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Full Length Research Paper

Crossbreeding Sweet Corn: Advancements in Taste and Nutrition of Green Maize Varieties

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Reports of improvement in sweet corn (*Zea mays saccharata*) for grain yield and agronomic traits through introgression of genes from the field corn (*Zea mays* L.) are common in literature. However, few studies have reported improvement in field corn varieties for organoleptic and/or nutritional properties through the transfer of recessive alleles that condition sweetness in sweet corn into the field corn. Field and laboratory studies were conducted to determine changes in quantitative and qualitative characteristics of three F_1 hybrids derived by crossing sweet corn (pollen parent) unto field corn and their F_2 populations derived by sibmating approximately 200 ears from each of the F_1 hybrids. Our results showed significant changes in grain yield, grain protein concentration, carbohydrate and calcium contents in the F_1 hybrids and F_2 populations. One hybrid (Pop31DMR x Sweet corn) had 21% grain yield advantage over the maternal parent while another hybrid (Obatanpa x Sweet corn) showed superiority for grain protein (27.3%) with corresponding lower carbohydrate content. Grains obtained from the F_2 populations had lower seed protein content than their respective maternal parents or the F_1 hybrids and with corresponding higher carbohydrate content. Percent (%) loss in grain protein in the F_2 seeds was higher than for other nutrient elements. Modest heterotic response was recorded for grain yield in Pop31DMR x Sweet corn cross and for grain protein concentration in Obatanpa x Sweet corn cross.

Key words: Grain yield, nutritional properties, inbreeding depression, heterotic response.

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop mainly used as staple food and animal feed in Nigeria (Fakorede et al., 1989; Lovenstein et al., 1995). It is cultivated both as rain- fed and under irrigation on more than five million hectares across agro-ecological zones of Nigeria, with savanna ecology accounting for more than half of total annual production (CRI, 1995). Although maize is mainly considered a carbohydrate source, it is also an important source of protein because of its considerable total protein yield per hectare (Bjarnson and Vasal, 1992). However, from nutritional perspective, protein of maize and that of other cereals is deficient in essential amino acids, particularly lysine and tryptophan that are essential for monogastric animals and humans (Bhatta and Rabson, 1987; Alan et al., 2007). Recent breeding efforts in the west and central Africa (WCA) sub region have focused on improvement in maize-grain quality characteristics of organoleptic and nutritional properties. The justification is premised on the belief that availability of such varieties is likely to increase utilization of maize grains for various forms of dishes, improve the nutritional status of resource-limited rural communities and increase the land area cultivated to maize in the sub

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region. Genetic improvement of sweet corn (*Zea mays saccharata*) for grain yield has been limited primarily because of its narrow genetic base, the lack of defined heterotic group and the greater effort devoted to improving yield in field corn (Tracy, 1990). Consequently, the focus in field corn x sweet corn crosses is the exploitation of hybrid vigour in the improvement of sweet corn varieties for grain yield, adaptation and genetic diversity (Tracy, 1990; 1994; Cartea et al., 1996). Transfer of mutant genes (su_1, sh_2, bt_2, wx and o^2) from sweet corn into field corn on the other hand, is for the improvement in nutritional contents (protein, lysine, soluble sugar, sucrose, reducing sugar, albumin, globulin and glutelin) of the grains, which has also been accompanied by a corresponding reduction in starch and zein either in the varieties *per se* (Tsyganash et al., 1988; Li and Liu, 1994) or in the resultant F_1 hybrids (Shao and Shao, 1994). Although characters associated with organoleptic and quality characters in maize is well documented (Anonymous, 1997; Ogunbodede, 1999; Olaoye et al., 2001; Akande and Lamidi, 2006; Gupta et al., 2009), there is limited information on the effects of transferring the mutant genes from sweet corn to field corn especially on endosperm attributes of the resulting populations. In an earlier study, Olaoye et al. (2008) reported improvement in flavour and grain texture characteristics of F_1 hybrids derived through the transfer of mutant *su*^{2} genes from sweet corn into three field corn varieties without adverse consequence on grain yield potential of the resulting hybrids. One of the hybrids (Pop31DMR x Sweet corn) had a modest yield advantage of 0.4t/ha^{-1} over the maternal parent while another hybrid (Obatanpa x Sweet corn) also had a 20% increase in grain protein concentration compared to the maternal parent. Analyses of the grains of the F_1 hybrids, their maternal parents and F_2 populations (Olaoye and Ajao, 2008), however showed differences in the suitability of the genotypes for different food values. For example, Obatanpa x Sweet corn cross and its F_2 population had higher amylase contents while one parent (Pop31DMR) had significantly higher starch content indicating its suitability for dry milling processes. Consistent with previous reports on maternal contribution to grain protein and essential amino acid contents in field x sweet corn crosses (Shao and Shao, 1994; Wang et al., 1994), these observations underscore the importance of the genetic background of maternal parents in transfer of recessive mutant traits conditioning grain quality attributes into the field corn. In other words, information on the effects of transferring mutant *su*^{2} genes from sweet corn to field corn on grain yield and quality characteristics will enhance maize breeding efforts in the development of maize varieties for utilization either in the green or processed form. This part of our study reports on changes in grain yield and endosperm quality attributes of F_1 hybrids and F_2 populations resulting from transfer of mutant *su*^{2} genes from the sweet corn into three field corn varieties. The second objective was to dertermine heterotic response in F_1 hybrids for grain yield and nutrient composition.

MATERIALS A ND METHODS

Details of the attributes of parents involved in the crosses and the field experimentation have been described elsewhere (Olaoye et al., 2008; Olaoye and Ajao, 2008). Suwan-1-SR and Pop31DMR are high in carotene content and also resistant to the Downy mildew disease. Obatanpa which is a high quality protein maize (QPM) variety developed in Ghana, has the opaque-2-gene which confers softer endosperm and contains almost double the levels of lysine and tryptophan in the normal maize (Pixley and Bjarnson, 1993; Andres et al., 2008). The sweet corn parent was the source of mutant genes (*su*^{2}) conditioning sucrose content. Briefly, F_1 hybrids were derived by crossing the three field corn parents unto the standard sweet corn as the pollen parent in the breeding nursery of the Institute of Agricultural Research and Training (IAR&T), Ibadan during the 1996 irrigation season. However, the F_2 populations were derived by sibmating approximately 200 ears from each of the F_1 hybrids at the Teaching and Research (T & R) farm, University of Ilorin during the 1998 growing season. At harvest, the best 150 ears based on cob appearance were selected. Equal number of seeds were thereafter obtained from the selected 150 cobs and mixed together to form a balanced bulk for each of the F_2 populations.

Field study

The 10 entries were planted at two sites. These are: the Faculty of Agriculture (FAG) and the T&R farms of the University of Ilorin in a typical Southern Guinea Savanna ecology (Lat. 8°29'N and 8°30'N; Long. 4° 30'E and 4° 32'E) during the 1999 cropping season. FAG farm is on a higher elevation while the T&R farm is at lower elevation. FAG farm is also high in %N, organic matter (%) and mineral contents of calcium and potassium while the T&R farm is higher in clay content as well as magnesium and available phosphorus. The experiment was laid out as a randomized complete block design (RCBD) on each site and each plot consisted of four rows 5M long with inter and intra-row spacing of 0.75 and 0.5 M respectively. Plantings were carried out on 28th and 30th of July, 1999 respectively. The plots were over planted but later thinned to two stands per hill to give a plant population of approximately 53,333 plants/ha. Weed was controlled at the FAG farm by hand while a pre-emergence herbicide application supplemented by one hoe weeding was carried out at the T&R farm. Fertilizer application at both sites was in split- dosage at three and seven weeks after planting at the rate of 80 kg N, 60 kg P and 60 kg/ha respectively from compound NPK fertilizer (20-10-10). Data were collected on seedling emergence and days to 50% anthesis and silking, plant and ear heights (cm) and grain yield (kg/plot). Data from seedling emergence were used to compute emergence percentage (E %) while grain yield obtained in kg/plot was converted to tones/hectare (t/ha^{-1}) assuming 85% shelling percentage after adjusting to 12% moisture at harvest.

Laboratory studies

At harvest, five (5) random ears were selected in a plot giving a total of 20 ears per variety, followed by careful removal of the grains by hand. From each variety, equal number of grains were selected from each plot, mixed together to form a balanced bulk and then subjected to proximate analyses in the laboratory. The grains obtained were grounded to form a fine powder and each sample was oven dried to a constant weight at 80°C to obtain grain moisture content (%MC). Two replicate determinations were analyzed for each variety and the mean recorded for each sample. Crude protein (CP) content and ash determination were carried out according to the methods described by AOAC (1980) and Pearson (1973) respectively. Crude lipid (EE) determination was by the Soxhlet method using petroleum ether at boiling point 40 - 60°C as solvent (AOAC, 1975). Crude fibre (CF) determination was by digestion of the defatted sample followed by drying of the residue obtained from washing with boiling distilled water in an oven to a constant weight at 80- 85°C. Nitrogen free extract (NFE) was determined by difference as;

%NFE = 100 - [%MC - %CP + %Ash + %CF + %EE]

Total carbohydrate was obtained by the summation of CF which represents the insoluble carbohydrate and the NFE which is the soluble carbohydrate (that is %CF + %NFE).

Two mineral elements viz: calcium and phosphorous were also analyzed for each variety using the standard laboratory procedure and the mean recorded for each sample.

Data analyses

Data collected from field experiments were subjected to analyses of variance (ANOVA) first on individual site basis before a combined ANOVA across sites. Data from proximate analyses and mineral content determinations were pooled across sites. Pertinent means were separated by use of Least Significance Difference (Steel and Torrie, 1980). Estimates of inbreeding depression (F_1-F_2) in actual units and percent inbreeding depression [$100(1-F_2/F_1)$] were computed for each F_1- F_2 pair in each replicate as described by Meghji et al. (1984) . F_1 and F_2 are means of first and second filial generation crosses respectively. Mid-parent (MP) and high-parent (HP) heterosis were also computed using the formulae

$MP = 100[(F_1-MP)/MP]$ and $HP = 100[(F_1-HP)/HP]$

Where MP is the average of the two parents for a trait and HP is the value of the higher parent for the same trait respectively. Significance of inbreeding depression was determined by Least Significance differences (LSD) estimated as

$LSD_{(0.05)} = t_{0.05} [(1/nF_2 + 1/nF_1)Mse]^{1/2}$

While that for both mid- and high parent heterosis was

$LSD_{(0.05)} = t_{0.05} [(1/nF_1 + 1/nP)Mse]^{1/2}$

Where $t_{0.05}$ is the tabular value of t at 5% level, n is the number of observations and Mse is the pooled error mean square. In computing these estimates, emphasis was only on characters for which the genotypes differed significantly.

RESULTS

Effects of planting sites on expression of quantitative and qualitative traits

Grain yield differed significantly between the two planting sites with FAG farm having 33% yield advantage over the T&R farm but with a corresponding higher ear placement than at the T&R farm (Table 1). Conversely, seedling emergence was better at the T&R farm while days to anthesis and mid-silk were similar between the two sites. In consonance with the native nutrient status of the planting sites, FAG farm also had higher grain moisture, grain protein and %Ca than the T&R farm (Table 2). However, Ca content was the only parameter which differed significantly between the planting sites with FAG farm having 11.5% higher Ca than the T&R Farm.

Genotypic performance for quantitative and qualitative traits

The genotypes differed for the quantitative characters including grain yield (Table 1). Seedling emergence was lower in the segregating F_2 populations compared to the parents and hybrids respectively. Days to mid-silk were delayed in the F_2 populations derived from Suwan-1-SR x Sweet corn and Obatanpa x Sweet corn crosses relative to their maternal parents. The sweet corn parent was the latest to attain mid-silk while Pop 31DMR was the earliest by approximately 4 days. Two of the hybrids (Suwan-1-SR x Sweet corn and Obatanpa x Sweet corn) attained mid-silk earlier than either parent and also had lower ear placement. However, Pop 31DMR x Sweet corn cross was similar to the maternal parent for this character. Grain yield in the F_2 populations was reduced by 17.3 and 22% respectively compared to those of the parents and hybrids. The range was from 3.94 - 25.7% of the parent value and 16.99 - 26.97% of the F_1 hybrids. Each of the hybrids except Obatanpa x Sweet corn, yielded higher than their respective maternal parents.

The genotypes also differed significantly for grain moisture, grain protein and carbohydrate contents as well as %Ca but similar for other characteristics (Table 2). Except for Suwan-1-SR, grain moisture in the parents was generally lower than either those of the hybrids or F_2 populations.

The sweet corn parent with significantly higher grain protein content was also superior for %Ca, indicating superiority in P absorption from the soil and assimilating it into the grains. Conversely, the hybrids had higher %P in the grains than their parents. Obatanpa x Sweet corn was the only hybrid with significantly higher grain protein concentration than the maternal parent.

The parents also had lower CF content than either hybrids or F_2 populations but differences were non significant. F_2 populations had lower grain protein concentration compared to their parents or their respective hybrids but with a corresponding higher carbohydrate content and NFE. %P remained relatively unchanged in all genotypes but other parameters especially %Ca showed no consistent trend between the different sets of genotypes. Ca content in the grains of F_2 population derived from Obatanpa x Sweet corn cross was higher than either that of the hybrid or maternal parent but the reverse was the case for the population derived from Suwan-1-SR x Sweet corn cross.

Table 1. Location and entry means (across locations) for grain yield and agronomic traits in parents and F_1 hybrids of Sweet corn x Field corn (Ilorin, Nigeria).

		Days to			
	Emergence percentage	Anthesis	Mid-silk	Ear height (cm)	Grain yield (tha-1)
Location					
Faculty of Agriculture Farm	73.01	60	62	57.45	1.87
Teaching and Research Farm	79.63	60	62	38.76	1.26
LSD 0.05	2.02**	ns	ns	4.40**	0.20**
SED	1.30	0.35	0.36	1.83	0.09
Parents					
Suwan-1-SR	73.5	63	65	57.6	1.75
Pop31DMR	86.9	57	59	48.4	1.52
Obatanpa	71.4	60	62	45.9	1.57
Sweet corn	77.0	63	66	50.4	1.65
F_1 Hybrids					
Suwan-1-SR x Sweet corn	79.6	60	62	45.0	1.78
Pop31DMR x Sweet corn	84.2	58	60	48.5	1.84
Obatanpa x Sweet corn	83.8	59	60	42.0	1.53
F_2 Populations					
Suwan-1-SR x Sweet corn	72.9	61	63	43.8	1.30
Pop31DMR x Sweet corn	73.6	58	60	52.9	1.46
Obatanpa x Sweet corn	60.4	60	63	46.6	1.27
Grand Mean	76.32	60	62	48.11	1.56
LSD 0.05	21.9**	5.78**	1.94**	13.11**	0.35*
SED	2.91	0.78	0.81	4.09	0.20
CV (%)	7.68	2.90	2.59	16.56	25.66

*, **; Significant F test at 0.05 and 0.01 levels of probability respectively.
SED = Standard error of mean.

Estimates of inbreeding and heterosis for quantitative and qualitative traits

Mean squares from ANOVA for inbreeding depression (actual units and %) for quantitative characters indicated significant differences among F_2 populations only for seedling emergence (Table 3). Values for these esti-mates in each population were similar for other characters except grain yield where % inbreeding depress-sion was larger in magnitude than in actual units. Inbreeding in Pop31DMR x Sweet corn cross did not adversely affect any of the traits except ear placement. Conversely, F_2 population from Obatanpa x Sweet corn showed decreased vigour for all characters except for grain yield. Negative estimates were obtained for days to flowering and ear placement in the F_2 populations.

Estimates of MP and HP heterosis among hybrids for quantitative characters studied were significant for days to anthesis (MP) and grain yield (MP and HP) respec-tively (Table 3) . However, MP values were larger in magnitude than for HP. Consistent with estimates of inbreeding, negative estimates were recorded for days to flowering and ear placement indicating that the hybrids matured earlier and had lower ear placement than their field corn for parents. However, of the three hybrids, Pop31DMR x Sweet corn demonstrated superiority for grain yield over the better parent while Suwan-1-SR x Sweet corn was superior only to the mid-parent for grain yield.

Estimates of inbreeding depression (%) for qualitative characters among different F_2 populations were significant for grain moisture and grain protein content but not for carbohydrate content (Table 4). Inbreeding depression for these traits was highest in F_2 population derived from Obatanpa x Sweet corn and ranged from two to three-fold loss compared to other populations. Negative estimates were obtained for F_2 population derived from Suwan-1-SR x Sweet corn cross for grain moisture at harvest. Estimates of % loss in grain protein by growing F_2 seeds when compared to either parent ranged from 6.1% in Obatanpa x Sweet corn to 15.20% in Suwan-1-SR x Sweet corn crosses while in the hybrids, it ranged from 14.6% in Pop31DMR x Sweet corn to 27.14% in Obatanpa x Sweet corn crosses.

MP heterosis for qualitative characters was significant only for grain protein (Table 4).

Heterotic response for grain moisture at harvest was positive in two hybrids and high in Obatanpa x Sweet corn cross. In consonance with the inbreeding estimates, hybrid from Suwan-1-SR x Sweet corn cross showed he-terotic advantage for earliness over either parent as indicated by estimates for both MP and HP heterosis for grain moisture while values for the other two hybrids indicated late maturity.

Table 2. Location and entry means (across locations) for nutrient composition and mineral elements in parents and F_1 hybrids of Sweet corn x Field corn (Ilorin, Nigeria).

Location	Grain moisture	Ash	Carbohydrate	Crude protein	Crude fat	Crude fibre	Nitrogen free extract	% P	% Ca
FAG Farm	10.10	1.50	72.83	8.85	6.35	3.58	69.26	0.306	0.243
T and R farm	9.23	1.73	73.54	8.82	6.67	3.74	69.78	0.3277	0.215
LSD 0.05	ns	ns	Ns	ns	ns	ns	ns	ns	0.028*
SED	0.417	0.289	0.935	0.0517	0.563	0.478	1.003	0.0118	0.053
				Genotypes					
Parents									
Suwan-1-SR	9.30	1.20	74.05	8.55	6.90	4.05	70.00	0.225	0.380
Pop 31 DMR	8.40	1.95	75.20	8.20	6.25	3.50	71.70	0.225	0.360
Obatanpa	9.15	2.00	74.25	8.25	6.35	3.90	70.35	0.200	0.140
Sweet corn	9.40	1.80	69.10	14.20	5.50	3.74	65.90	0.200	0.720
F_1 Hybrids									
Suwan-1-SR x Sweet corn	8.40	1.45	75.40	8.45	6.30	4.15	71.25	0.250	0.340
Pop 31 DMR x Sweet corn	9.95	2.15	72.35	8.20	7.35	3.15	69.20	0.225	0.200
Obatanpa x Sweet corn	13.90	1.00	68.10	10.50	6.50	3.75	64.40	0.290	0.195
F_2 populations									
Suwan-1-SR x Sweet corn	9.85	1.10	74.10	7.25	6.70	2.80	71.30	0.200	0.090
Pop 31 DMR x Sweet corn	9.00	2.00	74.75	7.00	6.25	4.00	70.75	0.250	0.235
Obatanpa x Sweet corn	9.30	1.50	74.55	7.75	7.00	4.10	70.35	0.225	0.255
Grand Mean	9.66	1.61	73.18	8.83	6.51	3.66	69.52	0.229	0.291
LSD 0.05	2.11**	ns	4.74*	2.62**	ns	ns	ns	ns	0.27*
SED	0.933	0.647	2.090	1.156	1.263	1.068	2.42	0.026	0.119
CV (%	9.65	20.20	2.86	13.09	19.36	29.19	3.23	11.54	21.04

*, **; Significant F test at 0.05 and 0.01 levels of probability respectively.
SED = Standard error of mean.

DISCUSSSION

Grain yield and grain protein content in the genotypes were significantly higher at the FAG farm which has higher native N and OM content than at the T&R farm. This is consistent with previous reports which showed that high organic status of the soil (Stanchev and Mitra, 1988; Kling and Okoruwa, 1994; Kamalakumari and Singaram, 1996; Singaram and Kamalakumari, 1999) as well as increase in dosage of inorganic N-fertilizer application (Oikeh et al., 1998; Kramarev et al., 2000) resulted in improved quality of maize grains by enhancing sugar, starch and crude protein contents. Pixley and Bjarnson (1993) also noted that such situation arises when N is limiting in the crop as often the case under low-input farming system. However, our results also showed that grain protein concentration decreased as crude fibre and NFE increased. This was probably due to conversion of protein into insoluble carbohydrate which also which also corroborates previous reports (Olaoye et al., 2001) which showed decline in grain protein for every day delay in harvesting maize for utilization in the green form. Except for %P, the native nutrient status of planting sites did not significantly alter the expression of other quailtative characters in the test varieties. Although the site with high Ca content produced maize grains with higher Ca content, %P in the genotypes was not consistent with nutrient status of planting site because maize grains from FAG with higher available P were low in P content than those from

Table 3. Inbreeding depression and heterosis for grain yield and related traits in three populations derived from field corn x sweet corn crosses (Ilorin, Nigeria).

	Inbreeding depression		(%) Heterosis	
Population	**Actual units**	**Percent %)**	**Mid-Parent**	**High Parent**
Emergence (%)				
Suwan-1-SR x Sweet corn	6.68	7.99	6.65	-2.06
Pop 31 DMR x Sweet corn	10.57	11.92	0.38	-2.90
Obatanpa x Sweet corn	23.41	27.86	13.20	7.08
LSD 005	12.82*	14.28*	15.27	12.94
SED	7.15	8.59	5.23	4.52
Days to Anthesis				
Suwan-1-SR x Sweet corn	-1.40	-2.35	-4.77	-2.03
Pop 31 DMR x Sweet corn	0.20	0.39	-3.40	2.48
Obatanpa x Sweet corn	- 2.0	-1.29	-7.39	-2.87
LSD 005	2.93	5.15	4.49*	5.72
SED	0.93	1.13	1.66	1.79
Days to Silking				
Suwan-1-SR x Sweet corn	-2.38	-2.27	-4.96	-10.79
Pop 31 DMR x Sweet corn	0.13	0.16	-3.99	- 5.53
Obatanpa x Sweet corn	-2.38	-3.61	-5.50	-11.62
LSD 005	2.36	6.43	4.49	6.12
SED	1.18	1.56	0.62	3.97
Ear height				
Suwan-1-SR x Sweet corn	1.26	2.84	-2.40	-16.24
Pop 31 DMR x Sweet corn	-4.38	-9.97	-4.28	- 5.14
Obatanpa x Sweet corn	-4.60	-16.90	-8.15	-22.12
LSD 005	18.75	38.8	3.67	16.74
SED	2.71	8.18	2.39	7.07
Grain yield				
Suwan-1-SR x Sweet corn	0.54	27.73	8.60	-8.48
Pop 31 DMR x Sweet corn	0.38	20.64	21.13	3.92
Obatanpa x Sweet corn	0.26	15.85	-6.96	-21.82
LSD 005	0.33	18.07	16.03*	4.91*
SED	0.11	4.88	11.49	10.51

*, Significant F test at 0.05 level of probability.
SED = Standard error of mean.

Table 4. Inbreeding depression and heterosis for grain moisture, grain protein and carbohydrate contents in three populations derived from field corn x sweet corn crosses (Ilorin, Nigeria).

	Inbreeding depression		(%) Heterosis	
Population	**Actual units**	**Percent %)**	**Mid-Parent**	**High Parent**
Grain moisture				
Suwan-1-SR x Sweet corn	-1.45	-18.25	-9.86	-12.74
Pop 31 DMR x Sweet corn	0.95	8.96	11.64	5.85
Obatanpa x Sweet corn	4.6	32.03	49.39	45.28
LSD 005	3.44*	30.61*	77.31	80.28
SED	2.67	41.36	43.92	44.41
Grain protein				
Suwan-1-SR x Sweet corn	1.20	12.73	-25.86	-40.49

Table 4. Contd.

Pop 31 DMR x Sweet corn	1.20	-15.07	-26.80	-42.26
Obatanpa x Sweet corn	3.10	28.22	- 3.08	-23.59
LSD 005	5.87	16.63*	17.43*	36.13
SED	0.90	12.22	10.97	8.42
Carbohydrate content				
Suwan-1-SR x Sweet corn	2.60	3.29	5.36	1.82
Pop 31 DMR x Sweet corn	-4.80	-10.38	-6.82	-3.75
Obatanpa x Sweet corn	-12.90	-19.38	-4.99	-8.12
LSD 005	80.26	19.48	16.59	24.85
SED	45.81	19.69	6.39	8.34

*,Significant F test at 0.05 level of probability.
SED = Standard error of mean

T&R farm.

Estimates of inbreeding depression in the F_2 populations did not follow any consistent pattern either for quantitative or qualitative characters. However, low seedling emergence and grain yield recorded for F_2 populations indicated low vigour due to inbreeding depression which is consistent with previous reports of between 30.1 and 35.5% yield reduction in the F_2 generation compared to the hybrids (Martin and Hallauer, 1976; Lopez-Perez, 1977). Similarly, the two to three-fold loss observed for qualitative attributes in F_2 population derived from Obatanpa x Sweet corn cross when compared with other populations, is probably due to rapid transformation of sugar to starch in F_2 generation especially since both grain protein and sucrose contents are conditioned by recessive alleles and are likely to be expressed in this generation. This population also showed low vigour for all characters except for grain yield probably because neither parent carries alleles for grain yield in the dominant form.

Earliness in days to flowering and reduced plant height, consequently low ear placement, are two attributes which are desired by maize breeders. Negative estimates of inbreeding depression and heterosis recorded for these traits in F_2 populations and hybrids, indicate that the genotypes matured earlier and had lower ear placement than their field corn parents. This also indicates that these traits are inherited through the maternal parent. The negative inbreeding depression obtained for days to flowering in this study, however contradicts earlier reports in literature (Hallauer and Miranda Fhilo, 1988) of positive inbreeding depression estimates for this trait. This may be due to the fact that F_2 populations in the present study were derived through sibmating rather than by selfing.

Estimates of MP heterosis for quantitative attributes which were larger in magnitude than HP suggest a modest increase in heterotic response for such charac-ters in the hybrids. However, Pop 31DMR x Sweet corn cross was the only hybrid which showed heterotic res-ponse for grain yield over either the MP or the HP which suggests superiority of the hybrid over the parents for this character. These low estimates are not unexpected since the trait actually being transferred is conditioned by recessive genes.

Differences in genetic background of the field corn parents influenced the results obtained for grain quality attributes in both F_1 hybrids and F_2 populations, depending on the parent used. For example, % loss in grain protein was low in Pop 31DMR x Sweet corn but high in Obatanpa x Sweet corn in the hybrids and also low in Obatanpa x Sweet corn and high Suwan-1-SR x Sweet corn in the F_2 generation. Letchworth and Lambert (1998) noted that endosperm of hybrids from self-pollinated grains were higher in grain protein content than those obtained from open-pollinated crosses while the reverse was the case for oil content and starch concen-tration. In other words, careful selection of maternal and pollen parent in flint x sweet corn crosses is important when breeding for maize endosperm qualities, since differences in genetic background of flint varieties will likely affect the effectiveness of improving the quality of the resulting hybrids (Shao and Shao, 1994). There was lack of heterosis for protein content in the hybrids obtained from the crosses. Therefore, backcrossing the F_1 hybrids to QPM parents such as Obatanpa followed by selection of progenies with the desired endosperm characteristics in the segregating populations will be necessary in order to enhance protein quality of the green maize varieties. However, Alan et al. (2007) noted that breeding procedure aimed at transferring recessive traits is more complicated because of the requirement for selfing between each backcross generation in order to fix the recessive alleles. The implication is that backcrossing the F_1 hybrids to QPM parents will require alternating with selfing in order to achieve the desired protein contents in future green maize varieties.

REFERENCES

Akande SR, Lamidi GO (2006). Performance of quality protein maize varieties and disease reaction in the derived-savanna agro-ecology of South-West Nigeria. Afr. J. Biotechnol. 5(19): 1744-1748.

Alan FK, Hugo DG, Nilupa SG, Alpha OD, Dennis F (2007). Breeding and disseminating quality protein maize (QPM) for Africa. Afr. J. Biotechnol. 6(4): 312-324.

Andres G, Paul SEM, Otto RL, Monica MD, Javier BD (2008). Phenotypic characterization of Quality Protein Maize Endosperm Modification and Amino Acid Contents in a Segregating Recombinant Inbred Population. Crop Sci. 48: 1714-1722.

Anonymous (1997). IITA Archival Report 1993-1995, Maize improvement Programme. IITA, Ibadan, Nigeria. p. 83.

AOAC (1975). Official methods of analysis of the Association of Official Analytical Chemists. 12th edition (W. Horowized) Washington D.C. Pp. 15-75.

AOAC (1980). Official methods of analysis of the Association of Official Analytical Chemists. 13th edition (W. Horowized) Washington D.C. Pp. 1018.

Bjarnson M, vassal SK (1992). Breeding of quality protein maize (QPM). In Janick (ed.). Plant Breeding Reviews, 9 John Wiley and Sons Inc. New York. pp. 181-216.

Bhatta CR, Rabson R (1987). Relationship of grain yield and nutritional quality. In Olson RA and Frey KJ (ed.). Nutritional quality of cereal grains. Genetic and agronomic improvement. Agron. Monogr. 28, ASA, CSSA, SSSA Madison, WI. pp 11-43.

Cartea ME, Malvar RA, Revilla P, Ordox A (1996). Identification of field corn populations to improve sweet corn for Atlantic European conditions. Crop Sci. 36(6): 1506-1512.

CRI (1995). Crop Research Institute. Research Briefs Bimonthly Bulletin of the Crop Research Institute, Ghana, NO. 1 Council for Scientific and industrial Research. p. 97.

Fakorede MAB, Iken JE, Kim SK, Mareck JH (1989). Empirical result from a study on maize yield potential indifferent ecologies of Nigeria. In Proceedings of maize towards production technologies in semi-arid west and central Africa. Fajemisin JM, Muleba N, Emechebe AM and Daire C (eds.).SAFGRAD and IITA. pp. 79-97.

Gupta HS, Agrawal PK, Mahjan V, Bisht GS, Kumar A, Verma P, Srivastava A, Saha S, Babu R, Pant MC and Mani VP (2009). Quality Protein maize for nutritional security: rapid development of short duration hybrids through molecular marker assisted breeding. Res. Acct. Curr. Sci. 96(2): 12-19.

Hallauer AR, Miranda Filho JB (1988). Quantitative genetics in Maize Breeding. 2nd Edition. Iowa State University Press, Ames Iowa 50010. p. 382.

Kamalakumari K, Singaram P (1996). Quality parameters of maize as influenced by application of fertilizers and manures. Madras-Agricultural-J. 83(1): 32-33.

Kling JG, Okoruwa AE (1994). Influence of variety and environment on maize grain quality for food uses. Paper presented at the American Society of Agronomy meetings, Seattle, WA. pp. 95-127.

Kramarev SM, Skripnik LN, Khorseva YL, Shevchenko VN, Vasil'-eva VV (2000). Increasing the protein content in maize grain by optimizing the nitrogen nutrition of the plants. Kukuruza-i-Sorgo. 1: 13-16.

Letchworth MB, Lambert RJ (1998). Pollen parent effects on oil, protein, and starch concentration in maize kernels. Crop-Sci. 38 (2): 363-367.

Li XY, Liu JL (1994). The effects of maize endosperm mutant genes and gene interactions on kernel components. IV. Relations among kernel components and their values for quality improvement. Acta-Agronomica-Sinica. 20(4): 439-445.

Lopez-Perez E (1977). Comparisons among maize hybrids made from unselected lines developed by selfing and Full sibbing. M. Sc. Thesis, Iowa State University. In Hallauer and Miranda Fihlo (eds.). Quantitative Genetics in Maize Breeding 2nd Edition. Iowa State University Press. Ames, Iowa 50010. pp. 299-336.

Lovenstein H, Lafinga EA, Rabbinge R, vankeulen HV (1995). Principle of Production Ecology. Wageningen agricultural University. The Nertherlands, p. 201.

Martin JM, Hallauer AR (1976). Relation between heterozygosis and yield for four types of maize inbred lines. Egyptian J. Genet. Cytol. 5: 119-135.

Meghji MR, Dudley JW, Lambert RJ, Sprague GF (1984). Inbreeding, inbred and hybrid grain yields and other traits of maize genotypes representing three eras. Crop Sci. 24: 545-549.

Ogunbodede BA (1999). Green maize production in Nigeria in the new millennium – Prospects and Problems. In Olaoye G and Ladipo DO (eds.) Genetics and food security in Nigeria on the Twenty-first century. Genetics Society of Nigeria special publication. pp. 33-37.

Oikeh SO, Kling JG, Okoruwa AE (1998). Nitrogen fertilizer management effects on maize grain quality in the West African moist Savanna. Crop-Science. 38(4): 1056-1061.

Olaoye G, Adegbesan NO, Onaolapo IO (2001). Interactive effects of Location x sampling time on organoleptic and nutritional qualities of six maize genotypes. Nig. J. Exp. Biol., 1(1): 99-108.

Olaoye G, Ogunbodede BA, Olakojo SA (2008). Breeding for improved organoleptic and nutritionally acceptable green maize varieties by crossing unto sweet corn (*Zea mays saccharata*). I. Comparative analyses of grain yield, organoleptic and nutritional properties of F_1 hybrids and their maternal parents. Nig. J. Genet. 22: 131- 148.

Olaoye G, Ajao FA (2008). Breeding for improved organoleptic and nutritionally acceptable green maize varieties by crossing unto sweet corn (*Zea mays saccharata*).II. Grain quality characteristics in F_1 hybrids and their F_2 segregating populations. Nig. J. Genet. 22: 149-166.

Pearson D (1973). Laboratory techniques of food analysis Butterworth, London. p. 7-20.

Pixley KV, Bjarnson MS (1993). Combining ability for yield and protein quality among modified-endosperm opaques-2-tropical maize inbred. Crop Sci. 33: 1229-1234.

Shao J, Shao JP (1994). Quality deficiency of maize F_1 hybrids from flint x sweet crosses for fresh edible maize. Acta-Agriculturae-Shanghai. 10(3): 32-36.

Singaram P, Kamalakumari K (1999). Effect of continuous manuring and fertilization on maize grain quality and nutrient soil enzyme relationship. Madras Agric. J. 86(1-3): 51-54.

Stanchev L and Mitra M (1987. Effect of fertilizers on grain quality of maize hybrid H-708. Pochvoznanie Agrokhimiya I Rastitelna Zashcita 22(1): 59-63.

Steel RGD, Torrie JH (1980). Principles and Procedures of Statistics. A Biometrical Approach. 2nd Edition. Mc Graw Hill Book Inc, New York. p. 580.

Tracy WF (1990). Potential of field corn germplasm for the improvement of sweet corn. Crop Sci. 30: 1041-1045.

Tracy WF (1994). Sweet corn. In A.R. Hallauer (ed.) Specialty types of maize. CRC Press, Boca Raton, FL. Pp. 147-187.

Tsyganash VI, Palii AF, Tsyganash DA, Rotar AI, Manolii VP (1988). Effect of the o^2 and su^2 mutations and their interaction on grain quality in maize.Selektsionno-geneticheskie-metody-povysheniya-urozhainosti,-kachestva-i-ustoichivosti-polevykh-kul'tur. pp. 18-24.

Wang LM, Shi DQ, Liu RD, Bai L (1994). Studies on combining ability of high-lysine maize. Acta-Agronomica-Sinica. 20(4): 446-452.