

# Agronomic and post-harvest characterization of three quality protein maize (QPM) hybrids developed in Ghana

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## ABSTRACT

Three 3-way quality protein maize (QPM) hybrid varieties, GH110-5, GH132-28 and GH2328-88, developed in Ghana were the most productive among several varieties tested between 1994 and 1996 within Ghana and elsewhere in Africa, South America, and East Asia. Yield potentials of the three hybrids ranged from 6.3 to 7.3 t ha<sup>-1</sup>, representing 19 to 38 per cent yield advantage over the leading open-pollinated variety, *Obatanpa*. These were subsequently released in 1997 with the common names, *Mamaba*, *Dadaba* and *CIDA-ba*, respectively. To satisfy the requirement of the Ghana National Varietal Release Committee for their release, and also guide seed growers and germplasm conservators, among others, in their operations, the hybrids were characterized by their agronomic traits, seed characters, and reaction to common foliar diseases. Among the agronomic traits, days to silking, tassel number, tassel arrangement, plant and ear heights, husk cover tightness, and leaf angle were the most useful characters in distinguishing among the three hybrids. The hybrid, GH110-5 (*Mamaba*), had the least number and the most compactly arranged tassels, and was also the shortest in plant height and ear placement. For the post-harvest characters, GH110-5 had the highest number of rows per cob, followed by GH132-28 (*Dadaba*) and GH2328-88 (*CIDA-ba*) in that order. Cob length and 1000-seed weight were highest in *Dadaba* (which was a mixture of flint and dent seeds), followed by *Mamaba* (flint) and *CIDA-ba* (dent). The long cobs, high number of rows, flinty nature, and high 1000-seed weight of *Mamaba* and *Dadaba* which possibly contributed to their high-yielding potential, are traits that plant breeders should be looking for when developing high-yielding crop varieties. All the hybrids showed high to moderate tolerance to common foliar diseases such as the maize streak virus disease, rust (*Puccinia polysora*), and *Bipolaris maydis*. The implications of these and other differences

## RÉSUMÉ

ASIEDU, E. A., SALLAH, P. Y. K., TWUMASI-AFRIYIE, S., OBENG-ANTWI, K., AHENKORA, K. & ADUSEI-AKOWUAH, P. *Caractérisation agronomique et de poste-récolte de trois hybrides de maïs qualitatif riche en protéines (MQP) développés au Ghana*. Trois variétés des hybrides de maïs qualitatif riche en protéines (MQP) à 3- caractères, GH110-5, GH132-28 et GH2328-88 développées au Ghana étaient découvertes d'être les plus productifs parmi plusieurs variétés mises à l'essai entre 1994-1996, au Ghana et ailleurs en Afrique, Amérique du sud et Asie orientale. Les potentiels de rendement de trois hybrides variaient de 6.3 à 7.3 t ha<sup>-1</sup>, représentant 19 à 38 pour cent d'avantage de rendement, sur la variété précédente de pollinisation libre, *Obatanpa*. Ceux-ci étaient sorties par la suite en 1997 avec les noms communs respectifs de *Mamaba*, *Dadaba*, et *CIDA - ba*. Afin de satisfaire l'exigence de la Comité Nationale Ghanéenne de la Sortie de Variété, pour les sortir et pour guider les producteurs de graine et les gardiens de germesplasma parmi d'autres, dans leurs opérations, les hybrides étaient caractérisés basés sur leur traits agronomiques, les caractères de graine et la réaction aux maladies foliaires communes. Parmi les traits agronomiques, jour à l'apparition de soies, nombre de gland, arrangement de gland, hauteur de plante et d'épi, étroitesse d'enveloppe de couverture et l'angle de feuille étaient découverts d'être les caractères les plus utiles pour distinguer entre les trois hybrides. L'hybride GH110-5 (*Mamaba*) avait le moindre nombre de gland qui est arrangé d'une façon le plus compacte et était le plus court en taille de plante et en placement d'épi. Pour les caractères de poste récolte, GH110-5 avait le plus élevé nombre de rayons par épi, suivi par GH132-28 (*Dadaba*) et GH 2328-88 (*CIDA - ba*) dans l'ordre logique. La longueur d'épi et le poids de 1000-graine étaient les plus élevés en *Dadaba* (qui était un mélange des graines de silex et d'entaille), suivi par *Mamaba* (silex) et *CIDA - ba*

observed are discussed.

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### Introduction

Maize variety development in Ghana in the past was concentrated on developing open-pollinated maize varieties because of socio-economic reasons, which included lack of efficient seed production and marketing systems. It was later realised that hybrid maize was more productive than the open-pollinated varieties. Therefore, most leading maize production countries in the world depend largely on hybrid maize.

A quality protein maize (QPM) development programme in maize was started in 1989 at the Crops Research Institute (Twumasi-Afriyie & Sallah, 1994a; Twumasi-Afriyie *et al.*, 1994b, 1994c). This initially led to the release of an open-pollinated variety, *Obatanpa*, which has been widely adopted in Ghana and elsewhere in Africa and beyond (Twumasi-Afriyie *et al.*, 1992, 1994b). Alongside the development of *Obatanpa*, a QPM hybrid maize development programme was initiated in 1991. Three 3-way QPM hybrids, namely, GH110-5 (*Mamaba*), GH132-28 (*Dadaba*), and GH2328-88 (*CIDA-ba*) developed in this programme were very productive, yielding between 6.3 and 7.3 t ha<sup>-1</sup> on experimental station, which represented an increase of 19 to 38 per cent over *Obatanpa*. In addition, infants, livestock and poultry fed on QPM grew faster and healthier when compared to the normal maize varieties. The QPM hybrids were, therefore, released for production in 1997 (Twumasi-Afriyie *et al.*, 1997). Characterization of these hybrids became necessary as source of information for the varietal release system, germplasm conservation, plant

(entaille). Les épis longs, le nombre élevé de rayons, la nature de silex et le poids élevé de 1000-graine de *Mamaba* et *Dadaba* qui contribuaient peut-être à leurs potentiels de rendement élevés sont des traits que les éleveurs de plante devraient chercher quand ils sont en train de développer les variétés de culture à rendement élevé. Tous les hybrides montraient une tolérance de haute à modérée aux maladies foliaires communes telles que la maladie virale de maïs strié. La Rouille (*Puccinia polysora*) et *Bipolaris maydis*. Les implications de ces différences et d'autre sont discutées.

variety protection, seed production, and farming.

Several studies indicated that characters of the reproductive organs of maize such as the ear and tassel are more constant than those of the vegetative structures (Anderson & Cuttler, 1942; Hernandez, 1988). Morphological characters selected for the purpose of germplasm collection were ear form (pyramidal, cylindrical, big but, oblong, spherical, and ramosa or ramified), length, number, and regularity of rows of grain. Grain texture (pop, flint, dent, floury, sugary and waxy), length, width, thickness, shape, and colour were also selected as reliable characters. Reid & Konopka (1998) suggested that the compilation of large data sets that cover morphological, physiological, and agronomic attributes would permit high resolution classification. In addition, electrophoretic mapping of zein polypeptides was used to discriminate between maize inbred lines in the USA (Wilson, 1985). The genetic potential of breeding materials, whether developed by conventional breeding or genetic engineering, is evaluated by phenotypic expression in target environments (ICRISAT, 1992; IRRI, 1996).

The objective of the study was to characterize the 3-way quality protein maize hybrid varieties to fulfil a requirement of the National Varietal Release Committee for releasing their release, and also to provide information for seed production, quality control, seed trade, and germplasm conservation.

### Materials and methods

A total of 54 hybrid combinations was evaluated for yield and agronomic characters, out of which

three were eventually released as *Mamaba* (GH110-5), *Dadaba* (GH132-28), and *CIDA-ba* (GH2328-88). The three inbred lines in each of the three hybrid combinations, *Mamaba*, *Dadaba* and *CIDA-ba*, were designated as Entry 6, Entry 70, and Entry 5; P23, P28, and Entry 88; and Entry 24, Entry 27, and P28, respectively. The inbred lines were initially developed by selfing the respective population for six generations, and the best 3-way hybrids selected out of several combinations. Table 1 shows these lines and their crosses in the

experiment was conducted at the Crops Research Institute's station at Kwadaso, Kumasi, in the forest zone of Ghana. Planting was done in the major season of 1996; standard agronomic practices were used. Annual rainfall was 1165.7 mm and monthly rainfall values for the growing period were 140.4, 169.9, 122.1, 142.3, and 118.0 for April, May, June, July and August, respectively. The vegetation which comprised mainly grasses with few broad leaves was initially slashed, and re-growth after 3 weeks was controlled by

TABLE 1

*Inbred Lines, Single Crosses and 3-way Crosses of the Three QPM Hybrids Developed and Released in Ghana*

Female	Single cross formation		Female	3-way cross formation		Common name
	Male	Single cross		Male	3-way cross	
Entry 6	Entry 70	GH110	GH110	Entry 5	GH110-5	<i>Mamaba</i>
Entry 24	Entry 27	GH132	GH132	P28	GH132-28	<i>Dadaba</i>
P23	P28	GH2328	GH2328	Entry 88	GH2328-88	<i>CIDA-ba</i>

hybrid formation.

Two inbred lines were crossed to form the single crosses. The cross between Entry 6 and Entry 70, Entry 27 and Entry 24, and P23 and P28 resulted in the single cross progenies, GH110, GH132 and GH2328, respectively. The single crosses GH110, GH132 and GH2328 were subsequently used as female parents and crossed to the inbred lines, Entry 5, P28 and Entry 88, respectively, to obtain GH110-5, GH132-28 and GH2328-88 which were designated as *Mamaba*, *Dadaba* and *CIDA-ba*, respectively.

The three 3-way hybrids, *Mamaba*, *Dadaba* and *CIDA-ba*, alongside their three single cross parents GH110, GH132 and GH2328 and eight inbred parents were planted in a randomised complete block design (RCBD). For simplicity, only the results of the 3-way crosses are presented. An experimental plot consisted of four rows, with row distance of 80 cm and hill spacing of 40 cm. Row length was 5 m. Two seeds were planted and thinned to one at establishment, that was 2 weeks after planting, resulting in a target plant population of 32,500 plants ha<sup>-1</sup>. The

applying a chemical herbicide, glyphosate (Roundup) at the rate of 4 l ha<sup>-1</sup>. Two additional weed control measures were taken by hand hoeing.

Quantitative data were collected on days to 50 per cent tassel and silk emergence, tassel number, plant height (cm), ear height (cm), number of tillers, leaf number, length of cob-bearing leaf, days to physiological maturity, days to harvest maturity, cob length, cob diameter, row number, and 1000-seed weight. Qualitative data were collected on tassel colour, tassel arrangement, silk colour, stem colour, sheath colour, sheath pubescence, husk cover tightness, husk colour, leaf angle, leaf shape, leaf margin colour, mid-vein colour, seed colour, and kernel texture. Foliar diseases, including the maize streak virus (MSV), rust (*Puccinia polysora*), and *Bipolaris maydis* were scored on the scale 1 to 5 (score of 1 indicating resistance and 5 indicating susceptibility). Ten plants per plot were randomly selected for the field assessments of agronomic characters, and 20 cobs per plot randomly selected for the post-harvest characteristics such as cob length, cob diameter, number of rows per cob, row arrangement, seed

colour, seed texture, and 1000-seed weight.

### Results and discussion

Tables 2, 3 and 4 show the results of the experiment. The most distinguishing characteristics are discussed. Among the pre-harvest agronomic characters of the 3-way hybrids, *Mamaba*, *CIDA-ba* and *Dadaba*, differences were observed in most of the characters. Characters that could be easily used to distinguish among these hybrids were number of tassels and tassel arrangement, silk colour and leaf inclination, among others (Table 2). Few exceptions were recorded where differences were not apparent. These included sheath colour, number of tillers, sheath pubescence, husk pubescence, leaf shape, and

days to harvest maturity. Among the three hybrids, *Mamaba* and *Dadaba* were early to show tassel and silk emergence. *Mamaba* was the shortest in plant and ear heights, followed by *CIDA-ba* and *Dadaba* in that order.

Among the post-harvest characters, number of rows per cob and 1000-seed weight showed differences (Table 2). The cobs of *Mamaba* and *Dadaba* were longer than the cobs of *CIDA-ba*. The highest number of rows, 18, was observed in *Mamaba*, followed by 16 in *Dadaba* and 14 in *CIDA-ba*. Thousand-seed weight was highest in *Dadaba* (which is a mixture of flint and dent seeds), followed by *Mamaba* (flint) and *CIDA-ba* (dent); the 1000-seed weight values were influenced by the flinty nature of the seed, which

TABLE 2

*Pre-harvest Agronomic Characteristics of Three 3-way Hybrids*

Pre-harvest agronomic characters	3-way hybrid		
	<i>GH110-5</i> ( <i>Mamaba</i> )	<i>GH2328-88</i> ( <i>CIDA-ba</i> )	<i>GH132-28</i> ( <i>Dadaba</i> )
Days to 50 % tassel emergence	48	51	48
Tassel colour	Green with purple shade	Green with purple shade	Green with purple shade
Tassel arrangement	Compact & alt.	Very compact & alt.	Medium open & alt.
Tassel number	10-19	16-20	18-21
Pollen production	Very profuse	Very profuse	Very profuse
Days to 50 % silking	51	54	51
Silk colour	Purple	Purple	Purple
Plant height (cm)	175	182	187
Ear height (cm)	75	80	89
Number of tillers	0	0	0
Stem colour	Green	Green	Green
Sheath colour	Green	Green	Green
Sheath pubescence	Low (2)*	Low (2)*	Medium (3)*
Husk pubescence	Low (2)*	Low (2)*	Medium (3)*
Husk cover	Segregating compact/lose	Lose open tip, dog ear	Lose open tip, dog ear
Leaf angle	Open and drooping	Open and drooping	Medium inclined
Leaf number at flowering	14-16	14-16	14-16
Length of cob-bearing leaf at flowering (cm)	91-98	83-94	83-94
Leaf shape at flowering	Long & tapering	Long & tapering	Long & tapering
Leaf margin colour	Cream	Cream	Cream
Mid-vein colour	Cream	Cream	Cream
Days to physiological maturity	90-100	90-100	90-100
Days to harvest maturity	105-110	105-110	105-110
Potential grain yield (t ha <sup>-1</sup> )	7.3	6.3	6.8

\*Rating was done on the scale 1-5; 1, very low level; 5, very high level

Alt. = Alternating

TABLE 3

*Post-harvest Characteristics of Three 3-way Hybrids*

<i>Post-harvest characters</i>	<i>3-way hybrid</i>		
	<i>GH110-5 (Mamaba)</i>	<i>GH2328-88 (CIDA-ba)</i>	<i>GH132-28 (Dadaba)</i>
Cob length (cm)	18.6	16.6	18.9
Cob diameter (cm)	4.9	4.5	4.5
Row number	18	14	16
Seed colour	White	White	White
Kernel texture	Flint	Dent	Flint/Dent
1000-seed weight (gm) at 12 % mc	324.4	274.4	329.5

TABLE 4

*Reaction to Foliar Diseases of Three 3-way Hybrids*

<i>Post-harvest agronomic characters</i>	<i>3-way hybrid</i>		
	<i>GH110-5 (Mamaba)</i>	<i>GH2328-88 (CIDA-ba)</i>	<i>GH132-28 (Dadaba)</i>
Maize streak virus (score)	2*	2*	3*
Rust ( <i>Puccinia polysora</i> )	1*	3*	2*
<i>Bipolaris maydis</i>	2*	1*	2*

\*Rating was done on the scale 1-5; 1, very low level; 5, very high level

makes it more compact and heavier than the dent seeds. The long cobs, high number of rows, flinty nature, and high 1000-seed weight of *Mamaba* and *Dadaba*, which possibly contributed to their high-yielding potential (Table 2), are traits that plant breeders should look for during selection for high-yielding varieties. These two varieties which were slightly earlier in maturity, as indicated by the days to 50 per cent tassel emergence and silking, than *CIDA-ba* incidentally were more productive.

For the common foliar diseases, the MSV disease, rust (*P. polysora*), *B. maydis* and *Fusarium*, all the three hybrids showed tolerance, giving scores below 3 (on the 1 to 5 scale, with the score of 1 as resistant and 5 as susceptible) (Table 4). *Mamaba* and *CIDA-ba* showed slightly better tolerance (score of 2) to the MSV than *Dadaba* (score of 3). Also, *Mamaba* and *Dadaba* showed better tolerance (scores of 1 and 2) to the maize rust disease than *CIDA-ba* (score of 3). These confirm suggestions by Reid & Konopka (1998) that compilation of large data covering

morphological, physiological, and agronomic attributes in characterizing germplasm permit high resolution classification.

### Conclusion

Three 3-way hybrids of QPM, GH110-5, GH132-28 and GH2328-88, were the most productive among several maize varieties tested in Ghana and elsewhere, and were released in 1997 as *Mamaba*, *Dadaba* and *CIDA-ba*, respectively. These, together with their single cross and inbred parents, were characterized by using agronomic and post-harvest traits. Outstanding agronomic characters that could be used to distinguish the hybrids were the tassel number which was highest in *Dadaba*, tassel arrangement, plant and ear height, and leaf angle (which was more inclined in *Dadaba* and drooping in the others). In addition, length of cob-bearing leaf was longer in *Mamaba* than the other two.

*Mamaba* and *Dadaba* were more tolerant to the MSV disease than *CIDA-ba*. *Mamaba* and *Dadaba* were also more tolerant to rust (*P.*

*polysora*). The long cobs, high number of rows, flinty nature and high 1000-seed weight of *Mamaba* and *Dadaba*, which possibly contributed to their high-yielding potential, are traits that plant breeders should look for during selection for high-yielding varieties. Although these two varieties showed higher yielding potential compared to *CIDA-ba*, they were slightly earlier in maturity as indicated by the days to 50 per cent tassel emergence and silking. The early maturity in *Mamaba* and *Dadaba* is added advantage in escaping drought whenever the rainfall period is reduced.

The knowledge of these characteristics, particularly silking and tasseling times, would enable seed growers to determine the time to plant the female and male parents of the hybrids to effect nicking for increased seed yield. The characters are also useful as source of information for the varietal release system, germplasm conservation, plant variety protection, seed production, and farming.

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