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On-farm evaluation and dissemination of Quality Protein Maize and High Protein Maize varieties in Nigeria

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Abstract
The paper presents on-farm evaluation and dissemination efforts on Quality Protein Maize (QPM) and High Protein Maize (HPM) varieties developed by the Institute of Agricultural Research and Training, Nigeria. The study was conducted in seven states of Nigeria comprising Kaduna, Niger, Bauchi, Ondo, Oyo, Ogun and Osun. Multi-stage sampling procedure was used for the selection of participating communities and farmers. On-farm trials were conducted during 2008 and 2009 cropping seasons in twenty-one predominantly maize growing communities of seven states in collaboration with Agricultural Development Programmes (ADPs) to introduce farmers to the improved maize varieties. Demonstration plots were also established on 66 farmers' fields across the selected states between 2010 and 2015. The major methods of dissemination used were demonstration plots, training of trainers and field days. Field records, and structured interviews were dominant instruments for data collection. Descriptive and inferential statistical tools were used to analyse the data collected. The results of the on-farm evaluation showed that QPM varieties gave the highest grain yield in all locations except Osun state. Sensory evaluation showed that QPM varieties were most preferred for corn soymilk and compared favourably with the farmers' local variety. HPM was preferred in terms of colour, flavour, texture and taste for most of the products except for corn soymilk. The mean score for the maize varieties as ranked by farmers revealed that farmers had high preference for QPM than the High Protein and local maize varieties in terms of yield potential, maturity days, tolerance to drought, grain size, resistance to diseases and insect pests. Farmers however, indicated low preference for white seeded variety of QPM. The results are useful for validation of the promising attributes of QPM and HPM and also for breeding improved QPM and HPM varieties in the future.
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Keywords: Demonstration, High protein maize, Promotion, Quality protein maize,

Introduction
Maize (*Zea mays L*) is one of the major crops grown in Nigeria. It is composed mainly of starch or carbohydrate (65-84%), protein (7-10%), moisture (10-15%), fat (3-5%), fibre (2-3%), ash (3%) and with energy calorie of about 410 calories (Ihekoronye and Ngoddy, 1985). It is a dominant staple consumed in diverse forms in all the geo-political zones of Nigeria as breakfast, lunch or dinner meals. It is also very important in child weaning, and as meals for the sick as well as the immune-compromised.

Quality Protein Maize (QPM) and High Protein Maize (HPM) are nutritionally enhanced maize varieties than the conventional varieties of maize. In response to the problem of malnutrition in children and other farm families, a concerted effort was made by the Institute of Agricultural Research and Training to develop suitable maize varieties that can combat nutritional deficiency and also possess suitable technological options. Varieties of nutritionally enhanced maize called Quality Protein Maize (QPM) were developed and released in 2009 by the Institute of Agricultural Research & Training (I.A.R&T), Nigeria (Olakojo, 2014; I.A.R&T Compendium, 2019). This was borne out of the low protein intake of the

Nigerian populace where average daily protein consumption was 5g as against 46-56g prescribed by the National Academy of Science for Food and Nutrition (Olakojo, 2014).

The nutritional value of QPM, both as human food and as animal feed for poultry and pigs, had been widely demonstrated in many countries (Vasal, 2000; Prasanna *et al*., 2001; Atlin *et al*., 2010; Gunaratna *et al*., 2010). QPM varieties have been reported to have higher lysine and tryptophan content than the regular maize varieties. Nutritional evaluation of QPM has shown its superiority over the normal/conventional maize (Fufa *et al*, 2003). QPM has double the amount of lysine and tryptophan that are present in conventional maize varieties which makes them important in addressing malnutrition especially among the poor (Lauderdale, 2000). The QPM varieties are both open-pollinated and early maturing. QPM (ART-98 -SW-6-OB) has a lysine level of 3.67% and tryptophan level of 0.89%, while QPM (ILE-1-OB) has lysine level of 3.72% and tryptophan level of 0.89% (Table 1). They are both tolerant to major fungal (downy mildew) and viral diseases (maize streak virus). The HPM (ART-96-SW-1) on the other hand is a high protein maize where the male parent is sweet corn and the female parent is Suwan-1-SR. Crude protein content of HPM is between 12.8% and 14.2% (Lawal *et al,* 2014).

Normal or conventional maize grain is deficient in essential amino acids- lysine, tryptophan and methionine (Mertz *et al*., 1965; Huang *et al,* 2006; Akalu *et al*., 2008; Edusei *et al*., 2008; Atlin *et al*. 2010). Quality Protein Maize (QPM) combines the high nutritional quality of opaque-2 gene (high lysine and high tryptophan) (Enwere, 1998). Consumption of Quality Protein Maize varieties has been reported to lead to greater protein utilization (Mbuya, 2010). Feeding trials with QPM significantly improve Protein-Energy Malnutrition and stop pellagra, a disease caused by insufficient intake of nicotinamide or its precursor tryptophan (Enwere, 1998).

Nutritionally enhanced crops are highly effective in combating malnutrition where large number of poor people eat large quantities of staple food, as is the case in rural areas of many developing countries, including Nigeria. Unlike other strategies to improve nutrition, such as improving the diet through home gardens or education, nutritionally enhanced foods can reach large groups of rural people cheaply, without changing their dietary habits.

QPM and HPM have demonstrated great productivity potential in adding nutritional value to resolve protein deficiency in areas where maize is a major

Table 1: Casein, lysine and tryptophan contents of Quality Protein Maize in comparison with other maize varieties.

Maize varieties	Protein quality (% casein)	Lysine (g/100g protein)	Tryptophan (g/100g protein)
Regular maize	32.1	2.90	0.51
Opaque- 2 maize	96.8	4.00	0.70
Quality protein maize	82.1	3.67	0.87

Source: Olakojo, 2014

staple. Thus, the varieties provide better options for farm families therefore contributing to household and nutritional security in Nigeria. Awareness and interest in the new varieties remain central to boosting food and nutritional security. From the foregoing the paper provides an evaluation of on farm trials and dissemination efforts aimed at popularising and enhancing technology adoption by maize farmers in Nigeria. Specifically, the objectives were to assess the agronomic and sensory characteristics of QPM and HPM varieties along with the popularly grown farmers variety, analyse dissemination methods and determine farmers' preference for the attributes of the improved maize varieties.

Methodology

The study area

The study was conducted in seven states of Nigeria which include Kaduna, Niger, Bauchi, Ondo, Oyo, Ogun and Osun states representing the North west, North central, North east and South west geopolitical zones. Agriculture is the mainstay and plays a vital role in the economy of the states. Maize cultivation is a major livelihood option for the agrarian population.

On-farm Evaluation

Multi-stage sampling technique was used to select predominantly maize growing communities and farmers for the study in collaboration with Agricultural Development Programmes (ADPs). The first stage entails selection of local government areas from each of the Agricultural Development zones. The second stage was the selection of predominantly maize growing communities from the selected local government areas. The third stage was the purposive selection of farmers from the selected communities. A total of twenty-one farmers were selected for the on-farm evaluation across the zones in all the states. Farmers were selected based on their innovativeness, years of experience in maize production, willingness to take risk and level of influence in the community. On farm research trials were sited on farmers' fields in all the locations.

The QPM varieties evaluated were ART-98 SW-6-OB and ILE-1-OB, while the HPM variety was ART-96-SW-1. The maize varieties were evaluated with the predominant local variety planted by farmers in each location. The plot size for each variety was 20mx20m. The experiment was laid out as a randomized complete-block design (RCBD). The plots served as demonstration and learning plots for farmers on improved agronomic practices. The trials were planted and managed by farmers. Inputs such as seeds, fertilisers, herbicides were provided for farmers. Research and extension staff provided technical backstopping and carried out monitoring and evaluation of the trials. The evaluation took place during 2008 and 2009 cropping seasons. Grain yield data were collected along with other agronomic data from each plot.

Sensory evaluation

Sensory evaluation was carried out to assess the acceptability of the products using the method of Iwe (2002). The evaluations were carried out by 185 farmers randomly selected from all the locations, comprising males and females. The parameters tested were colour, flavour, texture and taste. The products from the different maize varieties

were coded and randomly presented to the assessors who were also participating farmers. The samples were independently evaluated using the method described by Larmond (1977) and Iwe (2003). A nine-point hedonic scale was used to determine the preference of each assessor. Ratings were: 1 = "extremely dislike" and 9 = "extremely like." The assessors were allowed to drink water in between product testing.

The data were statistically analyzed using analysis of variance (ANOVA) and means were separated by Duncan's multiple range test (SAS, 1995).

Dissemination of QPM to farmers in Nigeria

The introduction of QPM into the cropping systems of Nigeria farmers were done using three major approaches viz field demonstrations, trainings sessions and field days in year 2010-2015.

On- farm Demonstrations

The method used to introduce and create awareness about the improved maize varieties and associated technologies to farmers was by establishing widespread, on-farm demonstration plots. Method and result demonstration plots were used to prove and show other farmers the advantages of the improved varieties and good agronomic practices over the local varieties and existing practices. The demonstrations were established in all the seven states-Ondo, Kaduna, Niger, Bauchi, Osun, Oyo and Ogun states. Three communities were selected in each ADP zone for the dissemination. A total of sixty-six farmers were selected for on- farm demonstration in all the zones. Farmers who hosted demonstrations were selected based on the availability of suitable land, years of experience in maize production, willingness to implement improved agronomic practices and allow other farmers to visit their plots during field tour thus allowing more farmers to be reached with the improved varieties and associated technologies. Efforts were made to encourage and include women farmers to host some of the demonstrations and transfer knowledge to other women farmers. There were field tours of demonstration plots from planting to harvesting stage, which helped to create awareness, learning and popularising the technologies among farmers.

Quality Protein Maize varieties (ART-98 SW-6-OB and ILE-I-OB) and High Protein Maize (Oloyin) (ART-96-SW-1) were evaluated with the popular farmers' variety. The plot size for each variety was 20mx20m. In order to achieve good results, careful selection of demonstration plots and participating farmers was done with the assistance of the extension agents of the state ADPs. The plots were laid out and evaluated with the farmers' variety (local check) to which the introduced varieties were compared. Best management/agronomic practices including timely and proper planting, thinning, weeding, fertilizer application, and pest management were employed. The demonstration plots were located close to roads making them accessible to neighbouring farmers.

Trainings and field days

Trainings were major method used to educate farmers on the technology and was done with demonstrations. Trainings were conducted mostly in local languages of the people and with interpreters in some areas.

Two levels of trainings were carried out. The first level was training of trainers (ToT) on good agronomic practices which forms part of the learning process in the demonstration plots. Method and result demonstrations were used to drive home the good agronomic points. The second level of training was done by training farmers on the different methods of adding value to the maize produce. Quality Protein Maize and HPM varieties were prepared into popular maize products (roasted maize, boiled maize, maize gruel (pap, ogi), and other new product developed in IAR&T (corn-soy milk). All the farmers were requested to train at least other five farmers (Figs 1 and 2).

Fig.1. Training session on utilization of maize

Fig 2. Farmers admiring QPM attributes

Field days were also organized by IAR&T in conjunction with Agricultural Development Programmes (ADPs). Field days were done at one location in each zone and was organized at the stage when clear comparison can be made between the QPM, HPM and farmers' varieties. The aim was to publicise information about the technologies being promoted and convince farmers of the performance of QPM and HPM compared to the farmers' conventional varieties. It also served as a means of obtaining feedback from farmers on the technology. Farmers' preference and feedback on the demonstration were reported through subjective ranking of some identified criteria during monitoring and field days. These include yield, adaptation, maturity, grain size, grain colour, drought tolerance, disease tolerance and insect pest resistance. Farmers were asked to evaluate the improved maize varieties (QPM and HPM) and the conventional maize variety in terms of yield, adaptation, drought tolerance, maturity, grain colour, disease tolerance and insect pest resistance using a five point Likert scale of 1-5 with very good (5),good (4), fairly good (3), poor (2) and very poor (1). A total of 185 farmers, purposively selected, participated in the evaluation across the states.

Data analysis

Data were obtained from field demonstrations during routine monitoring of the on-farm demonstration. Analysis of variance (ANOVA) was used to assess maize grain yield. The data for sensory evaluation were also statistically analyzed using analysis of variance (ANOVA) while means were separated by Duncan's multiple range test. Simple descriptive statistics (mean score) was used to analyse farmers' preference.

Results and Discussion

On-farm evaluation

Maize yield

Field evaluation showed significant differences among the maize varieties for yield in all the locations (Fig. 3). QPM (ART-98 SW-6-OB) gave the highest grain yield in all locations except Osun state, followed by QPM (ILE-1-OB). Farmers' variety yielded the least, in six states apart from Osun. QPM varieties had higher yield attributes and since it matured earlier than farmers' variety, it was therefore possible for farmers to plant QPM maize more than once in a year, especially in the forest zone where both early and late seasons exist. Integration of improved variety of maize with higher yield into cropping system is likely to increase farmers income, consumption pattern, household food and nutrition security.

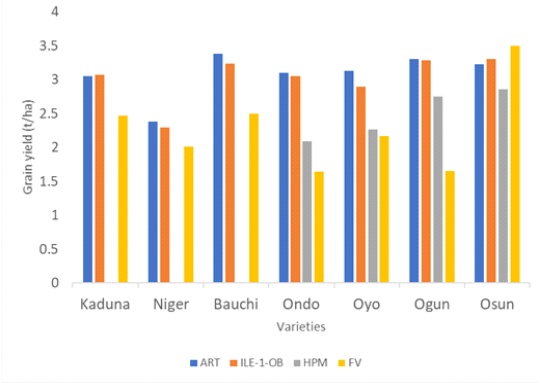

Fig. 3: Mean yields of ART-98-SW-6-OB, ILE-1-OB, HPM and farmers' local at the locations in Nigeria

On farm demonstrations

The relative newness of the technology made it necessary to create awareness about the varieties, characteristics, nutritional benefits among farmers as well as various ways of utilization by women at household and community levels (Figs. 4&5). This is expected to increase the adoption of the technologies. On farm demonstrations impacted new methods/skills associated with the improved maize varieties. These encouraged farmers to develop interest, try and adopt improved maize varieties.

Fig 4. Field tour of the demo plot

Sensory evaluation

The sensory evaluation results are presented in Tables 2-6. The sensory mean scores of boiled maize from different varieties are shown in Table 2. Boiled HPM had the highest scores for all the attributes. Farmers' local variety and QPM varieties were not significantly different in colour. Table 2 shows that mean sensory scores of QPM varieties were not significantly different in colour and flavour but significantly different in terms of texture and taste ($P < 0.05$). The sensory scores of the attributes of roasted maize showed a similar trend to boiled maize. Roasted High Protein Maize (HPM) was not significantly different at $P < 0.05$ from roasted farmers' local maize variety for sensory attributes of colour and flavour (Table 3).

Table 2: Sensory qualities of boiled maize from different maize varieties

Samples	Colour	Flavour	Texture	Taste
Boiled Maize				
QPM (ART-98 SW-6-OB)	6.90b	6.14b	6.01c	6.02c
QPM (ILE-1-OB)	6.89b	6.17b	6.02c	6.02c
High Protein Maize	8.23a	8.03a	8.02a	8.15a
Farmers' variety	7.55ab	7.01b	7.02b	6.90b

Value carrying different superscripts in a column are significantly different (P<0.05)

Fig.5. Women participants during field day

For all the sensory parameters, all of the roasted maize varieties were accepted by the assessors but HPM had the highest sensory scores for all the attributes (Table 3).

Roasted maize is a popular snack in Nigeria. Hence, promotion of HPM as roasted maize is highly acceptable by farmers in all the states probably as a result of its high sugar content. The HPM and farmers' local variety were not significantly different in appearance. Maize ogi (maize gruel) was prepared and also compared with the local maize variety with high acceptability among the assessors (Table 4). HPM ogi was rated highest for colour, flavour and taste. HPM ogi was not significantly different from QPM in flavor, texture and taste. Maize gruel from farmers' variety was rated least among the samples for all the attributes tested. Similar findings were observed in Oyo state among farmers and non-farmers (Fasoyiro *et al*, 2017). This shows high acceptability and preference for the QPM and HPM varieties by assessors compared to the local

Table 3: Sensory qualities of roasted maize from different maize varieties

Samples	Colour	Flavour	Texture	Taste
Roasted Maize				
QPM (ART-98 SW-6-OB)	7.07b	6.70b	6.05c	6.02c
QPM (ILE-1-OB)	7.05b	6.73b	6.02c	6.02c
High Protein Maize	8.10a	8.14a	8.01a	8.15a
Farmers' variety	7.40ab	7.20ab	7.02b	6.90b

Value carrying different superscripts in a column are significantly different (P<0.05)

Table 4: Sensory qualities of Maize gruel (Ogi) from different maize varieties

Samples	Colour	Flavour	Texture	Taste
Pap gruel				
QPM (ART-98 SW-6-OB)	8.05b	8.15a	8.44a	8.20a
QPM (ILE-1-OB)	8.07b	8.17a	8.42a	8.25a
High Protein Maize	8.64a	8.30a	7.85a	8.81a
Farmers' variety	7.15c	7.14b	7.10b	7.16b

Value carrying different superscripts in a column are significantly different (P<0.05)

varieties.

The sensory qualities of soy-corn milk from the different varieties of maize were compared with soymilk is shown in Table 5. Soy corn milk is a nutritionally improved soymilk product with fresh maize (Omueti *et al.,* 2000). All the varieties processed into soy-corn milk were more acceptable than ordinary soymilk for the various attributes tested. Soy-corn milk from QPM varieties, HPM and farmers' variety were not significantly different in colour when compared with ordinary soy milk ($P < 0.05$). Soy-corn milk from the QPM and HPM varieties were not significantly different in flavour ($P < 0.05$). The QPM varieties and farmers' variety were not significantly different in texture and taste when compared with ordinary soy milk. ART-98-SW-6-OB soy-corn milk, however, had the highest sensory scores for all the attributes. Similar acceptability was observed among farmers in South west, Nigeria (Lawal *et al*, 2014). The implication is that QPM soy-corn milk could not be differentiated from ordinary soymilk in terms of colour, flavour and texture. It could be consumed better and will provide more nutritional value than the ordinary soy milk. The combination of maize with soybean as in soy-corn milk is a good blend for improved amino acid profile and nutritional status.

The sensory results showed acceptability for the two QPM varieties as roasted, boiled, maize gruel and soy corn milk. The two QPM varieties could also be used for other maize-based food products, such as pudding, because of its relatively high scores in food products such as soy-corn milk.

Table 5: Sensory qualities of soy corn milk from different maize varieties

Samples	Colour	Flavour	Texture	Taste
Soy corn milk				
QPM (ART-98 SW-6-OB)	8.15a	8.35a	8.57a	8.50a
QPM (ILE-1-OB)	8.13a	8.37a	8.55a	8.51a
High Protein Maize	7.67a	7.68b	7.60b	7.25b
Farmers' variety	7.45a	7.60b	7.89b	7.81ab

Value carrying different superscripts in a column are significantly different (P<0.05)

Farmers' preferred attributes

The mean score for the maize varieties as ranked by farmers revealed that farmers had high preference for QPM than the High Protein Maize and local varieties for most of the attributes (Table 6). Reasons for farmers' preference for QPM included the high yield potential, early maturing (and as such had the potential of providing early harvests to poor farmers), good tolerance to drought, good levels of disease tolerant and insect pests resistance. QPM varieties have been reported to have the advantage of being downy mildew (fungal) and maize streak (viral) tolerant (Olakojo, 2014). However, farmers had high preference for the adaptability to local environment (M=4.94) and grain colour (M=4.91) of the farmers' variety. The yellow seeded colour commands high premium price than the white seeded variety. Low preference was recorded by farmers for HPM in terms of insect pest resistance (M=2.01).

Conclusion and Recommendations

QPM varieties had better grain yield than HPM and farmers' improved variety in most locations. Also, farmers had much preference for QPM varieties in most locations where the varieties were promoted. Sensory evaluation revealed that farmers highly preferred HPM variety in roasted and boiled forms probably because of its yellow colour. QPM corn soy milk had highest sensory scores for all sensory parameters tested. The improved maize varieties did not only serve as nutritionally improved food source for the maize growing communities but also as income generating opportunities for better productivity and livelihood of women.

The rating of QPM yield higher than farmers' variety is likely to lead to adoption and planting of larger areas in subsequent years using the improved maize varieties. Involvement of farmers in technology generation and dissemination could lead to technology promotion by farmers themselves and adoption which also takes place with continued evaluation.

The good agronomic and sensory attributes, coupled with continuous promotional campaigns, would enhance the chance of QPM and HPM varieties being

Table 6: Mean score of farmers' preferences for attributes in maize varieties

Traits/Attributes	ART-98-SW-6-OB	ILE-1-OB	HPM	Farmers' variety
Yield	4.69	4.73	3.47	3.95
Adaptation	4.30	4.26	4.25	4.94
Maturity	4.73	4.73	4.70	2.95
Grain size	4.81	4.74	4.72	3.81
Grain colour	3.02	3.03	4.91	4.91
Drought tolerance	3.87	3.88	3.86	3.50
Disease tolerance	4.74	4.74	3.65	3.82
Insect pest resistance	4.70	4.73	2.01	3.72

Key: 1= poor and 5 = very good
Source: Field survey

adopted by farmers for improved nutritional status and income generation. However, this is possible only with good synergy among research-extension-farmers and input agencies for wider awareness and adoption of improved maize varieties. Since QPM varieties could therefore be formulated into foods for household and commercial purposes, it becomes imperative to provide more demonstrations and other extension methods to promote large-scale adoption of the improved maize varieties. Effort should also be geared towards the breeding of yellow seeded varieties of the QPM and incorporation of new traits such as tolerance to pest in the HPM for wider adoption.

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