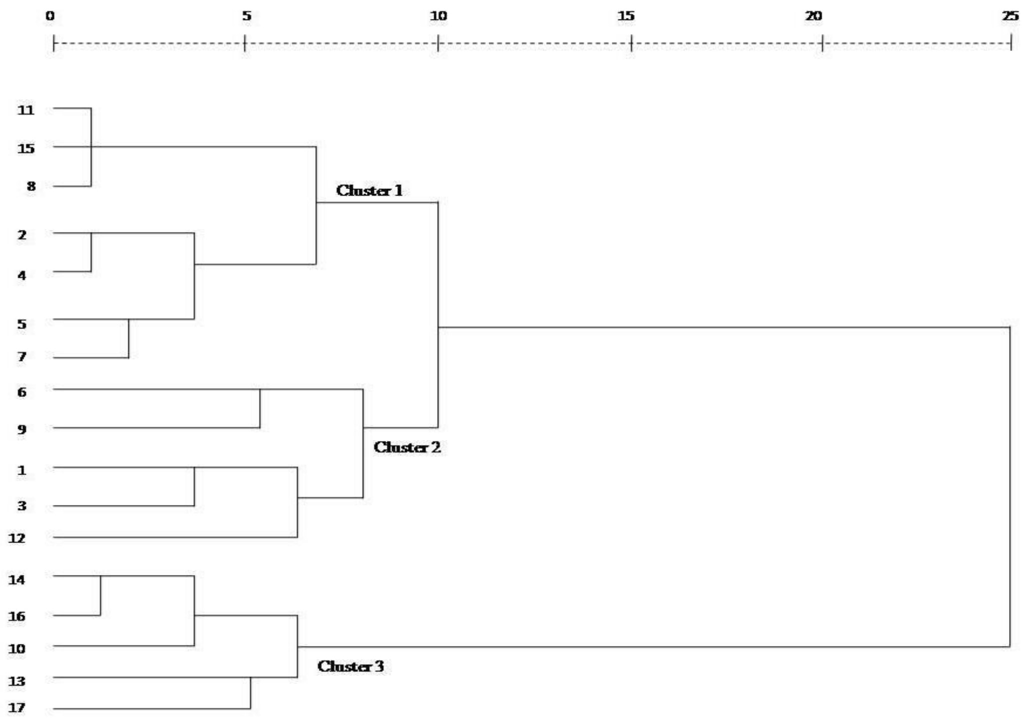

Figure 2: Dendogram of 17 accessions of *Amaranthus* following Ward`s method.

Conclusion

The dendrogram gave a clear separation of the accessions into 3 clusters at 10% similarity coefficient; with accession 15 sourced from Uba area clustering with the Tanzanian collection (Cluster 1), while accession 10 obtained from Tanzania collection clustering with the Nigeria collection (cluster 3). Accessions 10, 14 and 16 from cluster 3, which are high grain yielders, can be exploited for amaranths improvement.

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