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Evaluation of Yield and Quality Performance of Grain Amaranth Varieties in the Southwestern Nigeria

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Abstract: The production and use of amaranth as leaf vegetable and grain production and consumption, calls for more efforts in selecting varieties with high chemical composition and nutritive values. Four varieties of grain amaranth were evaluated for growth, yield, chemical composition and nutritive values in southern guinea savanna of southwestern Nigeria in 2003 and 2004. The varieties tested were NH_{84}/451, NH_{84}/452, NH_{84}/494 and NH_{84}/493-1. These were assigned randomly into three blocks and fitted into a randomized complete block design. Growth, yield and quality data were collected and subjected to analysis of variance and significant means compared using Duncan Multiple range test. Results revealed that the plant height and number of leaves of grain amaranth varieties increased as the plant aged. There were significant ($p<0.05$) differences among the varieties from one sampling occasion to another in the 2 years. The highest growth, shoot and grain yields parameters were recorded from NH84/493-1 closely followed by NH_{84}/451 while NH_{84}/452 gave the lowest values in both cropping season. In the two growing seasons, there were significant ($p<0.05$) different between the fresh and dry matter yields of different plant parts among the varieties with the stem recorded the highest values. The chemical compositions and the nutritional values in the leaves, stems and roots varied significantly among grain amaranth varieties with the leaves recorded the highest values. The distribution of protein, fat, carbohydrate, fibre and minerals in the plant parts of the grain amaranth were similar irrespective of the varieties. Although, all the four grain amaranth varieties are good sources of quality and mineral elements, the consistent better performance in term of higher yield and nutritive values in both planting seasons of NH_{84}/493-1 variety confirmed its ability to thrive well in the southern guinea savanna zone of Nigeria and its related ecological zones.

Key words: *Amaranthus cruentus*, varieties, growth, yield, quality, carbohydrate

INTRODUCTION

Amaranth species are a group of highly popular vegetables belonging to the family Amaranthaceae with many different species. They are the most commonly grown vegetable of the lowland tropics in Asia and Africa. Some of the most frequently cultivated species are *Amaranthus blitum*; *A. lividus*; *A. dubius*; *A. spinosus*; *A. thunbergii*; *A. graecizans* (vegetables); *A cruentus* and *A. hypochondriacus* (grain) (Schippers, 2000). The most commonly grown amaranth in Africa indigenous vegetable, *A. cruentus* L., is probably of American origin. It is best recognized by its leaves that are twice or three times as long as wide often have pointed leaf tips and by plume like inflorescence with raceme diameter of 10 mm or more (Schippers, 2000).

Although all African species are used for their leaves, they can also be grown for their seeds. *A. cruentus* is a broadleaf pseudocereal with an upright growth habit, cultivated for both its seeds which are used as grain and its leaves which are used as vegetables. Grain amaranths is the most important species cultivated for the production of flour (Breene, 1991). Amaranth seeds are occasionally used in Ethopia to brew the alcoholic beverage 'tala', a kind of beer. Amaranth also has a high nutritional value because of the high levels of essential nutrients like carotene, vitamin C, potassium, Iron and calcium. It is specially rich in protein and lysine, an essential amino acid that is lacking in diets based on cereals is usually processed into animal feed. Amaranth modern prospects also reported that unprocessed amaranthus grains can be used as animal feed, particularly for poultry. South pacific foods (1995) reported 2.6 mg iron and 654 μg vitamin A for 100 g of green leaves of Amaranth.

It could also be a source of vegetable oil because the seed contains 1½-3 times more oil than other grains. With protein levels of between 13-19%, amaranth is

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among the highest protein grains in the world. Spore (1992). But seed is not the only nutritious product from amaranth; the leaves are also rich in proteins, vitamins and minerals. Six of the 50 amaranth or more species are used as vegetables, mainly in the hot, humid regions of Africa (Nigeria and Benin), south east Asia (especially Malaysia and Indonesia), southern China, southern India and the Caribbean. In southeast Asia, its economic value as a popular vegetable crop ranks among the ten highest. It is probably the highest yielding leaf vegetable of the tropics (Spore, 1992).

In view of the relative importance of grain amaranths both to man and livestock, the production of high yielding, good quality and disease and pest resistant grain amaranth varieties is a worthwhile venture. There is thus the need to study the present status of available grain amaranthus in Nigeria with a view to exploring their full potentials. This study therefore, aims at evaluating the grain yield and quality of different plant parts of grain amaranth varieties.

MATERIALS AND METHODS

The experiment was sited at the Ladoke Akintola University of Technology Teaching and Research Farm, Ogbomoso, Nigeria. Ogbomoso lies between Longitude 4°10'E and latitude 8° 10'N with mean annual rainfall of between 1,150 and 1,250 mm of rain (Olaniyi, 2006).

The four varieties of grain amaranths: NH_{84}/451, NH_{84}/452, NH_{84}/494 and NH_{84}/493-1 obtained from National Horticultural Research Institute (NIHORT) Ibadan were grown for two consecutive growing seasons from August to December on beds. The plot of land used was formerly under maize cultivation and left to fallow for almost one cropping season.

The pretreatment soil samples were collected for analysis before the field was manually cleared. The pH was determined by means of the digital electronic pH meter using 1:2 (soil: water) suspension. Ammonium Acetate (NH_4AC) was used to leach 10 g of the soil sample. The calcium content was obtained through titration, the magnesium was determined by atomic absorption spectrophotometer while the potassium and sodium content were determined by flame photometry and total nitrogen by the micro-Kjeldahl method. The particle size analysis was done by hydrometer method.

The layout of the experiment was that of a randomized complete block design. Each block had an area of 19.5 by 4 m. Each block was further sub-divided into four plots each measuring 4 by 2 m with each plot consisting of 21 stands of grain amaranthus. The experiment was replicated 3 times. The 4 varieties were randomly assigned to plots within each replicate and the seeds were planted by direct seeding at a spacing of 1×0.5 m^2. Basal fertilizer treatment consisting of 50 kg. NPK (15-15-15) ha^{-1} was applied three Weeks After Sowing (WAS) to ensure better crop performance. The plants were thinned to one plant per stand just before fertilizer application. Crop protection practices were carried out with spraying of karate at 2, 4 and 6 Weeks After Sowing (WAS) against defoliating pests and weeding was done manually thrice at 3, 6 and 9 WAS.

Data collection on growth and yield of grain amaranth varieties began 3 WAS at 3-weekly intervals from six tagged plants per replicate. Plant height was measured with a meter ruler from the base to the tip of the main shoots. Number of leaves was recorded by counting of leaves. At 9 WAS, when all the vegetative development of grain amaranth has reached their maximum and at flower initiation destructive harvesting of 6 plant per treatments were done to determine the fresh and dry matter yields of the leaf and stem. Fresh weight of stems and leaves were separately measured using an electric weighing balance. The chopped up stems and leaves were dried separately at 65°C for 48 h in an oven and weighed to get the dry matter yield. The fruits were harvested when the heads were fully dried from six sampled plants in each replicate three months after sowing and processed manually to recover the seeds. Seed yield was recorded by weighing the seeds in an electric weighing balance.

After determination of fresh weight leaves, root and grains were dried in an oven at 60°C for 48 h. Dried samples were milled and ground for tissue analysis. Total P was determined by the Vanadomolybdate method, K and Ca were determined by flame photometry and Mg and Fe were determined by atomic absorption spectrophotometer. Total N was analysed by the micro-Kjheldahl procedure and crude protein was obtained by multiplying the total N by a factor of 6.25. Data collected were subjected to analysis of variance and the means were separated by the Duncan Multiple range test.

RESULTS AND DISCUSSION

The result of the soil analysis is shown in Table 1. The pre-cropping soil analysis showed that the soil is sandy loam with organic matter and good moisture retaining properties. Most of its chemical nutrient elements are below the critical values (Adeoye and Agboola, 1985). The pH of 7.5 is within the range of pH considered suitable for vegetables (Tindall, 1983) in which amaranth belong.

The mean plant height and number of leaves of grain amaranth varieties increased as the plant aged (Table 2). There were significant ($p<0.05$) differences among the

Table 1: Chemical and physical properties of the soil of the experimental site

Parameter	Pre-cropping value
PH (H_20)	7.5
Organic matter (%)	2.85
Total N (%)	0.14
Available P (Mg kg^{-1})	10.03
Exchangeable cations (C.mol. kg^{-1})	
Ca^{2+}	5.5
Mg^{2+}	4.2
K+	0.22
Na+	0.32
Exchangeable acidity (C.mol. kg^{-1})	0.4
ECEC	7.00
Base saturation (%)	87.4
Physical characteristics	
Sand (%)	82.8
Silt (%)	7.0
Clay (%)	10.2
Textural class	Standy loam

Table 2: Plant height and number leaves of grain amaranth varieties

	Weeks after sowing					
	Plant height (cm)			No. of leaves		
Variety	4	6	8	4	6	8
2003						
NH_{84}/451	22.4ab	35.3ab	62.0ab	8.9ab	18.6b	28.3ab
NH_{84}/452	18.6b	28.3c	46.4c	6.4b	12.3c	20.7b
NH_{84}/494	19.6b	33.8b	56.8b	8.3b	15.8bc	30.8a
NH_{84}/493-1	25.5a	48.4a	89.9a	10.5a	21.0a	30.8a
2004						
NH_{84}/451	20.1ab	20.1ab	58.5b	8.8ab	18.5ab	27.6b
NH_{84}/452	18.0b	18.0b	44.8c	6.1b	11.9c	20.4c
NH_{84}/494	18.7b	18.7b	55.1b	7.9b	15.5b	22.2c
NH_{84}/493-1	24.8a	24.8a	85.6a	10.3a	20.8a	30.1a

a,b,c,d.... mean separation by duncan multiple range, $p<0.05$, values followed by the same letter are not significant

Table 3: The fresh and dry weight of plants and total seed yield of grain amaranth varieties

	Fresh weight (g)		Dry weight (g)		Total seed
Variety	Stem	Leaves	Stem	Leaves	yield (kg ha^{-1})
2003					
NH_{84}/451	300.5b	150.0b	48.5ab	4.8ab	0.6b
NH_{84}/452	250.8c	125.5c	46.5b	4.0b	0.5b
NH_{84}/494	250.0c	105.7c	39.4b	3.6c	0.4c
NH_{84}/493-1	350.0a	175.5a	55.0a	5.6a	1.5a
2004					
NH_{84}/451	285.6ab	139.7b	47.3ab	4.6ab	0.5b
NH_{84}/452	242.5b	121.6bc	46.0b	3.8b	0.4c
NH_{84}/494	237.0b	100.5c	37.8b	3.5b	0.4c
NH_{84}/493-1	335.6a	167.3a	53.3a	5.2a	1.3a

a,b,c,d.... mean separation by Duncan Multiple Range, $p<0.05$, values followed by the same letter are not significant

varieties from one sampling occasion to another in the two years. The highest plant height and number of leaves were recorded from NH_{84}/493-1 closely followed by NH_{84}/451 while NH_{84}/452 gave the lowest values at all the sampling periods in both cropping seasons. In term of these growth parameters grain amaranth performed better during the 2003 growing season than the 2004.

The fresh and dry weights of different plant parts as well as total seed yield are presented in Table 3. The differences observed between the fresh and dry weight of grain amaranth varieties used is ue to the high water content in the plant tissues. This is true of most vegetables and so they are highly perishable (Olaniyi, 2004). There were significant ($p<0.05$) differences between the varieties for all the yield attributes. However, higher values were recorded for NH_{84}/493-1 while NH_{84}/452 had the least of all the yield parameters measured during the two growing seasons. In both cropping seasons, there were significant different between the fresh and dry matter yields of different plant parts among the varieties with the stem recorded the highest values. This might be due to the sturdy, strong and higher water content in the stem as compared with the leaves. Generally, all the parameters measured performed better in the year 2003 growing season compared to that of the 2004. The yield components also behaved in a similar manner which depicted their strong cumulative effect on grain yield. The varietal differences in growth and yield in both seasons might be attributed to the differences in ecological distribution of the amaranth varieties (Olaniyi, 2006). The variation in yield may also be due to genetic differences among the varieties since they were grown under the same environmental conditions (Olaniyi and Fagbayide, 1999). However, the consistent better performance in term of higher yield values in both planting seasons of NH_{84}/493-1 variety confirmed its ability to thrive well in the southern guinea savanna zone and related ecological zones similar to the experimental site.

Nutritional values of different plant parts of grain amaranth varieties are presented in the Table 4. The quality and mineral elements contents in the leaves, stems and roots varied significantly among grain amaranth varieties except for Ash in grain and CHO and Ca in leaves. The leaves contained the highest levels of protein, Calcium (Ca) and iron (Fe) followed by the grains while the stems recorded the least values. Similarly, the highest concentration of fat and Carbohydrates (CHO) were obtained from the leaves while the least values were recorded from the grains. The highest levels of moisture content and Ash were from the stem and the lowest from the grain. The grain was found to contain stem recorded the least values.

The distribution of protein, fat, CHO, fibre and other minerals in the plant parts of the grain amaranth was similar irrespective of the varieties. Generally various plant parts of grain amaranth makes and stored protein, which the body needs to grow and stay healthy. Any meals that do not include other protein sources such as meats, fish, eggs or beans should always include lots of dark green leaves especially grain amaranth leaves. Grain amaranth is very rich in minerals such as iron which makes blood strong and calcium which is necessary for healthy bones

Table 4: Nutritional values of grain amaranth varieties over the 2 years

	Nutrition values																				
	% Protein			% M. C.			% Fat			% Ash			% Fibre			% CHO			% Ca		
	Plant parts																				
Variety	Leaf	Steam	Grain	Leaf	Steam	Grain	Leaf	Steam	Grain	Leaf	Steam	Grain	Leaf	Steam	Grain	Leaf	Steam	Grain	Leaf	Steam	Grain
NH_{84}/451	22.42b	2.46b	16.45a	8.96ab	9.45ba	6.77a	3.4a	3.3a	4.36a	10.66b	23.07a	2.36a	1.2b	2.5ab	3.0ab	38.64a	28.27b	22.24a	6.4a	2.2b	3.2b
NH_{84}/452	22.55ab	42.41c	13.65ab	8.98ab	9.45ab	6.77a	2.6b	1.5b	2.98c	12.12a	22.21b	2.28a	1.3ab	2.7a	2.8ab	38.95a	37.37a	19.49b	8.5a	2.9c	3.4ab
NH_{84}/494	23.18a	3.68a	12.23c	8.62b	8.92b	6.72a	3.3a	1.6b	4.03ab	11.66ab	21.34bc	2.46a	1.1b	2.3ab	3.3a	39.97a	27.48b	18.12b	5.2a	2.3b	3.8a
NH_{84}/493-1	22.24b	2.26bc	14.02b	9.14a	9.64a	6.87a	2.7b	1.8b	3.76b	10.58b	20.58c	2.38a	1.4a	2.5ab	3.1a	37.98a	25.52b	19.67ab	7.8a	2.4ab	2.1c

a,b,c,d .... mean separation by Duncan Multiple Range, $p \leq 0.05$, values followed by the same letter are not significant

formation. The iron contents obtained in this study especially for leaves were higher than 2.6 mg recorded for amaranth (tropical spinach) by the South Pacific food (1992). The differences in the results may be due to the differences in the soil fertility levels, locations and the variety used. The plant parts, especially the leaves also provide a good source of dietary fibre which prevents constipation and helps the body to have regular bowel motions. It also tends to lower blood cholesterol and help prevent heart disease. Although, the CHO content was not significant in the leaves, grain amaranth contained reasonable amount of CHO, which can provide energy needed by the body during heavy work.

Although, all the four grain amaranth varieties are good sources of quality and mineral elements NH_{84}/45 was found to be more nutritiou's than the others. Similarly, all the plant parts are good edible portion of the plant but the leaves are more richer in nutritional values than the other plant. However, distribution of minerals needed for human health in the edible portions of plants can be affected by cultural production methods (Russo, 1996).

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