

Seed Characterization of Grain Amaranthus Using Morphological and Physiological Traits

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ABSTRACT

Amaranth is one of the most cultivated native leafy vegetable in Africa high leaves production within a short period. A factorial experiment was laid out using randomized complete block (RCBD) with the aim of comparing the seed characteristics of some selected amaranths based on morphological and physiological traits. Four varieties of grain Amaranth consisting of Num-Amaranth, White Amaranth, Red Amaranth, and Celosia as well as harvest before and after flowering in three replicates at the Teaching and Research Farm of Osun State University, Ejigbo Campus. Measurements were taken on growth components (leaf area index, leaf width, the number of branches per plant, numbers of leaves per plant, plant height (cm), and stem girth (cm). All data were analyzed using analysis of variance (ANOVA) and significant means separated by the least significant difference at five percent probability level (LSD0.05). The result showed high viability among the amaranth varieties for leaf area index, leaf width (m²), the number of branches per plant, number of leaves per plant, plant height (cm) and stem girth (cm). Highest values for characters for leafy vegetable were recorded for Num-Amaranth while lowest was found in Celosia. The number of branches per plant had high significant positive correlation with plant height. Principal component analysis (PCAs) accounted for 81% of the total variation were used for clustering the genotypes. Therefore, to ascertain within the same cluster while inter-crossing could be done between different clusters to achieve maximum yield. In this study, the maximum exploitation of grain amaranth potentials, Num-Amaranth and Red Amaranth can be included in future breeding programme for high yield of amaranth.

Keywords: Grain amaranth, principal components analysis, physiological, morphological, leaf area

Introduction

Grain amaranth (*Amaranthus cruentus* L.), is a leafy vegetable that is globally grown for its grains and leaves for human and animal consumption. (NRC, 2006; O'Brien and Price, 2008). Grain amaranth planting density varies depending on the prevailing environmental factors, farming systems and variety to be grown. In the

cultivation of grain amaranth, the recommended planting density varies considerably worldwide, depending on a number of factors such as the environment, the production system and the variety involved (O'Brien and Price, 2008). The growth of grain amaranth is rapid with high yield, and stress resistant. The crop is nutritious and high in fibre

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content. The crop has a great potential in alleviating poverty and malnutrition. As indicated by Tung (2010), immature amaranth green leaves are used in the preparation of soup in many parts of West Africa. Its mild flavour and tender texture complement many starchy dishes.

The leaves of crop are high in vitamins and essential minerals for proper function and maintenance of body system (Abolaji *et al.*, 2007). It is cheap source of protein and carbohydrate. It is rich in the amino acids methionine, cycteine and has the highest content of lysine compared with all grains. It also has three times the fibre of wheat (Abolaji *et al.*, 2007). Despite the nutritional attributes of grain amaranth, it remains underexploited crop for grain purposes. However, research towards the crop improvement has not received enough attention among researchers (Akin-Idowu *et al.*, 2017). Some grain amaranth varieties have been introduced and acclimatized well in the region, although agronomic evaluation and nutritional composition in different agro-ecological zones has not been carried out. The availability of genetic variation among and within the different accessions for these traits provides great scope for crop improvement through selection and other breeding methods to develop desired genotypes.

Low crop productivity is a general problem facing most farming systems in sub-Saharan Africa (SSA). Low leaf yields of less than 1.2 tons per hectare are normally realized against the potential of 32-40 tons per hectare in amaranth. Grain yield are very highly variable. Good grain yields, in relative terms would be considered to be 1000 kg/ha but reach 6000kg/ha under conventional agricultural practices have been reported. However, information on accessions or lines with both potential of morphological and physiological traits (dual purpose) has not been well documented. Therefore, the objective of the research is to compare the seed characteristics of some selected

amaranths based on morphological and physiological traits.

Materials and Methods

Description of experimental site

The experiment was carried out at the Osun State University Teaching and Research Farm, Ejigbo campus (Latitude 7° 52'28.37'N and Longitude 4° 18'13.76' E). The climatic condition of the area is typically a rain forest type, consisting of two peaks (Bimodal Rainfall) which is between 926.33-1995.17mm per annum (Musa *et al.*, 2016).

Experimental Materials

Four Amaranths seeds accessions were obtained from the Ejigbo Local Market. The seeds procured from agro-dealer were sown on a field during the early season in 2020. Field experiment was conducted at the Teaching and Research of Osun State University, Ejigbo Campus. Composite soil samples were collected randomly from the trial site at the depth of 0-15cm with soil auger prior to planting. The samples were analysed in the Soil, Water and Material Testing Agronomy Laboratory of Osun State University, College of Agriculture, Ejigbo Campus, for physico-chemical analysis (Table 1). Collected samples were air-dried and passed through 2 mm sieve. The sieved samples were analyzed for chemical properties. Soil pH was determined with a glass electrode pH meter in distilled water using 1:1 soil: water as described by Thomas (1996). Total nitrogen was determined by the macro-Kjeldahl method (Bremner, 1996); Exchangeable cations (Ca^{2+} , Mg^{2+} , K^{+} and Na^{+}) were extracted with neutral 1.0 M NH_4OAc solution of. The K^{+} , Ca^{2+} and Na^{+} concentrations in the extract were determined using the flame photometer while Mg^{2+} was determined using the atomic absorption spectrophotometer (AAS). For the determination of soil organic carbon, the Walkley-Black wet oxidation method (Nelson and Sommers, 1982) was adopted, Available P by the Bray-1 method as described by Kuo (1996). For soil physical properties, particle size analysis was

determined by hydrometer method according to Okalebo *et al.*, (2002). Soils of the sites for the two locations are sandy clay loam, low in nitrogen and other micro elements (Table 1).

Table 1: Physical and chemical properties of experimental soil.

Properties	Value
Sand %	70.00
Clay %	5.72
Silt %	22.00
Textural class	Sandy clay loam
pH (H ₂ O)	5.80
Organic matter %	1.90
Nitrogen %	0.08
Phosphorus (mg/kg)	8.60
Ca ²⁺ (cmol/kg)	1.61

Experimental design and Field Arrangement

The experimental site was cleared with the use of cutlasses and prepared with hoes, mapped out, and divided into three blocks of 3 m by 4.2 m each. Three seeds of each variety were sown per hole using a spacing of 0.5 by 0.75 between and thinned to one plant stand at two weeks after emergence, irrigation was applied. Randomized complete block design (RCBD) was used; Poultry manure was applied to each plot in the block.

Data Collection

Four (4) most competitive Amaranths plants were selected and tagged in each row for collection of morphological and agronomic traits. Plants at the edges of the plots was excluded to avoid data collection error. Data collected included the followings:

Number of branches: Number of branches per plant for twelve (16) plants selected randomly in the plot was counted.

Leaf length and width (cm): Leaf length and width was measured in centimeter using ruler during vegetative growth on leaf.

Number of leaves (NL): Number of leaves was counted every seven (7) days.

Leaf area index (LAI): was calculated using the following formular:

$$\begin{aligned} & \text{(Flag leaf Inde} \\ & = \text{flag leaf length} \times \text{flag leaf breadth} \times 0.75) \end{aligned}$$

Plant height (PH): was measured from the soil surface to the top of the plant at seven (7) days interval using tape measure.

Stem Girth (SG mm): was measured as diameter of root using vernier calliper.

Results

Variation in Morphological Characteristics

The growth performance of the four grain amaranth varieties is displayed in Table 2. Leaf area index was the highest with Num-amaranth (16.28) followed by White Amaranth (14.32). The lowest value for leaf area index was obtained Celosia (7.69). For leaf width, Celosia had 3.07 leaf width and was significantly different from other varieties. In addition, Red amaranth and Celosia had the same highest number of branches (12.44) while Num-Amaranth and White amaranth had significantly the lowest number of branches which were 11.67 and 7.89 respectively. Num-Amaranth and Red amaranth had highest number of leaf 68.22 and Red Amaranth respectively, while Celosia had the lowest significant value (43.22). Num-Amaranth and Red-Amaranth had highest plant height with 63.56 and 61.67 respectively and the shortest plant was White Amaranth (44.77) and Celosia (38.56) respectively. Lastly, Num-Amaranth had the highest value for stem girth (1.63) which was

significantly different from Celosia (0.83) which showed the lowest value for the same traits.

Correlation analysis

Association among the characters of selected four amaranth varieties grown during rainy season is given in Table 3. According to the results, leaf width showed significant negative association with number of branches (-0.03) but the remaining characters showed no significant correlation with leaf width. Inter-character association revealed number of branches depicted highly significant positive correlation (0.31) with plant height. Furthermore, plant height showed highly significant positive correlation (0.71) with stem girth.

Principal component analysis of the studied characters

The eigenvalues are often used to determine how many factors to retain. The sum of the eigenvalues

is usually equal to the number of variables. In this study, the principal component analysis results presented in Table 3, showed that the variable could be grouped into three component accounting for 90% of the total variation of grain yield. The first PC contributed 63% of the overall variance of the studied characters. The second PC contributed 18% of the overall variance of the studied characters while the third PC contributed 9%.

The leaf area index (0.48), leaf width (0.48) and stem girth (0.48) had positive loading on the PC1. Plant height contributed to PC2 contributed positive values with 0.20 while number of leaf contributed positively (0.83) to PC3 with number of branches contributing negatively to PC3 with (-0.53).

Table 1: Growth and yield performance on characters of grain amaranths varieties

Variety	Leaf area	Leaf width	No of branches	No of leaf	Plant height	Stem girth
Num Amaranth	16.28a	7.80a	11.67ab	68.22a	63.56a	1.63a
White Amaranth	14.3ab	6.90a	7.89b	52.00ab	44.78b	1.26ab
Red Amaranth	13.50b	6.58a	12.44a	60.00a	61.67a	1.50ab
Celosia	7.96c	3.07b	12.444a	43.22b	38.56b	0.83c

Mean with the same letter on a column are significantly different

Table 3: Correlation matrix of the variables used in the PC of four grain amaranth genotypes evaluated during rainy season

	Leaf area	Leaf width	No of branches	No of leaf	Plant height	Stem girth
Leaf Area	1.00	0.92ns	0.14ns	0.67ns	0.63ns	0.85ns
Leaf Weight		1.00	-0.03*	0.53ns	0.59ns	0.79ns
No Branches			1.00	0.23ns	0.31**	0.19ns
No of Leaf				1.00	0.51ns	0.67ns
Plant height					1.00	0.74**
Stem girth						1.00

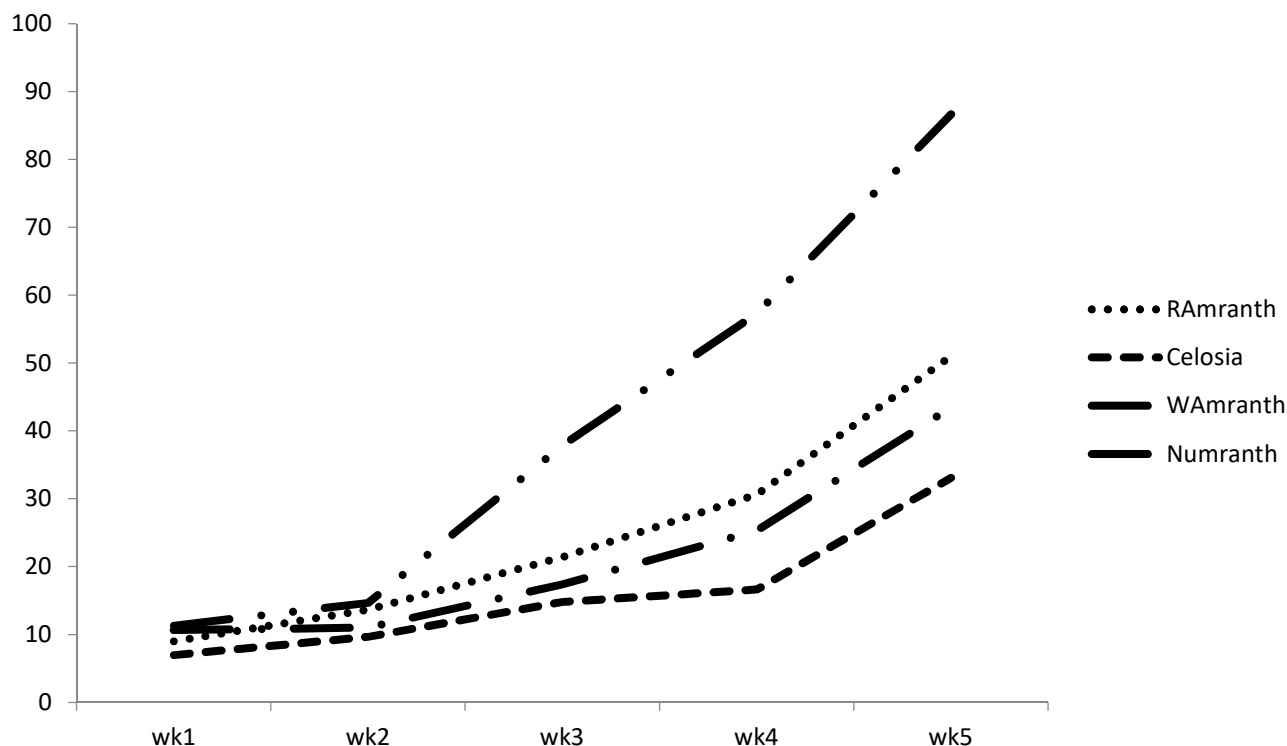


Fig. 1: Change in grain amaranth plant height with growth stage.

Table 4: Eigenvectors and Eigen values of the first three principal components (PC1, PC2 and PC3) axes for four lines evaluated for growth yield during rainy season

Characters	Prin1	Prin2	Prin3
Leaf. Area Index	0.48*	-0.16	0.02
Leaf. Width	0.45*	-0.33	-0.18
Number. Branches	0.13	0.90	-0.53*
Number Leaf.	0.39	0.11	0.83*
Plant. Height.	0.41	0.20*	-0.52
Stem Girth.	0.48*	-0.04	-0.08
Eigen value (ROOT)	3.82	1.08	0.51
Proportion Variation accounted for by PC	0.63	0.18	0.08
Cumulative Variance Expected.	0.63	0.82	0.90

Note: * Shown a high value indicates a high correlation between the traits and PC).

Discussion

The significance in mean sum of squares observed in stem girth for varieties indicated that the four grain amaranth varieties employed in this study were genetically different for this particular trait. Similar observation was reported by Abdoulamir and Amir (2017). Higher value recorded for variety sum of square for almost all the characters suggested that grain amaranth characters of the varieties tested are highly controlled by genetic effect. The non-significant effect of some studied agronomic characters (leaf area index, leaf width, number of branches, number of leaves, plant height) indicated that these characters were not different in the expression of these characters thus cannot be used for varietal selection (Nazir *et al.*, 2010).

The fact that Num-Amaranth depicted the highest value for the highest values for these characters; leaf area index, leaf width, number of leaves, plant height, and stem girth implied that this variety is superior above others for these particular characters. High leaf area index, leaf length and stem girth as well as plant height are characters which support maximum yield of crops when essential agricultural input, and water are available in adequate quantity (Onasanya *et al.*, 2009). Plants with higher number of leaves and broader leaves area tend to photosynthesis than those with small and few leaves (Chapin and Eviner, 2007). Celosia showing the lowest value for leaf area index, leaf width, number of leaves, plant height, and stem girth can be due to abiotic stress effect.

Furthermore, the significant positive correlation of number of plant height with number of branches indicated that selection of accessions with higher plant height would lead to higher number of branches which is essential for the production of leafy vegetable, these similar conclusions were made by Akter *et al.*, (2005) and Munguatosha *et al.*, (2017). The negative correlation of the number of leaf width with

number of branches per plant shown that selection of accessions with leaf size would result to low number of branches. This relation can be linked to the translocation of food to the leaf in account of the branches, which is common under nutrient deficient condition.

Traits with the highest absolute value closer to one within the first principal component have effect on the clustering more than those ones with lower absolute value closer to zero (Chahal and Gosal 2002). The first two PC axis contributed 81% of the multivariate variation among the amaranth genotypes, were the most important thus the characters loaded on the axes were used to group the genotypes into closely related clusters.

Principal component analysis (PCA) reflects the importance of the largest contributor to the total variation at each axis of differentiation (Sharma, 1998). The clustering pattern observed this study indicated the extent of genetic diversity among the varieties by occupying three different clusters. This finding is in agreement with the findings of Singh *et al.* (2005) and Liu *et al.* (2006). Kanthaswamy, (2006), reported that 74 amaranth genotypes of were grouped into 12 clusters, Oboh (2007) observed four clusters for 16 amaranth (*A. hybridus*), Shukla *et al.* (2010) obtained six clusters for 39 amaranth strains and Akhter *et al.* (2013) discriminated 17 amaranth genotypes into four clusters.

Conclusions

High viability was found among the amaranth varieties for leaf area index, leaf width, number of branches, number of leaves, plant height and stem girth. Highest values of leafy vegetable were recorded for Num-Amaranth while lowest was found in Celosia. Number of branches had high significant positive correlation with plant height. However, leaf width had negative significant correlation with number of branches. PCAs accounted for 81% of the total variation were used for clustering the genotypes. To ascertain the

maximum exploitation of grain amaranth potentials. Num -Amaranth and Red Amaranth can be included in future breeding programme for high yield of amaranth. Moreover, intra-crossing should be avoided within the same cluster while inter-crossing can be done between difference cluster to achieve maximum yield.

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