Nutrient Content and Proximate Analysis of Grain Amaranth Accessions Influenced by Accessions and Nitrogen Rates

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***Abstract*: - Amaranth (*Amaranthus spp.*) is a multi-purpose crop and leafy vegetables of high nutritional quality. The mineral content and proximate composition of five accessions of *Amarhanthus* accessions: 74-43, RRC8, RRC1351, RRC3991, RRC551 were investigated. With the issue of food security and inadequate supply of rich food especially in developing country, Amaranth, although an underutilized crop, can be a good source of protein, carbohydrate and important minerals. Hence, this experiment was carried out to investigate the nutritional content and proximate analysis of amaranth. The experiment was conducted at the National Horticultural Research Institute, Ibadan and Ladoke Akintola University, Ogbomoso, both in southwestern Nigeria. Treatments consisted of nitrogen fertilizer applied at 0, 30, 60, 90 and 120 kg ha^{-1}. Proximate analysis was carried out using standard methods. There was difference in the in interaction of accession and nitrogen rate on nutrient content of grain amaranth compared to the respective control (0 kg N ha^{-1}). At 60 kg ha^{-1}, RRC8 had the highest P, K, Na, Mg and Fe (32.03, 47.14, 83.61, 37.65 and 19.97 g/plant, respectively); at 120 kg ha^{-1} RRC551 and RRC399 recorded the highest N (5.29 g/plant) and Zn (6.38 g/plant), respectively. Accession and nitrogen rate affected proximate analysis of grain amaranth, with, 74-43, RRC551 and RRC8 having the highest water content (7.54), carbohydrate content (40.58) and Fat content (3.97); RRC3991 and RRC551 had the highest protein content at 7.32 g/plant. Nitrogen rate at 120 kg ha^{-1} had the highest values for all proximate compositions. The study shows that the nutritional content in amaranth is rich enough to substitute as alternatives for food sources that are expensive to get.**

***Keywords: Amaranthus*, dietary source, nutrition, underutilized crop, vegetable.**

I. INTRODUCTION

Grain amaranth is a beautiful crop with brilliantly coloured leaves, stems and flowers of purple, orange, red or gold. Its growth habit varies from prostate to erect and branched to unbranched. Its main stem axis terminates in an apical large branched inflorescence. Amaranth is one of the few multi-purpose crop which can supply grains and tasty leafy vegetables of high nutritional quality as a food and animal feed, and additionally, because of attractive inflorescence colouration, amaranth can be cultivated as an ornamental plant (Sliva *et al*., 2009). The genus Amaranthus, comprises of about 60 species, many of which are native of the Americas while others are indigenous to Asia, Australia and Africa. They are found mainly in the world's temperate and tropical climates (Sauer, 1967). The nutritional value of amaranth was first drawn to attention by an Australian investigator named Downtown, who in 1973, found out the high lysine concentration in grain of Amaranthus edulis. The nutritional value of amaranth and environmental adaptability creates an excellent potential for the crop to positively impact on thousands of poor farmers who rely on staple crops that are often neither resilient nor nutritious (Monica *et al*., 2011). Amaranth is one of the few plants whose leaves are eaten as a vegetable while the seeds are used in the same way as cereals. The genus Amaranthus comprises of about 60 species, many of which are native of the Americas while others are indigenous to Asia, Australia and Africa. They are found mainly in the world's temperate and tropical climates (Sauer, 1967). The quality of crop produced can be influenced by the source of nutrients involved in its production (Arthur, 1994). The nutrient content of Amaranth is very profound making it a very good source of rich diet. In amaranth, 78% of the starch content is found in the branched-chain amylopectin form, while the remaining 22% is in the amylose or unbranched form (Tomita *et al*., 1981; Okuno and Sakaguki, 1984). Amaranth is a promising crop owing to its quality seed protein content. It is one of the few plants whose protein content have comparable or higher amounts of essential amino acids as whole egg protein (Drzewiecki *et al*., 2001). Crude protein content from pale-seeded grain types has been reported to range from 12.5 to 22.5%, with an average of about 15% (Pedersen *et al*., 1987; Bressani *et al*., 1993). The lipid fraction of amaranth grain is similar to other cereals, being approximately 77% unsaturated, with linoleic acid being the predominant fatty acid. The lipid fraction is unique due to the unusually high squalene content which is usually between 5 to 8% of the total oil fraction. In addition, amaranth grain also contains high levels of calcium, iron, and sodium when compared to cereal grains (Becker *et al*., 1981). Amaranth can be considered as an alternative to rich supply of nutrient hence this study was carried out to determine the effect of accession and location of the nutrient content of amaranth.

II. METHOD AND MATERIAL

Field trials were conducted at the Vegetable research farm, National Horticultural Research Institute, Idi-Ishin, Nigeria (3º 56´ E and 7º 33´ N; 168 m above sea level) and the Teaching and Research Farm, Ladoke-Akintola University of Technology, Ogbomoso, Nigeria, (4º 10´E and 8º 10´ N; 275 m above sea level) from August to December, 2014. The region is within the savanna forest transition ecosystem of south-western Nigeria. Monthly rainfall distribution pattern for the region is bimodal with peaks in June and September. Annual rainfall, temperature and relative humidity vary to different degrees (Table 1).

The soils (Table 2) were similar. Ibadan is dominated by alfisols (Soil Survey, 1999), egbeda soil series, derived from fine-grained biotites gnesis (Smyth and Montgomery, 1962). The soil ay Ogbomoso is alfisol series (Smyth and Montgomery, 1962), derived from fine-grained gnesis. The soil is moderately drained, ferruginous soil with a sandy loam texture. Soil samples was taken randomly prior to planting to assess the nutrient status of the soil in Ibadan and Ogbomoso. Soil samples were collected in filed at a depth of 0-13 cm for physical and chemical analysis. The samples were bulked to form a composite sample from which a representative sample was taken which was air-dried and crushed.

The composite sample was sieved through a 2 mm mesh for determination of particles size, pH (H_2O), available phosphorus (P), and iron (Fe); copper (Cu) and zinc (Zn), as well as exchangeable cations and acidity. Chemical and physical properties of the soil pH, organic carbon, total nitrogen, the macro elements in both experimental sites were already loam soil. The mean sand (868 g kg^{-1}) and (860 g kg^{-1}) and (1200 g kg^{-1}) in both locations were sandyloam, but the clay content of Ogbomoso soil was slightly higher (20.0 g kg^{-1}) than at Ibadan (12.0 g kg^{-1}) (Table 2). The field was ploughed twice followed by harrowing. Seeds were sown directly in the field at a spacing of 50 × 35 cm: thin at 2 weeks after sowing (2 WAS) to provide a total of 40 plants per plot. Plots were separated by 1x1 m between replicates. Each replicate had 25 plots repeated 3 times for a total of 75 plots. The experiment was in a randomized complete block design. The treatments consisted of the accessions of amaranth (74-43, RRC1351, RRC399, RRC8, RRC551) as the main plot and the levels of nitrogen (0, 30, 60, 90 or 120 kg ha^{-1}) as the sub-plot. The urea was applied in split application 3 WAS and the other half applied at 5 WAS. Manual weeding with hoes occurred at 2 WAS. Application of Bremoni attacked insecticide with active ingredient of *lambdacyhalothrin* at 2, 5 emulsifiable concentrate in 100 litres of water·ha^{-1} at 2 weeks interval was begun at sowing. Ten plants were selected and tagged from the each plot. Data collection began at 6 WAS and continued biweekly until maturity. Destructive samples were harvested at 100% flowering and taken to the laboratory for nutrient analysis. Other inflorescences were harvested when they matured in each plot, and threshed and winnowed manually to recover grains which were weighed per plot.

Samplings of 5 plants/ plot (shoots) were harvested at flower initiation for nutrient uptake (Moll *et al*., 1982; Petigrew and Meredith, 1997; Ombo, 1999). Samples were oven dried conventionally to obtain 100 g of sample, at 75^0 C for 2 days to obtain constant weight of the sample to quantify its dry matter (AOAC, 1990). The blended sample (0.2 g) was weighed and digested at 360^0 C using a digestion block and tubes for 4 h in 10 ml concentrated sulphuric acid (H_2S0_4) with 1 tablet of selenium and sodium sulphate as the catalyst. Total N was determined from the digest by steam distillation with excess NaOH and boric acid as the indicator, and then titrated with 0.01 NH_4Cl solutions. The amount of N present in 100 g of sample was estimated using the relationship.

$$\% N = \frac{(T-B) \times N \times 1400}{S}$$

Where; T = sample titration (ml)

B = blank titration (ml)

N = normality of H_2S0_4 (to 3 decimal places)

S = sample weight (mg)

Concentration of phosphorus, potassium and magnesium in plants were determined by ashing 0.2 g plant samples in a muffle furnace at 550^0 C for 2 hours. The ash was cooled, dissolved in 1N HCl and the solution passed under gravity through the filter paper (Whatman No 42) into a 100 ml volumetric flask and the filtrate made up to the mark using distilled water. From the digest, P concentration was determined by the vanadomolybdate yellow colorimetric method using a spectrophotometer (model 400, Corning) Potassium was determined with using a flame photometer (model 400, Corning) while Mg, Fe and Zn were determined with an atomic absorption spectrophotometer (Tee *et al.*, 1996).

Nutrient accumulation in plants was calculated using the method of Gungula (1999). Phosphorus and potassium contents were estimated according to the procedure according to accepted methods for soil and plant analysis (IITA, 1989). 5.0 ml nitric/perchloric acid mix (ratio 2:1) was added into 0.2 g of each sample in a 25 ml conical flask and left overnight. The samples were heated to white fuming stage, at which 1.0 ml of hydrochloric acid/distilled water mix (ratio 1:1) was added and heated for a further 30 minutes. Distilled water was added to the digest and shaken before cooling to room temperature to avoid formation of insoluble perchlorate compounds. The digest was weighed into 50 ml volumetric flasks and made to mark with distilled water. Phosphorus and K were determined in the digest. Total phosphorus was determined by vanadomolybdate yellow colorimetric method (AOAC, 1990); K was determined by flame photometry.

Protein content was estimated using the Folin-Lowry method (Lowry *et al*., 1951) and bovine serum albumin as the standard. Protein contents were determined with the Kjeldahl method (AOAC, 2000) on an automated Kjeltec instrument.

Samples (1 g) were digested with 15 ml concentrated sulphuric acid using a heated aluminum block digester. The digest was diluted and made alkaline with 50 ml of 40% sodium hydroxide. This was followed by rapid steam distillation of ammonia from the diluted digest into 25 ml of 4% boric acid for manual titration with 0.2 N hydrochloric acid. A conversion factor of 6.25 was used to convert the nitrogen content to protein content. Water content was determined using the direct drying method. Samples (10 g) were dried conventionally in an oven at 70^0 C until constant weights of samples were obtained. The difference between initial weight and constant weight after drying was taken to be moisture lost and hence moisture content of sample (Tee *et al.*, 1996). Fat content was determined by the semi-continuous solvent extraction method. Ten-g of sample was extracted with 180 ml petroleum ether on a Soxhlet apparatus for 10 hours. Petroleum ether was removed by evaporation and the lipid residue weighed (Tee *et al.*, 1996). Carbohydrates were calculated by subtracting the sum of percent's of protein, fat, water, and ash from 100.

Data were subjected to analysis of variance in SAS (version 2009, SAS Institute, Cary, NC). If an interaction was significant it was used to explain the results. If an interaction was not significant, means were separated using least significant difference.

III. RESULTS

As indicated in Table 3, there was a significant ($P<0.05$) difference for all accessions on the in interaction of Accession and Nitrogen rate on the nutrient content of grain amaranth compared to their respective control (0 kg N ha^{-1}) plots. At 60 kg N ha^{-1}, RRC8 recorded the highest Phosphorus, Potassium, Sodium, Magnesium and Iron (32.03, 47.14, 83.61, 37.65 and 19.97 g/plant respectively). While at 120 kg N ha^{-1} RRC551 and RRC399 recorded the highest Nitrogen (5.29 g/plant) and Zinc (6.38 g/plant) respectively. There was a significant ($P<0.05$) difference in interaction of Location and Accession on the nutrient content of grain amaranth at both Ibadan and Ogbomoso. Accessions in Ibadan gave the highest values for Phosphorus, Potassium, Sodium, Magnesium and Iron, all of which was recorded under RRC8 as shown in table 4. Accessions RRC551 and RRC399 gave the highest value for Nitrogen (3.09 g/plant) and Zinc (5.63 g/plant) respectively. Table 5 showed that RRC8 gave the highest values for all mineral components except Zn (1.55 g/plant), whose highest value for recorded by RRC399 at 3.21 g/plant. Nitrogen rates were significantly ($P<0.05$) different compared with the control. However, 120 kg N ha^{-1} gave the highest for all mineral components. There was significant ($P<0.05$) difference in the proximate analysis of the grain amaranth (Table 6). The proximate analysis of grain amaranth influenced by the main effect of accession and Nitrogen rate reveals that Accessions 74-43, RRC551 and RRC8 had the highest values for water content (7.54), carbohydrate content (40.58) and Fats content (3.97) while Accessions RRC3991 and RRC551 both had the value for the protein content at 7.32 g/plant. Nitrogen rate at 120 kg N ha^{-1} still had the highest values for all proximate compositions. Table 7 showed that there was significant ($P<.0.05$) difference in the interaction of accession and Nitrogen rate with RRC551 having the highest values, though at different nitrogen rates.

IV. DISCUSSION

Mineral Content Composition

The mineral content of grain amaranth investigated in this study were significantly ($P<0.05$) different. Accession RRC8 gave highest level of Phosphorus, Potassium, Sodium and Magnesium which corresponds to the results obtained by Akin-Idowu *et al*., 2015 in which high mineral content were obtained from some amaranth accessions. High mineral content of amaranth has been documented (Shukla *et al*., 2006; Ozbucak *et al*., 2007; Revija, 2010; Olaniyi *et al*., 2017). From the results, high values of nutritional contents were recorded both in Ibadan and Ogbomoso. Although they both have approximately the same annual rainfall with relative humidity of 74-75%, one of the advantage attributes to their richness in soil nutrient and ecological distribution towards the uptake of nutrient by amaranth. Yield of grain amaranth were significantly ($P<0.05$) different to the application of different levels of nitrogen. Our study showed that 120 kg N ha^{-1} gave the highest mineral content as well as proximate composition. This result is in similar to the study of Oyinlola and Jinadu (2012) which reported highest dry matter values with the application of 120 kg N ha^{-1} in the study of tomato production. Report by Prokoshev (1993) and Oyeniyi *et al.* (2002) on the positive response of macronutrients uptake by vegetables with the application of fertilizers compared to when no fertilizers are applied also confirm our study. There was a significant ($P<0.05$) difference in the varietal response of grain amaranth accessions to nutrient uptake. Accession RRC8 had the highest values for most mineral contents while the least for most mineral contents was recorded by accession RRC1351. This is in agreement with the reports of Olaniyi (2007) and Souguir *et al*., (2008) that varietal differences seen among varieties grown under the same environmental conditions regarding nutrient uptake may be due to their genetic differences.

Proximate Composition

There was significant ($P<0.05$) difference in water, protein, carbohydrate and fat content among the varieties of grain amaranth studied. All accessions had considerably higher carbohydrate content with the highest value at 64.05 g/100g grain by RRC1351, while the least was by RRC8 at 33.73 g/100g grain. This is similar to the study by Akin-idowu *et al*., (2015) which reported high starch content ranging in different amaranth species. Although the water content was not significantly difference, accession 74-43 gave the highest value at 7.54 g/100g grain as shown in table 4. Accession 74-43 also had the least mineral content which aligns with the reports of Amir *et al*., (2007) that there is a negative correlation between dry matter and moisture content. High

protein and low fat contents was recorded in our study with RRC3991 and RRC551 both having the highest protein content (7.32 g/100g grain) while RRC8 had the highest fat content at (3.97 g/100g grain). Akin-idowu *et al*., (2015) reported a similar trend in the protein content of some amaranth species.

V. CONCLUSION

Nutritionally, vegetables play a vital role in providing high nutrients for growth and development especially in developing countries. Amaranth is widely cultivated and according to FAO (2003), it has the potential of substituting for animal protein in adding to its high carbohydrate content. Results of this study reveal that the mineral and proximate content of grain amaranth is high and thus amaranth can be an important source of dietary protein and energy especially to developing countries who cannot afford animal proteins.

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Table 1: Mean monthly temperature, relative humidity and rainfall of Ibadan and Ogbomoso 2014 cropping seasons.

Month	Ibadan				Ogbomoso			
	Max Temp ^{0}C	Min Temp ^{0}C	RH (%)	Rain-fall (mm)	Max Temp ^{0}C	Min Temp ^{0}C	RH (%)	Rain-fall (mm)
Jan	35.3	23.2	89	75	35.1	22.6	73	00
Feb	35.9	24.1	86	273	36.7	22.8	73	41
Mar	34.9	24.7	87	111	34.9	23.1	76	439
Apr	34.3	24.7	86	204	34.2	23.6	81	103
May	31.9	23.7	88	106	31.2	22.8	85	157
Jun	31.1	23.9	88	82	30.7	22.6	87	167
Jul	29.1	22.7	89	138	28.5	21.3	91	77
Aug	28.6	22.7	90	181	28.2	21.5	94	88
Sep	29.9	22.7	89	123	29.2	21.5	89	117
Oct	31.3	23.2	88	100	30.3	21.5	88	109
Nov	33.3	23.8	88	00	31.8	21.8	83	145
Dec	34.1	22.1	85	00	33.5	20.7	70	0.0
Mean	32.5	23.5	88	116	32.0	22.2	83	12

Ibadan data from: NIHORT Metrological station Ibadan, Oyo State.
Ogbomoso data from: Nigeria Meteorological Station, International Airport Ilorin, Kwara State.
RH = Relative Humidity; Max = Maximum; Min = Minimum; Temp = Temperature

Table 2: Physico-chemical ccharacteristics of soils of the experimental sites

Soil properties 0-15cm depth	2014	
	Ibadan	Ogbomoso
Chemical properties		
pH (H_2O)	5.80	5.80
Organic carbon (g kg^{-1})	3.84	3.23
Total N (g kg^{-1})	0.30	0.28
Available P (g kg^{-1})	3.80	6.00
Exchangeable acidity (C mol kg^{-1})		
Ex. K	0.34	0.31
Ex. Na	0.26	0.26
Ex. Ca	3.11	3.42
Ex. Mg	0.58	0.7
Ex. acidity (c mol kg^{-1})	0.28	0.08
CEC (c mol kg^{-1})	5.17	5.20
Physical properties (g kg^{-1})		
Sand	868	860
Clay	12	20
Silt	120	120
Textural class	Sandy loam	

Table 3: Interaction of accession and nitrogen rate on nutrient content of grain amaranth

Accession	Nitrogen rate (kg N ha^{-1})	N	P	K	Na	Mg	Fe	Zn
		←			(g /plant)			→
74-43	0	0.15	1.87	1.49	4.06	2.01	1.34	0.07
	30	0.71	22.10	8.78	11.45	5.26	4.28	0.47
	60	0.86	12.97	12.17	13.39	6.54	5.22	0.68
	90	0.95	16.59	17.27	18.84	8.52	6.01	0.96
	120	1.76	31.97	34.42	40.10	15.96	11.77	1.59
RRC1351	0	0.10	2.00	0.99	2.78	1.66	0.85	0.08
	30	0.42	4.92	4.69	9.54	4.57	2.14	0.41
	60	0.63	8.18	7.43	13.95	6.13	3.01	0.55
	90	0.94	12.82	18.83	21.09	9.14	5.39	0.80
	120	1.58	22.91	38.45	32.12	15.93	10.35	1.64
RRC399	0	0.15	1.27	1.81	4.78	1.33	1.16	0.14
	30	0.32	2.17	6.13	7.19	3.53	2.28	0.37
	60	1.05	8.48	16.45	19.64	9.27	6.15	3.33
	90	1.31	11.17	19.83	21.30	10.62	6.95	5.85
	120	2.15	18.03	33.33	33.54	14.99	11.17	6.38
RRC8	0	0.15	1.91	1.81	4.42	1.40	1.17	0.21
	30	0.52	4.84	6.46	11.90	3.71	2.85	0.52
	60	3.84	32.03	47.14	83.61	37.65	19.79	3.56
	90	3.95	24.27	25.53	48.36	18.91	9.95	1.83
	120	4.22	22.23	21.15	42.75	16.24	9.79	1.62
RRC551	0	0.15	1.37	2.06	4.63	0.87	1.16	0.17
	30	0.88	5.33	7.38	10.72	3.23	3.67	0.54
	60	1.64	10.04	11.15	14.43	4.83	4.67	0.94
	90	3.02	17.10	17.90	30.50	7.83	8.17	1.58
	120	5.29	31.17	27.58	51.74	20.70	15.01	2.22
LSD $_{0.05}$		1.35	13.76	17.33	30.94	13.60	6.77	1.70

LSD $_{0.05}$: Least significant different at 5% probability.

Table 4: Interaction of location and accession on nutrient content of grain amaranth

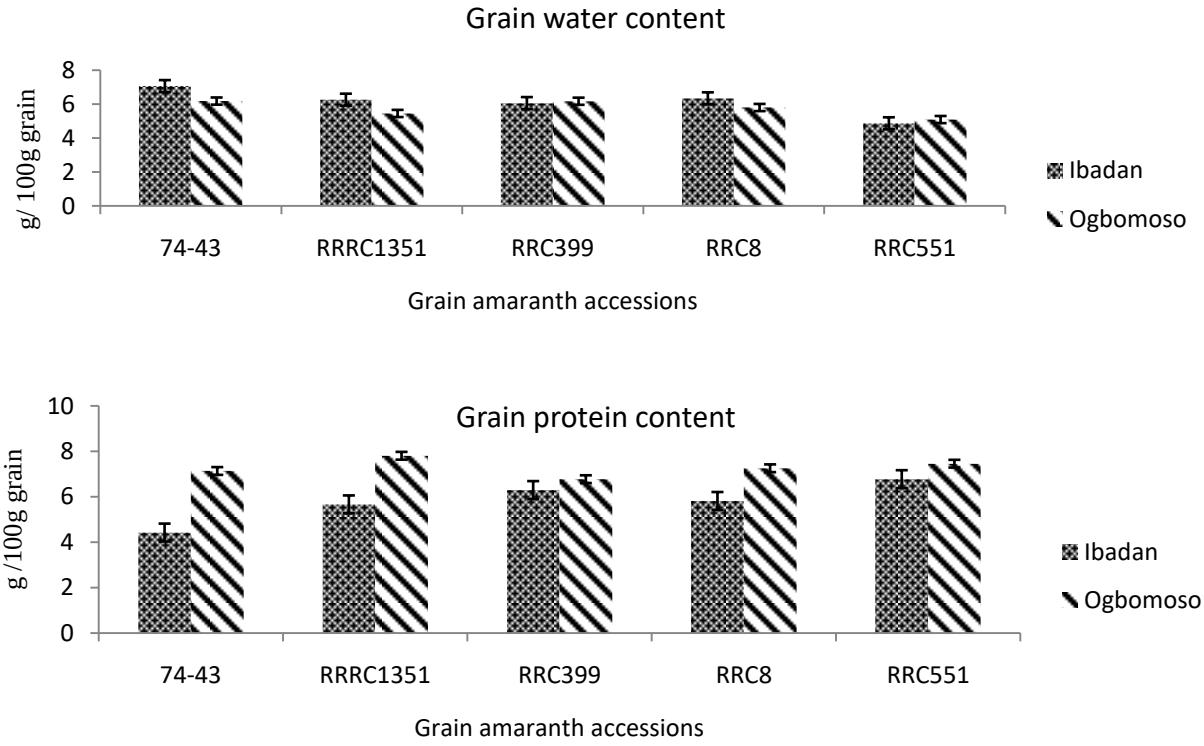
Location	Accession	N	P	K	Na	Mg	Fe	Zn
		←			(g /plant)			→
Ibadan	74-43	0.82	16.23	15.11	11.72	7.06	5.28	0.70
	RRC1351	0.54	8.49	15.59	14.86	5.29	3.46	0.56
	RRC399	0.85	8.78	21.17	23.56	8.34	5.21	0.78
	RRC8	1.97	20.31	28.53	53.85	20.95	12.08	2.09
	RRC551	1.51	11.75	14.57	25.41	5.41	6.55	1.12
Ogbomoso	74-43	0.95	17.96	14.54	23.31	8.25	6.24	0.81
	RRC1351	0.93	11.84	12.55	17.28	9.68	2.27	0.83
	RRC399	1.14	7.67	9.84	11.02	7.55	5.87	5.65
	RRC8	3.09	13.84	13.74	22.56	10.22	5.34	1.01
	RRC551	2.98	14.58	11.85	19.28	9.57	6.53	1.06
$LSD_{0.05}$		0.85	08.70	10.95	19.56	8.59	4.28	1.08

LSD $_{0.05}$: Least significant different at 5% probability.

Table 5: Main effect of accessions and nitrogen rates on nutrient content of grain amaranth accessions at Ibadan and Ogbomoso

Accession	N	P	K	Na	Mg	Fe	Zn
ACC	←			(g/plant)			→
74-43	0.89	17.07	14.83	17.57	7.49	5.76	0.75
RRC1351	0.73	10.17	14.08	16.08	7.49	4.36	0.69
RRC399	1.00	8.23	15.51	17.29	7.95	5.54	3.21
RRC8	2.53	17.10	21.14	38.21	15.58	8.71	1.55
RRC551	2.20	13.16	13.21	22.35	7.49	6.54	1.09
$LSD_{0.05}$	0.60	6.15	7.74	13.84	6.08	3.03	0.76
Nitrogen rates (kg N ha^{-1})							
0	0.13	1.68	1.63	4.15	1.45	1.14	0.13
30	0.57	7.87	6.69	10.16	4.06	3.08	0.46
60	1.60	14.34	18.87	28.02	12.88	7.79	1.81
90	2.03	16.55	19.79	28.94	11.00	7.29	2.20
120	3.00	25.28	31.79	40.21	16.76	11.62	2.69
$LSD_{0.05}$	0.60	6.15	7.75	13.84	6.08	3.03	0.76
Location (LOC)							
Ibadan	1.12 b	13.11 a	19.00 a	25.90 a	9.41 a	6.52 a	1.05 b
Ogbomoso	1.82 a	13.18 a	12.51 b	18.69 a	9.05 a	5.85 a	1.87 a
NR x ACC	**	Ns	Ns	Ns	Ns	*	**
LOC x ACC	Ns	Ns	Ns	*	Ns	*	**

$LSD_{0.05}$: Least significant different at 5% probability. Means having the same letter in a column are statistically non-significant using DMRT at 5% probability level. Ns: not significant.
*or ** indicate significance at 5% or 1% probability level respectively.



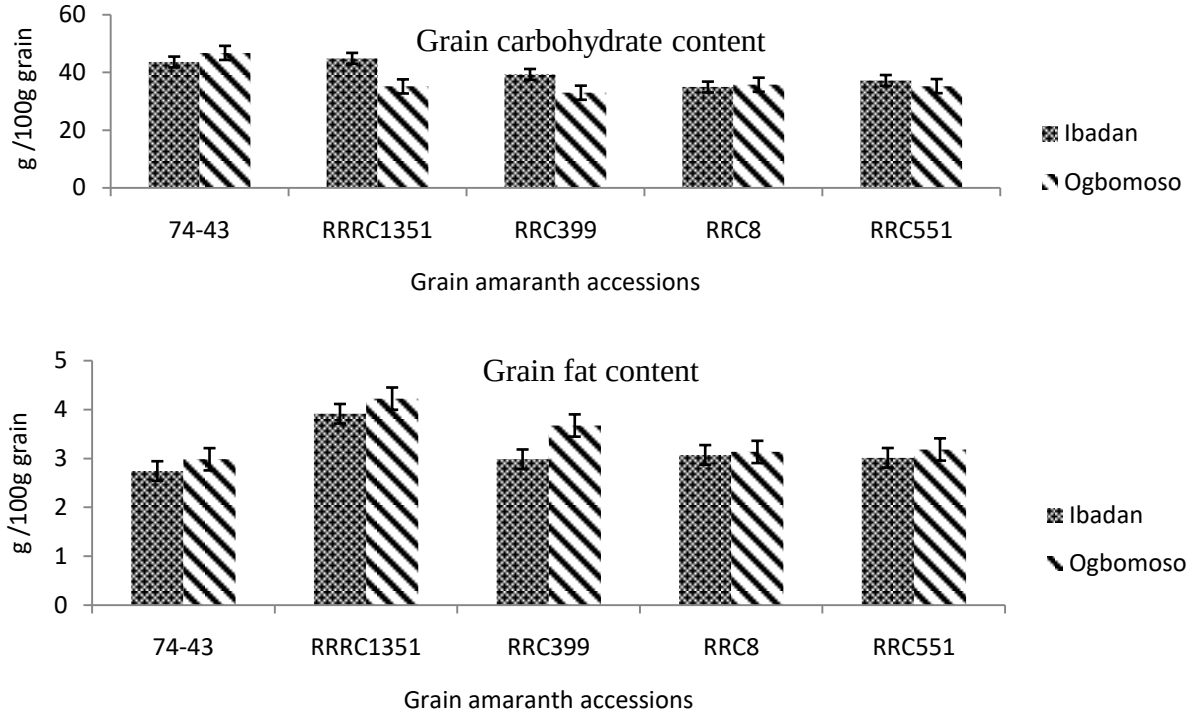


Figure 1: Effect of location and accession on proximate contents of grain amaranth

Table 6: Main effect of accession and nitrogen rate on proximate analysis of grain amaranth

Accessions (ACC)	Water	Protein	CHO (g /100g grain)	Fat content
74-43	7.54	5.64	35.08	2.79
RRC1351	6.83	7.00	64.05	3.47
RRC399	6.78	7.32	51.66	3.70
RRC8	6.57	6.46	33.73	3.97
RRC551	6.98	7.32	40.58	3.11
Nitrogen rate (kg N ha^{-1})				
0	4.71	3.89	29.15	1.53
30	5.77	4.32	37.37	2.78
60	6.47	5.03	47.13	3.47
90	7.71	8.36	50.65	3.96
120	10.04	12.13	60.79	5.30
Location (LOC)				
Ibadan	7.45 a	6.40 b	47.31 a	3.34 b
Ogbomoso	6.43 b	7.10 a	42.73 b	3.48 a
LSD $_{0.05}$				
Accession	0.42	0.57	3.39	0.18
Nitrogen rate	0.42	0.57	3.39	0.19
LOC x ACC	Ns	**	**	**
NR x ACC	*	**	**	**

LSD (0.05): Least significant different at 5% probability. Means having the same letter in a column are statistically non-significant using DMRT at 5% probability level. Ns: not significant *or ** indicate significance at 5% or 1% probability level respectively.

Table 7: Interaction of nitrogen rate and accession on proximate of grain amaranth accessions

Nitrogen rate (kg N ha^{-1})	Accession	Water	Protein (g /100g grain)	CHO	Fat content
0	74-43	6.37	3.77	23.80	1.45
	RRC1351	6.13	4.50	29.42	2.23
	RRC399	7.33	5.23	37.43	2.55
	RRC8	7.70	6.73	38.23	3.08
	RRC551	10.17	7.97	46.50	4.63
30	74-43	4.83	4.20	47.27	0.75
	RRC1351	5.50	4.22	56.38	2.98
	RRC399	6.63	5.70	63.75	3.75
	RRC8	7.70	9.17	75.23	4.35
	RRC551	9.47	11.70	77.63	5.53
60	74-43	4.02	4.12	25.60	1.63
	RRC1351	5.10	4.77	43.20	3.42
	RRC399	5.80	5.63	61.28	4.10
	RRC8	8.03	8.18	61.97	4.38
	RRC551	11.03	13.88	66.23	4.97
90	74-43	4.02	3.90	21.47	2.75
	RRC1351	5.83	3.77	26.57	2.95
	RRC399	5.97	3.95	33.00	3.50
	RRC8	7.07	7.18	33.93	4.28
	RRC551	9.97	13.52	53.70	6.37
120	74-43	4.40	3.47	27.63	1.09
	RRC1351	6.27	4.37	31.30	2.33
	RRC399	6.63	4.65	40.20	3.43
	RRC8	8.03	10.55	43.90	3.68
	RRC551	9.97	13.58	59.87	5.02
$LSD_{0.05}$		0.95	1.27	7.59	0.41

$LSD_{0.05}$: Least significant different at 5% probability.