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EFFECTS OF FERTILIZER TYPE, RATE AND PLANT ACCESSION ON SELECTED ESSENTIAL AMINO ACID CONTENTS OF GRAIN AMARANTH (*Amaranthus* spp)

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ABSTRACT

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food for an active and healthy life. Field investigations were carried out in 2014 and 2015 to determine the effects of five levels of poultry manure (PM 5, 10, 15 and 20 tonnes per hectare, and no fertilizer/PM as control) and NPK fertilizer (15-15-15 at 300 kg.ha-1) on amino acid content of some accessions of grain amaranth at the Crop Research Farm of the Federal University of Agriculture, Abeokuta. Data collected on nutritive qualities were subjected to analysis of variance and means were separated using the Duncan's Multiple Range Test ($p<0.05$). Effects of accession, poultry manure and their interaction on Lysine, Isoleucine and Tryptophan were significantly different. Accessions PI 633596 and PI 337611 had the highest Lysine content (0.86 g/16 gN). Accession PI 576480 had thehighest Iso-leucine content (0.76 g/16 gN). Tryptophan content was highest (0.70 g/16 gN) in accessions PI 576464, PI 576480 and PI 641055. Plants that received 15 t.ha^{-1} poultry manure had the highest Lysine and Iso-leucine contents (0.87g/16 gN; 0.75g/16gN, respectively). Highest Tryptophan content was observed from plants grown with 20t.ha^{-1} poultry manure. Interaction of accession and PM revealed that Lysine (0.95 g/16 gN) and Iso-leucine (0.92 g/16 gN) contents were highest at 15 t.ha^{-1}; Tryptophan content was highest (0.85 g/16 gN) at 20 t.ha^{-1}.The study concluded that application of 15 t.ha^{-1} PM enhances lysine content, an essential amino acid, of grain amaranth. It is recommended that incorporation of grain amaranth as protein supplement into existing food products such as breakfast and infant cereals should be encouraged; accessions PI 633596, PI 337611 and AMES 5644 could be cultivated wit)h 15 t.ha^{-1} PM for high lysine content.

***Keywords** – Lysine content, Iso-Leucine, Tryptophan, Protein content, Grain Amaranth, Food security*

INTRODUCTION

One of the interventions that could improve food security and the drive for good nutrition is the introduction of new or under-developed crops for which market demand can be developed. Grain amaranth is an important leaf and seed vegetable crop whose grain protein content is not only comparable to or higher than found in whole egg, but considered a potential food supplement to fortify the daily intake of recommended protein levels (Drzewiecki, 2001). The protein content is of unusually high quality because it contains lysine, a nutritionally critical essential amino acid that is negligible or completely missing in other grains (Venskutonis and Kraujalis, 2013), thus, the need to promote use of grain amaranth as a substitute or a complement to cereal staples such as maize, sorghum and rice. The grain oil has been found to have cholesterol-lowering properties and it is the only grain found to contain vitamin C (Coles, 2017).

Without prejudice to the socio-cultural backgrounds and the different food menu preferences across households, protein is one of the basic units of food required to quench hunger (Ahn *et al.*, 2015). Protein deficiency in the diet leads to a state of malnutrition in which insufficient amount of protein is taken in for the body to utilize in order to produce energy (Müller and Krawinkel, 2005). This deficiency condition is largely responsible for the high incidence of starvation and diseases in many developing countries. The human body does not store proteins, so it requires a daily supply of foods that contain proteins. Protein is a macronutrient that is needed relatively in large amounts daily to stay healthy. If there are no foods to nutritionally balance the different food menus, then, there is no food security.

Achieving food security for a rapidly expanding population in the tropics requires intensifying food production on the existing cropland through enhanced nutrient input and recycling (Juo and Wildling, 1996). Moyin (2007) stated that emphasis has shifted to the consumption of food produced with organic fertilizers. Organic fertilizers, in addition to improving soil texture and structure, also form complexes with soil colloids or minerals (especially, humic substances) thereby, giving the soil long lasting fertility effect. Long term conservation of the soils health is the key benefit of organic fertilizers, which is vital in sustainable agriculture (Ainika and Amans, 2011). With regards to food safety, foods grown with organic materials, like poultry manure, have the potential to produce high-quality products in terms of absence of toxic input residues. Despite its health and economic importance, grain amaranth has received low research attention with respect to the cultural practices that would enhance its nutritional quality. This study was carried out to determine the effects of source of nutrients on the nutritional quality of grain amaranth, using inorganic fertilizer (NPK) and poultry manure.

MATERIALS AND METHODS

Grain amaranth crops were planted under rain-fed conditions to determine the post harvest quality of harvested grains in response to poultry manure rate sin 2014 and 2015 between August and December at the Teaching and Research Farm, Federal University of Agriculture, Abeokuta, Ogun State, South-West Nigeria. Grain amaranth accessions were obtained from National Institute of Horticultural Research (NIHORT), Ibadan, Oyo State, Nigeria. Ten elite accessions were used for the experiment based on the recommendation of Adediran *et al* (2019) who examined twenty accessions of grain amaranth for yield and nutritional quality. The experiment was laid in a randomized complete block design, in a slit-plot arrangement, with three replicates. Each sub-plot measured 2 × 2 m with 1 m space between replicates. Main plot was the grain amaranth accessions, and sub-plots were the fertilizer treatments and control. The accessions included: AMES 2055, AMES 5644, PI 337611, PI 477913, PI 576460, PI 576464, PI 576480, PI 633596, PI 641049 and PI 641055. Seedlings were raised in the nursery for three weeks before transplanted to well-prepared sub-plots. Poultry manure was allowed to mineralize for two weeks before it was applied on the sub-plots. Poultry manure and pre-cropping soil analyses were determined on pH (using the hydrometer method (Ashworth *et al,* 2001), total organic carbon and organic matter using Walkley–Blackey dichromate oxidation method (Jha*et al,* 2014), total nitrogen, available phosphorus, cation-exchange capacity, iron, manganese, zinc, calcium, sodium, copper and soil particle size and textural class. The treatments were four rates of poultry manure (PM); 5, 10, 15 and 20 t.ha^{-1}, NPK 15-15-15 at 300 kg.ha^{-1} and no fertilizer as control. The inflorescence was harvested before the heads were fully dried from six sampled plants in each sub-plot, three months after sowing and processed manually to recover the grains. Laboratory analysis was carried out on the grains to determine amino acid (lysine, iso-leucine, and tryptophan) content and also done on the poultry manure sample which was air-dried, crushed, passed through a 2 mm sieve for analysis. The nutritional analysis was conducted at the chemical laboratory of the Institute of Agricultural Research and Training (IAR& T) Ibadan for lysine, iso-leucine and tryptophan content according to the methods of analysis described by the Association of Official Analytical Chemist (AOAC. 1990). The amino acids were determined by using the modified method of Ketiku (1973). Seven milliliters of 6N-HCL was added to 2 ml defatted sample in a glass ampoule. Nitrogen gas was bubbled in to prevent oxidation during hydrolysis. Samples were thereafter hydrolyzed at 100 ± 5^{oC} for 22 hours. After cooling, the hydrolysate was filtered and 4 ml of the filtrate was vacuum-dried. Citrate buffer (pH 2.2) was used in reconstituting the samples. 1ml of each solution was used in loading the Technic on 50 amino acid auto-analyzer. Data obtained were subjected to Analysis of Variance (ANOVA). Treatment means were separated using Duncan's Multiple Range Test (DMRT) at $P < 0.05$ using GenStat Discovery (ed. 12, VSN International, Hemel Hempstead, UK). Weather information was collected from the Meteorological Station, Department of Water Resources and Management, College of Environmental Resources and Management, Federal University of Agriculture, Abeokuta, Nigeria.

RESULTS

Pre-cropping soil and manure analyses

The experimental site was sandy in texture with dominant fraction of sand (Table 1). Soil pH was 6.09 in 2014 and 6.50 in 2015, indicating that the soil was acidic. The organic matter content of the soil was low (1.40 and 1.81%). Available phosphorus, exchangeable potassium and calcium were low, while the magnesium content of the soil was high (1.80 mg/L). The chemical properties of poultry manure (Table 1) indicate that the pH was alkaline (8.03) while organic matter content was 35.85%. The poultry manure was high in total nitrogen, high in potassium, high in calcium, low in available phosphorus and magnesium (Table 1).

In 2014, 433.50mm rainfall was recorded for the period of the study between August and December. Highest Maximum temperature was 34.60^{oC} in December while the lowest was 29.10$^{o\ C}$ in August. Highest Minimum temperature was 22.7^{o}C in September and lowest was 21.50^{o}C in August (Table 2).In 2015, 294.70 mm rainfall was recorded for the period of the study between August and December. Highest Maximum temperature in 2014 was 33.50^{oC} in November and December and the lowest minimum was 19.30^{oC} in December (Table 2).

Table 1:Pre-cropping chemical analyses of soil and manure samples

Parameter	Soil		Poultry Manure
	2014	**2015**	
% Sand	97.00	95.00	NA
% Clay	0.00	2.20	NA
% Silt	3.00	0.80	NA
pH	5.09	5.67	6.03
Total Nitrogen (%)	0.34	0.32	2.30
Organic matter (%)	1.40	1.81	35.85
Sodium (cmol/kg)	8.70	8.50	43.48

Table 2: Meteorological data during the experiment in 2014 and 2015

Parameter	Rainfall (mm)		Sunshine (hr)		Maximum Temperature (°C)		**Minimum** Temperature (°C)	
Year	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
August	92.70	29.40	2.30	2.30	28.60	21.10	22.10	22.80
September	165.10	71.10	3.20	2.80	28.60	22.40	22.70	22.50
October	159.10	70.20	5.30	5.90	31.70	23.10	22.00	23.00
November	16.60	67.30	5.30	6.30	33.10	23.50	22.60	23.80
December	0.00	56.70	6.50	5.10	33.00	22.40	21.80	19.30

Nutritional content of Grain Amaranth in response to year, accessions poultry manure rate and their interactions

Year of production had significant effect on Lysine, Iso-leucine and tryptophan contents of grain amaranth (Table 3). Poultry manure rate had significant effect on lysine, Iso-leucine and tryptophan contents of grain amaranth. The accession affected the contents of lysine, Iso-leucine and tryptophan of grain amaranth. Year of production and poultry manure rate influenced lysine,Iso-leucine and tryptophan contents of grain amaranth. Grain Amaranth Accession and poultry manure rate affected lysine, Iso-leucine and tryptophan contents of grain amaranth. The interaction of year of production, grain amaranth accession and poultry manure rate was significant on the contents of Lysine, Iso-leucine and tryptophan of grain amaranth (Table 3).The effect of accession on Lysine, iso-leucine and Tryptophan contents were significant in both years (Table 4). Accessions Pl 633596 and Pl 337611 had the highest Lysine content (0.86 g/16 gN) in both years. Accession Pl 576480 had the highest Iso-leucine content (0.76 g/16 gN) in both years. In year 2014, Tryptophan content was highest (0.70 g/16 gN) from accessions Pl 576464 and Pl 576480;while in 2015, accessions Pl 576464 and Pl 576480 had the highest. The effect of poultry manure on amino acid content of grain amaranth was significant (Table 4). Plants that received 15 t.ha^{-1}poultry manure had the highest Lysine and Iso-leucine contents (0.86 g/16 gN; 0.78g/16 gN, respectively) in both years. Highest Tryptophan content was observed from plants grown with 20 t.ha-^{1}poultry manure in both years.

Effect of Interaction of Accession and Poultry Manure Rate on Amino Acid

The effect of interaction of accession and poultry manure rate on Lysine was significant in both years (Table 5). Grain amaranth grown without fertilizer produced the highest lysine content from accession PI 337611 in year 2014, and from PI 633596 in year 2015.At 5 t.ha^{-1}poultry rate, the highest was observed from accession PI 337611 in both years; with 10 t.ha^{-1}application, accession PI 641055 had the highest in both years. At 15 t.ha^{-1}poultry manure rate, highest lysine content was observed from accession PI 477913 in year 2014; while in year 2015, it was highest from AMES 2055. At 20 t.ha^{-1} poultry manure rate, lysine recorded its highest value from accession AMES 5644 in year 2014; and from accessions AMES 5644 and PI 633596 in year 2015. When NPK fertilizer was applied, accession PI 337611 recorded the highest lysine content in both years.

The interaction of accession and poultry manure rate on Iso-leucine was significantly different in both years (Table 5). When no fertilizer was applied, Iso-leucine had it highest value from accession PI 477913 in year 2014; and was highest from PI633596 in year 2015. At 5 t.ha^{-1} poultry manure, Iso-leucine content was highest from accession PI 641049 in year 2014; and from PI 576480 in year 2015. At 10t.ha^{-1}poultry manure application rate, Iso-leucine content was highest from accession PI 641049 in both years. When 15 t.ha^{-1}poultry manure was applied, accession PI 633596 produced the highest Iso-leucine content in year 2014; while in 2015, it was highest in PI337611. At 20t.ha^{-1}poultry manure rate, Iso-leucine content recorded its value from accession PI 633596 in year 2014; while in year 2015, it was highest from PI 477913.When NPK fertilizer was applied, accession PI 633596 recorded the highest Iso-leucine content in year 2014; while in year 2015, it was highest from PI 641055. (Table 5)

The interaction of accession and poultry manure rate on Tryptophan was significantly different in both years (Table 5). Tryptophan content was highest when no fertilizer was applied to accession PI 337611 in year 2014; while in 2015, it was highest from AMES 2055 and PI 633596. At 5t.ha^{-1} poultry manure, the highest tryptophan content was obtained in accessions PI 576464 and PI 337611 in year 2014; and similarly in 2015, PI 337611 had the highest. When poultry manure rate was 10t.ha^{-1}, tryptophan content was highest in accession AMES 2055 in year 2014; and it was highest in PI 641055 in 2015. At 20t.ha^{-1} poultry manure rate, highest tryptophan content was produced in accessions AMES 2055 in year 2014; and it was highest from PI 477913 in 2015. When NPK fertilizer was applied, accession PI 576480 recorded the highest tryptophan content in year 2014; and PI 641055 had the highest in 2015.

Table 3: Analysis of variance for nutritional content in Grain Amaranth in response to year, Grain Amaranth Accessions and Poultry manure rate and their interactions

Source	Degree of freedom	Lysine content (g/16 gN)	Iso-leucine Content (g/16 gN)	Tryptophan content (g/16 gN)
Year (Y)	**1**	0.00020	0.00064	0.00240
Grain Amaranth Accession (A)	**9**	0.01122	0.01907	0.00465
Poultry Manure Rate (P)	**5**	0.04450	0.01986	0.27440
YxA	**9**	0.00011	0.00016	0.00020
YxP	**5**	0.00057	0.00036	0.00037
AxP	**45**	0.00825	0.01133	0.01007
YxAxP	**45**	0.00015	0.00014	0.00018

Table 4: Effect of accession and poultry manure rate on Amino acid content of grain amaranth in 2014 and 2015

	2014			**2015**		
Accession	**Lysine**	**Iso-Leucine**	**Tryptophan**	**Lysine**	**Iso-Leucine**	**Tryptophan**
			g/16 gN			
AMES 2055	0.80f	0.68h	0.66f	0.80f	0.69h	0.68d
AMES 5644	0.83c	0.71f	0.67e	0.82d	0.705	0.67e
PI 337611	0.85b	0.74c	0.69c	0.85b	0.74c	0.69c
PI 477913	0.82d	0.70g	0.69c	0.82d	0.70g	0.69c
PI 576460	0.82d	0.71f	0.68d	0.82d	0.71f	0.68d
PI 576464	0.81e	0.72e	0.70b	0.81e	0.73d	0.70b
PI 576480	0.82d	0.76a	0.69c	0.83c	0.75b	0.71a
PI 633596	0.86a	0.73d	0.68d	0.86a	0.735	0.69c
PI 641049	0.82d	0.74c	0.68d	0.83c	0.74c	0.69c
PI 641055	0.83c	0.74c	0.69c	0.83c	0.75b	0.69c
Poultry Manure rate						
5 t/ha	0.82c	0.69c	0.59d	0.81d	0.69d	0.59d
10 t/ha	0.82c	0.72b	0.63cd	0.82c	0.73abc	0.71abc
15 t/ha	0.86a	0.78a	0.70ab	0.87a	0.75a	0.72ab
20 t/ha	0.79d	0.73b	0.78a	0.80d	0.74ab	0.78a
NPK	0.85b	0.74b	0.74ab	0.86ab	0.72abca	0.62cd
Control	0.82c	0.73b	0.72abc	0.82c	0.72bc	0.71abc

Table 5: Interaction of accession and poultry manure rate on amino acid (g/16gN) content of grain amaranth in 2014 and 2015

		2014			2015		
Accession	**Poultrymanure (t.ha^{-1})**	**Lysine**	**Iso-Leucine**	**Tryptophan**	**Lysine**	**Iso-Leucine**	**Tryptophan**
				g/16 gN			
AMES 2055	5	0.81d-i	0.7e-k	0.6l-p	0.80e-j	0.7m	0.6v
AMES 5644		0.77hij	0.67i-l	0.58o-p	0.75ijk	0.66p	0.58w
PI 337611		0.88a-d	0.73c-j	0.62k-p	0.88a-e	0.72k	0.62u
PI 477913		0.83b-h	0.64jkl	0.61k-p	0.82c-j	0.64q	0.6v
PI 576460		0.86a-f	0.62kl	0.56op	0.85c-g	0.61r	0.55y
PI 576464		0.84b-h	0.69g-k	0.62j-p	0.83c-i	0.72k	0.6v
PI 576480		0.80e-i	0.74c-i	0.57nop	0.80e-j	0.74i	0.58w
PI 633596		0.79f-i	0.66i-l	0.59l-p	0.80e-j	0.66p	0.6v
PI 641049		0.86a-f	0.82bc	0.6l-p	0.84c-h	0.8c	0.6v
PI 641055		0.75ij	0.68g-k	0.55p	0.74jk	0.68p	0.54z
AMES 2055	10	0.84b-h	0.73c-j	0.68e-n	0.84c-h	0.7m	0.63t
AMES 5644		0.79f-i	0.68g-k	0.57nop	0.80e-j	0.73j	0.72k
PI 337611		0.80a-f	0.73c-j	0.64i-p	0.81d-i	0.73j	0.69n
PI 477913		0.77hij	0.68g-k	0.58m-p	0.77h-k	0.7m	0.69n
PI 576460		0.82c-i	0.75b-i	0.66h-p	0.82c-j	0.68p	0.7m
PI 576464		0.80a-f	0.7e-k	0.64i-p	0.81d-i	0.71l	0.72k
PI 576480		0.80a-f	0.76b-h	0.67g-o	0.80e-j	0.74i	0.72k
PI 633596		0.83b-h	0.72d-j	0.56op	0.82c-j	0.76g	0.73j
PI 641049		0.83b-h	0.77b-g	0.62j-p	0.83c-i	0.79d	0.72k
PI 641055		0.87a-e	0.69f-k	0.66h-p	0.88a-e	0.76g	0.77f
AMES 2055	15	0.87a-e	0.7e-k	0.66h-p	0.96a	0.6s	0.67p
AMES 5644		0.86a-f	0.71e-k	0.76a-h	0.84c-h	0.73j	0.65r
PI 337611		0.85b-g	0.76b-h	0.64i-p	0.85c-h	0.82a	0.8c
PI 477913		0.93a	0.79bcd	0.69d-l	0.88a-e	0.78e	0.74i
PI 576460		0.84b-h	0.77b-g	0.66h-p	0.84c-h	0.76g	0.79d
PI 576464		0.88a-d	0.73c-j	0.75a-i	0.90abc	0.76g	0.69n
PI 576480		0.81d-i	0.84ab	0.72b-j	0.81d-j	0.77f	0.73j
PI 633596		0.88a-d	0.92a	0.77a-g	0.95ab	0.81b	0.69n
PI 641049		0.89abc	0.8bcd	0.69d-l	0.87b-f	0.7m	0.72k
PI 641055		0.83b-h	0.79bcd	0.66h-p	0.82c-j	0.81b	0.76g
AMES 2055	20	0.81e-i	0.68g-k	0.85a	0.81d-j	0.73j	0.79d
AMES 5644		0.86a-f	0.75b-i	0.81abc	0.84c-h	0.71l	0.76g
PI 337611		0.80e-i	0.72d-i	0.81abc	0.81d-j	0.72k	0.75h
PI 477913		0.75ij	0.71d-k	0.79a-e	0.74jk	0.77f	0.85a
PI 576460		0.70j	0.66i-l	0.8a-d	0.71k	0.76g	0.73j
PI 576464		0.78ghi	0.7e-k	0.73b-j	0.77h-k	0.75h	0.82b
PI 576480		0.77hij	0.74c-i	0.8a-d	0.79f-k	0.76g	0.8c
PI 633596		0.84b-h	0.78b-f	0.73b-j	0.84c-h	0.75h	0.76g
PI 641049		0.82c-i	0.77b-g	0.8a-d	0.83c-i	0.69n	0.77f
PI 641055		0.81d-i	0.75b-i	0.72b-k	0.82c-j	0.75h	0.78e
AMES 2055	NPK	0.80e-i	0.74c-i	0.77a-g	0.82c-j	0.73j	0.68o
AMES 5644		0.88a-d	0.7e-k	0.74b-g	0.88a-e	0.68o	0.5y
PI 337611		0.90ab	0.72d-i	0.72b-k	0.90abc	0.73j	0.64s
PI 477913		0.84b-h	0.76b-h	0.74b-g	0.85c-h	0.66p	0.58w
PI 576460		0.86a-f	0.75b-i	0.72b-k	0.86b-g	0.74i	0.66q
PI 576464		0.84e-i	0.73c-j	0.7c-l	0.86b-g	0.7m	0.64s
PI 576480		0.86a-f	0.77b-g	0.8a-d	0.88a-e	0.76g	0.67p
PI 633596		0.88a-d	0.84ab	0.73b-j	0.89a-d	0.73j	0.57x
PI 641049		0.79f-i	0.68g-j	0.74b-g	0.80e-i	0.77f	0.64s
PI 641055		0.84b-h	0.75b-i	0.78a-f	0.84c-h	0.7m	0.66q
AMES 2055	Control	0.78ghi	0.58l	0.66g-p	0.78f-k	0.7m	0.69n
AMES 5644		0.78ghi	0.72d-j	0.65i-p	0.83c-i	0.72k	0.76g
PI 337611		0.81d-i	0.75b-i	0.79a-e	0.83c-i	0.77f	0.64s
PI 477913		0.81d-i	0.78b-f	0.75a-i	0.81c-j	0.66p	0.7m
PI 576460		0.81d-i	0.76b-h	0.77a-g	0.79f-k	0.7m	0.66q
PI 576464		0.83b-h	0.75b-i	0.68e-n	0.77g-k	0.74i	0.75h
PI 576480		0.87a-e	0.77b-g	0.73b-j	0.83c-i	0.77f	0.73j
PI 633596		0.83b-h	0.74c-i	0.69d-m	0.86b-g	0.7m	0.76g
PI 641049		0.85b-g	0.68g-j	0.7c-l	0.81c-j	0.7m	0.71l
PI 641055		0.85b-g	0.73c-j	0.76a-h	0.85c-h	0.78e	0.67p

DISCUSSION

The significant difference in the amino acid contents of lysine, Iso-Leucine and Tryptophan of the ten grain accessions used may be due to their genetic differences. It can also be due to difference in the nature of their aspartate and biosynthesis pathway with the long distance transportation from synthesis organ to storage organ (Le *et al.,* 2016). According to Hesse et al, (2004) and Le *et al*, (2016), dihydrodipicolinate synthase plays an important role for lysine accumulation. Thus the level of dihydrodipicolinate synthase in each of these ten grain accessions used varied and this resulted to difference in the lysine accumulation or content after planting. This confirmed the report of Galvez *et al.,* (2008) that lysine metabolic regulatory in the seeds may be different among plant species. Anthranilate synthase is responsible for tryptophan accumulation in plants and it sufficiently controls tryptophan accumulation in plants (Zhang *et al*, 2014). Variation of plants Anthranilate synthase could determine tryptophan accumulation as it occurred among accessions of grain amaranth used in this study. Zhang *et al*, (2014) reported that anthranilate synthase and protein level can influence tryptophan biosynthetic capacity.

Highest Lysine and Iso-leucine contents that increased with increasing rate of poultry manure were observed in this study when the plants were grown in both years with 15 t.ha^{-1} poultry manure. This could be as a result of high potassium content of the manure which increased with increase in the amount of the manure used. Potassium has been reported to be responsible for activation of enzymes that metabolize carbohydrates for synthesizing amino acid and proteins (Kow and Nabwami, 2015). It is believed that higher content of potassium in 15 t.ha^{-1} used accelerated the activation of enzymes that were responsible for synthesis of amino acid in the grain amaranth planted. This buttresses the reports of Lavon and Goldschmidt (1999); Mengel (1999); Ani and Baiyeri(2008) that potassium activates biochemical processes in the plant, particularly its ability to make proteins. The increase in the concentration of protein as the manure rate increased may probably be due to an increase in potassium. This is because the increase in poultry manure rate increased the concentration of potassium, which is an important mineral in fruit quality (Costa *et al*, 2006; Ani and Baiyeri 2008). Teutonico and Knorr (1985) reported that in raw grain amaranth seeds, lysine content of 5.1% was recorded which was higher than the value obtained in this study.

Tryptophan content was observed highest with 20 t.ha^{-1}poultry manure and with NPK application. This variation can be attributed to variation in environmental factors in both years. Brenner (2002) in his studies mentioned that amaranth's response strongly depends on environment, because organic systems use water more efficiently due to better soil structure formed and higher levels of organic matter particularly humus (Handrek and Black(2002).

The significant difference in the interaction of grain amaranth and manure rate on the amount of amino acid (Lysine, Isoleucine and Tryptophan) showed that grain amaranth accession planted with the different manure rates responded differently. This could be due to differences in the genetic makeup of the grain accessions used, and also as a result of variation in environmental factors during both years such as rainfall amount during the grain amaranth growth. It could also be as a result of nutrients released by the manure to the plants during the growth phase and the biosynthesis of the amino acid of the plants which affects the enzymatic activities.Poultry manure application in high rates enhances the quantities of Lysine detectable in the grains. Based on the high lysine content of grain amaranth planted with poultry manure, food manufacturers should be encouraged to include the grain flour as a protein supplement in breakfast and baby cereals at home, and in school feeding programs. Grain amaranths should be grown with poultry manure at 15t.ha^{-1}in place of synthetic fertilizers for appreciable amounts of grain amino acid content.

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