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Full Length Research Paper

Performance of quality protein maize varieties and disease reaction in the derived-savanna agro-ecology of South-West Nigeria

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Eight quality protein maize (QPM) varieties were evaluated for their agronomic performance and disease reaction in the derived savanna agro-ecology of south-west Nigeria for two years. The eight varieties comprised of three hybrid varieties (Mama-ba, Dada-ba and CIDA-ba) and five open pollinated (OP) varieties (Obatampa, EV8363, EV8766, Pool-18-SR and Pool-15-SR). Differences among the varieties were significant for plant and ear heights, number of days to 50% tasling and grain yield. Two hybrid varieties, Mama-ba and CIDA-ba had the highest grain yields of 4.59 and 4.20 t/ha respectively with Obatampa having the lowest yield of 2.95 t/ha. Mama-ba exhibited a yield advantage of 16.20% over the best OP variety (EV8363). All the QPM varieties were susceptible to southern leaf blight, curvelaria leaf spot and maize rust fungal diseases to varying degrees. The severity of each of these diseases on the QPM varieties was however low less than 3.0. The implications of these findings on QPM introduction and development in Nigeria were discussed.

Key words: Quality protein maize, grain yield, fungal diseases, Nigeria.

INTRODUCTION

In Nigeria maize (*Zea mays* L.) is a major cereal crop for livestock feed and human nutrition. It is also an important raw material for several agro-based industries. The grain is mainly processed and used in the preparation of several indigenous dishes. Despite its widespread use across the country however, maize consumed in Nigeria is mainly normal maize. Unlike in other West African countries such as Ghana, the adoption and cultivation of quality protein maize (QPM) is rather low in Nigeria. Normal maize proteins like other cereal proteins however, have poor nutritional value for monogastric animals such as humans and pigs because of reduced content of essential amino acids such as lysine and tryptophan. Cereal protein contain on average about 2% lysine which is less than one-half of the concentration recommended for human nutrition by Food and Agriculture Organization (FAO) of the United Nations (Prasanna et al., 2001). Hence, normal maize-dependent diets can lead to malnutrition. According to United Nation Development Programme (UNDP), almost one billion people living in developing countries are malnourished and do not consume enough protein for good health (Future harvest, 2004).

Research work at Purdue University in 1963 led to the discovery of a mutant maize called Opaque-2 whose protein content contained twice the normal levels of lysine and tryptophan. This mutant was however found to possess some undesirable characteristics such as soft endosperm, low yields and susceptibility to pests and diseases (National Research Council, 1988). Further research at CIMMYT (International Centre for Maize and Wheat Improvement) has provided a new class of maize called quality protein maize (QPM) that combines nutritional excellence of Opaque-2 with the kernel structure of normal maize varieties (Vassal et al., 1993). In Africa, Ghana is at the fore-front of QPM development. Efforts of the scientists at the Crops Research Institute, Kumasi, Ghana and others resulted in the development of and release of a medium maturing open pollinated QPM variety called Obatampa in 1992 and three QPM hybrid varieties, Mama-ba, Dada-ba and CIDA-ba in 1997 (Twumasi-Afriyie et al., 1997). Obatampa is adapted to

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Table 1. Source of collection and characteristics of the 8 QPM varieties evaluated.

QPM Variety	Source of collection	Seed colour	Kernel texture	Type
Mama-ba	CRI Ghana	White	Flint	Hybrid
CIDA-ba	CRI Ghana	White	Dent	Hybrid
Dada-ba	CRI Ghana	White	Flint/Dent	Hybrid
EV8766-SR	IITA/CMMYT	Yellow	Dent	OP
EV8363-SR	IITA/CIMMYT	White	Dent	OP
Obatampa	CRI Ghana	White	Flint/Dent	OP
Pool-18-SR	IITA/CIMMYT	Yellow	Flint	OP
Pool-15-SR	IITA/CIMMYT	White	Flint	OP

Table 2. Mean square values for the agronomic characters of 8 QPM varieties evaluated for two years.

Source of variation	Plant height	Ear height	Days to tasling	Days to silking	Root lodging	Stem lodging	Plant aspect	Ear aspect	Grain yield
Year	0.02	0.41**	0.02	0.39	0.25	0.02	0.004	1.41**	3.59**
Variety	0.12**	0.05**	3.09**	2.70	0.35	0.14	0.22	0.28	2.38
Y x V	0.01	0.007	0.77	0.89	0.18	0.16	0.32	0.46**	0.07
Error	0.01	0.009	1.01	1.29	0.29	0.23	0.19	0.15	0.15

the growing conditions in the lowland tropics and has been adopted extensively in Ghana and many other African countries (Sallah et al., 2003).

However, before a crop variety is adopted, its yield potential and reactions to the prevailing diseases in the target environment have to be evaluated. Hence the objectives of this work were to (i) evaluate the yield and agronomic performance of some OP and hybrid QPM varieties from Ghana and CIMMYT in the derived savanna agro-ecology of south-west Nigeria and to (ii) assess the reactions of the QPM varieties to three fungal diseases: southern leaf blight, curvelaria leaf spot and maize rust. This was with a view to identify high yielding and disease resistant/tolerant QPM genotypes for possible introduction and incorporation into breeding programmes.

MATERIALS AND METHODS

Eight quality protein maize varieties were evaluated for agronomic characteristics and disease reaction in the derived savanna agro-ecology of south-west Nigeria for two years. The eight varieties comprised of five open pollinated (OP) and three hybrid varieties. Seeds of one of the open pollinated QPM varieties (Obatampa) and the three hybrid varieties were collected from the Crops Research Institute (CRI), Kumasi, Ghana while seeds of the other four OP varieties were collected from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The characteristics of the seeds of the QPM varieties and source of collection are presented in Table 1. The QPM varieties were planted at Ilora in Oyo State, Nigeria, which falls within the derived savanna agro-ecology of south-west Nigeria with latitude/longitude 7°45'/3°55'E. Total annual rainfall in 2003 and 2004 were 994.60 mm and 1049.80 mm respectively. The monthly rainfall during the four months of the QPM evaluation in 2003 were 89.5, 141.8, 151.75 and 26.2 mm for August, September, October and November respectively and 82.9, 129.9, 222.1 and 33.3 mm respectively in 2004.

The maize varieties were planted in August of each year in a randomized complete block design with four replications in each year. Plot size was made up of four rows of 5 m long at a spacing of 75 x 25 cm. two seeds were planted per stand and later thinned to one seed two weeks after seedling emergence to provide a uniform plant population of about 53,333 plants /ha. NPK fertilizer was applied at the rate of 80 kg of Nitrogen, 40 kg of phosphorus and 40 kg of potassium for optimum plant growth. Manual weeding was carried out as at when due to keep the field clean.

At flowering (8-10 weeks after planting) the QPM varieties were observed for the natural development of symptoms of three fugal diseases which are southern leaf bright, curvelaria leaf spot and maize rust. Incidence of each of the diseases on the QPM varieties was assessed by counting the number of plants showing symptoms of each of the diseases and expressed as percentage. Severity of each of the three diseases was assessed using rating 1-5 where, 1 = no symptom, 2 = slight infection, 3 = moderate infection, 4 = high infection, 5 = very high infection. When the cobs were fully developed, the QPM varieties were assessed for their susceptibility to root and stem lodging based on scale of 1-5, where, 1= excellent (no lodging) 2 = very good, 3 = good, 4 = fair and 5 = poor.

The following agronomic characteristics were also collected from the two middle rows of each plot: Plant and ear heights and days to 50% tasling. Plant and ear aspects were assessed using rating of 1-5, where, 1 = excellent, 2 = very good, 3 = good, 4 = fair and 5 = poor. At harvest, ears from the middle two rows were harvested together, shelled and grain yield per plot was determined at 15% moisture content from which grain yield per hectare was estimated. Data collected were subjected to analysis of variance and means were separated using Duncan Multiple Range Test.

RESULTS AND DISCUSSIONS

Mean square values for the agronomic characters of the quality protein maize varieties are shown in Table 2. Significant year effect was observed for only three characters; ear height, ear aspect and grain yield. Average ear height in 2003 was 0.73 m and in 2004, it was

Table 3. Mean values for the agronomic and disease parameters of the 8 QPM varieties in 2003 and 2004.

Characters	Mean values	
	2003	2004
Plant height (m)	1.80	1.83
Ear height (m)	0.72	0.88
Days to tasling	55.38	55.41
Days to silking	57.16	57.31
Root lodging	1.53	1.41
Stem lodging	1.28	1.31
Plant aspect	2.78	2.79
Ear aspect	2.70	3.00
Grain yield (t/ha.)	3.53	4.00
Blight incidence (%)	26.48	27.36
Curvelaria incidence (%)	25.59	27.13
Rust incidence (%)	23.74	18.61
Blight severity	2.25	2.20
Curvelaria severity	2.16	2.14
Rust severity	2.56	2.20

0.89 m. Better ears were produced in 2003 with a rating of 2.70 against 3.0 recorded in 2004 (Table 3). Average grain yield in 2003 was 3.53 t/ha and in 2004 it was 4.0 t/ha. Differences in grain yield and the other two characters between the two years could be due to differences in environmental conditions which vary from year to year. Differences among the 8 QPM varieties were significant for plant and ear heights, days to 50% tasling and grain yield. The results indicate considerable genetic differentces among the QPM varieties for these characters and their potential in breeding for improved grain yield. There was no significant year by variety interaction for all the parameters except for ear aspect indicating that the relative ranking of the QPM varieties with respect to ear aspect was not the same in each of the two years.

There was no significant year effect on all the disease parameters expect for rust incidence (Table 4). This result suggests that variation in environmental conditions between the two years did not significantly influence the proportion and degree of susceptibility of QPM varieties to these diseases except for rust incidence. Average rust incidence in 2003 was 23.74% but in 2004, it was 18.61% indicating significantly less incidence of the disease in 2004 (Table 3). The QPM variety planted had significant effect on the severity of southern leaf blight but there were no significant varietal differences with respect to curvelaria leaf spot and maize rust diseases (Table 4).

Average values of the agronomic characters of the QPM varieties are shown in Table 5. Plant and ear heights ranged from 1.65 to 2.0 m and 0.72 to 0.91 m respectively. The hybrid maize variety Mama-ba had the shortest plant while Obatampa (OP) produced the tallest plants. There were no significant differences among the QPM varieties for root and stem lodging with the highest rating of 1.63 and 1.35 respectively. Generally, the QPM varieties did not suffer from lodging as indicated by the observed rating for this character (Table 5).

There were no significant differences among the varieties for plant aspect with Obatampa having a moderate score of 3.0. Ear aspect ranged between 2.56 to 3.12 with Poo1-15 producing the best ears. Number of days to 50% tasling varied from 54.38 to 56.0 while days to silking also ranged between 56.25 to 58.13 with Mama-ba being the earliest to flower and Poo1-18 taking longer period to flower. Grain yield per hectare varied significantly among the QPM varieties. Two hybrid varieties Mama-ba and CIDA-ba had the highest grain yields of 4.59 and 4.29 t/ha respectively while the best yielding OP variety , EV8363 produced grain yield of 3.95 t/ha. The results show that the best hybrid had a yield advantage of 16.20% over the best OP variety. Normal maize hybrid varieties were also known to be superior to OP varieties in yield potential as demonstrated by Kim et al. (1993) and Ajibade and Ogunbodede (2000). The superiority of Mama-ba over other materials from Ghana was reported by Asiedu et al. (2003). Dada-ba was also reported to be higher yielding than CIDA-ba. In this study however, CIDA-ba showed better yield potential than Dada-ba. Obatampa, Poo1-18 and Pool-15 were not significantly different in grain production (Table 5).

The reactions of the QPM varieties to the three fungal diseases are shown in Table 6. All the varieties were susceptible to the three fungal diseases to varying degrees with no significant varietal differences. Lack of significant differences among the QPM varieties in their susceptibility to the three diseases calls for the screening of larger germplasm of QPM varieties for resistance to these diseases. Resistance could also be incorporated into the available materials through recombination with resistant normal maize varieties. Quality protein maize varieties are known to be more vulnerable to diseases because of the soft floury endosperm of the Opaque-2 maize which foster fungal growth (National Research Council, 1988). Although there were no significant differences among the varieties with respect to the incidence of the diseases, Obatampa was the most susceptible to the three diseases (Table 5). Dada-ba had the least incidence of 19.36% for southern leaf blight. Pool-18 was the least susceptible to curvelaria leaf spot with disease incidence of 18.86% while Mama-ba had the least incidence of 14.87% for maize rust disease. Southern leaf blight is caused by the fungus *Helminthos-porium maydis*. The causative organism of the curvelaria leaf spot is *Curvelaria lunata* while maize rust is incited by *Puccinia polysora*. The three diseases often occur together on maize plants as mixed infections in south- west Nigeria and their occurrence is favoured by warm and humid climate (Ladipo et al., 1993). The three diseases are of major economic importance in this part of the country.

The severity of each of the three diseases is presented in Table 6. There were no significant varietal differences

Table 4. Mean square values for disease reaction of the QPM varieties.

S.V	Incidence			Severity		
	Blight	Curvelaria	Rust	Blight	Curvelaria	Rust
Year	12.62	37.74	418.43**	0.04	0.004	0.26
Variety	101.85	133.02	56.98	0.91*	1.03	0.63
Y x V	102.69	70.91	28.17	0.94*	0.38	1.53*
Error	55.47	94.24	43.07	0.40	0.50	0.55

S.V.= Source of variation. *, **, significant at P< 0.05 and 0.01, respectively.

Table 5. Average performance of the 8 QPM varieties evaluated for two years.

Variety	Plant height	Ear height	Days to tasling	Days to silking	Root lodging	Stem lodging	Plant aspect	Ear aspect	Grain yield
Mama-ba	1.65d	0.72c	54.38c	56.25a	1.38a	1.13a	2.81a	2.81a	4.59a
CIDA-ba	1.80b	0.75bc	55.75ab	57.63a	1.50a	1.13a	2.87a	2.81a	4.29ab
Dada-ba	1.79bc	0.81ab	55.0bc	57.38a	1.00a	1.50a	2.56a	2.69a	3.78c
EV8766-SR	1.81b	0.84ab	56.0ab	57.37a	1.63a	1.38a	2.88a	3.06a	3.95bc
EV8363-SR	1.82b	0.82abc	55.63ab	57.50a	1.62a	1.25a	2.94a	3.12a	3.94bc
Obatampa	2.03a	0.91a	55.0bc	56.75a	1.50a	1.30a	3.00a	2.96a	2.95d
Pool-18-SR	1.93a	0.90a	56.25a	58.13a	1.50a	1.38a	2.69a	2.81a	3.32d
Pool-15-SR	1.69cd	0.72c	55.13bc	56.88a	1.63a	1.35a	2.56a	2.56a	3.31d
Mean	1.81	0.81	55.39	57.23	1.47	1.30	2.79	2.85	3.77
SEM	0.01	0.01	0.13	0.14	0.07	0.06	0.05	0.05	0.05

Numbers within the same column with different letter(s) are significantly different at P<0.05.

Table 6. Disease reaction of the 8 QPM varieties evaluated for two years.

Variety	Incidence			Severity		
	Blight	Curvelaria	Rust	Blight	Curvelaria	Rust
Mama-ba	24.45a	29.14a	14.87a	2.19a	2.38a	1.75a
CIDA-ba	28.60a	21.93a	22.40a	2.38a	1.75a	2.50a
Dada-ba	19.36a	28.96a	22.36a	1.50b	2.25a	2.50a
EV8766-SR	27.32a	28.20a	21.84a	2.00bc	2.30a	2.50a
EV8363-SR	27.46a	27.69a	22.57a	2.38a	2.25a	2.38a
Obatampa	31.04a	30.80a	23.33a	2.50a	2.62a	2.62a
Pool-18-SR	28.11a	18.86a	20.79a	2.50a	1.50a	2.56a
Pool-15-SR	28.98a	25.28a	21.19a	2.38a	2.13a	
Mean	26.92	26.36	21.17	2.23	2.15	2.38
SEM	0.93	1.21	0.82	0.08	0.09	0.08

Numbers in the same column with different letters are significantly different at P<0.05.

except for southern leaf blight where Dada-ba appeared to be the most tolerant with a rating of 1.5. Generally, the severity of each of the three diseases on the QPM varieties was low with disease score of less than 3.0 in all cases. This result suggests a reasonable level of tolerance to the three diseases. Olakojo et al. (2005) also reported considerable level of tolerance of normal OP and hybrid maize varieties to these diseases in south-west Nigeria. The three hybrids were also reported to be tolerant to maize rust and southern leaf blight diseases in Ghana (Asiedu et al., 2003). Although the severity of each of the three diseases on the QPM varieties was low, the high rate of incidence of the diseases may soon become a problem particularly for Obatampa which may hinder its adoption in this environment.

In this study, two QPM hybrid maize varieties from Ghana (Mama-ba and CIDA-ba) have been identified to be higher yielding compared with other varieties evalua ted. The best hybrid variety (Mama-ba) had a yield advantage of 16.20% over the best OP variety (EV8363-

SR). All the QPM varieties were found to be susceptible to the three fungal diseases evaluated. They were however, observed to be tolerant to the diseases as the severity of each of the diseases on the varieties was low. There is however, a need to evaluate more QPM varieties in the various agro-ecologies of the country. This will reveal the comparative advantages of the different environment with respect to QPM varieties. It would also provide information on the QPM varieties for release in each environment. Successful introduction and integration of QPM varieties into the farming system will substantially improve the nutrition of man and livestock in the country.

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