Combining Ability and Progeny Performance of Nine Popcorn Inbred Lines (*Zea mays* L) in South Western Nigeria

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Received: November 2003 Accepted: May 2006

Resumé
Iken, J. E. & Olakojo, S. A. *Combiner la capacité et la performance de la progéniture de neuf mäis popcorn d'une ligne de consanguinité au sud-ouest du Nigéria.* Neuf lignes de consanguinité tirées des trois populations du mäis-popcorn étaient croisées à l'aide de système de moitié diallele en 1988 à la plantations de moor à Ibadan au Nigéria. L'objectif de cette étude était d'identifier un adaptable mäis-popcorn d'une ligne de consanquinité et de rendement élévé pour utiliser au sud-ouest du Nigéria. Les résultats de 36 fl hybrids étaient évaluées pour le rendement en graine et ses composants en trois localisations, representant les différentes zones agro-écologiques du sud-Ouest Nigérian lors de la siason de culture de 1999 et 2000. Les résultats ont montré que la moyenne carrée pour la capacité générale de la combinaison (GCA) et les effets de la capacité spécifique de la combinaison (SCA) étaient significatives (P<0.05) pour le pourcentage du décorticage et le rendement en graine. Les effets GCA de la ligne de consanquinité YCP1 R43 et GPC2 étaient significatifs (P<0.05) pour le poids d'épi et le rendenent en graine. Les effets SCA pour le rendement en graine étaient signicatifs pour neuf hybrids y compris YCP1 x YCP2 YCP2 x GPC1 et 9PC3 x RCP2. La performance de la progéniture pour les rendements en graines étaient 87.0% dans l'hybride fl suggérant la potentialité d'un rendement élévé des lignes de consanquinité parentale. Les hybrids fl étaient significativement (P<0.05) différentes d'un à l'autre en ce qui concerne le poids d'épis, le pourcentage du decorticage et le rendement en graine. A partir de cette étude, sept lignes prometteuses de consanguinité (YCP1, RCP3, GPC1, RCP1, YCP3, GPC2 et GPC3) étaient selectionnées pour la production de l'hybride du mäis-popcorn au sud-ouest écologies du Nigéria.

Mot clés: Mäis-popcorn de consanquinité, la capacite de combinaison, les croisements diallels, la performance de progéniture, le rendement en graine.

Abstract
Nine inbred lines extracted from three popcorn populations were crossed using half diallel system, in 1988 at Moor Plantation, Ibadan, Nigeria. The objective of the study was to identify adaptable high yielding popcorn inbred lines for use in south western Nigeria. The resulting 36F_1 hybrids were evaluated for grain yield and its components at three locations, representing the different agro-ecologies of south western Nigeria in 1999 and 2000

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cropping seasons. The results showed that mean square for general combining ability (GCA) and specific combining ability (SCA) effects were significant (P<0.05) for shelling per cent and grain yield. The GCA effects of inbred lines YCPI, RCP3 and GPC2 were significant (P<0.05) for cob weight and grain yield. The SCA effects for grain yield were significant for nine hybrids including YCP1 x YCP2, YCP2 x GPC1, and GPC3 x RCP2. Progeny performance for grain yields was 87% among F_1 hybrids suggesting high yield potential of the parental inbred lines. The F_1 hybrids were also different (P<0.05) from one another with respect to cob weight, shelling per cent and grain yield. From this study, seven promising inbred lines (YCP1, RCP3, GPC1, RCP1, YCP3, GPC2 and GPC3) were selected for hybrid popcorn production in southwestern Nigeria agro-ecologies.

Keywords: Popcorn inbred, combining ability, diallel crosses, progeny performance, grain yield.

Introduction

Combining ability in maize improvement programmes have been reported extensively (Baumann, 1981; Vassal *et al.*,1991; Han *et al.*, 1991 and Everett *et al.*, 1995). It has been widely used in the evaluation of extracted parent inbreds for possible use in commercial hybrids maize production. Similarly, the use of diallel analysis and combining ability for maize yield and disease or pest resistance have been found suitable by many plant breeders. Results from such studies have also evolved superior genotypes in terms of yields, desirable agronomic traits and high tolerance to pests and diseases in most cases (Pathak and Othieno, 1992 and Sfakianakis *et al.*, 1996).

The demand for popcorn in Nigeria is extremely high in such a way that supply could hardly match up with the demand. Although, Olakojo and Iken (2001) as well as Iken and Olakojo (2002) reported on the development and performance of popcorn varieties for adaptation to southwestern Nigeria, the varieties reported were open pollinated with slight yield increase over the existing cultivars. The yield of these varieties varied between 0.04 and 0.2t ha^{-1}. Hence, the need for high yielding popcorn genotypes (preferably hybrids) that are superior to the existing cultivars and are adaptable to various agro-ecologies of south western Nigeria. The development of hybrid popcorn therefore, involves the extraction and evaluation of parent inbreds for general combining ability (GCA) and specific combining ability (SCA) as well as the suitability of the inbreds for commercial hybrid popcorn production.

The objectives of this study, therefore, were to: (1) extract inbred lines from elite popcorn populations; (2) assess their general and specific combining abilities, progeny performance and their suitability for commercial hybrid popcorn production.

Table1. Sources and grain texture of the popcorn inbred lines evaluated in Ibadan.

Code Number	*Inbred line*	*Source*	*Grain texture*	*Presence or absence of awn*
1	YCP1	Mexico	Flint	-
2	YCP2	Mexico	Flint	-
3	YCP3	Mexico	Flint	-
4	GPC1	USA	Dent	-
5	GPC2	USA	Dent	-
6	GPC3	USA	Dent	-
7	RCP1	Nigeria	Flint or dent	◆
8	RCP1	Nigeria	Flint or dent	-
9	RCP2	Nigeria	Flint or dent	◆

◆Presence of awn. - Absence of awn.

Materials and methods

Nine inbred lines were extracted from three popcorn populations at the Institute of Agricultural Research and Training, Obafemi Awolowo Univeristy, Moor Plantation, Ibadan, Nigeria, between 1995 and 1998. The popcorn populations were Yellow composite popcorn, Golden yellow popcorn and Re-cycled population (Table 1), originating from Mexico, United States of America and Nigeria, respectively. Three promising popcorn lines were selected from each of the popcorn populations based on yield potential, desirable agronomic traits, seed setting as well as pollen production potential. They were thereafter subjected to inbreeding through five cycles of selfing (S_5). The nine popcorn inbreds were crossed in half diallel system to generate 36 F_1 popcorn hybrids.

The F_1 hybrids and their parent inbreds were evaluated at Ikenne (high rainforest), Ibadan (rainforest) and Ilora (derived savanna) ecologies of southwestern Nigeria for grain yields and its components in 1999 and 2000 cropping seasons. Each entry was planted to single row plots of 0.75 x 5 m with the intra row spacing of 75 x 25 cm at two seeds per hill. They were thinned to one stand per hill, two weeks after planting to obtain a plant population of 53,333 ha^{-1}. Compound fertilizer NPK 20-10-10 was applied at the rate of 200 kg ha^{-1} three weeks after planting and 100kg urea ha^{-1} at two weeks prior to anthesis (silking and tasseling).

Weeds were controlled with pre-emergence application of 5 l ha^{-1} of 300g l^{-1} metolachlor + 170g l^{-1} a. i. atrazine and 200 g l^{-1} a.i. paraquat at 2 l ha^{-1} post-emergence. These were supplemented with one regime of manual hoe weeding. Matured ears were harvested, shelled and weighed at an adjusted moisture percentage (%) of 15.0. Other parameters measured included cob weight, (cob without grains) kg ha^{-1}, shelling percentage (%) and grain yield (kg ha^{-1}). Data from the three stations were pooled and subjected to diallel analysis using Graffing (1956) method 1 model 11 to determine the general combining ability (GCA) of the parent inbreds and specific combining ability (SCA) of the F_1 hybrids with respect to yield and its components. Progeny performance were also computed for all the agronomic characters using Baker (1978) model, where progeny performance = $\frac{GCA}{GCA+SCA}$.

Results and Discussion

Mean square (MS) for GCA and SCA effects for yield and its components are in Table 2. General combining ability, shelling % and grain yield were significant. The significant positive GCA effects for yield obtained from these inbred lines was also similar to the report of Claure *et al.* (1993) in Mexico. Although cob weight recorded positive but insignificant GCA effect for the parent inbred lines mean square (MS) for specific combining ability (SCA) effects for grain yield were generally positive and significantly different among the popcorn hybrids. The magnitude of GCA effects were slightly greater than that of SCA for these three parameters assessed. The significant effects in these hybrids suggest the suitability of the popcorn inbred lines for use in hybrid popcorn production. Progeny performance of 41.0, 55.0 and 87.0% were recorded for cob weight,

Table 2. Mean squares for general combining ability (GCA) and specific combining ability (SCA) for yield and yield components of nine popcorn inbreds evaluated in Ibadan, south western Nigeria.

Source of variation	*Df*	*Mean squares (MS)*		
		Cob weight	*Shelling %*	*Grain yield*
GCA	8	156.5	231.80*	2324.6**
CA	35	216.3	183.4*	338.4**
Error	140	83.4	93.20	139.1
Progeny performance (GCA per GCA + SCA)		0.42	0.55	0.88

*,** significant at P<0.05 and 0.01 respectively.

Table 3. General combining ability (GCA) and means for yield and yield components of the popcorn inbreds.

Inbred	*Cob weight (kg ha^{-1})*	*Grain yield (kg ha^{-1})*	*General combining ability (GCA)*	
			Cob weight	*Grain yield*
YCP1	95	540	2.00*	8.00*
YCP2	82	484	-4.30	-14.10
YCP3	85	505	-3.00	-6.20
GPC1	89	471	-2.10	-19.20
GPC2	110	500	6.50*	-7.00
GPC3	99	510	2.10*	-3.00
RCP1	97	583	1.00*	26.00**
RCP2	100	503	-1.00	-6.60
RCP3	100	576	1.70*	22.2**
Mean	94	519		
S.E. (0.05)	0.26	0.96		

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

shelling % and grain yield respectively, showing the high potentials of the parent inbred lines for grain yield.

The GCA effects for the popcorn inbred lines for grain yield and its components are in Table 3. General combining ability effects for YCP1, GPC2 RCP1 and RCP3 were positive and significant for cob weight, (2.0, 6.5, 2.0, 1.0 and 1.7) respectively while YCP1, RCP1 and RCP3 were positive and highly significant for grain yield with GCA effects of 8.0, 26.0 and 22.0 respectively. Although mean cob weight among the hybrids was similar, YCP2 and YCP3 were the best for this trait with reduced values of 82 and 85kg ha^{-1} compared to across mean of 94kg ha^{-1}. GPC2 was however the poorest in terms of cob weight (110kg ha^{-1}). It was 16.4% inferior to the expected mean cob weight.

Mean grain yields across parent inbred lines were 520kg ha^{-1}, while RCP1 and RCP3 recorded yield advantages of 12.2 and 11.0% over the mean (Table 3). The two agronomic characters (cob weight and grain yield) were significantly different among the inbred groups. Martinez *et al.* (1993) reported high variability and performance of some tropical maize lines even in the temperate ecologies of Mexico; it is also possible that these inbred lines may be fully adapted to temperate ecologies, since they originated from temperate populations.

The SCA effects of the F_1 hybrids for grain yield are presented in Table 4. Inbred YCP combined favorably with GPC3 and RCP3 with significant SCA effects of 14.5 and 18.5 while YCP2 similarly combined favorably with GPC1 and RCP1 with significant SCA effects of 14.1 and 13.1. Inbred YCP3 combined with GPC2 and GPC3 with SCA effects of 19.0 and 15.8 GPC1 also recorded significant effects of 11.5 and 31.0. Similarly, GPC3 favourably combined with RCP2 and RCP3 with significant SCA effects of 32.8 and 13.2 for grain yield.

Out of 36 F_1 hybrids, ten promising combinations were identified as highly suitable for commercial popcorn production. From the ten, one each came from Yellow composite and Golden popcorn populations. None came from re-cycle popcorn populations. The other eight were combinations of one or more of the three populations (Table 4). Nevertheless, RCP featured in five of the combinations for high grain yield. This could be due to the broader genetic base of the population, compared to the other two. Significant SCA effects for grain yield have also been reported from diallel crosses (Perez-Valesques *et al.,* 1995; Seitz *et al.,* 1992 and Nevado and Cross, 1990). This shows the importance and suitability of this breeding technique especially for yield improvement in maize and popcorn development.

Means for grain yield and its components for the F_1 hybrids are in Table 5. The three yield parameters (cob weights, shelling % and grain yield) differed from one another ($P<0.05$).

Table 4. Specific combining ability (SCA) effects for grain yield among 36F_1 popcorn hybrids.

	YCP1	*YCP2*	*YCP3*	*GPC1*	*GPC2*	*GPC3*	*RCP1-*	*RCP2*	*RCP3*
YCP1	-	4.90	14.50*	2.80	2.80	-12.30	-16.9	-8.70	18.50
YCP2		-	-6.50	14.10*	8.90	5.70	13.10*	-2.50	-37.7
YCP3			-	30.0	19.00*	15.80*	4.50	-7.0	-10.3
GCP1				-	11.50*	-8.20	3.80	19.40	31.0**
GCP2					-	-36.2	-0.80	5.10	-10.3
GCP3						-	-10.80	32.8**	13.20**
RCP1							-	-5.60	1.5
RCP2								-	5.90
RCP3									-

*, ** Significant at $P<0.05$, 0.01 respectively.

Table 5. Performance of F_1 hybrids with respect to yields and yield component.

Hybrid	*Cob weight (kg ha^{-1})*	*Shelling %*	*Grain yield (kg ha^{-1})*
1x2	84.	86.6	555
1x3	93	86.7	601
1x4	86	86.0	528
1x5	120	82.5	566
1x6	104	83.9	540
1x7	95	86.8	618
1x8	95	85.1	545
1x9	107	86.7	694
2x3	74	86.7	483
2x4	82	85.8	497
2x5	106	83.0	516
2x6	88	85.6	524
2x7	82	88.4	629
2x8	82	85.7	494
2x9	76	86.7	495
3x4	67	86.3	421
3x5	110	83.7	566
3x6	95	85.8	572
3x7	93	87.0	623
3x8	86	85.0	507
3x9	86	87.6	585
4x5	114	818	510
4x6	95	83.3	475
4x7	95	86.1	587
4x8	87	83.4	439
4x9	110	85.3	639
5x6	107	80.6	444
5x7	116	84.0	610
5x8	111	82.8	536
5x9	118	82.8	578
6x7	104	85.1	594
6x8	116	83.0	605
6x9	111	85.4	646
7x8	102	86.0	626
7x9	110	86.4	696
8x9	94	86.5	599
Mean	97	85.16	559
S.E. (0.05)	13.46	1.75	67.84

Grain yields in YCP1 x RCP1, YCP1 x RCP3, YCP1 x RCP3, GPC2 x RCP1, as well as combinations having inbred parents GPC3, RCP2 and RCP3 gave significant grain yields. YCP3 x GPC1 was worst in terms of grain yield (420kg ha^{-1}). The trend was similar for shelling percentage and cob weight for all the hybrids. Therefore, it can be concluded that inbred lines YCP1, RCP3, GCP1, RCP1, YCP3, GCP2 and GCP3 are the most suitable parents for single cross hybrid popcorn production in south-western Nigeria agro-ecologies.

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