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Performance of single cross quality protein maize hybrids evaluated at Samaru-northern guinea savanna zone of Nigeria

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Diallel mating design was used to generate fifteen single cross hybrids including fifteen reciprocals. The hybrids were evaluated together with their parents and thirteen checks at Samaru, Northern Guinea Savannah, of Nigeria in the years 2005 and 2006. The experimental design used was 7 x 7 incomplete lattice designs with three replications. There were significant differences between the various genotypes for all the fifteen traits observed. There was a highly significant difference in replication within year for the traits; days to tasselling, ash contents and ear height while significant differences were observed for the traits; emergence count, plant height, one thousand grain weight and grain yield. The significant mean squares observed for all the agronomic traits indicates that the genetic variability could be utilized for the improvement of yield and other desirable traits in quality protein maize breeding programs. The combined analysis of variance, the source of variation for entries, was partitioned into hybrids vs. parent's mean squares which were significant for all traits observed except moisture content. This is a preliminary indication of the presence of heterosis in the single cross hybrids. The observed variabilities could be used to develop suitable hybrids and varieties.

Key words: Quality protein maize, variability, hybrids, performance.

INTRODUCTION

Maize (*Zea mays* L.) is an important staple crop produced in many countries in sub Saharan Africa. It is estimated that about 50% of the population in the sub Saharan region consumes maize as a staple food (Okoruwa, 1997). Maize, which was introduced into Africa about 400 years ago, and is one of the major cereal crops in Nigeria. It is utilized in more than 2000 forms and is the most diversified food, feed and industrial crop. It is an important source of carbohydrate in the diet of about 30 million people and contributes about 25% of the food intake in Nigeria (Akanya et al., 1991). Its production in Nigeria is estimated to be 1.3 million tonnes per year from a total area of 1.6 million hectares (CIMMYT, 1990). In view of the importance of maize in Nigeria efforts are being made to increase its yield through the introduction of high yielding varieties. For example, in 1979 efforts

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were made in Nigeria by the International Institute of Tropical Agriculture (IITA) to develop hybrid maize varieties (IITA, 1984). Maize is an important source of calories and dietary protein in human and animal diets in Nigeria. The protein of maize endosperm, however, is deficient in both lysine and tryphtophan, so, healthy diets for both humans and monogastric animals must include alternate sources of these essential amino acids of quality protein maize (QPM) is about 90% that of milk protein. Therefore, QPM nutritional benefits approach those of milk protein, a common standard of nutritional excellence. Graham et al. (1989) reported that qualityprotein maize, when it is the only source of protein and provides 60% of the energy in the diets of infants and small children, supports 45% greater apparent nitrogen retention than that of normal maize. Therefore, the use of QPM will help reduce malnutrition related diseases and deaths and significantly improve the nutritional status of individuals who depend primarily on maize for sustenance. Considering the benefits of quality protein maize to nutrition and the status of maize as a staple food in Nigeria, it is important to breed and evaluate new genotypes for their productivity. This paper reports performance of single cross hybrids of quality protein maize evaluated alongside checks in the Northern Guinea Savanna Agro ecology of Nigeria (11° 11´ N, 07° 38´ E, 860 m above sea level).

MATERIALS AND METHODS

Fifteen single cross hybrids and fifteen reciprocal hybrids were generated using six quality protein maize inbred parents in a 6 x 6 complete diallel mating design in the year 2004 at the experimental field of Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria. The inbred parents are of tropical, full season maturity and of modified opaque-2 types from International Centre of Maize and Wheat Improvement (CIMMYT) Zimbabwe. The parents were selected at CIMMYT, primarily for their vigor and good agronomic traits. These parents are the first generation of inbred lines derived from modified opaque-2 germplasm at CIMMYT (Vasal, 2001). The F_1 hybrids and the reciprocal crosses as well as the parents and thirteen checks were evaluated in two years (2005 and 2006 wet season).

The 36 entries which comprises 15 F_1 hybrids, 15 reciprocal crosses and six parents (Griffing's, 1956) and 13 checks, two of which are quality protein maize hybrids making a total of 49 entries were laid in a 7 x 7 partial lattice design with three replications in each year of evaluation. The fields were harrowed and ridged after which planting was done on June 29 - July 1 for each year of evaluation

Each plot consisted of 1 row of 5 m long. Inter and intra row spacing of 75 and 50 cm were used, respectively. Three seeds were planted per hill 3 to 4 cm deep in the ridges and thinned to 2 plants per hill to give a final plant density of approximately 53,300 plants per hectare. Fertilizer application was applied at a rate of 120 - 60 - 60 kg N, P_2O_5 and K_20 per hectare using NPK compound fertilizer. It was applied two weeks after planting (WAP) and the remaining half of N was side placed at 6 WAP using 46% Urea. Weed control was done by manual weeding three times each year at 5 and 7 weeks after planting each year. Remolding was done to achieve weed control, improve soil aeration and prevent root lodging.

Data collection

Data was collected on the following agronomic traits:

(i) Days to germination (DG): Number of days from sowing to germination.
(ii) Emergence count (EC): This was estimated at two weeks after sowing by counting the total number of stands in each plot.
(iii) Days to tassel (DT): Number of days from planting to the date 50% of the plants in a plot have emerged tassel.
(iv) Anthesis silking interval (ASI): Number of days between tasselling and silking.
(v) Days to silk (DS): Number of days from planting to the date when 50% of the plants in a plot have emerged silk.
(vi) Plant height (Ph) (cm): Measured from base of plant to base of tassel (the place where tassels begin branching).
(vii) Ear height (Eh) (cm): Measured from the base of plant to the node which bears the first ear from the ground.
(viii) Number of leaves (NL): The total leaves per plant were counted at maturity.
(ix) Days to maturity (DM): Recorded as the number of days from sowing to maturity in each plot.
(x) Thousand (1000) Grain weight (TGW) (g): Weight of 1000 grains randomly taken from each plot after threshing.
(xi) Grain yield (kg/plot): Harvested cobs were threshed and weighed per plot.
(xii) Protein content (Pro) (%): Estimated in the Food Science Laboratory using standard micro-kjeldahl procedure (A.O.A.C).
(xiii) Fat (Lipid) content (%): This was determined as follows: Two round bottom flasks were cleaned and few anti bump granules were added to prevent bumping. 300 ml of petroleum ether (40 to 60°C) boiling point were poured into the flask. These were fitted into the Soxhlet extraction units. Extraction thimbles were weighed and twenty milliliters of the sample was placed into it and weighed (W_1), the thimble was fixed into the Soxhlet extraction unit with forceps and cold water circulation put on. The heating mantle was switched on and solvent refluxing was adjusted at a steady rate. Extraction was carried out for eight hours. The thimble was removed and dried to constant weight in an oven at 70°C and was weighed (W_2). The extractible lipid was calculated as:

$$\%\ Lipid\ (W/W) = \frac{Wt.\ of\ lipid\ extracted}{Wt.\ of\ dried\ sample} \times \frac{100}{1}$$

Where, the weight of lipid extracted is given by the loss in weight $W_1 - W_2$ of thimble content after extraction (A.O.A.C., 1980).
(xvi) Ash content was determined, using the following procedure: Crucibles were cleaned and dried in the oven. After drying they were corked in the desiccators and weighed (W_1). 2 g of the grounded sample was placed in the crucible and weighed (W_2). They were transferred into furnace and set to 550°C. The sample was incinerated in the furnace for 8 h. The crucible containing the ash was removed and cooled in the desiccators and weighed (W_3). The weight of the residue in the crucible corresponds to the organic matter content (A.O.A.C., 1980):

$$\%\ Ash = \frac{Weight\ of\ ash}{Weight\ of\ sample} \times \frac{100}{1} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

(xv) Moisture content (Mois) was determined using the following method (A.O.A.C., 1980): Crucibles were washed and dried to a constant weight in an air oven at 100°C, they were later removed and cooled in a desiccator and weighed (W_1). 2 g of the grounded sample was placed in the weighed moisture dish (W_2); the crucible containing the sample was kept in an oven at 100°C for 24 h and weighed. It was kept back in the oven and re-weighed after about 3 h to ensure a constant weight (W_3). The moisture content was calculated as:

$$\% \, Moisture = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

RESULTS AND DISCUSSION

Combined mean squares from analysis of variance for the two years (2005-2006) of the genotypes are presented in Table 1. Significant differences between the various genotypes for all the fifteen traits were observed. The significant mean squares observed for all the agronomic traits (Table 1) indicates that, the genetic variability could be utilized in the improvement of yield and other desirable traits in quality protein maize breeding programs. The combined analysis of variance, the source of variation for entries was partitioned into hybrids vs. parent's mean squares which were significant for all traits observed except moisture content. The combined mean performance of the genotypes is shown in Table 2. The inbred parent; CML176 and the check; Oba-98 (QPM) took the longest time to germinate with a mean of (6-days) each while the hybrid; CML181 x CML493 took the shortest time to germinate with a mean of (5-days). The hybrid; The hybrids CML181 x CML493, CML181 x CML176 and the check; ACR-97.TZLCOMP.1 had the highest emergence count among all the genotypes with a mean of (15 plants) each, while the hybrid; CML493 x CML176 and the inbred parent; CML181 recorded the lowest emergence count with a mean of (10 plants). Days to tasselling varied significantly for all the genotypes, the check; JO-1 took the longest time to tassel with a mean of (64-days), while the hybrid; CML177 x CML492 took the least number of days to tassel with a mean of (56-days). Anthesis silking interval differed among all the genotypes studied, the hybrids; CML176 x CML492, CML176 x CML493 and CML177 x CML492 had the least anthesis silking interval with a mean of (1-day), while the inbred parent; CML491 had the highest anthesis silking interval with a mean of (6-days). Furthermore, the inbred parent; CML491 took the longest time to silk with a mean of (70-days). Protein content differed significantly among all the genotypes studied (Table 2). The hybrid; CML493 x CML177 had the highest protein content with a mean of (9%), while the inbred parent, CML491 had the lowest protein content. The hybrid CML177 x CML493 had the highest amount of fat (3%), and the inbred parent; CML493 had the highest ash content of 4%. The values for moisture content varied from 3.32% for the hybrid; CML176 x CML181 to 8.68% for the hybrid; CML492 x CML493, respectively, highest moisture content of 9% was obtained for the check; Oba-98 (QPM). Similarly, plant height ranged from 67.93 cm for the inbred parent; CML492 to 190.00 cm for the check; Oba-98QPM. Number of leaves per plant varied from 10 leaves for the hybrids; CML177 x CML181 and CML177 x CML491 to 13 leaves for the hybrid; CML491 x CML176 (Table 2). Moreover, the values for days to maturity ranged from 71 days for the inbred parent CML492 to 113 days for the check JO-F.

Furthermore, grain yield varied from 1 t/ha for the inbred parent CML492 to 9 t/ha for the hybrids; CML176 x CML181 and CML181 x CML493, respectively.

Evaluation of quality protein maize germplasm for yield and other agronomic traits had been undertaken in many African countries and elsewhere. For example in Ghana, the QPM variety Obatanpa, competed favourably in terms of grain yield with the full season normal maize varieties, this has been proved by field trials both on-station and on farmers fields (Twumasi-Afriyie et al., 1996). Similarly, in an international trial carried out in the years 1995 and 1996, results from Ghana indicated that mean grain yield was higher in 1995 (6006 kg/ha) than in 1996 (4530 kg/ha). Grain yield was generally low in 1996 due to poor rainfall distribution experienced throughout the country during the growing period.

The general means and their corresponding standard errors, ranges and coefficient of variations for the fifteen traits for the combined mean performance are shown in Table 3. There was wide variability among the fifteen traits observed. The lowest coefficient of variation (3.56%) was recorded for the trait; days to tassel, indicating the highest precision by which it was measured and the highest was recorded for the trait; anthesis silking interval (34.24%), which is an indication of less precision by which it was recorded as compared with the other traits. Number of leaves per plant had the lowest value of standard error of means which is an indication of less variability among the various genotypes for this trait. The highest value of standard error of means was obtained for the trait; one thousand seed weight (4.56). This is an indication of more variability for this trait among the genotypes studied.

Wide range was observed for the traits; plant height (67 to 190 cm), days to maturity (71 to 113 days), and grain yield (1 to 9 t/ha), this is an indication of wide genetic variability among the genotypes for these traits and there is ample opportunity for selection within the population under study.

Conclusion

The significant mean squares observed for most traits especially grain yield indicated broad genetic diversity present within the germplasm under study and therefore could be exploited to improve quality protein maize genotypes in Nigeria. Wide range was observed for the traits; plant height (67 to 190 cm), days to maturity (71 to 113 days), and grain yield (1 to 9 t/ha), this is an indication of wide genetic variability among the genotypes for these traits and there is ample opportunity for selection within the population under study.

Table 1. Combined mean squares for fifteen traits of maize genotypes evaluated in 2005 and 2006 at Samaru

Source of variation	**DF**	**DG**	**EC**	**DT**	**ASI**	**DS**	**Mois (%)**	**Pro (%)**	**Fat (%)**
Year	1	25.1564	14.8163	1.7040	10.6667	24.0000	4.1779	21.0693	77.7534
Rep (year)	4	1.2108	187.8435*	138.2449**	4.6259	164.6293*	3.9518	4.0458	142.5806
Genotypes	48	100.5543*	19.0624*	27.3193*	14.9444*	136.4914*	96.8951*	26.1907*	1236.3725*
Hybrids	29	90.7746*	18.2460*	19.0254*	13.2054*	122.1444*	55.7657*	30.0214*	1550.5390*
Reciprocals	14	36.8712	13.9125	2.5742	8.4321	19.3102	27.1031	16.3917	96.4013
Parents	5	82.0631*	20.6970*	12.0963*	14.5206*	88.3144*	45.3112*	26.5102*	1230.6811*
Checks	12	61.4905	21.0811*	8.6231*	16.6908*	72.0951**	53.0214*	29.0613*	1382.0621*
Hybrid x parent	1	88.6317*	32.6897*	26.8134*	125.8691**	2511.7802**	20.6134	125.3101*	2150.6873*
Hybrid x reciprocal	1	6.2515	9.5432	2.7815	11.7815	11.5237	8.6713	4.5231	19.5768
Hybrid x check	1	31.7932	28.7961*	5.2508*	23.5032*	160.5369*	42.5136*	88.5214*	1621.5421*
Genotype x Year	48	1.1495	8.9691	1.8221	1.6389	11.8403	11.8221	42.3790*	236.7060
Hybrid x Year	29	23.9507	14.5206	2.5161	5.9810	23.5740	15.5111	56.9711*	130.4651
Parent x Year	5	42.9541	12.5618	1.5321	7.3215	16.7943	13.5613	8.1251	160.2453
Check x Year	12	15.0351	16.8161	3.1061	6.9832	36.9314*	8.9341	11.0234	96.5316
Hybrid x Parent x Year	1	18.0974	11.5260	1.3252	3.2081	41.6981*	21.8122	13.5604	120.6305
Hybrid x Check x Year	1	36.0813	13.9162	0.8995	9.6813	28.6973*	32.6180	16.8956	150.8961
Error	192	75.6727	17.5519	3.9081	12.4384	25.3506	37.4216	25.3506	1110.5287
Total	389								
Source of variation	**DF**	**Ash**	**EH**	**PH**	**NL**	**DM**	**GY**	**TGW**	
Year	1	31.8810	117.3775	114.0960	36.0973	68.7463	204.1520	162.0290	
Rep(year)	4	1082.3940**	1234.4443**	2344.059*	12.0601	64.5960	1172.3810*	218.2800*	
Genotypes	48	2456.8290**	232.5341*	2544.600*	1332.0621*	602.5061*	1306.4085*	2682.1159**	
Hybrids	29	120.8687*	125.9420	1273.5738*	1444.0621*	1225.4991**	1232.0653*	1232.0112**	
Reciprocals	14	11.4321	83.6712	941.5602	734.7836	146.5691	1002.8749	162.1003	
Parents	5	130.5368*	136.3132	1482.2104*	1322.0631*	895.6310*	1122.5312	1888.0912**	
Checks	12	160.1051*	150.6130*	1242.0310*	1361.0840*	562.0110*	1355.6502*	1312.5312**	
Hybrid x parent	1	2150.0351**	188.5131*	321253.0910**	1562.5931*	1533.0101**	1265.0331*	51.0561	
Hybrid x reciprocal	1	43.5967*	98.6731	50.9871	345.8971	78.6514	758.4132	132.5782	
Hybrid x check	1	261.5831*	143.5971*	1500.3120*	1.4781	1333.6401**	1561.0640*	131.1251	
Genotype x Year	48	24.6571	95.2722	559.1340	53.5671	119.5209*	61420.5331**	1150.3618*	
Hybrid x Year	29	58.6712*	56.3345	322.6810	66.9851	233.0131*	1322.5321*	2183.6792**	
:Parent x Year	5	66.1052*	72.5163	621.8104	133.5670	45.5611	691.1110	199.5361	
Check x Year	12	73.5963*	66.7812	210.5531	235.6781	21.8110	1823.5371*	154.0632	
Hybrid x Parent x Year	1	44.9160*	78.5672	722.5230	562.8950	73.1310	43923.5912**	182.6501	
Hybrid x Check x Year	1	39.4012*	96.5983	925.8610	483.5667	82.5312	1762.5671*	136.5102	
Error	192	37.4216	137.0790	1113.1320	1000.3120	164.5912	1145.6348	221.0400	

*, ** Significant at 5 and 1% probability levels, respectively.

Table 2. Mean performance of maize genotypes for fifteen traits combined across years (2005 - 2006) at Samaru.

S/N	Hybrid/Parents/Checks	DG	EC	DT	ASI	DS	Mois%	Pro%	Fat%
1	CML176xCML177	6.00	13.00	59.00	2.00	61.00	4.11	7.57	1.44
2	CML176xCML181	5.00	11.00	62.00	4.00	63.00	3.32	6.70	2.31
3	CML176xCML491	6.00	14.00	62.00	2.00	64.00	4.92	5.36	1.74
4	CML176xCML492	5.00	12.00	56.00	1.00	57.00	4.63	6.66	1.67
5	CML176xCML493	6.00	14.00	61.00	1.00	62.00	4.34	5.62	1.66
6	CML177xCML181	6.00	13.00	58.00	3.00	61.00	4.04	4.87	2.15
7	CML177xCML491	6.00	14.00	57.00	4.00	61.00	5.26	5.49	1.61
8	CML177xCML492	5.00	13.00	56.00	1.00	57.00	6.10	5.46	2.30
9	CML177xCML493	6.00	12.00	58.00	2.00	60.00	4.52	7.95	2.76
10	CML181xCML491	5.00	14.00	62.00	1.00	64.00	5.41	5.30	1.57
11	CML181xCML492	6.00	11.00	60.00	2.00	63.00	4.44	5.34	1.39
12	CML181xCML493	5.00	15.00	58.00	2.00	59.00	3.59	5.16	1.61
13	CML491xCML492	5.00	11.00	62.00	2.00	64.00	5.88	5.74	1.52
14	CML491xCML493	6.00	14.00	60.00	2.00	62.00	5.24	4.32	1.86
15	CML492xCML493	6.00	12.00	58.00	2.00	59.00	8.68	5.49	1.42
16	CML177xCML176	6.00	12.00	62.00	2.00	64.00	6.66	5.17	2.44
17	CML181xCML176	6.00	15.00	59.00	3.00	62.00	4.49	7.87	2.20
18	CML491xCML176	6.00	12.00	58.00	3.00	62.00	4.04	6.64	1.52
19	CML492xCML176	6.00	14.00	58.00	4.00	61.00	7.62	5.21	1.56
20	CML493xCML176	6.00	10.00	58.00	3.00	61.00	5.65	6.68	1.24
21	CML181xCML177	6.00	13.00	60.00	3.00	62.00	4.67	7.55	1.39
22	CML491xCML177	6.00	12.00	58.00	3.00	60.00	4.85	7.45	1.17
23	CML492xCML177	6.00	14.00	58.00	2.00	61.00	4.07	5.53	1.16
24	CML493xCML177	6.00	14.00	59.00	3.00	62.00	3.85	8.81	1.55
25	CML491xCML181	6.00	11.00	60.00	2.00	62.00	4.27	5.44	1.51
26	CML492xCMl181	6.00	12.00	61.00	2.00	63.00	4.41	6.04	1.64
27	CML493xCML491	6.00	11.00	58.00	4.00	62.00	4.27	5.15	1.53
28	CML492xCMl491	6.00	13.00	62.00	2.00	64.00	3.67	5.89	1.56
29	CML493xCML491	6.00	14.00	59.00	3.00	62.00	6.58	5.45	1.61
30	CML493xCMl492	6.00	11.00	60.00	3.00	63.00	4.84	6.34	1.27
31	CML176	6.00	11.00	64.00	4.00	68.00	3.95	5.17	1.68
32	CML177	6.00	12.00	58.00	4.00	62.00	5.97	6.48	1.93
33	CML181	6.00	10.00	61.00	2.00	63.00	5.81	4.65	1.39
34	CML491	6.00	14.00	64.00	6.00	70.00	5.52	4.20	1.34
35	CML492	6.00	13.00	64.00	4.00	68.00	6.36	5.41	1.72
36	CML493	6.00	14.00	58.00	3.00	61.00	5.89	5.38	2.49
37	New Kaduna	6.00	14.00	59.00	3.00	62.00	5.88	5.17	1.63
38	Oba-Super-1	6.00	12.00	63.00	4.00	67.00	5.32	4.55	1.48
39	Oba-Super-2	6.00	14.00	60.00	4.00	64.00	6.65	5.22	1.53
40	Oba-98(QPM)	6.00	12.00	61.00	2.00	63.00	8.55	6.14	1.61
41	DMR-LSR-W	6.00	14.00	59.00	2.00	61.00	5.37	5.59	1.52
42	DMR-ESR-W	6.00	13.00	62.00	2.00	64.00	6.67	5.03	1.54
43	ACR-97.TZLCOMP.1	6.00	15.00	61.00	3.00	64.00	7.10	4.61	1.66
44	TZEE-W-SR-W	6.00	13.00	58.00	3.00	61.00	4.88	4.25	1.68
45	Obatanpa (Premier QPM)	6.00	12.00	61.00	2.00	63.00	5.30	4.61	1.83
46	SUWAN-1-SR(DMR)	6.00	14.00	60.00	3.00	63.00	4.11	4.17	1.68
47	JO-F	6.00	13.00	60.00	3.00	63.00	4.36	5.19	1.62
48	JO-2	6.00	14.00	61.00	3.00	64.00	6.59	5.16	1.35
49	JO-1	6.00	12.00	64.00	2.00	66.00	5.45	4.85	1.69
	Mean	5.88	12.83	59.93	2.69	62.43	5.27	5.64	1.67

Table 2. Contd.

S.E.±	0.05	0.19	0.30	0.14	0.35	0.18	0.15	0.05
C.V.	5.63	10.35	3.46	37.33	3.91	23.30	18.61	20.43

Table 3. Means, Standard errors, co-efficient of variations and Ranges of fifteen traits of quality protein maize genotypes evaluated in 2005 and 2006 at Samaru.

Trait	Mean	S.E.±	C.V. (%)	Range
Days to germination	5.92	0.04	5.28	5.17-6.17
Emergence count	12.69	0.19	10.25	9.83-14.67
Days to tassel	59.87	0.30	3.56	55.50-64.17
Anthesis silking interval	2.68	0.13	34.24	1.33-5.67
Days to silk	62.46	0.35	3.91	56.50-69.83
Protein (%)	5.64	0.15	18.61	4.20-8.81
Fat (%)	1.67	0.05	20.43	1.16-2.76
Ash (%)	2.14	0.08	26.98	1.21-3.96
Moisture (%)	5.27	0.18	23.30	3.32-8.69
Ear height (cm)	26.05	0.56	15.01	10.10-36.18
Plant height (cm)	140.41	2.61	13.99	67.93-190.00
Number of leaves/plant	11.25	0.09	5.66	10.13-12.50
Days to maturity	103.50	1.38	9.35	71.00-12.67
Thousand grain weight (g)	202.49	4.56	15.77	145.4-260.35
Grain yield (t/ha)	5.79	0.28	33.11	1.40-8.85

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