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DEVELOPMENT OF QUALITY PROTEIN MAIZE: BIOCHEMICAL AND AGRONOMIC EVALUATION

[DESARROLLO DE MAÍZ QPM: EVALUACIÓN BIOQUÍMICA Y AGRONÓMICA]

S.A. Olakojo*, O. Omueti, K. Ajomale and B.A. Ogunbodede

Institute of Agricultural Research and Training, Obafemi Awolowo University, P. M. B. 5029, Moor Plantation, Ibadan, Nigeria
**Corresponding author*

SUMMARY

Experiments were conducted on six newly developed Quality Protein Maize (QPM) lines to assess their lysine and tryptophan levels, and their suitability for cultivation in major agro-ecological zones of Nigeria. The results showed that the QPM lines varied from one to another, with respect to crude protein, *zein* dry matter, crude *zein*, lysine and tryptophan ($P<0.01$). Percentage crude protein varied between 6.22 and 8.75%, while % lysine and tryptophan were in the range of 3.31 to 3.72 and 0.49 to 0.87 respectively. Lysine was positively correlated to zein, while tryptophan was positively correlated with crude protein. There was a Location effect for plant height, while Variety x Location interaction was found for days to 50% silking ($P<0.05$). Mean grain yields across varieties and locations ranged between 0.25 (Amakama) and 4.50t/ha (Ibadan). ART98-SW6-OB and ILE1-OB appeared to be superior with higher lysine and tryptophan contents. Other agronomic and biochemical details of the QPM were discussed.

Key words: Quality protein, tryptophan, lysine, grain yield.

RESUMEN

Se evaluaron seis líneas de maíz QPM en relación a su contenido de lisina y triptófano y su valor para cultivo en zonas agroecologicas de Nigeria. Los resultados muestran que las líneas de maíz QPM tuvieron una gran variación en cuanto a su contenido de proteína, zeina, lisina y triptófano ($P<0.01$). El contenido de proteína cruda osciló de 6.22 a 8.75%, mientras que lisine y triptófano se encontraron en el rango de 3.31 a 3.72 y 0.49 a 0.87 respectivamente. La lisina estuvo correlacionada con la zeína y triptófano con la proteína cruda. Se encontró un efecto de localidad para altura de la planta. La producción de grano varió de 0.25 en Amakama a 4.50t/ha en Ibadan. ART98-SW6-OB e ILE1-OB parecen ser las variedades superiores y con un mayor contenido de lisina y triptófano. Otras características agronómicas y bioquímicas son discutidas.

Palabras clave: Maíz QPM, triptófano, lisina, producción de grano.

INTRODUCTION

Maize (*Zea mays L*) is an important cereal crop in Africa serving as source of food and industrial raw material for industries such as brewery, confectionary, livestock and flour feed mills (Olakojo, 2001). Maize is also known to be primary provider of calories supplying 20% of the world's food calories. It also provides 15% of all food crop protein (National Research Council, 1988). The poor nutritive value of maize grains is due to low contents of lysine and tryptophan in the maize protein component (Obi, 1980). Nevertheless, identification of Opaque-2 mutant gene by Bjarmason and Vasal, (1992) as the most amenable genotype for use in breeding programme for Quality protein maize (QPM) had changed the opinion of people about nutritive quality of maize.

The resulting maize is therefore known as quality protein maize (QPM) which has twice the lysine and tryptopham of normal maize. It also has much lower ratio of leucine to isoleucine than normal maize. There were also many data indicating that, when maize is the only source of dietary protein (as seen in many African countries). QPM is of tremendous advantage over normal maize (Bressani, 1992). It is a common phenomenon that many African babies are being fed with maize-base diets as weaning foods. This probably suggests the need to replace normal maize with QPM especially for the benefit of the babies and nursing mothers.

Maize nutritional studies showed that Opaque-2 maize protein was a quality protein compared to normal maize. It contains lysine and tryptophan which are essential amino acids for growth and development. Efforts at developing quality protein maize (QPM) at national, regional and international levels have therefore increased with a view to developing maize with high levels of lysine and tryptophan through breeding programmes. Pixley, (2000) thus highlighted steps to be taken in QPM breeding. These include conversion of broad-based populations and composites to Opaque-2, and selection of kernels with modifier genes that give the endosperm a normal or translucent appearance. This according to Pixley, should be done without relinquishing the increased protein quality contributed by the Opaque-2 gene.

Major problem confronting QPM breeding is the determination of maize with Opaque-2 gene and the expensive and cumbersome nature of assessing tryptophan and lysine content of QPM. Several methods have been proposed. These include use of light table, whereby segregating QPM kernels are spread on top of the acrylic surface, and with light switch on inside the box. Kernels are thereby classified according to the degree of endosperm modification. Kernels with 10 – 30% Opaque areas usually have good quality protein. Other methods include laboratory procedures described by Villegas *et al*., (1984), ELISA method highlighted by Wallace *et al,* (1990) and Marker Assisted Selection (MAS) used by CYMMIT in Mexico. The disadvantage of MAS is the expensive nature of the technology.

At the Biochemistry Laboratory of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, combination of light table and turbidimetric rapid method described by Drochioiu *et al;* (2002) was adopted for determination of lysine and tryptophan content of the developed QPM varieties even though a digitalized amino acid analyzer is available. This is because the method is simple, accurate, reproducible, cheaper to use and very suitable for large number of samples. The chemicals required for this analysis were also relatively available and affordable.

The importance of maize in the diet and farming system of many African countries can not be over emphasized. Available protein daily intake is generally low in tropical Africa (5g in Nigeria), compared to 46-56g for an average person and 96g for pregnant and lactating women as recommended by Food and Nutrition Board of National Academy of Science, Food and Nutrition Board, (1980). Millions of African children and nursing mothers therefore, suffer from protein deficient inducing diseases because of poverty. On the other hand, few individual adults who could afford the right quantity and quality animal protein are skeptical of the inherent heart diseases, sometimes occasioned by body accumulated cholesterol. Breeding and production of quality protein maize therefore stands out as an alternative protein source for poor-resource African farmers and its teeming population. The QPM is cheaper, more affordable and easy to produce compared to animal protein.

The objectives of this study therefore were (i) To assess some QPM varieties that were developed for acceptable level of lysine and tryptophan. (ii.) Evaluate them at various agro-ecological zones for agronomic and yield performance, and suitability for planting in some maize producing belts of Nigeria. (iii.) And to make available seeds of desirable lines through the National Seed distributing System for propagation and utilization.

MATERIAL AND METHODS

Laboratory experiments:

Six newly developed QPM varieties were selected for the study. The varieties which included TZPB-OB, ART98-SW4-OB, ART98-SW5-OB, ART98-SW6-OB, ILE1-OB and Obatampa (check entry), were milled to fine flour. Samples (1-2g), were defatted with petroleum ether in a soxhlet apparatus and the resulting flour dried to 10-12% moisture. Samples from 50-200mg of defatted maize flour were placed in 25ml or 50ml Erlenmeyer flask containing 5-20ml ethanol having 0.5% sodium acetate. The flasks were stoppered, shaken for 1hr, and the solution filtered.

One milliliter of filtrate was pipetted into Colorimeter tube and 5ml (2.5% aqueous) trichloroacetic acid (TCA) solution added. The mixture was shaken vigorously and after standing for an hour, the absorbance of each sample was thereafter read at 440-nm in 1cm path cuvettes, using a spectrometer or colorimeter. The absorbance was measured against a mixture of 1ml water and 5ml TCA. The analysis was repeated thrice for each sample. Prolamin concentration was calculated from a standard curve based on value, for prolamin as a percentage of dry matter (DM). Thus, the absorbance of 18 samples (three from each variety) was read for the QPM. Consequently, the content of each sample (alcohol-soluble protein) was determined from nitrogen content values as detailed below.

Duplicate samples of the material were each extracted in 20ml of ethanol for an hour. The contents of the flasks were filtered and each 20ml of filtrate was evaporated in a 100-ml Kjeldahl flask to dryness. Nitrogen content was assayed using a classical micro-kjedahl procedure (Villegas and Merbz, 1975). The values for nitrogen content were multiplied by 6.25 to give the prolamin content of maize grain samples.

Since a highly significant correlation had been established between zein (maize prolamin) content in ethanol and the turbiding of the sample r = 0.99 (Drochioiu *et al*, 2002). The equation governing the regression therefore was

$y = 725.01 x + 0.218$

Where:
y = zein concentration expressed as µg ml^{-1}, in ethanol and
x = the absorbance at 440-nm in a 1cm glass cuvette.

The value of nitrogen content was assayed using the microkjeldahl procedure. These values were multiplied by 6.25 to determine crude protein content of each sample.

% zein in dry matter = % crude protein x 0.386 – 2.22

Relationship between lysine and tryptophan had also been established by Hernanvas and Bates (1996), and confirmed by Drochioiu *et al*., (2000). The % lysine was calculated from the relationship

$y = 0.347x + 3.7185$

Where:
x = % zein in dry matter and
y = % lysine

Since lysine and tryptophan contents in the samples were highly correlated, tryptophan was calculated from the relationship;

% lysine = % tryptophan x 3.04 + 0.5

Data taken from the samples included % crude protein, zein crude, lysine and % tryptophan. They were statistically analyzed using Gensat software to compute mean square (MS) for each parameter at P<0.01, while differences in character means were determined using LSD. The degree of variation was determined using % co-efficient variation, all at P<0.05. Correlation coefficient were computed for pairs of parameters taken at P<0.05 to assess the level of their relationships.

Field evaluation for agronomic performance

The earlier identified six QPM varieties and an additional one (ART98-SW1-OB) were selected for the evaluation in three locations Ibadan (Rainforest), Amakama (High rainforest) and Eruwa (Derived savanna) representing the major agro-ecological zones of Nigeria. The evaluation took place in 2004 and 2005 cropping seasons. Land preparation were done mechanically in each of the location by two ploughing and one regime of harrowing. Plantings were done on 4-row plots of 3 x 5m at spacing of 75 x 50cm, with 3 seeds per hill. This was later thinned to 2 stand/hill three weeks after planting to obtain a population density of 53,333 per hectare.

NPK 20-10-10 fertilizer was applied at 200kg/ha three weeks after planting, and, 100kg/ha 2 weeks before anthesis. Weed control was done chemically by use of 5 litres per hactare pre-emergence herbicides (a. i. 3kg/l metolachlor and 170g/l atrazine) and 2 litres per hectare post-emergence herbicides (a.i.3kg Paraquat). This was supplemented by a regime of hand weeding 6 weeks after planting.

Data were collected from the two middle rows of each plot at flowering stage. These parameters included: plant stand, days to 50% silking, plant and ear heights (cm), root lodging, husk tip cover, using ratings 1-5, where 1 = excellent, 2 = very good, 3 = good, 4 = fair and 5 = poor. Other yield related characters included plant and ear harvest, grain yield (t/ha), ear aspect and ear rot scores using ratings scale of 1-5. Data were collected from the three locations and were statistically analysed using Mstat. Mean squares were computed for all agronomic and yield related characters while significant differences were determined at P<0.05 and 0.01. Variety x location interaction were also determined, and pertinent means separated for significant parameters at P<0.05.

RESULTS

Table 1 shows seed characteristics of the QPM lines evaluated. The seed size varied from small (ILE1-OB) through medium (TZPB-OB, ART98-SW4-OB, ART98-SW6 and Obatampa) to large as found in ART98-SW5-OB, while seed colour and texture were flint and white in many of the varieties. ART98-SW6-OB was however of dent and flint. Percentage modified endosperm varied between 25 and 30% among the tested varieties.

Biochemical analyses of the QPM lines are presented in Table 2. Mean square (MS) for the crude protein, zein dry matter, zein in crude form, lysine and tryptophan were significantly different from one QPM line and another at P<0.01. The magnitude of MS ranged between 0.006 in tryptophan to 1823.1 in zein dry matter. Similarly, character means for the QPM lines are presented in Table 3. Crude protein were generally low ranging from 5.68 (ILE-OB) to 8.75% (ART98-SW5). Mean crude protein across varieties was 6.99. Zein (DM) was very low in ILE 1-OB with 0.04 compared to 0.84 for the check (Obatampa). ART98-SW5-OB yielded the highest amount of zein (DM) with 1.30%. Other fell within these two extreme

limits. Mean zein across varieties was 0.51%. Amount of zein ml/µg varied from 125.28 (TZPB-OB) and 191.62 (ART98-SW6OB). This character recorded across varietal mean of 149.46, with co-efficient of variation (C.V) 8.1%. Lysine content of the QPM lines varied significantly from one line to another. ILE-OB gave the highest amount of lysine with a value of 3.72%. Three of the QPM lines (TZPB-OB, ART98-SW4-OB and ART98-SW5-OB) compared favourably with reference check (Obatampa) with % lysine 3.55, 3.49 and 3.31%. The other two lines (ART98-SW6-OB and ILE1-OB) were superior to check with percentage lysine content of 3.67 and 3.72. These two QPM gave a lysine yield advantages of 3.38 and 4.78% respectively over check. The tryptophan contents also differed significantly from one QPM line and another. The trend was very similar to that of lysine, with two QPM lines (ART98-SW4 and ART98-SW5) slightly inferior to standard check recording 0.75 and 0.79% respectively. TZPB-OB and Obatampa (check) each yielded 0.81% tryptophan. ILE-OB and ART98-SW6 again exhibited superiority over check with 0.89% tryptophan content. Mean tryptophan content across varieties was 0.81% (Table 3).

Table 4 presents Pearson correlation coefficient (r) among various biochemical components of QPM lines. Crude protein content was significantly negatively correlated with lysine and zein contents, with co-efficient (r) = -0.91** and -0.93**. Crude protein in this trial was also positive and significantly correlated with tryptophan (r = 0.56**), it correlated positively and significantly with zein (DM) with co-efficient r = 0.71** and 0.06*. Tryptophan on the other hand was negatively and significantly correlated with zein (DM).

Mean squares (MS) for agronomic characters of QPM across locations are presented in Table 5. Location was significant for all agronomic characters assessed for the QPM lines. These includes plant stand, days to silking, plant and ear heights, root lodging, husk cover and plant aspect at P<0.05 and 0.01 respectively. The MS magnitude was relatively larger for plant stand, days to silking, as well as plant and ear heights with values of 4168.21, 126.20, 13978.81 and 5193.01 respectively. Variety was only significant for plant height, while variety x location interaction was highly and only significant (0.01) for days to silking (Table 5).

Table 6 presents mean square (MS) for yield related characters and ear rot ratings of the QPM lines across locations. Location was highly (P<0.01) significant for plant harvest, grain yield, ear aspect, ear harvest and ear rot ratings. The MS magnitudes were generally high for plant stand, plant and ear harvests and grain yield with a range of between 108.87 and 5783.15.

Mean separation under variety x location interaction for days to silking are presented in Table 7. The significant differences were as a result of differential performances of varieties such as ART98-SW1-OB and ART98-SW1-OB in Eruwa and Ibadan. For example, ART98-SW1-OB took 64 days to silk in Ibadan as against 51 days in Eruwa. ILE1-OB which silked within 48 days in Amakama took 65days to silk in Eruwa. The differences might not be unconnected with variation in climatological data and soil type of each location (Table 8). The amount of rainfall and temperature in Ibadan was relatively higher than in Eruwa. This was nevertheless, an advantage for enhanced higher yield especially for late season planting. On the other hand, Amakama is an area of high precipitation with acid soil (pH of 5.0-5.5). Thus, poor adaptation and reduced grain yield as seen from this study.

Table 1. Seed characteristic of QPM evaluated.

Variety	Seed size	Seed colour	Texture	% modified endosperm
TZPB-OB	Medium	White	Flint	25.0
ART98-SW4-OB	Medium	White	Flint	30.0
ART98-SE5-OB	Large	White	Flint	27.0
ART98-SW6-OB	Medium	White	Dent/Flint	30.0
ILE1-OB	Small	White	Flint	30.0
OBATAMPA (check)	Medium	White	Flint	28.0

Table 2. Mean square for crude protein and essential amino acid contents of the QPM.

Source of Variation	DF	Crude protein	Zein (DM)	Zein crude	Lysine	Tryptophan
Replicate	3	0.25	0.0025	2.64	0.0044	0.00014
Variety	5	3.45**	1823.1**	0.59**	0.063**	0.006**
Error	12	0.06	0.58	0.02	0.001	0.00004
Total	20					

** Significant at P<0.01

Table 3. Character means of essential amino acids and crude protein of the QPM varieties.

Variety	Crude protein (%)	Zein (DM) (%)	Zein crude ml/µg	Lysine (%)	Tryptophan (%)
TZPB-OB	7.00	0.48	128.27	3.55	0.81
ART98-SW4-OB	7.43	0.65	157.18	3.49	0.49
ART98-SW5-OB	8.75	1.30	156.07	3.31	0.75
ART98-SW6-OB	6.12	0.14	191.62	3.67	0.87
ILE1-OB	5.68	0.04	125.28	3.72	0.87
OBATAMPA (check)	7.00	0.48	138.32	3.55	0.81
Mean	6.99	0.51	149.46	3.54	0.81
C.V (%)	11.8	0.50	28.10	0.90	0.8
LSD (0.05)	0.44	0.26	1.36	0.06	0.01

Table 4. Correlation coefficient (r) of amino acids and crude protein among the QPM varieties.

	Crude protein	Lysine	Tryptophan	Zein	Zein (DM)
Crude protein	-				
Lysine	-0.91**	-	-	-	-
Tryptophan	0.56**	0.86**	-	-	-
Zein	-0.93**	0.71**	-0.27	-	-
Zein (DM)	-0.45	0.60*	-0.67*	0.21	-

*, ** Significant at P<0.05 and 0.01 respectively

Table 5. Mean square for QPM agronomic characters across locations.

Source of variation	DF	Days to silking	Plant stand	Plant height	Ear height	Root lodging	Husk cover	Plant aspect
Replication (R)	2	59.06	10.63	407.52	29.91	0.33	1.15*	1.20
Location (L)	2	126.20*	4168.21**	13978.81**	5193.01**	5.09**	3.82*	4.39**
Variety (V)	6	65.92	10.31	506.77*	213.76	0.53	0.10	0.41
V x L interaction	12	113.98**	13.00	198.83	119.97	0.81	0.17	0.53
Error	40	8.25	37.88	208.33	76.01	0.90	0.39	0.56
Total	62							

*, ** Significant sat P<0.05 and 0.01 respectively

Table 6. Mean square for QPM yield related characters and ear rot rating across locations.

Source of variation	DF	Plant harvest	Grain yield	Ear aspect	Ear harvest	Ear rot
Replication (R)	2	13.82	0.84	0.11	4.39	0.02
Location (L)	2	2663.30**	108.87**	5.82**	5783.15**	6.30**
Variety (V)	6	37.78	0.86	0.51	15.40	0.18
V x L interaction	12	195.84	0.42	0.68	150.34	0.56
Error	40	1314.35	0.39	0.74	1271.21	0.59
Total	62					

** Significant sat P< 0.01 respectively

Performances of the QPM lines for grain yield across locations are presented in Table 9. Grain yields varied from 3.97t/ha (ART 98 – SW6-OB) to 4.97t/ha (ILE 1-OB) in Ibadan. Across variety mean yield was 4.5t/ha in Ibadan. Yield was generally low in Amakama (an acid soil environment) ranging from 0.14 (ART 98-SW1-OB) to 0.4tha (Obatampa). Yield was also low in Eruwa though a good maize producing belt, this was however as a result of drought experienced during anthesis). Nevertheless, QPM lines such as ART 98-

SW1-OB- ART 98-SW6-OB, ILE 1-OB and Obatampa were able to produce above 1 ton/ha in this location even under moisture stress (Table 9).

Table 10 presents the reaction of the QPM lines to ear rot under natural infection. Maize lines were fairly tolerant to ear rot with reduced ratings of below 2.5 in Ibadan and Amakama. ART 98-SW6-OB, ILE1-OB and Obatampa also recorded similar performance at Eruwa, while TZPB-OB, ART98-SW4-OB and ART98-SW1-OB were slightly susceptible to ear rot in Eruwa with ratings of between 3.0 and 3.33 (Table 10).

Table 7. Variety x location means for days to 50% silking.

Variety	Ibadan	Amakama	Eruwa
TZPB-OB	55.67	53.00	62.67
ART98-SW-4-OB	54.67	53.67	51.67
ART98-SW1-OB	64.00	53.00	51.33
ART98-SW5-OB	64.00	57.00	63.67
ART98-SW6-OB	50.33	56.67	62.00
ILE1-OB	59.67	48.33	65.33
Obatampa	61.67	55.33	45.00
Mean	58.57	53.86	57.38
LSD (0.05)			10.16

Table 8. Climatological information and soil classification of the QPM trial locations.

Location And Year	Longitude	Latitude	Rainfall (mm) 2004	Rainfall (mm) 2005	Temperature °C Min. 2004	Temperature °C Max. 2004	Temperature °C Min. 2005	Temperature °C Max. 2005	Soil classification
Ibadan	3°54'E	7°26'N	1145	1465.0	21.0	30.0	20.29	30.61	Ustalfs,with medium Nitrogen (0.16-0.20%); low phosphorus (3-7 $mgkg^{-1}$); pH(6.1-6.5); potassium (0.31-0.36 $cmolk^{g-1}$); Organic carbon (0.4-1.0%).
Amakama			1530	1227.5	20.00	30.2	20.0	29.0	Ultisol with medium Nitrogen (0.16-0.20%); Phosphorus (7-20 $mgkg^{-1)}$ pH(5.0-5.5); Potassium 0.12-0.2 $cmolk^{g-1}$); Organic carbon (1.0-1.4%);
Eruwa	3°24'E	7°25'N	1140	1360.0	21.8	31.0	20.8	30.0	Ustalfs,with medium Nitrogen (0.16-0.20%); low phosphorus (3-7 $mgkg^{-1}$); pH(6.1-6.5); potassium (0.31-0.36 $cmolk^{g-1}$); Organic carbon (0.4-1.0%).

Source:Adapted from National Special Programm for Food security (FAO), Nigerian Soil maps, 2005.

DISCUSSION

The importance of QPM cannot be over emphasized in Tropical Africa. The need for cheap, readily available and affordable source of protein is imperative for the teaming African population especially at rural level and more importantly for lactating mothers and babies. In this study, the QPM lines tested possessed modified endosperm of 25 to 30% as suggested by Pixley, (2001). These lines, shall, therefore be suitable for further QPM cultivar development and, for direct QPM production. Bressani, (1992), had earlier confirmed the tremendous advantage of QPM over normal maize.

In the present study, the tested QPM lines differed significantly from one another with respect to percentage crude protein, zein DM, zein crude, lysine

and tryptophan. Similar observations were made by Obi, (1982), when lysine content of some maize varieties tested varied significantly at P<0.05 from one variety to another. This probably suggests high variability that exists in maize genotypes with respect to these biochemical components. Plant breeders may therefore found this attribute useful in genetic manipulation and cultivar development for enhance protein biochemical components.

Table 9. Performance of QPM varieties for grain yield t/ha in different locations.

Variety	Ibadan	Amakama	Eruwa
TZPB-OB	4.06	0.20	0.66
ART98-SW-4-OB	4.90	0.30	0.93
ART98-SW1-OB	4.67	0.14	1.06
ART98-SW5-OB	4.67	0.20	0.76
ART98-SW6-OB	3.97	0.23	1.07
ILE1-OB	4.97	0.33	1.32
Obatampa	4.96	0.40	2.53
Mean	4.5	0.25	1.18
LSD (0.05)			0.38

Table 10. Reaction of QPM lines to ear rots in each location.

Variety	Ibadan	Amakama	Eruwa
TZPB-OB	1.67	2.00	3.00
ART98-SW-4-OB	1.33	2.00	3.00
ART98-SW1-OB	1.67	2.33	3.00
ART98-SW5-OB	1.00	2.33	3.33
ART98-SW6-OB	2.00	2.00	2.67
ILE1-OB	2.00	2.33	2.00
Obatampa	1.67	2.00	2.00
Mean	1.62	2.14	2.71
LSD(0.05)			0.48

Protein quality in maize, especially lysine was negatively correlated with grain protein content in this study. Pixley and Bjarnason, (1993) also reported the need for monitoring both protein content of grains as well as tryptophan and lysine while breeding or selecting for QPM. This will ensure desirable levels of these amino acids of the evolving genotypes, the performance of QPM evaluated at different locations showed that location effect differed significantly for the QPM varieties with respect to all agronomic characters. V x location interaction also differed significantly for days to silking. In the same vein, yield related parameters such as plant harvest, grain yield, ear harvest, ear aspect and ear rot resistance also differed from one location to another. This suggests that climatic effects of individual location (rainfall, humidity, temperature and volume of ear rot pathogen) varied from one location to another. Olakojo, (2000), Olakojo *et al.,* (2005) and Olakojo *et al.,(* 2005b) reported similar findings. The implication of this V x L interaction is that, newly developed QPM varieties should be tested for yield, agronomic performance, adaptation and stability before release for use.

Findings from research on QPM have shown that mutant maize with modified endosperm is usually with brittle texture, susceptibility to insect pests and of inferior functional characteristics when used for flour production (Brenda *et al*, 2002). Opaque-2 maize however, stands out to be useful quality protein maize. Breeding of QPM using different available laboratory methods (Drochiou *et al*, 2000), and the use of Opaque modified endosperm maize with capacity for accumulated soluble lysine (Ricardo *et al,* 2003), as source of gene for QPM will no doubt enhance and promote production of QPM.

CONCLUSION

From the present study, QPM lines evaluated are generally of considerable lysine and tryptophan content. ART98-SW6-OB and ILE1-OB seem superior to others with percentage lysine of 3.67 and 3.72 and tryptophan levels of 0.87% for each of the genotypes. Even-though, yield varied widely (0.14 to 4.97t/ha) among QPM lines at different locations, as a result of acid soil of Amakama and the drought experienced in Eruwa. This consequently resulted in low yields from these two locations. Nevertheless, ART98-SW4-OB, ILE1-OB and Obatampa are proportionately consistent in all locations for grain yield. These varieties are therefore, generally suitable for evaluation in Southwestern Nigeria, and southern guinea savanna ecology of the country. Hence, recommended for on-farm trial for possible release to farmers.

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